I. del

PREGLED HIDROLOŠKIH RAZMER V LETU 2006

Part I

REVIEW OF HYDROLOGICAL CONDITIONS IN THE YEAR 2006

A. POVRŠINSKE VODE

Vodostaji in pretoki rek

Igor Strojan

Pregled hidrološkega stanja na slovenskih rekah v letu 2006 je narejen na podlagi podatkov šestnajstih izbranih reprezentativnih vodomernih postaj, ki so nekako enakomerno porazdeljene po celotnem območju države. Izbor vključuje večje in manjše vodotoke, reke s hudourniškim in kraškim značajem ter tudi reke, kjer je naravni režim spremenjen zaradi obratovanja hidroelektrarn.

Leta 2006 je bila vodnatost rek gledano v celoti trinajst odstotkov manjša od dolgoletnega povprečja. Najznačilnejše za to leto je bilo hidrološko suho obdobje v zadnjih treh mesecih leta, v katerih je vodnatost rek navadno kar obilna. Večjih poplav ali dolgotrajnih hidrološko suhih obdobij leta 2006 ni bilo. Glede na geografsko razporejenost so bili pretoki rek v zahodnem delu države nekoliko manjši od povprečja, v vzhodnem delu pa nekoliko večji (slika 9).

V prvi polovici leta so bili pretoki rek večji kakor v drugi (slike 10, 11 in 12). Tako je bil najbolj moker

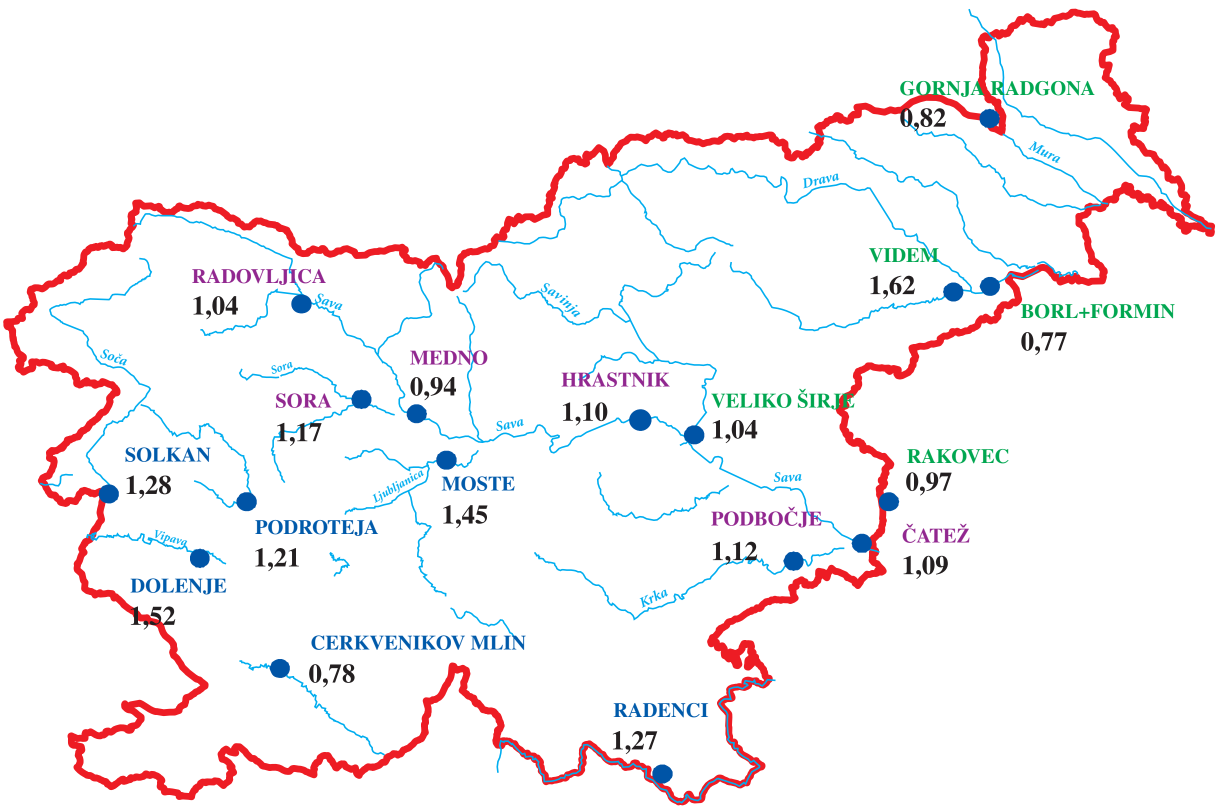
A. SURFACE WATERS

Water levels and discharges

Igor Strojan

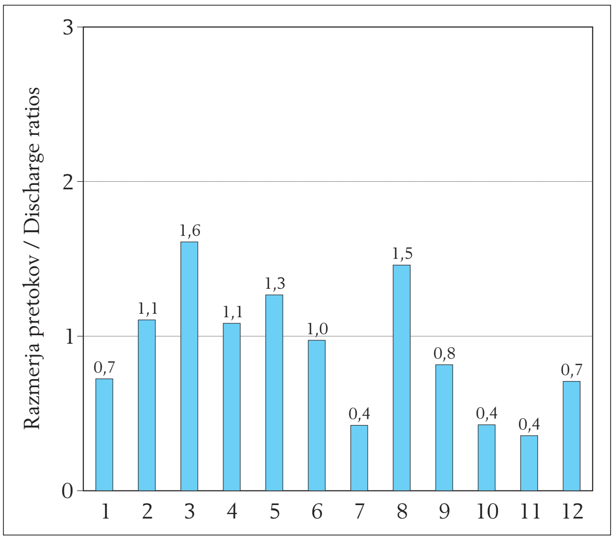
The review of hydrological conditions on Slovenian rivers for 2006 has been made on the basis of the data for 16 selected representative gauging stations, which are more or less evenly distributed on the entire territory of the Republic of Slovenia. The selection includes major and minor streams, rivers with torrential and karstic character, as well as rivers for which the natural regime was changed due to the operation of hydro-electric power plants.

In 2006, the river stages were – taken as a whole – 13% below the multi-annual average. Most characteristic for 2006 was a hydrologically dry period in the last three months of the year, when the river stages are usually high. There were no major floods or long hydrologically dry periods in 2006. With regard to the geographical location, river discharges were slightly below the average in the western part of the country, and in the eastern part slightly above the average (Figure 9).



Slika 9: Razmerja med srednjimi letnimi pretoki leta 2006 in srednjimi letnimi pretoki v dolgoletnem obdobju 1971–2000 na slovenskih rekah.

Figure 9: *Ratios between mean annual discharges in 2006 and mean annual discharges in the 1971–2000 reference period on Slovenian rivers.*



Slika 10: Razmerja med srednjimi mesečnimi pretoki v letu 2006 in obdobnimi srednjimi mesečnimi pretoki. Razmerja so izračunana kot povprečja razmerij na izbranih postajah.

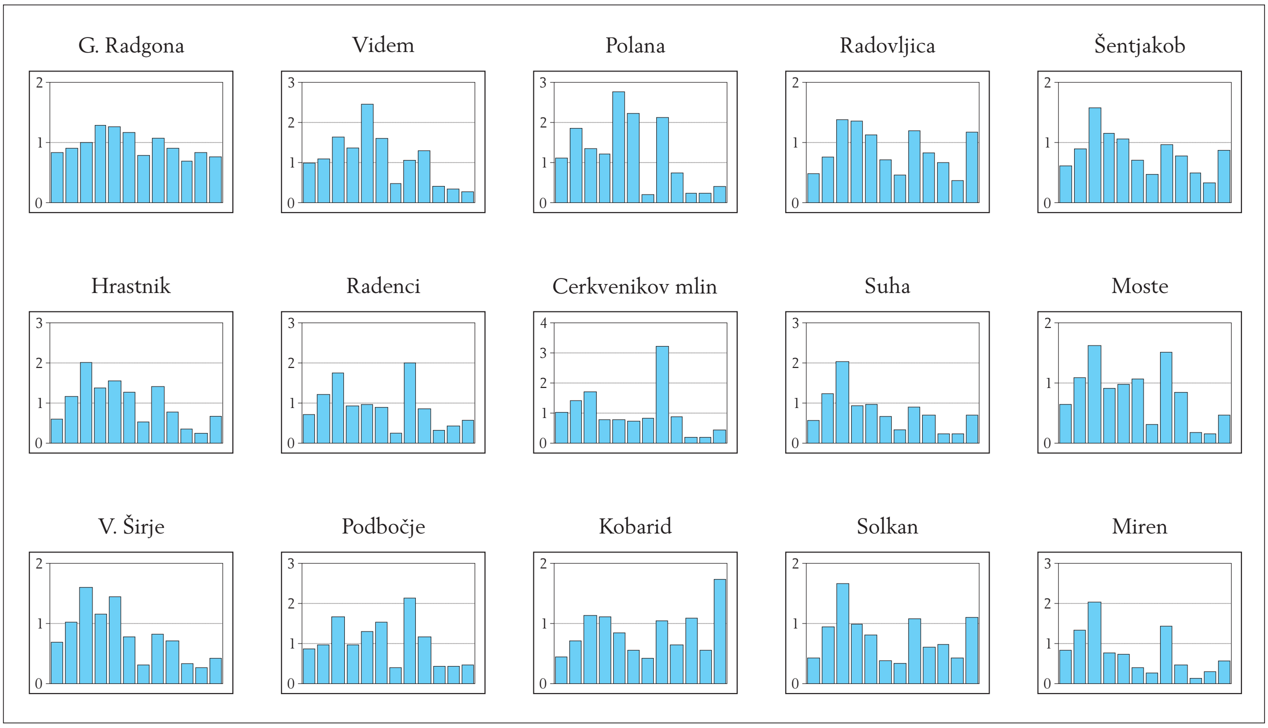
Figure 10: *Ratios between the monthly mean discharges in 2006 and the monthly mean discharges in the reference period. The ratios are calculated as average ratios at selected stations.*

marec, ko je bila vodnatost rek 60 odstotkov večja od povprečja v primerjalnem obdobju. V drugi bolj sušni polovici leta so bili najbolj hidrološko suhi meseci julij, oktober in november. V teh mesecih je bila vodnatost

In the first half of the year, river discharges were higher than in the second half (Figure 10, Figure 11 and Figure 12). March had above-average precipitation, with water stages more than 60% above the average of the reference period. In the second, drier, half of the year, the driest months in hydrological terms were July, October and November. During these months, river stages were about 60% lower than normal. The high assessment values for the overall water stage in August might be slightly deceptive, because some smaller rivers, in particular, for example the Reka at Cerkvenikov mlin (Cerkvenik mill), had high hydrological indexes.

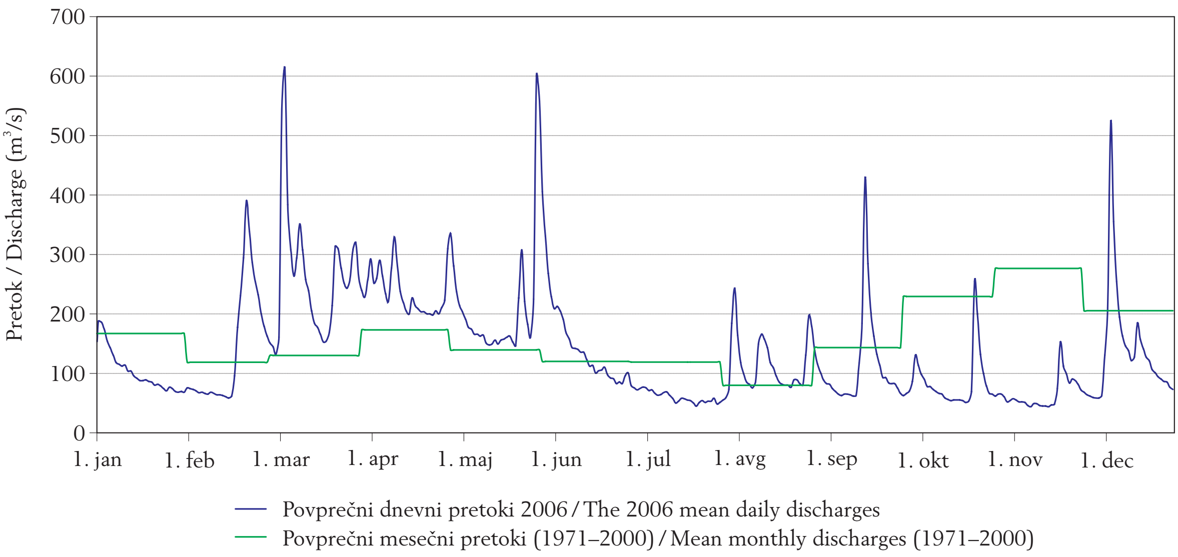
Comparison of characteristic discharges with the multi-annual reference period

In 2006, all of the highest discharges were, with the exception of the Krka in Podbočje, below the average highest discharge levels in the multi-annual reference period (Figure 13 and Table 1). The high-water peaks on the Sava in Radovljica and the Reka at Cerkvenikov mlin differed only slightly from the lowest high-water peaks measured so far. River discharges were highest at the beginning of March and at the end of May. Mean annual river discharges were, in general, slightly lower than usual. On most rivers, they were lower by 25%, whereas in the north-eastern part of the country they



Slika 11: Razmerja med srednjimi mesečnimi pretoki rek v letu 2006 in obdobju 1971–2000. Vrednost razmerja 1 pomeni, da je bil v določenem mesecu leta 2006 srednji mesečni pretok enak povprečju srednjih mesečnih pretokov v dolgoletnem obdobju.

Figure 11: *Ratios between the monthly mean discharges in 2006 and the period 1971–2000. The value of ratio 1 means that, in a specific month in 2006, the monthly mean discharge equals the average of monthly mean discharges in the multi-annual reference period.*



Slika 12: Srednji dnevni pretoki v letu 2006 in srednji mesečni pretoki v dolgoletnem obdobju 1961–2000 na reki Savi v Hrastniku.

Figure 12: *Daily mean discharges in 2006 and monthly mean discharges in the multi-annual period 1961–2000 on the Sava in Hrastnik.*

rek kar okoli 60 odstotkov manjša kakor navadno. Avgustovska visoka ocena celotne vodnatosti je lahko nekoliko varljiva, saj so imele visok količnik vodnatosti predvsem nekatere manjše reke, kakor je npr. reka Reka pri Cerkvenikovem mlinu.

Primerjava karakterističnih pretokov z dolgoletnim obdobjem

Vsi največji pretoki v letu 2006 so bili, razen na Krki v Podbočju, manjši od povprečnih največjih pretokov v dolgoletnem primerjalnem obdobju (slika 13 in preglednica 1). Visokovodni konici na Savi v Radovljici in reki Reki pri Cerkvenikovem mlinu so se le malo razlikovale od do zdaj najmanjših visokovodnih konic. Pretoki rek so bili največji v začetku marca in konec maja. Srednji letni pretoki rek so bili v celoti nekoliko manjši kakor navadno. Na večini rek so bili do četrtino manjši, v severovzhodnem delu države pa nekoliko večji kakor v primerjalnem obdobju. Tako je bil pretok Ledave v Polani in Dravinje v Vidmu dvanajst oz. pet odstotkov večji kakor navadno. Po Krki je leta 2006 pretekla povprečna količina vode. Najmanjši pretoki v letu so bili podobni povprečnim najmanjšim pretokom iz dolgoletnega primerjalnega obdobja. Najmanjša sta bila pretoka na Savi v Radovljici 14. februarja in Kolpi v Radencih 30. julija. Pretoki rek so bili sicer večinoma najmanjši sredi februarja in ob koncu julija, ko se je končalo zimsko oziroma poletno sušno obdobje. Pretoka Save v Hrastniku in Ljubljanice v Mostah sta bila najmanjša 13. in 18. novembra, tj. v času, ko so navadno pretoki rek veliki.

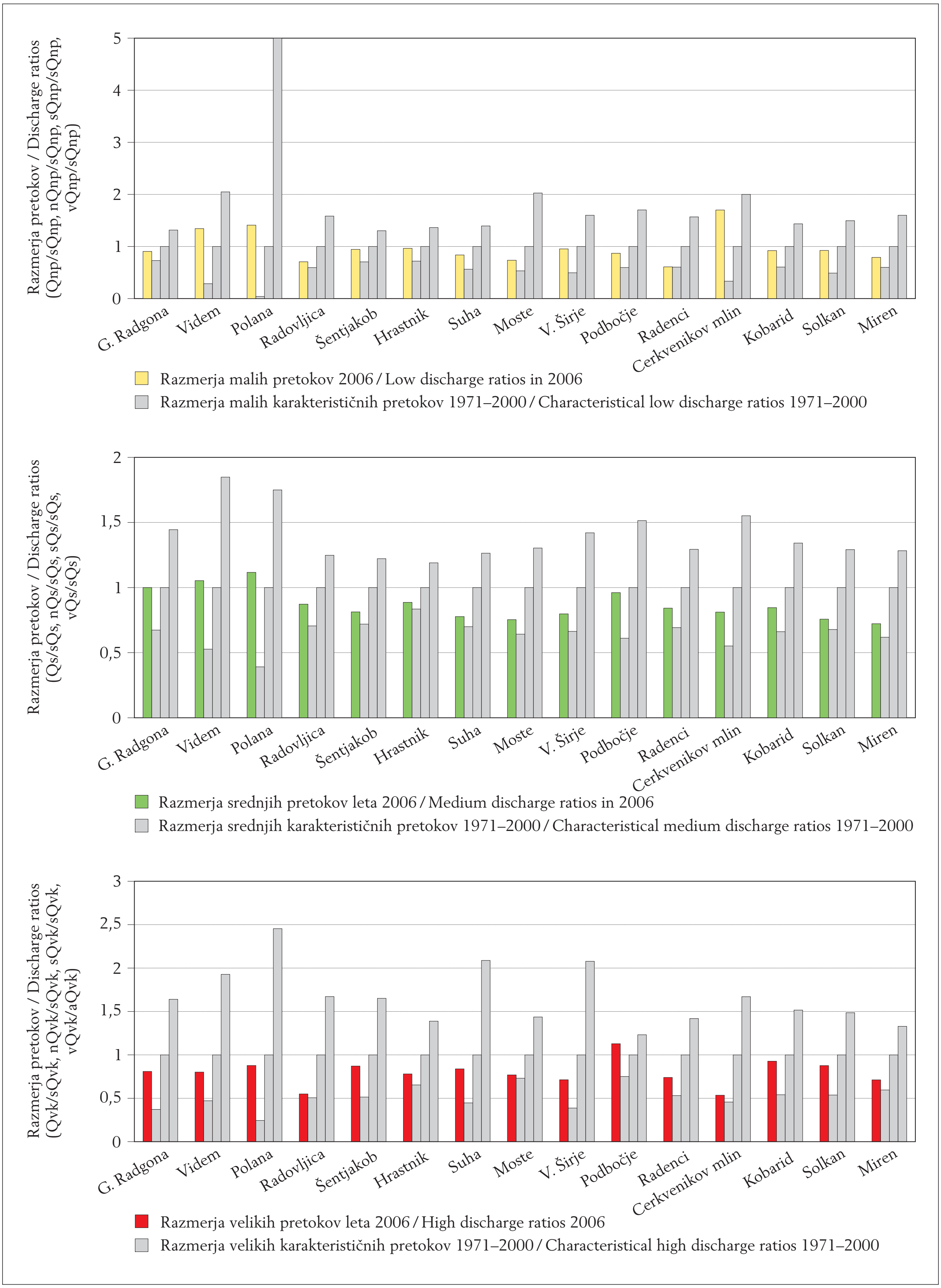
Podrobneje so visokovodne in sušne razmere v letu 2006, opisane v naslednjih prispevkih letopisa.

were slightly higher compared with the reference period. The discharge of the Lendava in Polana was, for example, 12% higher than usual, whereas the discharge of the Dravinja in Videm was 5% higher. In 2006, the discharge values of the Krka were average. The lowest discharges in 2006 were similar to the average lowest discharges in the multi-annual reference period. The lowest discharge value was recorded on the Sava in Radovljica on 14 February and on the Kolpa in Radenci on 30 July. The lowest river discharges were recorded mostly in mid-February and at the end of July i. e. at the end of the dry winter and summer periods. The discharges of the Sava in Hrastnik and the Ljubljanica in Moste were lowest on 13 and 18 November i. e. during the period when the river discharge levels are usually high.

High-water and dry periods for 2006 are described in more detail in the contributions to the Yearbook that follow.

Monthly shares of annual discharges in 2006 and discharge regimes

In February, March and April, the monthly shares of annual discharges exceeded the monthly shares of discharges recorded in the period 1971–2000. The highest river discharge surplus was recorded in March, when the share of monthly discharges was twice as high as usual. The highest river discharge shortages were recorded in July, October, November and December. In October and November, the monthly discharge shares were 50% lower than in the multi-annual reference period (Figure 14).



Slika 13: Razmerja malih, srednjih in velikih pretokov v letu 2006 ter razmerja karakterističnih pretokov obdobja 1971–2000. Vrednosti so podane relativno glede na srednje vrednosti malih, srednjih in velikih obdobnih pretokov.

***Figure 13:** Ratios between low, mean and high river discharges in 2006 and ratios of characteristic discharges in the 1971–2000 period. These are relative values with regard to the mean values of multi-annual low, mean and high discharges.*

Preglednica 1: Značilni pretoki v letu 2006 in obdobju 1971–2000.

Table 1: *Characteristic discharges in 2006 and in the 1971–2000 reference period.*

Reka / *River*	Postaja/ *Station*	2006		1971–2000		
		Qnp		**nQnp**	**sQnp**	**vQnp**
		m^3/s	dan / *day*	m^3/s	m^3/s	m^3/s
Mura	Gornja Radgona	56,2	01.02.	45,3	62,1	81,7
Dravinja	Videm	2,8	23.08.	0,6	2,1	4,3
Ledava	Polana	0,1	19.07.	0,004	0,1	0,5
Sava	Radovljica	5,9	14.02.	5,0	8,4	13,3
Sava	Šentjakob	25,6	10.09.	19,1	27,1	35,3
Sava	Hrastnik	44,0	13.11.	32,8	45,6	62,2
Sora	Suha	3,2	22.07.	2,14	3,8	5,3
Ljubljanica	Moste	5,7	18.11.	4,1	7,7	15,6
Savinja	Veliko Širje	9,1	20.07.	4,7	9,5	15,2
Krka	Podbočje	9,0	25.07.	6,2	10,4	17,7
Kolpa	Radenci	3,5	30.07.	3,5	5,8	9,1
Reka	Cerkvenikov mlin	1,0	31.09.	0,2	0,6	1,2
Soča	Kobarid	7,0	14.02.	4,6	7,6	10,9
Soča	Solkan	18,1	16.12.	9,6	19,6	29,3
Vipava	Miren	1,6	21.07.	1,2	2	3,2
		Qs		**nQs**	**sQs**	**vQs**
		m^3/s		m^3/s	m^3/s	m^3/s
Mura	Gornja Radgona	153		103	153	221
Dravinja	Videm	11,8		5,9	11,2	20,7
Ledava	Polana	1,3		0,47	1,2	2,1
Sava	Radovljica	37,6		30,4	43,1	53,8
Sava	Šentjakob	69,2		61,2	85,1	104
Sava	Hrastnik	140		132	158	188
Sora	Suha	15,0		13,5	19,3	24,4
Ljubljanica	Moste	41,9		35,7	55,6	72,5
Savinja	Veliko Širje	35,1		29,2	44	62,5
Krka	Podbočje	49,9		31,7	51,9	78,6
Kolpa	Radenci	42,7		35,1	50,7	65,6
Reka	Cerkvenikov mlin	6,3		4,3	7,8	12,1
Soča	Kobarid	28,0		21,9	33,1	44,4
Soča	Solkan	68,0		60,9	89,8	116
Vipava	Miren	12,5		10,7	17,3	22,2
		Qvk		**nQvk**	**sQvk**	**vQvk**
		m^3/s	dan / *day*	m^3/s	m^3/s	m^3/s
Mura	Gornja Radgona	595	29.04.	273	735	1205
Dravinja	Videm	121	31.05.	71,1	151	291
Ledava	Polana	29	30.05.	8	32,8	80,5
Sava	Radovljica	226	05.03.	208	411	687
Sava	Šentjakob	750	05.03.	442	861	1422
Sava	Hrastnik	938	05.03.	786	1202	1668
Sora	Suha	276	05.03.	147	329	687
Ljubljanica	Moste	217	30.05.	206	282	405
Savinja	Veliko Širje	511	30.05.	278	717	1490
Krka	Podbočje	326	01.06.	217	289	356
Kolpa	Radenci	495	30.05.	355	669	949
Reka	Cerkvenikov mlin	97,8	30.05.	83,3	183	305
Soča	Kobarid	406	24.10.	237	438	664
Soča	Solkan	1219	05.03.	747	1391	2066
Vipava	Miren	171	05.03.	143	240	319

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

Mesečni deleži letnih pretokov leta 2006 in pretočni režimi

Mesečni deleži letnih pretokov so bili februarja, marca in aprila večji od mesečnih deležev pretokov v obdobju 1971–2000. Največji presežek pretokov je bil marca, ko je bil delež mesečnega pretokov enkrat večji kakor navadno. Primanjkljaji pretokov so bili poleg julija največji oktobra, novembra in decembra. Oktobra in novembra sta bila mesečna deleža pretokov pol manjša kakor v dolgoletnem primerjalnem obdobju (slika 14).

Odstopanje od celotnega ustaljenega letnega pretočnega režima je bilo najmanjše na Muri v Gornji Radgoni, največje pa na Sori na vodomerni postaji Suha. V posameznih mesecih sta najbolj odstopala mesečna presežka v marcu na vodomerni postaji Sora Suha in vodomerni postaji Vipava Miren. Primanjkljaji so bili največji novembra na vodomerni postaji Sava Hrastnik in vodomerni postaji Reka Cerkvenikov mlin (slika 15).

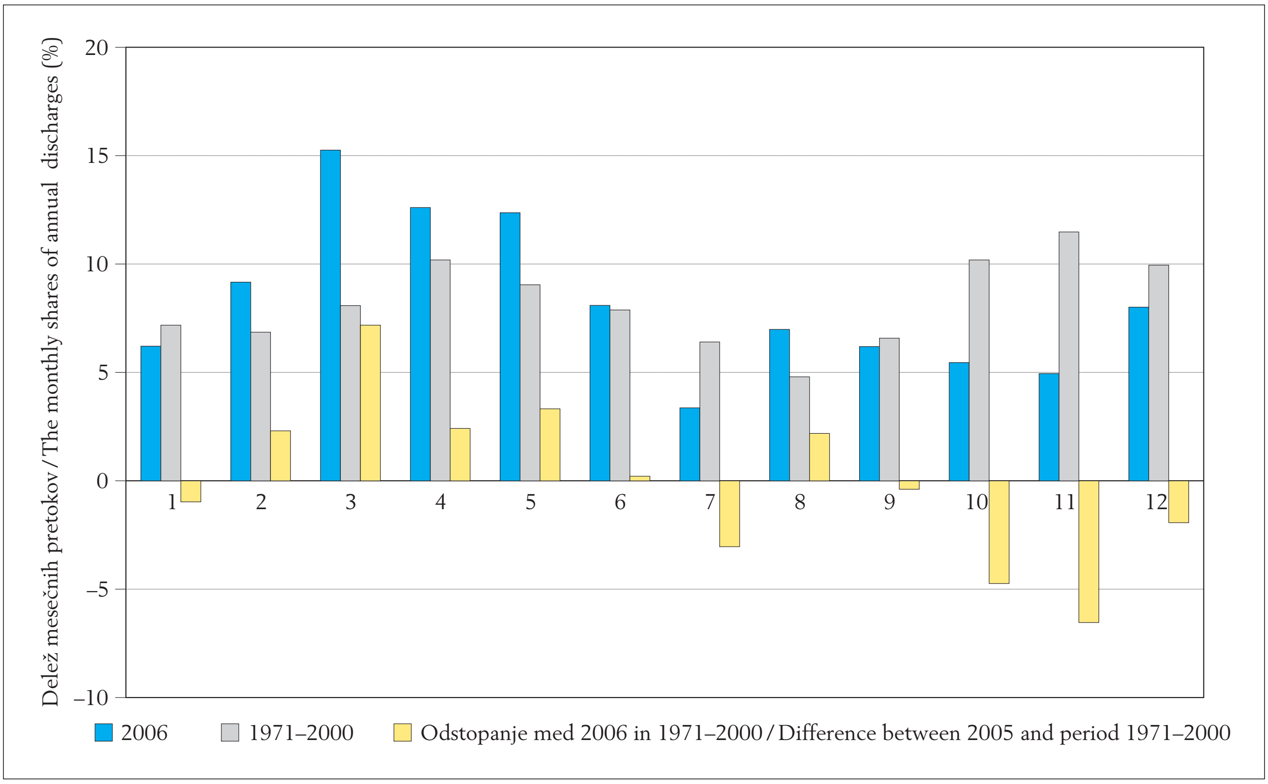
Kronološki pregled hidroloških razmer na rekah v posameznih mesecih leta

Januarja so se v prvih dneh meseca pretoki povečali do velikih pretokov, nato pa se je vodnatost vse do konca

Derogations from the overall usual annual discharge regime were lowest on the Mura in Gornja Radgona and highest on the Sora at the Suha gauging station. In individual months, the monthly surpluses derogated most in March at the Sora Suha gauging station and the Vipava Miren gauging station. The highest shortages were recorded in November at the Sava Hrastnik and Reka Cerkvenikov mlin gauging stations (Figure 15).

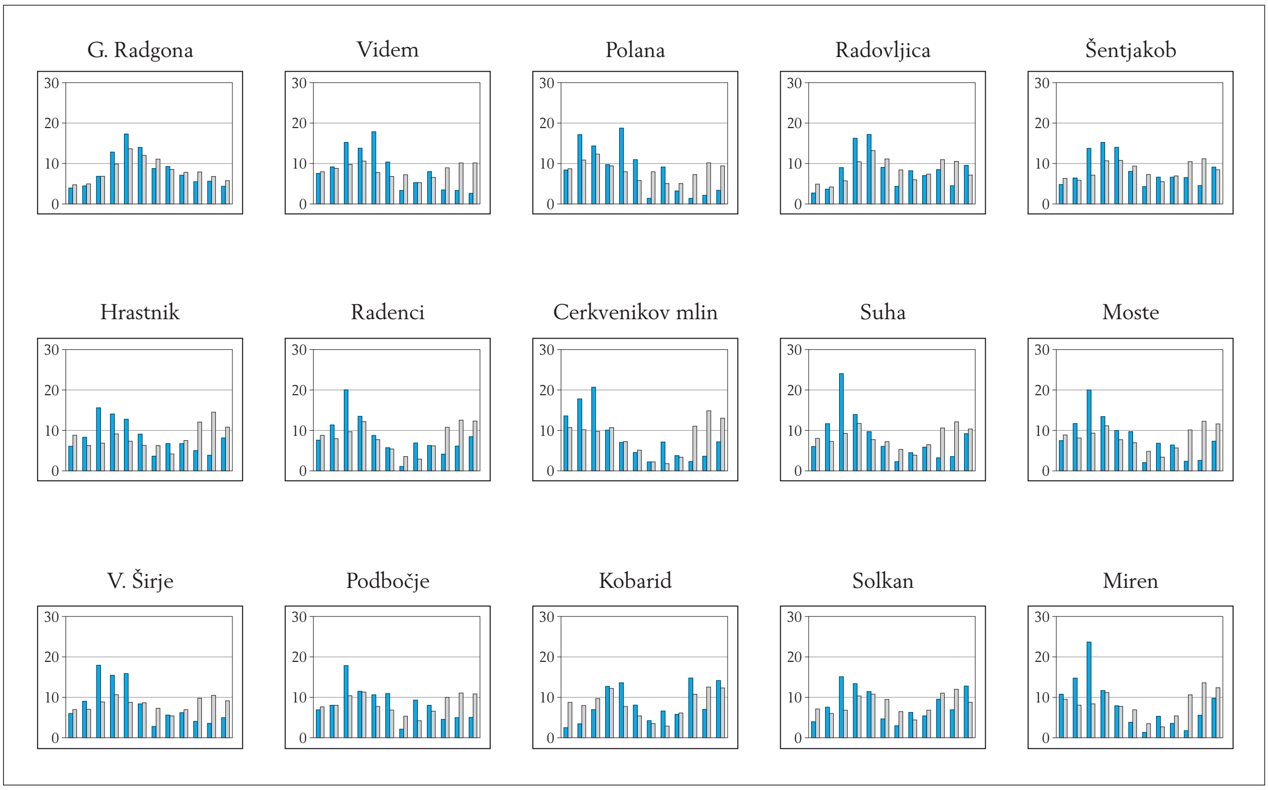
Chronological overview of hydrological conditions on rivers in individual months of the year

In the first days of January, discharges increased up to the high levels, while water stages fell by the end of the month, and in the last days of January the discharges were small. The mean monthly river discharges were lower in the western part of the country than in the eastern part. In February, discharges were small up to the second half of the month, when there was an extremely large increase. The increase in the river discharges was different on different rivers, therefore the mean monthly river discharges differed significantly. On the Sava in Radovljica, the mean monthly discharge was 50% lower, whereas on the Idrijca in Podroteja it was 50% higher than usual. In **March,** the water stage was extremely abundant. The discharges significantly



Slika 14: Mesečni deleži letnih pretokov v odstotkih v letu 2006 in obdobju 1971–2000. Na grafu je podano tudi odstopanje mesečnih deležev pretokov v letu 2006 od mesečnih deležev v obdobju 1971–2000.

Figure 14: *Monthly shares of annual discharges (expressed in percentages) for 2006 and the 1971–2000 reference period. The graph also shows derogations of monthly discharge shares in 2006, from monthly shares in the 1971–2000 reference period.*



Slika 15: Deleži mesečnih pretokov v letu 2006 (modri stolpci) in v obdobju 1971–2000 (sivi stolpci) kot ponazoritev odstopanj od ustaljenih režimov pretokov rek na izbranih reprezentativnih lokacijah v letu 2006.

Figure 15: *Shares of monthly discharges in 2006 (blue columns), and the 1971–2000 reference period (grey columns), to illustrate deviation from normal river discharge regimes at selected representative locations in 2006.*

meseca zmanjševala, tako da so bili v zadnjem delu januarja pretoki rek mali. Srednji mesečni pretoki rek so bili v zahodnem delu države manjši kakor v vzhodnem. **Februarja** so bili pretoki mali vse do druge polovice meseca, ko so se pretoki izraziteje povečali. Povečanje pretokov rek se je na različnih rekah razlikovalo, tako da so bili srednji mesečni pretoki rek zelo različni. Na Savi v Radovljici je bil srednji mesečni pretok polovico manjši, na Idrijci v Podroteji pa polovico večji kakor običajno. **Marca** je bila vodnatost rek izdatna. Pretoki so se kar trikrat izraziteje povečali in bili od 20 do 80 odstotkov večji kakor v dolgoletnem primerjalnem obdobju.

Aprila so se srednji mesečni pretoki rek malo razlikovali od povprečja v dolgoletnem primerjalnem obdobju. Pogosta povečanja pretokov z manjšo intenziteto so vzdrževala nivo srednjih pretokov. Pretok Mure je bil 35 odstotkov večji kakor navadno. **Maj** je bil bolj vodnat kakor navadno. V celoti je maja po rekah preteklo okoli 30 odstotkov več vode kakor v primerjalnem obdobju. V vzhodnem delu države so bili pretoki večji kakor v zahodnem. Po Dravinji je preteklo 123 odstotkov vode več kakor navadno. Za **junij** je bila spet značilna manjša vodnatost v zahodnem in večja vodnatost v vzhodnem delu države. Po prvih dneh meseca, ko so bili pretoki srednji do veliki, so se pozneje večji del meseca postopno zmanjševali. Pretoki rek, na katere vplivajo režimi hidroelektrarn, so se spreminjali v manjši meri. **Julija** se je zmanjševanje pretokov rek

increased three times and were 20% to 80% higher than in the multi-annual reference period.

In **April**, the mean monthly river discharges slightly differed from the average in the multi-annual reference period. Frequent increases in discharges with smaller intensity kept the discharge levels at mean values. The discharge of the Mura was 35% higher than usual. In **May**, the river stages were higher than usual. On the whole, **in May**, the river discharge was 30% higher than in the reference period. In the eastern part of the country, discharges were higher than in the western part. The discharge of the Dravinja was 123% higher than usual. In **June**, the discharge was again lower in the western part of the country and higher in the eastern part. After the first few days of the month, when the discharges were medium to high, they gradually decreased later in the month. The river discharges that depend on hydro-electric power station regimes were changed to a smaller extent. In **July**, river discharges mostly continued to decrease. The occurrence of very small discharges was prevented by temporary smaller and mostly local increases of discharges. On average, discharges were 60% lower than usual. In **August**, the river stages significantly increased three times. The intensity of the increases differed by different areas. In the southern parts of the country the discharges were much higher, whereas in the northern parts of the country they were much lower. In **September**, river discharge

Velik pretok reke Sotle v Rakovcu 11. marca 2006 (foto: Mira Kobold).

High discharge on the Sotla in Rakovec on 11 March 2006 (photo: Mira Kobold).

Mali pretok reke Kozbanjšček pri Neblem 24. novembra 2006 (foto: Arhiv ARSO).

Small discharge of the Kozbanjšček near Neblo on 24 November 2006 (photo: EARS Archives).

večinoma nadaljevalo. Pojav zelo majhnih pretokov so preprečevala občasna manjša in večinoma lokalna povečanja pretokov. V povprečju so bili pretoki 60 odstotkov manjši kakor navadno. **Avgusta** se je vodnatost rek trikrat izraziteje povečala. Intenziteta povečanj je bila na različnih območij različna. Pretoki so bili v južnem delu države veliko večji, v severnem delu države pa manjši kakor navadno. **Septembra** so se pretoki rek povečali samo sredi meseca. V prvi polovici in v zadnjem delu meseca so se pretoki zmanjševali. V celoti so bili okoli 20 odstotkov manjši kakor v dolgoletnem obdobju. **Oktober** je bil hidrološko suh mesec. Pretoki so bili 60 odstotkov manjši, kakor so navadno v novembrskih mesecih. Pretoki so se sicer povečali dvakrat, vendar so bila povečanja majhna. Tudi **november** je bil hidrološko suh mesec. Pretoki so bili v povprečju spet 60 odstotkov manjši kakor v dolgoletnem primerjalnem obdobju. Večji del meseca so se pretoki večinoma zmanjševali, kar je za november, ki je sicer eden najbolj vodnatih mesecev v letu, nenavadno. Edino povečanje pretokov v zadnji tretjini meseca je bilo majhno.

Podpovprečna vodnatost rek se je decembra nadaljevala. Pretoki so bili tokrat v povprečju 30 odstotkov manjši kakor v dolgoletnem primerjalnem obdobju. Nekoliko bolj vodnate so bile reke v zahodni polovici države.

Podrobneje so hidrološke razmere na rekah v letu 2006 opisane v mesečnih biltenih Agencije Republike Slovenije za okolje.

increased only in the middle of the month. In the first half and last part of the month, discharges decreased. On average, the discharges were 20% lower compared with the multi-annual reference period. **October** was a hydrologically dry month. The discharges were 60% lower than the usual for November. Discharges, however, increased twice, but to a small extent. **November**, too, was in hydrological terms a dry month. On average, discharges were 60% lower compared to the multi-annual reference period. For most of the month, discharges decreased, which is unusual for November as it is usually one of the most water-abundant months. The only discharge increase in the last third of the month was low.

In **December**, the river stages remained below average. On average, discharges were 30% lower compared with the multi-annual reference period. The rivers in the western parts of the country were slightly more water abundant.

The hydrological conditions on rivers in 2006 are described in more detail in the monthly bulletins of the Environmental Agency of the Republic of Slovenia.

Visoke vode rek in poplave

Janez Polajnar

V letu 2006 sta bila število in časovna razporeditev visokih voda drugačna od običajne. Enako velja za povišano plimovanje morja ob slovenski obali. Največ visokih voda je bilo spomladi, običajnih jesenskih visokih voda ni bilo.

Leta 2006 beležimo 27 pojavov visokih voda, ko so reke na vodomernih postajah in gladina morja ob slovenski obali presegle opozorilne vodostaje, ob tem pa so reke in gladina morja poplavili skupno 38-krat. Morje se je 8-krat razlilo po nižjih delih obale, večje reke in potoki 30-krat. Leta 2006 je bilo število teh pojavov za približno polovico manj kakor običajno. Največ visokih voda rek in potokov je bilo marca (8) in maja (8), morje je poplavilo nižje dele obale trikrat marca. Visoke vode so bile tudi v Pomurju, kjer sta Bukovniško jezero in Bukovniški potok prestopila bregove. Na Dolenjskem so od večjih rek najbolj narasle Temenica, Mirna in Krka. Reke so poplavljale povečini kmetijske površine na območjih vsakoletnih poplav in krajevne cestne povezave. Konec maja so v večjem obsegu poplavljale reke v osrednji, vzhodni in jugovzhodni Sloveniji, zlasti reka Krka, jeseni visokih voda ni bilo (slika 16).

Večje reke so poplavljale povečini na območjih vsakoletnih poplav, obsežnejše poplave so bile ob Krki, Mirni, Sotli in Ljubljanici. Potoki so zlasti na območjih vzhodne in jugovzhodne in osrednje Slovenije poplavljali tudi na območjih, kjer poplave niso pogoste. Poplave ob potokih v vzhodni in jugovzhodni Sloveniji so povzročile gmotno škodo na stanovanjskih in gospodarskih objektih, prometnicah, infrastrukturi in kmetijskih površinah. V preglednici 2 so opisane reke in

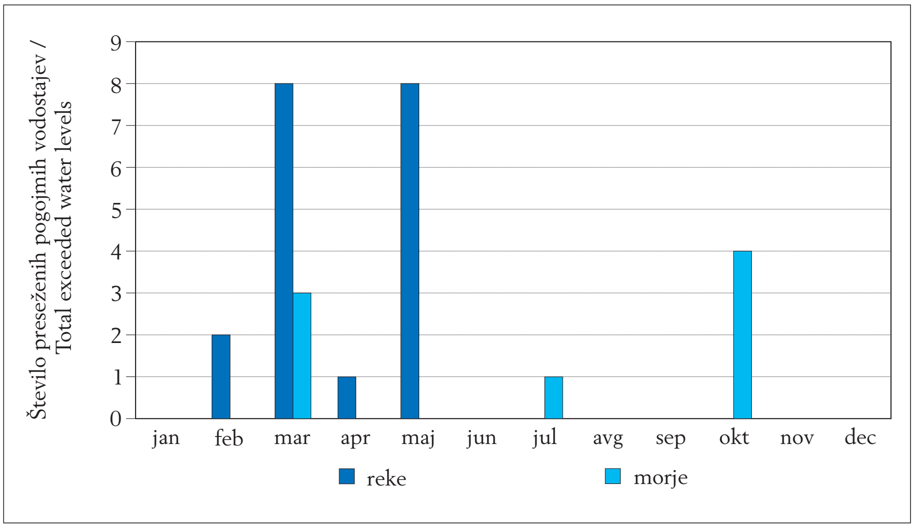
River high waters and floods

Janez Polajnar

In 2006, the number and temporal distribution of high waters differed from the usual ones. The same applies to the increased tidal action of the sea along the Slovenian coast. Most high waters were recorded in spring, whereas there were none of the usual high waters in autumn.

In 2006, high waters occurred 27 times, when the rivers at gauging stations and the sea level along the Slovenian coast exceeded the critical water levels, while the rivers and the sea together flooded 38 times. The sea spilled over the low-lying parts of the coast 8 times, whereas larger rivers and creeks flooded 30 times. In 2006, the number of these phenomena dropped by half compared with the past. Most river and creek high waters occurred in March (8) and May (6), whereas the sea spilled over the low-lying parts of the coast 3 times in March. High waters were also recorded in Pomurje, where the Bukovnik Lake and the Bukovnik creek broke the banks. In the Dolenjska region, the water level increased most on the Temenica, Mirna and Krka rivers. The rivers mostly spilled over agricultural land in areas of the usual annual floods and over local road connections. At the end of May, rivers flooded extensively in central, eastern and south-eastern Slovenia, in particular the Krka, whereas in autumn there were no high waters (Figure 16).

Larger rivers flooded mostly the areas of the usual annual floods with floods most extensive along the Krka, Mirna, Sotla and Ljubljanica. In the areas of eastern, south-eastern and central Slovenia, in particular, creeks also flooded the areas where floods are rather unusual. In eastern and south-eastern Slovenia, the floods along the creeks caused material damage on residential and



Slika 16: Število preseženih pogojnih vodostajev slovenskih rek na opazovanih vodomernih postajah, nekaterih hudournikih in gladine morja ob slovenski obali leta 2006

Figure 16: *Number of exceeded critical water levels of Slovenian rivers at monitored gauging stations, some torrents and water levels along the Slovenian coast in 2006.*

Preglednica 2: Visoke vode in njihovo razlitje leta 2006 (ARSO, CORS, razlitja manjših hudournikov niso upoštevana).
Table 2: *High waters and their spillage in 2006 (Environmental Agency of the Republic of Slovenia, CORS, the spillages of smaller torrents are not taken into account).*

Reka, potok, hudournik *Rivers, streams, torrents*	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec
Vipava			•									
Idrijca			•									
Dravinja			•		•							
Ljubljanica		•	•		•							
Krka					•							
Temenica					•							
Sotla			•		•							
Gradaščica			•									
Sotla												
Mestinjščica			•		•							
Mirna					•							
Cerkniščica					•							
Polskava					•							
Vranski potok / *Stream Vranski potok*					•							
Blanščica					•							
Voglajna					•							
Hudinja					•							
Bistrica					•							
Hajinski potok / *Stream Hajinski potok*					•							
Potok Bukovnica / *Stream Bukovnica*					•							
Slomščica					•							
Pešnica					•							
Ložnica					•							
Velikovrški potok / *Stream Velikovrški potok*					•							
Šmarski potok / *Stream Šmarski potok*					•							
Žahenberški potok / *Stream Žahenberški potok*					•							
Potok v Zgornji Dragi / *Stream in Zgornja Draga*					•							
Morje ob slovenski obali / *Sea at Slovenian coast*			•••				•			••••		

nekateri potoki, ki so poplavljali v letu 2006, ter poplavljanje morja ob slovenski obali.

Visoke vode maja so bile edine obsežnejše visoke vode v letu 2006.

Visoke vode in poplave konec maja niso pogoste, čeprav so bile maja leta 1910 in v začetku junija leta 1954 v vzhodni Sloveniji zabeležene velike povodnji, ki so zahtevale tudi 11 človeških življenj.

Leta 2006, 30. maja, se je ciklonsko območje iznad Italije pomaknilo nad Balkan in se tam še poglobilo. Hladna vremenska fronta se je počasi pomikala prek Slovenije, v nižjih plasteh ozračja je zapihal hladen severovzhodnik. Padavine z nevihtami so se od zahoda razširile nad vso državo, ohladilo se je, ponekod na Notranjskem je tudi snežilo. V tem času je v jugovzhodni Sloveniji padlo okoli 120 mm dežja, krajevno tudi več. Izdatne padavine in večja predhodna namočenost tal od običajne sta med 30. majem in 1. junijem povzročila nastanek visokih voda zlasti na območjih jugovzhodne in vzhodne Slovenije. Poplave v tem delu države so pov-

commercial buildings, traffic routes, infrastructure and farmland. Table 2 describes rivers and their tributaries that flooded in 2006 and the sea floods at the Slovenian coast.

The only extensive high waters in 2006 were recorded in May. In general, at the end of May, high waters and floods are not frequent, although in May 1910 and at the beginning of June 1954, eastern Slovenia recorded extreme floods, which claimed 11 human lives.

On 30 May 2006, a low-pressure area moved from Italy to the Balkans and there intensified even further. A cold weather front started to move slowly across Slovenia and in the lower atmospheric levels a cold north-eastern wind began to blow. Rainfalls with storms spread from the west across the entire country, temperatures dropped and in some parts of central Slovenia it was even snowing. At that time, around 120 mm of rain fell in south-eastern Slovenia, and in some parts even more. Between 30 May and 1 June, abundant precipitation and ground which was previously wetted zročile nekaj gmotne škode in predvsem nevšečnosti v prometu.

V jutranjih urah 30. maja so najbolj narasle reke v porečju Dravinje na širšem celjskem območju, v Posavju in ponekod v osrednji Sloveniji. Pretoki večjih rek na teh območjih so bili manjši od dveletne povratne dobe velikih pretokov. Dravinja je ta dan v Ločah dosegla pretok 39 m^3/s. V okolici Majšperka je poplavila okoli 120 ha kmetijskih površin ter del magistralne ceste Majšperk–Jurovci. Savinja je v Velikem Širju dosegla pretok 506 m^3/s, Mestinjščica v Sodni vasi 52 m^3/s, Sotla je v Rakovcu presegla 100 m^3/s, Ljubljanica pa je v Mostah dosegla pretok 245 m^3/s. Poleg omenjenih rek so ta dan poplavljale tudi manjše reke. Obsežnejše poplave so bile v nižinskih območjih ob Voglajni, Slomščici in Pešnici. Voglajna je na več mestih poplavila glavno cesto Šentjur–Slivnica in nekatere stanovanjske in gospodarske objekte na območju Šentjurja. Poplavljena je bila celotna dolina Slomščice od Grobelnega do Šentjurja. Poplavila je tudi Ložnica nad Celjem, pretežno kmetijske površine med Trnovcem in Bukovžlakom. Sotla je poplavljala med Dobovcem in Rogatcem, poplavila je tudi del avtokampa v Atomski vasi. Na tem območju je poplavljala Mestinjščica, zlasti njeni manjši pritoki: Šmarski in Žahenberški potok in drugi. Visoke vode so bile tudi v Pomurju, kjer sta Bukovniško jezero in Bukovniški potok prestopila bregove. Na Dolenjskem so od večjih rek najbolj narasle Temenica, Mirna in Krka, ki je ta dan še naraščala. Reke so poplavljale povečini kmetijske površine na območjih vsakoletnih poplav in krajevne cestne povezave, Temenica je poplavila stanovanjsko hišo v Mirni Peči.

31. maja je večina rek že začela upadati. Zaradi kraškega zadržka sta še vedno naraščali reki Ljubljanica in Krka. Poplava na Ljubljanskem barju je bila v teh dneh obsežnejša od običajnih letnih poplav in je zajela območje med Bevkami, Sinjo Gorico, Podpečjo, zaradi zajezene reke Iške se je voda razlila tudi ob Črni vasi. Reka Krka je ta dan že začela poplavljati travnike v spodnjem toku, naraščala pa je vse do 1. junija, ko je v Podbočju dosegla pretok z dve- do petletno povratno dobo velikih pretokov 315 m^3/s. Poplave v spodnjem toku Krke so bile nekoliko obsežnejše od običajnih zlasti na območju Kostanjevice. Poplave ob Krki in na kraških območjih v zaledju Krke, v Suhi krajini, so bile še nekaj dni. V prvem tednu junija se je voda na omenjenih poplavljenih območjih postopno umaknila v struge rek.

more than usual caused high waters, particularly in south-eastern and eastern Slovenia. Floods in this part of the country caused some material damage, in particular traffic problems.

In the morning of 30 May, the water level increased most in rivers of the Dravinja basin in the wider Celje area, in Posavje and in central Slovenia. The discharges of most rivers in that area were lower than in the two-year return period of high discharges. The discharge of the Dravinja in Loče on that day reached 39 m^3/s. In the area around Majšperk, the river spilled over 120 ha of farmland and part of the main Majšperk-Jurovci road. The discharge of the Savinja in Veliko Širje reached 506 m^3/s, while that of Mestinjščica creek in Sodna vas 52 m^3/s; the discharge of the Sotla in Rakovec exceeded 100 m^3/s, whereas the discharge of the Ljubljanica in Moste amounted to 245 m^3/s. In addition to these rivers and creeks, some smaller rivers also flooded. More extensive floods were in the lowland area along the Voglajna and the Slomščica and Pesnica creeks. The Voglajna spilled over the main Šentjur–Slivnica road in several sections and also flooded some residential and commercial buildings in the Šentjur area. The entire Slomščica Valley from Grobelno to Šentjur was also flooded. The Ložnica near Celje also flooded and covered mainly farmland between Trnovec and Bukovžlak. The Sotla flooded the area between Dobovec and Rogatec and the campsite in Atomska vas. That area was also flooded by Mestinjščica creek, in particular by its small tributaries: the Šmarje and Žahenberk creeks and others. High waters were also recorded in Pomurje, where the Bukovnik Lake and Bukovnik creek spilled over. In the Dolenjska region, the highest discharges were recorded in the larger Temenica, Mirna and Krka rivers, the water level of which increased still further on that day. The rivers mostly spilled over farmland in areas of usual annual flooding and local road connections; while the Temenica also flooded a residential building in Mirna Peč.

On 31 May, most rivers began to recede. Because of the retaining of water by the karst, the level of the Ljubljanica and Krka was still increasing. On these days, the flood on the Ljubljana moor was more extensive than the usual annual floods and covered the are between Bevke, Sinja Gorica and Podpeč, and, because of the dam on the Iška, the water also spilled over at Črna vas. On that day, the Krka started to flood the meadows downstream and the water level increased until 1 June 2006, when the discharge in Podbočje reached 315 m^3/s with a two- to five-year return period of high discharges. The floods in the downstream part of the Krka were slightly more extensive in comparison to the usual floods, in particular in the Kostanjevica area. The floods along the Krka and in the karstic areas in the Krka basin and in Suha krajina lasted a few more days. In the first week of June, the water gradually receded into the riverbed.

Nizke vode rek in hidrološka suša

dr. Mira Kobold

River low waters and hydrological drought

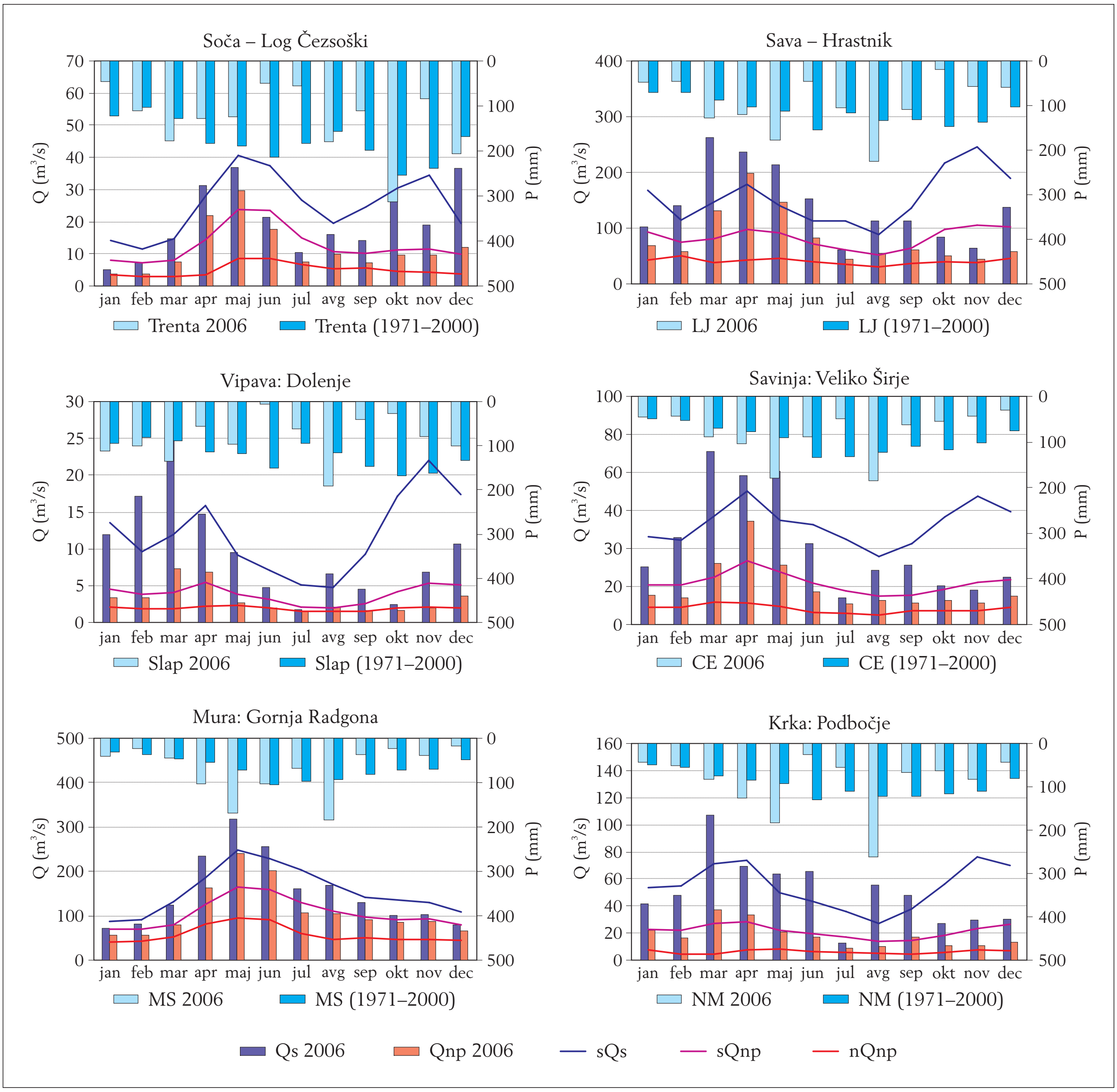
Mira Kobold, PhD

Analiza mesečnih pretokov

V letu 2006 je v večjem delu Slovenije padlo manj padavin od dolgoletnega povprečja 1971–2000. Večinoma je padlo med 80 in 100 % padavin, v Vipavski dolini med 60 in 70 %. Dolgoletno povprečje padavin

Analysis of Monthly Discharges

In 2006, in most parts of Slovenia, precipitation was below the multi-annual average of the 1971–2000 reference period. The amount of precipitation was mostly from 80% to 100%, though in the Vipava valley from



Slika 17: Srednji (Qs) in minimalni mesečni pretoki (Qnp) v letu 2006 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 2006 z reprezentativnih padavinskih postaj.

Figure 17: *Mean (Qs) and minimum monthly discharges (Qnp) in 2006 and monthly reference period discharge values: mean reference period (sQs), mean low (sQnp) and minimum low (nQnp) monthly discharges, monthly amount of precipitation for the reference period 1971–2000 and monthly amount of precipitation in 2006 from representative precipitation stations.*

je bilo preseženo le na območju Murske Sobote, kjer je bil presežek 5 %.

Podpovprečna količina padavin se je odražala v manjši vodnatosti rek, ki pa je bila po mesecih različna (slika 17). V začetku leta so bili najmanjši mesečni pretoki večinoma manjši od srednjih malih obdobnih mesečnih pretokov sQnp, najbolj v severozahodnem delu države, kjer je v januarju padlo manj kakor polovico običajnih padavin. V spomladanskih mesecih so bile padavine skoraj povsod po državi nad dolgoletnim povprečjem. Najmanj jih je bilo v Vipavski dolini in na Krasu. Srednji mesečni pretoki v teh mesecih so bili v mejah srednjih obdobnih mesečnih pretokov sQs, najmanjši mesečni pretoki pa v mejah srednjih malih obdobnih mesečnih pretokov sQnp. Na Savi in Muri so se ti približali srednjim obdobnim pretokom. V juniju je bilo padavin malo, na zahodu države, Notranjskem in v delu Dolenjske je padla manj kakor četrtina dolgoletnega povprečja. Tam so srednji in najmanjši mesečni pretoki padli pod obdobne mesečne vrednosti, drugje so bili v mejah obdobnih pretokov. Julija je padavin povsod primanjkovalo, pretoki pa so padli pod obdobne mesečne vrednosti. Ponekod so se celo srednji mesečni pretoki približali najmanjšim malim junijskim pretokom, vendar pa najmanjši pretoki v juniju niso padli pod najmanjše obdobne pretoke. V avgustu so padavine povsod presegle dolgoletno povprečje tudi za dvakrat in srednji kot najmanjši mesečni pretoki so bili v mejah srednjih obdobnih avgustovskih pretokov. Od septembra pa vse do konca leta je padavin močno primanjkovalo, kar je imelo za posledico dolgo nizkovodno stanje rek. Srednji in najmanjši mesečni pretoki so bili manjši od obdobnih mesečnih pretokov.

Časovni potek srednjih dnevnih pretokov

Hidrološko najbolj suh je bil julij, saj je v juliju ponekod padlo le okrog 10 % dolgoletnega povprečja padavin, vendar najmanjši pretoki niso nikjer dosegli najmanjših malih obdobnih pretokov. Večje hidrološke suše ni bilo občutiti, saj so se že avgusta pretoki večkrat povečali, tudi nad povprečne obdobne pretoke. Avgust je bil neobičajno moker, saj je marsikje avgustovska količina padavin presegla 200 mm, lokalno močni nalivi pa so povzročili povečanje pretokov do visokih. Dolgo obdobje s pretežno malimi pretoki smo potem beležili v zadnji četrtini leta, ko je padlo v povprečju le okrog 40 % običajne količine padavin.

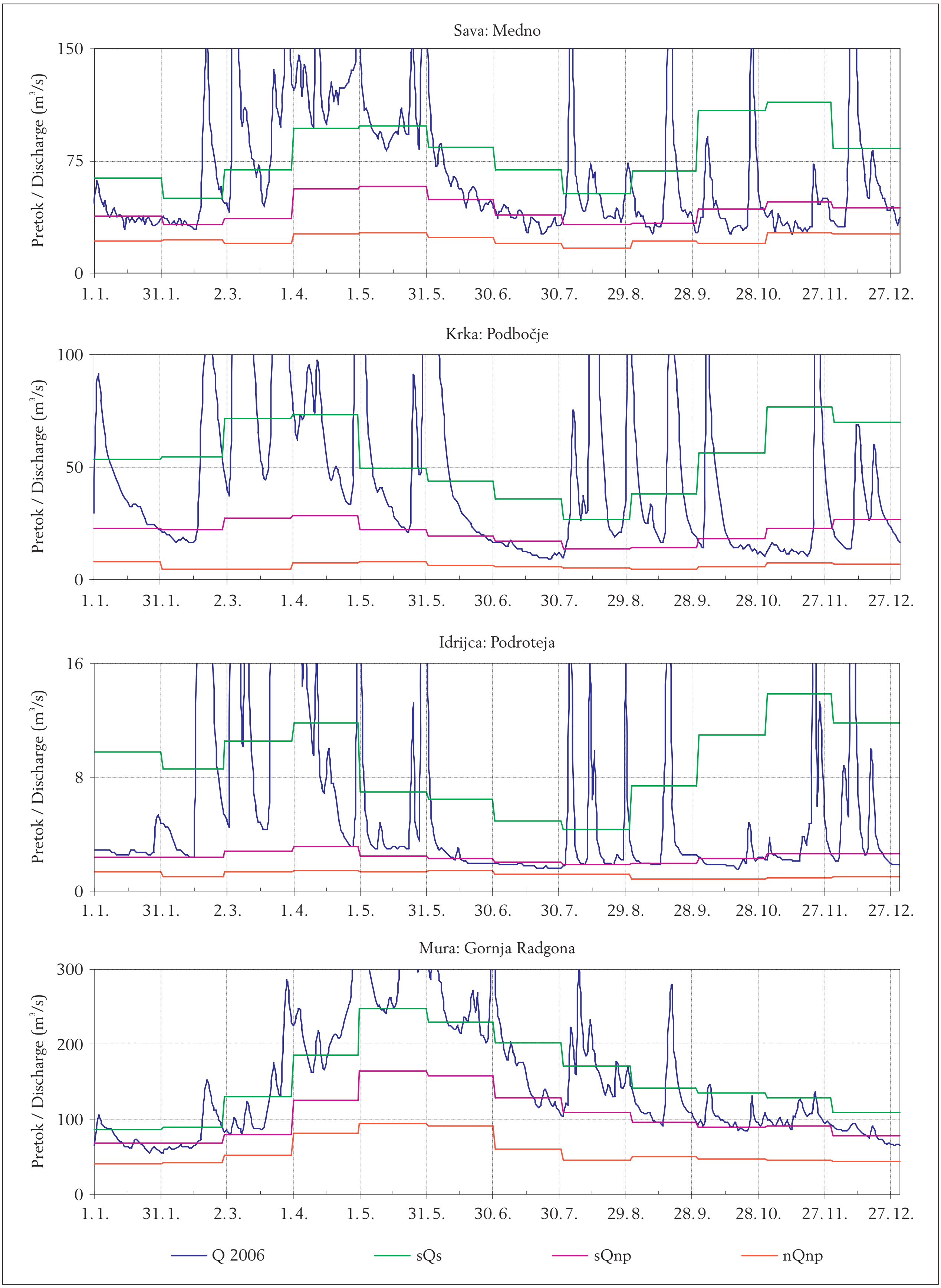
Na sliki 18 je za nekaj postaj z različnih delov Slovenije prikazan potek srednjih dnevnih pretokov za leto 2006. Za primerjavo so dodani obdobni pretoki: srednji mesečni (sQs), srednji mali (sQnp) in najmanjši mesečni pretoki (nQnp). Daljša nizkovodna stanja smo beležili v juniju in juliju ter v oktobru in novembru, ponekod pa še v začetku leta. Vodnatost rek je bila najmanjša julija, ko so bili srednji dnevni pretoki skoraj cel mesec pod srednjim malim julijskim pretokom,

60% to 70%. The multi-annual precipitation average was exceeded only in the area of Murska Sobota i. e. by 5%.

The average amount of precipitation also resulted in lower river stages, which, however, differed by months (Figure 17). At the beginning of the year, the minimum monthly discharges were in most cases below the mean low monthly discharges of the reference period (sQnp), in particular in the north-eastern parts of the country, where there was in January less than 50% of the usual amount of precipitation. During the spring months, in almost all parts of the country, the amount of precipitation was above the multi-annual average. The lowest amount of precipitation was recorded in the Vipava valley and the Karst. The mean monthly discharges during these months were within the limits of mean monthly reference period discharges (sQs), whereas the minimum monthly discharges were within the limits of the mean low reference period discharges (sQnp). On the Sava and Mura, they almost reached the mean reference discharge values. In June, the amount of precipitation was low and reached less than 25% of the multi-annual average in the western parts of the country and in the Notranjska and Dolenjska regions. The mean and minimum monthly discharges in those parts of the country fell below the monthly reference period values, whereas elsewhere in the country they were within the limits of the reference period discharges. In July, precipitation was extremely scarce throughout the country, with discharges falling below the monthly reference period values. In some parts of the country, even the mean monthly discharges almost reached the minimum low June discharge values; however, the minimum discharges in June did not fall below the minimum reference period discharge values. In August, precipitation exceeded the multi-annual average everywhere, and in some parts there was even twice the reference period amount of precipitation, while the mean as well as minimum monthly discharges were within the limits of mean reference period discharge values for August. From September to the end of the year, precipitation was again extremely scarce, which resulted in low-water river conditions. The mean and minimum monthly discharges were below the monthly reference period discharge values.

Timeline of Mean Daily Discharges

In hydrological terms, the driest month was July, because in some parts of the country the amount of precipitation was only around 10% of the multi-annual precipitation average; although the lowest discharges did not reach the minimum low discharge values of the reference period in any part of the country. However, no hydrological drought was observed, because already in August, discharges had increased several times and even exceeded the average discharge values of the reference



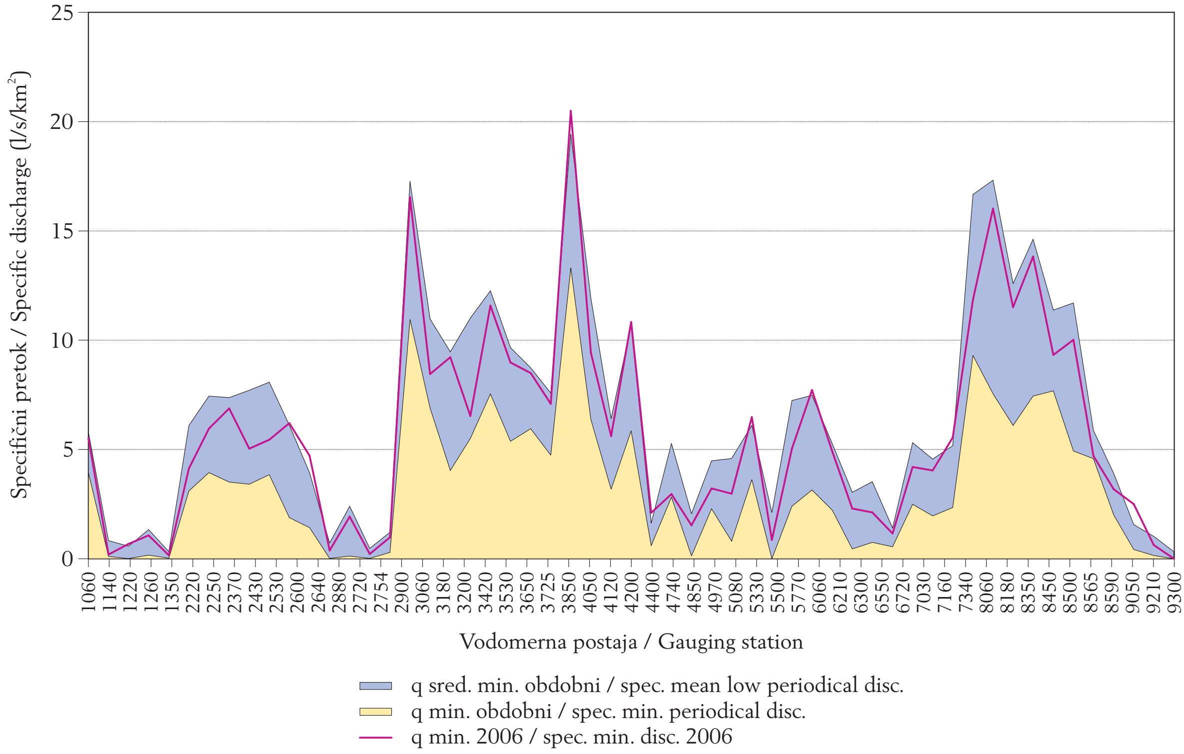
Slika 18: Srednji dnevni pretoki na izbranih vodomernih postajah za leto 2006 ter obdobne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) obdobni pretok.

Figure 18: *Mean daily discharges at selected gauging stations for 2006 and the reference period discharge values: mean (sQs), mean low (sQnp) and minimum low (nQnp) discharges of the reference period.*

Preglednica 3: Najmanjši izmerjeni pretoki v letu 2006 v primerjavi z obdobnima srednjim malim pretokom (sQnp) in najmanjšim pretokom (nQnp) iz obdobja delovanja postaje.

***Table 3:** Lowest measured discharges in 2006 in comparison with mean low reference period discharge (sQnp) and minimum reference period discharge (nQnp) from the period of station operation.*

Šifra *Code*	Vodomerna postaja *Gauging Station*	2006 Qnp (m³/s)	2006 Datum / *Date* Qnp	Obdobne vrednosti *Periodic discharges* sQnp (m³/s)	nQnp (m³/s)
1060	Mura – Gornja Radgona	56,2	01. 02.	59	40
1140	Ščavnica – Pristava	0,053	12. 09.	0,227	0,03
1220	Ledava – Polana	0,141	18. 07.	0,119	0,002
1260	Ledava – Čentiba	0,916	01. 08.	1,145	0,145
1350	Velika Krka – Hodoš	0,017	22. 07.	0,034	0,003
2220	Meža – Črna	0,391	20. 11.	0,578	0,294
2250	Meža – Otiški Vrh	3,28	12. 09.	4,101	2,17
2370	Mislinja – Dovže	0,499	29. 12.	0,535	0,255
2432	Bistrica – Muta	0,738	28. 12.	1,13	0,5
2530	Radoljna – Ruta	0,404	15. 09.	0,599	0,285
2600	Dravinja – Zreče	0,257	19. 11.	0,253	0,078
2640	Dravinja – Makole	1,42	24. 07.	1,185	0,43
2720	Rogatnica – Podlehnik	0,022	17. 11.	0,041	0,001
2754	Polskava – Tržec	0,363	05. 02.	0,452	0,024
2880	Pesnica – Gočova	0,063	10. 11.	0,135	0,006
2900	Pesnica – Zamušani	0,47	22. 07.	0,58	0,141
3060	Sava Dolinka – Jesenice	4,26	11. 02.	4,45	2,82
3180	Radovna – Podhom	1,41	15. 02.	1,83	1,15
3200	Sava Bohinjka – Sveti Janez	0,867	24. 01.	0,89	0,38
3420	Sava – Radovljica	5,93	14. 02.	10	5
3530	Sava – Medno	25,5	22. 11.	27	16,6
3650	Sava – Litija	43,3	22. 11.	46,6	25,9
3725	Sava – Hrastnik	44	33. 11.	45,2	30,8
3850	Sava – Čatež	72,2	23. 07.	77,3	48,3
4050	Tržiška Bistrica – Preska	2,48	01. 02.	2,35	1,61
4120	Kokra – Kokra	1,06	24. 01.	1,34	0,716
4200	Sora – Suha	3,18	22. 07.	3,63	1,8
4400	Kamniška Bistrica – Kamnik	2,11	14. 09.	2,08	1,14
4740	Sotla – Rakovec	1,18	17. 07.	0,91	0,337
4850	Kolpa – Radenci	3,53	30. 07.	6,29	3,36
4970	Lahinja – Gradac	0,339	28. 07.	0,456	0,03
5078	Ljubljanica – Moste	5,67	18. 11.	7,9	4,04
5330	Borovniščica – Borovnica	0,104	05. 11.	0,16	0,028
5500	Gradaščica – Dvor	0,51	05. 11.	0,48	0,285
5770	Cerkniščica – Cerknica	0,041	20. 07.	0,1	0
6020	Savinja – Solčava	0,321	13. 02.	0,461	0,153
6060	Savinja – Nazarje	3,53	14. 02.	3,42	1,44
6210	Savinja – Veliko Širje	9,06	20. 07.	9,71	4,1
6300	Paka – Šoštanj	0,302	21. 11.	0,399	0,059
6550	Bolska – Dolenja vas	0,36	19. 11.	0,598	0,127
6720	Voglajna – Celje	0,235	20. 07.	0,284	0,11
7030	Krka – Podbukovje	1,35	17. 11.	1,71	0,8
7160	Krka – Podbočje	9,04	25. 07.	10,2	4,4
7340	Prečna – Prečna	1,63	15. 11.	1,52	0,69
8060	Soča – Log Čezsoški	3,85	25. 01.	5,41	3,02
8080	Soča – Kobarid	7	28. 01.	7,57	3,3
8180	Soča – Solkan	18,1	16. 12.	19,8	9,6
8350	Idrijca – Podroteja	1,56	19. 10.	1,65	0,84
8450	Idrijca – Hotešk	4,13	15. 11.	5,04	3,4
8480	Trebuša – Dolenja Trebuša	0,548	13. 09.	0,64	0,27
8565	Vipava – Dolenje	1,49	19. 07.	1,86	1,45
8590	Vipava – Dornberk	1,49	21. 07.	1,83	0,94
9050	Reka – Cerkvenikov mlin	0,944	04. 11.	0,59	0,16
9210	Rižana – Kubed	0,128	10. 11.	0,21	0,03
9300	Dragonja – Podkaštel	0,001	30. 07.	0,03	0



Slika 19: Najmanjši specifični srednji dnevni pretoki v letu 2006 glede na obdobne srednje male in najmanjše specifične srednje dnevne pretoke.

Figure 19: *Minimum specific mean daily discharges in 2006 with regard to mean low reference period discharges and specific minimum mean daily discharges.*

razen Mure, kjer je bila vodnatost najmanjša v začetku leta. Podobno je bila vodnatost mala še v oktobru in novembru, kjer pa so padavine lokalno povzročile dvig pretokov nad srednje male obdobne pretoke. Najmanjši mali obdobni pretoki niso bili nikjer doseženi.

V preglednici 3 so za več vodomernih postaj zbrani najmanjši srednji dnevni pretoki ter dodana srednji mali in najmanjši mali obdobni pretok. Na večini vodomernih postaj je bil najmanjši srednji dnevni pretok v letu 2006 manjši od srednjega malega obdobnega pretoka, medtem ko najmanjši mali obdobni pretoki niso bili nikjer doseženi. Najmanjša vodnatost rek v letu 2006 je na sliki 19 prikazana s specifični pretoki.

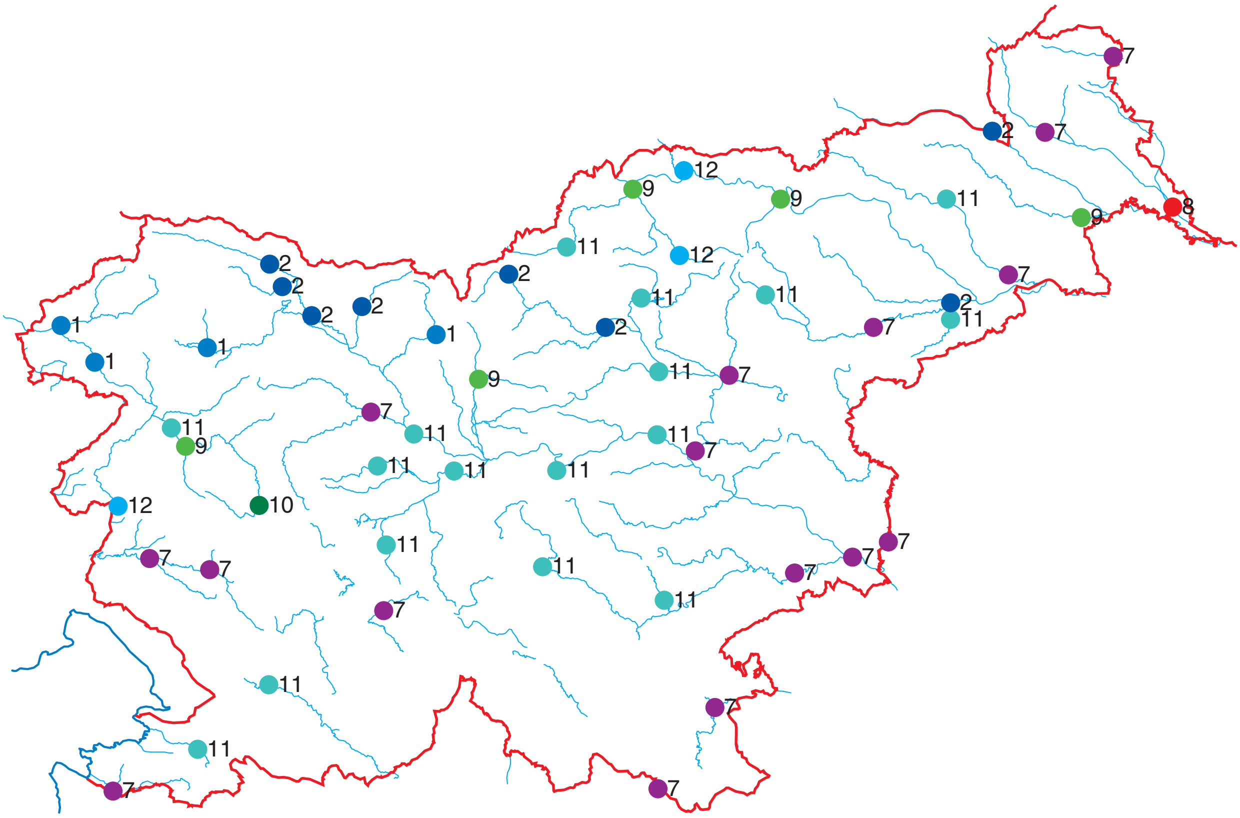
Krajevna in časovna porazdelitev najmanjših pretokov po državi je bila različna. V zgornjem Posočju in povirnem delu Save so bili najmanjši pretoki zabeleženi v januarju in februarju, v večjem delu osrednje in severne Slovenije ter delu Primorske v novembru, v Vipavski dolini, južni, vzhodni in severovzhodni Sloveniji pa julija (slika 20). Izjemoma so bili ponekod v severni in zahodni Sloveniji najmanjši srednji dnevni pretoki zabeleženi v septembru ali decembru.

Analiza nizkovodnih razmer uvršča leto 2006 med hidrološko suha leta, podobno kakor velja za leta po letu 2000, za katera so značilna dolga obdobja z malimi pretoki. Pomanjkanje vode je v juliju najbolj občutila

period. August was extremely wet, as in some parts of the country the amount of precipitation exceeded 200 mm, whereas strong local thunderstorms caused increased discharges up to high discharge values. Long periods with mostly low discharges were then recorded in the last quarter of the year, with an average of 40% of the usual amount of precipitation.

Figure 18 shows the mean daily discharges for 2006 at selected gauging stations in different parts of Slovenia. For comparison, discharges for the reference period are added: mean monthly (sQs), mean low (sQnp) and minimum low (nQnp) discharges. Longer low-water conditions were recorded in June and July and in October and November, in some parts of the country also at the beginning of the year. River stages were lowest in July, when the mean daily discharges were for almost the entire month below the mean low discharge values for June, with the exception of the Mura, the water stage of which was lowest at the beginning of the year. The river stages had similar values also in October and November, but, at that time, local precipitation caused discharges to increase above the mean low discharge values of the reference period. The minimum low discharge values of the reference period were not reached anywhere.

Table 3 shows the minimum mean daily discharges for several gauging stations with added mean low and



Slika 20: Meseci, v katerih so bili na vodomernih postajah površinskih voda doseženi najmanjši srednji dnevni pretoki v letu 2006.
Figure 20: *Months, in which the lowest mean daily discharges in 2006 were reached at surface water gauging stations.*

Nizka voda na postaji Trpčane na Reki, 26. julij 2006 (foto: Mira Kobold).

Low water on station Trpčane on the Reka River 26 July 2006 (photo: Mira Kobold).

južna, vzhodna in severovzhodna Slovenija. V večjem delu države so najmanjši pretoki nastopili v zimskih mesecih, ko vegetacija miruje in izrazitega pomanjkanja vode v teh mesecih ni bilo čutiti.

minimum low discharges of the reference period. At most gauging stations, the minimum mean daily discharge value in 2006 was below the mean low discharge value of the reference period, whereas the minimum low discharge values of the reference period were not recorded anywhere. The lowest river water stage in 2006 is shown in Figure 19 with specific discharges.

The spatial and timely distribution of the lowest discharges throughout the country was different. In the Upper Posočje area and the headwaters of the Sava, the lowest discharges were recorded in January and February, in the major part of central and northern Slovenia and in part of the Primorska region in November, whereas July recorded the lowest discharges in the Vipava Valley, in the south, east and north-east of Slovenia (Figure 20). Exceptionally, in some parts of northern and western Slovenia, minimum mean daily discharges were recorded in September and December.

Analysis of low-water conditions classifies 2006 among dry years in hydrological terms, similar to 2000, with characteristic long periods of low discharges. Water shortage in July was most evident in southern, eastern and north-eastern Slovenia. In most parts of the country, the lowest discharges occurred in the winter months, when vegetation is at a standstill and no extreme water shortage was recorded during these months.

Temperature rek in jezer

Barbara Vodenik

Leta 2006 je bila povprečna temperatura (povprečje je izračunano iz srednjih letnih temperatur na 53 vodomernih postajah) 10,1 °C, kar je za 0,2 °C več kakor v večletnem primerjalnem obdobju. Povprečna temperatura Blejskega jezera je znašala 13,1 °C, Bohinjskega pa 9,1 °C, kar je primerljivo z večletnim obdobjem. Odstopanje od večletnega povprečja pri rekah je bilo izrazito v juliju, ko je bila povprečna temperatura rek za 2,5 °C nad dolgoletnim povprečjem, in v avgustu, ko je bila 1,8 °C pod dolgoletnim povprečjem. Odstopanje od večletnega povprečja Bohinjskega jezera bilo največje v juliju, ko je povprečna temperatura za 4,2 °C presegla dolgoletno povprečje, in v januarju, ko je bila srednja mesečna temperatura za 2,7 °C pod dolgoletnim povprečjem. Za izračun povprečja so upoštevani razpoložljivi nizi podatkov, najdaljši nizi so od leta 1954 naprej.

Časovno spreminjanje temperatur rek

Temperaturna nihanja slovenskih rek na izbranih vodomernih postajah v letu 2006 prikazuje slika 21. Temperature izbranih rek so januarja in februarja nihale med 0 °C in 9,2 °C. V zadnji tretjini januarja je večina rek dosegla najnižje letne vrednosti, razen Kamniške Bistrice, ki je najnižjo vrednost dosegla osmega februarja (preglednica 4). V marcu in do šestindvajsetega aprila se je temperatura vode postopoma zviševala, nato pa se je začela strmo zniževati do prvega maja. Ta potek je najočitnejši pri Dravinji, Muri, in Savinji. Na Dravinji se je v tem času voda ohladila za 5,4 °C. V prvi polovici maja so se reke segrevale, do konca meseca pa je opaziti več izrazitih nihanj temperature. Prve dni junija smo izmerili izrazito nizke temperature vode, pri nekaterih rekah nižje ali enake dolgoletnemu povprečju (Mura, Ljubljanica). Temperature rek so nato cel mesec postopoma naraščale in dosegle najvišje vrednosti devetindvajsetega junija. V začetku julija je hitremu padcu temperatur vode sledilo ponovno naraščanje in na vseh izbranih rekah smo v tem mesecu izmerili najvišje vrednosti. Znatna ohladitev rek je sledila v prvih dneh avgusta, ko so se temperature vode znižale za 8,4 °C na Vipavi, za 8,1 °C na Soči, 7,0 °C na Savinji, 7 °C na Muri in 5,9 °C na Ljubljanici. Temperature rek so v prvi tretjini septembra dosegle dokaj visoke vrednosti. Najvišja izmerjena vrednost je bila na Dravinji, in sicer 20,8 °C, ter na Savinji 18 °C. Temperature rek so se z večjimi ali manjšimi nihanji zniževale vse do konca leta.

Temperatures of rivers and lakes

Barbara Vodenik

In 2006, the average temperature (calculated from the mean annual temperatures at 53 hydrometric stations) was 10.1 °C, which is 0.2 °C higher than in the multi-annual reference period. The average temperature of Lake Bled and Lake Bohinj amounted to 13.1 °C and 9.1 °C respectively, which is comparable to the multi-annual reference period. The deviation from the multi-annual mean of rivers was significant in July, when the average river temperature exceeded the multi-annual mean by 2.5 °C, and in August, when it was 1.8 °C below the multi-annual mean. Deviation from the multi-annual mean of Lake Bohinj was greatest in July, when the average temperature exceeded the multi-annual mean by 4.2 °C, and in January, when the mean monthly temperature was 2.7 °C below the multi-annual mean. For the calculation of the mean value, the available series of data were taken into account; the longest series of data go back to 1954.

Timeline of river temperature changes

Figure 21 shows temperature fluctuations in 2006 for Slovenian rivers at selected hydrometric stations. In January and February the temperatures of selected rivers fluctuated between 0 °C and 9.2 °C degrees. In the last third of January, most rivers reached the lowest annual values, with the exception of Kamniška Bistrica, which reached the lowest temperature on 8 February (Table 4). In March and up to 26 April, the water temperature gradually increased and then again started to decrease rapidly until 1 May. This timeline is most evident on the Dravinja, Mura and Savinja. During that period, the water in the Dravinja cooled rapidly by 5.4 °C. In the first half of May, the rivers warmed up, and until the end of the month some extreme temperature fluctuations were recorded. In the first days of July, the measurements showed extremely low water temperatures, in some rivers below or equal to the multi-annual mean (Mura, Ljubljanica). Then, river temperatures gradually increased throughout the month and reached the highest values on 29 June. At the beginning of July, the rapid drop in water temperature was followed by a new temperature rise and in all selected rivers the highest temperatures were measured in that month. In the first days of August, the rivers cooled rapidly and temperatures dropped by 8.4 °C on the Vipava, by 8.1 °C on the Soča, by 7.0 °C on the Savinja, by 7 °C on the Mura and by 5.9 °C on the Ljubljanica. In the first third of September, the river temperatures

Slika 21: Temperature vode slovenskih rek leta 2006: Mure v Gornji Radgoni, Dravinje v Vidmu, Ljubljanice v Mostah, Soče v Solkanu, Save v Litiji, Savinje v Celju in Vipave v Dornberku.

Figure 21: *Water temperatures of Slovenian rivers in 2006. Mura in Gornja Radgona, Dravinja in Videm, Ljubljanica in Moste, Soča in Solkan, Sava in Litija, Savinja in Celje and Vipava in Dornberk.*

Časovno spreminjanje temperatur jezer

Bohinjsko jezero je na mestu, kjer poteka merjenje temperature, že v začetku januarja zaledenelo in ostalo zamrznjeno do zadnje tretjine marca, ko se je začelo naglo segrevati in se je v zadnjih osmih dneh temperatura dvignila na 5,4 °C. Temperatura Blejskega jezera se prve tri mesece ni veliko spreminjala, gibala se je med 2,6 °C in 4,7 °C, šele proti koncu marca se je začela temperatura zviševati in se je z manjšimi nihanji zviševala do zadnjih dni maja, ko se je jezero v nekaj dneh ohladilo. Tudi temperatura Bohinjskega jezera je od druge tretjine marca do druge tretjine aprila hitro naraščala, nato je sledilo nihanje v maju. Po prvih dneh junija sta se jezeri začeli segrevati in dosegli najvišje letne vrednosti triindvajsetega julija. V prvih dneh avgusta vidimo hitro ohlajanje do sredine meseca. Bohinjsko jezero se je z 21,4 °C ohladilo na 15,6 °C. Po nihanju temperature v avgustu pa nas prve dni septembra preseneti visoka temperatura Bohinjskega jezera, v katerem so izmerili 21,0 °C. Podoben, le malo manj izrazit potek opazimo tudi pri Blejskem jezeru. Tam so sedmega septembra izmerili 21,6 °C. Nato se je temperatura obeh jezer postopno zniževala vse do konca leta. Bohinjsko jezero je bilo vse leto hladnejše od Blejskega, in sicer v celoletnem povprečju za 3,3 °C.

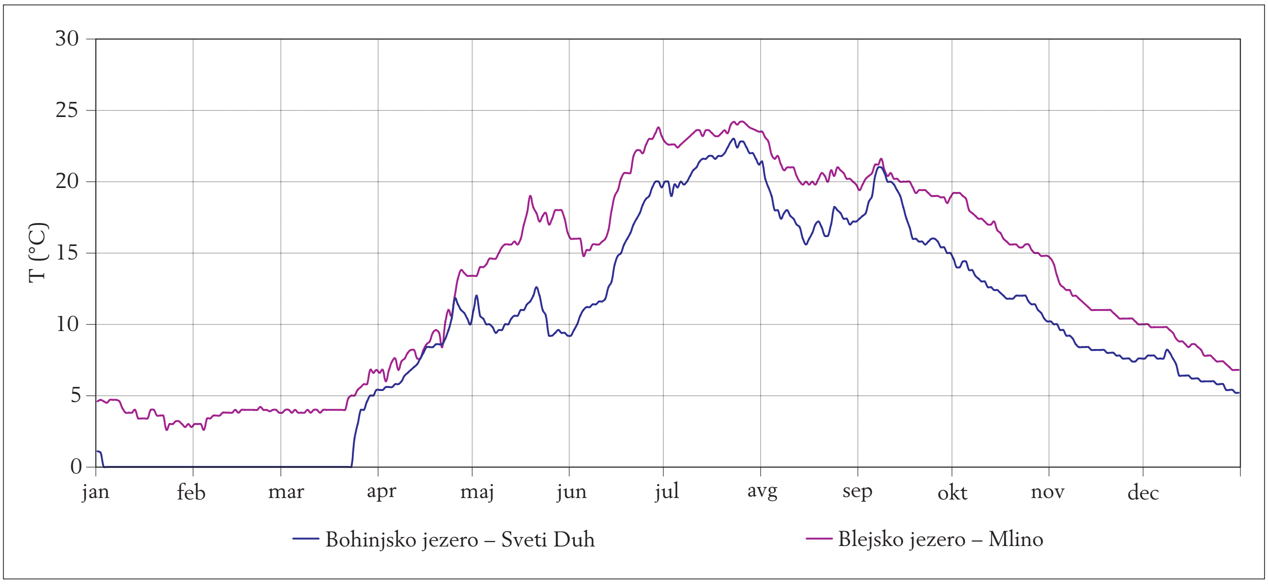
Primerjava značilnih temperatur rek z večletnim obdobjem

V prvih treh mesecih leta so bile srednje mesečne temperature nižje kakor v primerjalnem obdobju. Aprila je bila povprečna temperatura rek enaka obdobni vrednosti. Maja in junija se je temperatura le malo razlikovala od povprečja. Največje odstopanje od dolgoletnega

reached relatively high values. The highest value was measured on the Dravinja – 20.8 °C, and on the Savinja – 18 °C. The river temperatures gradually decreased by the end of the year with major or minor fluctuations.

Timeline of lake temperature changes

On the gauging site where the temperatures of Lake Bled are measured, the lake froze already at the beginning of January and remained frozen until the last third of March, when it began to warm up rapidly; in the last eight days of the month, the temperature increased to 5.4 °C. In the first three months of the year, the temperatures of Lake Bled did not change significantly and ranged from 2.6 °C to 4.7 °C. Only at the end of March did the temperature start to increase, with minor fluctuations, until the last days of May, when the lake cooled rapidly in a few days. The temperature of Lake Bohinj also rapidly increased from the second third of March to the second third of April, whereas in May, temperature fluctuations were recorded. In the first days of June, the lakes started to warm up and reached the highest annual values on 23 July. In the first days of August, a rapid cooling until the middle of the month was observed. The temperature of Lake Bohinj dropped from 21.4 °C to 15.6 °C. The temperature fluctuations in August were followed by the surprisingly high temperatures of Lake Bohinj in the first days of September, reaching 21.0 °C. The timeline for Lake Bled was similar, only slightly less significant. On 7 September, the temperature of Lake Bled was 21.6 °C. The temperatures of both lakes then gradually decreased to the end of the year. Throughout the year, temperatures at

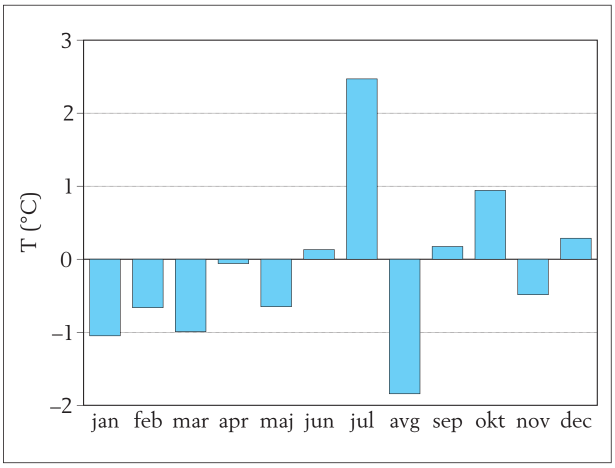


Slika 22: Temperature vode Blejskega in Bohinjskega jezera leta 2006.

***Figure 22:** Water temperatures of Lake Bled and Lake Bohinj in 2006.*

Slika 23: Odstopanja srednjih mesečnih temperatur rek v letu 2006 od srednjih mesečnih temperatur obdobja v °C.

Figure 23: *Deviations of mean monthly river temperatures in 2005 from mean monthly river temperatures in the reference period in °C.*



Slika 24: Odstopanja srednjih mesečnih temperatur v letu 2006 od srednjih mesečnih temperatur primerjalnega obdobja na izbranih rekah. Odstopanja so izračunana kot povprečja odstopanj na desetih rečnih merilnih postajah.

Figure 24: *Deviations of mean monthly temperatures in 2006 from mean monthly temperatures in the reference period for selected rivers. The deviations are calculated as deviation averages at ten river gauging stations.*

Lake Bohinj were lower than at Lake Bled, on average by 3.3 °C.

Comparison of characteristic river temperatures with the normal levels

In the first three months, the mean monthly temperatures were lower than in the reference period. In April, the average temperature was equal to the reference period value. In May and June, temperature deviated only slightly from the average. The greatest deviations from the multi-annual average were recorded in July. The average temperature was 19.3 °C and was 2.5 °C above the multi-annual average. In observing individual rivers, the greatest deviations from the multi-annual average were recorded on the Sava in Litija (4.6 °C) and on the Soča in Solkan (4.2 °C) (Figure 23). In August, average river temperatures were 1.8 °C lower than in the reference period. From September to December, the average temperatures significantly differed from the reference period values only in October, when they were 0.9 °C above the multi-annual average.

povprečja je opaziti v juliju. Povprečna temperatura je znašala 19,3 °C in je bila za 2,5 °C višja od dolgoletnega povprečja. Pri posameznih rekah je najvišja odstopanja od dolgoletnega povprečja v juliju opaziti na Savi v Litiji za 4,6 °C in Soči v Solkanu za 4,2 °C (slika 23). V avgustu so bile povprečne temperature rek za 1,8 °C nižje kakor v primerjalnem obdobju. Od septembra do decembra so se povprečne temperature rek bistveno razlikovale od obdobnih vrednosti le oktobra, in sicer so bile za 0,9 °C višje od dolgoletnega povprečja.

Primerjava značilnih temperatur jezer z večletnim obdobjem

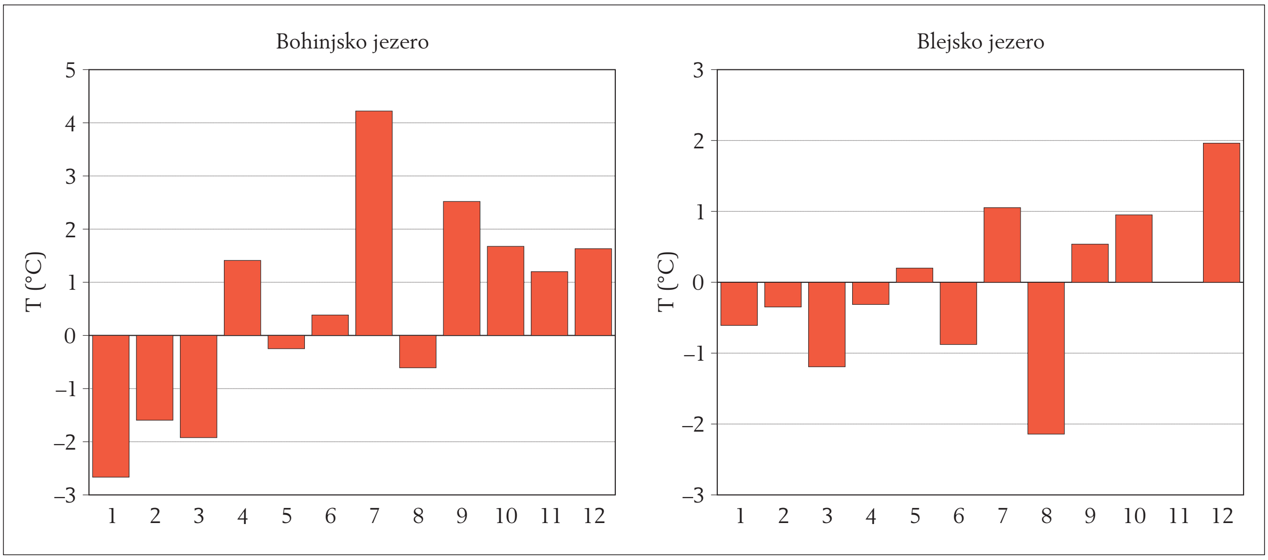
Srednje mesečne temperature Bohinjskega in Blejskega jezera so bile v prvih treh mesecih nižje kakor v večletnem primerjalnem obdobju. Januarja za 2,7 °C, februarja za 1,6 °C in marca za 1,9 °C nižje kakor v primerjalnem obdobju. Srednje mesečne temperature Blejskega jezera pa so bile v prvih dveh mesecih le nekolike

Comparison of characteristic lake temperatures with multi-annual averages

In the first three months of the year, the mean monthly temperatures of Lake Bled and Lake Bohinj were below the multi-annual reference period values. In January, they were 2.7 °C, in February 1.6 °C and in March 1.9 °C lower than in the reference period. In the first two months, the mean monthly temperatures of Lake Bled were only slightly below the reference period values, whereas in March they were 1.2 °C lower. In April, the average temperature of Lake Bohinj was 8.0 °C, 1.4 °C above the multi-annual average. In May and June, the average monthly temperatures of both lakes deviated only slightly from the reference period values. In July, the mean monthly temperature of Lake Bohinj significantly deviated from the multi-annual average and exceeded the normal average by 4.2 °C, whereas the temperature of Lake Bled was only 1.1 °C above the reference period value in the same period. In August, the deviation was more evident for Lake

Preglednica 4: Najnižje temperature izbranih rek in jezer v letu 2006 in v obdobju opazovanj.
Table 4: *The lowest temperatures of selected rivers and lakes in 2006 and in the reference period.*

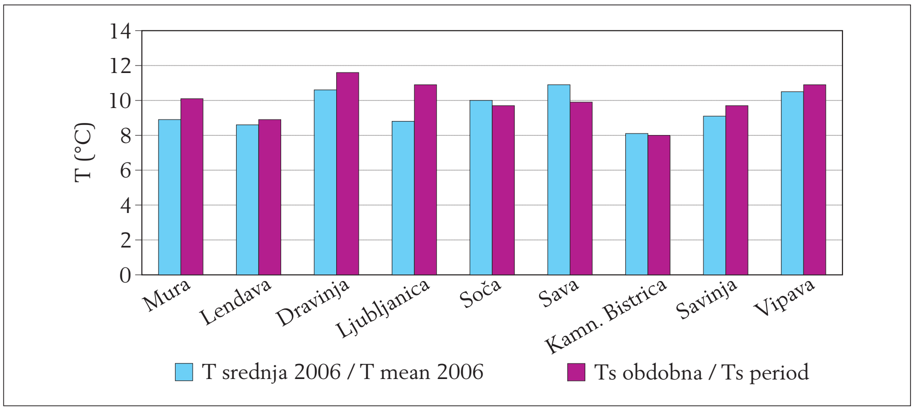
Vodotok *Stream*	Vodomerna postaja *Gauging Station*	Leto 2006 / *Year 2006* Tnk	Leto 2006 / *Year 2006* Datum / *Date*	Obdobje / *Period* Tnk	Obdobje / *Period* Datum / *Date*	Obdobje opazovanj
Mura	Gornja Radgona	0	24. 1.	0	4. 1. 1997	1989–2005
Dravinja	Videm	0,4	17. 1.	0	17. 2. 1983	1982–2005
Ljubljanica	Moste	2,9	25. 1.	1,0	11. 2. 1956	1954–2005
Soča	Solkan	3,0	27. 1.	0	15. 2. 1956	1953–2005
Sava	Litija	2,1	26. 1.	0	3. 2. 1954	1953–2005
Savinja	Celje	0,6	26. 1.	0	1. 12. 1973	1973–2005
Vipava	Dornberk	1,0	25. 1.	0,1	6. 1. 1985	1980–2005
Blejsko jezero	Mlino	2,6	23. 1.	1,2	29. 1. 1987	1985–2005
Bohinjsko jezero	Sveti Duh	0	3. 1.	0	14. 2. 1952	1951–2005



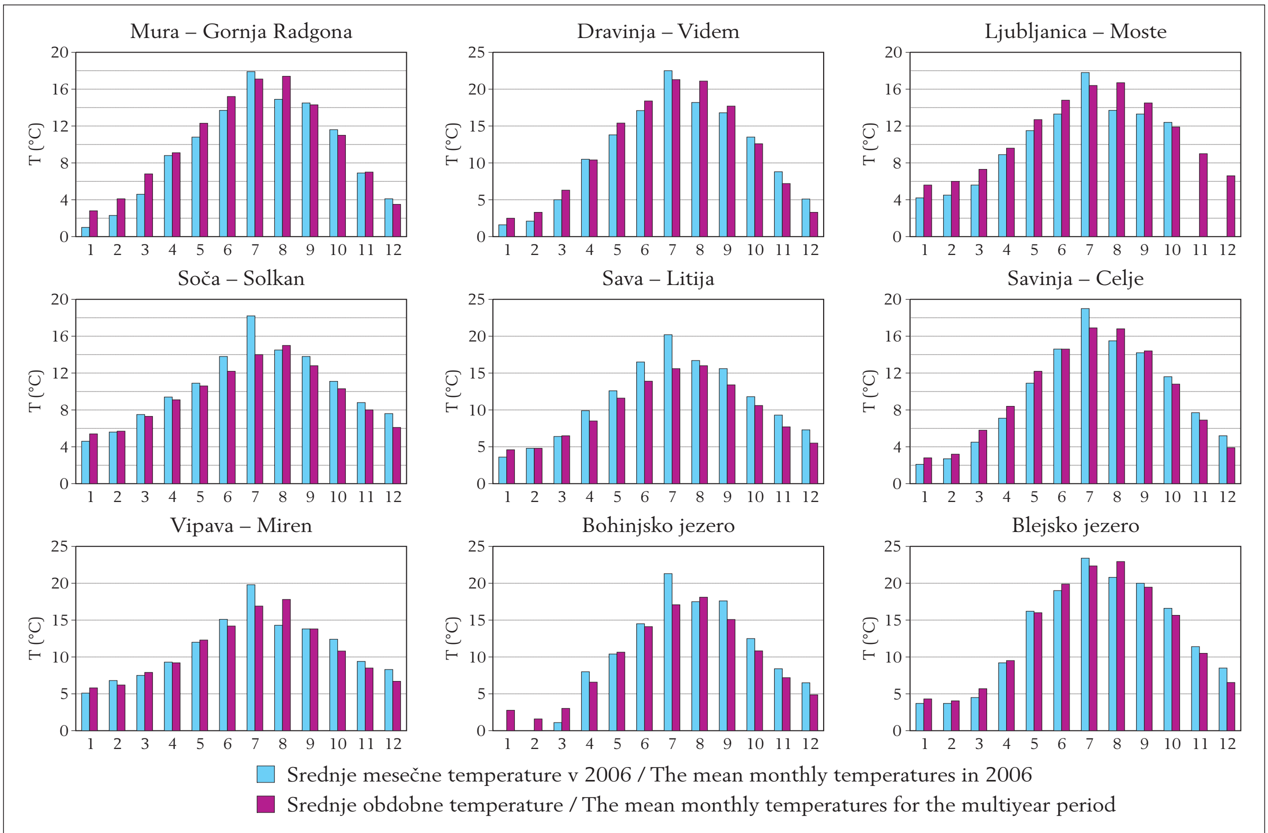
Slika 25: Odstopanja srednjih mesečnih temperatur v letu 2006 od srednjih mesečnih temperatur primerjalnega obdobja na Bohinjskem in Blejskem jezeru.
Figure 25: *Deviations of mean monthly temperatures for Lake Bled and Lake Bohinj in 2006 from mean monthly temperatures of the reference period.*

Preglednica 5: Najvišje temperature izbranih rek in jezer v letu 2006 in v obdobju opazovanj.
Table 5: *The highest temperatures of selected rivers and lakes in 2006 and in the reference period.*

Vodotok *Stream*	Vodomerna postaja *Gauging Station*	Leto 2006 / *Year 2006* Tvk	Datum / *Date*	Obdobje / *Period* Tvk	Datum / *Date*	Obdobje opazovanj
Mura	Gornja Radgona	20,0	29. 7.	23,3	23. 7. 2003	1989–2005
Dravinja	Videm	24,8	11. 7.	28,6	2. 8. 1994	1982–2005
Ljubljanica	Moste	18,9	24. 7.	23,8	16. 8. 1988	1954–2005
Soča	Solkan	19,8	27. 7.	20,0	9. 8. 1994	1953–2005
Sava	Litija	22,4	24. 7.	24,6	8. 8. 2003	1953–2005
Savinja	Celje	21,2	31. 7.	24,0	10. 8. 1994	1973–2005
Vipava	Dornberk	21,0	17. 7.	24,0	13. 8. 2003	1980–2005
Blejsko jezero	Mlino	24,2	23. 7.	25,4	9. 8. 1998	1985–2005
Bohinjsko jezero	Sveti Duh	23,0	23. 7.	24,1	31. 7. 1983	1951–2005



Slika 26: Primerjava srednjih letnih temperatur rek in jezer v letu 2006 s srednjimi letnimi temperaturami obdobja.
Figure 26: *Comparison of the annualtemperatures rivers and lakes in 2006 with the mean annual period temperatures.*



Slika 27: Primerjava srednjih mesečnih temperatur rek in jezer v letu 2006 s srednjimi mesečnimi temperaturami obdobja.
Figure 27: *Comparison of the mean monthly temperatures rivers and lakes in 2006 with the mean monthly period temperatures.*

Led na Bohinjskem jezeru (foto:Peter Frantar).
Ice on Bohinj lake (photo: Peter Frantar).

nižje od dolgoletnega povprečja, marca pa so bile za 1,2 °C nižje. Povprečna temperatura Bohinjskega jezera je aprila znašala 8,0 °C in je bila za 1,4 °C višja od temperature primerjalnega obdobja. Maja in junija sta se povprečni mesečni temperaturi obeh jezer le malo razlikovali od obdobnih vrednosti. Julija je od dolgoletnega povprečja znatno odstopala srednja mesečna temperatura Bohinjskega jezera, ki je bila višja za 4,2 °C, temperatura Blejskega jezera pa višja za 1,1 °C. Avgusta je bilo odstopanje višje pri Blejskem jezeru, katerega srednja mesečna temperatura je bila za 2,1 °C nižja od dolgoletnega povprečja. Septembra, oktobra in novembra so bile srednje mesečne temperature Bohinjskega jezera v povprečju za 2,1 °C višje kakor v primerjalnem obdobju, srednje mesečne temperature Blejskega jezera pa se v teh mesecih niso veliko razlikovale od dolgoletnega povprečja. Decembra sta bili povprečni mesečni temperaturi obeh jezer višji od obdobnih vrednosti, Blejsko jezero za 2,0 °C, Bohinjsko pa za 1,6 °C.

Bled, where the mean monthly temperature was 2.1 °C lower compared with the multi-annual average. In September, October and November, the mean monthly temperatures of Lake Bohinj were on average 2.1 °C above the reference period values, whereas the mean monthly temperatures of Lake Bled in the same period did not deviate much from the multi-annual average. In December, the average monthly temperatures of both lakes were above the reference period values for Lake Bled by 2.0 °C, and for Lake Bohinj by 1.6 °C.

Vsebnost in transport suspendiranega materiala v rekah

mag. Florjana Ulaga

Material, ki se pod vplivom turbulence premešča po reki, imenujemo rečni nanos. 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 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 visokih valov.

V letu 2006 smo redna merjenja vsebnosti suspendiranega materiala izvajali na šestih vodomernih postajah: v Gornji Radgoni na Muri, v Hrastniku na Savi, v Velikem Širju na Savinji in v Mirnu na Vipavi. Na teh merilnih mestih se enkrat dnevno odvzame vzorec vode s prostornino enega litra. Razen na postaji v Velikem Širju je odvzem vzorcev potekal dokaj redno. Na postajah Radovljica na Savi in Suha na Sori je odvzem vzorcev potekal z avtomatskim vzorčevalnikom. Vzorci so analizirani v laboratoriju po klasični filtracijski metodi. Rezultati analiz so izmerjene vsebnosti suspendiranega materiala (c), izražene v g/m^3 vode. Rezultati meritev so objavljeni v drugem delu publikacije.

Poleg rednega odvzema in analiziranja vzorcev poteka tudi odvzem vzorcev ob izrednih hidroloških razmerah na osmih 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. Ročni izredni odvzemi vzorcev so v letu 2006 potekali na Dravinji v Vidmu, na Sotli v Rakovcu, na Soči v Kobaridu, na Idrijci v Hotešku, na Bači v Bači pri Modreju, na Reki v Cerkvenikovem mlinu ter na dveh novo uvedenih postajah monitoringa suspendiranega materiala na Rižani v Kubedu in na Dragonji v Podkaštelu.

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.

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

Concentration and transport of suspended material in rivers

Florjana Ulaga, MSc

The material which is carried along the river bed under the influence of turbulence is called river sediment. With regard to size of particles and carrying speed, the sediment is divided into suspended sediment load and gravel, which is moved along the riverbed by rolling. The EARS monitors the total quantities of suspended material that is transported through a selected cross-section of a stream within a defined time. The dynamics of the suspended material transported in the rivers are monitored by measuring the concentration of suspended material, from which the quantity of material transported can be calculated using a measured river discharge. The majority of material is transported during high-water periods; sampling therefore needs to be frequently performed at the time of high-water waves.

In 2006, regular measurements of suspended material concentration were performed at six hydrometric stations: on the Mura in Gornja Radgona, on the Sava in Hrastnik, on the Savinja in Veliko Širje and on the Vipava in Miren. At these gauging sites, 1-litre water samples were taken daily. With the exception of the site in Veliko Širje, the samples were taken quite regularly. At the Radovljica station on the Sava and at the Suha station on the Sora, the samples were taken by an automatic sampler. The samples were analysed at a laboratory using classic filtration methods. The results of the analysis are measured concentrations of suspended material (c), expressed in g/m^3 of water. The measurement results are published in the second part of the publication.

In addition to regular sampling and sample analyses, sampling is also performed in extreme hydrological conditions at eight supplementary hydrometric stations. Analyses of these samples taken from the supplementary network makes evaluation of regular measurements easier and more accurate, while the results give an overview of high-water conditions throughout Slovenia. In 2006, manual extraordinary sampling took place on the Dravinja in Videm, on the Sotla in Rakovec, on the Soča in Kobarid, on the Idrijca in Hotešk, on the Bača in Bača near Modrej, on the Reka at Cerkvenik Mill and at two new stations performing suspended material monitoring i. e. on the Rižana in Kubed and on the Dragonja in Podkaštel.

Several times a year, cross-section measurements of suspended material are performed at all water gauging stations performing suspended material monitoring: samples are taken at a number of points along the cross-section. Based on material concentrations in the samples taken, the mean cross-section concentration

Rezultati meritev vsebnosti suspendiranega materiala v letu 2006

Ob pregledu izmerjenih vsebnosti suspendiranega materiala na postajah z dnevnim odvzemom vzorcev ugotovimo, da v letu 2006 na večini vodomernih postaj monitoringa nismo zabeležili izrednih vsebnosti suspendiranega materiala v vzorcih. Izjema je le postaja na Sori, kjer je bila izmerjena največja vsebnost do zdaj, 1196 g/m^3. Na preostalih postajah so bile izmerjene vsebnosti majhne, saj ob visokovodnih stanjih vzorci niso bili odvzeti. V Muri je bila največja izmerjena vsebnost 577 g/m^3, v Savinji 558 g/m^3, v Savi 317 g/m^3, v Vipavi pa le 121 g/m^3.

Na postaji Suha na Sori smo v mesecu juniju poskusno namestili avtomatski merilnik motnosti, turbidimeter OBS-3+ (D & A Instrument), ter rezultate meritev primerjali z laboratorijskimi analizami vzorcev, odvzetih z avtomatskim vzorčevalnikom. Sočasne meritve, ki smo jih ustrezno nadzorovali, so potekale do oktobra. Podrobneje je potek meritev opisan v prispevku v uvodnem delu publikacije.

Izvajanje polnoprofilne meritve vsebnosti suspendiranega materiala na Sori z batometrom in s turbidimetrom OBS-3+ (foto: Florjana Ulaga, 7. 6. 2006).

Cross-section measurement of suspended material on the Sora with suspended material water sampler and OBS-3+ turbidity sensor (photo: Florjana Ulaga, 7 June 2006).

and, with the help of the river discharge values, the instantaneous transport of suspended material are calculated.

The network of hydrometric stations where sampling takes place is shown in Map A in part III of this publication.

Results of suspended material concentration measurements in 2006

On reviewing the measured concentrations of suspended material at stations with daily sampling, we found that in 2006, at most hydrometric stations performing monitoring, no extraordinary concentrations of suspended material in samples were recorded. The only exception was the station on the Sora with the highest concentration measured so far (1196 g/m^3). At all other stations, the measured concentrations were low, because in high-water conditions no samples were taken. In the Mura, the highest measured concentration was 577 g/m^3, in the Savinja 558 g/m^3, in the Sava 317 g/m^3, and in the Vipava only 121 g/m^3.

In June, an automatic turbidity measuring device, the OBS-3+ sensor (D & A Instrument), was put into trial operation at Suha station on the Sora. The results of sensor measurements were compared with laboratory analyses of samples taken from the automatic sampler. Properly controlled parallel measurements were carried out until October. The measurement procedure is described in more detail in the survey in the introduction of the publication.

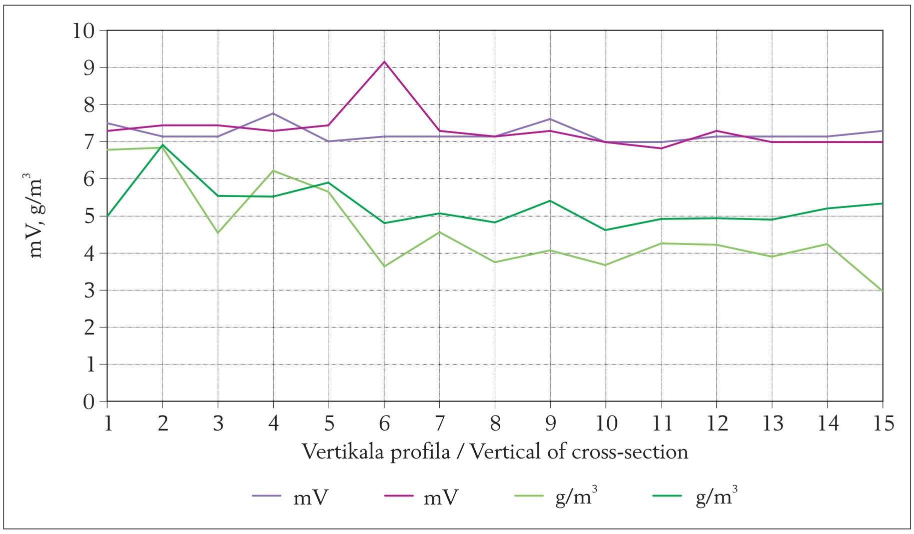
On 7 June, on the Sora, a cross-section measurement of suspended material concentration was performed. The samples were taken by a suspended material water sampler, at the same time samples were also taken by the OBS-3+ turbidity sensor. The samples taken by the suspended material water sampler were analysed at the ARSO laboratory using classic filtration methods. The results of measurements with the OBS-3+ sensor were known immediately after the measurement and are

Preglednica 6: Največje vsebnosti suspendiranega materiala vzorcev izbranih postaj z enkrat dnevnim odvzemom v letu 2006 in v obdobju 1985–2005.

Table 6: *The maximum concentration of suspended material in samples from selected stations with daily samplings from 2006 and from the 1985–2005 period.*

Vodotok / – *Stream* Vodomerna postaja / *Gauging station*	2006		1985–2005		
	Vsebnost c (g/m^3) *Concentration c (g/m^3)*	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	577	30. 04.	2364	16. 05. 1996	46
Sava – Hrastnik*	317	18. 09.	2200	06. 12. 2005	21
Savinja – Veliko Širje	558	25. 10.	6026	07. 11. 2000	58
Vipava – Miren	121	31. 05.	1105	27. 10. 2004	17
Sora – Suha**	1196	17. 09.	1196	17. 09. 2006	20
Sava – Radovljica***	113	13. 04. in 10. 12.	972	10. 10. 2004	21

* vzorčenje poteka od leta 1997 ** vzorčenje poteka od leta 2002 *** vzorčenje poteka od leta 2004



Slika 28: Rezultati polnoprofilne meritve na vodomerni postaji Suha na Sori.

Figure 28: *Results of cross-section measurement at Suha gauging station on the Sora River.*

Na Sori je bila 7. junija izvedena tudi polnoprofilna meritev vsebnosti suspendiranega materiala. Vzorci so bili odvzeti z batometrom, sočasno pa je potekala meritev vsebnosti s turbidimetrom OBS-3+. Vzorci, odvzeti z batometrom, so bili analizirani v laboratoriju ARSO s klasično filtracijsko metodo. Rezultati turbidimetra OBS-3+ so bili znani takoj ob meritvi in so na sliki izraženi v mV. Meritve so bile izvedene od levega brega proti desnemu in nazaj, tako da je v isti vertikali profila odvzetih več vzorcev. Ker je bila meritev izvedena v času nizkovodnega stanja, so razlike vsebnosti suspendiranega materiala med vertikalami majhne, turbidimeter OBS-3+ pa je skoraj v vseh točkah profila izmeril enake vrednosti. Ujemanje rezultatov meritev obeh instrumentov ni najboljše.

Rezultati meritev na vodomernih postajah z občasnim odvzemom vzorcev

Na postajah z občasnim odvzemom vzorcev smo izmerili veliko vsebnost suspendiranega materiala mar-

expressed in mV in the figure. The measurements were carried out from the left river bank to the right river bank and vice versa, so that in each vertical of the river profile several samples were taken. As the measurements were carried out at a time of low-water conditions, the differences of suspended material concentrations between the verticals were small; the results of measurements with the OBS-3+ sensor were the same in almost all points of the profile. The correlation of the measurement results received from the two instruments was not optimal.

Results of measurements at hydrometric stations with occasional sampling

At stations with occasional sampling, high suspended material concentrations were measured in March on the Dravinja and in October on the Soča. On the Soča, the concentration exceeded 500 g/m^3 several times in the year, in particular in October, when the discharges of the Soča also increased.

Preglednica 7: Največje vsebnosti suspendiranega materiala vzorcev odvzetih ob izrednih hidroloških razmerah (max c_1 – največja obdobna vsebnost, max c_2 – druga največja obdobna vsebnost).

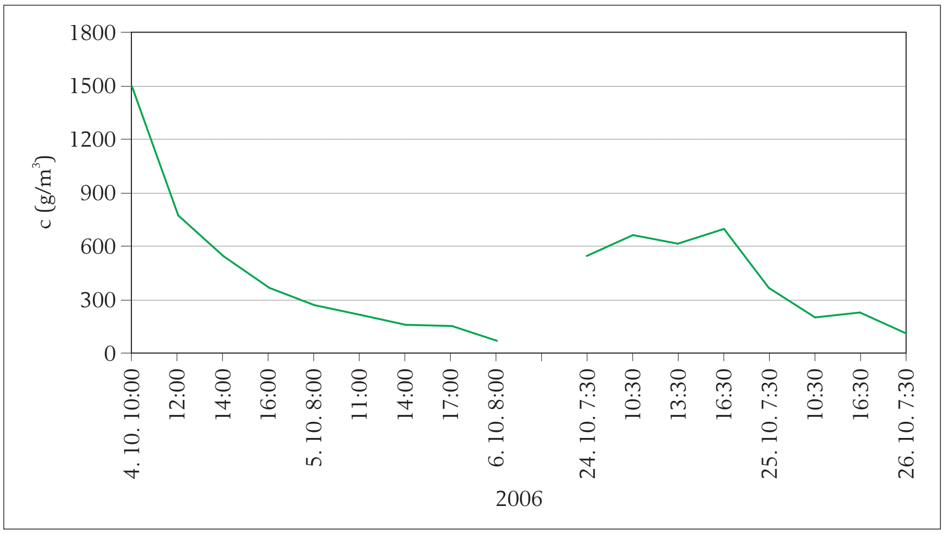
Table 7: *The maximum concentrations of suspended material in samples taken during extreme hydrological conditions (max c_1 – the maximum concentration in the reference period, max c_2 – the second highest concentration in the reference period).*

Vodomerna postaja *Gauging station*	Vodotok *Stream*	2006		1990–2005			
		Vsebnost c (g/m^3) *Concentration c (g/m^3)*	Datum odvzema vzorca *Date of sampling*	Največja obdobna vsebnost *The highest concentration in the period*			
				max c_1 *max c_1*	datum *date*	max c_2 *max c_2*	datum *date*
Videm	Dravinja	2136	11. 03.	4832	22. 05. 1999	4627	26. 01. 2001
Rakovec	Sotla	556	11. 03.	1818	14. 04. 2002	758	11. 07. 1999
Kobarid	Soča	1496	04. 10.	8112	17. 11. 2000	3200	05. 10. 2003
Hotešk	Idrijca	247	05. 03.	3743	09. 10. 1993	2988	01. 11. 1990
Bača pri Modreju	Bača	342	29. 08.	3086	10. 10. 2005	1959	27. 10. 1990

Preglednica 8: Vsebnost suspendiranega na vodomernih postajah dopolnilne mreže monitoringa suspendiranega materiala.
Table 8: *Concentration of suspended material at hydrometric stations of the supplementary network monitoring suspended material.*

Datum in ura *Date and time*		Vsebnost suspendiranega materiala (g/m³) *Concentracion of suspended sediment (g/m³)*
Dravinja Videm		
17. 02.	8:00	224,8
10. 03.	8:00	303,6
11. 03.	8:00	2135,5
12. 03.	8:00	494,4
29. 04.	8:00	145,3
30. 04.	8:00	182,4
25. 05.	8:00	115,0
19. 09.	8:00	230,6
20. 09.	8:00	56,6
30. 09.	8:00	154,3
Sotla Rakovec		
18. 01.	7:30	332,3
20. 01.	7:30	299,6
21. 01.	8:00	211,2
11. 03.	8:30	396,9
11. 03.	18:00	555,5
12. 03.	8:00	306,5
12. 03.	12:00	215,8
09. 04.	7:00	229,2
10. 04.	7:00	35,8
12. 04.	12:00	176,7
29. 04.	7:00	109,5
30. 04.	7:00	200,7
30. 05.	7:00	379,2
30. 05.	14:10	144,0
31. 05.	7:00	81,7
31. 05.	11:10	85,3
01. 06.	7:00	67,3
31. 08.	7:00	78,5
17. 09.	12:45	268,2
18. 09.	7:00	161,6
05. 10.	7:00	351,4
Idrijca Hotešk		
16. 02.	17:30	4,9
17. 02.	12:00	15,3
19. 02.	11:00	13,3
20. 02.	19:00	73,1
04. 03.	16:00	134,2
05. 03.	9:30	247,4
05. 03.	16:00	236,2
06. 03.	17:30	27,6
08. 03.	17:00	2,6
10. 03.	17:00	32,7
22. 03.	17:00	16,1
11. 04.	18:00	4,5
30. 04.	14:30	9,1
25. 05.	18:00	4,9
29. 05.	18:30	45,0
30. 05.	17:30	21,5
31. 05.	17:00	7,0
04. 08.	19:30	43,8
29. 08.	16:00	17,6
16. 09.	17:00	3,9
17. 09.	19:30	69,1
18. 09.	16:30	3,8
25. 10.	14:00	3,1
22. 11.	16:00	115,0
23. 11.	16:00	5,1
07. 12.	17:50	1,6
08. 12.	15:00	54,9
09. 12.	13:30	26,1
10. 12.	14:30	28,8
18. 12.	16:00	2,7
Rižana Kubed		
23. 05.	15:00	2,7
01. 08.	19:00	23,4
05. 08.	15:00	36,7
13. 08.	11:00	11,3
14. 08.	13:00	189,4
14. 08.	19:00	37,4
15. 08.	10:00	35,5
19. 08.	13:00	7,3
25. 08.	8:00	128,8

Datum in ura *Date and time*		Vsebnost suspendiranega materiala (g/m³) *Concentracion of suspended sediment (g/m³)*
Reka Cerkvenikov mlin		
21. 02.	9:30	57,9
Soča Kobarid		
29. 03.	8:00	83,4
29. 03.	10:30	111,6
29. 03.	13:00	62,9
29. 03.	15:30	1017,2
11. 04.	8:30	433,9
11. 04.	11:00	223,0
11. 04.	13:30	122,1
11. 04.	16:00	165,6
03. 08.	17:00	203,9
03. 08.	19:00	481,3
04. 08.	7:30	63,5
04. 08.	10:00	40,5
29. 08.	7:30	134,4
29. 08.	10:00	57,0
29. 08.	12:30	21,9
04. 10.	10:00	1496,2
04. 10.	12:00	771,4
04. 10.	14:00	543,6
04. 10.	16:00	362,6
05. 10.	8:00	271,2
05. 10.	11:00	215,0
05. 10.	14:00	161,3
05. 10.	17:00	152,1
06. 10.	8:00	69,6
24. 10.	7:30	542,1
24. 10.	10:30	665,3
24. 10.	13:30	613,3
24. 10.	16:30	696,6
25. 10.	7:30	367,6
25. 10.	10:30	198,2
25. 10.	16:30	227,9
26. 10.	7:30	109,7
07. 12.	11:00	310,6
07. 12.	13:30	258,6
07. 12.	16:00	197,7
09. 12.	8:00	156,9
09. 12.	10:30	234,5
09. 12.	13:00	453,9
09. 12.	15:30	502,7
10. 12.	9:00	167,5
10. 12.	11:30	158,2
10. 12.	14:00	143,7
10. 12.	16:30	131,3
11. 12.	9:00	115,7
Bača Bača pri Modreju		
04. 01.	16:00	19,8
20. 01.	16:00	26,0
30. 01.	16:00	19,6
17. 02.	16:30	20,7
19. 02.	13:00	2,7
22. 02.	16:30	3,3
02. 03.	17:30	0,3
04. 03.	16:00	41,4
06. 03.	16:30	38,4
10. 03.	16:30	50,2
05. 04.	18:55	3,0
10. 04.	15:00	1,2
30. 04.	14:15	13,6
08. 05.	20:00	169,5
21. 05.	15:50	0,4
25. 05.	18:40	1,2
04. 08.	17:00	116,5
29. 08.	17:00	342,4
17. 09.	13:00	7,1
02. 10.	17:00	16,5
04. 10.	15:00	21,5
24. 10.	16:30	139,9
20. 11.	15:30	11,6
06. 12.	16:00	103,3
Dragonja Podkaštel		
23. 05.	7:00	2,3
26. 08.	7:00	128,6
22. 11.	12:30	25,6
18. 12.	13:20	0,2



Slika 29: Povečana vsebnost suspendiranega materiala v Soči na vodomerni postaji Kobarid.
Figure 29: *Increased suspended material concentration on the Soča at Kobarid hydrometric station.*

ca v Dravinji in oktobra v Soči. V Soči je bila vsebnost še večkrat v letu večja od 500 g/m^3, predvsem v oktobru, ko so bili povečani tudi pretoki Soče.

Transport suspendiranega materiala

Količini transporta plavin v vodi sledimo z merjenjem vsebnosti suspendiranega materiala, iz katere pri izmerjenem pretoku izračunamo prenos suspendiranega materiala S (kg/s) na dan. V preglednici 9 so zbrani podatki o srednjih vrednostih transporta suspendiranega materiala za postaje z daljšim opazovanim nizom. Vrednosti v letu 2006 izkazujejo podpovprečen transport suspendiranega materiala, saj so bili tudi pretoki v primerjavi z dolgoletnim obdobjem nižji. Največje vrednosti transporta suspendiranega materiala v Savi v Hrastniku in v Vipavi niso bile izračunane za iste dneve, ko je bila največja tudi vsebnost suspendiranega materiala. Ob največjem transportu so bili povečani pretoki rek, v Hrastniku je bil dan pred odvzemom vzorca zabeležen celo največji letni pretok.

Transport of suspended material

The quantity of suspended load in the water is monitored by measuring the concentration of suspended material, from which the quantity of material transported S (kg/s) per day can be calculated using a measured river discharge. In Table 9. data are collected on the mean values of the suspended material transported from gauging stations with the longest time series. The values for 2006 show a below-average transport of suspended material, since the discharges were also lower in comparison to the multi-annual reference period. The highest values for transport of suspended material in the Sava in Hrastnik and in the Vipava were not calculated for the same days when the suspended material concentrations were also highest. When the transport values were the highest, the river discharges were increased; in Hrastnik, for example, the highest annual discharge value was recorded on the day preceding the sampling.

Preglednica 9: Največji letni transport suspendiranega materiala med odvzetimi vzorci ter srednje obdobne vrednosti vsebnosti in transporta suspendiranega materiala.
Table 9: *Highest annual transport of suspended material from samples taken and mean reference period values of suspended material concentrations and transport.*

Vodotok / *Stream* / Vodomerna postaja / *Gauging station*	2006		1985–2005
	Največji letni transport S (kg/s) / *The highest anual transport S (kg/s)*	Datum odvzema vzorca / *Date of sampling*	Srednji obdobni transport (kg/s) / *Mean transport in the period (kg/s)*
Mura – Gornja Radgona	293	30. 04.	13
Sava – Hrastnik*	165	06. 03.	8
Savinja – Veliko Širje	34	25. 10.	8
Vipava – Miren	10	02. 01.	0,8

* vzorčenje poteka od leta 1997

B. PODZEMNE VODE

Stanje zalog podzemne vode v aluvialnih vodonosnikih v letu 2006

Urša Gale

V letu 2006 je prevladovalo običajno stanje zalog podzemnih vod. V delih aluvialnih vodonosnikov severovzhodne in vzhodne Slovenije je prevladovalo nadpovprečno vodno stanje. Od hidrološke suše iz let 2002 in 2003 sta si po večletnem nizkem stanju opomogla tudi osrednji del vodonosnikov Apaškega in Prekmurskega polja. Nadpovprečne zaloge podzemnih vod v delih Prekmurskega, Murskega, Ptujskega in Krškega polja so bile posledica prekomernega napajanja z infiltracijo padavin. Zelo visoke vodne zaloge Vrbanskega platoja so bile odraz umetnega bogatenja podzemne vode filtrata iz reke Drave. V aluvialnih vodonosnikih osrednje in zahodne Slovenije so bila na manjših območjih odstopanja od normalnega vodnega stanja. Tam so bile ponekod nizke vodne zaloge. V Vipavski dolini so leta 2006, podobno kakor v letu pred tem, prevladovale zelo nizke zaloge podzemnih vod, k čemur je pripomogel letni primanjkljaj padavin in visoka stopnja evapotranspiracije v vročih poletnih mesecih. Zelo nizke vodne zaloge pretežnega dela vodonosnika Sorškega polja in podpovprečno vodno stanje dela Kranjskega polja ob Savi so bile posledica umetnega režima nihanja reke Save. Nizke zaloge podzemnih vod ob reki Kokri so bile odraz režima nihanja vodotoka.

Nihanje zalog podzemnih voda je v splošnem odraz celotnega hidrološkega cikla z določenim časovnim zaostankom za padavinskim dogodkom ali za spremembo gladine v reki. Nanje poleg naravnih hidroloških in meteoroloških parametrov vplivajo tudi umetni posegi v vodonosnik ter oblika in hidrodinamične lastnosti vodonosnika.

Letni padavinski presežek na območju Murske kotline in na jugu Slovenskih goric je leta 2006 ugodno vplival na vodne zaloge vodonosnikov Prekmurskega, Murskega in Ptujskega polja, ki so se deloma še vedno obnavljale po večletni suši med letoma 2000 in 2004. Največji letni primanjkljaj padavin je bil že drugo leto zapored zabeležen na območju vodonosnikov Vipavsko-Soške doline, zaradi česar je nizko vodno stanje prevladovalo tudi v vodonosniku Vipavske doline. Na območju vodonosnikov Dravske in Celjske kotline je bil padavinski primanjkljaj nekoliko manjši kot na območju Vipavsko-Soške doline, zato se zaloge podzemnih vod v teh vodonosnikih kljub neugodnim klimatskim razmeram niso spustile pod običajno raven.

Večja vodnatost rek, ki so v hidravlični povezavi z vodonosnikom, ugodno vpliva na stanje zalog podzemne

B. GROUNDWATER

Groundwater storage in alluvial aquifers in 2006

Urša Gale

In 2006, annual storage of groundwater was predominantly normal. In parts of the alluvial aquifers of north-eastern and eastern Slovenia, groundwater levels were predominantly above average. After the low groundwater reserves of recent years, the central part of the aquifers of the Apače and Prekmurje fields recovered from the hydrological droughts of 2002 and 2003. The above-average storage capacity of groundwater in parts of the Prekmurje, Mura, Ptuj and Krško fields resulted from the excessive feed from precipitation infiltration. The very high groundwater levels of Vrbanski plato were a reflection of artificial enrichment of groundwater with the filtrate from the Drava. In alluvial aquifers of central and western Slovenia, discrepancies from normal groundwater levels were noted in some smaller areas. These had low groundwater levels. In the Vipava valley, very low groundwater levels prevailed in 2006, as in the year before, which was due to the annual deficit of precipitation and a high level of evapotranspiration in the hot summer months. Very low groundwater levels in most of the Sora field aquifer and the below-average groundwater reserves of part of the Kranj field by the Sava were the result of the artificial regime of the Sava river stage fluctuation. Low annual storage of groundwater by the Kokra reflected the watercourse fluctuation regime.

In general, the fluctuation of groundwater levels reflects the entire hydrological cycle with a certain delay after precipitation events or altered river levels. Besides natural hydrological and meteorological parameters, this fluctuation is influenced by artificial interventions in aquifers and the form and hydrodynamic characteristics of the aquifer.

The annual precipitation surplus in the area of the Mura basin and the south of Slovenske gorice in 2006 had an advantageous effect on the annual groundwater storage of the aquifers of the Prekmurje, Mura and Ptuj fields, which were still partly recovering after the droughts between 2000 and 2004. For the second year in a row, the biggest annual deficit of precipitation was recorded in the area of aquifers of the Vipava and Soča valleys, which resulted in the low groundwater levels prevalent in the Vipava valley aquifer. In the area of the aquifers of the Drava and Celje basins, the precipitation deficit was slightly lower than that in the area of the Vipava and Soča valleys, so the groundwater levels in these aquifers did not drop below the average regardless of unfavourable climatic conditions.

vode in obratno. V letu 2006 so vodotoki na mestih, kjer so hidravlično povezani z gladino podzemne vode na zaloge podzemnih vod vplivali nekoliko negativno. Zaradi nizkih vodostajev rek v mesecih juliju, oktobru in novembru, je bilo napajanje aluvialnih vodonosnikov na območjih, kjer je gladina podzemne vode povezana z gladino vodotokov, manjše kakor običajno.

Prostorska variabilnost zalog podzemne vode v letu 2006

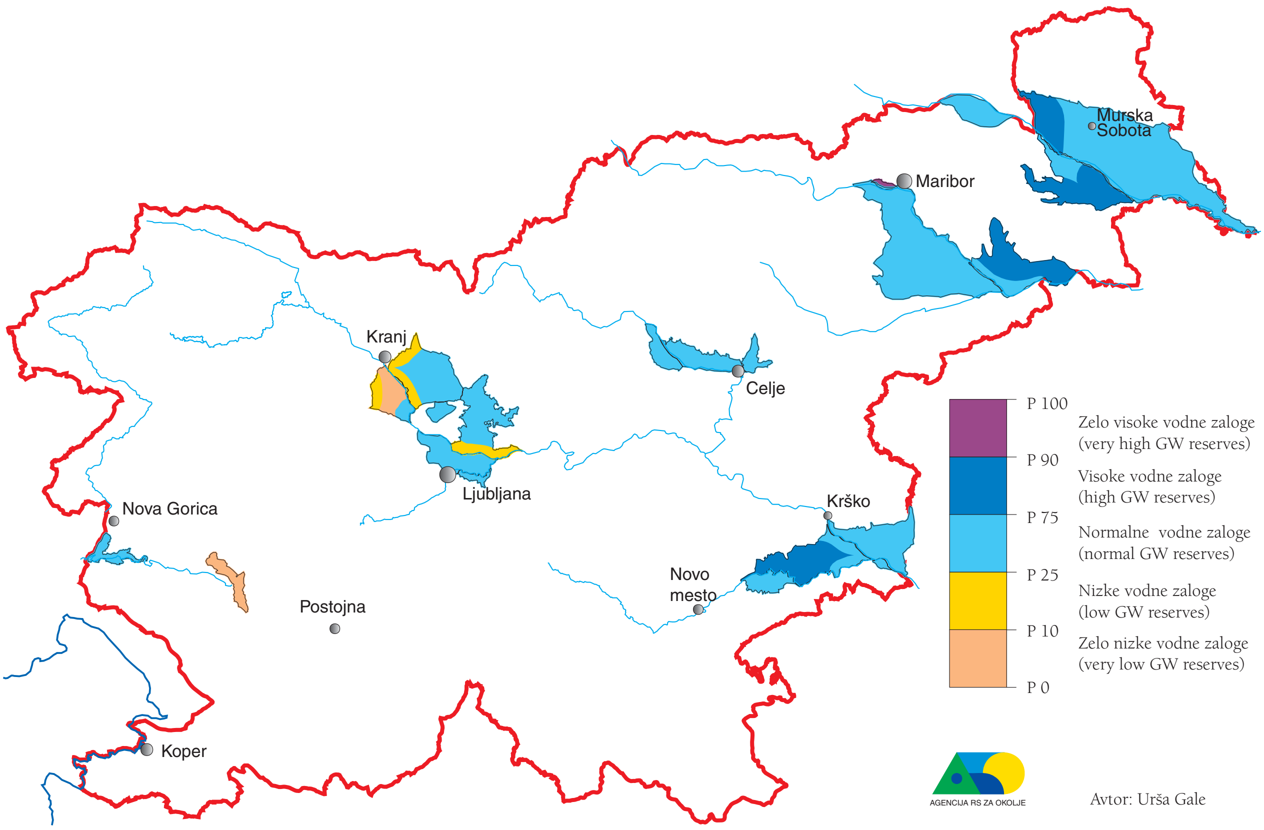
Zaloge podzemnih voda so bile v večini aluvialnih vodonosnikov leta 2006 v območju običajnih vrednosti. Takšne vrednosti so prevladovale v vodonosnikih Apaškega, Prekmurskega in Dravskega polja, v vodonosnikih spodnje Savinjske doline, na Brežiškem, Čateškem, Šentjernejskem, Ljubljanskem, Vodiškem in Kranjskem polju ter v vodonosniku Kamniške Bistrice in na Mirensko-Vrtojbenskem polju. Od normalnih vrednosti zalog so odstopali nadpovprečno vodnati deli vodonosnikov vzhodne in severovzhodne Slovenije in območja z nizkimi in zelo nizkimi zalogami podzemnih vod osrednje in zahodne Slovenije. Značilne letne gladine podaja preglednica 10, prostorsko variabilnost zalog podzemnih voda v letu 2006 pa slika 30.

Značilne letne gladine Hnk, Hs in Hvk so grobi pokazatelj vodnih zalog oziroma statistično povprečenega

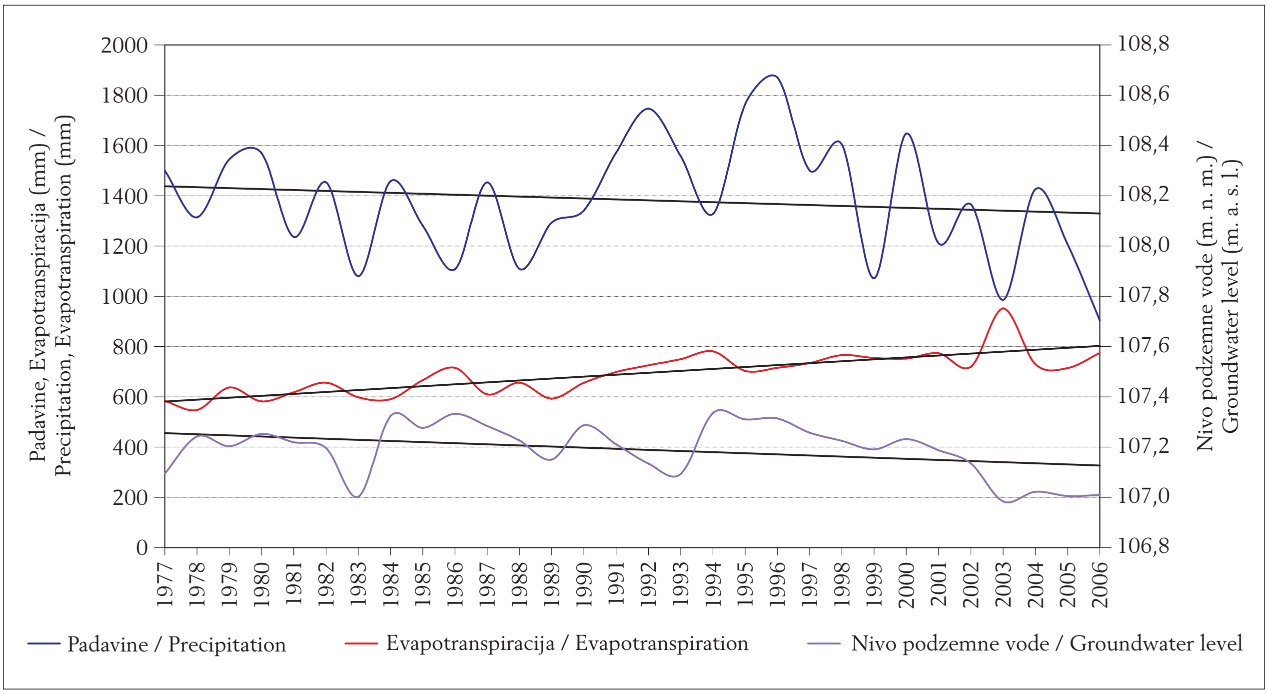
Higher water stages of rivers hydraulically related to the aquifer have a favourable impact on groundwater reserves, and vice versa. In 2006, watercourses had a slightly negative effect on groundwater storage in areas where they are hydraulically connected with the groundwater level. Due to low river levels in July, October and November, the feeding of alluvial aquifers in areas where the groundwater level is connected with the level of watercourses was lower than average.

Spatial Variability of Groundwater Reserves in 2006

In 2006, groundwater reserves were within the average in most alluvial aquifers. Such values prevailed in the aquifers of the Apače, Prekmurje and Drava fields, in the aquifers of the lower Savinja valley, on Brežice, Čatež, Šentjernej, Ljubljana, Vodice and Kranj fields, and in the aquifer of the Kamniška Bistrica and the Miren-Vrtojba field. Deviating from the normal values, annual groundwater levels were above-average in parts of aquifers of eastern and north-eastern Slovenia, and low and very low in areas of alluvial aquifers in central and western Slovenia, respectively. Typical annual water levels are provided in Table 10, while spatial variability of groundwater reserves in 2006 is provided in Figure 30.



Slika 30: Srednje letne gladine leta 2006 v večjih slovenskih aluvialnih vodonosnikih.
Figure 30: *Mean annual levels in 2006 in major Slovenian alluvial aquifers.*



Slika 31: Dolgoletni trend nihanja vsote letnih padavin, vsote letne evapotranspiracije in povprečne letne gladine podzemne vode na območju vodonosnika Vipavske doline.

Figure 31: *Long-term trend of total annual precipitation volume, annual evapotranspiration volume and average annual level of groundwater in the area of the Vipava valley aquifer.*

režima na letni ravni. Ti statistični parametri omogočajo grobo oceno variabilnosti v prostoru, ne morejo pa zajeti časovne variabilnosti med letom. Primerjavo med značilnimi nivoji v letu 2006 in značilnimi dolgoletnimi nivoji podzemnih voda v primerjalnem obdobju podaja slika 33.

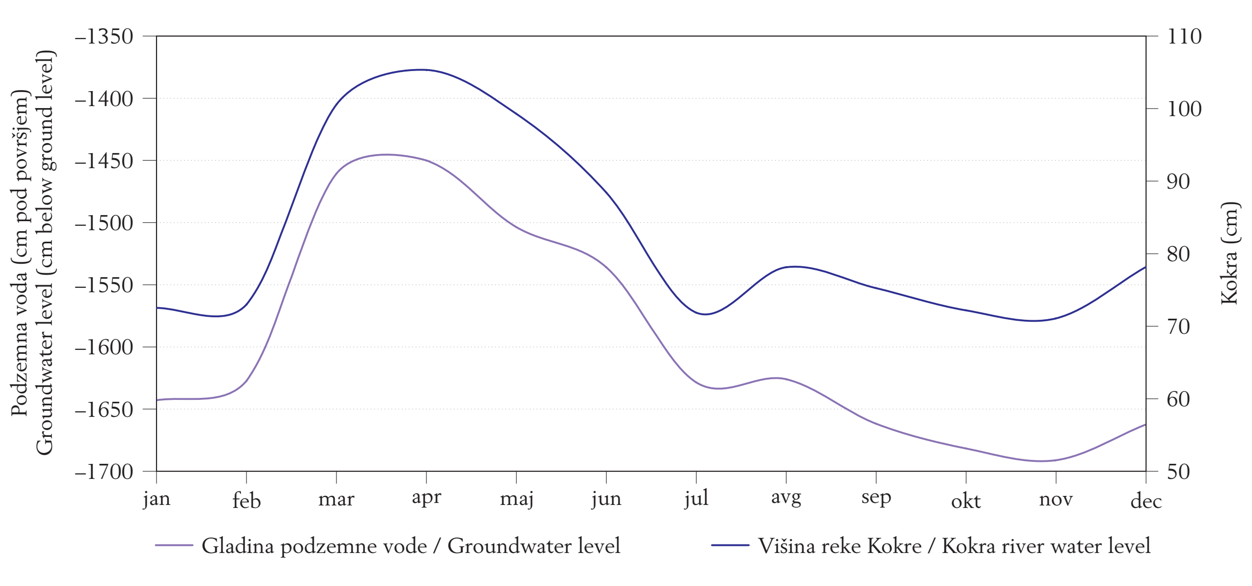
Merilno mesto na območju vodonosnika Vipavske doline – Vipavski Križ (foto: Vlado Savić).

Gauging station in the area of the Vipava valley aquifer – Vipavski Križ (photo: Vlado Savić).

The characteristic annual levels of Hnk, Hs and Hvk are a rough indicator of groundwater storage or the statistically averaged regime at the annual level. These statistical parameters enable a rough estimate of variability in space, but cannot cover time variability during the year. The comparison between characteristic levels in 2006 and the characteristic long-term levels of groundwater in the comparable period is provided by Figure 33.

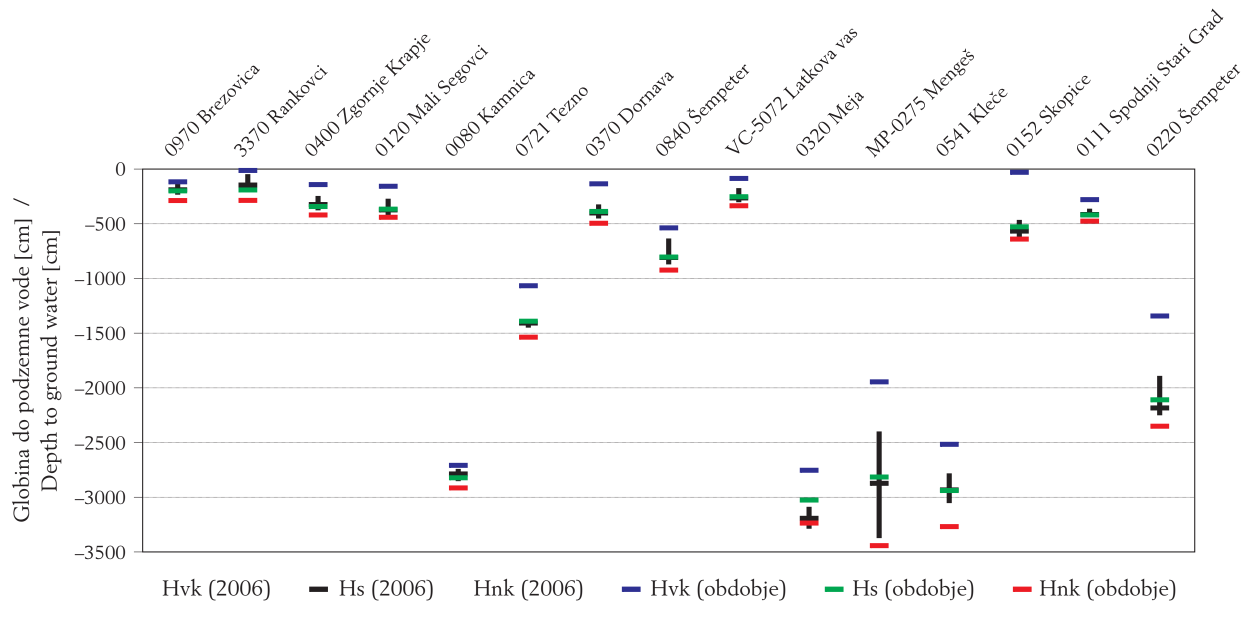
As in 2005, the average values of groundwater levels in the Vipava valley aquifer were below the periodic minimum in 2006. The reasons for the very low storage of groundwater in this aquifer were the annual precipitation deficit and an increased level of evapotranspiration; in addition, the groundwater reserves have also deteriorated due to the consumption of water used for the irrigation of agricultural land. The decreasing long-term trend of the total annual precipitation volume and the increasing long-term trend of the fluctuation of the annual potential evapotranspiration volume indicate the need for additional expert attention devoted to the problem of the increasingly common low and very low groundwater storage of the Vipava valley aquifer (Figure 31).

In 2006, the average annual volume of groundwater of Miren-Vrtojba field aquifer was also under the long-term average; it did not drop, however, under the average fluctuation range. Very low groundwater reserves prevailed in the Sora field aquifer, too. The reason lies in the changed regime of groundwater fluctuation in the aquifer, which is influenced by silting up of the bottom of the accumulation lake on the Sava hydraulically



Slika 32: Primerjava srednjih mesečnih višin gladin reke Kokre v Kranju in srednjih mesečnih globin do podzemne vode na merilnem mestu v Britofu (leto 2006).

Figure 32: *Comparison of mean monthly levels of Kokra river in Kranj and mean monthly depths to groundwater at the gauging station in Britof (2006).*



Slika 33: Primerjava značilnih globin do podzemne vode v letu 2006 z značilnimi gladinami za primerjalno obdobje (Preglednica 10) (Hs – srednja letna/obdobna gladina, Hnk – najnižja letna/obdobna gladina, Hvk – najvišja letna/obdobna gladina).

Figure 33: *Comparison of characteristic depths to groundwater in 2006 with characteristic water levels for the comparable period (Table 10) (Hs – mean annual/periodical level, Hnk – lowest annual/periodical level, Hvk – highest annual/periodical level).*

Podobno kakor v letu 2005 so bile tudi leta 2006 povprečne vrednosti gladin podzemne vode v vodonosniku Vipavske doline pod obdobnim minimumom. Razlog za zelo nizko vodno stanje zalog podzemnih vod v tem vodonosniku je v letnem padavinskem primanjkljaju, povečani letni stopnji evapotranspiracije, vodno stanje pa poslabšuje tudi poraba vode za namakanje kmetijskih površin. Upadajoči dolgoletni trend vsote

connected with the aquifer. In 2006, low groundwater levels also prevailed in the aquifer of the Kranj field by the Kokra, where the fluctuation regime is influenced by the fluctuation of the river level (Figure 32).

In the Vrbanski plato aquifer, very high groundwater levels prevailed in 2006, regardless of the below-average aquifer feed via precipitation infiltration. The reason for this high water level is artificial enrichment of letnih padavin in naraščajoči dolgoletni trend nihanja vsote letne potencialne evapotranspiracije opozarjata, da je treba problemu vse pogostejšega nizkega in zelo nizkega stanja zalog podzemnih vod vodonosnika Vipavske doline posvetiti dodatno strokovno pozornost (slika 31).

Povprečne letne vrednosti gladin podzemnih vod so bile v letu 2006 pod dolgoletnim povprečjem tudi na Mirensko-Vrtojbenskem polju, vendar se le-te niso znižale pod običajni razpon nihanja. Podobno je zelo nizko vodno stanje prevladovalo tudi v vodonosniku Sorškega polja. Razlog je v umetno spremenjenem režimu nihanja podzemne vode v vodonosniku, na katerega vpliva zamuljevanje dna akumulacijskega jezera na reki Savi, ki je v hidravlični povezavi z vodonosnikom. Nizke zaloge podzemnih vod so v letu 2006 prevladovale tudi v vodonosniku Kranjskega polja ob reki Kokri, kjer je režim nihanja pogojen z nihanjem vodostajev reke (slika 32).

V vodonosniku Vrbanskega platoja so v letu 2006 kljub podpovprečnemu napajanju vodonosnika z infiltracijo padavin prevladovale zelo visoke gladine podzemne vode. Vzrok za visoko vodno stanje je umetno bogatenje podzemne vode, ki zagotavlja varovanje izčrpane podzemne vode pred možnim onesnaženjem in povečanju zmogljivosti črpanja. Vrbanski plato je namreč največji vodni vir pitne vode v severovzhodni Sloveniji, ki pokriva do 65 % potreb po pitni vodi vodovodnega sistema, ki ga upravlja Mariborski vodovod.

Nadpovprečne vrednosti zalog podzemnih vod pretežnega dela Ptujskega in Murskega polja ter severnega dela Prekmurskega polja lahko pripišemo nadpovprečnim količinam padavin, ki so bile leta 2006 zabeležene v delu Murske kotline in Slovenskih goric.

groundwater providing protection of the extracted groundwater from potential pollution and increased extraction capacity. Vrbanski plato is the biggest source of drinking water in the north-eastern Slovenia, providing up to 65% of the requirement for drinking water of the water supply system managed by the Mariborski vodovod company.

The above-average values of groundwater levels of the predominant part of the Ptuj and Mura fields and of the northern part of the Prekmurje field may be attributed to the above-average quantities of precipitation recorded in 2006 in part of the Mura Basin and the Slovenske Gorice region.

Temporal Variability of Groundwater Reserves in 2006

In the first half of 2006, average and high values of groundwater levels prevailed in alluvial aquifers; in the second half of the year, the levels were within the range of average and low groundwater reserves. The fluctuation of monthly groundwater levels is revealed in the Table 11 and in Figure 35.

In **January**, the groundwater reserves were diverse due to the uneven distribution of precipitation. While high groundwater levels were predominant in some areas, others recorded very low monthly water storages. In January, the feeding of aquifers was most intense in the area of north-eastern Slovenia, where the groundwater reserves were in the range of average and high values, with the exception of the Apače field. At the beginning of the year, very high groundwater levels were recorded in the majority of the Krško field area, while

Preglednica 10: Primerjava značilnih globin do podzemne vode v letu 2006 z značilnimi globinami primerjalnega obdobja 1990–2001 (Vlado Savić).

Table 10: *Comparison of typical depths to groundwater in 2006 with typical depths of the reference period 1990–2001 (Vlado Savić).*

Postaja *Station*	Vodonosnik *Aquifer*	2006 Hnk (cm)	2006 Hs (cm)	2006 Hvk (cm)	Obdobje *Period* Hnk (cm)	Obdobje *Period* Hs (cm)	Obdobje *Period* Hvk (cm)
0970 Brezovica	Prekmursko polje	235	190	117	287	203	129
3370 Rankovci	Prekmursko polje	210	146	46	286	181	56
0400 Zgornje Krapje	Mursko polje	377	324	246	405	344	241
0120 Mali Segovci	Apaško polje	410	337	240	441	363	151
0080 Kamnica	Vrbanski plato	2853	2787	2741	2915	2832	2725
0721 Tezno	Dravsko polje	1450	1408	1374	1537	1436	1267
0370 Dornava	Ptujsko polje	457	389	300	497	411	260
0840Šempeter	Sp. Savinjska dolina	872	809	634	923	802	537
VC-5072 Latkova vas	Dolina Bolske	303	264	174	322	255	86
0320 Meja	Sorško polje	3288	3192	3087	3252	3058	2754
MP-0275 Mengeš	D. Kamniške Bistrice	3373	2872	2398	3441	2793	1946
0541 Kleče	Ljubljansko polje	3067	2952	2831	3194	2976	2635
0152 Skopice	Krško polje	632	567	464	638	539	108
0111 Sp. Stari Grad	Brežiško polje	439	415	362	470	418	279
0220 Šempeter	Vipavsko-Soška dolina.	2251	2183	1890	2323	2154	1378

Časovna variabilnost zalog podzemne vode v letu 2006

V prvi polovici leta 2006 so v aluvialnih vodonosnikih prevladovale običajne in visoke vrednosti zalog podzemnih vod, v drugi polovici leta pa so bile zaloge v območju običajnih in nizkih vodnih stanj. Nihanje mesečnih gladin podzemnih vod prikazujejo preglednica 11 in sliki 35.

Januarja je bilo stanje zalog podzemnih vod raznoliko zaradi neenakomerne porazdelitve padavin. Ponekod so prevladovali visoka stanja podzemne vode, v istem času pa so bile drugod zabeležene tudi zelo nizke vodne zaloge. Napajanje vodonosnikov je bilo januarja najintenzivnejše na območju severovzhodne Slovenije, kjer je bilo vodno stanje razen Apaškega polja v območju običajnih in visokih vrednosti. Zelo visoke zaloge podzemnih vod so bile v začetku leta zabeležene na pretežnem območju Krškega polja, nadpovprečno vodno stanje pa je prevladovalo še na Ljubljanskem in Brežiškem polju. Zelo nizke zaloge podzemnih vod so januarja prevladovale v delih Kranjskega polja, doline Kamniške Bistrice ter na večini merilnih mest Apaškega in Čateškega polja. Podobno kakor v januarju je bilo tudi **februarja** vodno stanje raznoliko. V večjem delu vodonosnikov vzhodne Slovenije se je tedaj podzemna voda dvignila do visokega in celo do zelo visokega stanja, območje zelo nizkih vodnih zalog pa je bilo zabeleženo na območju Sorškega polja in pretežnega dela vodonosnika doline Kamniške Bistrice. **Marca** so se gladine podzemne vode zvišale do običajnih in nadpovprečnih vrednosti tudi v vodonosnikih Ljubljanske kotline, ki so se tedaj napajali iz nadpovprečno vodnatih vodotokov in iz taljenja snežne odeje, ki se je od prvih dneh pa do zadnje dekade meseca ohranila na površini vodonosnikov. Gladine podzemne vode Vipavske doline so se od normalnih vrednosti iz preteklega meseca v marcu spet znižale pod običajno raven. Stanje zalog podzemnih vod se je zaradi velikega padavinskega primanjkljaja v aprilu in maju v tem vodonosniku znižalo do zelo nizkih vodnih zalog. V ostalih aluvialnih vodonosnikih se je podzemna voda **aprila** zaradi nadpovprečnega napajanaja z infiltracijo padavin ponekod dvignila do zelo visokih vodnih stanj. Zelo visoke zaloge podzemnih vod so aprila tako prevladovale v vodonosnikih Prekmurskega, Murskega, Apaškega, Ptujskega in Krškega polja ter v delu Ljubljanskega polja. Podobno je nadpovprečno vodno stanje v večini aluvialih vodonosnikov z izjemo Vipavsko Soške doline prevladovalo tudi v **maju**, k čemur je pripomogla povečana vodnatost rek, ki so se napajale iz taljenja snega v visokogorju.

Tudi **junija** je bilo v večini vodonosnikov Murske, Dravske in Krško-Brežiške kotline vodno stanje nadpovprečno do zelo visoko, v ostalih aluvialnih vodonosnikih pa je tedaj prevladovalo povprečno do nizko stanje zalog podzemnih vod. V vodonosniku Vipavske doline so bile še vedno zelo nizke vodne zaloge, ki se niso obnovile vse do konca leta 2006. Z julijem se je končalo ugodno

Izvir Kamniške Bistrice v zgodnjem poletju, ko se izvir napaja snežnico iz visokogorskega zaledja (foto: Niko Trišić, junij 2006).

The spring of the Kamniška Bistrica in early summer when fed by snowmelt from the mountainous rear area (photo: Niko Trišić, June 2006).

water reserves were also above average in the Ljubljana and Brežice fields. Very low groundwater levels were predominant in parts of the Kranj field, the Kamniška Bistrica valley and at most gauging sites of the Apače and Čatež fields. As in January, the water reserves were diverse in **February**, too. In most aquifers of eastern Slovenia, the groundwater reached the high or very high level, while an area of very low water storage was recorded in the area of the Sora field and in most of the aquifer of the Kamniška Bistrica valley. In **March**, groundwater levels reached average and above-average values also in the aquifers of the Ljubljana Basin, which had previously been fed from watercourses with above-average water stages and from the melting of snow layer remaining on the aquifer surface from the first days to the last ten days of the month. The groundwater levels of the Vipava valley dropped from the normal values from the previous month to below the average level in March. The groundwater storage in this aquifer was reduced to very low water levels due to a major shortage of precipitation in April and May. In **April**, groundwater in some other alluvial aquifers increased to very high water levels due to above-average feeding from precipitation infiltration. Very high groundwater storage thus prevailed in the aquifers of Prekmurje, Mura, Apače, Ptuj and Krško fields as well as in part of the Ljubljana field. Similarly, above-average water levels in most alluvial aquifers, with the exception of the Vipava and Soča valleys, were also prevalent in **May**, which was due to the increased water stages of rivers feeding from melting snow in high mountain ranges.

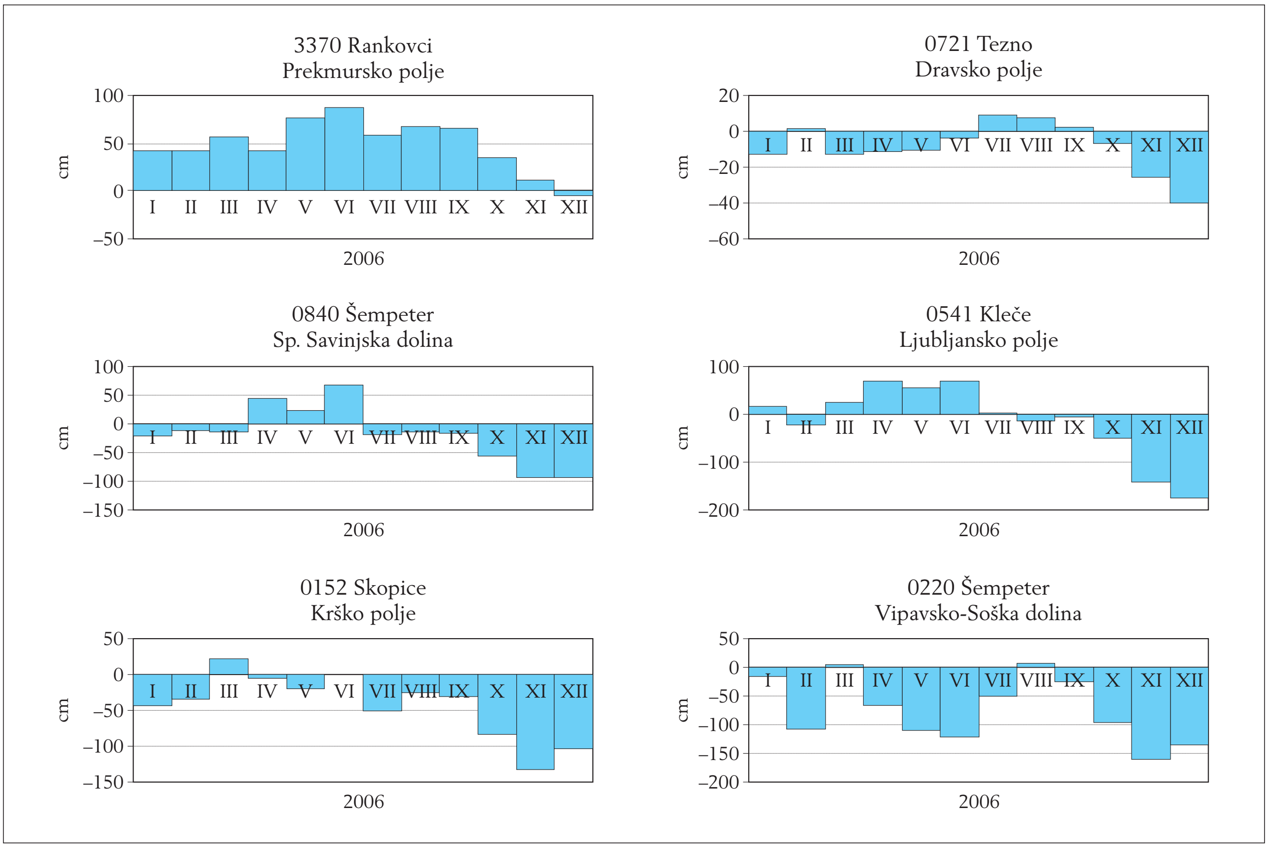
In **June**, the water levels in most aquifers of the Mura, Drava and Krško-Brežice basins continued to be above average to very high, while average to low groundwater reserves prevailed in other alluvial aquifers. The Vipava valley aquifer still experienced very low groundwater

Preglednica 11: Srednje mesečne globine do podzemne vode v letu 2006 (Vlado Savić).
Table 11: *Mean monthly depths to groundwater in 2006 (Vlado Savić).*

Postaja / *Station*	Vodonosnik / *Aquifer*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0970 Brezovica	Prekmursko polje	169	177	166	182	169	180	209	212	197	214	207	201
3370 Rankovci	Prekmursko polje	138	129	110	135	114	110	151	151	148	170	188	203
0400 Zgornje Krapje	Mursko polje	322	327	298	311	278	270	309	335	340	354	369	375
0120 Mali Segovci	Apaško polje	339	333	257	293	292	296	328	355	368	384	397	404
0080 Kamnica	Vrbanski plato	2827	2845	2824	2787	2752	2752	2763	2763	2762	2771	2793	2804
0721 Tezno	Dravsko polje	1406	1398	1408	1388	1375	1378	1381	1398	1420	1432	1442	1442
0370 Dornava	Ptujsko polje	385	386	325	350	357	347	388	417	415	409	441	453
0840 Šempeter	Sp. Savinjska dolina	805	824	829	760	796	747	825	845	846	847	860	867
VC-5072 Latkova vas	Dolina Bolske	248	275	193	221	255	228	276	293	287	290	300	299
0320 Meja	Sorško polje	3133	3202	3140	3094	3133	3150	3183	3220	3243	3254	3275	3281
MP-0275 Mengeš	D. Kamniške Bistrice	2553	2757	2664	2585	2672	2642	2806	2961	3063	3158	3263	3340
0541 Kleče	Ljubljansko polje	2882	2969	2950	2879	2874	2867	2931	2976	2994	3007	3040	3055
0152 Skopice	Krško polje	555	568	506	508	530	526	590	593	591	605	621	604
0111 Sp. Stari Grad	Brežiško polje	392	416	386	407	414	393	429	435	427	419	434	433
0220 Šempeter	Vipavsko-Soška dolina	2061	2162	2085	2163	2227	2245	2213	2197	2205	2220	2227	2188

stanje zalog podzemnih vod v aluvialnih vodonosnikih, saj so bile od tega meseca dalje zaloge v pretežnih delih aluvialnih vodonosnikov v območju običajnih in nizkih vrednosti. **Julija** so se nad običajnim vodnim stanjem ohranili le še osrednji deli Prekmurskega, Dravskega in Krškega polja razen Vrbanskega platoja, kjer so bili od maja pa vse do konca koledarskega leta gladine podzemne

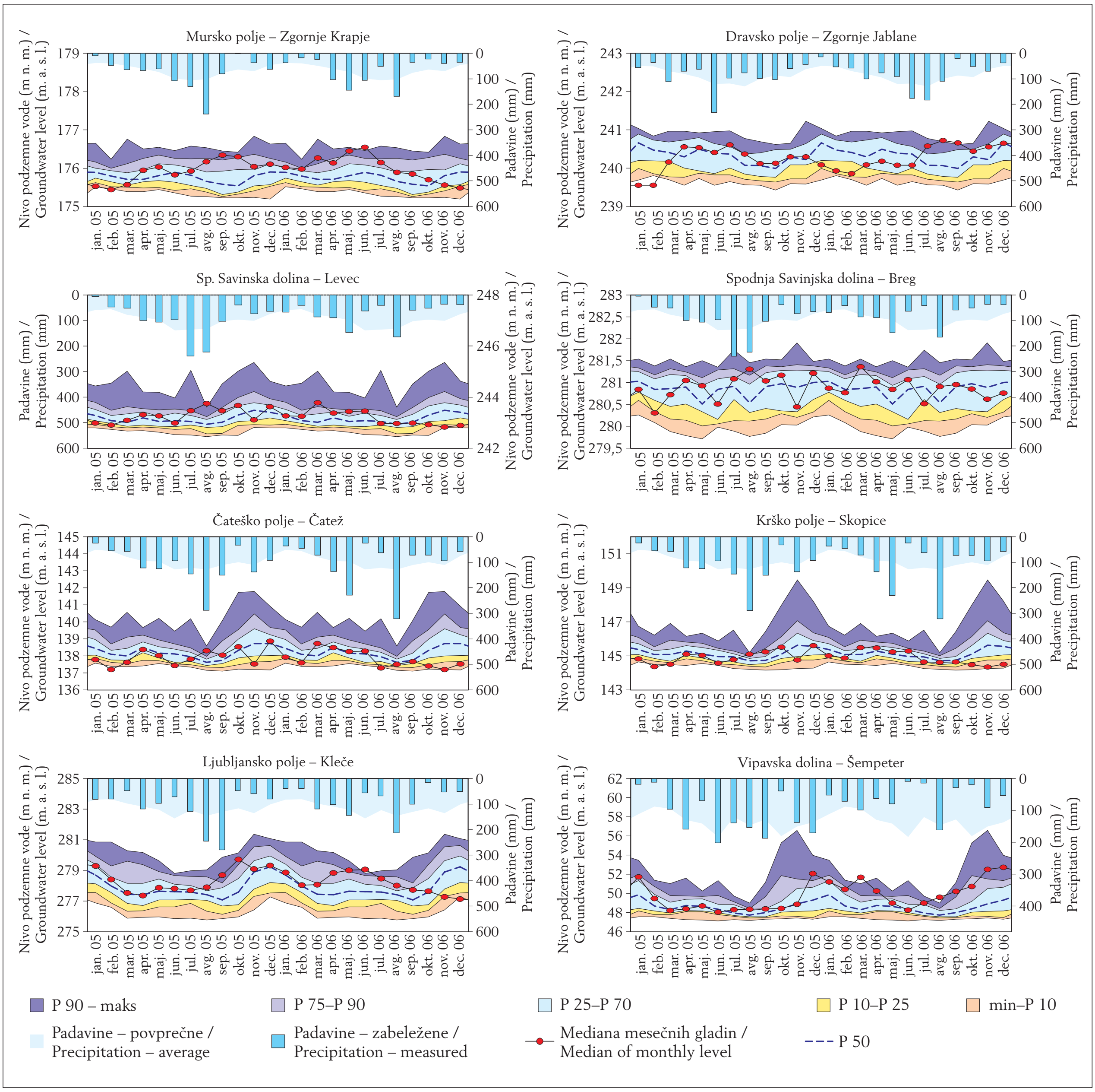
stages, which did not recover until the end of 2006. July marked the end of favourable groundwater storage in alluvial aquifers, water reserves in alluvial aquifers were predominantly in the range of average to low values from this month onwards. In **July**, the water levels remained above average only in the central parts of the Prekmurje, Drava and Krško fields with the exception of Vrbanski



Slika 34: Odstopanja srednjih mesečnih gladin podzemne vode v letu 2006 glede na srednje mesečne gladine za primerjalno obdobje 1990–2001 (Vlado Savić).
Figure 34: *Deviations from mean monthly groundwater levels in 2006 with regard to mean monthly levels for the reference period 1990–2001 (Vlado Savić).*

vode zelo visoke zaradi umetnega bogatenja podzemne vode iz filtrata Drave. Poleg Vipavske doline je bilo zelo nizko stanje zalog tudi na Čateškem polju ter v manjših delih večine aluvialnih vodonosnikov. V tem mesecu se je močno povečala tudi stopnja evapotranspiracije, v spodnji Vipavski dolini so izmerili doslej najvišjo julijsko temperaturo zraka. Kljub nadpovprečnim **avgustovskim** padavinam se stanje v aluvialnih vodnonosnikih ni znatno izboljšalo. Zelo nizke gladine podzemne vode so tedaj prevladovali v delih Krškega polja in v delih doline Kamniške Bistrice, na Sorškem in Kranjskem polju ter v vodonosnikih Vipavsko-Soške doline. Zaradi padavinskega primanjkljaja so se zaloge podzemnih vod

plato, where groundwater levels were very high from May to the end of the year due to artificial enrichment of groundwater with the filtrate from the Drava. Besides the Vipava Valley, very low water levels were experienced on Čatež field aquifer and in small parts of most alluvial aquifers. This month saw a considerable increase in the evapotranspiration level; in Vipava Valley, the all-time highest July air temperature was recorded. Regardless of the above-average **August** precipitation, water storage in alluvial aquifers did not improve considerably. Very low groundwater levels prevailed in parts of the Krško field and parts of the Kamniška Bistrica valley, on the Sora and Kranj fields and in the aquifers of



Slika 35: Mediane mesečnih gladin podzemnih voda (m nm. viš.) v letih 2005 in 2006 – rdeči krogci, v primerjavi z značilnimi percentilnimi vrednostmi gladin primerjalnega obdobja 1990–2001.

Figure 35: *Medians of monthly groundwater levels (in m above sea level) in 2005 and 2006 – red circles, in comparison with typical percentile values of river levels in the reference period 1990–2001.*

Črpalni vodnjak G črpališča podzemne vode Medlog v Spodnji Savinjski dolini (foto: Vlado Savić).
Pumping well G of groundwater pumping station at Medlog in Spodnja Savinjska dolina (photo: Vlado Savić).

v aluvialnih vodonosnikih postopoma zmanjševalo vse do konca leta 2006. Zelo nizko vodno stanje je bilo decembra poleg Vipavske doline zabeleženo tudi na celotnem Sorškem, Kranjskem, Vodiškem, Čateškem in Apaškem polju ter v delih ostalih aluvialnih vodonosnikov. Drugje je bilo vodno stanje ponekod nizko, ponekod pa v območju običajnih vrednosti.

Povprečne vrednosti zalog podzemnih vod so bile leta 2006 v območju običajnih vrednosti. V aluvialnih vodonosnikih severovzhodne in vzhodne Slovenije so poleg običajnih ponekod prevladovale tudi nadpovprečne vrednosti, v delih vodonosnikov osrednjega in zahodnega dela države pa podpovprečne vrednosti zalog podzemne vode. Mesečna nihanja gladin so bila v prvi polovici leta pretežno v mejah visokih in zelo visokih vrednosti, v drugi polovici pa v mejah nizkih do zelo nizkih vrednosti zalog podzemne vode.

the Vipava and Soča valleys. The precipitation deficit caused a gradual decrease of groundwater levels in alluvial aquifers for the rest of 2006. In December, very low water reserves were recorded in the Vipava valley as well as in the entire area of the Sora, Kranj, Vodice, Čatež and Apače fields and parts of other alluvial aquifers. Elsewhere, the water storage was sometimes low and sometimes within the range of average values.

In 2006, mean values of groundwater storage were within the range of average values. Some alluvial aquifers of north-eastern and eastern Slovenia experienced above-average values, while below-average values of groundwater reserves prevailed in parts of aquifers of the central and western part of the country. In the first half of the year, monthly fluctuations of river levels were mostly within the range of high and very high values, while they were in the range of low to very low groundwater storage values in the second half of the year.

C. IZVIRI

Izviri

Niko Trišić

V letu 2006 je program monitoringa izvirov obsegal 13 lokacij, kjer so bile na različnih tipih kraških vodonosnikov v Sloveniji vzpostavljene merske postaje že v preteklih letih, v drugi polovici leta pa so bile vzpostavljene še 3 postaje, in sicer dve, Mošenik in Završnica, na območju Karavank, ter tretja na izviru Polterca pri Krki. Usmeritev na območje Karavank je narekovala potreba po podatkih o pretokih iz obsežnega čezmejnega vodnega telesa podzemne vode, ki se razteza vzdolž avstrijsko-slovenske meje.

V letopisu objavljamo podatke zbrane na postajah, ki prikazujejo različne tipe kraških vodonosnikov v Sloveniji. Za postaje na izvirih Podroteja, Kamniška Bistrica in Letošč navajamo parametre vodostaj, temperatura in specifična električna prevodnost, za Težko vodo, Krupo in Veliki Obrh podajamo vrednosti pretoka in temperature, za vrtino na območju Brestovice pa podatek o vodostajih in temperaturah kraške podzemne vode.

Podroteja – izvir

Režim nihanja vodostajev, specifične električne prevodnosti in temperatur izvira Podroteja predstavlja kombinirani grafikon na sliki 36. Zima v letu 2005/2006 se v januarju in februarju odraža z nizkimi vodostaji ter s povprečnimi temperaturami in specifično električno prevodnostjo. Spomladanska otoplitev in taljenje snega sta skupaj s padavinami v marcu dvignili vodostaj izvira do letnega maksimuma 225 cm, ki pa ne predstavlja izjemne vrednosti v obdobju opazovanj, ki je bil zabeležen v letu 2001. Ob tem letnem maksimumu vodostajev pa sta nastopile letna minimuma temperatur in spec.el.prevodnosti. Bazni iztok iz vodonosnika je bil v območju srednje letnih vodostajev vse do junija, nakar je nastopilo dvomesečno obdobje upadanja vodostajev. Obratno glede na vodostaje so v tem obdobju

C. SPRINGS

Springs

Niko Trišić

In 2006, the spring monitoring programme covered 13 locations where gauging stations on different types of karst aquifers in Slovenia had been established in previous years; in the second half of the year, 3 additional stations were established: at Mošenik and Završnica, in the Karavanke area, and on the Polterca spring near Krka. The orientation towards Karavanke was initiated by the need for data on discharge rates from the extensive cross-border body of groundwater spreading along the border of Slovenia and Austria.

The Yearbook publishes data collected by stations showing different types of karst aquifers in Slovenia. The stations located at the Podroteja, Kamniška Bistrica and Letošč springs provide water level, temperature and specific electrical conductivity parameters, the Težka voda, Krupa and Veliki Obrh stations provide values for discharge rate and temperature, while the well in the Brestovica area provides data on the water levels and temperatures of the Karst groundwater.

Podroteja spring

The water level fluctuations, specific electrical conductivity and temperatures of the Podroteja spring are presented in the combined diagram in Figure 36. In January and February, the winter of 2005/2006 is reflected in low water levels, as well as average temperatures and specific electrical conductivity. In March, the air warming and melting snow combined with precipitation raised the spring water level to the annual maximum of 225 cm, which, however, does not constitute the maximum value in the observation period (recorded in 2001). At this annual maximum of water levels, the annual minimum of temperatures and specific electrical conductivity was recorded. The base flow from the aquifer was in the range of mean annual water levels

Preglednica 12: Značilni mesečni in letni vodostaji izvira Podroteja v cm.

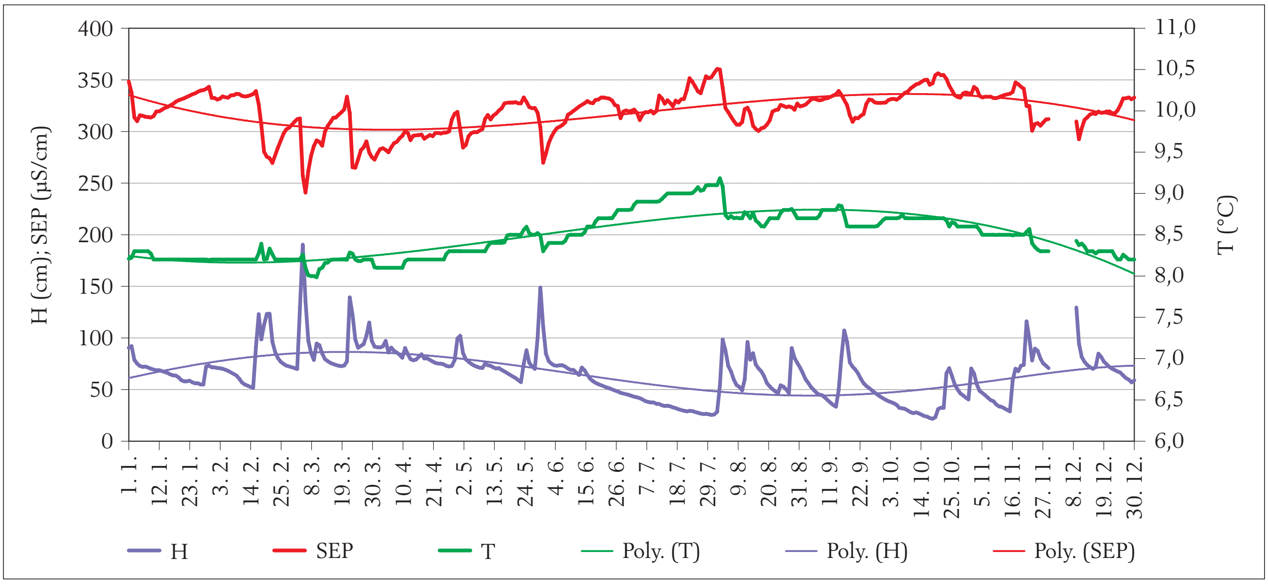
***Table 12:** Characteristic monthly and annual water levels of the Podroteja spring in cm.*

	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Hs	Hvk	Hnk
1999	100,7	99,6	125,2	129,0	98,9	92,6	79,8	62,6	66,1	96,9	100,8	127,3	98,1	239,8	40,0
2000	85,5	101,4	114,8	105,0	95,1	69,4	83,1	45,6	71,8	101,3	159,8	121,7	96,1	268,4	
2001	138,5	105,8	143,2	108,8	93,4	94,5	66,2	35,6	82,2	84,9	82,2	55,2	90,7	322,3	35,6
2002	66,8	98,7	80,7	81,6	89,1	85,6	72,7	93,2	56,8				80,9	254,0	30,0
2003															
2004			84,8	91,5	77,4	72,7	57,6	45,2	47,2	85,8	82,6	79,8	71,3	174,4	25,1
2005	61,4	39,6	60,4	73,5	0,0	28,8	50,1	64,4	70,3	77,3	72,6	78,2	63,1	210,3	21,7
2006	67,3	77,8	94,3	82,5	77,1	62,4	33,8	63,0	56,9	36,8	60,0	74,0	65,2	225,1	20,9
Hs	86,7	87,2	100,5	96,0	75,9	72,3	63,3	58,5	64,5	80,5	93,0	89,4	80,8	322,3	20,9

Preglednica 13: Značilne mesečne, letne in obdobne vrednosti temperatur – T (°C) in specifične električne prevodnosti – SEP (µS/cm) izvira Podroteja.

Table 13: *Characteristic monthly, annual and periodical values of temperature – T (°C) and specific electrical conductivity – SEP (µS/cm) of the Podroteja spring.*

	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letni
SEP 2006	328	316	293	295	313	318	331	320	327	341	330	319	319
SEP 1999–2006	317	310	300	296	314	329	327	325	329	324	320	312	317
T 2006	8,2	8,2	8,2	8,2	8,4	8,6	9	8,8	8,7	8,7	8,5	8,3	8,5
T 1999–2006	8,3	8,2	8,3	8,4	8,7	8,8	9	9	8,9	8,6	8,5	8,4	8,6



Slika 36: Potek vodostajev, specifične električne prevodnosti in temperature v letu 2006 na izviru Podroteja.

Figure 36: *Water levels, specific electrical conductivity and temperature of the Podroteja spring in 2006.*

vrednosti temperatur in specifična električna prevodnost, naraščale in so konec julija dosegle letna maksimuma. Konec julija izmerjeni nizki vodostaj v izviru Podroteja pa ne predstavlja letnega minimuma. Ta je nastopil šele 18. oktobra v jesenski suši, in predstavlja tudi obdobno najnižjo izmerjeno vrednost.

Na podlagi primerjave podatkovnih nizov leta 2006 in obdobnih vrednosti 1999–2006 se vrednosti vodostajev izvira Podroteja za leto 2006 uvrščajo med najnižje v obdobju, z doseženim obdobnim minimumom v letu 2006, vrednosti ostalih dveh parametrov, specifične električne prevodnosti in temperature pa so bile v območju srednjih obdobnih vrednosti. Tudi časovni razpored vrednosti vseh treh parametrov v letu 2006 je normalen, s tem da je nizka obdobna konica vodostajev beležena konec meseca oktobra.

Kamniška Bistrica

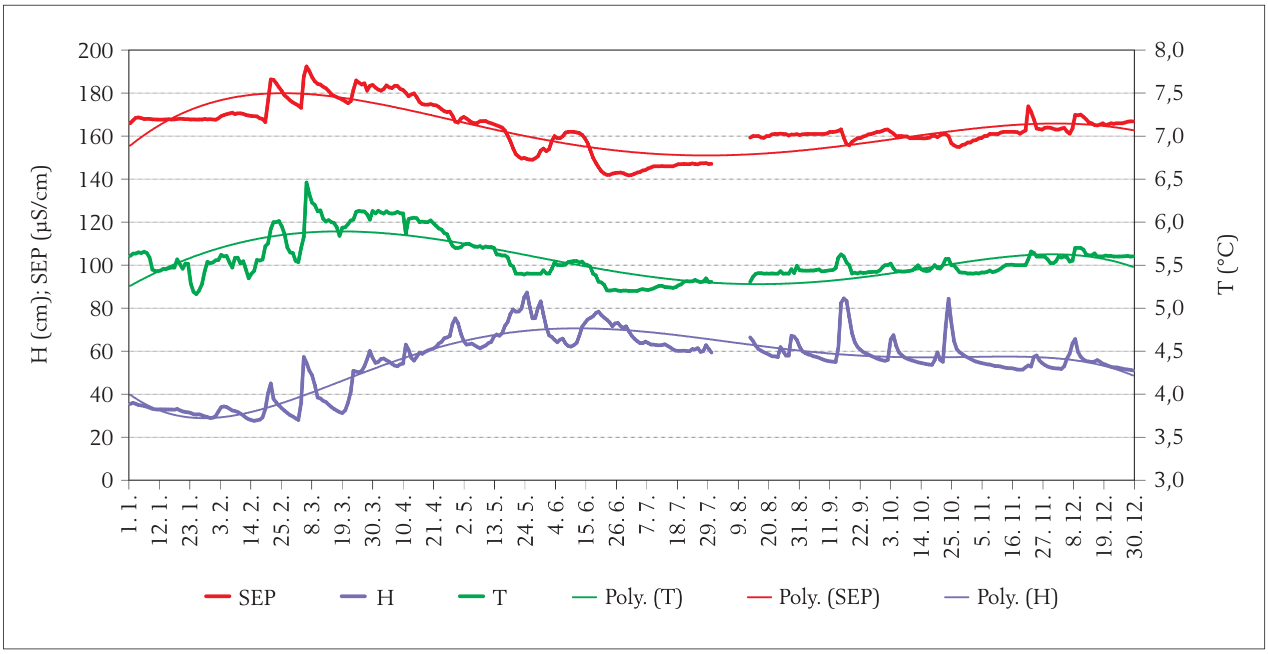
Podatkovni registrator na izviru Kamniške Bistrice beleži podatke o vodostaju, specifični električni prevodnosti in temperaturi. Časovna razporeditev in velikostni razred temperatur in specifične električne prevodnosti, podaja specifičnost v primerjavi z beleženimi parametri na ostalih postajah. Oba omenjena parametra (T, SEP)

until June, when a two-month period of reduced water levels occurred. Conversely to the water levels, the values of temperatures and specific electrical conductivity increased and reached their annual maximums at the end of July. The low water level measured in the Podroteja spring at the end of July does not, however, constitute the annual minimum. This occurred on 18 October, in the autumn drought, and constitutes the lowest measured value in the comparison period.

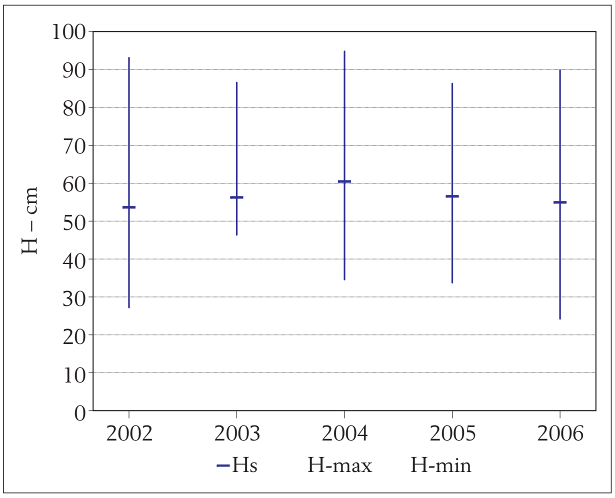
On the basis of the comparison of data sets for 2006 with the periodical values of the period 1999–2006, the values of water levels of the Podroteja spring for 2006 rank among the lowest in the period, with the periodical minimum reached in 2006, while the values of the other two parameters, specific electrical conductivity and temperature, were within the range of the mean periodical values. The timescale of the values for all three parameters in 2006 is normal, too, with the exception of the low periodical extreme of water levels recorded at the end of October.

Kamniška Bistrica

The data-recording device at the Kamniška Bistrica spring records data on water level, specific electrical conductivity



Slika 37: Potek vodostajev, specifične električne prevodnosti in temperature v letu 2006 na izviru Kamniška Bistrica.
Figure 37: *Water levels, specific electrical conductivity and temperature of the Kamniška Bistrica spring in 2006.*



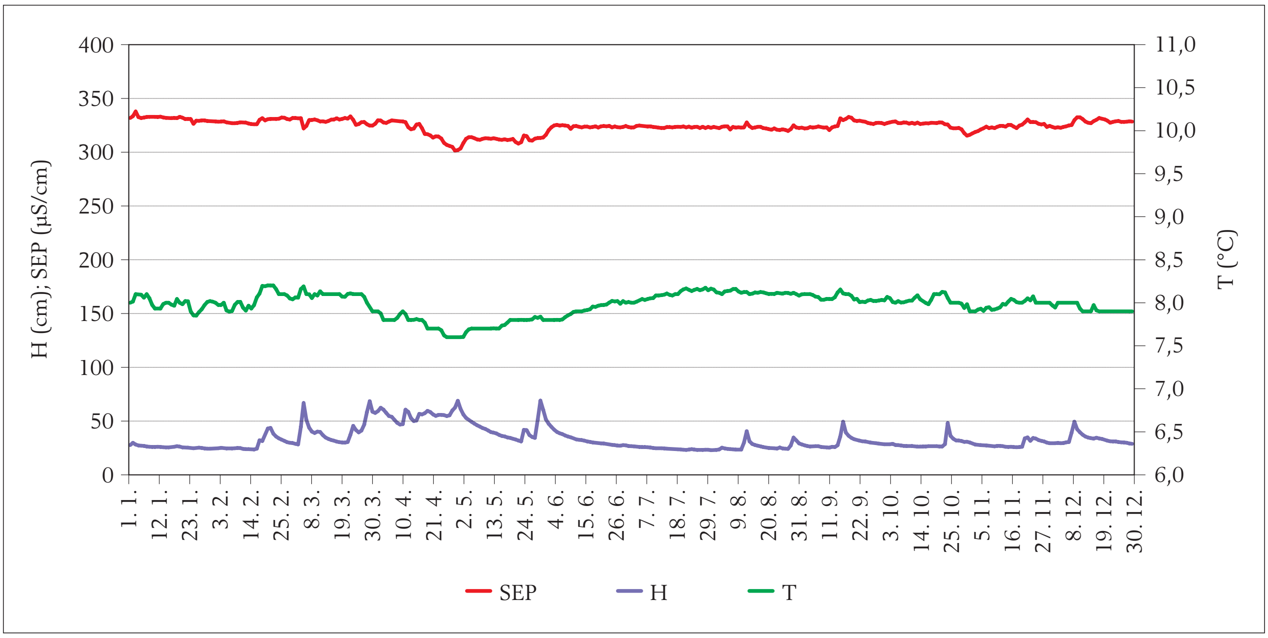
Slika 38: Kamniška Bistrica – značilni obdobni vodostaji H-s, H-maks., H-min.
Figure 38: *The Kamniška Bistrica spring – characteristic periodical water levels H-s, H-max, H-min.*

sta na izviru Kamniška Bistrica najnižja merjena med vsemi postajami monitoringa izvirov. Nižjo temperaturo smo beležili ob izrednih meritvah le na izvirih Krajcarce in Soče, 4,8 °C oziroma 4,5 °C. Kljub ozkemu razponu nihanj, so ta ob točnem beleženju razpoznavna in sezonsko značilna. Tudi v letu 2006 nastopa nizko vodno stanje v zimskem obdobju, ko v alpskem visokogorju ni efektivnih padavin, akumulirana snežna odeja pa kasneje napaja iztok iz vodonosnika še v poznem poletju, kar se odraža tudi z nizkimi temperaturami in nizko specifično električno prevodnostjo v poletnih mesecih. V februarju 2006 je beležen obdobni minimum vodostajev (24,6 cm).

and temperature. The temporal distribution and the magnitude category of temperatures and specific electrical conductivity reveal specificity in comparison with recording parameters at other stations. At the Kamniška Bistrica spring, both mentioned parameters (T, SEC) are the lowest measured by any spring monitoring station. Lower temperatures were recorded only on extraordinary measuring at the Krajcarca and Soča springs: 4.8 °C and 4.5 °C respectively. Regardless of the narrow range of fluctuations, these are recognisable and seasonally typical upon accurate recording. In 2006, too, low water levels occur in the winter period when there is no effective precipitation in the high mountain range, while the accumulated snow layer later feeds the flow from the aquifer until the late summer, which reflects in low temperatures and low specific electrical conductivity in the summer months. The periodical minimum of water levels was recorded in February 2006 (24.6 cm).

Letošč Spring

The station was established in November 2005. The measuring profile is located about 100 m below where the spring is captured for water supply. Average daily quantities of abstracted water are about 1300 m^3. The Letošč spring is situated at the foothill of Menina planina and is only one of the springs draining the extensive karstic aquifer. The flow regime of the spring does not reveal similar characteristics to those recorded at the springs in the areas of the Dinaric or Alpine karst. The flows are fed by the snow-water in the spring period, which also causes the lowered values of temperature and specific electrical conductivity, while the timescale



Slika 39: Časovni potek urnih vrednosti vodostajev, specifične električne prevodnosti in temperatur v letu 2006 za izvir Letošč.
Figure 39: *Time sequence of hourly values of water levels, specific electrical conductivity and temperature of the Letošč spring in 2006.*

Izvir Letošč

Postajo smo vzpostavili v novembru 2005. Merski profil se nahaja pribl. 100 m pod izvirom, ki je zajet za vodooskrbo. Dnevne količine odvzemov so povprečno okoli 1300 m^3. Izvir Letošč se nahaja na obrobju Menine planine in je le eden v nizu izvirov, ki drenirajo obsežen kraški vodonosnik. Režim iztokov izvira ne podaja podobnih značilnosti, kakor so beležene na izvirih na območjih Dinarskega ali Alpskega krasa. Iztoki se bogatijo z snežnico v spomladanskem obdobju, kar povzroči tudi znižanje vrednosti temperatur in specifične električne prevodnosti, časovni razpored vrednosti beleženih parametrov pa v preostalem obdobju leta ne niha v večjem razponu. Tekom leta 2006 sta bili izvedeni le dve meritvi pretoka, obe ob nižjem vodostaju, zato pretočna krivulja ni točna na celem območju nihanja vodostajev in so vrednosti pretokov, ki jih podajamo, samo informativne. Najnižji pretok znaša okoli 0,05 m^3/s, srednji 0,2 m^3/s in največji v letu 2006 0,7 m^3/s

Težka voda

V letu 2006 beleženi podatkovni nizi podajajo nastop obdobnega maksimuma pretokov 30. maja z vodostajem 175 cm. Ob tako visokem stanju tok reke preplavlja

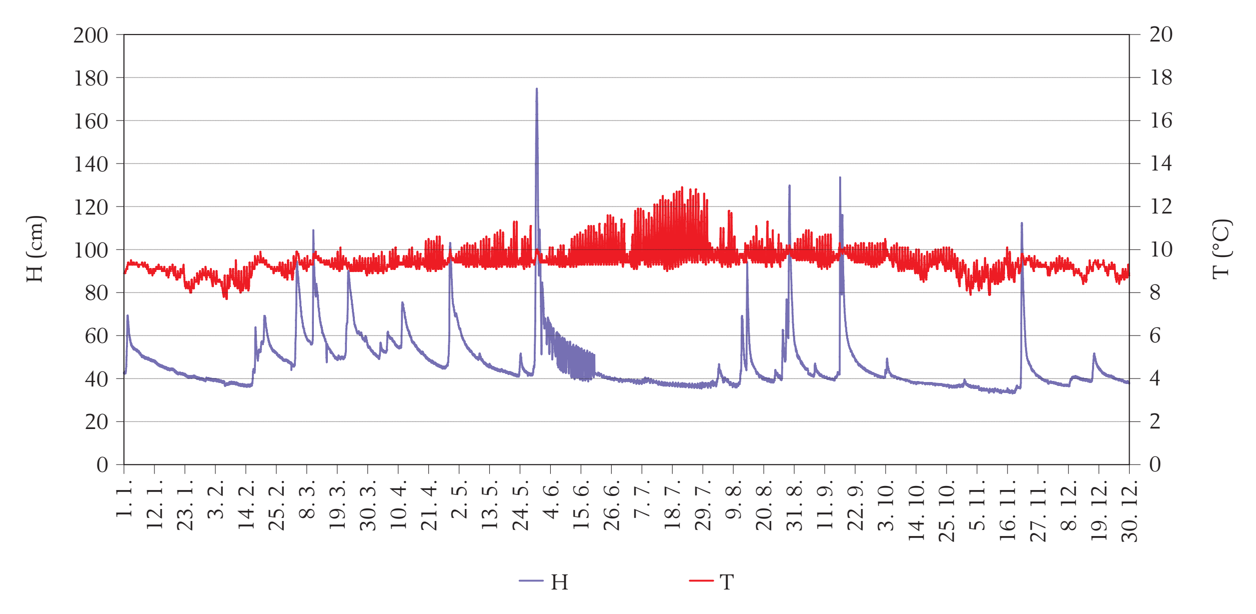
of the value of recorded parameters does not fluctuate considerably in the remaining period of the year. Only two discharge measurements were implemented during 2006, both upon a lower water level, so the rating curve is not accurate in the entire area of water level fluctuation, and the discharge values provided are just for information. The lowest discharge rate recorded in 2006 was about 0.05 m^3/s, the mean 0.2 m^3/s, and the highest 0.7 m^3/s.

Težka voda

The data series recorded in 2006 reveals the onset of the periodical discharge maximum on 30 May with a water level of 175 cm. With the water level this high, the river stream floods the left bank, which makes an accurate discharge estimate unreliable. Accurate information on discharge at a water level this high may be acquired only by discharge measuring, which is difficult to implement due to the rapid reduction of water levels. The mean annual discharge values for 2006 are within the range of the average period, while the low discharge value confirms that the low discharge value recorded in 2005 is a consequence of an artificial impact.

Preglednica 14: Značilni mesečni in letni pretoki v obdobjih opazovanj za izvir Težka voda.
Table 14: *Characteristic monthly and annual discharge rates in observation periods for the Težka voda spring.*

Q (m^3/s)	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Qs letni	Qmax	Qmin
Qs 1955–1985	0,617	0,608	0,795	0,894	0,654	0,552	0,399	0,344	0,406	0,545	0,753	0,794	0,613	10,7	0
Qs 2005	0,280	0,241	0,782	1,008	0,569	0,240	0,508	0,798	0,505	0,736	0,995	1,300	0,575	10,4	0,004
Qs 2006	0,43	0,42	1,06	0,80	0,85	0,59	0,21	0,55	0,59	0,24	0,32	0,26	0,526	12,4	0,12



Slika 40: Časovni potek urnih vrednosti vodostajev in temperatur v letu 2006 za izvir Težka voda.
Figure 40: *Time sequence of hourly values of water levels and temperature of the Težka voda spring in 2006.*

levi breg in je točna ocena pretoka nezanesljiva. Točen podatek o pretoku pri tako visokem stanju lahko pridobimo le z meritvijo pretoka, kar pa je zaradi hitrega upadanja vodostajev težko izvedljivo. Srednje letne vrednosti pretoka za leto 2006 so v območju povprečja obdobja, vrednost nizkega pretoka pa potrjuje, da je v letu 2005 beležena vrednost nizkega pretoka posledica umetnega vpliva.

Podatke o temperaturi vode v merskem profilu podajamo le grafično, saj vrednosti zaradi oddaljenosti merilnega mesta od izvira niso relevantne vrednostim temperatur na samem izviru Težke vode.

Merski profil je opremljen s podatkovnim registratorjem, ki beleži urne vrednosti vodostajev in temperatur. Kontrole delovanja in prenosi podatkov se izvajajo mesečno. Ker je merski profil približno 500 m oddaljen od izvirnega območja, je temperatura vode v profilu izpostavljena dnevnim nihanjem. Temperature na samem izviru se gibljejo v razponu med 8 °C in 9 °C. V mesecu juniju so opazna tudi nihanja vodostajev, ki so posledica umetnega vpliva, ki pa v nizu srednje dnevnih vrednosti niso opazna.

Krupa

Podatkovni niz Krupe v letu 2006 podaja nekaj višjo srednje letno vrednost pretokov kakor v letu 2005, maksimum 31. 5. 2006 pa je nižji kot je obdobni. Visoki valovi tekom leta sicer niso presegali 20 m^3/s, le najvišji je konec maja dosegel vodostaj 275 cm in s tem pretok blizu 50 m^3/s. Tekom leta so nastopila tri obdobja brez padavin in z daljšim upadanjem vodostajev. Prvo obdobje je nastopilo v zimskem času po januarskem vodnem valu in je trajalo do sredine februarja, drugo obdobje

Data on the water temperature in the measurement profile is provided only graphically, since these values, due to the distance of the gauging station from the spring, are not relevant for the temperature values of the Težka voda spring itself.

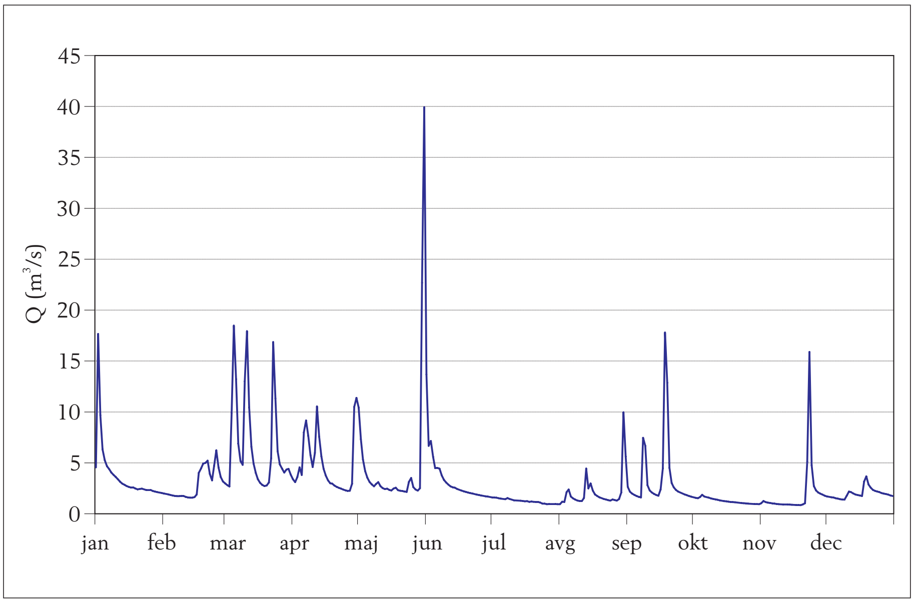
The measuring profile is equipped with a data-recording device noting hourly values of water levels and temperatures. Operation controls and data transmissions are carried out monthly. Since the measuring profile is located about 500 m from the spring area, the water temperature in the profile is subject to daily fluctuations. The temperatures at the spring itself were in the range of 8–9 °C. In June, water level fluctuations were recorded as the result of an artificial impact; they are not, however, evident in the series of mean daily values.

Krupa

The Krupa data series in 2006 reveals a slightly higher mean annual discharge value than in 2005, with the maximum recorded on 31 May 2006 being lower than the periodical maximum. During the year, high waves did not exceed 20 m^3/s; only the highest, in late May, reached a water level of 275 cm and thus put the discharge near 50 m^3/s. The year saw three periods without precipitation, with long reductions in water levels. The first such period began in the winter period after the January water wave and lasted until mid-February, while the second period with a long reduction of water levels occurred in the period from the annual maximum at the end of May to the beginning of August. Nevertheless, the minimum of 2005 was not achieved. The third period of low water levels came in the autumn period, from the end of October to the beginning of

Preglednica 15: Značilni mesečni in letni pretoki (m³/s) v obdobjih opazovanj izvira Krupa.
Table 15: *Characteristic monthly and annual discharge rates (m³/s) in observation periods for the Krupa spring.*

Qs	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Qs	Qmin	Qmax
1956–1979	4,32	4,97	5,40	5,99	4,53	3,29	2,77	2,09	3,00	3,55	5,70	5,40	4,17	0,01	63,4
2005	1,56	1,21	3,82	4,4	2,97	0,96	1,55	3,59	2,41	4	4,63	4,96	2,47	0,55	61,6
2006	3,76	2,9	6,69	4,84	5,02	3,31	1,25	2,11	3,46	1,28	1,96	1,99	3,21	0,81	47,9



Slika 41: Časovni potek vrednosti urnih pretokov v letu 2006 za izvir Krupa.
Figure 41: *Time sequence of values of hourly discharge rates of the Krupa spring in 2006.*

z daljšim upadanjem vodostajev pa je v razdobju od letnega maksimuma konec maja do začetka avgusta. Kljub temu ni bil dosežen minimum iz leta 2005. Tretje obdobje nizkih vodostajev pa je v jesenskem času od konca oktobra do začetka decembra. Posledica teh daljših sušnih obdobij so tudi nizki srednje mesečni pretoki v juliju, 1,25 m³/s in v oktobru, 1,28 m³/s.

Veliki Obrh

Izvir Veliki Obrh izdanja na Loškem polju na nadmorski višini pribl. 485 m nadm. v., ponikalnica Trbuhovica pri Prezidu, ki napaja izvir, pa na 770 m nadm. v. Višinska razlika okoli 200 m ne predstavlja velik akumulacijski bazen podzemne vode v hidrogeološkem pogledu. Zato se tudi režim nihanj vodostajev izvira odraža s kratkimi in ostrimi visokovodnimi valovi. Recesijski del vala hitro upade v območje nizkih pretokov in nato le še počasi upada. Mesečni minimumi v letu 2006 se gibljejo v ozkem razponu med 0,2 in 0,74 m³/s in le marca in aprila presežejo 0,4 m³/s, srednje mesečni Qavg pa le marca preseže 2 m³/s. Po skoraj triletnem nizu, lahko ocenimo, da je minimalni beleženi pretok v oktobru 2004 z 0,05 m³/s, res posledica manipulacij na jezu v območju izvira. Srednje vrednosti in visoka konica pretoka se gibljejo v okviru vrednosti v letih 2004

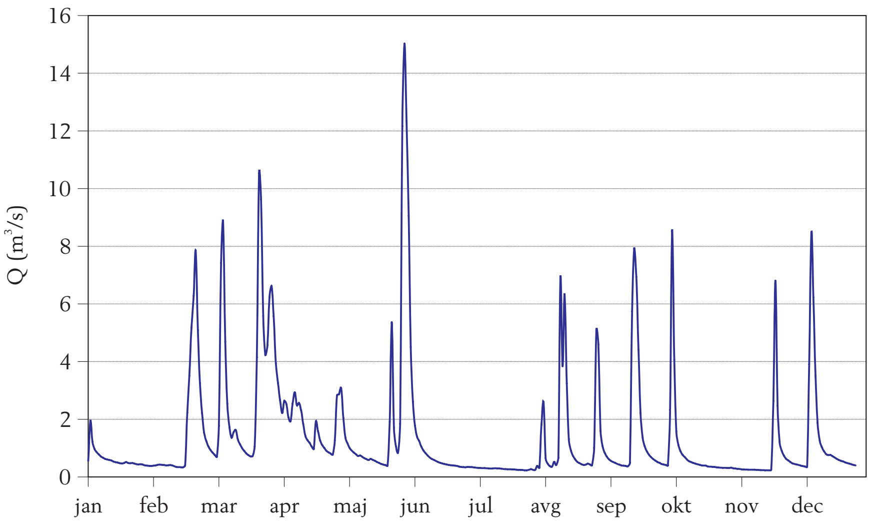
December. The results of these prolonged drought periods were the low mean monthly discharges in July – 1.25 m³/s, and in October – 1.28 m³/s

Veliki Obrh

The Veliki Obrh spring is located on the Loka field about 485 m above sea level, while the sinking stream Trbuhovica feeding the spring is located near the village of Prezid, 770 m above sea level. The difference in altitude of about 200 m does not constitute a major accumulation pool of groundwater in the hydro-geological aspect. Thus, the regime of water level fluctuation is reflected in short and sharp high-water waves. The recessive part of the wave rapidly declines to the range of low discharge and continues to decline slowly. Monthly minimums in 2006 moved in a narrow range between 0.2 and 0.74 m³/s, exceeding 0.4 m³/s only in March, while the mean monthly Qavg exceeded 2 m³/s only in March. After a series of almost three years, it may be concluded that the minimum discharge of 0.05 m³/s recorded in October 2004 is indeed the result of manipulations at the dam near the spring. Mean values and the high extreme of discharge are within the range of values of 2004 and 2005. In summer months, the determination of discharge is hindered by the overgrown measuring profile.

Preglednica 16: Veliki Obrh značilni mesečni in letni pretoki v letih 2004, 2005, 2006 (m^3/s).
Table 16: *Veliki Obrh – characteristic monthly and annual discharge rates in 2004, 2005, 2006 (m^3/s).*

	Q (m^3/s)	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letni
	Qs				1,72	1,77	1,08	0,97	0,31	0,21	2,96	3,06	2,82	1,65
2004	Qmax				3,11	6,91	5,57	6,06	1,36	0,44	16,83	17,01	17,40	17,40
	Qmin				0,90	0,46	0,25	0,27	0,05	0,16	0,05	0,21	0,11	0,05
	Qs	1,12	0,28	2,05	2,99	1,18	0,49	1,12	1,09	2,21	2,08	1,50	2,39	1,55
2005	Qmax	4,54	0,64	6,66	10,47	5,61	2,66	7,84	6,26	9,45	9,07	13,30	11,19	13,30
	Qmin	0,11	0,11	0,19	0,70	0,51	0,22	0,30	0,34	0,41	0,42	0,25	0,36	0,11
	Qs	0,61	1,66	3,33	1,83	1,92	1,50	0,28	1,52	1,46	0,94	0,73	1,26	1,42
2006	Qmax	2,30	8,50	11,52	3,66	16,17	13,53	0,43	7,78	8,58	9,88	8,02	8,84	16,17
	Qmin	0,36	0,20	0,68	0,74	0,38	0,22	0,21	0,22	0,27	0,23	0,21	0,26	0,20



Slika 42: Potek vrednosti urnih pretokov v letu 2006 za izvir Veliki Obrh.
Figure 42: *Sequence of values of hourly discharge rates of the Veliki Obrh spring in 2006.*

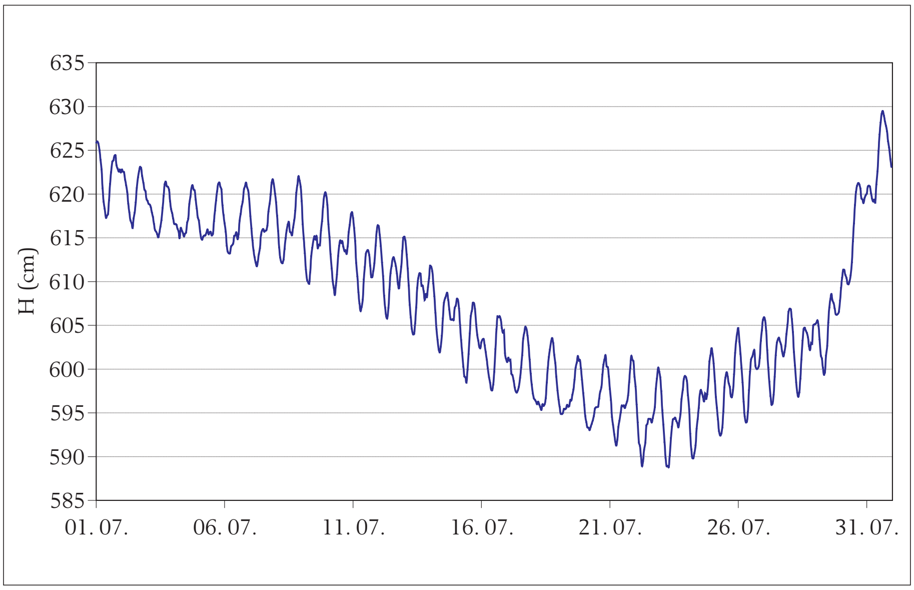
in 2005. V poletnih mesecih pa določitev pretoka ovira močna zaraščenost merskega profila.

Brestovica B-2

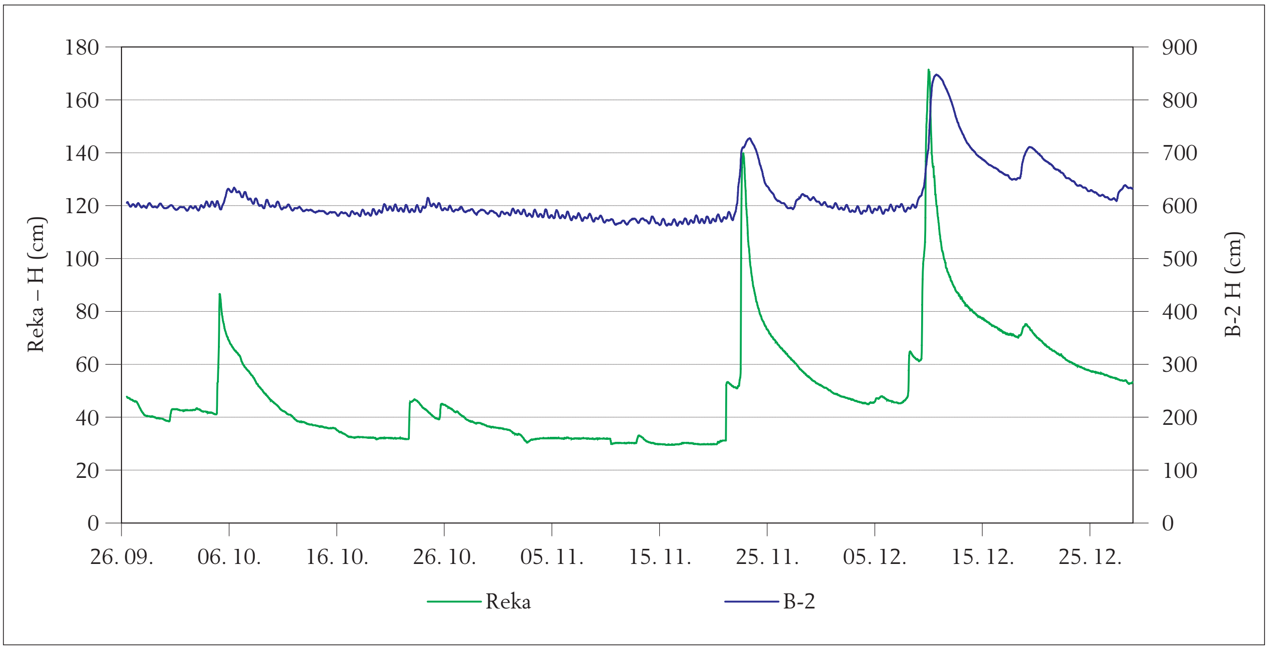
V decembru 2005 smo v vrtino B-2 v Globoki dolini v bližini črpališča Klariči na Krasu vstavili podatkovni registrator za beleženje nihanj gladine kraške podzemne vode. Vrtina je bila izdelana v sklopu kompleksnih hidrogeoloških raziskav Tržaško-Komenskega kraškega vodonosnika v 70. letih prejšnjega stoletja. Osrednji del planote gradi antiklinorij krednih apnencev in dolomitov, fliš na južnem obrobju, na katerega je narinjena Komenska narivna gruda, pa deluje kot hidrogeološka bariera kraškega vodonosnika. Na stiku s flišem se iztekajo med Devinom in Tržičem v morje vode izvirov Timave in izvir Brojnice pri Nabrežini. Raziskave so podale osnovne hidrodinamične lastnosti vodonosnika, in so jasno nakazale možnost izdelave vodnjakov za vodooskrbo širšega območja občine Sežana. Predvsem

Brestovica B-2

In December 2005, a data recording device monitoring the fluctuations of the Karst groundwater levels was inserted in well B-2 in the Globoka dolina valley near the Klariči pumping station in the Karst. The well was made as part of the complex hydro-geological explorations of the Trieste-Komen Karst aquifer in the 1970's. The central part of the plateau consists of the anticlinorium of cretaceous limestone and dolomite, while flysch on the southern foothills overlapping with the Komen thrust sheet functions as a hydro-geological barrier of the Karst aquifer. At the point of contact with flysch between Duino and Monfalcone, the waters from the springs of Timava and Brojnica near Nabrežina flow into the sea. The research provided the basic hydrodynamic characteristics of the aquifer and clearly indicated the possibilities for constructing wells for the water supply of the broader area of the Sežana municipality. The results of the pumping experiments provided a range of interesting data for better understanding



Slika 43: Vpliv plimovanja na vodostaje v vrtini B-2.
Figure 43: *Effect of tide on water levels in the B-2 well.*



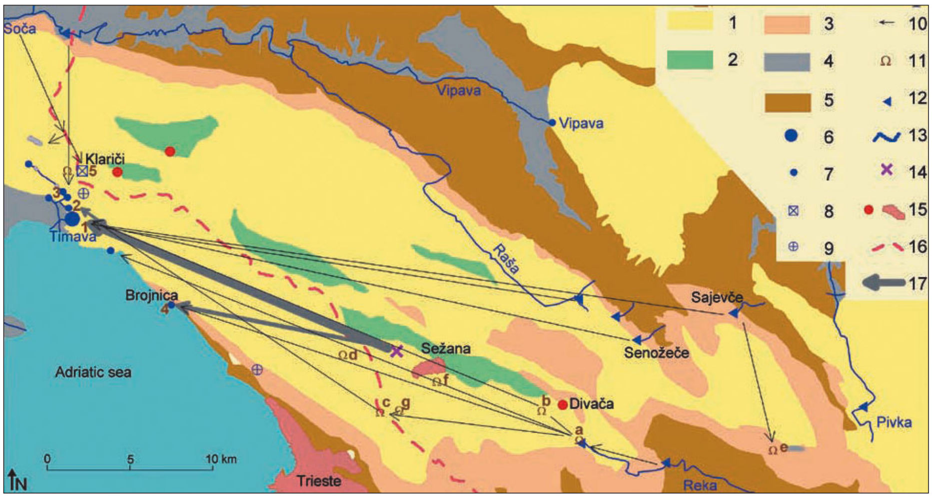
Slika 44: Urna nihanja gladin v vrtini B-2 in vodostajev na VP Reka – Matavun.
Figure 44: *Hourly fluctuations of water levels in the B-2 well and levels at the Reka-Matavun gauging station.*

rezultati črpalnih poskusov so dali vrsto zanimivih podatkov za boljše razumevanje zgradbe in delovanja kraškega vodonosnika in o možnosti zajetja večjih količin podzemne vode. Zaključki raziskav zagotavljajo odvzemanje 0,5 m^3/s vode iz vodonosnika, z oceno, da je možen odvzem celo 1,0 m^3/s kraške podtalnice.

V opazovani vrtini so, tako kakor tudi v drugih opazovalnih piezometrih v okolici Brestovice, opažena periodična nihanja gladine podtalnice, ki so posledica razširjanja valov plimovanja v notranjost kraškega vodonosnika. Nihanja so izrazita le ob nizkih vodostajih gladin v vrtini.

of the composition and functioning of the Karst aquifer, as well as of the possibility of capturing major quantities of groundwater. The results from the research guarantee the abstraction of 0.5 m^3/s of water from the aquifer, with an estimate that as much as 1.0 m^3/s of the Karst groundwater can be abstracted.

The observed well, as with other observation piezometers in the surroundings of Brestovica, records periodical fluctuations of the groundwater level, which are the result of tidal waves spreading inside the Karst aquifer. These fluctuations are marked only upon low water levels of the levels in the well.



Slika 45: Hidrogeološka karta Krasa z rezultati sledilnih poskusov.
(Legenda: 1. dobro prepusten kredni apnenec, 2. nekoliko slabše prepusten kredni dolomit, 3. dobro prepustni terciarni apnenci in dolomiti, 4. medzrnski vodonosnik, 5. zelo slabo prepusten eocenski fliš, 6. izvir Timave, 7. izvir, 8. črpališče, 9. piezometer, 10. s starejšim sledilnim poskusom dokazana podzemna vodna zveza, 11. kraška jama (a. Škocjanske jame, b. Kačna jama, c. Labodnica, d. Lazzaro, e. Gabranca, f. 1 v Kanjaducah, g. Brezno v Stršinkni dolini), 12. ponikalnica, 13. površinski tok, 14. odlagališče Sežana, 15. naselje, 16. državna meja, 17. pri sledenju 2005 dokazana podzemna vodna zveza). 1. izvir Timave, 2. izvir Sardoč, 3. izvir N, 4. izvir Brojnica, 5. črpališče Klariči. (Kogovšek, Petrič: Acta Carsologica 36/3, 413–424, Postojna 2007).

Figure 45: *Hydrogeological map of the Karst with the results of tracer tests.*
(Legend: 1. Well-permeable Cretaceous limestone, 2. Slightly less-permeable Cretaceous dolomite, 3. Well-permeable Tertiary limestone and dolomite, 4. Porous aquifer, 5. Very low-permeable Eocene flysch, 6. Timava spring, 7. Spring, 8. Pumping station, 9. Piezometer, 10. Underground water connection, proved by previous tracer tests, 11. Karst cave (a. Škocjanske jame, b. Kačna jama, c. Labodnica, d. Lazzaro jerko, e. Gabranca, f. jama 1 v Kanjaducah, g. Brezno v Stršinkni dolini), 12. Sinking stream, 13. Surface flow, 14. Landfill, 15. Settlement, 16. State border, 17. Underground water connection, proved by tracer test in 2005). 1 Timava spring, 2. Sardoč spring, 3. Brojnica spring, 5. Klariči pumping station (Kogovšek, Petrič: ACTA CARSOLOGICA 36/3, 413–424, Postojna 2007).

Postaja je vzpostavljena in deluje kot testno merilno mesto, ker je treba za točne podatke o absolutnih višinah gladin izvesti še geodetske meritve kote »0« točke. Približna nadmorska višina ustja vrtine je okoli 25 m, podatkovni registrator pa je vstavljen 30 m pod ustjem.

Vodonosnik se napaja s padavinami, ki pronicajo skozi nezasičeno cono karbonatnih skladov, ter s pretoki ponikalnic Reka, Sajevški in Senožeški potok, z vodami Raše, Vipave in Soče.

The station has been established and operates as the gauging site where survey and mapping measurements of the gauge zero must be made in order to obtain exact data on absolute water levels. The approximate elevation of the well mouth is 25 m, with the data recording device being placed 30 m below the mouth.

The aquifer feeds from precipitation seeping through the non-saturated zone of carbonate rocks, and from the flows of the disappearing Reka, Sajevški and Senožeče streams, and the waters of the Raša, Vipava and Soča rivers.

D. MORJE

Plimovanje morja

Mojca Robič

Plimovanje je izraz za pojav periodičnega spreminjanja gladine v morjih in oceanih. Na menjavanje morskih men; plime in oseke, vpliva predvsem gravitacijska sila Lune in Sonca, kar imenujemo astronomska plima. To je zaradi znanega cikličnega gibanja nebesnih teles mogoče napovedati vnaprej. Ko sta Sonce in Luna v konjunkciji oz. opoziciji, to je v času ščipa ali polne lune, se vplivi plimotvornih sil seštevajo in amplitude plimovanja so velike. Plimovanje je časovno enakomerno in v dnevu se pojavljata po dve plimi in dve oseki. Ob prvem in zadnjem krajcu, ko sta Sonce in Luna v kvadraturi, so amplitude manjše, plimovanje pa ima manj izrazito obliko. Število plim in osek v dnevu ni enakomerno porazdeljeno.

Izmerjena plima pa se od astronomske lahko bistveno razlikuje. Stalni dejavniki, ki vplivajo na višino lokalne plime so: konfiguracija obale, globina in topografija morskega dna. Ker običajno merimo gladino morja na enem mestu, so za odstopanje izmerjene plime od astronomske pomembni dejavniki, ki se s časom spreminjajo. To pa sta vreme in pojav lastnega nihanja. Od meteoroloških dejavnikov sta najvplivnejša 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. Obratno burja znižuje gladino, saj piha s kopnega proti odprtemu morju. Na zvišanje gladine morja v Kopru lahko vpliva tudi močnejši južni veter v Dalmaciji. Lastno nihanje morja se pojavi v zaprtih in delno zaprtih morjih. V Jadranu ima ob južnem vetru periodo 21 do 22 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 preglednici D.3.), iz teh srednjo mesečno (SMV v preglednici D.3.) in iz teh srednjo letno vrednost (SLV v preglednici D.3.).

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

Podobno velja za nizke vode, kjer določamo nižjega od obeh ekstremov (NNV) ter iz njih računamo povprečje (SNNV v preglednici D.2.). Srednja nizka voda (SNV v preglednici D.2.) je povprečje vseh nizkih voda

D. SEA

Sea tides

Mojca Robič

Tide is the expression used to describe periodical fluctuations of the sea and ocean levels. The alteration of sea tides, high and low tides, is influenced especially by the gravitational force of the Moon and the Sun, the astronomical tide. Due to the known cyclical movement of celestial bodies, this may be forecast. When the Sun and the Moon are in conjunction or opposition i. e. at the time of full moon, the effects of tidal forces are aggregated, which results in large tide amplitudes. Tide is evenly distributed in time, with two high and two low tides occurring daily. Upon the first and the third quarter moons, when the Sun and the Moon are at aright angle, amplitudes are smaller and the tide is less marked. The number of high and low tides in the day is not evenly distributed.

The measured tide may vary considerably from the astronomical tide. Constant factors influencing the local tide level are the following: shore configuration, depth and sea bottom topography. Since the sea level is usually measured in a single spot, the recorded deviations of the measured and astronomical tides are subject to factors varying in time. These are the weather and the occurrence of internal fluctuations. The most influential meteorological factors are wind and air pressure. A decrease in air pressure increases the sea level. The southern or south-eastern wind drives water masses towards the shore of the Northern Adriatic, thus contributing to a raised sea level. The Bora has an adverse effect, for it blows from the shore to the open sea. The raised sea level in Koper may be also the result of a strong southern wind in Dalmatia. Internal sea fluctuations occur in enclosed and partly enclosed seas. In the Adriatic, the oscillation period is 21 to 22 hours with the southern wind but just a few hours with the south-western wind.

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

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

v dnevu, mesecu ali letu. Najnižja gladina morja v mesecu ali letu je označena z NNNV in jo najdemo v preglednicah D.2. in D.4.

Preglednice s podatki so objavljene v drugem delu Letopisa.

Višine morja v primerjavi z dolgoletnim povprečjem

Morje je bilo v letu 2006 zelo visoko. Srednja letna višina morja je bila 222,7 cm, kar je ena najvišjih vrednosti vsega opazovalnega obdobja (slika 46).

Najvišja srednja mesečna višina morja je bila oktobrska, 232,5 cm in s svojo višino ni izstopala. Najnižja srednja mesečna vrednost je bila decembrska, 210,2 cm, in je bila v primerjavi z dolgoletnim obdobjem nadpovprečno visoka. Značilna je majhna amplituda – razlika med najvišjo in najnižjo mesečno višino morja je bila le 22,3 cm.

Najvišja je bila srednja mesečna višina v oktobru. Močno nadpovprečne so bile tudi srednje mesečne višine v marcu in avgustu. Najnižja mesečna vrednost je bila zabeležena v januarju in je bila v primerjavi z ostalimi januarskimi mesečnimi vrednostmi primerjalnega obdobja povprečno visoka. Kako visoka je bila gladina morja v letu 2006, nam ilustrira podatek, da sta bili le januarska in decembrska srednja mesečna višina morja nižji od srednje obdobne višine morja (216 cm). V primerjavi z mesečnimi obdobnimi vrednostmi je bila januarska srednja mesečna višina povprečna, vse ostale pa nadpovprečne (slika 47).

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

Tables with data are published in the second section of the Yearbook.

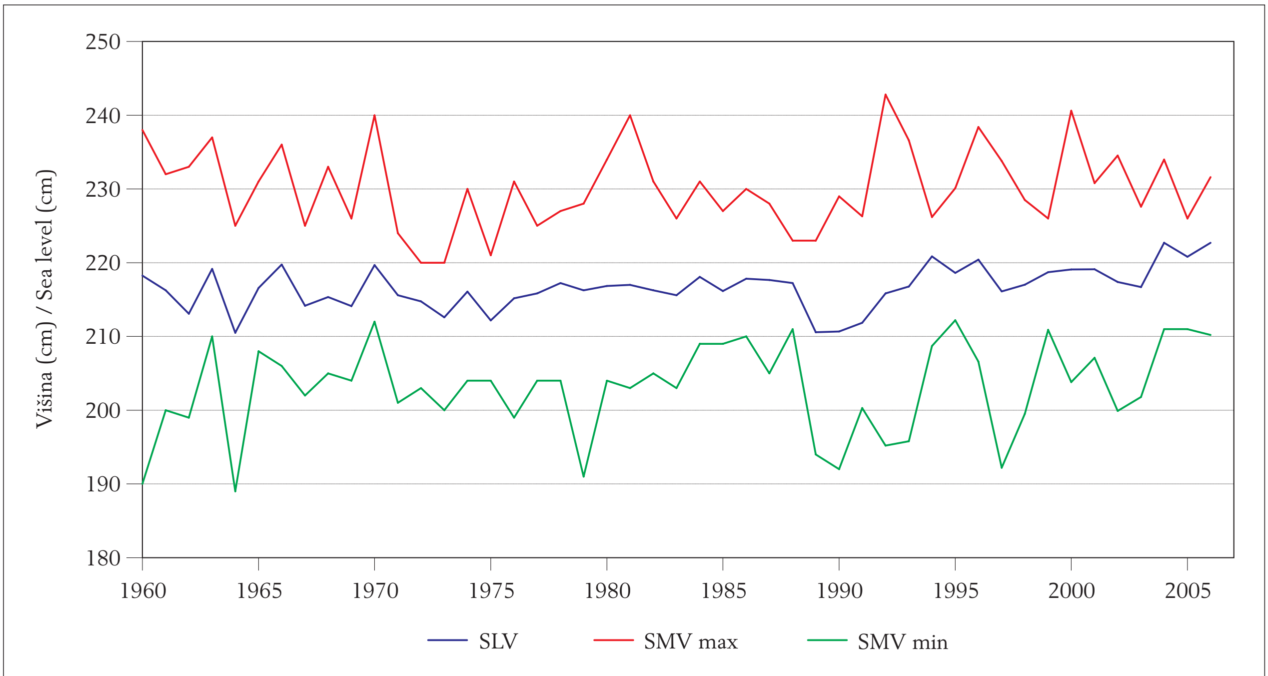
Sea Levels in Comparison with Long-term Average

The mean sea level in 2006 was one of the highest in the observation period.

In 2006, sea levels were very high. The mean annual sea level was 222.7 cm, which is one of the highest values in the entire observation period (Figure 46).

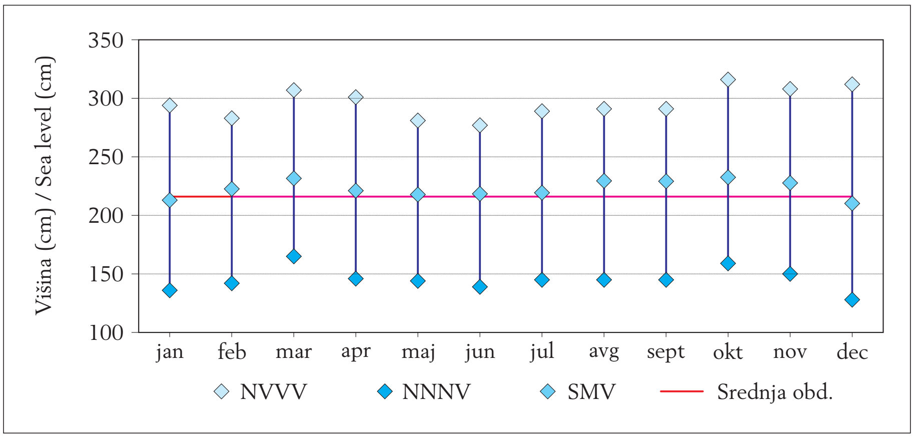
The highest mean monthly sea level, 232.5 cm, was recorded in October and did not deviate from the average. The lowest mean monthly value, 210.2 cm, was recorded in December; it was above average compared with the long-term period. A small amplitude is typical – the difference between the highest and the lowest monthly sea level being only 22.3 cm.

The mean monthly level was highest in October. Mean monthly levels in March and August were also high above the average. The lowest mean monthly value was recorded in January; it was average in comparison with other January monthly values of the reference period. The high sea level in 2006 is illustrated by the fact that



Slika 46: Srednje letne višine morja (SLV) ter najvišja in najnižja srednja mesečna višina vode (SMV) v dolgoletnem obdobju. Srednja letna višina morja leta 2006 je bila ena najvišjih v opazovalnem obdobju.

Figure 46: *Mean annual sea level (SLV), the highest and lowest mean monthly sea levels (SMV) in long term period.*



Slika 47: Srednje mesečne višine morja (SMV) z najnižjimi (NNNV) in najvišjimi (NVVV) mesečnimi višinami za leto 2006.
Figure 47: *Mean monthly sea levels (SMV), with the lowest (NNNV) and highest (NVVV) monthly levels for 2006.*

Najvišja gladina morja v letu 2006 je dosegla višino 316 cm, kar je niže od obdobnega povprečja. Dosežena je bila 24. oktobra ob prvi plimi. Najnižja letna višina morja je bila s 128 cm glede na obdobje precej nadpovprečna. Dosežena je bila 21. decembra ob popoldanski oseki.

Kronološki pregled po mesecih

Morje je bilo v prvih dneh leta precej visoko in je doseglo opozorilno vrednost. Najvišja gladina morja v mesecu januarju je bila dosežena **1. januarja**. 294 cm je nekoliko nadpovprečna vrednost v primerjavi z obdobnimi januarskimi visokimi vrednostmi, ni pa izjemna. Tudi najnižja gladina morja v mesecu ni bila ekstremna, vendar je vseeno povzročila nekaj neprijetnosti. To je bila druga najnižja gladina morja v letu 2006.

only the January and December mean monthly values were lower than the mean periodical sea level (216 cm). In comparison with monthly periodic values, only January recorded a mean sea level, whereas the sea levels for the other months were above the average (Figure 47).

The highest sea level in 2006 reached 316 cm, which is lower than the periodical average. It was recorded on 24 October, on the first tide. The lowest annual sea level – 128 cm – was quite high above the average for the period. It was recorded on 21 December, on the afternoon low tide.

Chronological Overview by Months

The sea was rather high in the first day of the year, reaching the limit value. The highest sea level in January was recorded on **1 January.** Although 294 cm is a value

Nizka oseka 31. januarja 2006 je povzročila, da so nekateri čolni ostali na suhem (foto: Igor Strojan).
Low tide on 31 January with the beaching of boats on dry land (photo: Igor Strojan).

Srednja januarska gladina morja je bila druga najnižja v letu, v primerjavi z dolgoletnim obdobjem pa je bila povprečna.

Februarja je bilo morje nekoliko nadpovprečno visoko. V primerjavi z obdobnimi vrednostmi je najbolj odstopala najnižja oseka v mesecu, ki je bila precej nadpovprečna. Najvišja plima je dosegla 283 cm, kar je precej pod obdobnim povprečjem.

Marca je prevladovalo ciklonalno vreme z nizkim zračnim pritiskom z obdobji močnega južnega vetra. Morje je bilo zato zelo visoko. Vse značilne vrednosti so bile bistveno višje od povprečja. Gladina morja je bila ves mesec višja od pričakovane, največje je bilo odstopanje v prvi polovici meseca (slika 3). V začetku meseca so bile zaradi meteoroloških pogojev (močan južni veter in zelo nizek zračni pritisk) dosežene največje residualne višine, preko 50 cm, vendar niso sovpadale z visoko astronomsko plimo in do ekstremnih gladin morja ni prišlo. Najvišja gladina morja je nastopila ob koncu meseca, 28. marca zvečer in je dosegla 307 cm. Prvič v letu 2006 je morje prestopilo obalno črto in za krajši čas poplavilo nižje ležeče dele obale. Srednja mesečna vrednost je bila izjemno visoka. Z 232 cm je bila druga najvišja v letu in višja od najvišje srednje marčevske vrednosti v obdobju 1961–2000. V letu 2006 je bila od nje višja le srednja mesečna vrednost oktobra. Močno navzgor je odstopala tudi najnižja oseka, ki je bila s 164 cm najvišja v letu. Najvišjo obdobno vrednost je presegla kar za 13 cm.

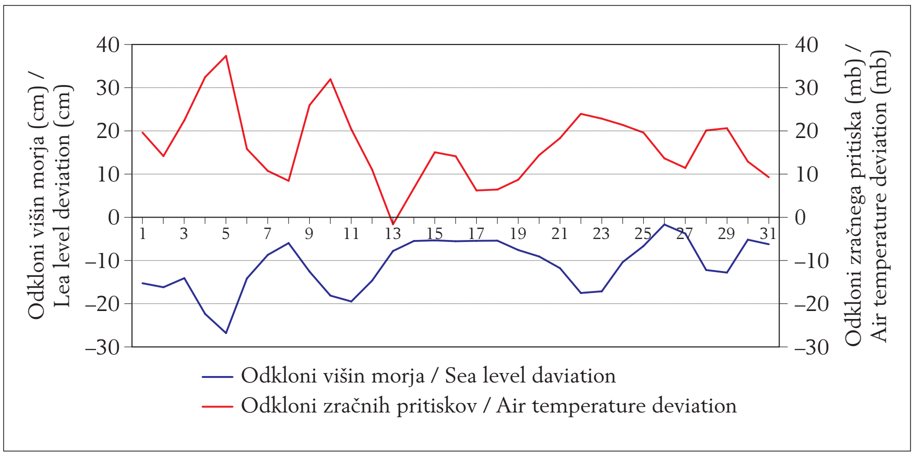
Aprila je bilo vremensko dogajanje še vedno pestro, naklonjeno povišanju gladine morja, vendar manj intenzivno kakor mesec pred tem. Pritisk je bil ves mesec nižji od povprečnega, vendar je bilo odstopanje manjše (v povprečju 10 do 15 mb). Tako so bila kratkotrajna močnejša povišanja gladine morja predvsem vpliv vetrovnih razmer. Prvo tako povišanje je bilo med 5. in 7. aprilom, vendar ni sovpadalo z visoko astronomsko plimo, zato izmerjene vrednosti niso bile ekstremne. Naslednja podobna situacija je bila med 9. in 11. aprilom, slightly above the average in comparison with periodical January high values, it is not exceptional. The lowest sea level in the months was not extreme either; still, it caused some difficulties. This was the second lowest sea level in 2006.

The mean monthly value in January was second lowest of the year; it was, however, average in comparison with the long-term period.

In February, the sea level was slightly above average. In comparison with values for the period, the most notable deviation was that of the lowest low tide in the month, which was far below average. The highest tide recorded was 283 cm, which is far below the periodical average.

In **March**, cyclonal weather with low air pressure and periods of strong southern wind prevailed. Therefore the sea levels were very high. All characteristic values were considerably above average. The sea level was higher than expected for the entire month, with the greatest deviation in the first half of the month (Figure 3). Early in the month, meteorological conditions (a strong southern wind and very low air pressure) brought about the maximum residual height, over 50 cm, but this did not coincide with the high astronomical tide, so extreme sea depths did not occur. The maximum sea depth occurred at the end of the month, on 28 March in the evening, and reached 307 cm. For the first time in 2006, the sea burst the shoreline and caused a brief flood of the lower parts of the shore. The mean monthly value was extremely high. At 232 cm, it was the second highest in the year and higher than the mean March value in the period 1961–2000. In 2006, only the mean monthly value of October was higher. There was also a considerable deviation in the low tide value, which was, at 164 cm, the highest in the year. The highest value for the period was exceeded by as much as 13 cm.

In **April**, weather conditions were still varied, and inclined towards a raised sea level, but less intense than in the month before. The pressure was lower than average



Slika 48: Odkloni zračnega pritiska in višine morja od dolgoletnega povprečja v marcu.

Figure 48: *Deviations of air pressure and sea level from long-term average in March.*

in takrat je bila izmerjena tudi najvišja mesečna vrednost, 301 cm. To je bil tudi edini dogodek, ko je bila presežena opozorilna vrednost. Vse značilne vrednosti so bile nekoliko nadpovprečne, a nobena od njih ekstremna.

Maja je bila srednja mesečna vrednost 2 cm višja od obdobnega povprečja, tudi najnižja mesečna vrednost je bila nekoliko nadpovprečna. Najvišja mesečna višina morja je bila podpovprečna. Nadpovprečna nizka in podpovprečna visoka mesečna višina morja sta povzročili zelo majhno mesečno amplitudo, 137 cm.

Podobna situacija se je ponovila v **juniju**. Srednja mesečna in najnižja mesečna vrednost je bila malo nadpovprečna, najvišja močno podpovprečna. Amplituda je bila le centimeter večja od majske. Najvišja gladina morja v juniju je dosegla le 277 cm in je bila najnižja v letu. Vremenski pogoji, ki so povzročili povišanje gladine morja, so nastopili v dveh obdobjih, v prvih in zadnjih dneh meseca. Ker je bilo v obeh obdobjih astronomsko plimovanje precej majhno, se povišanje odraža predvsem pri nadpovprečnih nizkih vodah. Ob nastopu največjega astronomskega plimovanja je bila vremenska situacija umirjena in residualne višine niso presegale 20 cm.

Tudi **julija** je bilo morje nekoliko nadpovprečno visoko. Vse značilne vrednosti so bile nekoliko nadpovprečne, vendar ne izjemne. Izmerjene vrednosti so le malo odstopale od napovedanih.

Avgusta je območje slovenske obale navadno pod vplivom anticiklona, kar se odraža z visokim zračnim pritiskom, šibkimi vetrovi in visokimi temperaturami. Vendar je bil avgust leta 2006 vremensko zelo pester.

Ves mesec je bil zračni pritisk nižji od povprečnega. Skupaj z občasnim močnejšim vetrom z juga je povzročil, da je bila tudi gladina morja cel mesec višja od napovedane. Tako vremensko dogajanje za konec poletja če gledamo dolgoletno obdobje sicer ni značilno, vendar se je pojavilo v štirih zaporednih letih od leta 2003 do 2006.

Srednje dnevne višine morja so bile od 10 do 25 cm višje od povprečja. Vse značilne vrednosti so bile nadpovprečne, močno navzgor je odstopala srednja mesečna

Pijavica, posneta v Vrsarju. (foto: Igor Strojan).
Tornado in Vrsar. (photo: Igor Strojan).

for the entire month, but the deviation was smaller (10 to 15 mb on average). Thus the significant short-term rises in sea level were especially the result of wind conditions. The first such rise occurred between 5 and 7 April, but did not coincide with the high astronomical tide, so the recorded values were not extreme. The next similar situation occurred between 9 and 11 April, when the highest monthly value – 301 cm – was recorded. This was also the only event when the limit value was exceeded. All characteristic values were slightly above average, but none of these were extreme.

In **May**, the mean monthly value was 2 cm above the average for the period, with the lowest monthly level also being slightly above average. The highest monthly sea level was below average. The above-average low sea level and the below-average high sea level caused a very small monthly amplitude, 137 cm.

A similar situation was repeated in **June**. The mean monthly and the lowest monthly values were just slightly above average, while the highest value was considerably below average. The amplitude exceeded the May amplitude by just 1 cm. The highest sea level in June reached 277 cm, which is the lowest value of the year. Weather conditions which caused the raised sea level occurred in two periods, on the first and the last days of the month. Since the astronomical tide was rather low in both periods, the rise is reflected especially in low waters, which were above average. At the time of the highest astronomical tide, the weather situation was moderate and residual heights did not exceed 20 cm.

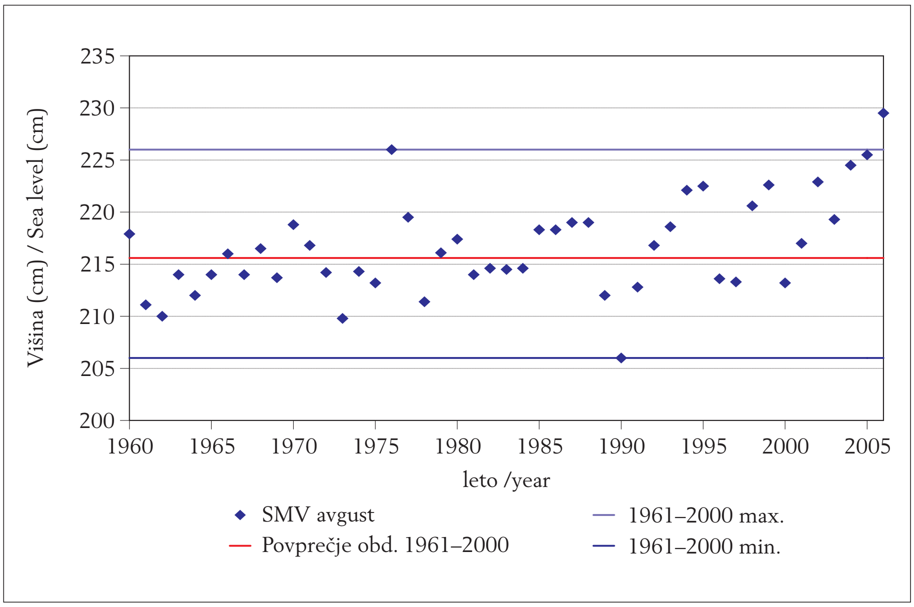
In **July**, too, the sea level was slightly above average. All characteristic values were slightly above average, but not extreme. The measured values revealed very little deviation from the values forecast.

In **August**, the Slovenian sea shore area is usually under the influence of anticyclones, which is reflected in high air pressure, weak winds and high temperatures. However, the August of 2006 was very diverse in weather.

Air pressure was below average for the entire month. Combined with an occasional stronger southern wind, it caused the sea level to be higher than the predicted values for the entire month. In the long-term period, this weather situation is not typical of the end of the summer, but it nevertheless occurred in four successive years from 2003 to 2006.

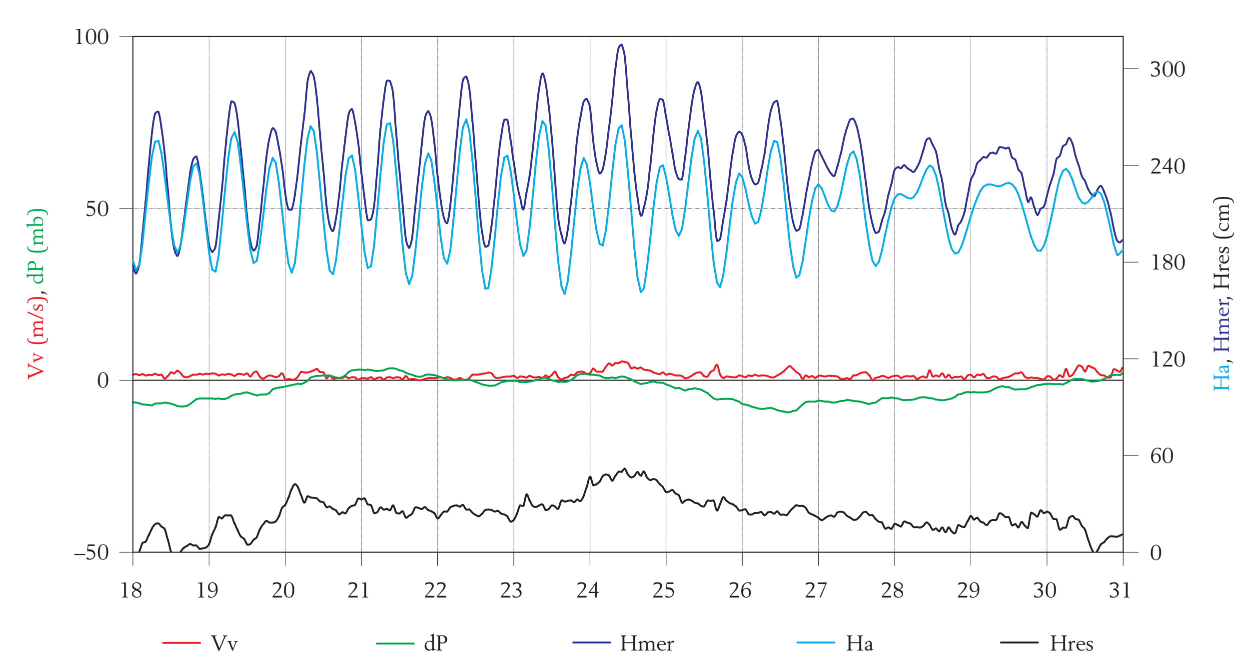
Mean daily sea levels were from 10 to 25 cm above average. All characteristic values were above average, with considerable deviations of the mean monthly value as much as 3.5 cm higher than the highest August value of the period 1961–2000.

In the first half of **September**, the weather became moderate and the sea level did not deviate significantly from the average values. The middle of the month, however, saw the onset of lower air pressure and especially the strong and persistent southern wind. The wind, in particular, maintained the conditions for constant rise in the sea level for several weeks, which ceased only



Slika 49: Največja, najmanjša in srednja obdobna vrednost za mesec avgust v primerjavi s srednjimi mesečnimi višinami morja v letih od 1960 do 2006.

Figure 49: *Highest, lowest and mean monthly sea level in August, with mean sea levels for August in the period 1960–2006.*



Legenda: Hmer = izmerjena višina morja
Ha = astronomska višina morja
Hres = residualna višina je razlika med astronomsko in izmerjeno višino morja
dP = odklon zračnega pritiska od povprečja (1016 mb)
Vv = hitrost vetra

Legend: Hmer = measured sea level
Ha = astronomical sea level
Hres = residual sea level is the difference between the measured and astronomical sea level
dP = deviation of air pressure from average (1016 mb)
Vv = wind velocity

Slika 50: Izmerjena, astronomska in residualna višina morja ter odklon zračnega pritiska od povprečja in hitrost vetra ob pojavu najvišje gladine morja v oktobru 2006.

Figure 50: *Measured sea level, astronomical sea level and residuals, and deviation of air pressure and wind velocity upon the highest sea level in October 2006.*

višina, ki je bila celo za 3,5 cm višja od najvišje avgustovske vrednosti obdobja 1961–2000.

V prvi polovica **septembra** se je vremensko dogajanje umirilo in gladina morja ni bistveno odstopala od povprečnih vrednosti. Sredi meseca pa je nastopilo obdobje znižanega zračnega pritiska, predvsem pa močnega in vztrajnega južnega vetra. Predvsem veter je ohranjal pogoje za nekaj tednov trajajoče konstantno povišanje gladine morja, ki se je prekinila šele v prvi tretjini oktobra. Nadpovprečne so bile vse značilne vrednosti, vendar ni bilo izjemnih višin.

V začetku **oktobra** se je nadaljevalo obdobje povišanega plimovanja morja iz prejšnjega meseca. Morje je v tem času trikrat doseglo ali preseglo opozorilno vrednost. Sledilo je desetdnevno obdobje visokega zračnega pritiska in povprečnih višin morja. To obdobje je sovpadalo z nizkim astronomskim plimovanjem. V zadnji tretjini meseca pa so vremenski pogoji spet povzročili pomembno odstopanje višin morja od napovedanih. Kar petkrat je višina morja dosegla ali presegla opozorilno vrednost. Gladina je bila najvišja 24. oktobra ob prvi plimi in je dosegla 316 cm. To je višina, ko morje že poplavi nižje dele obale.

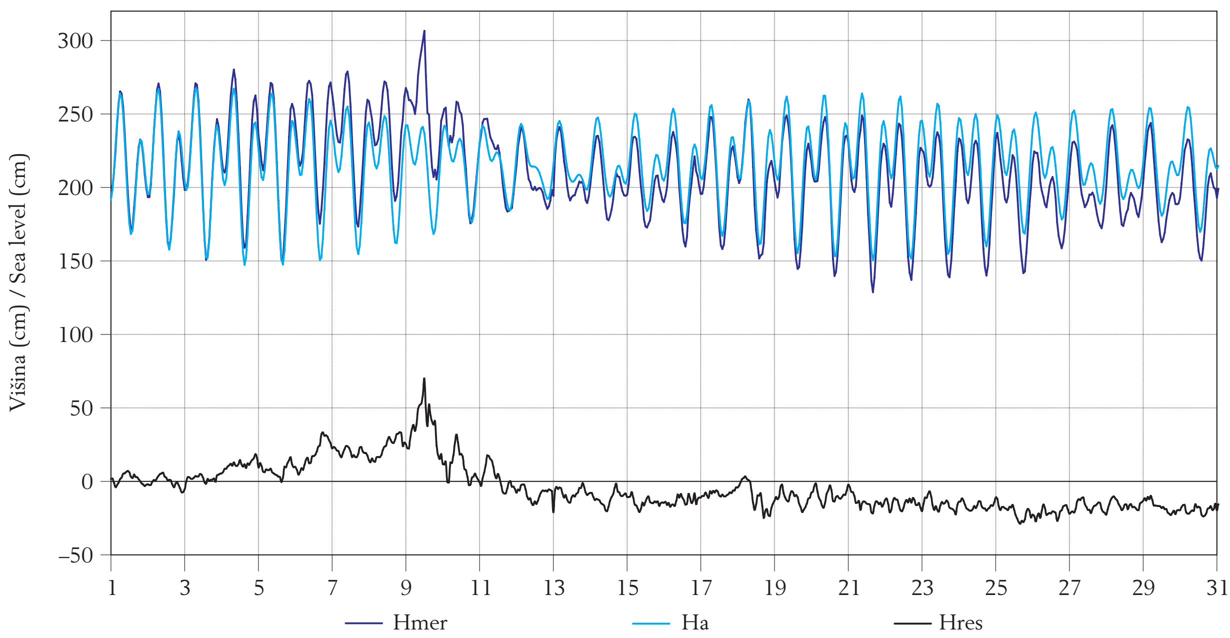
Srednja višina morja v oktobru je bila zelo visoka, 232,5 cm, najvišja v letu. Jesen je najobičajnejši čas za pojav visokih višin morja. Večina izstopajoče visokih plim se zgodi med septembrom in decembrom.

in the first third of October. All characteristic values were above average, but without extremes.

The beginning of **October** saw the continuation of the increased sea tides from the previous month. In this period, the sea reached or exceeded the limit value three times. This was followed by a ten-day period of high air pressure and average sea levels. This period coincided with the astronomical tide. In the last third of the month, weather conditions caused another important deviation of the sea levels from the forecast values. The sea level reached or exceeded the limit value as many as five times. The sea level was highest on 24 October on the first tide, reaching 316 cm. This is a level at which the sea has already flooded the lower parts of the shore.

At 232.5 cm, the mean sea level in October was very high, the highest of the year. Autumn is the most common time for the occurrence of high sea levels. Most extremely high tides occur between September and December.

In **November**, the sea level was high but not extreme. High sea levels occurred in the first days of the month and between 19 and 26 November. In this period, the sea exceeded the limit value several times. It was highest on 22 November when it reached 308 cm. This is slightly below the average highest value for November compared with statistics for the period. The lowest and mean monthly sea levels were slightly above average.



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

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

Slika 51: Izmerjena, astronomska in residualna višina morja v decembru 2006.

Figure 51: *Measured, astronomic and residual sea level in December 2006.*

V **novembru** je bila gladina morja visoka, vendar ne izstopajoča. Visoke višine morja so se pojavljale v prvih dneh meseca in med 19. in 26. novembrom. V tem obdobju je morje nekajkrat preseglo opozorilno vrednost. Najvišje je bilo 22. novembra, ko je doseglo 308 cm. To je celo nekoliko podpovprečna najvišja vrednost za november, če jo primerjamo z obdobnimi statistikami. Najnižja in srednja mesečna višina morja sta bili nekoliko nadpovprečni.

Prve dni **decembra** gladina morja ni bistveno odstopala od povprečnih vrednosti. Med 7. in 10. decembrom pa je prišlo do močnega padca zračnega pritiska, ki je skupaj z južnim vetrom povzročil dvig morske gladine. 9. decembra je bila kljub nizki astronomski višini dosežena najvišja mesečna višina morja 312 cm. Residualna višina je bila kar 70 cm.

Naslednjega dne, 11. decembra, so se močno spremenile vremenske razmere, pritisk se je zvišal, veter se je umiril. Do konca meseca so bile izmerjene višine morja nižje od napovedanih. Nekaj dni trajajoče obdobje burje in zračni pritisk, ki je bil visok preko 1030 mb, sta skupaj z izrazitim astronomskim plimovanjem povzročila zelo nizke oseke v drugi polovici meseca. Najnižja gladina morja je bila najnižja v celem letu, 128 cm. Raznoliko dogajanje se opazi tudi pri karakterističnih vrednostih za mesec december. Po eni strani nadpovprečno visoka najvišja plima, po drugi pa podpovprečna najnižja oseka. Odraz pestrega dogajanja je tudi največja mesečna amplituda, razlika med najvišjo in najnižjo gladino morja je bila 184 cm.

On the first days of **December**, the sea level did not considerably deviate from the mean values. Between 7 and 10 December, a major drop in air pressure occurred, causing an increase of sea level together with the southern wind. On 9 December, the highest monthly sea level – 312 cm – was reached despite the low astronomical level. Residual height was as high as 70 cm.

On the following day, 11 December, weather conditions changed dramatically, with air pressure increasing and the wind subsiding. Until the end of the month, the measured levels were lower than those forecast. A period of Bora, which lasted a few days and air pressure over 1030 mb combined with a marked astronomical tide to cause very low tides in the second part of the month. The lowest sea level was the lowest in the entire year – 128 cm. A diverse weather situation is noticeable in the characteristic values for December. While the highest tide is above average, the lowest tide is below average. This diverse situation is also reflected in the highest monthly amplitude, with the difference between the highest and the lowest sea levels recorded being 184 cm.

E. VODNA BILANCA

Vodna bilanca porečij

Peter Frantar

Izračun vodne bilance temelji na konceptu vodnega kroga, na primerjavi odtoka, padavin, izhlapevanja ter sprememb vodnih zalog. Iz trenutno razpoložljivih podatkov sprememb vodnih zalog ne moremo količinsko ovrednotiti, zato niso upoštevani, moramo pa jih imeti v mislih pri interpretaciji bilančnih členov. Za izračun smo torej uporabili poenostavljeno enačbo vodne bilance, ki predpostavlja ravnovesje padavin z odtokom in izhlapevanjem:

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

Bilanco smo izdelali za Jadransko in Črnomorsko povodje, ki smo ju pri računanju odtokov še notranje razdelili. Jadransko povodje smo razdelili na porečje Soče, ki zajema pritoke Soče in Vipave, ter na povodje Jadranskih rek, ki zajema preostanek povodja Jadranskega morja. Črnomorsko povodje pa smo razdelili na Pomurje, Podravje in Posavje. Izračunane količine padavin in izhlapevanja temeljijo na analizi posameznih enot glavnih povodij z uporabo geoinformacijske tehnologije. Izhlapevanje v tekstu enačimo s pojmom evapotranspiracija, ki zajema evaporacijo (izhlapevanje z vodnih površin) in transpiracijo (izhlapevanje iz rastlin).

Členi vodne bilance

Letno količino padavin smo izračunali iz rastrskih kart Slovenije z velikostjo celice 100 m × 100 m. Osnova so bili podatki merilnih mest za padavine. Za karto padavin so bile uporabljene korigirane padavine. Padavine smo korigirali s temperaturo, vetrom in intentizeto padavin. Izhlapevanje smo izračunali s pomočjo bilančne formule po enačbi P – Q = ET.

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

Vodna bilanca po glavnih slovenskih porečjih

Pomurje je hidrogeografska regija s površino 1390 km^2 in z najmanjšo povprečno količino padavin v Sloveniji.

E. WATER BALANCE

Water balance of the river basins

Peter Frantar

The calculation of the water balance is based on the water cycle concept, on the comparison of runoff, precipitation, evaporation and changed water stocks. Changes in water storage cannot be evaluated in quantity from the data currently available (so these data are not considered), but must instead be calculated by interpreting balance terms. The basis of our calculation was therefore a simplified equation of water balance, which implies the balance of precipitation with runoff and evaporation:

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

The balance was made for the Adriatic and Black Sea drainage basins, which were internally divided in the calculation of runoffs. The Adriatic drainage basin was divided in the Soča river basin encompassing the tributaries of the Soča and the Vipava, and the drainage basin of Adriatic rivers encompassing the rest of the Adriatic drainage basin. The Black Sea drainage basin was divided into Pomurje, Podravje and Posavje. The calculated quantities of precipitation and evaporation are based on analysis of individual units of the main drainage basins with the use of geo-information technology. In the text, evaporation is equivalent to the term of evapotranspiration, encompassing evaporation (evaporation from water surfaces) and transpiration (evaporation from plants).

Water Balance Terms

The annual quantity of precipitation was calculated from raster map of Slovenia with the cell size of 100 m × 100 m. The basis was the data from gauging sites for precipitation. The precipitation map was based on corrected precipitation. Precipitation was corrected by temperature, wind and intensity of precipitation. Evaporation was calculated by a balance formula under the equation P – Q = ET.

Runoffs are, as a rule, the most reliable terms of the river basin water balance. At representative gauging stations, the runoff of a certain area is gathered in a single hydrometric profile. Our calculations observed the discharges of gauging stations covering most inflows and outflows from the country, as well as the estimated discharges for watercourses with sources in Slovenia. For those areas without relevant measurements, the discharges were established by observing specific runoffs (l/km^2/s) of gauging stations comparable in hydrological terms, Leta 2006 je v Pomurju padlo v povprečju 876 mm padavin (v obdobju 1971–2000: 897 mm), kar je enako 38,7 m^3/s. Padavin je bilo v tem porečju za malenkost manj kakor v dolgoletnem obdobju. Bilančno izhlapevanje je bilo 658 mm oz. 29,1 m^3/s. Najmanj padavin je leta 2006 padlo na skrajnem vzhodnem delu Pomurja, v porečju Velike Krke okrog 770 mm in na skrajnem Lendavskem delu okrog 750 mm; največ padavin pa je padlo na jugovzhodnem delu Slovenskih goric, in sicer okoli 1000 mm. Na osrednjem delu Goričkega in na severnem delu Goric je bilo okrog 900 mm padavin. Po ravninah in v dolinah je bilo padavin med 850 in 900 mm. Pri vtoku površinskih voda v Slovenijo smo upoštevali Muro, del porečja Kučnice in Ledave izven Slovenije. Pri odtoku iz države pa smo upoštevali Muro, Veliko Krko, Ledavo, Ščavnico ter odtok s preostalega območja, ki ga ne zajamemo z vodomernimi postajami. Vsi dotoki v Pomurje so leta 2006 doprinesli 154,2 m^3/s, iz območja Pomurja pa je odteklo skupaj 163,8 m^3/s. Količina vode, ki je leta 2006 odtekla iz Pomurja, je bila v povprečju 9,6 m^3/s.

Podravje meri 3265 km^2 in skozenj teče naša največja prehodna reka Drava. Podravje je imelo leta 2006 za desetino manj padavin kakor je obdobno povprečje. Leta 2006 je bilo tu v povprečju 1115 mm padavin (v obdobju 1971–2000: 1244 mm), kar je 115,6 m^3/s. Najmanj padavin v Podravju je bilo leta 2006 na vzhodnem delu – v osrednjem delu Slovenskih Goric v okolici Lenarta, kjer je bilo padavin okrog 900 mm. Od tod je količina rasla proti višjim predelom in proti zahodu. Vrhovi Haloz so tako imeli okrog 1200 mm padavin. Največ padavin je bilo na Pohorju, kjer je bilo okrog 1800 mm padavin. V predelu Karavank, ki sega v Podravje, pa jih je bilo do 1400 mm. Količino dotoka vode iz Avstrije smo določili s pretoki na Dravi v Dravogradu, na Bistrici v Muti ter na povirju Pesnice. Skupni odtok vsega Podravja je Drava na iztoku iz Slovenije pri Ormožu. V Podravje je leta 2006 v povprečju priteklo slabih 220 m^3/s vode, odteklo pa je 268,4 m^3/s. Neto prispevek Podravja k odtoku Drave je bil torej skoraj 49 m^3/s. Z upoštevanjem padavin ter neto odtoka dobimo, da je iz Podravja bilančno izhlapelo 66,7 m^3/s vode.

Posavje zajema dobro polovico (11.750 km^2) Slovenije. Leta 2006 je bilo na območju slovenskega Posavja v povprečju 1315 mm (v obdobju 1971–2000: 1589 mm) padavin oz. za 490,4 m^3/s. To je šestina manj kakor v dolgoletnem obdobju. V porečju je velik razpon v količini padavin, ki je bil leta 2006 od okoli 1000 mm v Posotelju ter spodnjem Posavskem hribovju do 3100 mm na pobočjih južnih in zahodnih Bohinjskih gora v Julijcih. Od vzhoda količina padavin raste proti zahodu. Ljubljanska kotlina je imela tako med 1100 in 1400 mm padavin, Kamniške Alpe so jih prejele do 2000 mm, nad 2000 mm pa jih je bilo na obrobju Snežnika ter v Julijcih. Pritoki v slovensko Posavje iz hrvaškega dela porečja Ljubljanice, Kolpe, Krke in Sotle so prispevali 32,7 m^3/s, skupen iztok iz Slovenije pa je bil 305,4 m^3/s.

or by correlation values on the basis of mean annual discharge values.

Water Balance by Principal Slovenian River Basins

Pomurje (the Mura River Basin) is a hydro-geographical region with an area of 1,390 km^2 and with the lowest average precipitation level in Slovenia. In 2006, the average precipitation level of Pomurje was 876 mm (897 in the period 1971–2000), which equals 38.7 m^3/s. In this river basin, the precipitation level was slightly lower than the average in the long-term period. Balance evaporation was 658 mm or 29.1 m^3/s. The precipitation level was lowest in the most northeastern part of Pomurje, in the Velika Krka river basin – about 770 mm, and in the most sourtheastern part – about 750 mm; the precipitation level was highest in the south-eastern part of Slovenske gorice at around 1,000 mm. The precipitation level in the central part of Goriško and in the northern part of Gorice was around 900 mm. In plains and valleys, the precipitation level was between 850 and 900 mm. In the inflow of surface waters to Slovenia, we took note of the Mura, a part of the Kučnica river basin and the Ledava river basin outside Slovenia. In the outflow from Slovenia, we took note of the rivers Mura, Velika Krka, Ledava and Ščavnica and the outflow from the remaining area not covered by gauging stations. All inflows to Pomurje in 2006 contributed 154.2 m^3/s, while the outflow from the Pomurje area amounted to 163.8 m^3/s in total. The average quantity of water flowing from Pomurje in 2006 was 9.6 m^3/s.

Podravje (the Drava River Basin) covers the area of 3,265 km^2 and is crossed by the biggest transitional river of Slovenia, the Drava. In 2006, the precipitation level of Podravje was lower than the long-term average by a tenth. In 2006, the average precipitation level was 1,115 mm (in the period 1971–2000: 1,244 mm), which equals 115.6 m^3/s. In 2006, the precipitation level of Podravje was lowest in the eastern part – in the central area of Slovenske Gorice around Lenart, where it amounted to about 900 mm. From there, the quantity rose towards higher areas and towards the west. Thus, the highest parts of Haloze received about 1,200 mm of precipitation. The precipitation level was highest in Pohorje, amounting to about 1,800 mm. In the area of the Karavanke mountain range of Podravje, it amounted to 1,400 mm. The quantity of the water inflow from Austria was established by the discharges on the Drava in Dravograd, on the Bistrica in Muta and at the source of the Pesnica. The total runoff of the entire Podravje area is the Drava at the point of leaving the territory of Slovenia near Ormož. In 2006, the average inflow to Podravje was slightly under 220 m^3/s, while the outflow amounted to 268.4 m^3/s. The net contribution of Podravje to the Drava runoff was thus almost 49 m^3/s. The precipitation and the net runoff are the basis for

Neto odtok iz slovenskega Posavja je bil 272,7 m^3/s. Po bilančni enačbi izračunano izhlapevanje je bilo 217,7 m^3/s.

Posočje meri 2320 km^2 in je po specifičnih odtokih naše najbolj vodnato porečje. Tudi leta 2006 je tu padlo največ padavin v Sloveniji: 1786 mm oz. 131,4 m^3/s. Količina je za četrtino pod dolgoletnim povprečjem obdobja 1971–2000 z 2386 mm. Leta 2006 je bilo v Posočju največ padavin v Julijcih, kjer je bilo padavin preko 3100 mm, kar je manj kakor v obdobju. Najbolj namočene Južnobohinjske gore so dobile le do 3000 mm padavin (leta 2004 preko 3500 mm). Visoki dinarski planoti Nanos in Trnovski Gozd sta dobili nad 2100 mm padavin, Javorniki 1600 mm, v Vipavski dolini pa je bilo padavin med 1000 in 1200 mm. Najmanj padavin je bilo v okolici Mirna v spodnjem delu Vipavske doline, nekaj nad 950 mm. Manjša količina padavin se pozna tudi na odtoku iz porečja. Skoraj vse Posočje pripada Sloveniji. Izjeme so povirja Učje, Nadiže ter deloma Idrije, ki so prispevali v Slovenijo 5,60 m^3/s. Iz slovenskega Posočja voda odteka v največji meri po Soči, Vipavi in Nadiži, nekaj pa tudi po Idriji, Reki v Goriških Brdih in Korenu. Skupaj je odteklo 85 m^3/s. Bilančno izhlapevanje je bilo leta 2006 v Posočju 52,0 m^3/s, neto odtok pa 79,4 m^3/s.

Povodje preostalih Jadranskih rek zajema 1530 km^2, največji vodotok je reka Reka. Tu je padlo leta 2006 za šestino manj padavin od dolgoletnega povprečja. Bilo jih je 1350 mm (v obdobju 1971–2000: 1619 mm), kar je slabih 65,5 m^3/s. Najmanjše količine padavin so bile

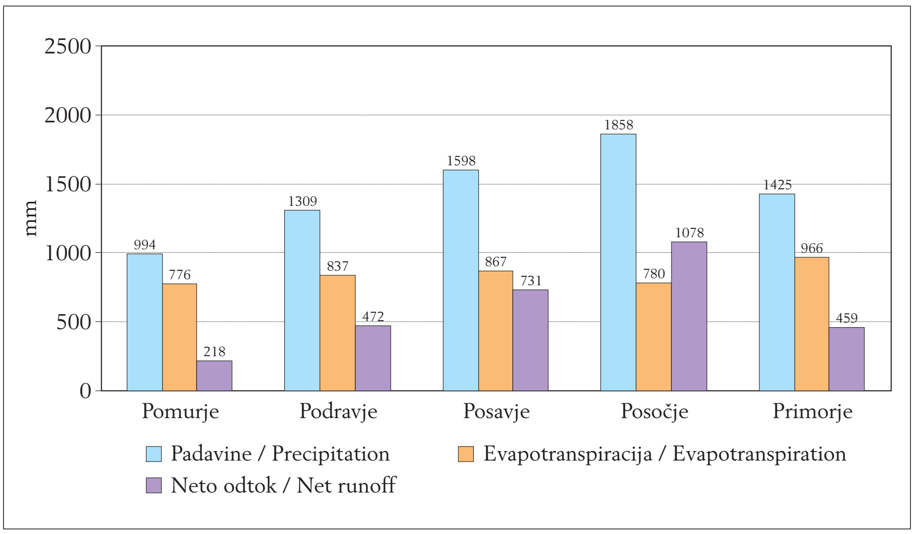
the calculation of the balance evaporation from Podravje, which equals 66.7 m^3/s of water.

Posavje (the Sava River Basin) covers over a half (11.750 km^2) of Slovenia. In 2006, the average precipitation level of the Slovenian part of Posavje was 1,315 mm (in the period 1971–2000: 1,589 mm), which equals 490.4 m^3/s. This is a sixth less than in the long-term period. The basin displays a great variety in terms of precipitation quantity, which ranged in 2006 from about 1,000 mm in Posotelje and in the lower Posavje Highlands to 3,100 mm in the slopes of the southern and western Bohinj mountains in the Julian Alps. The quantity of precipitation grows towards the west. Thus the precipitation level was between 1,100 and 1,400 mm in the Ljubljana basin, up to 2,000 mm in the Kamnik Alps, and over 2,000 mm in the foothills of Snežnik and in the Julian Alps. The inflows to Slovenian Posavje from the Croatian parts of the basins of the Ljubljanica, Kolpa, Krka and Sotla contributed 32.7 m^3/s, while the total outflow from Slovenia was 305.4 m^3/s. The net outflow from the Slovenian Posavje was 272.7 m^3/s. The evaporation calculated by the balance equation was 217.7 m^3/s.

Posočje (the Soča River Basin) covers an area of 2,320 km^2 and is the most water abundant river basin in Slovenia in terms of specific runoff. In 2006, too, it had the highest precipitation level in Slovenia: 1,786 mm or 131.4 m^3/s. This is a quarter below the long-term average of the period 1971–2000 i. e. 2,386 mm. In 2006,

Preglednica 17: Členi vodne bilance leta 2006 glavnih porečjih Slovenije.
Table 17: *Table 17: Terms of water balance of 2006 in the main river basins of Slovenia*

(mm)	Pomurje	Podravje	Posavje	Posočje	Primorje
padavine / *precipitation*	876	1115	1315	1786	1350
izhlapevanje / *evapotranspiration*	658	643	584	708	891
neto odtok / *net runoff*	218	472	731	1078	459
odtočni količnik / *runoff coeficient*	0,25	0,42	0,56	0,60	0,34



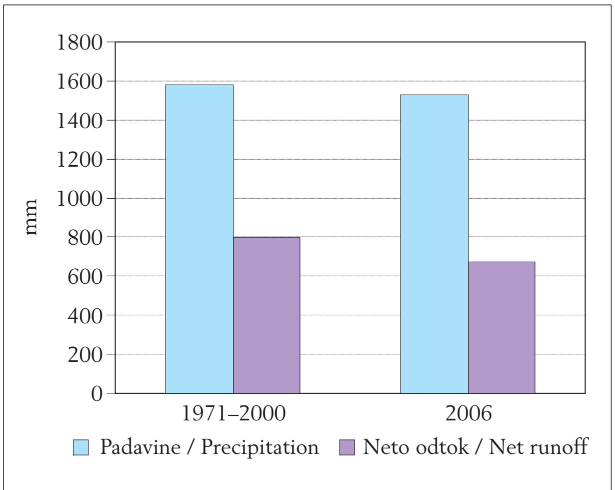
Slika 52: Členi vodne bilance leta 2006 po glavnih porečjih Slovenije v mm.
Figure 52: *Terms of water balance of 2006 by main river basins of Slovenia in mm.*

na Koprskem, v okolici Kaštela celo pod 900 mm. Drugod po Koprskem primorju je bilo padavin med 900 in 1000 mm, od tod pa je bilo padavin več proti vzhodu in severu. Planota Krasa je prejela med 1100 in 1300 mm padavin, Brkini in okolica okoli 1400 mm, največ pa pogorje Snežnika, preko 2000 mm. Na najvišjih predelih Snežnika je padlo skoraj 2400 mm padavin. Tekoče vode v Slovenijo pritečejo preko povirij Rižane, Reke ter Dragonje. Skupaj je priteklo v Slovenijo manj kot 0,89 m^3/s vode. Iztokov je več: poleg večine Krasa (s podzemnim odtokom) ter obale se v Italijo odtaka tudi Osapska reka, na Hrvaško pa teče voda iz povirja porečja reke Mirne. Skupni odtok je bil leta 2006 23,2 m^3/s, neto odtok pa 22,3 m^3/s. Leta 2006 je po bilančni metodi izhlapelo 43,2 m^3/s.

Primerjava z obdobno vodno bilanco

Vse člene vodne bilance leta 2006 smo primerjali z referenčno obdobno vodno bilanco 1971–2000 in sicer za Črnomorsko in Jadransko povodje (Bat et al., 2008).

V slovenskem delu **Črnomorskega povodja** je leta 2006 padlo manj padavin kakor je obdobno povprečje. Med leti 1971–2000 je bila povprečna količina padavin 1462 mm, leta 2006 pa jih je padlo 1238 mm.



Slika 53: Padavine v Sloveniji in odtok iz ozemlja Slovenije v referenčnem obdobju 1971–2000 ter letu 2006 v mm.

***Figure 53:** Precipitation in Slovenia and outflow from the territory of Slovenia in reference period 1971–2000 and in 2006 in mm.*

the highest precipitation level in Posočje was that of the Julian Alps with over 3,100 mm, which is less than in the reference period. The wettest South Bohinj mountains received only up to 3,000 mm of precipitation (over 3,500 mm in 2004). The high Dinaric plateaus Nanos and Trnovski gozd received over 2,100 mm of precipitation, and Javorniki 1,600 mm, while the Vipava Valley received between 1,000 and 1,200 mm of precipitation. The precipitation level was lowest in the area of Miren in the lower part of the Vipava Valley – slightly over 950 mm. A lower precipitation level is also evident in the runoff from the basin. Almost the entire area of Posočje is located in Slovenia. The exceptions are the sources of the Učja, the Nadiža and partly the Idrija rivers, which contributed 5.60 m^3/s to Slovenia. The water of the Slovenian Posočje mostly runs off through the Soča, the Vipava and the Nadiža; some also runs off through the Idrija, the Reka in Goriška Brda and the Koren. The total runoff was 85 m^3/s. In 2006, the balance evaporation in Posočje was 52.0 m^3/s, while the net runoff amounted to 79.4 m^3/s.

The basin of other Adriatic rivers covers 1,530 km^2, with the Reka river as the major watercourse. In 2006, the precipitation level was lower than the long-term average by a sixth. It amounted to 1,350 mm (in the period 1971–2000: 1,619 mm), which equals slightly less than 65.5 m^3/s. The precipitation levels were lowest in the Koper area; in the surroundings of Kaštel they were even below 900 mm. The rest of the Koper littoral had between 900 and 1,000 mm of precipitation, with the precipitation level growing towards the east and the north. The Karst plateau received between 1,100 and 1,300 mm of precipitation, Brkini hill range and its surroundings about 1,400 mm, and the Snežnik mountain range over 2,000 mm, which was the highest level. The highest parts of Snežnik received almost 2,400 mm of precipitation. Running waters enter Slovenia trough the sources of the Rižana, the Reka and the Dragonja. In total, less than 0.89 m^3/s of water entered Slovenia over the year. There are several outflows: besides the waters from most of the Karst area (with underground runoff) and the coast, the Osp river flows to Italy while Croatia receives water from the source of the Mirna river basin. In 2006, the total runoff was 23.2 m^3/s, while the net runoff amounted to 22.3 m^3/s. In 2006, the evaporation calculated by the balance equation was 43.2 m^3/s.

Preglednica 18: Primerjava členov vodne bilance 2006 z dolgoletnim obdobjem 1971–2000.

***Table 18:** Comparison of water balance terms of 2006 with those of long-term period of 1971–2000.*

(mm)	Podonavje		Jadran		Slovenija	
	1971–2000	2006	1971–2000	2006	1971–2000	2006
padavine / *precipitation*	1462	1238	2081	1613	1579	1309
izhlapevanje / *evapotranspiration*	713	602	735	780	717	636
neto odtok / *net runoff*	749	636	1346	833	862	673
odtočni količnik / *runoff coeficient*	0,51	0,51	0,65	0,52	0,55	0,51

Reka Soča pri Novi Gorici (foto:Peter Frantar).
River Soča passing by the city of Nova Gorica (photo: Peter Frantar).

Leta 2006 je bilančno izhlapelo 602 mm vode, v obdobju 1971–2000 pa 713 mm. V obdobju 1971–2000 smo iz ozemlja Slovenije v črnomorsko povodje prispevali 390 m^3/s vode oz. 749 mm, v letu 2006 je bila ta količina nekoliko manjša: 331 m^3/s oz. 636 mm. Vsi trije elementi bilančnega kroga so se zmanjšali za okrog 15 odstotkov.

V slovenskem delu **Jadranskega povodja** je v letu 2006 padlo znatno manj padavin kakor v dolgoletnem obdobju. V tem letu je bila količina padavin zgolj 1613 mm, obdobno povprečje pa je 2081 mm. Izhlapevanja je bilo po letnem vodnobilančnem izračunu 780 mm, kar je 6 % več kakor v obdobju 1971–2000. V letu 2006 je bil povprečni odtok v Jadran 102 m^3/s (833 mm), medtem ko je dolgoletni povprečni odtok preko 164 m^3/s (1346 mm). Odtok v letu 2006 je bil od povprečja manjši predvsem zaradi manjše količine padavin, pa tudi zaradi večjega izhlapevanja.

Leta 2006 je bilo v Sloveniji v primerjavi z referenčnim obdobjem 1971–2000 padavin manj za 17 %, izhlapevanja za 11 % in odtoka za 22 %. V Podonavju je bil primanjkljaj vode v vodnem krogu leta 2006 manjši kakor je bil primanjkljaj vode v Jadranskem povodju.

Comparison with Periodical Water Balance

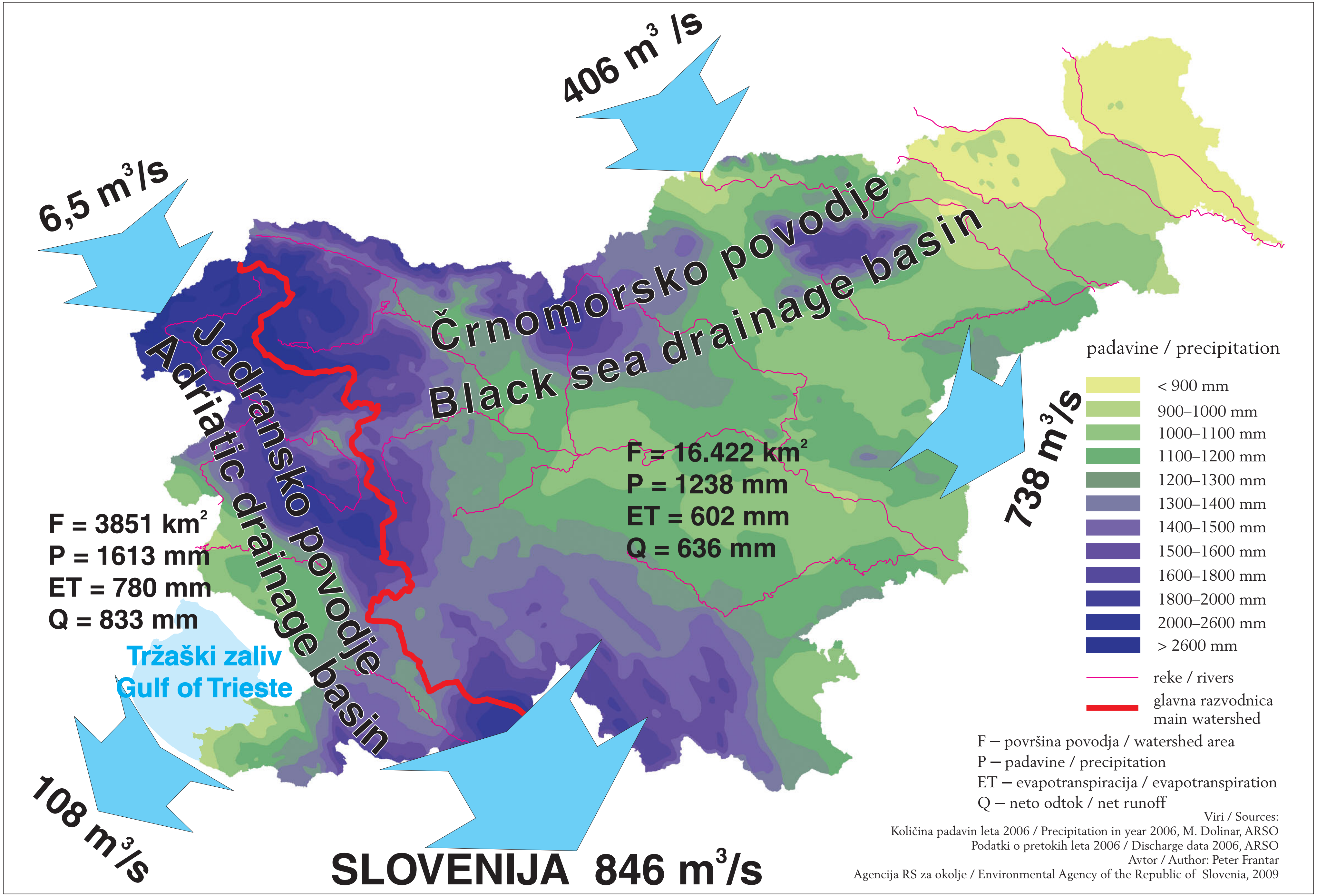
All terms of the 2006 water balance were compared with the reference period water balance of 1971–2000 for the Black Sea and the Adriatic drainage basin (Bat et al., 2008).

In 2006, the precipitation level in the Slovenian part of the **Black Sea drainage basin** was below the average for the period. In the period 1971–2000, the average precipitation level amounted to 1,462 mm, while the average precipitation level in 2006 was 1,238 mm. In 2006, the balance evaporation level was 602 mm, while in the period 1971–2000 it amounted to 713 mm. In the period 1971–2000, the contribution to the Black Sea drainage basin from the territory of Slovenia was 390 m^3/s of water or 749 mm, while the quantity was slightly lower in 2006: 331 m^3/s or 636 mm. All three elements of the balance cycle decreased by about 15%.

In 2006, the precipitation level in the Slovenian part of the **Adriatic drainage basin** was considerably below the long-term period average. In this year, the precipitation level was only 1,613 mm, with a periodical average of 2,081 mm. The evaporation under the annual water balance calculation was 780 mm, which is 6% more than in the period 1971–2000. In 2006, the average runoff to the Adriatic was 102 m^3/s (833 mm), while the long-term average runoff amounts to 164 m^3/s (1,346 mm). The runoff in 2006 was lower than the average due to a lower precipitation level, as well as an increased evaporation.

In 2006, the precipitation level in Slovenia was 17% lower than that of the reference period 1971–2000; the evaporation level decreased by 11% and the runoff by 22%. In the Danube river basin, the water deficit in the water cycle in 2006 was smaller than the water deficit in the Adriatic drainage basin.

Slika 54: Karta vodnobilančnih členov v Sloveniji leta 2006.
***Figure 54:** Map of water balance components in Slovenia in 2006.* ➤ *str. 88*


406 m³ /s
6,5 m³/s
Črnomorsko povodje
Black sea drainage basin
Jadransko povodje
Adriatic drainage basin
738 m³/s
F = 16.422 km²
P = 1238 mm
ET = 602 mm
Q = 636 mm
F = 3851 km²
P = 1613 mm
ET = 780 mm
Q = 833 mm
Tržaški zaliv
Gulf of Trieste
108 m³/s
SLOVENIJA 846 m³/s
padavine / precipitation
< 900 mm
900–1000 mm
1000–1100 mm
1100–1200 mm
1200–1300 mm
1300–1400 mm
1400–1500 mm
1500–1600 mm
1600–1800 mm
1800–2000 mm
2000–2600 mm
> 2600 mm
reke / rivers
glavna razvodnica
main watershed
F – površina povodja / watershed area
P – padavine / precipitation
ET – evapotranspiracija / evapotranspiration
Q – neto odtok / net runoff
Viri / Sources:
Količina padavin leta 2006 / Precipitation in year 2006, M. Dolinar, ARSO
Podatki o pretokih leta 2006 / Discharge data 2006, ARSO
Avtor / Author: Peter Frantar
Agencija RS za okolje / Environmental Agency of the Republic of Slovenia, 2009