I. del

PREGLED HIDROLOŠKIH RAZMER V LETU 2005

Part I

REVIEW OF HYDROLOGICAL CONDITIONS IN THE YEAR 2005

A. POVRŠINSKE VODE

Vodostaji in pretoki rek

Igor Strojan

Leta 2005 so se časovna razporeditev vodnatosti ter velikosti in lokacije največjih pretokov dokaj razlikovale od običajnih. Vodnatost je bila manjša v prvi polovici in večja v drugi polovici leta. Velika vodnatost v poletnih mesecih je spominjala na možne neugodne scenarije posledic podnebnih sprememb. Reke so najmočneje poplavljale avgusta. Predvsem veliki pretoki Mure in manjših hudourniških rek v vzhodnem delu države, ki so presegali tudi 50 letne povratne dobe, so povzročili veliko škode. Na Muri v Gornji Radgoni je bil izmerjen do tedaj največji pretok 1380 m^3/s. Sicer je bila vodnatost rek v letu 2005 v celoti nekaj več kot deset odstotkov manjša od dolgoletnega povprečja v obdobju 1971–2000. Brez upoštevanja avgustovske velike vodnatosti rek bi bila povprečna letna vodnatost rek v letu 2005 veliko manjša. Večji del leta je bila mesečna vodnatost rek manjša kot v primerjalnem obdobju. Ker je bila v običajno poletno sušnem obdobju vodnatost rek povečana, izrazitega sušnega obdobja ni bilo.

Povprečni letni pretoki rek so bili najmanjši v zahodnem in največji v vzhodnem delu države. Najmanj vode

A. SURFACE WATERS

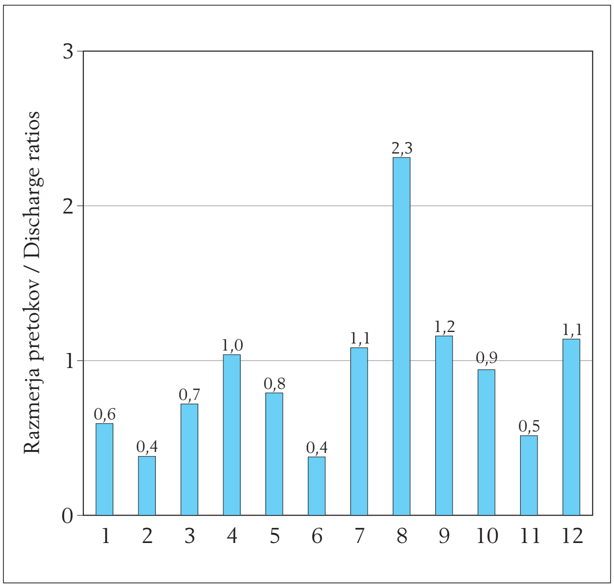
River stages and discharges

Igor Strojan

In 2005, the temporal distribution of stages and the size and location of the highest discharges differed a good deal from the usual. The river stages were lower in the first half and higher in the second half of the year. The great stages in the summer months hinted at the possible unfavourable scenarios of the consequences of climate change. Rivers caused the most severe floods in August. It was the high discharges of the Mura River and the smaller torrential rivers in the eastern part of the country especially that even exceeded the 50-year return periods and caused a lot of damage. The highest discharge to date (1380 m^3/s) was measured on the Mura River at Gornja Radgona. Otherwise, the river stages in 2005 were on the whole somewhat more than 10% lower than the multi-annual mean of the 1971–2000 reference period. If the high river stages in August were not taken into account, the average annual river stages in 2005 would be much lower. For a major part of the year, the monthly river stages were lower than in the reference period. However, because the river stages in the usually dry summer period

Slika 5: Razmerja med srednjimi mesečnimi pretoki leta 2005 in obdobja 1971–2000. Vrednost razmerja 1 pomeni enak pretok leta 2005 kot v povprečju dolgoletnega obdobja.

Figure 5: *Ratios between mean monthly discharges in 2005 and in the 1971–2000 reference period. The ratio value of 1 means that the discharge in 2005 was the same as the multi-annual mean.*



Slika 6: Razmerja med srednjimi mesečnimi pretoki v letu 2005 in obdobnimi srednjimi mesečnimi pretoki. Razmerja so izračunana kot povprečja razmerij na izbranih postajah.

***Figure 6:** The ratios between the mean monthly discharges in 2005 and the multi-annual mean monthly discharges. The ratios are calculated as average values of the ratios at selected stations.*

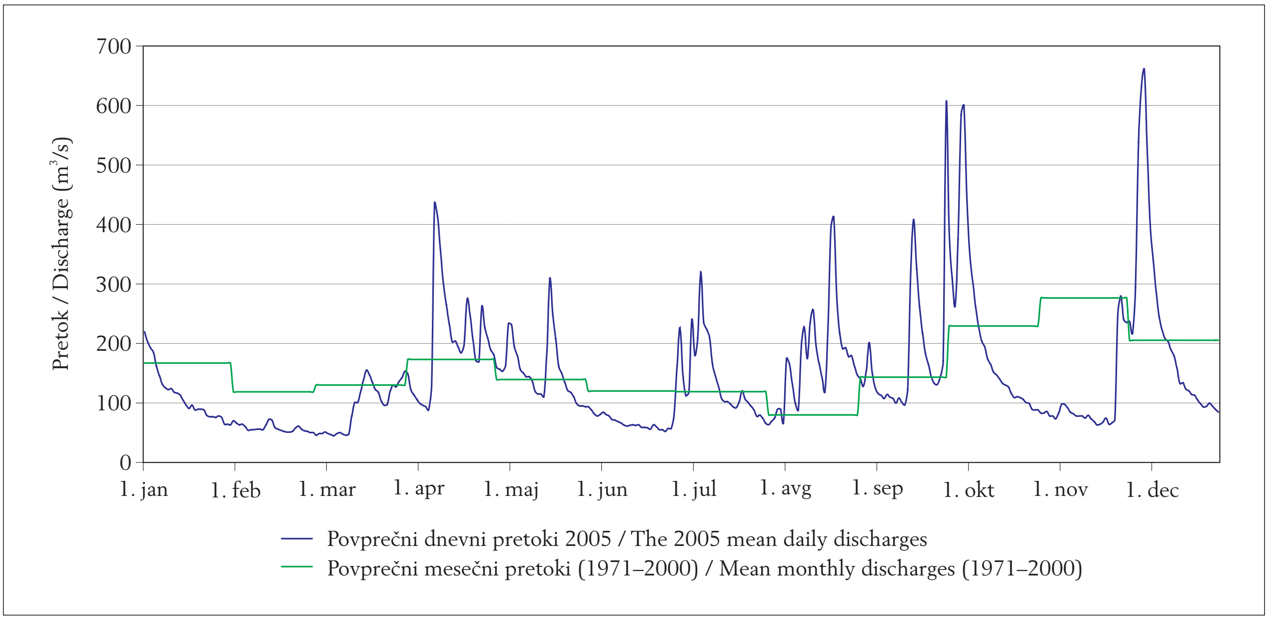
je tako preteklo po Soči (38 odstotkov manj kot navadno) in največ po Muri (15 odstotkov več kot navadno). Letni pretoki Save so bili v zgornjem toku manjši (25 odstotkov manjši kot navadno) kot v spodnjem (10 odstotkov manjši kot navadno). Vodnatost Ljubljanice je bila 15 odstotkov manjša, vodnatost Krke 12 odstotkov večja kot v primerjalnem obdobju.

were increased, there was no pronounced drought period.

The average annual river discharges were lowest in the western and highest in the eastern parts of the country. The least water flowed in the Soča River (38% less than usual) and the most in the Mura River (15% more than usual). The annual discharges of the Sava River were lower in the upstream part (25% lower than usual) than in the downstream part (10% lower than usual). The river stages of the Ljubljanica River were 15% lower, while those of the Krka River were 12% higher than in the reference period.

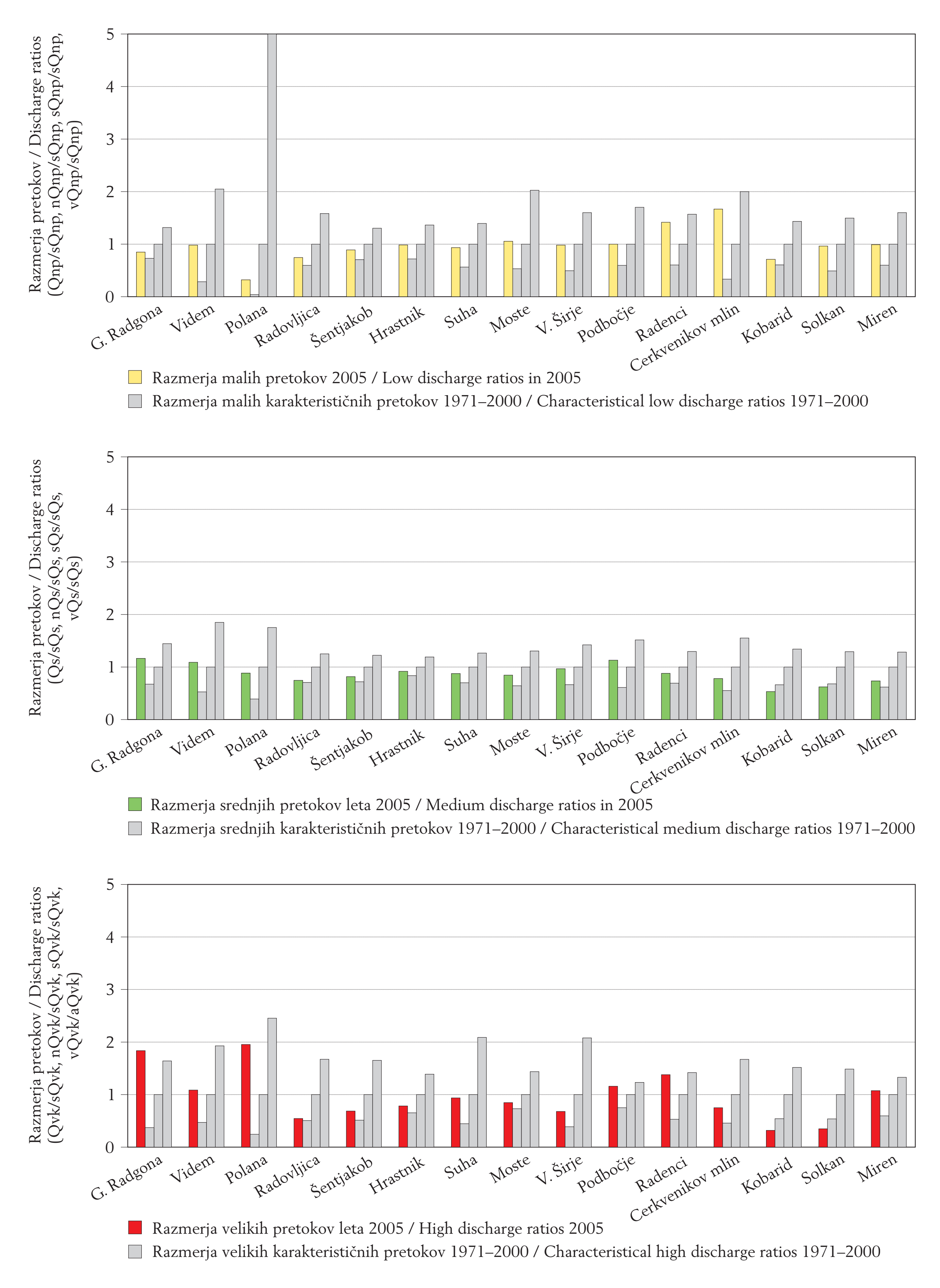
The majority of months in 2005 were hydrologically dry. The mean river discharges of the multi-annual period were exceeded in the summer months, especially in August, when the monthly discharges were exceeded 2.3 times on average. In September and December, the monthly discharges were exceeded by around 15%. They were similar to the multi-annual mean in April, while in the remaining months they were lower than the multi-annual mean. Discharges were lowest in February and June, when they were as much as 62% lower than the multi-annual mean. In November, the river stages were lower than usual by a half.

The majority of the highest discharges in the larger rivers were not higher than in the multi-annual reference period. The high-water peaks were largest on the Mura River at Gornja Radgona (a 1.8-times higher peak than the multi-annual mean), the Ledava River at Polana (a 1.9-times larger peak than the multi-annual mean), the Kolpa River at Radenci (a 1.4-times larger peak than the multi-annual mean) and the Krka River at Podbočje (a 1.1-times larger peak than the multi-annual mean). The high-water peaks were smallest on the



Slika 7: Srednji dnevni pretoki v letu 2005 in srednji mesečni pretoki v dolgoletnem obdobju 1961–2000 na reki Savi v Hrastniku.

***Figure 7:** The mean daily discharges in 2005 and the mean monthly discharges in the 1961–2000 reference period on the Sava River at Hrastnik.*



Slika 8: Razmerja malih, srednjih in velikih pretokov v letu 2005 ter razmerja karakterističnih pretokov obdobja 1971–2000. Vrednosti so podane relativno glede na srednje vrednosti malih, srednjih in velikih obdobnih pretokov.

Figure 8: *The ratios of low, mean and high discharges in 2005 and the ratios of the characteristic discharges in the 1971–2000 reference period. The values are given in relation to the mean values of the all-time low, mean and high discharges.*

Preglednica 3: Značilni pretoki v letu 2005 in obdobju 1971–2000.
Table 3: *Characteristic discharges in 2005 and in the 1971–2000 reference period.*

Reka / *River*	Postaja/ *Station*	**Qnp** Avgust / *August* 2005 m^3/s	dan / *day*	**nQnp** m^3/s	**sQnp** Avgust / *August* 1961–1990 m^3/s	**vQnp** m^3/s
Mura	G. Radgona	136	15	67,3	115	223
Drava#	Borl + Formin	227	11	103	250	393
Dravinja	Videm	3,0	1	0,99	3,1	8,1
Savinja	Veliko Širje	16,0	2	6,2	12	22,2
Sotla	Rakovec	2,0	2	1	1,3	2,8
Sava	Radovljica	11,0	5	8,7	16,2	33,5
Sava	Medno	34,0	20	24,5	39,9	62,7
Sava	Hrastnik	51,0	1	39,3	67,3	97,6
Sava	Čatež	69,0	1	63,6	102	156
Sora	Suha	4,5	2	3,2	5,3	10,5
Krka	Podbočje	11,0	1	5,7	14,9	25,8
Kolpa	Radenci	8,3	1	3,9	7,3	12,6
Ljubljanica	Moste	11,0	2	5,7	11,4	21,1
Soča	Solkan	11,0	20	19,2	28,8	53,6
Vipava	Dolenje	2,6	1	0,79	2,0	4,0
Idrijca	Podroteja	1,7	20	1,1	1,9	3,1
Reka	Cerkvenikov mlin			0,2	0,71	2,3
		Qs m^3/s		**nQs** m^3/s	**sQs** m^3/s	**vQs** m^3/s
Mura	G. Radgona	331		87,4	178	457
Drava#	Borl + Formin	427		203	379	740
Dravinja	Videm	13,8		2,3	8,5	26,1
Savinja	Veliko Širje	96,0		12,0	30,6	92,1
Sotla	Rakovec	16,1		0,94	4,4	10,8
Sava	Radovljica	32,8		22,1	35,9	74,2
Sava	Medno	83,0		39,0	66,8	133
Sava	Hrastnik	158		58,2	118	241
Sava	Čatež	315		87,5	185	430
Sora	Suha	19,2		4,6	11	32,2
Krka	Podbočje	70,7		7,7	30,7	80,9
Kolpa	Radenci	41,4		6,9	22,9	64,8
Ljubljanica	Moste	49,7		9,6	28,9	74,0
Soča	Solkan	73,4		28,4	59,3	168
Vipava	Dolenje	10,4		1,0	5,25	23,7
Idrijca	Podroteja	7,8		1,6	5,0	16,1
Reka	Cerkvenikov mlin			0,38	2,2	11,3
		Qvk m^3/s	dan / *day*	**nQvk** m^3/s	**sQvk** m^3/s	**vQvk** m^3/s
Mura	G. Radgona	1211	23	120	411	1142
Drava#	Borl + Formin	1097	23	447	866	2540
Dravinja	Videm	56,2	17	4,8	45,6	193
Savinja	Veliko Širje	389	22	18,1	232	781
Sotla	Rakovec	72,6	23	1,6	28,8	131
Sava	Radovljica	91,0	23	38,4	141	561
Sava	Medno	220	23	77,2	275	915
Sava	Hrastnik	400	23	116	408	1127
Sava	Čatež	1008	22	150	677	1993
Sora	Suha	55,0	22	11,2	72,2	269
Krka	Podbočje	247	23	10,8	116	276
Kolpa	Radenci	114	24	10,2	204	720
Ljubljanica	Moste	177	22	24,5	124	240
Soča	Solkan	197	15	62,7	327	1844
Vipava	Dolenje	24,0	12	2,0	31,1	153
Idrijca	Podroteja	60,0	12	1,8	41,8	154
Reka	Cerkvenikov mlin			0,8	23,2	118

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*

Večina mesecev je bila leta 2005 hidrološko suhih. Dolgoletna povprečja pretokov rek so bila presežena v poletnih mesecih, najbolj avgusta, ko so bili mesečni pretoki v povprečju preseženi 2,3 krat. Septembra in decembra so bili mesečni pretoki preseženi za okoli 15 odstotkov, aprila so bili podobni dolgoletnemu povprečju, v vseh ostalih mesecih pa manjši od dolgoletnega povprečja. Pretoki so bili najmanjši februarja in junija, ko so bili kar 62 odstotkov manjši od dolgoletnega povprečja. Novembra je bila vodnatost pol manjša kot navadno.

Večina največjih pretokov večjih rek ni bila večja kot v dolgoletnem primerjalnem obdobju. Visokovodne konice so bile največje na Muri v Gornji Radgoni (1,8 krat večja konica od dolgoletnega povprečja), Ledavi v Polani (1,9 krat večja konica od dolgoletnega povprečja), Kolpi v Radencih (1,4 krat večja konica od dolgoletnega povprečja) in Krki v Podbočju (1,1 krat večja konica kot dolgoletno povprečje). Visokovodne konice so bile najmanjše na Soči v Kobaridu in Solkanu (68 in 65 odstotkov manjše od dolgoletnega povprečja) (slika 8 in preglednica 3).

Najmanjši pretoki v letu so bili le nekoliko manjši od povprečnih najmanjših pretokov dolgoletnega primerjalnega obdobja. Izrazitih in daljših hidrološko sušnih obdobij ter njihovih posledic ni bilo. Zaradi omenjene večje vodnatosti poleti so bila sušna obdobja bolj izrazita v prvi polovici leta. Tako so bili pretoki rek najmanjši februarja in marca (slika 8 in preglednica 3).

Podrobneje so visokovodne in sušne razmere v letu 2005 opisane v naslednjih poglavjih te publikacije.

Mesečni deleži letnih pretokov in pretočni režimi

Odstopanje mesečnih deležev pretokov v letu 2005 od mesečnih deležev v obdobju 1971–2000 je bilo najbolj izrazito v poletnih mesecih, ko je bila vodnatost rek večja kot navadno. Tako je bilo odstopanje avgusta sedem odstotno. Odstopanje od ustaljenega pretočnega režima je bilo v tem času največje na manjših rekah v vzhodnem delu države (Ledava Polana 31 %) ter na Savinji (12 %), Krki (8 %) in Muri (8 %). Februarja, junija in novembra so bili mesečni deleži za štiri odstotke manjši kot običajno. Februarja je bilo odstopanje od ustaljenih režimov v večjem delu države od štiri do šest odstotkov. Odstopanje je bilo manjše na Muri in Soči, večje na Ledavi. Podobna odstopanja kot februarja so bila tudi junija in novembra. Novembra so bila odstopanja večja na Soči in manjša na Krki in Kolpi. Marca, maja, junija in oktobra so bili pretoki glede na celoletno količino podobno razporejeni kot v dolgoletnem primerjalnem obdobju. Mesečni deleži pretokov so le za en odstotek odstopali od obdobnih (slika 9).

Soča River at Kobarid and Solkan (68 and 65% lower that the multi-annual mean) (Figure 8 and Table 3).

The lowest discharges in the year were only slightly lower than the average minimum discharges in the multi-annual reference period. There were no pronounced and longer hydrological drought periods and their consequences. Because of the higher river stages in the summer, the drought periods were more pronounced in the first half of the year. Thus the river discharges were lowest in February and March (Figure 8 and Table 3).

The high-water and drought conditions in 2005 are described in greater detail in the following chapters of this publication.

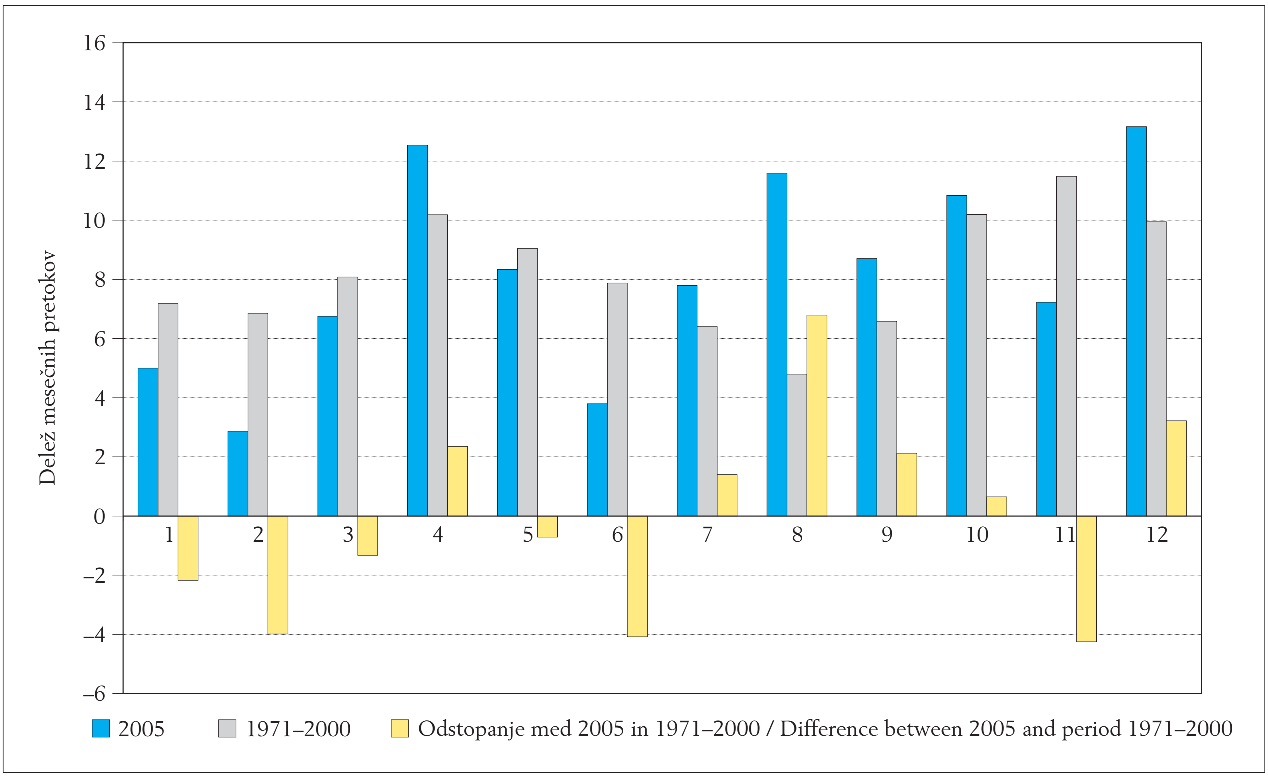
The Monthly Shares of Annual Discharges and Discharge Regimes

The deviations of the monthly discharges in 2005 from the monthly discharges in the 1971–2000 reference period were most pronounced in the summer months, when the river stages were higher than usual. The August deviation stood at 7%. The deviation from the normal discharge regime during that time was highest on smaller rivers in the eastern part of the country (the Ledava River at Polana 31%) and on the Savinja (12%), Krka (8%) and Mura rivers (8%). In February, June and November, the monthly shares were 4% lower than usual. The deviation from the normal discharge regimes in February was between 4 and 6 percent for the major part of the country. The deviation was lower on the Mura and Soča rivers and higher on the Ledava River. Deviations similar to those in February also occurred in June and November. In November, the deviations were higher on the Soča River and lower on the Krka and Kolpa rivers. In March, May, June and October, the discharges were distributed similarly to the discharge distribution in the multi-annual reference period with respect to the total quantity. The monthly discharge shares deviated from the reference period ones by one percent (Figure 9).

Chronological Overview of Hydrological Conditions on Rivers in the Individual Months of the Year

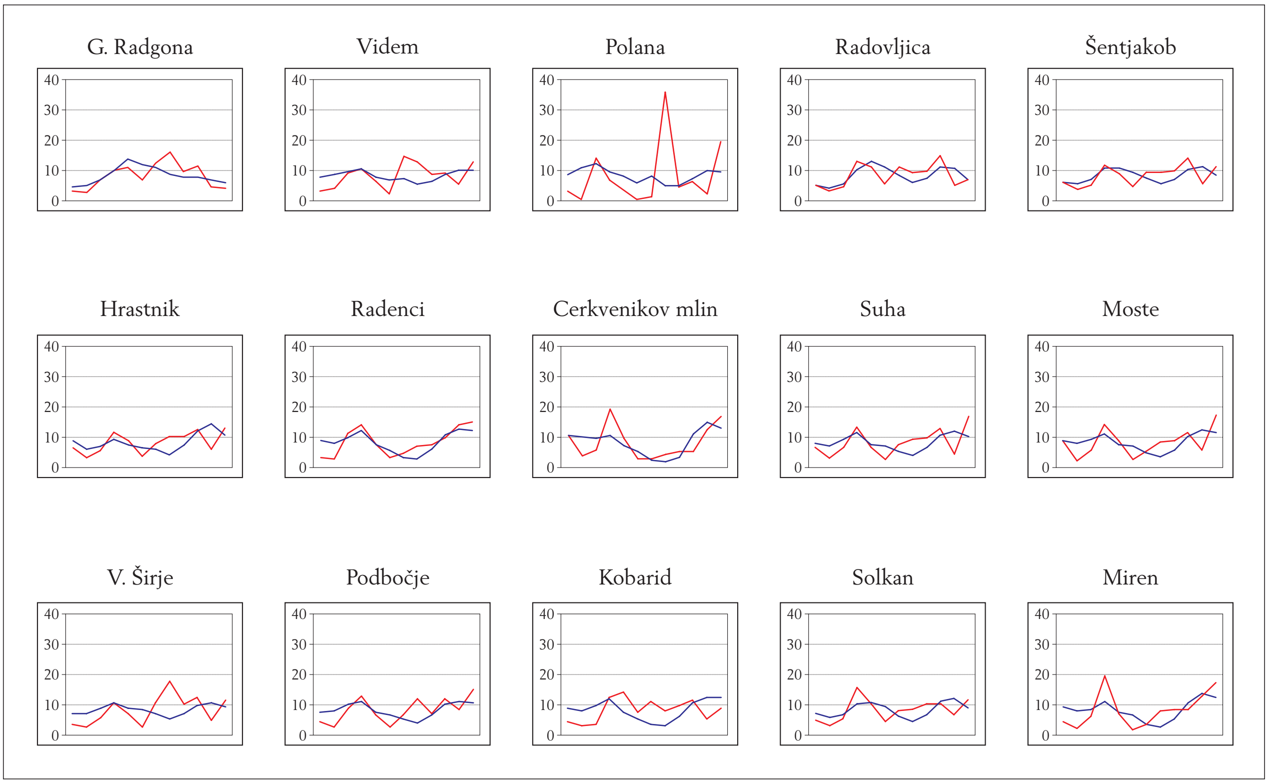
In January, the period of hydrologically dry months beginning in November of 2004, continued. Discharges were higher by somewhat more than a half compared to the average January discharges in the multi-annual reference period.

In February, the low-water conditions on Slovenian rivers were slightly more pronounced than in the previous months. If we exclude the average monthly discharges of the Mura and Drava rivers, which are predominantly recharged in neighbouring Austria and are under the influence of artificial water regimes to



Slika 9: Mesečni deleži letnih pretokov v odstotkih v letu 2005 in obdobju 1971–2000. Na grafu je podano tudi odstopanje mesečnih deležev pretokov v letu 2005 od mesečnih deležev v obdobju 1971–2000.

Figure 9: *The monthly shares of annual discharges expressed in percentages in 2005 and in the 1971–2000 reference period. The graph also gives the deviation of the monthly shares of discharges in 2005 from the monthly discharges in the 1971–2000 reference period.*



Slika 10: Delež mesečnih pretokov v letu 2005 (rdeče linije) in v obdobju 1971–2000 (modra linija) kot ponazoritev odstopanj od ustaljenih režimov pretokov rek na izbranih reprezentativnih lokacijah v letu 2005.

Figure 10: *The share of monthly discharges in 2005 (red lines) and in the 1971–2000 reference period (blue line) to illustrate the deviation from the normal river discharge regimes at the selected representative locations in 2005.*

Kronološki pregled hidroloških razmer na rekah v posameznih mesecih leta

Januarja se je nadaljevalo obdobje hidrološko suhih mesecev, ki se je pričelo novembra leta 2004. Pretoki so bili nekaj več kot polovico večji od povprečnih januarskih pretokov v dolgoletnem primerjalnem obdobju.

Februarja je bilo nizkovodno stanje na slovenskih rekah še nekoliko bolj izrazito kot v predhodnih mesecih. Če izvzamemo povprečna mesečna pretoka Mure in Drave, ki se večinoma napajata v sosednji Avstriji in sta v veliki meri pod vplivom umetnih vodnih režimov, so bili pretoki rek februarja dve tretjini manjši kot v dolgoletnem primerjalnem obdobju.

Marca se je hidrološko suho obdobje nadaljevalo. Pretoki so bili v povprečju okoli 40 odstotkov manjši kot navadno.

Večmesečno obdobje hidrološko suhih mesecev, ki je trajalo od novembra 2004, se je končalo **aprila**. April je bil hidrološko povprečno vodnat. Pretoki so bili v povprečju le nekaj odstotkov manjši kot v dolgoletnem primerjalnem obdobju.

Maj je bil zopet nekoliko hidrološko suh mesec. V povprečju so bili pretoki 23 odstotkov manjši kot navadno v tem mesecu.

Junija se je primanjkljaj vodnatosti glede na dolgoletno povprečno vodnatost še povečal. V povprečju so bili pretoki več kot šestdeset odstotkov manjši kot običajno. Pretoke so občasno povečevale količinsko manjše padavine. Vsi karakteristični junijski pretoki so bili med najmanjšimi v primerjalnem obdobju.

Julija se je vodnatost rek glede na predhodne sušne mesece povečala. V celoti so bili pretoki podobni povprečnim dolgoletnim julijskim pretokom. Prvi del meseca je bil vodnat, drugi suh. Glede na prostorsko porazdelitev je bila vodnatost rek večja kot navadno v severovzhodni Sloveniji, manjša pa na zahodu države. Pod vplivom močnejših lokalnih padavin so se občasno močneje povečali pretoki manjših rek in potokov.

Avgusta je sledilo presenečenje. V povprečju so bili pretoki rek 80 odstotkov večji kot navadno. Reke so močno poplavljale predvsem v vzhodnem delu države. Pretoki rek so bili največji 22. in 23. avgusta, ko so bregove prestopile reke Ljubljanica, Dravinja, Savinja, Krka, Sava in Mura ter njeni pritoki. Najbolj je poplavljala Mura, ostale reke so poplavljale vsakoletna poplavna območja. Več škode so naredili manjši potoki in hudourniki, ki so ob intenzivnih lokalnih padavinah močno narastli. Padavine, tudi preko 100 mm/dan, ki so povzročile izreden porast pretokov, so bile zelo intenzivne in so prihajale večinoma z jugovzhoda. Pretok Mure je bil največji v zadnjih 50 letih. Mura je preplavila inundacijske površine znotraj visokovodnih nasipov ter s tem tudi nekatere javne površine. Visokovodni nasipi ob Muri, ki so jih ponekod utrjevali in nadgrajevali z vrečami peska vzdolž celotnega toka Mure, so bili najbolj ogroženi v spodnjem delu toka reke ob meji

a considerable extent, the river discharges in February were lower by two thirds compared to the multi-annual reference period.

In March, the hydrologically dry period continued. Discharges were around 40% lower than usual on average.

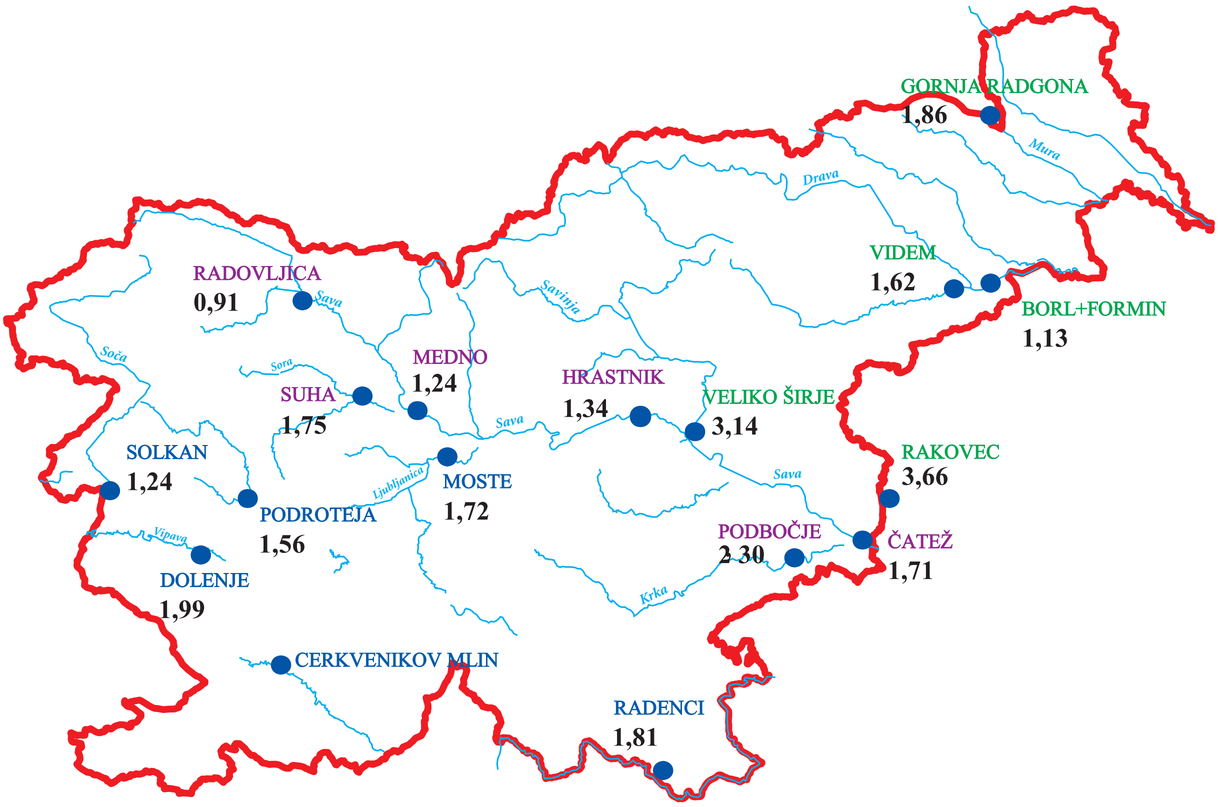
A period of several hydrologically dry months lasting since November 2004 came to an end in **April**. April was a hydrologically average month in terms of the river stages. The discharges were just a few percent lower than in the multi-annual reference period on average.

May was again a somewhat hydrologically dry month. On average, the discharges were 23% lower than usual for the month.

In June, the shortage of water with respect to the multi-annual one increased further. On average, discharges were lower than usual by more than 60%. Discharges were occasionally increased by meagre precipitation. All the characteristic June discharges were among the lowest in the reference period.

In July, the river stages increased compared with the previous months of drought. On the whole, the discharges were similar to the all measured time average July discharges. The first part of the month was water-abundant, while the second was dry. Considering the spatial distribution, the river stages were higher than usual in north-eastern Slovenia and lower in the west of the country. Under the influence of increased local precipitation, the discharges of smaller rivers and creeks occasionally increased significantly.

August brought a surprise as, on average, the river discharges were 80% higher than usual. Rivers caused severe flooding, primarily in the eastern part of the country. River discharges were at their highest on 22 and 23 August, when the Ljubljanica, Dravinja, Savinja, Krka, Sava, and Mura rivers and its tributaries broke their banks. The Mura flooded the most, while other rivers inundated areas that are flooded annually. More damage was caused by smaller creeks and torrents, which incresed significantly during intense local precipitation. Precipitation was very intense, even exceeding 100 mm/day and causing an extraordinary increase in discharges, and came predominantly from the south-east. The discharge of the Mura River was the highest in 50 years. The Mura flooded the inundation areas inside the high-water levees and consequently some public areas. The high-water levees along the Mura, which were reinforced and augmented with sandbags along the entire course of the River, were most at risk in the downstream area along the border with Croatia. The major risk for the parts lying outside the levees diminished after two days. Damage to property caused during the flooding was extensive (Figure 11). River discharges were low and mean in some places in the beginning of August. Precipitation that came in intervals of several days and ranging from 20 mm/day to 30 mm/day (in places even up to 50 mm/day or more)



Slika 11: Razmerja med srednjimi pretoki avgusta 2005 in povprečnimi srednjimi avgustovskimi pretoki v dolgoletnem obdobju na slovenskih rekah.

Figure 11: *The ratios between the mean discharges in August 2005 and the average mean August discharges in the multi-annual reference period on Slovenian rivers.*

s Hrvaško. Večja ogroženost predelov izven nasipov se je zmanjšala po dveh dneh. Materialna škoda ob poplavah je bila velika (slika 11). Pretoki rek so bili v začetku avgusta mali do ponekod srednji. Padavine od 20 mm/dan do 30 mm/dan, ponekod do 50 mm/na dan ali več so v nekajdnevnih presledkih povečevale pretoke rek do srednjih in velikih vrednosti. Visokovodne konice ob povečanih pretokih so se zaradi vedno večje namočenosti zemljin ter večjih začetnih pretokov sčasom povečevale. Dne 21. in 22. avgusta so močne padavine povzročile izreden porast pretokov rek, kar je zapisano v prispevku: Visoke vode in poplave med 20. in 23. avgustom 2005 (M. Kobold in M. Sušnik). V zadnjih dneh avgusta so se pretoki večinoma zmanjševali.

Septembra so bili pretoki rek v celoti zopet tretjino manjši kot v dolgoletnem primerjalnem obdobju.

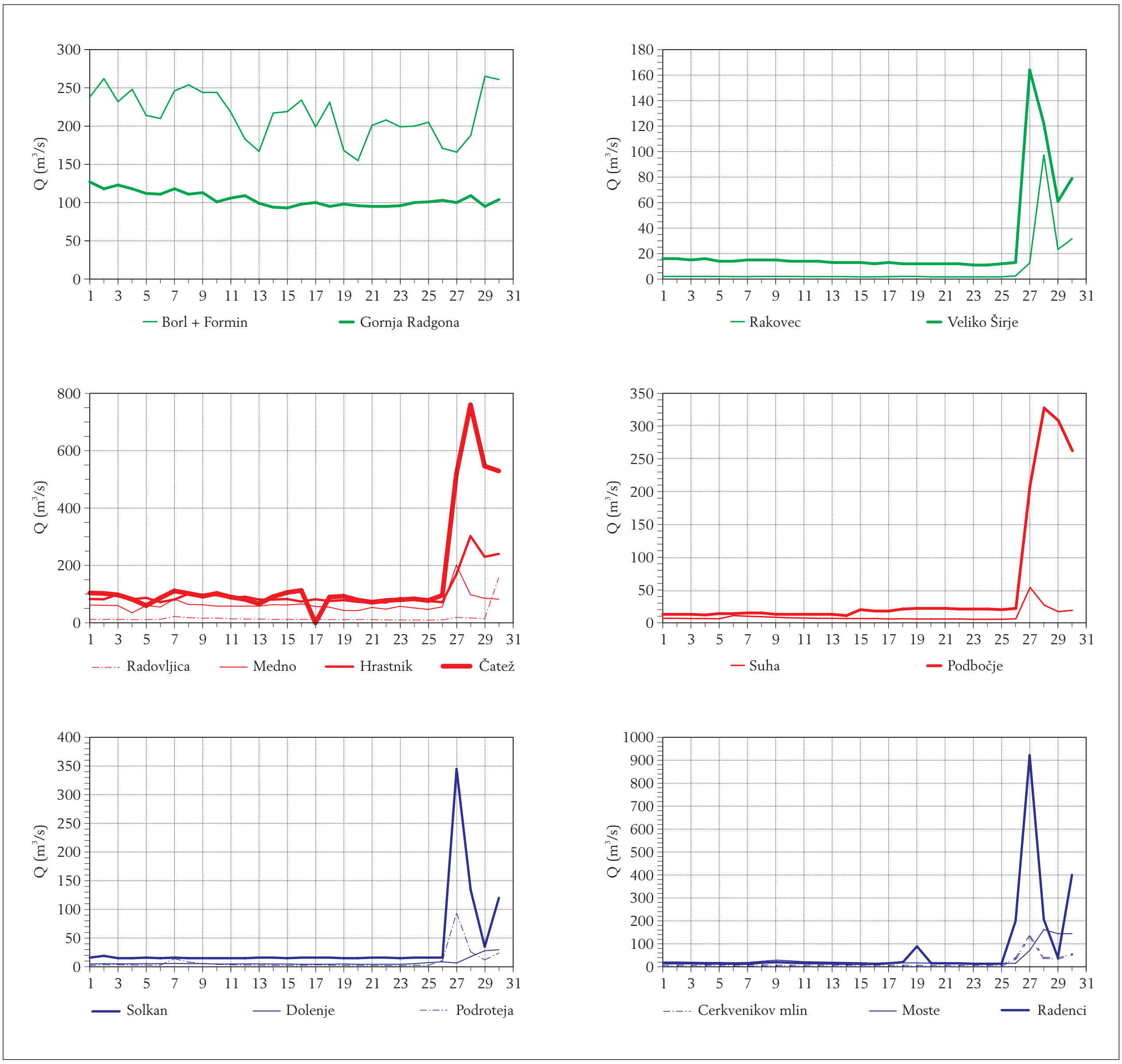
Oktober je bil nadpovprečno vodnat. Petega in šestega oktobra so se pretoki rek močneje povečali in predvsem v vzhodnem delu države so reke prestopile bregove. Poplavljale so reke Mura, Drava, Dravinja, Hudinja ter hudourniki na Štajerskem in Koroškem. V območju vsakoletnih poplav je poplavljala tudi Ljubljanica. Na zahodu Slovenije so bili pretoki rek nekoliko manjši kot drugje.

increased the river discharges up to the mean and high values. High-water peaks during periods of increased discharges gradually increased because of the increasing water content in the soil and the higher initial discharges. On 21 and 22 August, severe precipitation caused an extraordinary increase in river discharges, mentioned in the article: High Waters and Floods between 20 and 23 August 2005 (M. Kobold and M. Sušnik). Discharges for the most part diminished in the last days of August.

In September, the river discharges were, on the whole, again lower by a third than in the multi-annual reference period.

October had above-average river stages. On 5 and 6 October, river discharges increased more significantly and rivers broke their banks, primarily in the eastern part of the country. The Mura, Drava, Dravinja and Hudinja rivers and torrents in Štajerska (Styria) and Koroška (Carinthia) were flooding. The Ljubljanica River also flooded the areas that are flooded each year. In western Slovenia, river discharges were slightly lower than elsewhere.

In November, river discharges were low for the major part of the month, and it was only in the last days that the precipitation and snowmelt increased discharges



Slika 12: Srednji dnevni pretoki nekaterih slovenskih rek novembra 2005. Pretoki so bili večji del meseca majhni, v noči na 26. november so padavine in taljenje snega povečale pretoke do velikih pretokov.

Figure 12: *The mean daily discharges of some Slovenian rivers in November 2005. Discharges were low for the major part of the month and during the night on 26 November the precipitation and snowmelt increased the discharges up to the high levels.*

Novembra so bili pretoki rek večji del meseca majhni, le v zadnjih dneh so padavine in taljenje snega povečali pretoke do srednjih in velikih pretokov. V teh dneh sta predvsem kraški reki Krka in Ljubljanica poplavljali širša poplavna območja. V povprečju so bili pretoki polovico manjši kot v primerjalnem obdobju.

Decembra se je vodnatost rek zopet povečala. Največ vode je glede na dolgoletno primerjalno obdobje decembra preteklo po Ljubljanici, Krki, Sotli in notranjski Reki. Na omenjenih rekah so bili pretoki več kot pol-krat večji kot navadno. Poplavljale so reke Ljubljanica, Krka, Sotla in Mestinjščica.

Podrobneje so hidrološke razmere na rekah v letu 2005 opisane v Mesečnih biltenih Agencije Republike Slovenije za okolje.

up to the mean and high discharges. During these last days, it was primarily the karstic Krka and Ljubljanica rivers that inundated their flood plains. On average, the discharges were lower by a half compared to the reference period.

In December, the river stages increased again. Compared to the multi-annual reference period, the most water in December flowed in the Ljubljanica, Krka, Sotla and Notranjska Reka rivers. The discharges in these rivers were higher than usual by more than a half. The Ljubljanica, Krka, Sotla and Mestinjščica rivers were also flooding.

Detailed descriptions of the hydrological conditions on rivers in 2005 are given in the monthly bulletins of the Environmental Agency of the Republic of Slovenia.

Temperature rek in jezer

Barbara Vodenik

Leta 2005 je bila povprečna temperatura (povprečje je izračunano iz srednjih letnih temperatur na postajah) Mure, Ledave, Dravinje, Save, Kamniške Bistrice, Ljubljanice, Savinje, Vipave in Soče 9,5 °C, kar je za 0,9 °C manj kot v večletnem primerjalnem obdobju, povprečna temperatura Blejskega in Bohinjskega jezera pa je znašala 11,3 °C, kar je za 0,1 °C več kot v primerjalnem obdobju. Odstopanje od večletnega povprečja pri rekah je bilo izrazito v avgustu, ko je bila povprečna temperatura rek za 2,1 °C pod dolgoletnim povprečjem, in v juniju, ko je bila 1,6 °C nad dolgoletnim povprečjem. Odstopanje od večletnega povprečja pri obeh jezerih je bilo največje v juniju, ko je povprečna temperatura jezer za 1,6 °C presegla dolgoletno povprečje, in v marcu, ko je bila 1,4 °C pod dolgoletnim povprečjem. Za izračun povprečja so upoštevani podatki na petih postajah za obdobje 1954–2004, le za Muro, Ledavo, Dravinjo, Savinjo, Vipavo in Blejsko jezero so nizi podatkov krajši.

Časovno spreminjanje temperatur rek

Temperature rek so bile januarja in februarja med 0 °C in 8,4 °C. Konec januarja sta Mura in Savinja dosegli najnižje letne vrednosti in sicer 0 °C. Med petim in desetim februarjem pa so najnižje letne vrednosti izmerili na Dravinji, Savi, Kamniški Bistrici, Savinji, Vipavi in Soči in sicer med 0 °C in 2,7°C (preglednica 4). Obdobje nizkih temperatur je bilo najdaljše na Ledavi v Polani, kjer se je temperatura vrtela okoli ledišča v obdobju od 25. 1. do 12. 3. in je bil 16 dni na vsej strugi led, ob bregu pa 32 dni. V drugi polovici marca se je temperatura vode postopoma zviševala. V aprilu ni bilo večjih nihanj, le v zadnji dekadi aprila je temperatura rek začela strmo naraščati vse do tretjega maja, ko je temperatura Ledave znašala kar 18,6 °C, Dravinje pa 17,8 °C. Nato so se temperature zniževale, konec meseca pa spet dosegle zelo visoke vrednosti in sicer Dravinja 22,4 °C in Ledava 20,8 °C. Junij je bil vroč in zaradi pomanjkanja padavin so bili pretoki slovenskih rek močno pod dolgoletnim povprečjem. To je vplivalo na temperature rek zlasti v drugi polovici meseca. Dravinja in Soča sta že v juniju dosegli najvišje letne vrednosti (preglednica 5). V začetku julija so hitremu padcu sledile nizke temperature vode. V drugi polovici julija pa se je temperatura rek ponovno dvignila in večina rek je zadnjega julija ali prve dni avgusta dosegla najvišje letne vrednosti. Znatna ohladitev rek je sledila po prvih dneh avgusta, ko so se temperature vode v nekaj dneh znižale za 8,6 °C na Dravinji, 7,8 °C na Ledavi, 7,4 °C na Vipavi in 6,8 °C na Savinji. Temperature

The temperatures of rivers and lakes

Barbara Vodenik

In 2005, the average temperature (calculated from the mean annual temperatures at the hydrometric stations) of the Mura, Ledava, Dravinja, Sava, Kamniška Bistrica, Savinja, Vipava and Soča rivers was 9.5 °C, which is 0.9 °C lower than in the multi-annual reference period. The average temperature of lakes Bled and Bohinj amounted to 11.3 °C, which is 0.1 °C higher than in the reference period. The deviation from the multi-annual mean in the rivers was pronounced in August (when the average temperature of the rivers was 2.1 °C below the multi-annual mean) and in June (when it was 1.6 °C above the multi-annual mean). The deviation from the multi-annual mean of both lakes was greatest in June (when the average lake temperature exceeded the multi-annual mean by 1.6 °C) and in March (when it was 1.4 °C below the multi-annual mean). To calculate the mean value, we took into account the data from five stations for the 1954–2004 period, while the series was only shorter for the Mura, Ledava, Dravinja, Savinja and Vipava rivers and Lake Bled.

The Timeline of River Temperature Changes

The river temperatures in January and February were between 0 °C and 8.4 °C. At the end of January, the Mura and Savinja rivers achieved the lowest annual values, namely 0 °C. Between the 5th and the 10th of February, the lowest annual values were measured on the Dravinja, Sava, Kamniška Bistrica, Savinja, Vipava and Soča rivers, namely between 0 °C and 2.7 °C (Table 4). The period of low temperatures was longest on the Ledava River at Polana, where the temperature ranged around the freezing point from 25 January to 12 March and the ice sheet persisted for 16 days in the entire river channel and for 32 days along the riverbank. In the second half of March, the water temperature gradually increased. There were no major fluctuations in April. It was only in the last third of April that the temperatures of the rivers started increasing steeply until 3 May, when the temperature of the Ledava was as high as 18.6 °C and that of the Dravinja 17.8 °C. Then the temperatures decreased but, at the end of the month, reached very high values again with 22.4 °C on the Dravinja and 20.8 °C on the Ledava. June was a hot month and the lack of precipitation caused the discharges of Slovenian rivers to decrease to significantly below the multi-annual mean. This affected the river temperatures in the second half of the month especially. The Dravinja and Soča reached their highest annual values as early as June (Table 5). In the beginning of July, a rapid decrease was

Ledave in Savinje je v prvi polovici septembra spet nekoliko narasla, temperature ostalih rek pa se v povprečju niso znatno spreminjale vse do druge polovice septembra, nakar so se z večjimi ali manjšimi nihanji zniževale vse do konca leta. Grafični prikaz je objavljen v II. delu publikacije.

Časovno spreminjanje temperatur jezer

Temperatura Blejskega jezera se je cel januar postopoma zniževala, februarja se skoraj ni spreminjala, v marcu pa je najprej počasi, proti koncu meseca pa strmo naraščala. Bohinjsko jezero se je sredi januarja hitro ohladilo na 0 °C, nakar se temperatura vode ni spreminjala vse do sredine marca. Obe jezeri sta se od druge polovice marca z večjimi ali manjšimi nihanji začeli segrevati in sta dosegli najvišje letne vrednosti v začetku avgusta. Nato se je temperatura postopno zniževala vse do konca leta. Najnižja letna vrednost temperature Bohinjskega jezera je bila izmerjena v drugi polovici januarja in sicer 0 °C, Blejskega jezera pa zadnjega januarja in sicer 2,6 °C. Bohinjsko jezero je bilo vse leto hladnejše od Blejskega in sicer v celoletnem povprečju za 2,9 °C.

Primerjava značilnih temperatur rek z večletnim obdobjem

V prvih treh mesecih so bile srednje mesečne temperature nižje kot v primerjalnem obdobju in sicer se januarja 2005 povprečne temperature rek niso veliko razlikovale od dolgoletnega povprečja. Povprečna temperatura 3,4 °C je bila za 0,5 °C nižja kot v primerjalnem obdobju. Februarja in marca je bila povprečna temperatura rek 2,8 °C oz. 5,2 °C kar je 1,6 °C oz. 1,2 °C manj kot v večletnem primerjalnem obdobju. Aprila je povprečna temperatura rek znašala 8,8 °C in je bila enaka obdobni vrednosti. V maju in juniju so bile povprečne temperature rek višje kot navadno, v maju 12,7 °C in v juniju 15,9 °C. V juniju so povprečne mesečne temperature presegle dolgoletno povprečje za 1,6 °C. Pri posameznih rekah je najvišja odstopanja od dolgoletnega povprečja v juniju opaziti na Savi v Litiji (3,6 °C), na Soči v Solkanu (3,0 °C), Vipavi v Mirnu (2,0 °C) in na Savinji v Celju (1,8 °C) (slika 13). V juliju je povprečna temperature rek znašala 16,2 °C, kar je za 0,1 °C manj kot v primerjalnem obdobju. Največje odstopanje od dolgoletnega povprečja je opaziti v avgustu, povprečje mesečnih temperatur rek je bilo za 2,1 °C nižje kot v primerjalnem obdobju. Največje odstopanje od dolgoletnega povprečja je bilo na Dravinji v Vidmu (4,2 °C), na Vipavi v Mirnu (3,5 °C), ter na Muri v Gornji Radgoni in Ljubljanici v Mostah (3,0 °C). Od septembra do decembra se povprečne temperature rek niso bistveno razlikovale od obdobnih vrednosti.

followed by low water temperatures, but in the second half of July, the temperature of the rivers rose again and the majority of them reached their highest annual values on the last day of July or in the first days of August. A substantial cooling came after the first days of August, when the water temperatures decreased by 8.6 °C on the Dravinja, 7.8 °C on the Ledava, 7.4 °C on the Vipava and 6.8 °C on the Savinja in just a few days. The temperatures of the Ledava and Savinja rose slightly again in the first half of September, though the average temperatures of other rivers did not significantly change until the second half of September, after which they decreased to the end of the year with higher or lower fluctuations. The data is shown in part II of this publication.

The Timeline of Lake Temperature Changes

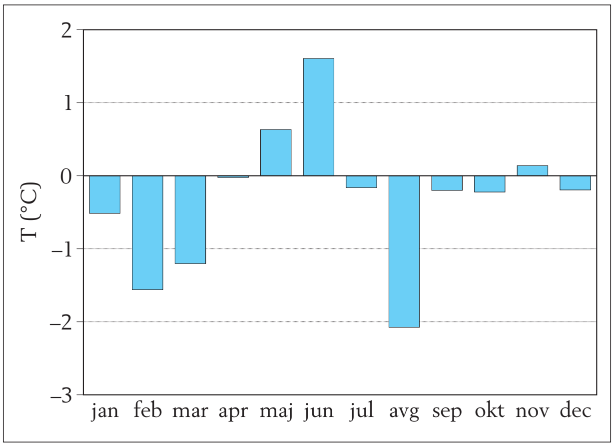
The temperature of Lake Bled decreased gradually throughout January. In February, it was almost constant, while in March it increased – slowly at first and then rapidly towards the end of the month. Lake Bohinj cooled rapidly to 0 °C in the middle of January, after which the water temperature did not change until the middle of March. Both lakes started warming up from the second half of March onwards with larger or smaller fluctuations, reaching the highest annual values in the beginning of August. Then the temperature gradually decreased through to the end of the year. The lowest annual value of the temperature of Lake Bohinj was measured in the second half of January, namely 0 °C, while that of Lake Bled was measured on the last day of January at 2.6 °C. Lake Bohinj was cooler than Lake Bled throughout the year by 2.9 °C on an annual average.

Comparison of the Characteristic River Temperatures with the Normals

In the first three months, the mean monthly temperatures were lower than in the reference period, though the average river temperatures in January of 2005 did not differ much from the normals. The average temperature of 3.4 °C was 0.5 °C lower than in the reference period. In February and March, the average river temperature was 2.8 °C and 5.2 °C, which is 1.6 °C and 1.2 °C less than in the multi-annual reference period. In April, the average river temperature amounted to 8.8 °C and was equal to the reference period value. In May and June, the average river temperatures were higher than usual, namely 12.7 °C in May and 15.9 °C in June. In June, the average monthly temperatures exceeded the normals by 1.6 °C. When we look at the individual rivers, the greatest deviations from the normals in June could be observed on the Sava River at

Slika 13: Odstopanja srednjih mesečnih temperatur rek v letu 2005 od srednjih mesečnih temperatur obdobja v °C.

Figure 13: *The deviations of the mean monthly river temperatures in 2005 from the mean monthly temperatures of the reference period in °C.*



Slika 14: Odstopanja srednjih mesečnih temperatur v letu 2005 od srednjih mesečnih temperatur primerjalnega obdobja na izbranih rekah. Odstopanja so izračunana kot povprečja odstopanj na desetih rečnih merilnih postajah.

Figure 14: *The deviations of the mean monthly temperatures in 2005 from the mean monthly temperatures of the reference period on the selected rivers. The deviations are calculated as deviation averages from ten river gauging stations.*

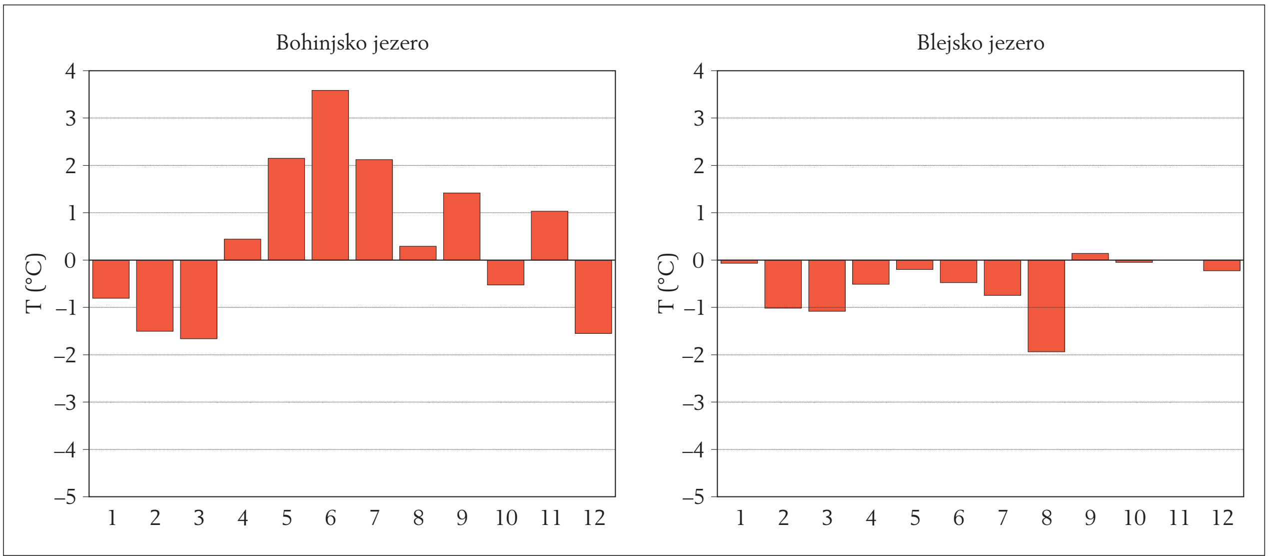
Litija (3.6 °C), the Soča River at Solkan (3.0 °C), the Vipava River at Miren (2.0 °C) and the Savinja River at Celje (1.8 °C) (Figure 13). In July, the average temperature of the rivers was 16.2 °C, which is 0.1 °C lower than in the reference period. The greatest deviations from the normals could be observed in August, when the average monthly temperature of the rivers was 2.1 °C lower than in the reference period. The greatest deviation from the normals was observed on the Dravinja River at Videm (4.2 °C), the Vipava River at Miren (3.5 °C), the Mura River at Gornja Radgona and the Ljubljanica River at Moste (3.0 °C). From September to December, the average river temperatures did not differ significantly from the reference period values.

Primerjava značilnih temperatur jezer z večletnim obdobjem

Januarja 2005 je bila temperatura Blejskega jezera enaka obdobni vrednosti, temperatura Bohinjskega jezera pa je bila za 0,8 °C nižja kot navadno. Februarja in marca so bile povprečne temperature obeh jezer od 1,0 °C do 1,5 °C nižje od obdobnih vrednosti. Aprila temperature niso veliko odstopale od povprečja. Maja, junija in julija so srednje mesečne temperature Bohinjskega jezera presegale dolgoletno povprečje kar za 2,1 °C, 3,5 °C in 2,0 °C. Srednje mesečne temperature Blejskega jezera pa so bile v teh mesecih nekoliko nižje od dolgoletnega povprečja. Avgusta je od dolgoletnega povprečja znatno odstopala samo srednja mesečna temperatura Blejskega jezera, ki je bilo hladnejše za 2,0 °C. Od septembra do decembra je opaziti odstopanje od dolgoletnega povprečja samo pri Bohinjskem jezeru.

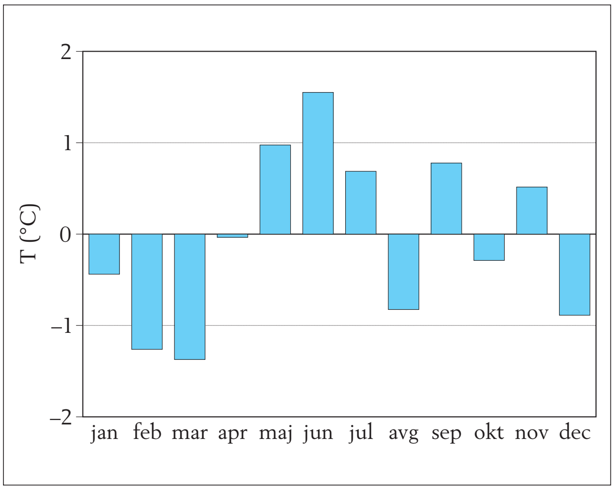
Comparison of the Characteristic Temperatures of Lakes with the Normals

In January 2005, the temperature of Lake Bled was equal to the reference period value, while the temperature of Lake Bohinj was 0.8 °C lower than usual. In February and March, the average temperatures of both lakes were lower than the reference period values by 1.0 °C to 1.5 °C. In April, the temperatures did not deviate much from the average. In May, June and July, the mean monthly temperatures of Lake Bohinj exceeded the normals by as much as 2.1 °C, 3.5 °C and 2.0 °C. The mean monthly temperatures of Lake Bled in these months were lower than the normals. In August, only the mean monthly temperature of Lake Bled deviated significantly from the normals, being cooler by 2.0 °C. From September to December, a deviation from the normals could only be observed on Lake Bohinj.



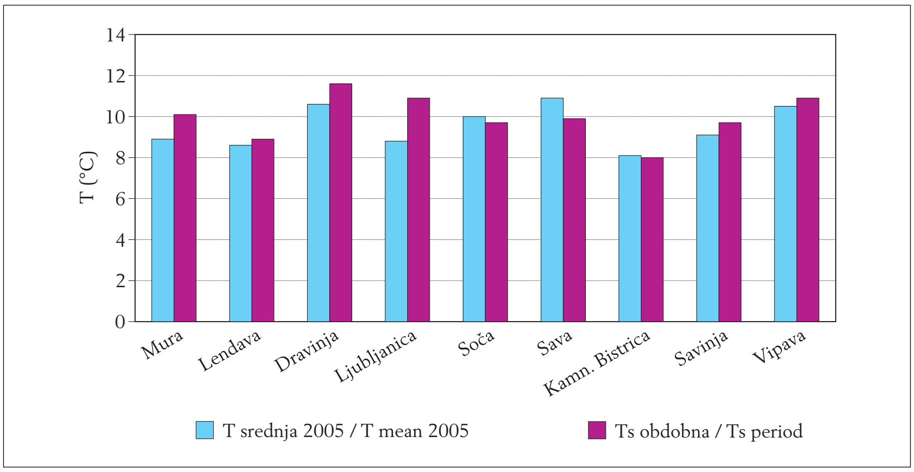
Slika 15: Odstopanja srednjih mesečnih temperatur jezer v letu 2005 od srednjih mesečnih temperatur obdobja.

Figure 15: *The deviations of the mean monthly river temperatures in 2005 from the mean monthly temperatures of the reference period.*

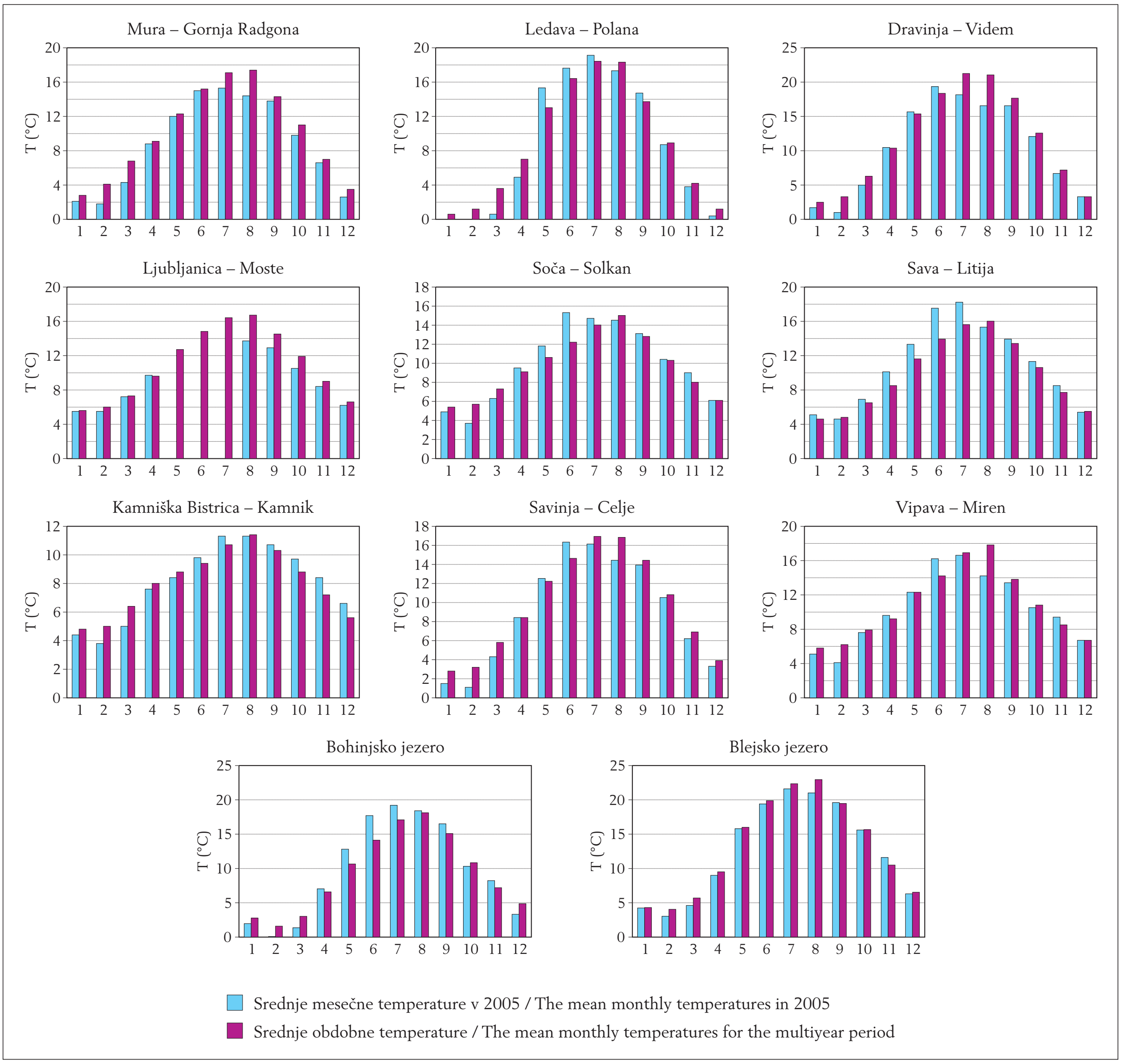


Slika 16: Odstopanja srednjih mesečnih temperatur v letu 2005 od srednjih mesečnih temperatur primerjalnega obdobja na Bohinjskem in Blejskem jezeru.

Figure 16: *The deviations of the mean monthly temperatures in 2005 from the mean monthly temperatures of the reference period on Lake Bled and Lake Bohinj.*



Slika 17a: Primerjava srednjih letnih temperatur rek in jezer v letu 2005 s srednjimi letnimi temperaturami obdobja.
Figure 17a: *Comparison of the annual temperatures rivers and lakes in 2005 with the mean annual period temperatures.*



Slika 17b: Primerjava srednjih mesečnih temperatur rek in jezer v letu 2005 s srednjimi mesečnimi temperaturami obdobja.
Figure 17b: *Comparison of the mean monthly temperatures rivers and lakes in 2005 with the mean monthly period temperatures.*

Preglednica 4: Najnižje temperature izbranih rek in jezer v letu 2005 in v obdobju.
Table 4: *The lowest temperatures of selected rivers and lakes in 2005 and in the reference period.*

Vodotok *Stream*	Vodomerna postaja *Gauging Station*	Leto 2005 / *Year 2005* Tnk	Datum / *Date*	Obdobje / *Period* Tnk	Datum / *Date*	Časovni niz
Mura	Gornja Radgona	0	30. 1.	0	4. 1. 1997	1989–2004
Ledava	Polana	0	1. 1.	0	28. 12. 1973	1962–2004
Dravinja	Videm	0	8. 2.	0	17. 2. 1983	1982–2004
Ljubljanica	Moste	3,9	27. 11.	1,0	11. 2. 1956	1954–2004
Soča	Solkan	2,7	5. 2.	0	15. 2. 1956	1953–2004
Sava	Litija	1,4	10. 2.	0	3. 2. 1954	1953–2004
Kamn. Bistrica	Kamnik	2,0	8. 2.	1,0	2. 2. 1991	1954–2004
Savinja	Celje	0	30. 1.	0	1. 12. 1973	1973–2004
Vipava	Dornberk	0,6	10. 2.	0,1	6. 1. 1985	1980–2004
Blejsko jezero	Mlino	2,6	31. 1.	1,2	29. 1. 1987	1985–2004
Bohinjsko jezero	Sveti Duh	0	21. 1.	0	14. 2. 1952	1951–2004

Preglednica 5: Najvišje temperature izbranih rek in jezer v letu 2005 in v obdobju
Table 5: *The highest temperatures of selected rivers and lakes in 2005 and in the reference period.*

Vodotok *Stream*	Vodomerna postaja *Gauging Station*	Leto 2005 / *Year 2005* Tvk	Datum / *Date*	Obdobje / *Period* Tvk	Datum / *Date*	Časovni niz
Mura	Gornja Radgona	19,0	31. 7.	23,3	23. 7. 2003	1989–2004
Ledava	Polana	22,8	31. 7.	25,9	12. 8. 2003	1962–2004
Dravinja	Videm	24,2	29. 6.	28,6	2. 8. 1994	1982–2004
Ljubljanica	Moste	17,7	31. 7.	23,8	16. 8. 1988	1954–2004
Soča	Solkan	18,6	27. 6.	20,0	9. 8. 1994	1953–2004
Sava	Litija	22,6	1. 8.	24,6	8. 8. 2003	1953–2004
Kamn. Bistrica	Kamnik	13,1	7. 8.	18,4	28. 8. 1992	1954–2004
Savinja	Celje	20,7	31. 7.	24,0	10. 8. 1994	1973–2004
Vipava	Dornberk	20,2	3. 8.	24,0	13. 8. 2003	1980–2004
Blejsko jezero	Mlino	23,8	31. 7.	25,4	9. 8. 1998	1985–2004
Bohinjsko jezero	Sveti Duh	23,0	3. 8.	24,1	31. 7. 1983	1951–2004

Vsebnost in transport suspendiranega materiala v rekah

mag. Florjana Ulaga

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 2005 smo redna merjenja vsebnosti suspendiranega materiala izvajali na štirih 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, ki ga analiziramo 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. Na postajah Radovljica na Savi in Suha na Sori je potekal občasen odvzem vzorcev z avtomatskim vzorčevalnikom. Vzorčevalnika sta bila zaradi nizkih temperatur pozimi izklopljena, zato na teh dveh merilnih mestih nimamo podatkov o vsebnosti suspendiranega materiala za celo leto.

Poleg rednega odvzema in analiziranja vzorcev poteka tudi odvzem vzorcev ob izrednih hidroloških razmerah na petih 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 2005 potekali na Dravinji v Vidmu, na Sotli v Rakovcu, na Soči v Kobaridu, na Idrijci v Hotešku in na Bači v Bači pri Modreju.

Nekajkrat letno se na vseh vodomernih postajah monitoringa suspendiranega materiala opravljajo profilne meritve suspendiranega materiala: vzorci se odvzamejo v večih 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 A v III. delu publikacije.

Rezultati meritev vsebnosti suspendiranega materiala

Ob pregledu izmerjenih vsebnosti suspendiranega materiala v letu 2005 na postajah z dnevnim odvzemom

The concentration and transport of suspended material in rivers

Florjana Ulaga, MSc

The Environmental Agency of the Republic of Slovenia (ARSO) is carrying out monitoring of the total quantity of suspended material that is transported through a selected transverse cross-section of a stream within a defined time unit. 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 the measured river discharge. The majority of material is transported during high-water periods and sampling therefore needs to be performed frequently during periods of high-water waves.

In 2005, regular measurements of suspended material concentration were performed at four hydrometric stations: at Gornja Radgona on the Mura River, at Hrastnik on the Sava River, at Veliko Širje on the Savinja River and at Miren on the Vipava River. 1-litre water samples were taken once daily at these gauging stations and analysed at the laboratory using classic filtration methods The results of the analyses are the measured concentrations of suspended material (c) in g/m^3 of water. The results of the measurements are published in the second part of the publication. Occasional sampling took place at the Radovljica station on the Sava River and the Suha station on the Sora River using the automatic sampler. The samplers were deactivated during the winter because of low temperatures, which is why we do not have data on the concentration of suspended material at these two gauging sites for the entire year.

In addition to regular sampling and analysis, extraordinary samples are also taken during extreme hydrological conditions at five supplementary hydrometric stations. Through analyses of these samples taken by the supplementary network, data from the regular measurements can be more easily and accurately evaluated, while the results give an overview of the high-water conditions throughout Slovenia. Manual extraordinary sampling in 2005 took place on the Dravinja River at Videm, on the Sotla River at Rakovec, the Soča River at Kobarid, the Idrijca River at Hotešk and the Bača River at Bača near Modrej.

Cross-section measurements of suspended material are performed at all the water gauging stations with suspended material monitoring several times a year. This is where samples are taken at a number of points along the transverse cross-section. Based on the material concentrations in the samples taken, the mean cross-section concentration is calculated and, with the help of the river discharge values, the instantaneous transport

Odvzem vzorca z batometrom (foto: Florjana Ulaga).
Suspended material water sampler (Photo: Florjana Ulaga).

vzorcev smo ugotovili, da je bila na vodomerni postaji v Hrastniku na Savi v začetku decembra izmerjena največja vsebnost doslej. V Muri in Savinji smo izmerili povečano vsebnost v času visokih voda v avgustu. V Muri je bila največja izmerjena vsebnost 22. 8. Kar 27-krat je presegla povprečno obdobno vsebnost suspendiranega materiala v vodi. Tudi naslednje dni je bila vsebnost nadpovprečna. V Savinji smo izmerili 5982 g/m^3, kar je 100-kratni presežek povprečne obdobne vsebnosti. To je v Savinji v obdobju spremljanja od leta 1967 tretja največja izmerjena vsebnost suspendiranega materiala.

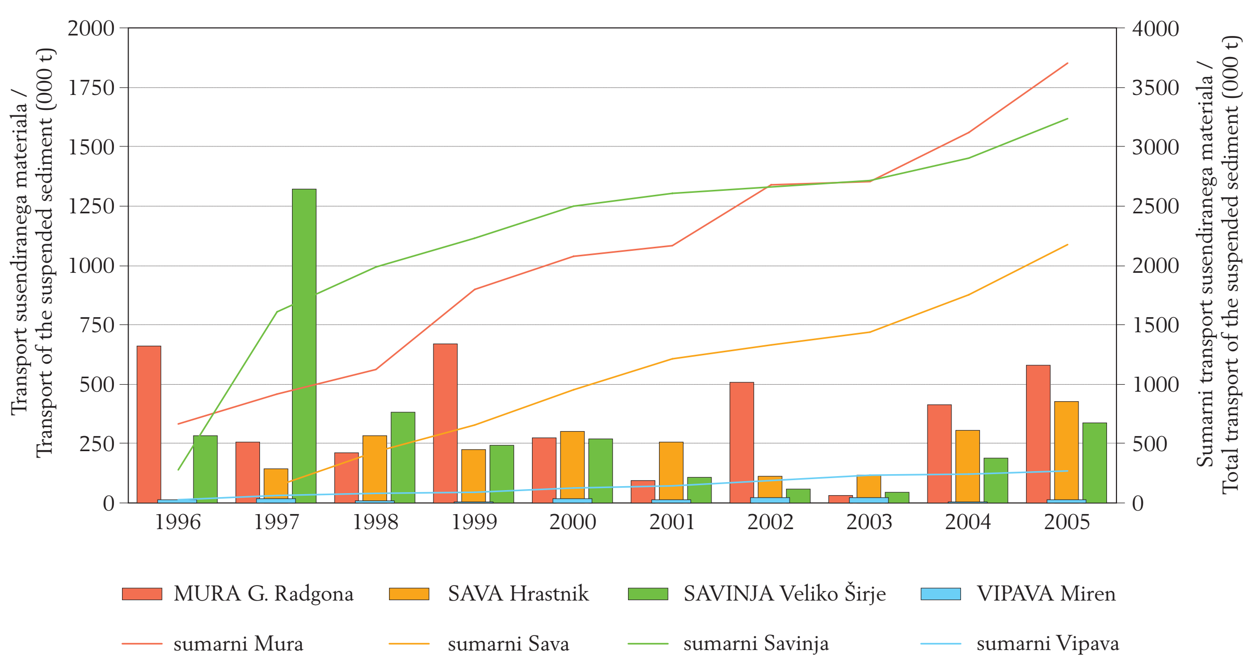
Na postajah dopolnilne mreže so bili vzorci z veliko vsebnostjo suspendiranega materiala odvzeti v pomladnih ter poletnih mesecih. V času visokih voda med

of suspended material can be calculated. The network of hydrometric stations where sampling takes place is shown in Map A in part III of this publication.

The Results of Suspended Material Concentration Measurements

On reviewing the measured concentrations of suspended material in 2005 from stations with daily sampling, we found that the greatest concentration till now was measured at the hydrometric station at Hrastnik on the Sava River in the beginning of December. In the Mura and Savinja rivers, we measured increased concentrations during high-water conditions in August. The highest measured concentration in the Mura River was 22th of August. The average reference period concentration of suspended material in the Mura River was exceed 27-fold. Even in the days that followed, the concentration remained above-average. In the Savinja River, we measured 5982 g/m^3, which means that the average reference period value was exceeded 100-fold. This is the third highest concentration of suspended material measured in the Savinja since observations started in 1967.

At the stations of the supplementary network, samples with high suspended material concentrations were taken in the spring and summer months. During the high-water conditions between 20 and 30 August 2005, samples were also taken at an additional 19 hydrometric stations in the supplementary network. Some of the results of the analysis can be seen in Table 3. The abundant precipitation in August was reflected in the



Slika 18: Vsebnost suspendiranega materiala, pretok in padavine za Muro in Savinjo v avgustu 2005.
Figure 18: *The suspended material concentration, discharge and precipitation for the Mura and Savinja rivers in August of 2005.*

Preglednica 6: Največje vsebnosti suspendiranega materiala vzorcev izbranih postaj z enkrat dnevnim odvzemom v letu 2005 in v obdobju 1985–2004.

Table 6: *The maximum concentration of suspended material in samples from selected stations with daily samplings from 2005 and from the 1985–2004 period.*

Vodotok / – *Stream* Vodomerna postaja / *Gauging station*	2005 Vsebnost c (g/m^3) *Concentration c (g/m^3)*	2005 Datum odvzema vzorca *Date of sampling*	1985–2004 Največja obdobna vsebnost c (g/m^3) *The highest concentration in the period*	1985–2004 Datum največje obdobne vsebnosti *Date of the highest concentration in the period*	1985–2004 Srednja obdobna vsebnost *Mean concentration in the period*
Mura – G. Radgona	1247	22. 08.	2364	16. 05. 1996	46,3
Sava – Hrastnik*	2200	06. 12.	885	01. 11. 2004	21,7
Savinja – Veliko Širje	5982	21. 08.	6026	07. 11. 2000	59
Vipava – Miren	1013	21. 11.	1105	27. 10. 2004	18,4

* vzorčenje poteka od leta 1997

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*	2005 Vsebnost c (g/m^3) *Concentration c (g/m^3)*	2005 Datum odvzema vzorca *Date of sampling*	1990–2004 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	836	11. 07.	4832	22. 05. 1999	4627	26. 01. 2001
Rakovec	Sotla	497	13. 04.	1818	14. 04. 2002	758	11. 07. 1999
Kobarid	Soča	487	08. 07.	8112	17. 11. 2000	3200	05. 10. 2003
Hotešk	Idrijca	254	05. 12.	3743	09. 10. 1993	2988	01. 11. 1990
Bača pri Modreju	Bača	129	09. 04.	3086	10. 10. 2005	1959	27. 10. 1990
Radovljica	Sava	344	05. 08.				
Suha	Sora	267	01. 07.				

Preglednica 8: Vsebnost suspendiranega materiala v času avgustovskih visokih voda na vodomernih postajah dopolnilne mreže monitoringa suspendiranega materiala.

Table 8: *The suspended material concentration during the high-water conditions in August at hydrometric stations of the supplementary suspended material monitoring network.*

2005	Reka *Stream*	Vodomerna postaja *Gauging station*	Vsebnost suspendiranega materiala c (g/m^3) *Concentration of suspended sediment c (g/m^3)*
22. 8.	Sava	Jesenice na Dolenjskem	609,55
22. 8.	Sava	Čatež	352,37
22. 8.	Mirna	Martinja vas	101,11
22. 8.	Mirna	Jelovec	178,19
22. 8.	Radulja	Škocjan	145,42
24. 8.	Prečna	Prečna	83,76
24. 8.	Krka	Podbukovje	5,27
24. 8.	Krka	Soteska	8,82
24. 8.	Radešca	Meniška vas	2,50
24. 8.	Mlinščica	Domžale	2,42
24. 8.	Višnjica	Trebnja Gorica	6,68
25. 8.	Pšata	Pšata	4,69
25. 8.	Pšata	Topole	4,40
25. 8.	Pšata	Trzin	8,59
25. 8.	Rača	Podrečje	5,36
25. 8.	Rača	Vir	10,61
25. 8.	Kamniška Bistrica	Vir	2,85
25. 8.	Kamniška Bistrica	Kamnik	2,38
26. 8.	Nevljica	Nevlje	2,23

20. in 30. avgustom 2005 so bili odvzeti vzorci tudi na dodatnih 19 vodomernih postajah dopolnilne mreže. Nekateri rezultati analiz so vidni v preglednici 3. Avgustovske obilne padavine so se odražale v povečani vsebnosti suspendiranega materiala rek vzhodne Slovenije. V spodnjem toku Save in v Mirni, Radulji in Sotli so bile vsebnosti glede na povprečje slovenskih rek zelo visoke. Vzorci, odvzeti v Krki in nekaterih njenih pritokih, ponovno izkazujejo kraški značaj rek z izredno nizko vsebnostjo suspendiranega materiala tudi ob visokih vodah. Reke s povirjem v Kamniških Alpah, v katerih smo odvzeli izredne vzorce, prav tako niso premeščale večje količine materiala. V rekah zahodne Slovenije je bila vsebnost suspendiranega materiala nad dolgoletnim povprečjem le v Idrijci. V času desetdnevnega vzorčenja nismo v nobeni reki sekundarne ali dopolnilne mreže monitoringa izmerili ekstremne količine suspendiranega materiala.

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). Iz dnevnih vrednosti izračunamo mesečne in letne vrednosti transportiranega materiala. V preglednici 9 so zbrani podatki o srednjih vrednostih pretokov, vsebnosti in transporta suspendiranega materiala za postaje z daljšim opazovanim nizom. Z njihovo pomočjo lažje vrednotimo podatke tekočega leta. Srednje vrednosti v letu 2005 izkazujejo nekoliko nadpovprečen transport na Muri, Savi in Savinji. V Vipavi pa je bil transport suspendiranega materiala nekoliko podpovprečen.

increased concentration of suspended material in the rivers of eastern Slovenia. In the downstream parts of the Sava, Mirna, Radulja and Sotla rivers, the concentrations were very high compared to the average in the Slovenian rivers. Samples taken from the Krka River and some of its tributaries are again exhibiting the character of karstic rivers with extremely low concentration of suspended material even during high-water conditions. Rivers with headwaters in the Kamniške Alps, where extraordinary sampling took place, also did not transport greater quantities of material. In the rivers of western Slovenia, the suspended material concentration was only above the multi-annual mean in the Idrijca River. During the ten days of sampling, we did not measure extreme quantities of suspended material in any of the rivers of the secondary or supplementary network.

The Transport of Suspended Material

The quantity of suspended load in the water is monitored through measurement of the concentration of suspended material from which the quantity of material transported S (kg/s) can be calculated using the measured river discharge. The monthly and annual values of the transported material are calculated from the daily values. Table 9 collects the data on the mean discharge values, concentrations and the transport of suspended material from the gauging stations with the longer time series. They enable easier evaluation of the data from the current year. The mean values in 2005 show a slightly above-average transport on the Mura, Sava and Savinja rivers. In the Vipava River, the suspended material transport was slightly below average.

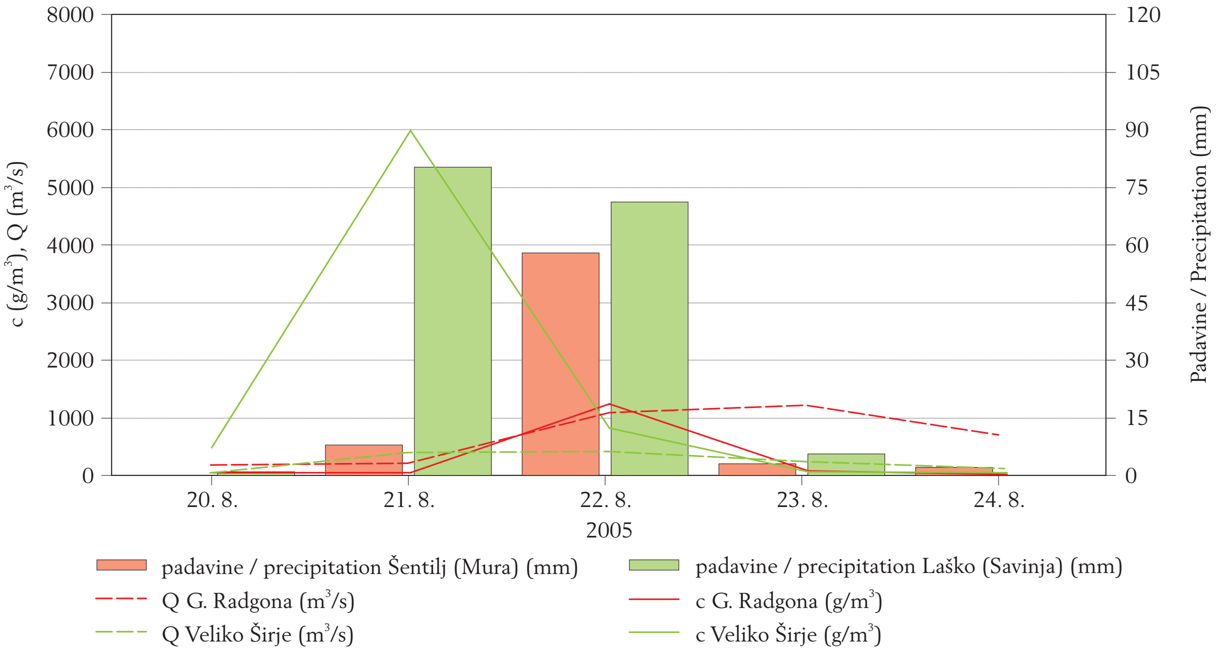
Preglednica 9: Srednje letne in obdobne vrednosti pretokov rek, vsebnosti in transporta suspendiranega materiala.
Table 9: *The mean annual and reference period values of river discharges, concentrations and the transport of suspended material.*

Vodotok / *Stream* – Vodomerna postaja / *Gauging station*	2005			1985–2004		
	Qsr (m^3/s)	csr (g/m^3)	Ssr (kg/s)	Qsr (m^3/s)	csr (g/m^3)	Ssr (kg/s)
Mura – G. Radgona	178	50	18,4	153	46,3	12,9
Sava – Hrastnik*	145	46	13,5	152	21,7	7,3
Savinja – Veliko Širje	42,5	57	10,7	44	59	7,5
Vipava – Miren	12,7	16	0,76	16,8	18,4	0,9

* vzorčenje poteka od leta 1997

Preglednica 10: Letne vrednosti prenešenega suspendiranega materiala za obdobje 1996–2005 (tisoč ton).
Table 10: *The annual values of transported suspended material for the 1996–2005 period (in thousands of tons).*

Vodomerna postaja *Gauging station*	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Vsota *Sum*
Mura – G. Radgona	661	255	211	670	275	96	508	31	412	581	3700
Sava – Hrastnik		146	285	226	300	256	113	115	308	425	2174
Savinja – Veliko Širje	283	1322	381	244	269	109	57	47	191	337	3240
Vipava – Miren	25	37	20	9	32	24	42	43	12	24	268



Slika 19: Količina transportiranega suspendiranega materiala v desetletnem obdobju (tisoč ton).
Figure 19: *The quantity of transported suspended material in a ten-year period (in thousands of tons).*

Ker je v letu 2005 v vzhodni Sloveniji padlo izjemno veliko padavin ter so bili povečani tudi pretoki rek, je bila skupna vsota transportiranega materiala v Muri, Savi in Savinji v primerjavi s preteklimi leti precej večja. Največ, dobrih 580 tisoč ton materiala, je v letu 2005 prenesla Mura, na Savi v Hrastniku pa je bila skupna letna količina transportiranega materiala največja v devetih letih monitoringa, saj je le v enem letu prenesla 20 odstotkov količine v obdobju.

Because precipitation was extremely abundant in 2005 in eastern Slovenia, increasing the river discharges, the total amount of transported material in the Mura, Sava and Savinja rivers was much higher in comparison with the previous years. The most material in 2005, well over 580 thousand tons, was transported by the Mura River, while the total annual quantity of transported material on the Sava River at Hrastnik was the highest in nine years of monitoring as the river transported 20% of the entire reference period quantity within a single year.

Visoke vode rek in poplave

Janez Polajnar

V letu 2005 je bila časovna razporeditev visokih voda slovenskih rek in visoke gladine morja ob slovenski obali drugačna od običajne. Največ visokih voda je bilo poleti. Julija in avgusta so bile hudourniške visoke vode v jugovzhodni Sloveniji, reka Mura je dosegla rekordni pretok. Jeseni je bilo maj visokih voda kot običajno. Časovna razporeditev in značaj visokih voda v letu 2005 sta bila podobna predvideni razporeditvi visokih voda kot jo znanstveniki opredeljujejo v scenarijih o možnih posledicah klimatskih sprememb na vodni krog. Visoke vode z rekordno velikimi pretoki rek naj bi bili zgoščeni v topli polovici leta, hudourniki naj bi poplavljali tudi na območjih, kjer takšni pojavi niso pogosti. Visoke vode leta 2005 in njihove posledice kažejo na možnost podobnih pojavov tudi v prihodnjih letih.

Leta 2005 je bilo zabeleženih 86 pojavov visokih voda, ko so reke na vodomernih postajah in gladina morja ob slovenski obali presegle pogojne vodostaje. Število teh pojavov zaradi poplavljanja velikega števila manjših potokov in hudournikov ni natančno opredeljeno. Leta 2005 je bilo število takih primerov večje kot v zadnjih letih prejšnjega desetletja, pred letom 2001. Največ visokih voda je bilo julija (13), avgusta (21) in septembra (11), manj oktobra (10), novembra (7) in decembra (8). Julija in avgusta so poplavljali hudourniki v osrednji, vzhodni in jugovzhodni Sloveniji, jeseni pa so bile visoke vode po vsej državi, zlasti v osrednji, vzhodni in južni Sloveniji (slika 20).

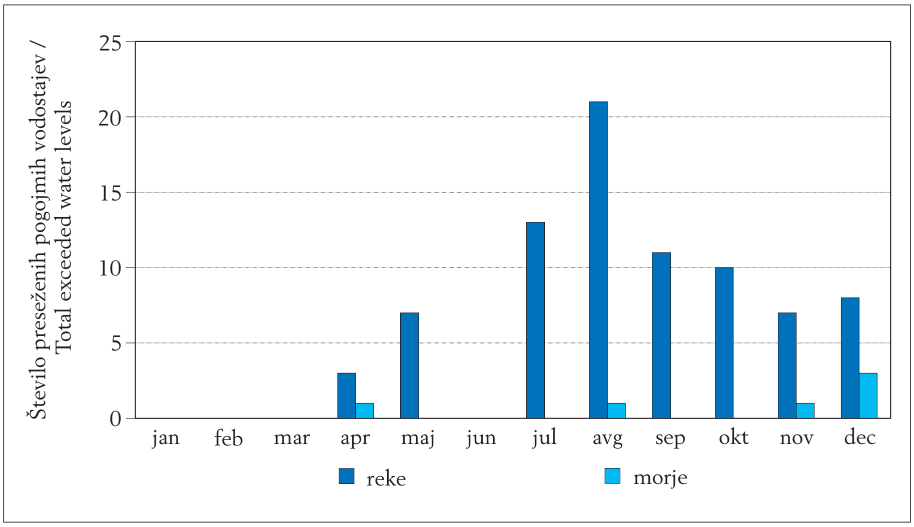
Reke, potoki, hudourniki in morje so skupno 100-krat prestopili bregove in morsko obalo. Morje se je 6-krat razlilo po nižjih delih obale, večje reke so poplavljale

River high waters and floods

Janez Polajnar

In 2005, the temporal distribution of high-water conditions on Slovenian rivers and the high sea levels along the Slovenian Coast was different from the usual one. The most high-water events occurred in the summer. In July and August, torrential high waters occurred in south-eastern Slovenia. The Mura River experienced a record discharge at the same time. There were fewer high-water events than usual in the autumn. The temporal distribution and character of high-water conditions in 2005 were similar to the distribution of high waters forecast by scientists in scenarios on the possible effects of climate change on the water cycle. High waters with record high river discharges would be concentrated in the warm part of the year and torrents would even flood areas where such phenomena are not frequent. The high waters in 2005 and their consequences are pointing to the possibility of similar phenomena also occurring in the years to come.

In 2005, there were 86 instances of high waters recorded when the river levels at the gauging stations or the sea level along the Slovenian Coast exceeded the critical water levels when warnings are issued to the public, though the number of these phenomena is not precisely determined owing to the flooding of a larger number of smaller creeks and torrents. In 2005, the number of these cases was greater than in the last years of the previous decade, namely prior to 2001. The most instances of high waters occurred in July (13), August (21) and September (11), while there were fewer in October (10), November (7) and December (8). In July and August, torrents flooded in central, eastern and



Slika 20: Število preseženih pogojnih vodostajev slovenskih rek na opazovanih vodomernih postajah, nekaterih hudournikih in gladine morja ob slovenski obali leta 2005.

Figure 20: *The number of instances in 2005 where Slovenian river levels at the monitored hydrometric stations, some torrents and the sea levels along the Slovenian Coast exceeded the critical water levels where warnings are issued to the public.*

Preglednica 11: Visoke vode in njihovo razlitje leta 2005 (ARSO, CORS, razlitja manjših hudournikov niso upoštevana).
Table 11: *High waters and their spillage in 2005 (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
Drava										•		
Mura								•		•		
Vipava												•
Irijca									•		•	•
Reka											•	
Ljubljanica				•				•	•	•	•	
Krka				•				•	•	•	•	
Temenica								•				
Poljanska Sora									•			
Gradaščica									••			•
Drvinja							•	•	•	•		•
Sotla												•
Mestinjščica												•
Kolpa											•	
Rinža											•	
Pšata								•	•			
Radulja								•			•	
Medija									•			
Sevnična								•				
Mirna								•			•	
Sušica								•			•	
Čadraški potok / *Stream Cadraški potok*											•	
potok Derenčinka / *Stream Derenčinka*											•	
potok Radešica / *Stream Radeščica*											•	
potok Rakitnica / *Stream Rakitnica*											•	
potok Bregana / *Stream Bregana*								•			•	
potok Kolja / *Stream Kolja*								•				
potok Turja / *Stream Turja*												•
Lakovški potok / *Stream Lakovški potok*								•				
potok Reka / *Stream Reka*								•				
potok Hrastnica / *Stream Hrastnica*												•
potok Rečica / *Stream Rečica*								•				
potok Gračnica / *Stream Gračnica*								•				
potok Trnava / *Stream Trnava*								•				
potok Črnec / *Stream Crnec*								•				
Zelenbreški potok / *Stream Zelenbreški potok*										•		
Artišnica								•				
Paka										•		
Hudinja										•		
Boljska								•				
Hudinja								•				
Ščavnica								•				
Kučnica								•				
Ledava								•				
Grajena								•				
Mislinja							••					
Polskava							•					
hudourniki v SV in JV Sloveniji / *Torrents in NE and SE Slovenia*					•		•••••••	••	•••	•	••	
hudourniki v osrednji Sloveniji / *Torrents in central Slovenia*							•••	•	•••			
hudourniki na območju Gorenjske / *Torrents in Gorenjska region*							•					
morje ob slovenski obali / *Sea at Slovenian coast*				•				•			••	••

51-krat, potoki 19-krat in nekateri hudourniki 24-krat. Večje reke so poplavljale povečini na območjih vsakoletnih poplav, obsežnejše poplave so bile ob Krki in Muri. Potoki in hudourniki so zlasti na območjih vzhodne, jugovzhodne in osrednje Slovenije poplavljali tudi na območjih, kjer poplave niso pogoste. Poplave ob potokih in hudournikih v jugovzhodni Sloveniji so povzročile precejšnjo gmotno škodo na stanovanjskih in gospodarskih objektih, prometnicah, infrastrukturi in kmetijskih površinah. V preglednici 11 so opisane reke, nekateri potoki in hudourniki, ki so poplavljali v letu 2005, ter poplavljanje morja ob slovenski obali.

Največ visokih voda, ki so zlasti na območjih jugovzhodne in vzhodne Slovenije prizadele veliko gmotno škodo, je bilo julija in avgusta. V boju z naravnimi silami smo bili ob pojavu hudourniških poplav v tem času brez moči. Ob poplavah reke Mure pa se je obrestovala požrtvovalnost in vzrajnost občanov, ki so več dni vzdrževali dotrajane zaščitne nasipe ob Muri in s tem preprečili povodenj večjega obsega. Več o hidroloških razmerah agusta leta 2005 je opisano v naslednjem poglavju Poplave v avgustu 2005.

south-eastern Slovenia, while autumn saw high water conditions throughout the country, especially in central, eastern and southern Slovenia (Figure 20).

Together, rivers, creeks, torrents and the sea have spilled over 100 times. The sea spilled over the low-lying parts of the coast 6 times, the larger rivers flooded on 51 occasions, creeks flooded 19 times and torrents 24 times. Larger rivers flooded predominantly in areas that experience floods each year, with more extensive floods occurring along the Krka and Mura rivers. Creeks and torrents, especially those in eastern, south-eastern and central Slovenia, even flooded areas where floods are not frequent. Floods along creeks and torrents in south-eastern Slovenia caused significant damage to residential and commercial buildings, traffic routes, infrastructure and farmland. Table 11 describes the rivers and some of the creeks and torrents that flooded in 2005 as well as the flooding of the sea along the Slovenian Coast.

The most high-water events causing extensive property damage, especially in south-eastern and eastern Slovenia, occurred in July and August. In our fight against the forces of nature, we were powerless during the torrential floods of that period. During the flooding of the Mura River, the self-sacrifice and perseverance of the locals who maintained the decrepit protective levees along the Mura River paid off as they prevented an inundation of greater proportions. The hydrological conditions in August of 2005 are described in next chapter in Floods in August 2005.

Poplave v avgustu 2005

dr. Mira Kobold, Mojca Sušnik

Za slovenske reke so, z izjemo Mure in Drave, značilne hudourniške poplave. Hudourniške poplave nastanejo zaradi intenzivnih, običajno lokalnih padavin, ki jih je skoraj nemogoče napovedati. Skoraj vsako leto se v različnih delih Slovenije pojavljajo lokalni nalivi in hudourniške poplave, ki poleg materialne škode ob ekstremnih razmerah ogrožajo tudi človeška življenja. V letu 2005 so bile razmere najhujše med 20. in 23. avgustom na območju jugovzhodne Slovenije, Posavja in Pomurja, ko je samo v dveh dneh (21. in 22. avgusta) padlo nad 100 mm padavin. Zaradi lokalno močnih nalivov so hitro narasli in poplavljali hudourniki in manjši vodotoki na območju Posavja. Od večjih rek je močneje narasla le Krka v obsegu vsakoletnih poplav, zaradi obilnega deževja v Avstriji pa Mura, katere pretok je bil največji v zadnjih petdesetih letih. V Gornji Radgoni je bil 22. avgusta izmerjen dotlej največji pretok v obdobju od leta 1946 naprej, in sicer 1350 m^3/s. Izmerjeni pretoki ostalih večjih rek niso presegli vrednosti običajnih visokih voda, pretoki manjših rek pa so dosegli tudi do 50-letno povratno dobo.

Meteorološka situacija

Avgust je bil najbolj moker mesec v letu 2005 in padavine so si sledile z manjšimi presledki že od začetka meseca, zaradi česar so bili pretoki večji kot običajno. Avgustovska količina padavin je bila skoraj povsod po državi večja od avgustovskega povprečja obdobja 1971–2000. Že do 19. avgusta 2005 je bilo padavin v Sloveniji več od obdobnega avgustovskega povprečja. Najhuje je bilo med 20. in 23. avgustom na območju jugovzhodne Slovenije in Posavja, ko je samo v dveh dneh, 21. in 22. avgusta padlo nad 100 mm padavin (sliki 21 in 22). Avgustovska količina padavin je na tem območju za dva do trikrat presegla avgustovsko povprečje obdobja 1971–2000.

V padavinski situaciji med 20. in 22. avgustom so se padavine najprej začele pojavljati v zahodni in severni Sloveniji, kasneje se je težišče padavin z lokalno močnimi nalivi preneslo na vzhod. Plohe in nevihte so 20. avgusta zvečer zajele jugovzhodno Slovenijo, nato se je dež razširil nad osrednjo in del vzhodne Slovenije. V nedeljo, 21. avgusta dopoldne, se je glavnina padavin preselila severneje, od juga so padavine počasi začele slabeti. Popoldne so bili najmočnejši nalivi v Prekmurju. Novo obsežno padavinsko območje je v noči na ponedeljek, 22. avgusta, zajelo najprej jugovzhodni in osrednji del Slovenije in se proti jutru pomaknilo nad zahodni in severni del države. Sredi dneva je v osrednji in severovzhodni Sloveniji nastalo nekaj ploh in neviht, ki so se kasneje pojavljale tudi drugod po državi. Predvsem

Floods in August 2005

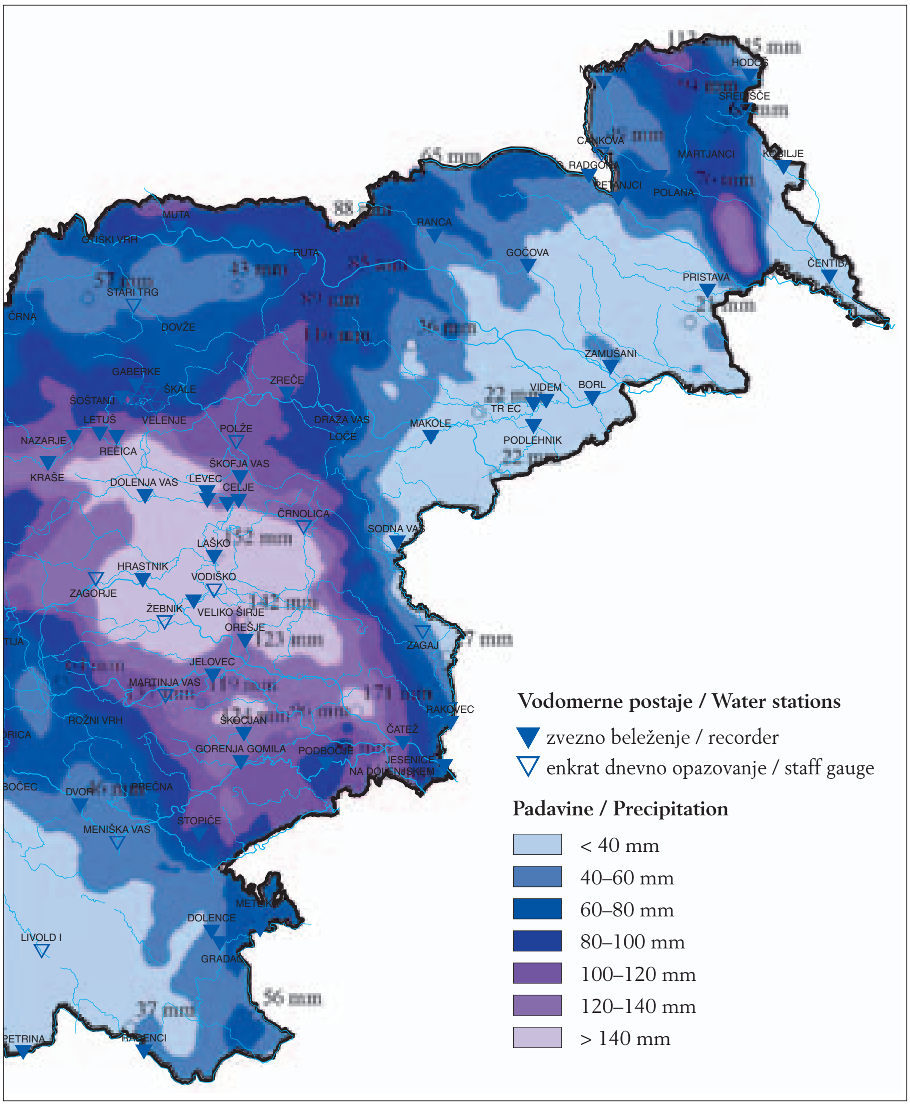
Mira Kobold, PhD and Mojca Sušnik

With the exception of the Mura and Drava, the Slovenian rivers are characterised by torrential flooding. Torrential floods occur because of intense, usually localised precipitation that is almost impossible to forecast. Almost every year, local thunderstorms and torrential floods occur in various parts of Slovenia, endangering human lives and causing extensive damage to property. The conditions in 2005 were at their worst between 20 and 23 August in the area of south-eastern Slovenia, Posavje and Pomurje, when there was more than 100 mm of precipitation in two days (21 and 22 August). Because of the localised severe thunderstorms, torrents and smaller streams incresed and flooded in the area of Posavje. Of the larger rivers only the Krka incresed significantly in the scope of annual floods, as did the Mura whose discharge was at its highest in the last fifty years because of the abundant precipitation in Austria. At Gornja Radgona, the highest discharge since 1946 was measured on 22 August with 1350 m^3/s. The measured discharges of the other larger rivers did not exceed the values of the usual high waters, while the discharges of smaller rivers even reached their 50-year return periods.

The Meteorological Situation

August was the wettest month in 2005 as precipitation events followed one another with only brief interruptions from the beginning of the month, meaning that the discharges were higher than usual. The August precipitation amount was greater than the August average in the 1971–2000 reference period almost throughout the country. From 19 August 2005 onwards, there was more precipitation in Slovenia than the multi-annual period mean. The situation was at its worst between 20 and 23 August in the area of south-eastern Slovenia and Posavje, when 100 mm of precipitation (Figures 21 and 22) fell in just two days – on 21 and 22 August. The August quantity of precipitation in this area exceeded the August mean value in the 1971–2000 reference period 2- or 3-fold.

In the precipitation situation between 20 and 22 August, precipitation first began appearing in western and northern Slovenia, while the main focus of precipitation later transferred to the east with localised severe rain showers. Thunderstorms and storms on 20 August covered south-eastern Slovenia before spreading over central and a part of eastern Slovenia. In the morning of Sunday, 21 August, the majority of the precipitation moved northward and began slowly falling off from the south. In the afternoon, the strongest thunderstorms occurred in Prekmurje. In the night of Sunday,



Slika 21: Vsote 2-dnevnih padavin od 8. ure 20. avgusta 2005 do 8. ure 22. avgusta 2005 (vir: M. Dolinar et al.) in merilna mesta hidrološkega monitoringa na površinskih vodah.

Figure 21: *The amounts of 2-day precipitation from 8 a. m. on 20 August to 8 a. m. on 22 August 2005 (Source: M. Dolinar et al.) and the surface water hydrological monitoring gauging sites.*

v Prekmurju je ob nalivih lokalno padla večja količina padavin. V torek, 23. avgusta, so padavine povsod ponehale, najkasneje v severovzhodni Sloveniji.

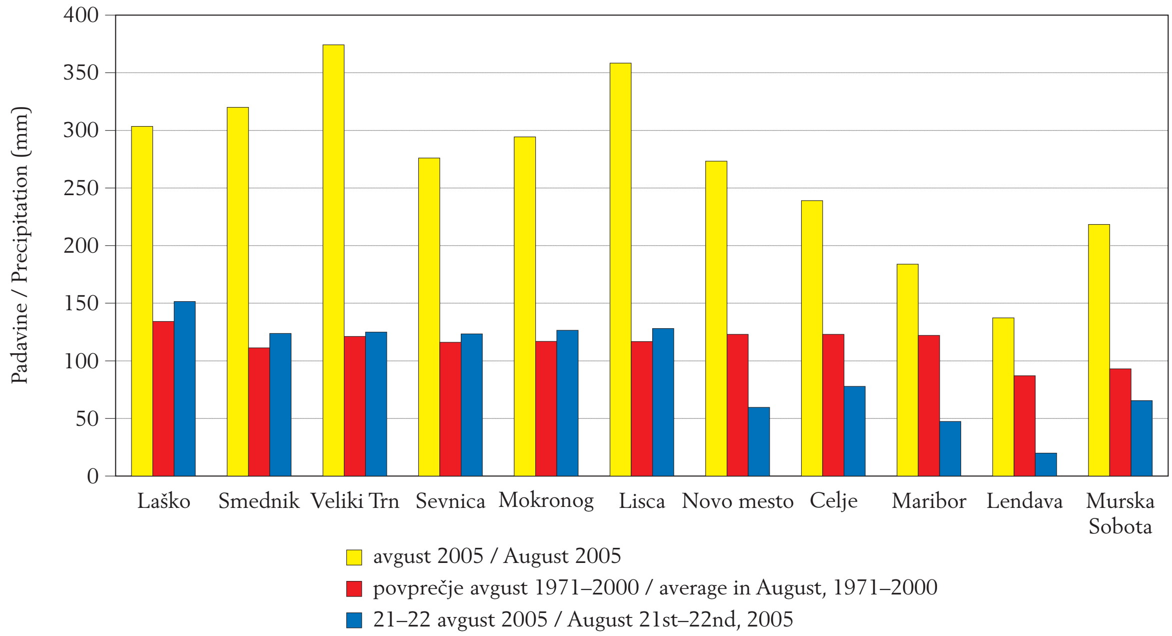
Na nekaterih meteoroloških postajah, predvsem v Posavski regiji, so bile zabeležene rekordne intenzitete in količine padavin. Izjemno visoke povratne dobe tudi preko 100 let so bile zabeležene tako za krajše nalive (Krško, Murska Sobota in Lisca), kot tudi za 2-dnevne vsote padavin (Laško, Mokronog, Lisca in Krško).

Opis hidroloških razmer

Že od začetka avgusta 2005 so bili pretoki večji kot običajno, saj je bil avgust povečini moker mesec. Pretoki so se glede na zgoraj opisano vremensko dogajanje najbolj povečali 22. in 23. avgusta. Zaradi velike predhodne namočenosti tal, obilnih padavin in lokalno močnih

21 August, a new extensive precipitation front first encompassed the south-eastern and central parts of Slovenia, then moved over the western and northern parts of the country toward the morning. At midday, several showers and storms appeared in central and north-eastern Slovenia that later appeared elsewhere in the country as well. Localised greater quantities of precipitation during thunderstorms primarily fell in Prekmurje. On Tuesday, 23 August, the precipitation ceased everywhere with north-eastern Slovenia seeing the end last.

Some meteorological stations, primarily in the Posavje region, recorded record intensities and quantities of precipitation. Extremely high return periods, even in excess of 100 years, were recorded both for the shorter thunderstorms (Krško, Murska Sobota and Lisca) and for the 2-day precipitation amounts (Laško, Mokronog, Lisca and Krško).



Slika 22: Avgustovska količina padavin na nekaterih postajah vzhodne Slovenije.
Figure 22: *August precipitation amount at some stations in eastern Slovenia.*

nalivov so najbolj narasli hudourniki in manjši potoki v jugovzhodni Sloveniji, reke na območju Zasavja, Posavja, na širšem celjskem območju in na območju Laškega. Poplavljali in uničevali so predvsem manjši vodotoki, od večjih rek pa Krka in Mura. Mura je bila visoka zaradi obilnega deževja v Avstriji. Na območju Posavja, kjer so se sprožili številni zemeljski plazovi, prevladuje gričevnat in hribovit svet s terciarnimi kamninami, pliokvartarnimi sedimenti in glinenimi vložki, ki so nagnjeni k plazenju. Preperelina z obilico gline ima tudi majhne zadrževalne sposobnosti.

Odtok s povodij, z najvišjimi padavinami 21. in 22. avgusta, Radulje, Sevnične in Mirne, je presegel maksimalne obdobne pretoke. Maksimalni izmerjeni pretok Radulje v Škocjanu je bil 21. avgusta 2005 in je znašal 50,3 m^3/s, kar je več kot 100-letna povratna doba. Po krajši prekinitvi dežja je Radulja nekoliko upadla in ob padavinah v noči na ponedeljek, 22. avgusta je ponovno začela naraščati. Druga konica, v ponedeljek, 22. avgusta 2005, je bila le nekoliko nižja in je znašala 45,8 m^3/s (slika 23).

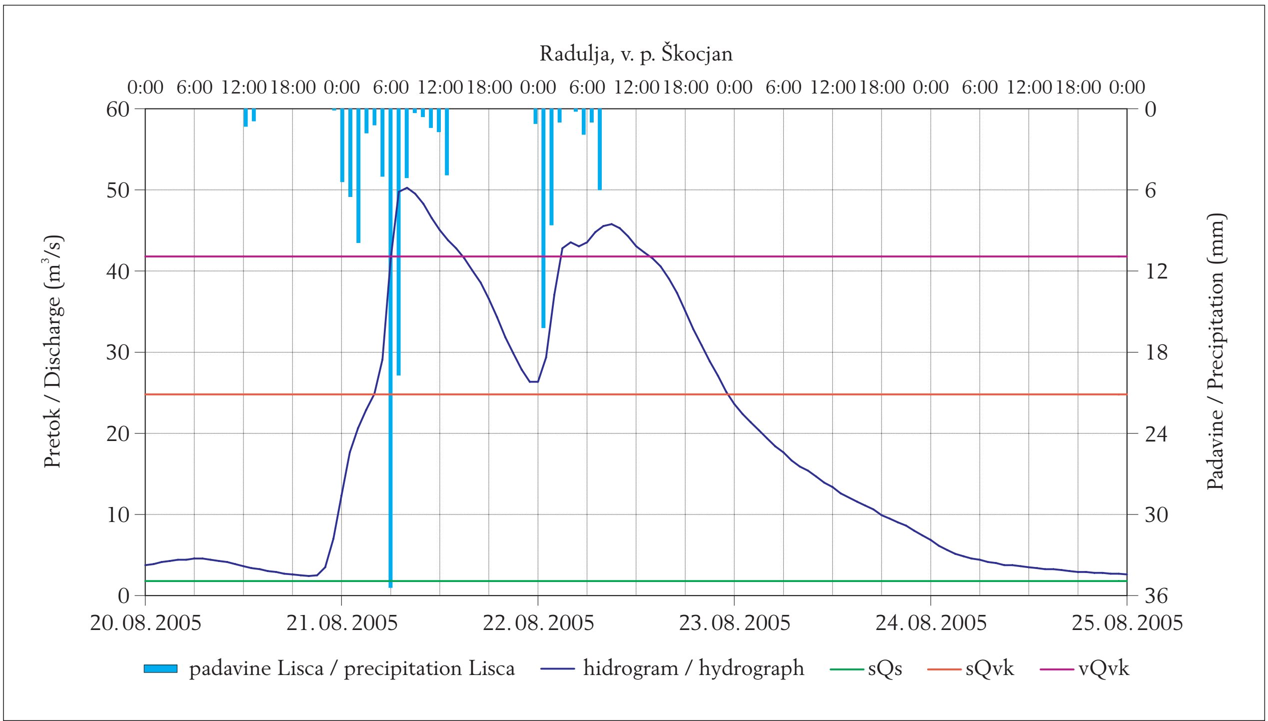
Sevnična je 21. avgusta prav tako močno narasla in poplavljala v Sevnici in ob cesti Sevnica–Planina ter povzročila veliko škode. Hidroloških podatkov za Sevnično ni, saj je narasla in deroča voda je 21. avgusta na vodomerni postaji v Orešju odtrgala in odnesla kovinsko hišico z aparatom za zvezno beleženje višine vodne gladine in vodomerno letev.

Visoka je bila tudi Mirna, ki je v Jelovcu 21. avgusta dosegla maksimalni pretok 90,1 m^3/s, kar je 25-letna povratna doba velikih pretokov, in s tem presegla dotlej maksimalni izmerjeni pretok 69,3 m^3/s iz leta 1999 (slika 24).

Description of Hydrological Conditions

From the very beginning of August 2005, discharges were higher than usual and August was a wet month for the most part. Because of this, discharges increased the most on 22 and 23 August. Because of the previously accumulated high moisture content in the unsaturated zone, the abundant precipitation and the localised intense thunderstorms, torrents and smaller creeks in south-eastern Slovenia incresed, as did the rivers in the areas of Zasavje, Posavje, the wider Celje region and in the area of Laško. It was the smaller streams especially that flooded and caused destruction, while among the larger rivers it was the Krka and Mura. The Mura was high because of the abundant precipitation in Austria. The area of Posavje where numerous landslides occurred, is characterised by hilly and mountainous terrain with tertiary rocks, Plio-Quaternary sediments and clay interbeds that are prone to triggering slides. Weathered debris with plenty of clay also has a poor retention capacity.

The runoff from the catchment areas of the Radulja, Sevnična and Mirna rivers (which had the most precipitation on 21 and 22 August) exceeded the maximum reference period discharges. The maximum measured discharge of the Radulja River at Škocjan occurred on 21 August 2005 and amounted to 50.3 m^3/s, meaning a more than 100-year return period. After a brief cessation of rain, the Radulja River receded somewhat, then began incresing again following the precipitation that occurred in the night of Sunday, 21 August. The second peak on Monday 22 August 2005 was slightly lower and amounted to 45.8 m^3/s (Figure 23).



Slika 23: Hidrogram Radulje v Škocjanu od 20. 08. 2005 do 25. 08. 2005 v primerjavi z obdobnim srednjim (sQs) in obdobnimi velikimi pretoki (sQvk in vQvk) ter urna intenziteta padavin z Lisce.

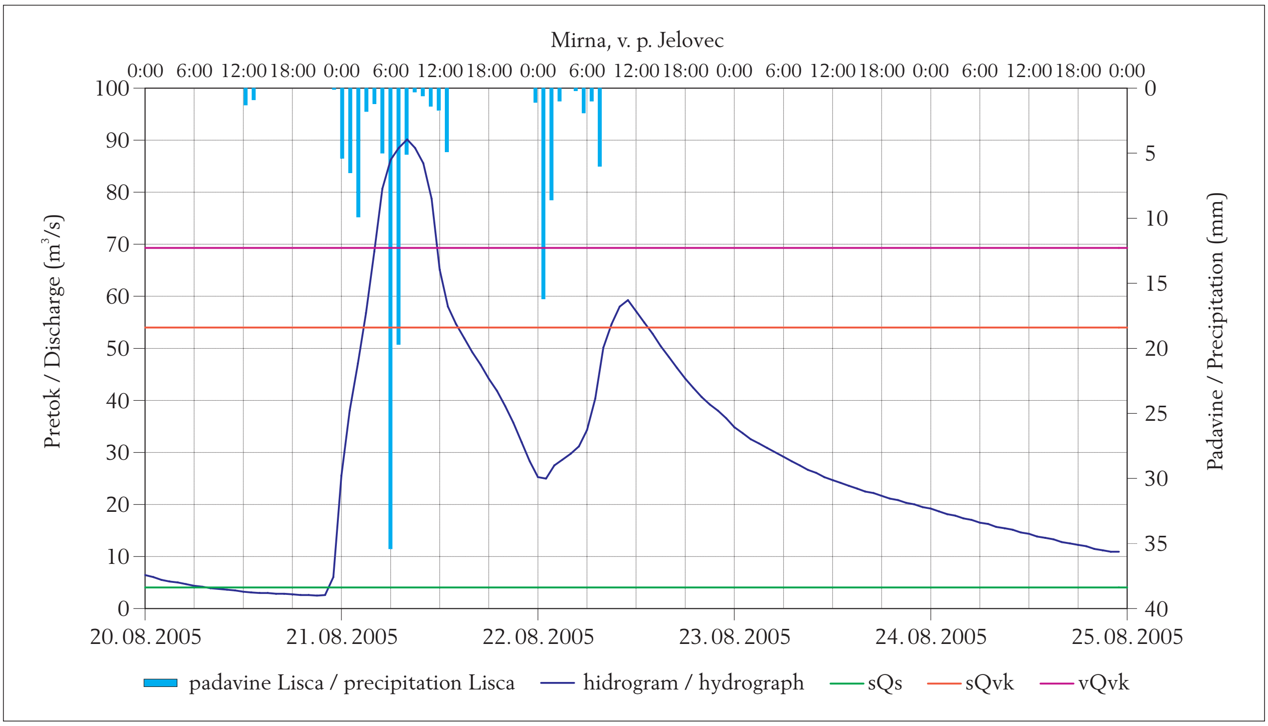
Figure 23: *The hydrograph of the Radulja River at Škocjan from 20 August 2005 to 25 August 2005 in comparison with the reference period mean (sQs) and the reference period high discharges (sQvk and vQvk) and the hourly intensity of the precipitation in Lisca.*

Poplava Sevnične v Sevnici dne 21. avgusta 2005 (foto: Jože Uhan).

The flood of the Sevnična River at Sevnica on 21 August 2005 (Photo: Jože Uhan).

Stanje na vodomerni postaji Orešje na Sevnični 22. avgusta 2005, po vodnem razdejanju (foto: Marko Burger).

The situation on the Orešje hydrometric station on the Sevnična River on 22 August 2005 following the water devastation (Photo: Marko Burger).



Slika 24: Hidrogram Mirne v Jelovcu od 20. 08. 2005 do 25. 08. 2005 v primerjavi z obdobnim srednjim (sQs) in obdobnimi velikimi pretoki (sQvk in vQvk) ter urna intenziteta padavin z Lisce.

***Figure 24:** A hydrograph of the Mirna River at Jelovec from 20 to 25 August 2005 in comparison with the reference period mean (sQs) and the reference period high discharges (sQvk and vQvk) and the hourly intensity of the precipitation in Lisca.*

Na manjših potokih in hudournikih, ki so tudi narasli in poplavljali na območju Posavja, hidroloških meritev ne izvajamo. Savinja je imela v nedeljo, 21. avgusta 2005, v zgornjem toku manjše pretoke kot v ponedeljek, 22. avgusta, medtem ko je imela v spodnjem toku, zlasti od Laškega dolvodno, v nedeljo, 21. avgusta, izrazito večje pretoke kot v ponedeljek, 22. avgusta (slika 25). V Velikem Širju je Savinja dosegla največji pretok 21. avgusta dopoldne in sicer 481 m^3/s, kar je manj od srednjega obdobnega velikega pretoka (640 m^3/s) in pod dvoletno povratno dobo velikih pretokov.

Od večjih rek je močneje narasla le še Krka v obsegu vsakoletnih poplav. Krka je v zgornjem toku, v Podbukovju, dosegla največji pretok 21. avgusta zjutraj, 45,7 m^3/s, kar je 16,5 % pod srednjim obdobnim velikim pretokom. V spodnjem toku, v Podbočju (slika 25), pa je dosegla največji pretok 23. avgusta malo po polnoči, 259 m^3/s, kar je 12 % pod srednjim obdobnim velikim pretokom.

Največji zabeleženi pretoki Save med 21. in 23. avgustom 2005 pa niso dosegli srednjih obdobnih velikih pretokov. Prva konica Save v Čatežu, ki je bila 21. avgusta ob 14. uri, je bila v glavnem posledica visoke Sevnične, Mirne in Savinje. Druga visokovodna konica pa je bila 23. avgusta ob pol enih zjutraj, predvsem zaradi visoke Save v zgornjem toku in Krke. V Hrastniku je bil izmerjen maksimalni pretok 562 m^3/s 22. avgusta ob 20. uri.

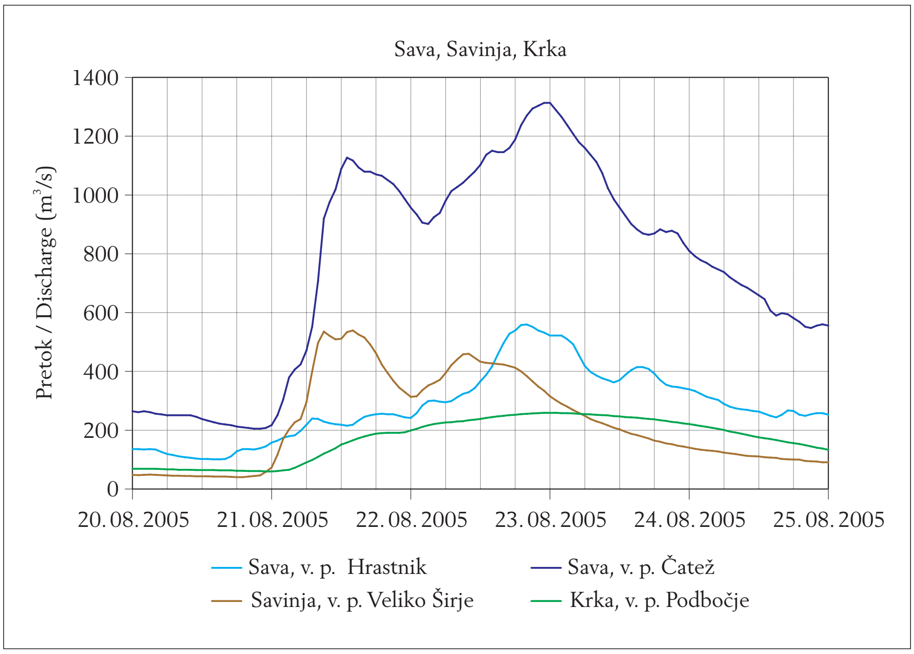
Dravinja s svojim razlivanjem iz struge ni povzročila večjih nevšečnosti. Največji pretok v Ločah, 37,9 m^3/s,

The Sevnična River also incresed on 21 August and inundated areas in Sevnica and along the Sevnica-Planina road, causing extensive damage. There is no hydrological data for the Sevnična River because it incresed on 21 August causing supercritical flow that ripped off and carried away the metallic housing at the Orešje hydrometric station that held the staff gauge and the device for the continuous recording of the water stage.

The Mirna River was also high. On 21 August at Jelovec, it reached its maximum discharge of 90.1 m^3/s, which means a 25-year return period of high discharges, thus exceeding the previous measured maximum discharge of 69.3 m^3/s from 1999 (Figure 24).

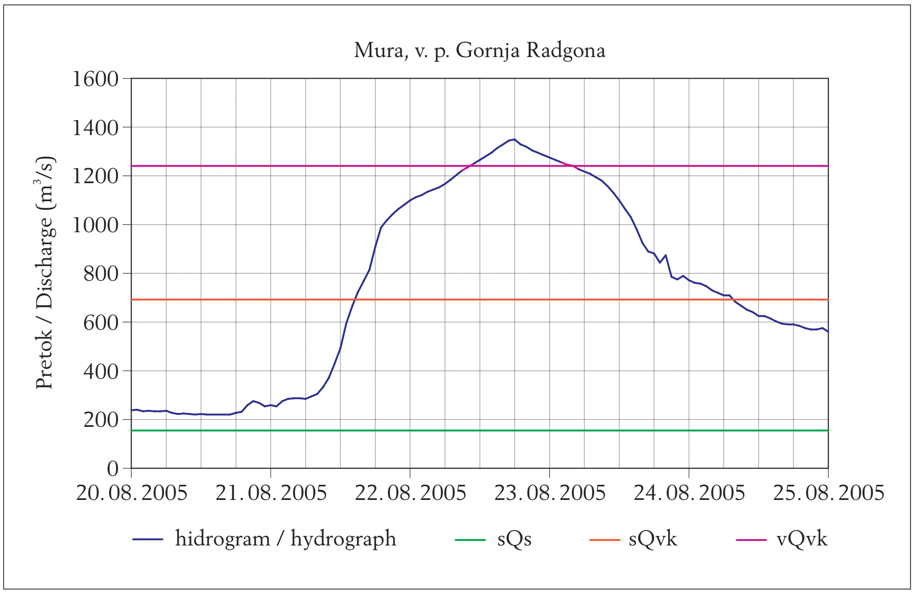
Hydrological measurements are not performed on the smaller creeks and torrents that also incresed and flooded in the area of Posavje. On Sunday, 21 August 2005, the Savinja had lower discharges in its upstream part than on Monday, 22 August, while in the downstream part – especially downstream from Laško – it had expressly higher discharges on Sunday, 21 August than on Monday, 22 August (Figure 25). At Veliko Širje, the Savinja River reached its highest discharge in the morning on 21 August with 481 m^3/s, which is less than the mean high discharge of the reference period (640 m^3/s) and below the 2-year return period of high discharges.

Of the larger rivers, only the Krka incresed significantly within the scope of annual floods. In its upstream part at Podbukovje, the Krka reached its highest discharge on the morning of 21 August with 45.7 m^3/s,



Slika 25: Hidrogram Save v Hrastniku in Čatežu, Savinje v Velikem Širju in Krke v Podbočju od 20. 08. 2005 do 25. 08. 2005.

Figure 25: *A hydrograph of the Sava River at Hrastnik and Čatež, the Savinja River at Veliko Širje and the Krka River at Podbočje from 20 to 25 August 2005.*



Slika 26: Hidrogram Mure v Gornji Radgoni od 20. do 25. 08. 2005, v primerjavi z obdobnim srednjim (sQs) in obdobnimi velikimi pretoki (sQvk in vQvk).

Figure 26: *A hydrograph of the Mura River at Gornja Radgona from 20 to 25 August 2005 in comparison with the reference period mean (sQs) and the reference period high discharges (sQvk and vQvk).*

je bil pod dvoletnim velikim pretokom. Zaradi obilnega deževja v Avstriji je bila izredno visoka Mura, katere pretok je bil največji v zadnjih petdesetih letih. V Pomurju so bile zato izredne razmere, predvsem ob Muri in njenih pritokih, ki jih je Mura zajezila. Mura je začela naraščati v jutranjih urah 21. avgusta. Ob 14. uri je že dosegla pretok, ko se voda začne razlivati znotraj obrambnih nasipov. Do 19. ure se je pretok še ves čas hitro povečeval, potem pa je intenziteta narašča-

which is 16.5% below the mean high discharge of the reference period. In its downstream part at Podbočje (Figure 25), it reached its highest discharge slightly after midnight on 23 August, with 259 m^3/s or 12% below the mean high discharge of the reference period.

The highest recorded discharges of the Sava River, between 21 and 23 August 2005, did not reach the mean high discharges of the reference period. The first peak of the Sava at Čatež, at 2 p. m. on 21 August, was nja nekoliko upadla. Tako smo naslednjega dne, 22. avgusta ob 18. uri zabeležili rekordni pretok 1350 m^3/s (slika 26), ki se uvršča med 50 in 100-letno povratno dobo. Marsikje je ta visoka voda dosegla krono nasipov. Pretok je skoraj cel dan vztrajal nad dotlej največjim izmerjenim pretokom 1241 m^3/s iz junija 1954. Naslednji dan je Mura le začela upadati.

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for the most part the result of the high Sevnična, Mirna and Savinja rivers. The second high water peak occurred 12.30 a. m. on 23 August, primarily because of the high Sava River in its upstream part and the Krka River. At Hrastnik, the maximum discharge was measured at 8 p. m. on 22 August – 562 m^3/s.

The Dravinja River did not cause serious problems by spilling from its channel. The highest discharge at Loče, 37.9 m^3/s, was below the 2-year high discharge. Because of the abundant rainfall in Austria, the Mura River was extremely high, with its discharge being the highest in the last 50 years. This caused extreme conditions in Pomurje, primarily along the Mura River and its tributaries, which the Mura has captured. The Mura began incresing in the morning hours on 21 August. At 2 p. m., it reached the point when the water began spilling over the defence levees. By 7 p. m., the discharge continued to increase rapidly, but then the intensity of the increase subsided somewhat. The next day, on 22 August at 6 p. m., we recorded a record discharge of 1350 m^3/s (Figure 26), which ranks between a 50- and 100-year return period. In many places, the high water reached the top of the levees. The discharge persisted above the highest discharge previously measured (1241 m^3/s from June of 1954) for almost the entire day, but on the next day, the Mura began to recede.

Nizke vode rek in hidrološka suša

dr. Mira Kobold

Analiza mesečnih pretokov

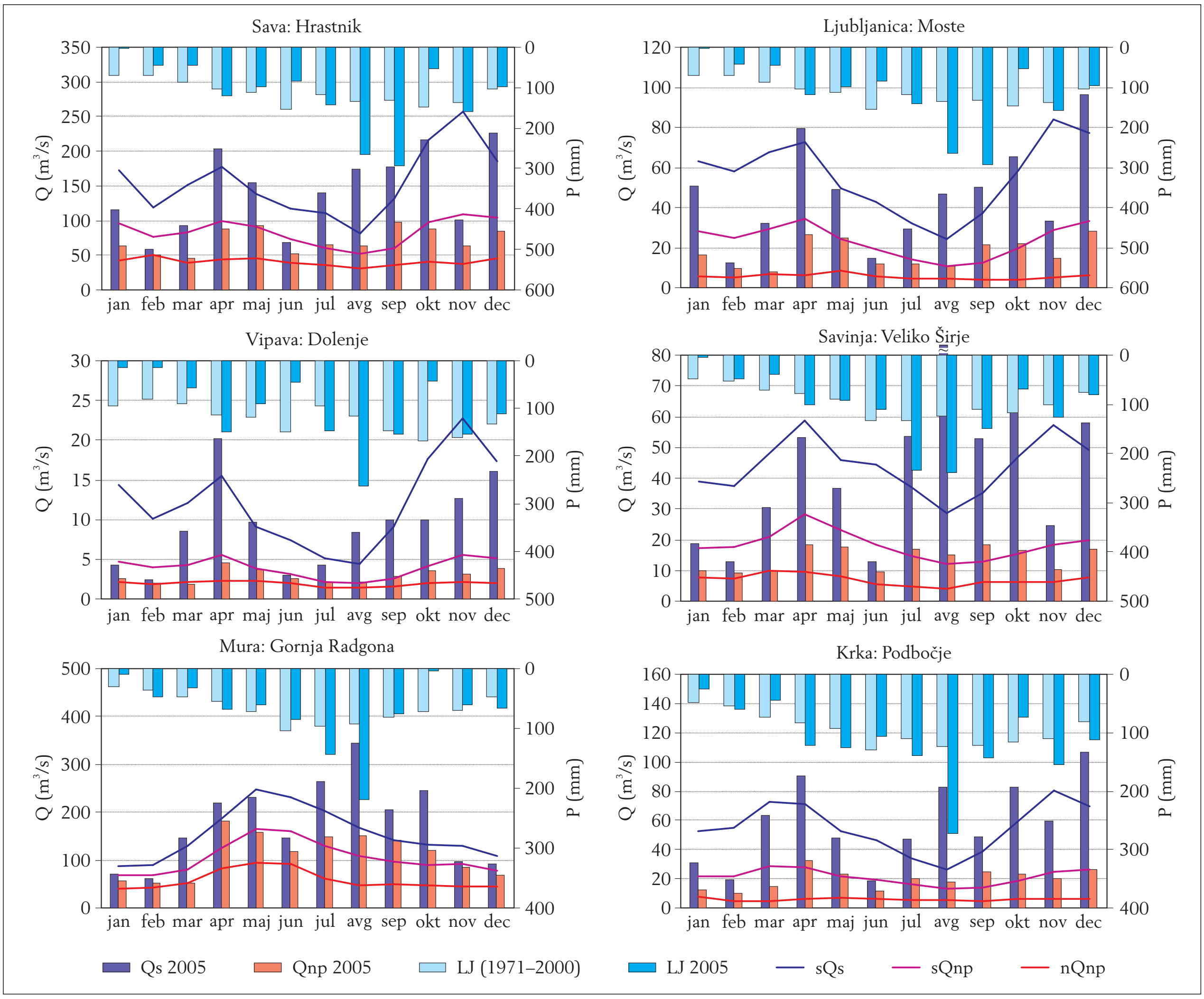
Najmanjši mesečni pretoki so bili v začetku leta 2005, od januarja do marca večinoma blizu najmanjšim malim obdobnim mesečnim pretokom nQnp, srednji mesečni pretoki pa v mejah srednjih malih obdobnih mesečnih pretokov sQnp (slika 27). Razlog za nizkovodno stanje v začetku leta je bila majhna količina padavin, ki je bila povsod po Sloveniji, z izjemo februarja v severovzhodni in južni Sloveniji, precej manjša od obdobnega povprečja 1971–2000. V januarju je bila

River low waters and hydrological drought

Mira Kobold, PhD

Analysis of Monthly Discharges

The minimum monthly discharges occurred at the beginning of 2005. From January to March, they were mostly close to the minimum low monthly discharges of the reference period (nQnp), while the mean monthly discharges were within the limits of the mean low monthly discharges of the reference period (sQnp) (Figure 27). The reason for the low-water situation in the beginning of the year was the low amount of precipitation, which was significantly lower than the mean value of the



Slika 27: Srednji (Qs) in minimalni mesečni pretoki (Qnp) v letu 2005 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 2005 z reprezentativnih padavinskih postaj.

***Figure 27:** The mean (Qs) and minimum monthly discharges (Qnp) in 2005 and the monthly discharge values of the reference period: the mean reference period discharges (sQs), the mean low (sQnp) and minimum low (nQnp) monthly discharges, the monthly precipitation amounts of the 1971–2000 period and the monthly precipitation amounts in 2005 from the representative precipitation stations.*

količina padavin povsod po državi majhna, od 3 % povprečne januarske količine padavin v Posočju pa do 50 % povprečne januarske količine padavin v severovzhodni Sloveniji in na Dolenjskem. Februarja so bile razlike v količini padavin po državi velike. V zahodni in osrednji Sloveniji je bila količina padavin pod obdobnim februarskim povprečjem, v vzhodni in južni Sloveniji pa malo nad februarskim povprečjem. V marcu je bilo padavin po državi okrog 60 % povprečne količine za marec. Padavine v aprilu in maju, ko je bila skoraj povsod po državi količina padavin blizu povprečnim obdobnim mesečnim vrednostim, je ugodno vplivala na vodnatost rek. Srednji mesečni pretoki v teh dveh mesecih so bili v mejah srednjih obdobnih mesečnih pretokov sQs, najmanjši mesečni pretoki pa v mejah srednjih malih obdobnih mesečnih pretokov sQnp. V juniju se je vodnatost rek zopet znižala, saj je bila količina padavin skoraj povsod po Sloveniji nižja od povprečne junijske količine padavin. Tako srednji kot najmanjši junijski mesečni pretoki so bili pod srednjimi malimi obdobnimi mesečnimi pretoki sQnp. Julij, avgust in september so bili nadpovprečno mokri, zlasti avgusta je marsikje padla dvakratna obdobna količina padavin za avgust. Temu primerno so bili srednji mesečni pretoki vse od julija do oktobra večinoma večji od srednjih obdobnih mesečnih pretokov sQs, najmanjši mesečni pretoki pa nad srednjimi malimi obdobnimi mesečnimi pretoki sQnp. Oktobra je padavin zopet izrazito primanjkovalo, najbolj v Prekmurju, v novembru in decembru pa so bile padavine v mejah dolgoletnega povprečja. Srednji in najmanjši mesečni pretoki so bili manjši od obdobnih vrednosti le še v novembru, v decembru pa so bili pretoki zopet v mejah srednjih obdobnih vrednosti.

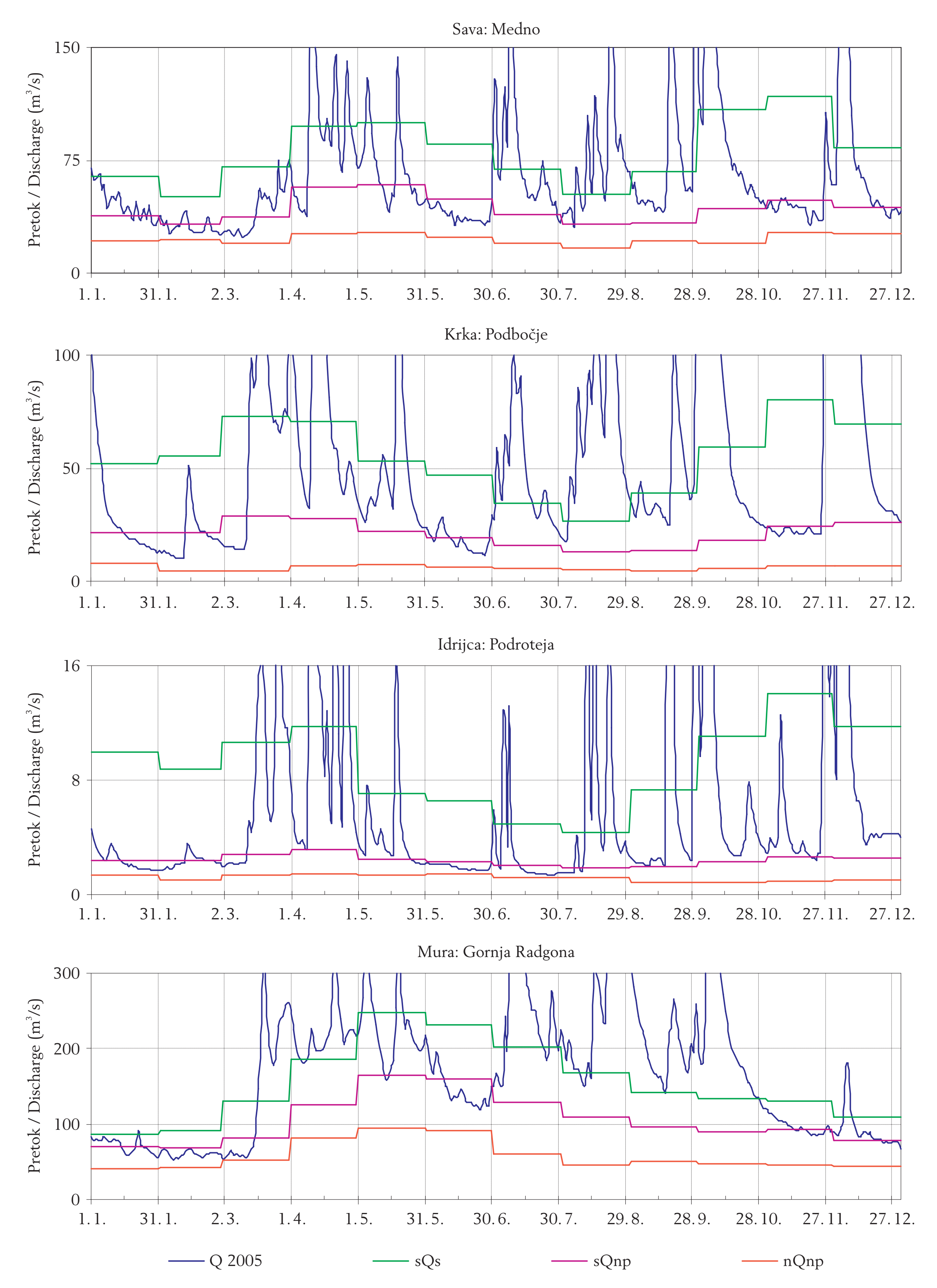
Hidrološko najbolj suha meseca sta bila februar in junij, vendar najmanjši pretoki niso nikjer dosegli najmanjših malih obdobnih pretokov. Na dokaj ugodno hidrološko stanje preko leta so vplivale padavine, ki so bile sicer v prvem četrtletju precej manjše od dolgoletnega povprečja 1971–2000, v osrednji Sloveniji za okrog 40 %, v južni Sloveniji za okrog 30 %, v zahodni Sloveniji pa so bile nižje tudi do 70 % glede na dolgoletno povprečje, vendar je bila v ostalih mesecih razporeditev in količina padavin ugodna. Najmanjši primanjkljaj padavin v začetku leta je bil v severovzhodni Sloveniji in na Dolenjskem, od 20 do 30 %. Celotna letna količina padavin je bila v zahodni Sloveniji pod povprečjem obdobja 1971–2000, drugod po Sloveniji pa je bila letna količina padavin nekoliko nad dolgoletnim povprečjem.

Časovni potek srednjih dnevnih pretokov

Na sliki 28 je za nekaj postaj z različnih delov Slovenije prikazan potek srednjih dnevnih pretokov za leto 2005. Za primerjavo so dodani obdobni pretoki: srednji mesečni (sQs), srednji mali (sQnp) in najmanjši

1971–2000 reference period throughout Slovenia (with the exception of February in north-eastern and southern Slovenia). In January, the amount of precipitation was low throughout the country, from 3% of the average January precipitation amount in Posočje and up to 50% in north-eastern Slovenia and Dolenjska. Differences in the amount of precipitation around the country were considerable in February. In western and central Slovenia, the amount of precipitation was below the reference period February mean, while in eastern and southern Slovenia it was slightly above. In March, there was around 60% of the average precipitation amount for the month around the country. When the amount of precipitation in April and May was close to the reference period mean monthly values throughout the country, it had a favourable effect on the river water stages. The mean monthly discharges in the two months were within the limits of the mean monthly reference period discharges (sQs), while the minimum monthly discharges were within the limits of the mean monthly reference period discharges (sQnp). In June, the water stages of rivers decreased again as the amount of precipitation was lower than the average June precipitation amount throughout Slovenia. Both the mean and the minimum June monthly discharges were below the mean low monthly reference period discharges (sQnp). July, August and September had above-average precipitation, especially August when there was twice the reference period amount of precipitation for the month of August in many places. Accordingly, the mean monthly discharges from July to October were for the most part higher than the reference period mean monthly discharges (sQs), while the minimum monthly discharges were above the reference period mean low monthly discharges (sQnp). In October, precipitation was again extremely scarce, especially in Prekmurje. In November and December, precipitation was within the normals. The mean and minimum monthly discharges were only lower than the reference period values in November, while in December the discharges were again within the limits of the reference period mean values.

In hydrological terms, the driest months were February and June, though the minimum discharges did not reach the minimum low discharges of the reference period anywhere. Precipitation had a rather favourable effect on the hydrological situation. The precipitation was significantly lower in the first quarter than the mean of the 1971–2000 reference period – by around 40% in central Slovenia, around 30% in southern Slovenia and as much as 70% in western Slovenia compared to the normals. The distribution and amount of precipitation in other months was, however, favourable. The lowest precipitation deficit in the beginning of the year – from 20 to 30% – was in north-eastern Slovenia and in Dolenjska. The total annual precipitation amount in western Slovenia was below the mean value of the 1971–2000 reference period, while the annual precipitation amount was slightly above the normals elsewhere in Slovenia.

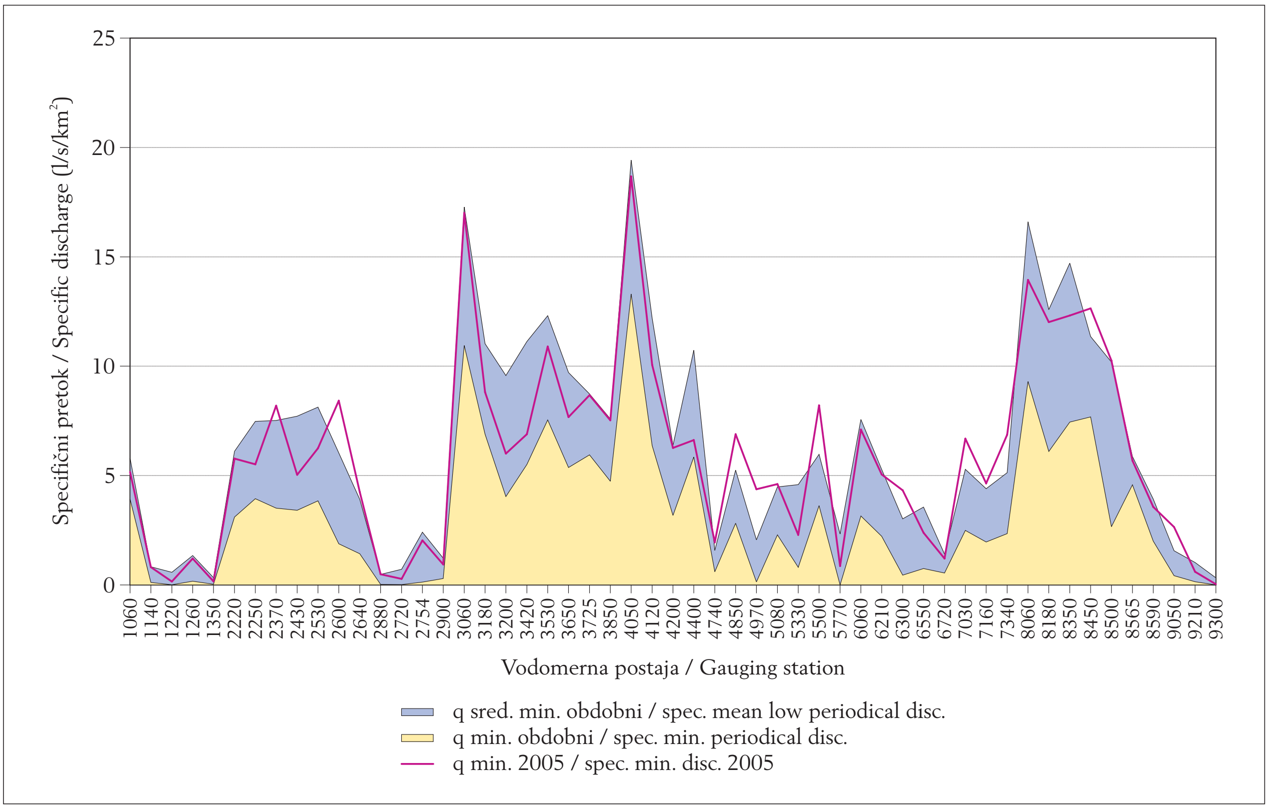


Slika 28: Srednji dnevni pretoki na izbranih vodomernih postajah za leto 2005 ter obdobne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) obdobni pretok.
Figure 28: The mean daily discharges at selected gauging stations for 2005 and the reference period discharge values: mean (sQs), mean low (sQnp) and minimum low (nQnp) discharges from the reference period.

Preglednica 12: Najmanjši izmerjeni pretoki v letu 2005 v primerjavi z obdobnima srednjim malim pretokom (sQnp) in najmanjšim pretokom (nQnp) iz obdobja delovanja postaje.

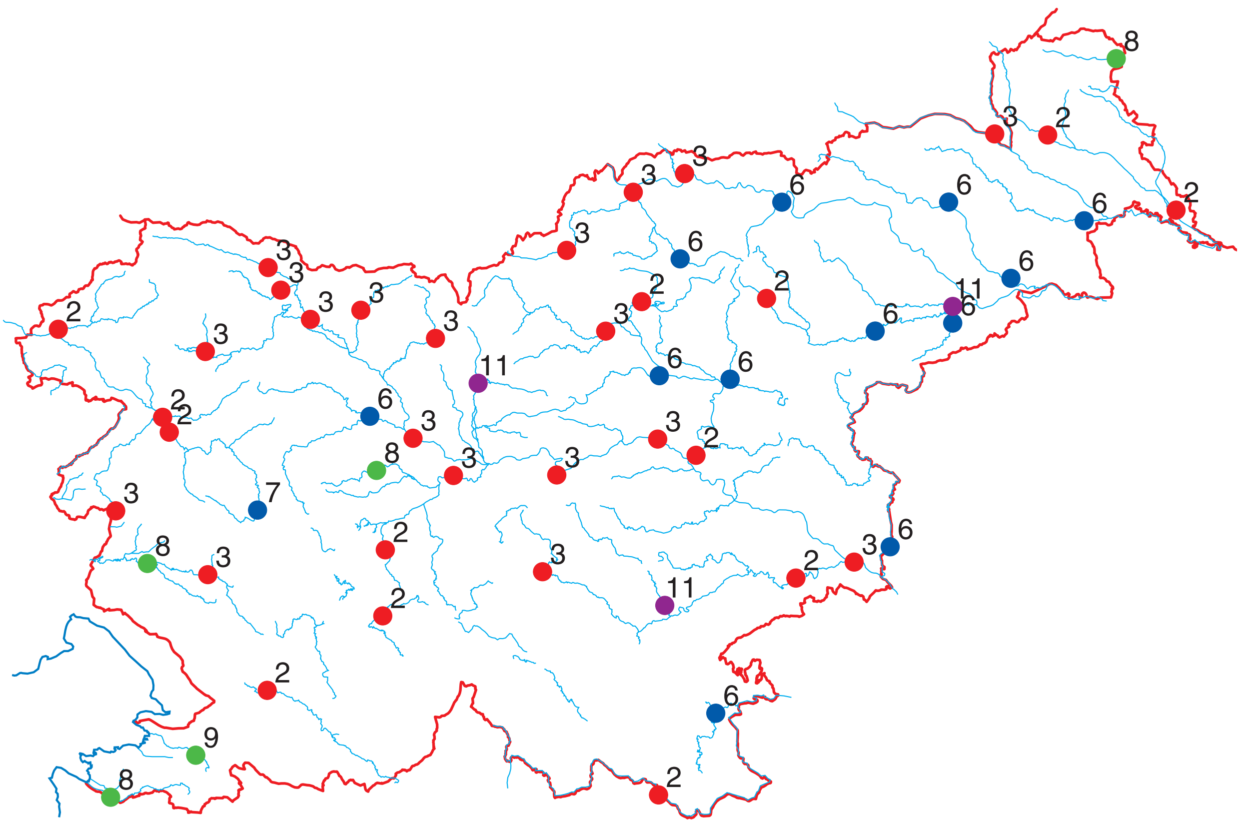
Table 12: *The lowest measured discharges in 2005 in comparison with the mean low reference period discharge (sQnp) and the minimum discharge (nQnp) from the period of the operation of the station.*

Šifra *Code*	Vodomerna postaja *Gauging Station*	2005 Qnp (m^3/s)	2005 Datum / *Date* Qnp	Obdobne vrednosti *Periodic discharges* sQnp (m^3/s)	Obdobne vrednosti *Periodic discharges* nQnp (m^3/s)
1060	Mura – Gornja Radgona	52,7	01. 03.	59,1	40,0
1140	Ščavnica – Pristava	0,221	06. 06.	0,227	0,030
1220	Ledava – Polana	0,032	06. 02.	0,121	0,002
1260	Ledava – Čentiba	1,03	11. 02.	1,15	0,145
1350	Velika Krka – Hodoš	0,017	02. 08.	0,035	0,003
2220	Meža – Črna	0,547	09. 03.	0,579	0,294
2250	Meža – Otiški Vrh	3,04	01. 03.	4,12	2,17
2370	Mislinja – Dovže	0,595	24. 06.	0,546	0,255
2430	Bistrica – Muta	0,738	05. 03.	1,13	0,500
2530	Radoljna – Ruta	0,463	21. 06.	0,603	0,285
2600	Dravinja – Zreče	0,349	26. 02.	0,25	0,078
2640	Dravinja – Makole	1,28	25. 06.	1,18	0,430
2880	Pesnica – Gočova	0,137	25. 06.	0,135	0,006
2720	Rogatnica – Podlehnik	0,016	26. 06.	0,041	0,001
2754	Polskava – Tržec	0,384	26. 11.	0,454	0,024
2900	Pesnica – Zamušani	0,449	23. 06.	0,583	0,141
3060	Sava Dolinka – Jesenice	4,38	07. 03.	4,45	2,82
3180	Radovna – Podhom	1,47	05. 03.	1,84	1,15
3200	Sava Bohinjka – Sveti Janez	0,564	13. 03.	0,900	0,380
3420	Sava – Radovljica	6,26	08. 03.	10,1	5,00
3530	Sava – Medno	24,0	10. 03.	27,1	16,6
3650	Sava – Litija	37,0	07. 03.	46,8	25,9
3725	Sava – Hrastnik	44,9	07. 03.	45,2	30,8
3850	Sava – Čatež	76,7	07. 03.	77,3	48,3
4050	Tržiška Bistrica – Preska	2,26	05. 03.	2,35	1,61
4120	Kokra – Kokra	1,13	07. 03.	1,37	0,716
4200	Sora – Suha	3,55	26. 06.	3,61	1,80
4400	Kamniška Bistrica – Kamnik	1,29	19. 11.	2,09	1,14
4740	Sotla – Rakovec	1,09	26. 06.	0,887	0,337
4850	Kolpa – Radenci	8,21	08. 02.	6,25	3,36
4970	Lahinja – Gradac	0,968	25. 06.	0,456	0,030
5080	Ljubljanica – Moste	8,12	07. 03.	7,89	4,04
5330	Borovniščica – Borovnica	0,080	10. 02.	0,160	0,028
5500	Gradaščica – Dvor	0,646	05. 08.	0,470	0,285
5770	Cerkniščica – Cerknica	0,041	15. 02.	0,110	0,000
6060	Savinja – Nazarje	3,25	01. 03.	3,46	1,44
6210	Savinja – Veliko Širje	9,31	10. 02.	9,72	4,10
6300	Paka – Šoštanj	0,568	18. 02.	0,396	0,059
6550	Bolska – Dolenja vas	0,404	20. 06.	0,603	0,127
6720	Voglajna – Celje	0,244	25. 06.	0,285	0,110
7030	Krka – Podbukovje	2,15	03. 03.	1,70	0,800
7160	Krka – Podbočje	10,4	07. 02.	9,85	4,40
7340	Prečna – Prečna	2,02	21. 11.	1,51	0,690
8060	Soča – Log Čezsoški	4,53	28. 02.	5,39	3,02
8180	Soča – Solkan	18,9	09. 03.	19,8	9,60
8350	Idrijca – Podroteja	1,39	29. 07.	1,66	0,840
8450	Idrijca – Hotešk	5,60	27. 02.	5,03	3,40
8500	Bača – Bača pri Modreju	1,46	22. 02.	1,45	0,379
8565	Vipava – Dolenje	1,80	02. 03.	1,86	1,45
8590	Vipava – Dornberk	1,67	01. 08.	1,84	0,940
9050	Reka – Cerkvenikov mlin	1,00	17. 02.	0,590	0,160
9210	Rižana – Kubed	0,123	17. 09.	0,210	0,030
9300	Dragonja – Podkaštel	0,003	01. 08.	0,030	0,000



Slika 29: Minimalni specifični pretoki v letu 2005 in srednji minimalni in najmanjši specifični obdobni pretoki.

***Figure 29:** The minimum specific discharges in 2005 and the mean minimum and lowest specific discharges of the reference period.*



Slika 30: Mesec, v katerem so bili doseženi najnižji srednji dnevni pretoki v letu 2005.

***Figure 30:** The month when the lowest mean daily discharges in 2005 were reached.*

mesečni pretoki (nQnp). Daljših nizkovodnih obdobij čez leto nismo beležili. Povsod po državi je bila vodnatost najmanjša v prvi četrtini leta, ko so bili srednji dnevni pretoki v mejah srednjih malih obdobnih pretokov in so v februarju in začetku marca tudi padli pod srednje male obdobne mesečne vrednosti, vendar najmanjših obdobnih pretokov niso dosegli. Pretoki so padli pod srednje male pretoke še v juniju ter ponekod v novembru.

Najmanjši srednji dnevni pretoki so za več vodomernih postaj prikazani v preglednici 12. Za primerjavo sta dodana srednji mali in najmanjši mali obdobni pretok. Najmanjši mali obdobni pretoki (nQnp) niso bili nikjer doseženi. Na večini postaj je bil najmanjši pretok v letu 2005 manjši od srednjega malega obdobnega pretoka (sQnp). Večji je bil le ponekod v vzhodni in južni Sloveniji. Večinoma so bili najmanjši pretoki zabeleženi v februarju in marcu, ponekod v severni in severovzhodni Sloveniji v juniju in le izjemoma v drugih mesecih (slika 30). Minimalni specifični pretoki so prikazani na sliki 29, poleg najmanjšega specifičnega pretoka v letu 2005 še srednji mali in najmanjši specifični obdobni pretoki. Analiza nizkovodnih razmer kaže, da v letu 2005 ni bilo izrazitega pomanjkanja vode.

Timeline of Mean Daily Discharges

The 2005 timeline of mean daily discharges from some stations from in parts of Slovenia is shown in Figure 28. The following reference period discharges are given for the purpose of comparison: mean monthly (sQs), mean low (sQnp) and minimum monthly discharge (nQnp). We have not recorded longer low-water periods during the year. Throughout the country, water abundance was lowest in the first quarter of the year, when the mean daily discharges were within the limits of the mean low reference period discharges and even fell below mean low monthly discharges of the reference period in February and the beginning of March, though without reaching the minimum reference period discharges. Discharges fell below the mean low discharges in June and, in places, also in November.

The minimum mean daily discharges for several gauging stations are shown in Table 12. For comparison, the mean low and minimum low discharges of the reference period are also provided. The minimum low discharges of the reference period (nQnp) were not reached anywhere. At the majority of stations, the minimum discharge in 2005 was lower than the mean low reference period discharge (sQnp). It was only higher in some parts of eastern and southern Slovenia. The minimum discharges were, for the most part, recorded in February and March – and in June in some places in northern and north-eastern Slovenia and only exceptionally in other months (Figure 30). The minimum specific discharges are shown in Figure 29; in addition to the minimum specific discharge in 2005, the mean low and minimum specific reference period discharges are given. The analysis of low-water conditions shows that there was no distinct water shortage in 2005.

B. PODZEMNE VODE

Stanje zalog podzemne vode v aluvialnih vodonosnikih v letu 2005

Urša Gale

V letu 2005 je bilo stanje zalog podzemnih voda v aluvialnih vodonosnikih bolj ugodno kot v letih pred tem. Prevladovale so normalne vrednosti vodnih zalog (slika 31). Kljub temu, da si je večina aluvialnih vodonosnikov že opomogla od hidrološke suše iz let 2002 in 2003, se je vpliv le te še vedno odražal v osrednjih delih Prekmurskega in Apaškega polja, kjer so bile zaloge podzemne vode v letu 2005 podpovprečne. Od normalnih vrednosti so odstopala tudi nizka vodna stanja v severnem delu vodonosnika Prekmurskega polja in zelo nizke vodne zaloge v vodonosniku Vipavske doline, kar je bil odraz lokalnega primanjkljaja padavin zahodnega dela Slovenije in Goričkega v letu 2005. Nizko vodno stanje v vodnonosnikih Sorškega polja in dela Kranjskega polja pri Savi je posledica umetnega režima nihanja podzemne vode, ki je z zajezitvijo Save pri Mavčičah in z zamuljevanjem akumulacijskega jezera pred jezom povzročil zvezno upadanje gladin podzemne vode v vplivnem območju. Nadpovprečne zaloge podzemnih voda so bile v vodonosniku Ljubljanskega polja, pa tudi na južnem delu Apaškega polja, kjer so visoke vodne zaloge posledica intenzivnega napajanja vodonosnika iz prispevnega zaledja Slovenskih Goric. V vodonosniku Vrbanskega platoja so bile vrednosti vodnih zalog v letu 2005 zelo visoke, kar je posledica povečane vodnatosti reke Drave, s katero je vodonosnik hidravlično povezan.

Nihanje zalog podzemnih voda je v splošnem odraz celotnega hidrološkega cikla z določenim časovnim zaostankom za padavinskim dogodkom ali spremembo gladine v reki. Nanje poleg naravnih hidroloških in meteoroloških parametrov vplivajo tudi umetni posegi v vodonosnik ter oblika in hidrodinamične lastnosti vodonosnika. Pri interpretaciji zalog podzemnih vod moramo tako upoštevati dinamične kot tudi statične parametre, ki vplivajo na režim podzemne vode obravnavanega vodonosnika. Z letopisom 2005 za opis stanja zalog podzemne vode uvajamo enotno primerjalno obdobje dvanajstih let, med leti 1990 in 2001, ki smo ga uporabili tudi za opis količinskega stanja podzemnih voda, k čemur je Slovenija kot članica Evropske skupnosti zavezana z okvirno vodno direktivo (Directive 2000/60/EC2000).

V letu 2005 je v nekaterih delih Slovenije padlo več, v nekaterih pa manj padavin kot znaša dolgoletno povprečje. Padavine so bile pod dolgoletnim povprečjem na zahodu države in na Goričkem, kar se je posredno

B. GROUNDWATERS

The state of the groundwater reserves in the alluvial aquifers in 2005

Urša Gale

The state of the groundwater reserves in alluvial aquifers in 2005 was more favourable than in the previous years, with normal water reserve values prevailing (Figure 31). Despite the majority of alluvial aquifers recovering from the hydrological drought that occurred in 2002 and 2003, the effect of this drought was still reflected in the central parts of the Prekmurje and Apače fields, where the groundwater reserves were below-average in 2005. The low-water conditions in the northern part of the aquifer of the Prekmurje field and the very low water reserves in the aquifer of the Vipava Valley deviated from the normal values, which was a reflection of the local deficit in precipitation in the western part of Slovenia and Goričko in 2005. The low-water condition in the aquifers of the Sora field and part of the Kranj field on the Sava River is a result of the artificial regime of the fluctuation of groundwater that, owing to the impoundment of the Sava River at Mavčiče and the silting-up of the storage reservoir in front of the dam, caused a continuous decrease in groundwater levels in the zone of influence. Above-average groundwater reserves were recorded in the aquifer of the Ljubljana field, as well as in the southern part of the Apače field where the high water reserves were the result of intensive recharging of the aquifer from the drainage basin of Slovenske Gorice. In the aquifer of the Vrbanski Plateau, the groundwater reserve values in 2005 were very high, which is the result of the increased water stages of the Drava River, with which the aquifer is hydraulically connected.

The fluctuation of the groundwater reserves in general is a reflection of the entire hydrological cycle, though with a certain temporal delay after the precipitation event or change in river water stages. Both the form and hydrodynamic properties of the aquifer and artificial interventions with it affect the groundwater reserves in addition to the natural hydrological and meteorological parameters. When interpreting the groundwater reserves, we must therefore take into account both the dynamic and static parameters that affect the groundwater regime of the aquifer in question. In the 2005 Yearbook, we are introducing a uniform period of twelve years for the description of the state of groundwater reserves, namely between 1990 and 2001, which we also used for the description of the quantitative state of the groundwater reserves, which, as a Member State of the European Community, Slovenia is obliged to measure odražalo tudi z nizkim stanjem zalog podzemnih voda v vodonosniku Vipavske doline in severnem delu Prekmurskega polja. Nadpovprečne količine padavin so bile z eno petino presežka zabeležene na Dolenjskem, kar je pripomoglo k ponovni vzpostavitvi ravnotežja v zalogah podzemnih voda vodonosnikov Krško Brežiške kotline, ki je bilo porušeno s hidrološko sušo v letih 2002 in 2003. Letni padavinski presežek v Celjski kotlini je na zaloge podzemnih voda v vodonosnikih spodnje Savinjske kotline vplival le krajši čas, saj se ti plitvi vodonosniki hitro odzovejo na povečane količine padavin oziroma na spremembo nivoja gladine Savinje. Presežek padavin je bil v letu 2005 značilen tudi za Ljubljansko kotlino. Na območju Prekmurskega in Dravskega polja so prevladovale normalne vrednosti letnih padavin.

Povprečna izguba vlage zaradi izhlapevanja in porabe rastlin je zaradi nadpovprečnih temperatur in povečanega sončnega obsevanja rahlo negativno vplivala na stanje zalog podzemnih vod v letu 2005. Pretežni del države je bil namreč v povprečju toplejši od dolgoletnega povprečja do pol stopinje, v Ljubljani pa do okoli ene stopinje Celzija. Nekoliko nadpovprečen delež izgub vode zaradi evapotranspiracije je bil zato v letu 2005 značilen za aluvialne vodonosnike Ljubljanske, Celjske, Dravske in Murske kotline.

Večja vodnatost rek, ki so v hidravlični povezavi z vodonosnikom, ugodno vpliva na stanje zalog podzemne vode in obratno. Podpovprečna vodnatost rek v letu 2005 je tako nekoliko neugodno vplivala na povprečno letno stanje zalog podzemnih voda v delu aluvialnih vodonosnikov, ki se napajajo iz površinskih vod.

Prostorska variabilnost zalog podzemne vode v letu 2005

Zaloge podzemnih voda so bile v pretežnih delih aluvialnih vodonosnikov leta 2005 v mejah normale. Takšne vrednosti so bile značilne tako za vodonosnike spodnje Savinjske doline in Krško Brežiške kotline, kot tudi za vodonosnike Kamniške Bistrice, Kranjskega polja ter Mirensko Vrtojbenskega polja. Značilne letne gladine podaja preglednica 13, prostorsko variabilnost zalog podzemnih voda v letu 2005 pa sliki 31 in 32.

Značilne letne gladine Hnk, Hs in Hvk so grobi pokazatelj vodnih zalog oziroma statistično povprečnega režima na letni ravni. Ti statistični parametri omogočajo grobo oceno variabilnosti v prostoru, ne morejo pa zajeti časovne variabilnosti med letom. Primerjavo med značilnimi nivoji v letu 2005 in značilnimi dolgoletnimi nivoji podzemnih voda v primerjalnem obdobju podaja slika 32. Razvidno je, da je gladina podzemne vode na večini merilnih mest nihala v mejah normalne spremenljivosti. Maksimalni nivoji gladin primerjalnega obdobja so bili v letu 2005 preseženi le na nekaterih merilnih mestih vodonosnikov Krško Brežiške kotline ter vodonosnika Vrbanskega platoja, kar je posledica intenzivnega napajanja v času visokih voda v drugi

in line with the Water Framework Directive (Directive 2000/60/EC).

There was more precipitation than the normals in some parts of Slovenia and less in other parts in 2005. Precipitation was below the normals in the west of the country and in Goričko, which was indirectly reflected in the low state of the groundwater reserves in the aquifer of the Vipava Valley and in the northern part of the Prekmurje field. Above-average precipitation quantities with a surplus of one fifth were recorded in the Dolenjska region, which contributed to achieving an equilibrium in the groundwater reserves in the aquifers of the Krško-Brežice Basin (previously upset by the hydrological drought in 2002 and 2003). The annual precipitation surplus in the Celje Basin only affected the groundwater reserves in the aquifers of the Lower Savinja Valley for a brief period, as these shallow aquifers respond quickly to increased quantities of precipitation or to a change in the water stage of the Savinja River. The surplus in the precipitation in 2005 was also characteristic for the Ljubljana Basin. Normal annual precipitation values prevailed in the areas of the Prekmurje and Drava fields.

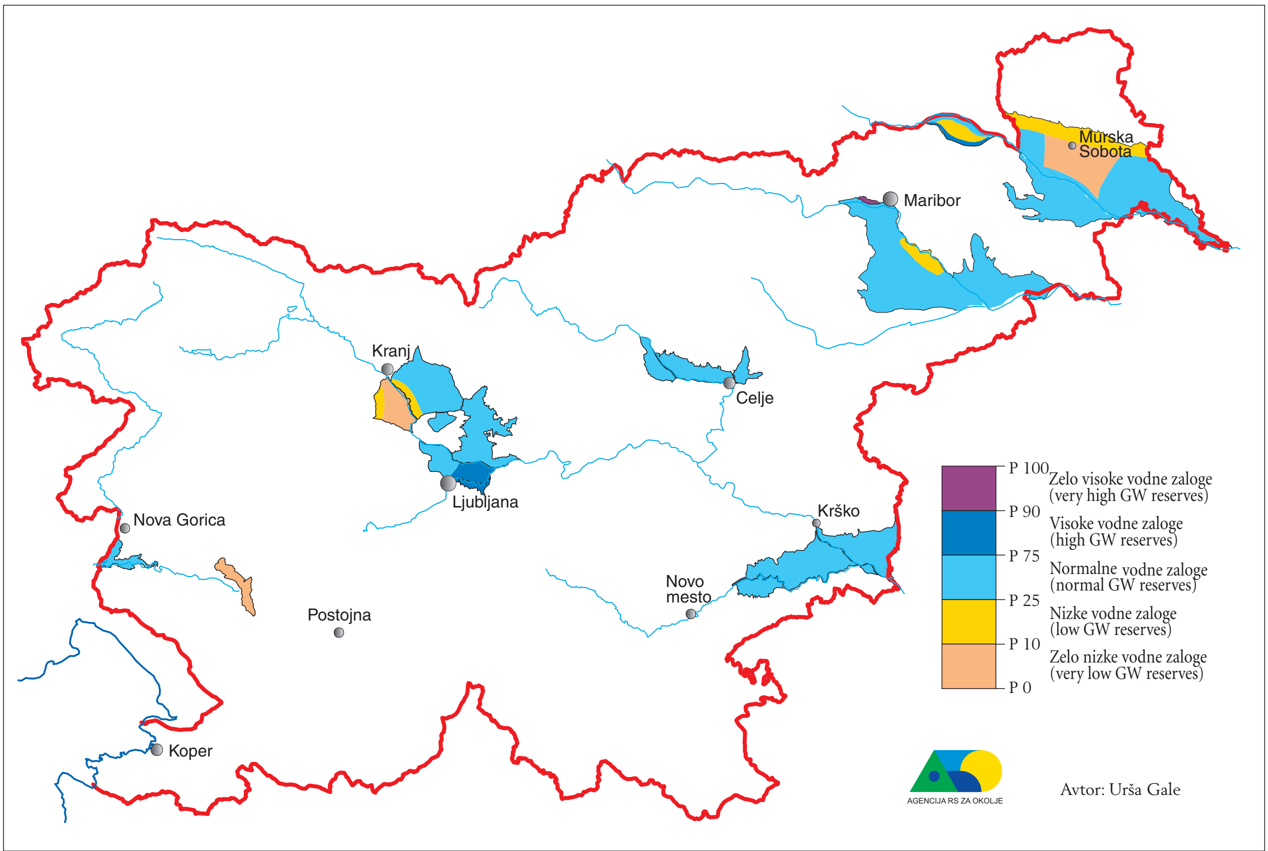
The average loss of moisture on account of evaporation and consumption by plants had a slightly negative effect on the state of the groundwater reserves in 2005 because of above-average temperatures and increased insolation. The major part of the country was warmer than the normals by half a degree Celsius on average, while it was warmer in Ljubljana by around a degree. A slightly above-average share of the loss of water through evapotranspiration in 2005 was therefore characteristic for the alluvial aquifers of the Ljubljana, Celje, Drava and Mura basins.

An increased stage of rivers that are hydraulically connected to the aquifer favourably affects the state of the groundwater reserves and vice versa. The below-average stages of the rivers in 2005 thus had a slightly negative effect on the average annual state of the groundwater reserves in a part of the alluvial aquifers that are recharged from surface waters.

The Spatial Variability of the Groundwater Reserves in 2005

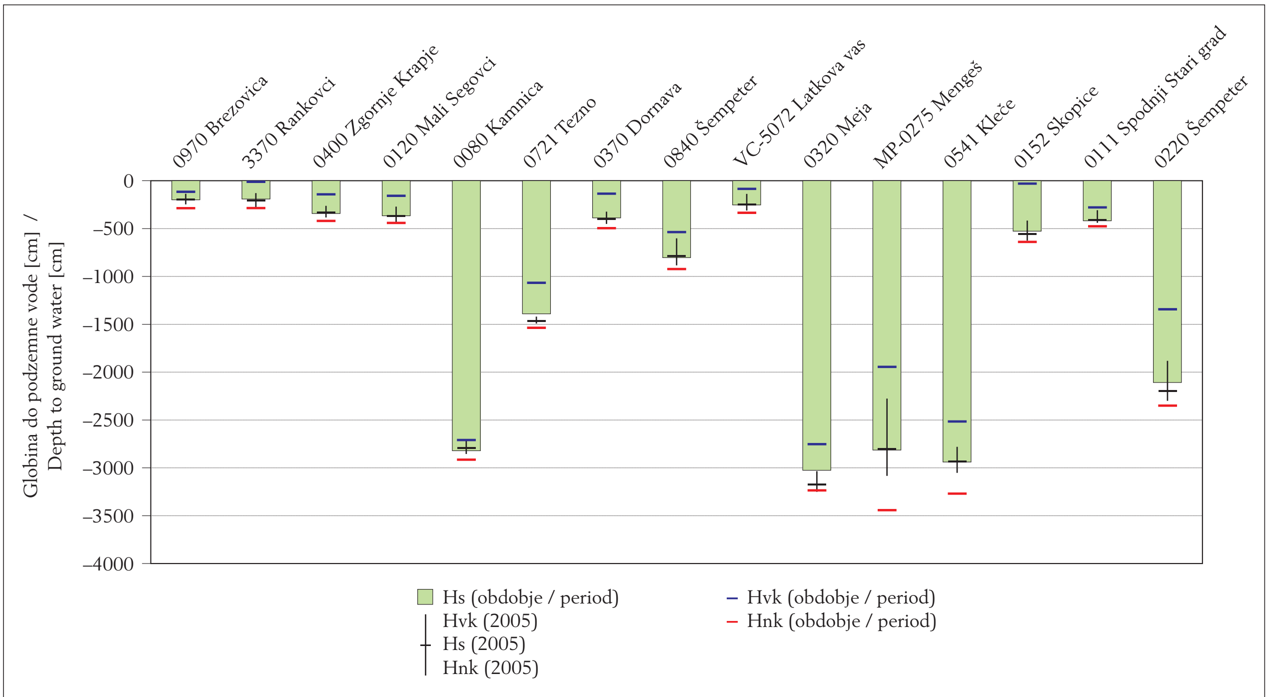
In the major parts of the alluvial aquifers in 2005, the groundwater reserves were within the normal limits. Such values were characteristic of the aquifers of the Lower Savinja Valley and the Krško-Brežice Basin, as well as for the aquifers of the Kamniška Bistrica, the Kranj field and the Miren-Vrtojba field. The characteristic annual groundwater levels are given in Table 13, while the spatial variability of the groundwater reserves in 2005 is given in figures 31 and 32.

The characteristic annual levels, low (Hnk), mean (Hs) and high (Hvk) are a rough indicator of the water reserves as well as an indicator of the statistically averaged



Slika 31: Srednje letne gladine leta 2005 v večjih slovenskih aluvialnih vodonosnikih.

***Figure 31:** The mean annual groundwater levels in 2005 in the major Slovenian alluvial aquifers.*



Slika 32: Primerjava značilnih globine do podzemne vode v letu 2005 z značilnimi gladinami za primerjalno obdobje (Preglednica 13) (Hs – srednja letna/obdobna gladina, Hnk – najnižja letna/obdobna gladina, Hvk – najvišja letna/obdobna gladina).

***Figure 32:** A comparison of the characteristic groundwater levels in 2005 with the characteristic groundwater levels of the reference period (Table 13) (Hs – mean annual /reference period level, Hnk – minimum annual/reference period level, Hvk – maximum annual /reference period level).*

polovici leta. Minimalni nivoji so v letu 2005 padli pod obdobne minimume na merilnih mestih vodonosnikov Vipavske doline in Sorškega polja. Razlog za tako nizke nivoje podzemne vode v vodonosniku Vipavske doline deloma pripisujemo letnemu primanjkljaju padavin, deloma pa melioracijam tamkajšnjih kmetijskih površin. Nizke vodne zaloge v vodonosniku Sorškega polja povezujemo z umetnim režimom nihanja podzemnih voda, ki je nastal z zajezitvijo Save pri Mavčičah. Ob zajezitvi leta 1986 je podzemna voda, ki je v hidravlični povezavi z reko, močno narasla, sledilo pa je počasno upadanje gladine, ki je posledica zamuljevanja dna akumulacijskega jezera. Kljub trendom zniževanja vodnih zalog od zajezitve dalje nivoji podzemne vode še niso dosegli naravnih spremenljivosti pred zajezitvijo.

Kot že rečeno, so si vodonosniki severovzhodne Slovenije v letu 2005 povečini že opomogli od hidrološke suše iz let 2002 in 2003. Zelo nizke vodne zaloge so prevladovale le v osrednjem delu Prekmurskega polja, nizki nivoji podzemne vode pa so bili v letu 2005 značilni za osrednji delu Apaškega polja. Nizke zaloge podzemnih vod na delu Dravskega polja ob Dravi so posledica znižanja gladine Drave med Mariborom in Ptujem, ko so rečno vodo preusmerili v vodotesni dovodni kanal HE Zlatoličje. Podpovprečne vodne zaloge na severnem delu Prekmurskega polja so posledica negativne vodne bilance Goričkega, od koder se napaja ta del vodonosnika.

Zelo visoke zaloge podzemne vode v vodonosniku Vrbanskega platoja so bile v letu 2005 posledica povečane vodnatosti reke Drave, s katero je vodonosnik hidravlično povezan. Visoke vodne zaloge južnega dela Apaškega polja so odraz intenzivnega napajanja iz prispevnega zaledja Slovenskih Goric.

regime at an annual level. These statistical parameters enable a rough assessment of spatial variability, though they cannot encompass the temporal variability during the year. The comparison between the characteristic levels in 2005 and the characteristic multi-annual period groundwater levels are given in Figure 32. It is evident that the groundwater level at the majority of observation stations fluctuated within the limits of normal variability. In 2005, the maximum groundwater levels of the reference period were only exceeded at some observation stations in the aquifers of the Krško-Brežice Basin and the aquifer of the Vrbanski Plateau, which is the result of intensive recharging during the high waters in the second part of the year. The minimum levels in 2005 dropped below the multi-annual period minima at observation stations in the aquifers of the Vipava Valley and the Sora field. The reason behind such low levels of groundwater in the aquifer of the Vipava Valley is partly ascribed to the annual shortage of precipitation, and partly to the melioration of the farmland in that area. The low water reserves in the aquifer of the Sora field are linked to the artificial regime of groundwater fluctuation that began with the damming the Sava River at Mavčiče. Upon the erection of the dam in 1986, the groundwater, which is hydraulically connected to the river, rose significantly, followed by a slow decrease in the groundwater level as a result of the silting up of the bottom of the storage reservoir. Despite the trends of decreasing water reserves since the damming, the groundwater levels have still not achieved their natural variability prior to the erection of the dam.

As stated above, the aquifers of north-eastern Slovenia for the most part recovered in 2005 from the

Preglednica 13: Primerjava značilnih globin podzemne vode v letu 2005 z značilnimi globinami primerjalnega obdobja 1990–2001 (V. Savić, U. Gale).

Table 13: *A comparison of the characteristic groundwater levels in 2005 with the characteristic levels of the 1990–2001 reference period (V. Savić, U. Gale).*

Postaja *Station*	Vodonosnik *Aquifer*	2005 Hnk (cm)	2005 Hs (cm)	2005 Hvk (cm)	Obdobje *Period* Hnk (cm)	Obdobje *Period* Hs (cm)	Obdobje *Period* Hvk (cm)
0970 Brezovica	Prekmursko polje	247	195	137	287	203	129
3370 Rankovci	Prekmursko polje	275	207	129	286	181	56
0400 Zgornje Krapje	Mursko polje	384	330	263	405	344	241
0120 Mali Segovci	Apaško polje	433	371	271	441	363	151
0080 Kamnica	Vrbanski plato	2855	2791	2702	2915	2832	2725
0721 Tezno	Dravsko polje	1492	1466	1420	1537	1436	1267
0370 Dornava	Ptujsko polje	452	402	323	497	411	260
0840 Šempeter	Sp. Savinjska dol.	885	787	602	923	802	537
Vc-5072 Latkova vas	Dolina Bolske	311	249	138	322	255	86
0320 Meja	Sorško polje	3251	3173	3035	3252	3058	2754
Mp-0275 Mengeš	D. Kamniške Bistrice	3084	2801	2277	3441	2793	1946
0541 Klece	Ljubljansko polje	3052	2932	2781	3194	2976	2635
0152 Skopice	Krško polje	627	559	417	638	539	108
0111 Sp. Stari Grad	Brežiško polje	440	409	308	470	418	279
0220 Šempeter	Vipavsko-Soška d.	2300	2195	1882	2323	2154	1378

Časovna variabilnost zalog podzemne vode v letu 2005

V splošnem so v prvi polovici leta v aluvialnih vodonosnikih prevladovale nizke in zelo nizke vodne zaloge, v drugi polovici pa visoke in zelo visoke zaloge podzemnih vod. Nihanje mesečnih gladin podzemnih vod prikazujejo preglednica 14 in sliki 33 in 34.

Prva dva meseca leta 2005 so na območju aluvialnih vodonosnikov zaradi januarskega padavinskega primanjkljaja in zadrževanja snega v zaledju vodonosnikov gladine podzemne vode zvezno upadale. Kljub nizkim količinam padavin v marcu so se tedaj nivoji podzemne vode na večini merilnih postaj zaradi taljenja snega pričeli postopoma zviševati do normalnih vrednosti vodnih zalog. Zviševanje nivojev podzemnih voda se je nadaljevalo v april, vendar so bile kljub obilnejšim padavinam v tem času na pretežnih aluvialnih vodonosnikih severovzhodne Slovenije še vedno zelo nizke vodne zaloge. Podobno vodno stanje kot v mesecu aprilu se je v aluvialnih vodonosnikih nadaljevalo tudi v maju in juniju, čeprav so se gladine tedaj glede na tiste iz aprila nekoliko znižale. V času pozne pomladi in potem v poletju se je zaradi višjih temperatur zraka in večje porabe vode za rast rastlin povečal tudi delež evapotranspiracije. Kljub izgubam vlage zaradi izhlapevanja in porabe rastlin so se julija, avgusta in septembra zaradi zelo obilnih padavin zaloge podzemnih voda pričele postopoma obnavljati. V juliju so prevladovale običajne vrednosti zalog, vendar je bilo ponekod na severovzhodu države še vedno zabeleženo zelo nizko vodno stanje. Avgusta in septembra hidrološke suše praktično ni bilo več beležili, saj so poleg normalnih vodnih zalog v vseh večjih aluvialnih vodonosnikih po Sloveniji prevladovale visoke in zelo visoke vrednosti zalog podzemne vode. V tem času so bile na območju vodonosnikov ob Muri izvedene simultane meritve gladin podzemne vode, ki so pomembne za razumevanje hidrogeološkega režima podzemnih voda na tem hydrological drought in 2002 and 2003. Very low groundwater reserves prevailed only in the central part of the Prekmurje field, while less extreme low groundwater levels were characteristic of the central part of the Apače field. The low groundwater reserves in a part of the Drava field along the Drava River were the result of the decrease in the water stages of the Drava between Maribor and Ptuj when the river water was redirected into the watertight supply channel of the Zlatoličje hydroelectric power plant. Below-average water reserves in the northern part of the Prekmurje field are the result of the negative water balance of Goričko, from where this part of the aquifer is recharged.

The very high groundwater reserves in the aquifer of the Vrbanski Plateau in 2005 were the result of the increased stages of the Drava River, with which the aquifer is hydraulically connected. The high water reserves in the southern part of the Apače field are a reflection of the intensive recharging from the drainage basin of Slovenske Gorice.

The Temporal Variability of Groundwater Reserves in 2005

In general, low and very low water reserves prevailed in the alluvial aquifers in the first part of the year, while high and very high groundwater reserves prevailed in the second part. The fluctuation of the monthly groundwater levels is shown in Table 14 and figures 33 and 34.

In the area of alluvial aquifers, the first two months of 2005 saw a continuous decrease in groundwater levels on account of the January precipitation deficit and the retention of snow in the catchment area of the aquifers. Despite the low precipitation quantities in March, the groundwater levels at the time began gradually increasing up to the normal water reserve values at the majority of observation stations due to snowmelt.

Preglednica 14: Srednje mesečne globine podzemne vode v letu 2005 (V. Savić, U. Gale).

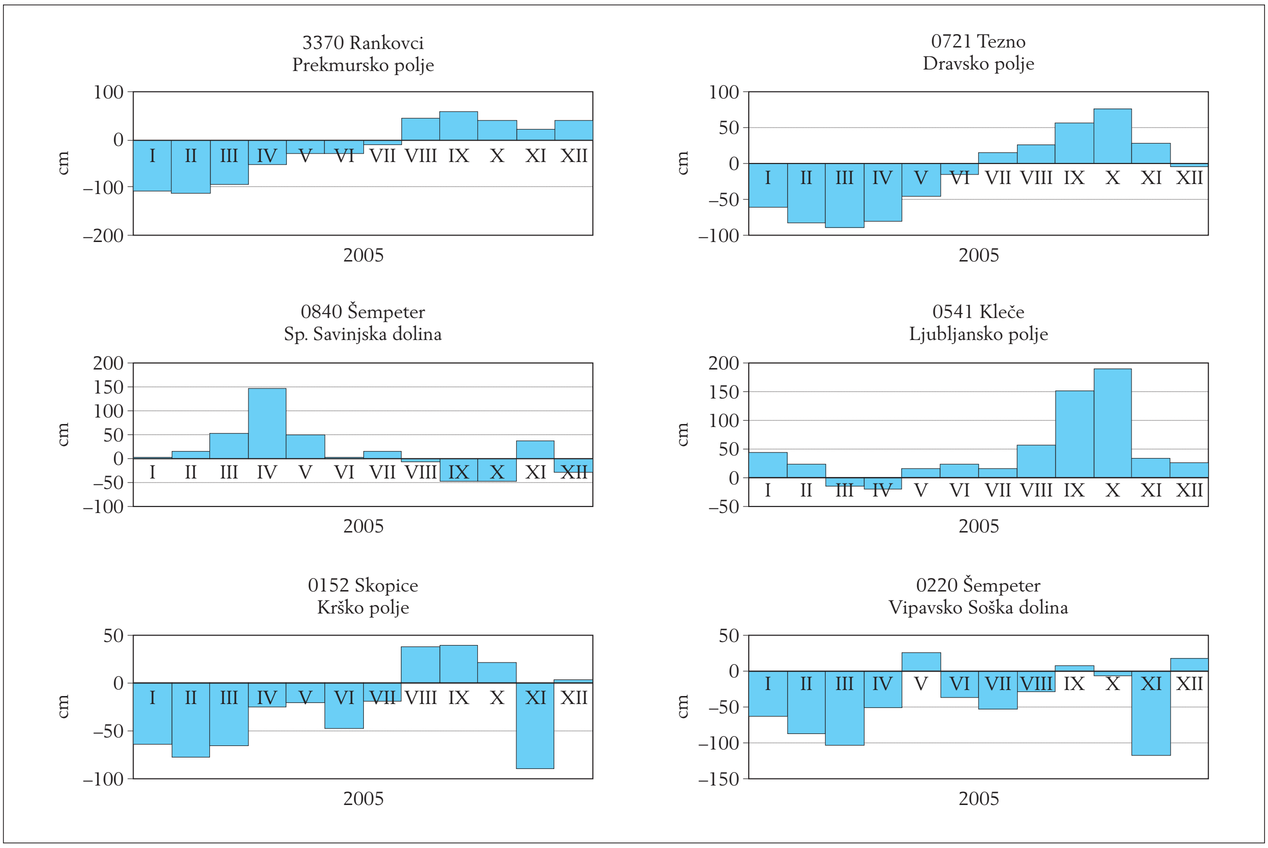
***Table 14:** The mean monthly groundwater levels in 2005 (V. Savić, U. Gale).*

Postaja / *Station*	Vodonosnik / *Aquifer*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0970 Brezovica	Prekmursko polje	204	202	190	182	196	233	201	193	186	189	198	169
3370 Rankovci	Prekmursko polje	266	272	256	223	216	227	221	174	157	165	179	275
0400 Zgornje Krapje	Mursko polje	372	380	367	330	322	341	332	307	290	294	320	313
0120 Mali Segovci	Apaško polje	423	431	423	402	388	387	367	338	313	321	344	334
0080 Kamnica	Vrbanski plato	2811	2832	2851	2840	2826	2822	2762	2724	2731	2736	2767	2796
0721 Tezno	Dravsko polje	1461	1474	1485	1484	1449	1424	1408	1411	1395	1385	1387	1407
0370 Dornava	Ptujsko polje	433	446	430	390	395	418	397	366	370	375	411	387
0840šempeter	Sp. Savinjska dol.	766	795	774	679	778	823	794	842	871	818	729	801
Vc-5072 Latkova vas	Dolina Bolske	269	299	295	268	261	280	248	200	195	201	261	212
0320 Meja	Sorško polje	3121	3186	3231	3244	3227	3223	3218	3204	3156	3064	3118	3090
Mp-0275 Mengeš	D. Kamniške Bistrice	2682	2841	2985	3047	3011	3034	3044	2926	2678	2377	2597	2403
0541 Klece	Ljubljansko polje	2847	2933	3018	3029	2982	2990	2997	2974	2898	2808	2864	2853
0152 Skopice	Krško polje	572	617	603	546	552	598	577	545	531	504	578	495
0111 Sp. Stari Grad	Brežiško polje	423	426	407	398	418	435	432	385	394	391	417	365
0220 Šempeter	Vipavsko-Soška D.	2141	2241	2289	2212	2139	2218	2263	2275	2217	2134	2184	2034

Vodnjak v Lešanah na Apaškem polju, vključen v mrežo simultanih meritev avgusta 2005 (foto: N. Trišić).

The well at Lešane on the Apače field, which was included in the network of simultaneous measurements in August of 2005 (Photo: N. Trišić).

The increasing groundwater levels continued in April, though the water reserves in the major part of the alluvial aquifers in north-eastern Slovenia were still very low despite the abundant precipitation that occurred during this time. A similar water situation in the alluvial aquifers continued in May and June as well, despite the levels decreasing slightly at the time compared to those in April. In late spring and the summer, the higher air temperatures and the increased consumption of water by plant life increased the share of evapotranspiration. Despite the losses of moisture and the consumption by plant life, groundwater reserves gradually began to recover in July, August and September owing to the highly abundant precipitation. The usual reserve values prevailed in July, though a very low water situation was still recorded in parts of the north-eastern part of the country. There was practically no hydrological drought observed in August and September, as high and very high groundwater reserve values prevailed in addition to the normal water reserves in all major alluvial aquifers around Slovenia. During this time, simultaneous measurements of groundwater levels were performed in the area of the aquifers along the Mura River, which are important for understanding the hydrogeological regime of the groundwater in this area during high-water events (Photo of the well on the Apače field).



Slika 33: Odstopanja srednjih mesečnih gladin podzemne vode v letu 2005 glede na srednje mesečne gladine za primerjalno obdobje 1990–2001 (V. Savić).

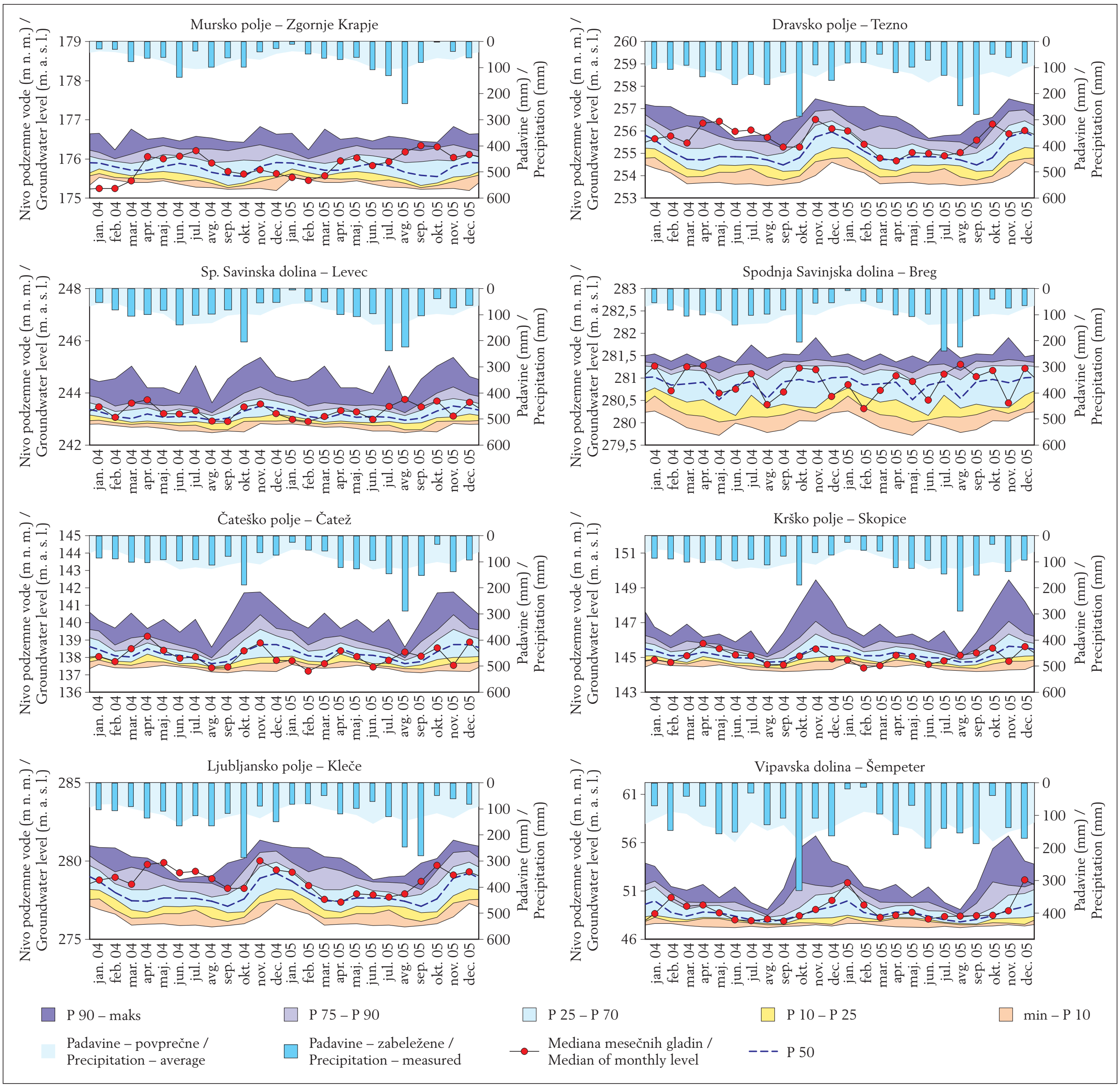
Figure 33: *The deviations of the mean monthly groundwater levels in 2005 compared with the mean monthly groundwater levels for the 1990–2001 reference period (V. Savić).*

območju v času visokih voda (fotografija vodnjaka na Apaškem polju). Prostorska porazdelitev padavin je bila v zadnjih mesecih leta razmeroma neenakomerna, kar je povzročilo, da so se gladine podzemnih vod v nekaterih vodonosnikih dvigovale, v drugih pa upadale. Ob zaključku leta so bile v večini aluvialnih vodonosnikov po Sloveniji še vedno običajne in visoke vrednosti zalog podzemne vode.

Povprečne zaloge podzemnih vod v letu 2005 so bile glede na dolgoletno povprečje v večini aluvialnih vodonosnikov po Sloveniji normalne. Mesečna nihanja gladin so bila v prvi polovici leta pretežno v mejah nizkih in zelo nizkih vrednosti, v drugi polovici pa v mejah visokih do zelo visokih vrednosti zalog podzemne vode.

The spatial distribution of the precipitation in the final months of the year was relatively imbalanced, which caused the groundwater levels to increase in some aquifers and decrease in others. At the end of the year, there were still normal and high groundwater levels in the majority of the aquifers around Slovenia.

The average groundwater reserves in 2005 were normal compared to the multi-annual period average in the majority of the alluvial aquifers around Slovenia. The monthly fluctuation of the groundwater levels in the first half of the year were predominantly within the limits of low and very low values, while they were within the limits of high to very high levels in the second part of the year.



Slika 34: Mediane mesečnih gladin podzemnih voda (m. n. v.) v letih 2004 in 2005 – rdeči krogci, v primerjavi z značilnimi percentilnimi vrednostmi gladin primerjalnega obdobja 1990–2001 (U. Gale).

Figure 34: *The medians of the groundwater levels (m. n. v.) in 2004 and 2005 – the red circles – in comparison with the characteristic percentile groundwater level values of the 1990–2001 reference period (U. Gale).*

C. IZVIRI

Izviri

Niko Trišić

Program hidrološega monitoringa izvirov smo dopolnjevali tudi v letu 2005 s postavitvijo še dveh novih postaj. Na izviru Letošč pri Bočni ob Paki sta postavljena podatkovni zapisovalec in vodomerna letev v profil cca 100 m pod zajetjem za vodooskrbo. S tem je vzpostavljena prva postaja monitoringa izvirov v povodju Savinje. Drugo postajo smo postavili na izviru Bilpa ob Kolpi. Postaji sta pričeli z delovanjem v drugi polovici leta, zato teh podatkov še ne objavljamo. Objavljamo hidrološke podatke šestih izbranih postaj, ki karakterizirajo hidrodinamiko iztekanja iz vseh tipov kraških vodonosnikov v Sloveniji. Za izvire Podroteja, Kamniška Bistrica in Metliški Obrh predstavljamo podatke o vodostajih, temperaturi in specifični električni prevodnosti, za postaje Krupa, Težka voda in Veliki Obrh pa podatke o pretokih. V II. delu publikacije so podani grafični in tabelarični podatki kot srednje dnevne vrednosti, ekstremi pa so izbrani iz urnih oz. 15-min nizov.

Podroteja – izvir

Merilno mesto postaje Podroteja-izvir se nahaja v bazenu črpališča za vodooskrbo Idrije in okolice. Izviri Podroteje so sicer razporejeni v cca 200 m dolgi izvirni coni na desnem bregu Idrijce. Izvira Podroteja in Divje jezero imata skupno zaledje in ga ni mogoče ločevati. Zaledje zajema celotno Črnovrško planoto, del Križne gore in Javornikov, severno obrobje Hrušice, del Hotenjskega podolja in povodje hotenjskih ponikalnic južno od Medvedjega brda. Verjetno je, da v izvir Podroteja zateka tudi del voda površinske Zale. Razvodje proti Hublju poteka znotraj Trnovskega pokrova, nekje med Križno goro, Colom in Javorniki. V območju Hrušiškega pokrova pa je razvodje na območju med Vodicami, Javornikom in Hotedrščico. Zaledje obeh izvirov obsega okoli 125 km^2 območja visokega dinarskega krasa ob tem predstavlja izvir Divje jezero iztok prelivnih voda, izvir Podroteja pa iztok baznih voda iz zaledja. Ocenjujemo, da pretoki izvirov Podroteje nihajo v razponu od 1–5 m^3/s. Podatki so le ocena, saj pretokov izvirov Podroteja ni možno direktno meriti.

Režim izvirov Podroteje se razlikuje od režima izvirov na območju alpskega krasa. Časovni razpored vodostajev izkazuje nastop spomladanskega in jesenskega visokega vala in najnižje vodostaje poleti in drugi minimum pozimi. Jasen je vpliv topljenja snega v spomladanskem obdobju. Razpon temperatur je večinoma med 8 °C in 9 °C in ekstremi med 7,7 °C in 10,4 °C. Potek mesečnih vrednosti temperatur in specifične električne prevodnosti

C. SPRINGS

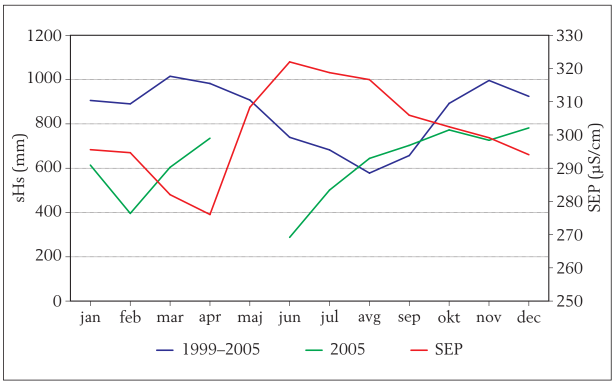
Springs

Niko Trišić

The hydrological monitoring programme for springs was augmented in 2005 with the setup of two new stations. At the Letošč Spring near Bočna ob Paki, a data logger and staff gauge have been set up in a cross-section approximately 100 m below the water supply catchwork. This was the first spring monitoring station set up in the catchment area of the Savinja River. The second station was set up at the spring of Bilpa near Kolpa River. The stations became operational in the second half of the year, which is why their data is not published yet. We are publishing the hydrological data from six selected stations that characterise the hydrodynamics of the outflow from all the types of karstic aquifers in Slovenia. For the springs of Podroteja, Kamniška Bistrica and Metliški Obrh, we are presenting data on water stages, temperature and specific electrical conductivity, while there is data on discharges for the Krupa, Težka voda and Veliki Obrh stations. The second part of the publication gives graphic and tabular data such as the mean daily values, while the extremes are selected from the hourly or 15-minute data sets.

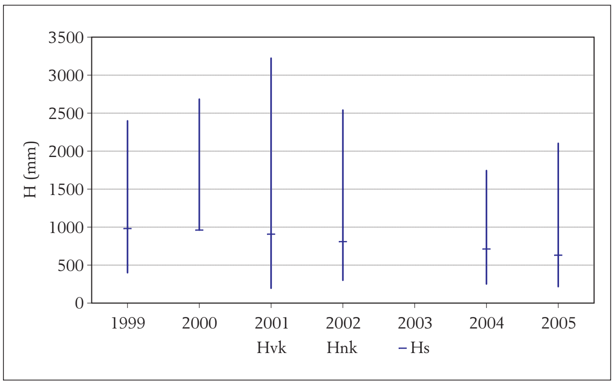
Podroteja – Spring

The gauging site of the Podroteja – Spring station is located in the pump storage for the water supply of Idrija and its surroundings. The springs of Podroteja are otherwise distributed in an approximately 200 m long zone on the right bank of the Idrijca River. The Podroteja and Divje jezero springs have a common catchment area that cannot be differentiated. The catchment area encompasses the entire Črni Vrh Plateau, part of Mount Križna gora and Javorniki, the northern outskirts of Hrušica, a part of the Hotenja planated lowland and the catchment basin of the Hotenja losing streams south of the Medvedje brdo hill. It is probable that a part of the water of the surface-running Zala River seeps into the Podroteja spring. The watershed divide toward Hubelj runs within the Trnovo nappe somewhere between Mount Križna gora, Col and Javorniki. In the area of the Hrušica nappe, the watershed divide lies in the area between Vodice, Javornik and Hotedrščica. The catchment area of both springs encompasses around 125 km^2 of the area of the High Dinaric Karst – of which the spring of Divje jezero represents the outflow of overflow, while the spring of Podroteja represents the outflow of the base flow from the catchment area. We estimate that the discharges of the springs of Podroteja fluctuate within the range of 1–5 m^3/s. The data is only



Slika 35: Podroteja – potek srednje mesečnih letnih in obdobnih vrednosti sHs in SEP.

Figure 35: *Podroteja – the trend of the mean monthly, annual and reference period values sHs and SEC (specific electrical conductivity).*



Slika 36: Podroteja – značilni letni vodostaji v mm.

Figure 36: *Podroteja – the characteristic annual water levels in mm.*

Preglednica 15: Značilni mesečni in letni vodostaji v mm.

Table 15: *The characteristic monthly and annual water levels in mm.*

	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	sHs	kHvk	kHnk	sHs
1999	1007	996	1252	1290	989	926	798	626	661	969	1008	1273	981	2398	400	981
2000	855	1014	1148	1050	951	694	831	456	718	1013	1598	1217	961	2684		961
2001	1385	1058	1432	1088	934	945	662	356	822	849	822	552	907	3223	356	907
2002	668	987	807	816	891	856	727	932	568				809	2540	300	809
2003																
2004			848	915	774	727	576	452	472	858	826	798	713	1744	251	713
2005	614	396	604	735		288	501	644	703	773	726	782	631	2103	217	631
avg	906	890	1015	982	908	739	682	578	657	892	996	924	834	3223	217	834

Izvir Podroteje 2. 2. 2005 (foto: Niko Trišić).

The spring of Podroteja on 2 February 2005 (Photo: Niko Trišić).

je obratno sorazmeren s potekom vrednosti vodostajev. Vrednosti specifične električne prevodnosti so v območju med 230 in 367 µS/cm, povprečna letna vrednost pa znaša 328 µS/cm. Ob visokovodnih konicah vrednosti specifične električne prevodnosti in tudi temperatur praviloma strmo upadejo kot znak dotoka nizkomineralizirane sveže vode.

V letu 2005 so bile dosežene najnižje beležene vrednosti vodostajev, pa tudi srednja letna vrednost sHs je najnižja beležena v obdobju 1999–2005. Pri tem pa je

an estimate, as the discharges of the springs of Podroteja cannot be directly measured.

The regime of the springs of Podroteja differs from the regime of the springs in the area of the Alpine Karst. The temporal distribution of water levels shows spring and autumn high-water waves while the lowest water levels are in the summer, and the second minimum in the winter. What is clear is the effect of the snowmelt in the spring period. The range of temperatures is between 8 °C and 9 °C for the most part and that of the extremes is between 7.7 °C and 10.4 °C. The trend of the monthly values of the temperatures and specific electrical conductivity is inversely proportional to the trend of the water level values. The specific electrical conductivity values are within the range of 230 and 367 µS/cm, while the average annual value amounts to 328 µS/cm. During the high-water peaks, the specific electrical conductivity and temperature values decrease sharply as a rule, as a sign of the inflow of fresh water with a low mineral content.

2005 saw the lowest recorded water level values and the mean annual sHs value is the lowest recorded value in the 1999–2005 period. It should be noted at this point that the station on the spring of Podroteja did not operate in 2003 owing to a malfunction of the device.

potrebno opozorilo, da v letu 2003 postaja na izviru Podroteja žal ni delovala zaradi okvare aparata.

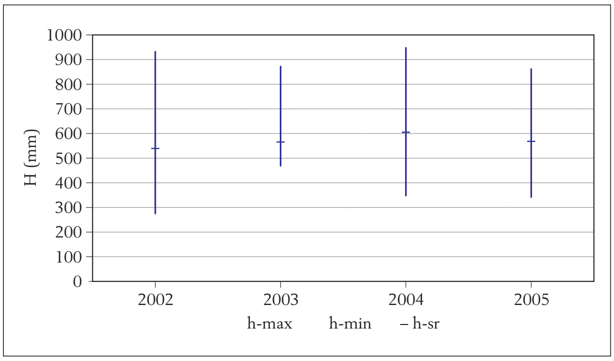
Kamniška Bistrica

Postaja na izviru Kamniške Bistrice beleži režim nihanja vodostajev, temperature in specifične električne prevodnosti. Ker v merskem profilu ni zajeta celotna količina iztoka iz zaledja, ne predstavljamo količin pretoka izvira. Parametri, ki se beležijo v izviru in njihov časovni razpored zadostujejo za predstavitev značilnosti režima, ki je specifičen za območje alpskega krasa. Zaradi prevladujoče vertikalne komponente pretakanja vode v vodonosniku, so zadrževalni časi v zaledju krajši kot na drugih kraških območjih v Sloveniji. To se kaže predvsem v nižjih vrednostih specifične električne prevodnosti v izviru in tudi nižjih temperaturah, ki ne vrednosti, značilne za iztok iz globokih delov vodonosnika.

Časovni razpored vodostajev v letu 2005 predstavlja podobne značilnosti, kot smo jih opazovali tudi v preteklih letih. Jasno izraženi so nizki vodostaji v zimskem času, ki pri vrednostih pod 50 cm strmo upadejo v območje vodostajev okoli 30 cm. Pri pregledu podatkov za pretekla leta, je potrebno opozorilo, da v letu 2003 nizki vodostaji niso bili registrirani, ker je prav v zimskem času v tem letu prekinjen niz podatkov.

V letu 2005 niso bile dosežene ekstremne obdobne vrednosti (2002–2005), konice visokih valov so razporejene v obdobju med aprilom in oktobrom, nizko vodno stanje pa nastopa v zimskih mesecih, ko v visokogorju prevladujejo nizke temperature pod lediščem. Pozimi so zaradi relativno daljšega zadrževalnega časa vode v vodonosniku, temperature in specifična električna prevodnost vode višje kot v poletnih mesecih.

Časovni razpored parametrov temperatur in specifične električne prevodnosti je premosorazmeren. Temperature dosežejo najnižje letne vrednosti v poletnih mesecih, junija in julija, enako velja za vrednosti specifične električne prevodnosti. Takrat pretok izvira bogati snežnica, ki se topi v visokogorju. Zadrževalni čas v vodonosniku je zaradi pretežno vertikalne komponente pretakanja kratek, zato je tudi vsebnost raztopljenih snovi



Slika 37: Kamniška Bistrica – značilni letni vodostaji v mm.

Figure 37: *Kamniška Bistrica – the characteristic annual water levels.*

Kamniška Bistrica

The station on the spring of the Kamniška Bistrica River records the regime of fluctuation of water levels, temperature and specific electrical conductivity. Because the total quantity of outflow from the catchment area is not encompassed in the water-gauging cross-section, we are not presenting the spring's discharge quantities. The parameters that are recorded in the spring and their temporal distribution suffice for presenting the characteristics of the regime that is specific for the area of the Alpine Karst. Because of the prevailing vertical component of the water flow in the aquifer, the water residence times in the catchment area are shorter than in other Karst areas in Slovenia. This is primarily reflected in the lower specific electrical conductivity values in the spring and in lower temperatures, which do not represent values that are characteristic of the outflow from the deep parts of the aquifer.

The temporal distribution of the water levels in 2005 exhibits the same characteristics as the ones observed in previous years. Low water levels in the wintertime are clearly expressed. At values of below 50 cm, they decrease sharply to a water level range of around 30 cm. When reviewing the data from previous years, it needs to be said that the low water conditions were not registered in 2003 because the data set was interrupted in the wintertime of that year.

No extreme reference period values (2002–2005) were achieved in 2005. High-water waves are distributed over a period between April and October, while the low-water condition occurs in the winter months when low temperatures – below freezing point – prevail in the high mountains. The temperatures and specific electrical conductivity are higher in the winter than in the summer months because of the relatively longer residence time of the water in the aquifer.

The temporal distribution of the temperature and specific electrical conductivity parameters is directly proportional. The temperatures reach their lowest annual values in the summer months – June and July – and the same applies to the specific electrical conductivity values. At this time, the spring discharge is increased by snow melt from the high mountains. The residence time in the aquifer is short because of the dominant vertical component of the water flow, which is why the concentration of dissolved matter in the water, and therefore also the SEC values, are low. A peculiarity in the annual data set is the occurrence of high annual peaks in temperature (6.2 °C) and specific electrical conductivity (191 µS/cm) on 5 December. This phenomenon can be interpreted as a consequence of a lower water wave in the beginning of December, which occurred after a two-month period without precipitation. The occurrence of high values of temperature and SEC is the result of the outflow of the accumulated base flow of water.

v vodi nizka in s tem tudi nizke vrednosti SEP. Posebnost v letnem nizu podatkov predstavlja pojav visokih letnih konic temperature (6,2 °C) in specifične električne prevodnosti (191 µS/cm), ki nastopata 5. decembra. Pojav lahko interpretiramo kot posledico nastopa nižjega vodnega vala v začetku decembra, ki pa je nastopil po dvomesečnem obdobju brez padavin, in je nastop visokih vrednosti temperatur in SEP posledica iztoka akumuliranega baznega toka vode.

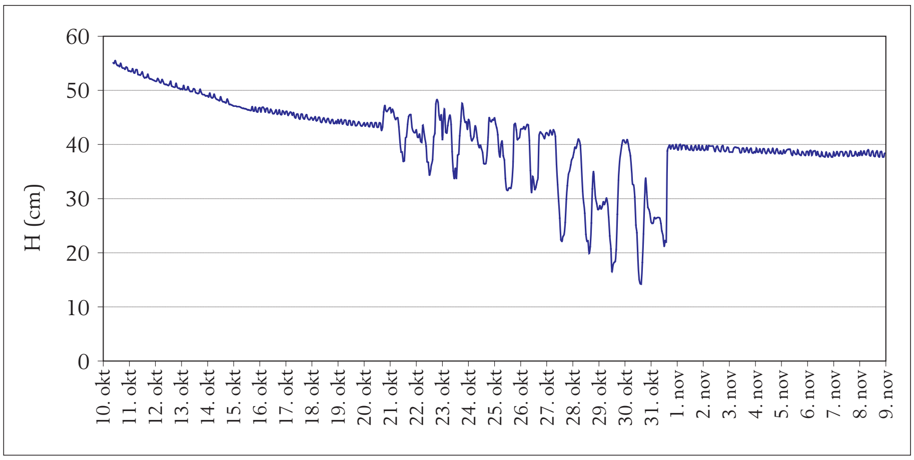
Težka voda

Postaja na profilu Težka voda – Stopiče je reaktivirana v letu 2004, po ukinitvi delovanja leta 1985. Merski profil smo aktivirali v okviru programa monitoring izvirov, z namenom, spremljati režim najpomembnejših izvirov v Sloveniji. Postaja je locirana cca 50 m dolvodno od prejšnjega profila in je opremljena z vodomerom in podatkovnim registratorjem za beleženje vodostaja in temperature. Izvir je zajet za vodooskrbo in je poleg zajetja Jezero najpomembnejši vodni vir za območje Novega mesta. Izviri Težke vode ležijo v območju močno razpokanega in tektonsko pretrtem zgornjetriasnem zrnatem dolomitu. Dolomitno zaledje Težke vode in Metliškega Obrha je zakraselo in ne kaže funkcije hidrološke bariere. Dolomit je narinjen na močno zakrasele dobro prepustne jurske in kredne apnence, ki omogočajo globinsko kraško raztekanje z bifurkacijskim območjem na Gorjancih med izviri Metliškega Obrha in Težko vodo.

Težka voda

The station at the Težka voda and Stopiče cross-section was reactivated in 2004 following its discontinuation in 1985. The water-gauging cross-section was activated within the scope of the spring monitoring programme, with the aim of monitoring the regime of the most important springs in Slovenia. The station is located approximately 50 m downstream form the previous cross-section and is equipped with a gauge and a data logger for recording the water level and temperature. The spring is capped for water supply and, in addition to the Jezero catchwork is, the most important source of water for the area of Novo mesto. The Težka voda spring lie in an area of heavily fractured and tectonically disrupted Late Triassic grained dolomite. The dolomite catchment area of the Težka voda and Metliški Obrh springs has become karstified and does not exhibit the function of a hydrological barrier. The dolomite is thrust onto the heavily karstified, highly permeable Jurassic and Cretaceous limestones, which enable deep karstic bifurcation with the bifurcation area on Gorjanci between the Metliški Obrh and Težka voda springs.

In 2005, following the low discharge in the winter months, high-water waves occurred in March and April, which is also a characteristic phenomenon of the reference period. The low summer discharges are equal to the winter ones. The lowest discharge was recorded on 31 October, but it was obvious that it was the result of an artificial effect. We estimate that the lowest natural discharge since the reactivation of the sta-



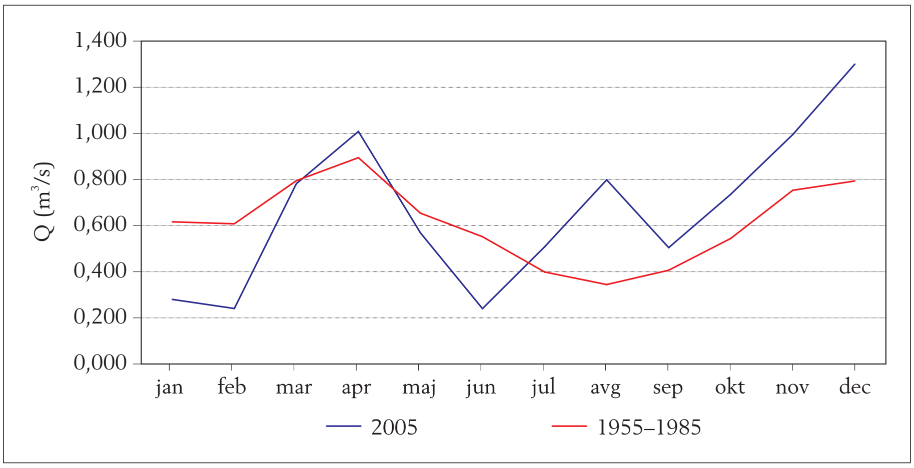
Slika 38: Težka voda – nihanje nizkih vodostajev konec oktobra 2005.

Figure 38: *Težka voda – low water level fluctuations at the end of October 2005.*

Preglednica 16: Primerjava podatkov Qs 2005/Qs 1955–1985.

Table 16: *A comparison of data – Qs 2005/Qs 1955–1985.*

	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Qs	Qmax	Qmin
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 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	0,000



Slika 39: Težka voda – Qs 2005/ Qs 1955–1985.
Figure 39: *Težka voda – Qs 2005/Qs 1955–1985.*

V letu 2005 so po nizkem pretoku v zimskih mesecih visoki valovi nastopili v marcu in aprilu, kar je tudi značilen obdobni pojav, nizki poletni pretoki pa so enaki zimskim. Najnižki pretok je beležen 31. oktobra, vendar je očitno posledica umetnega vpliva. Ocenjujemo, da je najnižji naravni pretok v času od reaktiviranja postaje v letu 2004 in do konca leta 2005 dosegel vrednost okoli 0,1 m^3/s.

Najvišji pretok je zabeležen v decembru s konico 10,4 m^3/s in je blizu obdobnemu visokemu ekstremu 10,7 m^3/s.

Kontrolne meritve specifične električne prevodnosti se gibljejo med 400 in 440 µS/cm, temperature pa med 8–13,7 °C. Ker je merski profil cca 500 m oddaljen od izvirnega območja, so vrednosti temperatur že pod atmosferskim vplivom.

Metliški Obrh

Na izviru Metliški Obrh od leta 2003 beležimo parametre: vodostaj, temperaturo in specifično električno prevodnost. Izvir je najpomembnejši vodni vir za vodooskrbo Metlike in okolice, zaradi lege v središču mesta pa je izpostavljen in ogrožen. Najnižji vodostaji izvira nastopajo v poletnih mesecih, ko izvir ob stalnem odvzemu za vodooskrbo skoraj presahne. Takrat je profil izvira tudi močno zaraščen. Najnižji vodostaji v opazovanem obdobju so nastopili avgusta 2003, v letu 2005 takega ekstrema ni bilo.

V liniji časovnih potekov vodostajev je opazna razlika med volumni visokih valov v poletnih mesecih in visokimi valovi v ostalih mesecih. Vodni valovi v poletnih mesecih so kratki in ostri, s strmim upadom vodostajev, klasična oblika recesijske krivulje se pojavi šele pri vodostajih pod 40 cm. Vodni valovi v ostalih mesecih so bistveno širši oz. daljši v trajanju visokega iztoka, upad vodostajev pa je tudi ob teh valovih strm.

Potek vrednosti temperatur in specifične električne prevodnosti je premosorazmeren tudi v izviru Metliškega

tion in 2004 by the end of 2005 reached a value of around 0.1 m^3/s.

The highest discharge was recorded in December with a peak of 10.4 m^3/s, which is close to the reference period high extreme of 10.7 m^3/s.

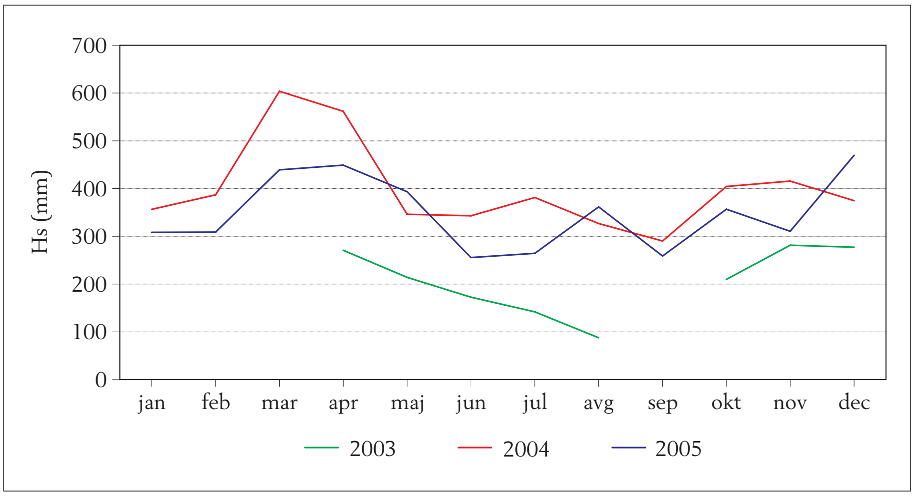
Control measurements of specific electrical conductivity range between 400 and 440 µS/cm and measurements of temperature range between 8 and 13.7 °C. As the water-gauging cross-section is approximately 500 m from the spring area, the temperature values are already under atmospheric influence.

Metliški Obrh

We have been measuring the following parameters since 2003 at the spring of Metliški Obrh: water stage, temperature and the specific electrical conductivity. This spring is the most important source of water for the water supply of Metlika and its surroundings and it is exposed and endangered because of its location in the city centre. The lowest water stages of the spring occur in the summer months, when the spring almost runs dry owing to the continuous abstraction for the water supply. That is also the time when the spring cross-section is heavily overgrown. The lowest stages in the observation period occurred in August of 2003, though there was no such extreme recorded in 2005.

A difference can be observed in the line of the temporal trends of water stages between the volume of the high-water waves in the summer months and those at other times. The water waves in the summer months are short and strong, and feature a sharp decline in the water stages. The classic form of the recession curve only appears at stages below 40 cm. The water waves in the other months are significantly wider or longer in terms of the duration of the high outflow. The decline of the water stages is sharp even for these waves.

The trend of the temperature and specific electrical conductivity values is also directly proportional in the



Slika 40: Mesečne vrednosti vodostajev Hs (mm).
Figure 40: *The monthly water stage values Hs (mm).*

Obrha, s tem, da so vrednosti signifikantno višje kot na območjih alpskega in visokega dinarskega krasa. Opazni in značilni so sunki dvigov vrednosti obeh parametrov tik ob nastopu visokega vala, ki pa takoj nato, kot posledica dotoka nizkomineralizirane in hladnejše vode, strmo upadejo. Ti sunki dvigov vrednosti ob nastopu vala predstavljajo pojav starejše akumulirane vode, ki jo iz vodonosnika izrine sveža padavinska voda na začetku vala.

Zanimiv je tudi nastop najvišjih temperatur v novembru 2005. Najnižje temperature izvira so zabeležene v marcu, ob nastopu prvega višjega vodnega vala v letu,

spring of Metliški Obrh, but the values are significantly higher than in areas of Alpine and High Dinaric Karst. The thrusts of the value increases in both parameters during the occurrence of a high-water wave are noticeable and characteristic, but they immediately and sharply subside as a result of cooler water with a low mineral content. These thrusts of value increases during the occurrence of a wave represent the occurrence of older accumulated water pushed out from the aquifer by the fresh precipitation water at the beginning of the wave.

The occurrence of higher temperatures in November of 2005 is also interesting. The spring's lowest tem-

Preglednica 17: Srednji mesečni vodostaji v mm.
Table 17: *The mean monthly water stages in mm.*

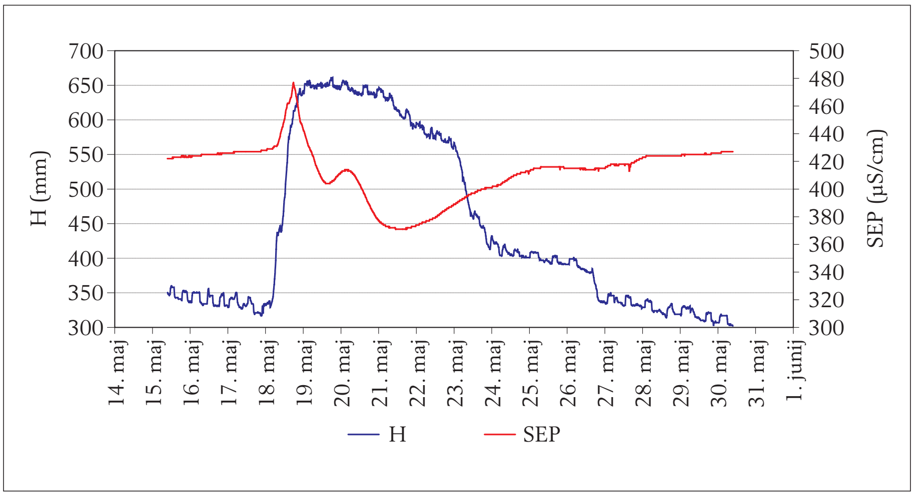
Hs	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letni
2003				271	214	173	142	88		210	281	277	211
2004	357	387	604	562	346	343	381	327	290	405	416	375	395
2005	308	309	439	449	393	256	264	362	259	357	310	470	349

Preglednica 18: Srednji mesečni vrednosti SEP v µS/cm.
Table 18: *The mean monthly value SEC in µS/cm.*

SEP	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letni
2003				418	436	442	426	227		435	437	426	419
2004	426	417	406	393	433	439	429	445	454	445	438	450	433
2005	446	446	418	421	421	440	429	428	441	453	462	442	437

Preglednica 19: Srednje mesečne vrednosti T v °C.
Table 19: *The mean monthly values T in °C.*

Ts	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letni
2003				10,0	10,4	10,7	11,4	13,4		10,7	10,7	10,7	10,9
2004	10,4	10,0	9,9	9,9	10,4	10,6	10,5	10,8	11,0	10,8	10,8	10,6	10,5
2005	10,4	10,5	10,0	10,1	10,3	10,6	10,7	10,7	10,9	10,9	11,1	10,6	10,6



Slika 41: Metliški Obrh – potek vodostajev in specifične elektro prevodnosti ob visokem valu v maju 2005.
Figure 41: *Metliški Obrh – the trend of water stages and spec. el. conductivity during a high-water wave in May of 2005.*

Izvir Metliškega Obrha (foto: Niko Trišić).
The spring of Metliški Obrh.

v nadaljevanju pa se je temperatura izvira dvigala do najvišjih vrednosti v novembru, ko se vrednosti ob zadnjem vodnem valu v letu znižajo.

Krupa

Izvir Krupa je najmočnejši vodni vir v Beli krajini. Ob raziskavah za izkoriščanje vira za vodooskrbo se je ugotovilo onesnaženje s PCB, s čimer je možnost uporabe vode za vodooskrbo seveda odpadla, saj je PCB še vedno prisoten v izviru.

Zaledje Krupe gradijo prevladujoče jurski in kredni apnenci z manjšimi vložki dolomitov in rožencev. Zgornje triasni dolomiti pa nastopajo na ožjem območju med Črmošnjicami in Rožnim dolom ter v zaledju Težke vode in Metliškega Obrha. Ti predstavljajo delno visečo bariero in pod njimi se vode normalno kraško pretakajo. Široka bifurkacijska območja med izviri

peratures were recorded in March during the occurrence of the first higher water wave of the year. Afterwards, the spring temperature increased up to its highest values in November before decreasing during the last water wave in the year.

Krupa

The spring of Krupa is the most potent water source in Bela krajina. During the survey to assess the feasibility of exploiting the source for water supply, PCB pollution was discovered and the idea of using the source for water supply was discarded, as PCB is still present in the spring.

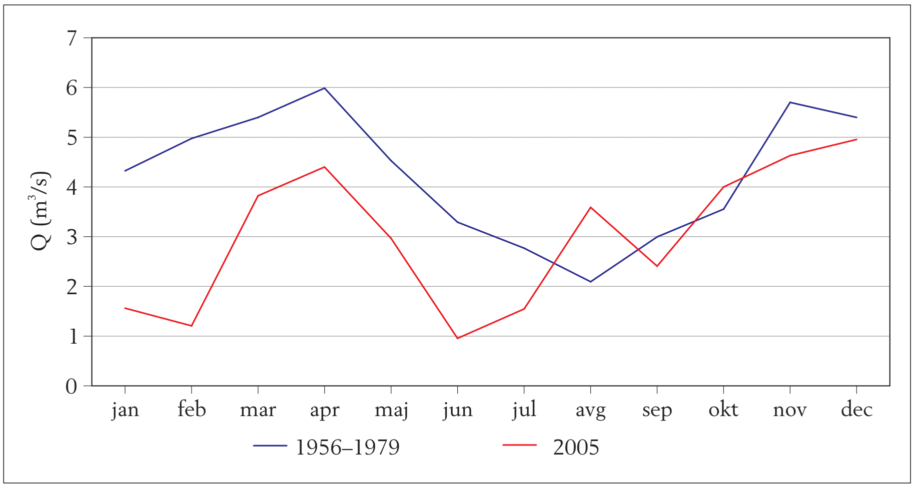
The catchment area of the Krupa River is predominantly Jurassic and Cretaceous limestones with smaller interbeds of dolomites and cherts. The Late Triassic dolomites occur in the narrower area between Črmošnjice and Rožni dol as well as in the catchment area of the Težka voda and Metliški Obrh springs. These represent a partial perched barrier and the waters normally flow karstically beneath them. The wide bifurcation areas between the springs of Težka voda, Metliški Obrh and Krupa occur both in Gorjanci and in the areas of Rožni dol above Semič, between Sušica and Krupa and on Mount Mirna gora between Radešca, Dobličica and Krupa. Krupa is the lowest-lying spring from a deep aquifer and it drains the base flows of an extensive karstic aquifer.

The Krupa-Dolence I cross-section was included in the regular hydrological gauging network in the 1956–1979 period. We incorporated a gauging cross-section with a data logger at a new location into the regular gauging network in 2004.

In recent years, the discharge of the Krupa has been measured in the cross-section above the dam for the mill with the ADCP profiler. It is the data on the low

Preglednica 20: Srednje mesečni in značilni letni pretoki Krupe v obdobju 1956–1979 in v l. 2005 (m^3/s).
Table 20: *The mean monthly and characteristic annual discharges of the Krupa River in the 1956–1979 period and in 2005 (m^3/s).*

Qs	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	sQs	Qnk	Qvk
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	63,40
2005	1,56	1,21	3,82	4,40	2,97	0,96	1,55	3,59	2,41	4,00	4,63	4,96	2,47	0,55	61,70



Slika 42: Primerjava mesečnih Qs v obdobju in letu 2005.
Figure 42: *A comparison of the monthly Qs values in the reference period and in 2005.*

Težke vode, Metliškega Obrha in Krupo nastopajo tako na Gorjancih kot tudi na območjih Rožnega dola nad Semičem, med Sušico in Krupo in na Mirni gori med Radešco, Dobličico in Krupo. Krupa je najnižji izvir iz globokega vodonosnika in drenira bazne odtoke obsežnega kraškega vodonosnika.

Profil Krupa – Dolence I je bil v letih 1956–1979 vključen v redno hidrološko merilno mrežo, ponovno smo merski profil na novi lokaciji s podatkovnim registratorjem vključili v redno mersko mrežo v letu 2004.

Pretok Krupe merimo v zadnjih letih v profilu nad jezom za mlin in to z ADCP merilcem. Iz primerjave podatkov niza obdobja 1956–1979 in leta 2005 izstopa predvsem podatek o nizkem pretoku Krupe. Ocenjujemo, da je podatek o minimalnem obdobnem pretoku 0,01 m^3/s nerealen oz. možno je, da je ta vrednost merjena ob umetnem vplivu (zapora jezu). Leto 2005 izstopa tudi po srednji vrednosti letnega pretoka Qs, saj je ta bistveno nižji kot obdobna vrednost. Vrednosti največjega pretoka pa sta praktično identični, letni maksimum je nastopil konec novembra 2005. Razpored srednje mesečnih pretokov v obdobju in v letu 2005 je tudi podoben, s tem, da izstopa višji Qs v avgustu leta 2005 kot posledica padavin v juliju in avgustu. Značilno nastopata tudi spomladanski in jesenski visoki vrednosti Qs v mesecu aprilu, novembru oz. decembru.

Ob kontrolnih meritvah se merjene vrednosti specifične električne prevodnosti gibljejo v razponu od 383 do 485 µS/cm, vrednosti temperatur pa zaradi oddaljenosti merskega profila od izvira niso več reprezentativne za izvirno vodo.

discharge of the Krupa that stands out especially when comparing the data sets of the 1956–1979 period and the set for 2005. We estimate that the data on the minimum reference period discharge of 0.01 m^3/s is not valid. It is possible that this value was measured during an artificial influence (the closure of the dam). 2005 also stands out in terms of the mean value of the annual discharge Qs, as this is significantly lower than in the reference period value. The values of the maximum discharge are practically identical, with the annual maximum occurring at the end of November 2005. The distribution of the mean monthly discharges in the reference period and in 2005 is also similar, with the higher Qs in August of 2005 standing out as a result of the precipitation in July and August. The spring and autumn high values Qs occur characteristically in April, November or December.

During control measurements, the measured values of specific electrical conductivity range between 383 and 485 µS/cm, while the temperature values are no longer representative of the spring water because of the distance of the water gauging cross-section from the spring.

Veliki Obrh – Vrhnika

The Veliki Obrh Spring is the first spring of the Ljubljanica River on Slovenian territory and, together with the Bajer and Mali Obrh springs and the springs by the Snežnik castle, it represents a part of the outflow that feeds the flow of the Obrh River, which crosses the

Veliki Obrh – Vrhnika

Izvir Veliki Obrh je prvi izvir Ljubljanice na slovenskem ozemlju in predstavlja del iztoka, ki skupaj z izviri Bajer, Mali Obrh in izviri pri gradu Snežnik napaja tok Obrha, ki po prečenju Loškega polja ponikuje v jami Golobine. Zaledje izvira sega tudi na hrvaško ozemlje, kjer se nahaja prvi izvir Ljubljanice, Trbuhovica pri Prezidu. Po rezultatih sledenja je v letu 2005 tudi območje Retij v prispevnem zaledju izvira Veliki Obrh.

V letu 2005 so najnižji pretoki izvira nastopili v februarju. Ker najnižji vodostaji nastopajo po dalj časa trajajočem obdobju brez padavin, je tudi vrednost srednje mesečnega pretoka nizka in je v območju najnižjih obdobnih srednje mesečnih vrednosti. Padavine in topljenje snega v spomladanskih mesecih so po visokovodnih valovih v marcu in aprilu dvignile srednje mesečne vrednosti do letne konice srednje mesečnih vrednosti v aprilu, kar je tudi v okviru značilnih obdobnih vrednosti. Neznačilen je nastop drugega minimuma srednje mesečnih vrednosti v juniju, ki je za skoraj 1,5 m^3/s nižji od obdobnih vrednosti.

V poletnih mesecih je beleženih nekaj višjih vodnih valov, ki so dvignili srednje mesečne vrednosti v območje obdobnih vrednosti. Visoki valovi v septembru in oktobru so vzdrževali razmere v območju obdobnih srednje mesečnih vrednosti, nizka vrednost Qs za november pa je posledica upadanja vodostajev od sredine oktobra do konca novembra, ko je nastopil visokovodni val z letno visoko konico 13,3 m^3/s. Druga letna visoka konica je v začetku decembra, za njo vodostaji do konca leta upadajo v območje nizkih pretokov.

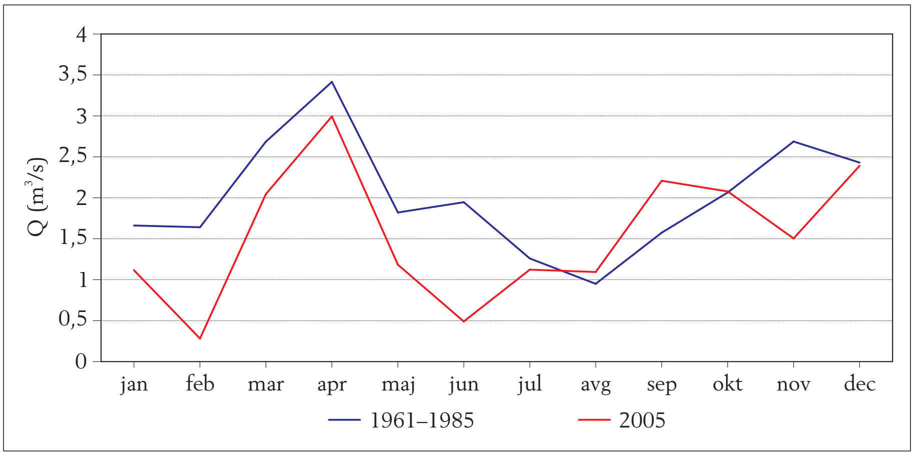
Loško field and infiltrates in the Golobina Cave. The spring catchment area extends into Croatian territory, where the first spring of the Ljubljanica River – Trbuhovica pri Prezidu – is located. According to the results of the monitoring, the area of Retje also lies in the drainage basin of the Veliki Obrh Spring in 2005.

In 2005, the spring's lowest discharges occurred in February. Because the lowest water stages occur after longer periods without precipitation, the value of the mean monthly discharge is also low and is within the range of the lowest reference period mean monthly value. After the high-water waves in March and April, precipitation and snow melt in the spring months raised the mean monthly values up to the annual peak of the mean monthly values for April, which is also within the scope of the characteristic reference period values. What is uncharacteristic is the occurrence of a second minimum of the mean monthly values in June, which is lower than the reference period values at almost 1.5 m^3/s.

There were a few higher water waves recorded in the summer months, which raised the mean monthly values up to the range of the reference period values. High-water waves in September and October maintained the conditions within the range of the reference period mean monthly values. The low Qs value for November however, is the result of the decreasing stages from the middle of October up to the end of November, when the high-water wave occurred with the annual peak of 13.3 m^3/s. The second annual high-water peak occurred in the beginning of December, after which the water stages start declining towards the end of the year down to the range of the low discharges.

Preglednica 21: Veliki Obrh – srednje mesečne in značilne letne in obdobne vrednosti pretokov.
***Table 21:** Veliki Obrh – the mean monthly and characteristic annual and reference period discharge values.*

Qs	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	sQs	Qvk	Qnk
1961–1985	1,66	1,64	2,69	3,42	1,82	1,95	1,26	0,95	1,57	2,07	2,69	2,43	2,01	36,8	0,100
2005	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	13,30	0,108
2004				1,72	1,77	1,08	0,97	0,31	0,21	2,96	3,06	2,82	1,65	17,4	0,050



Slika 43: Veliki Obrh – razporeditev srednjih mesečnih, letnih in obdobnih vrednosti pretokov.
***Figure 43:** Veliki Obrh – the distribution of the mean monthly, annual and reference period discharge values.*

D. MORJE

Plimovanje morja

Mojca Robič

Plimovanje, ki je poleg valovanja najizrazitejši pojav spreminjanja gladine morja, je posledica astronomskih in meteoroloških dejavnikov ter lastnega nihanja Jadranskega morja. V Jadranskem morju se navadno dnevno zamenjata dve plimi in dve oseki. Na plimovanje v največji meri vpliva gravitacijska privlačnost med Luno, Soncem in Zemljo, kar imenujemo astronomska plima. To je zaradi znanega cikličnega gibanja nebesnih teles možno napovedati vnaprej.

V času mlaja in ščipa, ko sta Sonce in Luna v konjunkciji oz. opoziciji, se vplivi plimotvornih sil seštevajo in amplitude plimovanja so velike. Ob prvem in zadnjem krajcu, ko sta Sonce in Luna v kvadraturi, so amplitude manjše.

Razliko med izračunano astronomsko in dejansko izmerjeno višino morja imenujemo residualna višina. Njena vrednost je odvisna največkrat od meteoroloških dejavnikov, včasih pa tudi od lastnega nihanja morja. Od meteoroloških dejavnikov sta najbolj vplivna veter in zračni pritisk. Z zniževanjem zračnega pritiska se gladina morja zviša. Južni ali jugovzhodni veter nariva vodne mase na obalo severnega Jadrana in prav tako povzroči zvišanje gladine. 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 okoli 21 ur, ob jugozahodniku pa le nekaj ur.

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

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

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

D. SEA

Sea levels

Mojca Robič

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

The difference between the calculated astronomical sea levels and those actually measured is known as the residual sea level. Its value most frequently depends on atmospheric forcing and sometimes on the seiche. The most influential atmospheric forcing parameters are the air pressure and the wind. With a decrease in air pressure, the sea level rises. Also, southern and south-eastern winds push the water towards the shore of the north Adriatic Sea, also causing a rise in sea level. Conversely, the bora wind decreases the sea level as it blows from the land out towards the high seas. The stronger southern wind from Dalmatia also affects the rising of the sea levels. The Seiche appears in enclosed and partially enclosed seas. In the Adriatic, with a south wind blowing, it has a period of around 21 hours, and of only a few hours with a south-western wind.

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

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

Zgodovinski pregled spremljanja meritev

Višine morja na slovenski obali spremljamo od leta 1958, ko je bilo postavljeno merilno mesto v Kopru, na pomolu pri Luški Kapitaniji. Ob koncu leta 2005 je bila postaja v celoti obnovljena in posodobljena z najmodernejšo merilno opremo.

Višine morja se na novi postaji merijo sočasno z instrumentom na plovec ter dvema radarskima merilnikoma, od katerih je eden nameščen izven objekta, drugi pa v objektu. Radarski merilnik v objektu je namenjen spremljanju plimovanja. Radarski merilnik, nameščen zunaj objekta, pa lahko spremlja tudi nizkofrekvenčno spreminjanje gladine morja, podatki pa bodo uporabljeni kot dodatna informacija pri interpretaciji izrednih dogodkov, na primer izjemnih višin, velikih residualnih višin, ob zanimivih vremenskih situacijah itd. Poleg spremljanja višine morja potekajo na postaji tudi meritve meteoroloških parametrov.

Način merjenja višin morja se je od začetka merjenj v letu 1958 nenehno spreminjal in izpopolnjeval. Sprva so bili mareografi še nezanesljivi in je večkrat prišlo do izpada podatkov, višine pa so se odčitavale ročno in zapisovale v preglednico. Z začetkom digitalizacije so se podatki začeli shranjevati tudi v digitalni obliki. Preskok v kvaliteti podatkov je pomenila postavitev avtomatske postaje v Luki Koper leta 1991. Za postajo v Luški kapitaniji pa je to pomenilo izgubo statusa primarne postaje in je kar nekaj let delovala le kot pomožna postaja (obdelava podatkov je potekala le v primeru izpada podatkov iz Luke). Leta 1999 je bil v Kapitaniji postavljen podatkovni registrator, kar je pomenilo nov kvaliteten preskok v pridobivanju podatkov. V tem času so se začeli pojavljati tudi prvi predlogi o prenovi postaje.

V okviru projekta ESEAS RI v letu 2005 (projekt je opisan na spletni strani Agencije Republike Slovenije za okolje: **http://www.arso.gov.si/vode/morje/projekti/ESEASnet3.pdf**) je bil sprejet dogovor, da so za analize višin morja na postaji v Kopru potrebne pripadajoče meritve valovanja in morskega toka. Zato je bil del sredstev projekta namenjen nakupu ADCP merilnega instrumenta za meritve valovanja in morskega toka na

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

A Historical Overview of the Monitoring Measurements

We have been monitoring the sea levels on the Slovenian Coast since 1958, when the tide gauge station in Koper was set up on a pier at Luška kapitanija. At the end of 2005, the station was entirely renovated and upgraded with the latest gauging equipment.

At the new station, sea levels are measured simultaneously with a float instrument and two radar gauges, one of which is situated outside the facility and the other within it. The radar gauge within the facility is intended for monitoring tidal action, while the one outside the station can also perform low frequency monitoring of changes in sea levels. The data thus obtained will be used as additional information when interpreting extraordinary events, e. g. exceptional levels, high residual sea levels, interesting weather conditions, etc. In addition to monitoring the sea levels, measurements of meteorological parameters are also performed.

The methods of measuring sea levels have changed and improved continuously since the start of measuring in 1958. At first, the tide gauges were unreliable and there was often a shortfall of data, with the sea levels being read manually and recorded in a table. With the start of digitalisation, the data began to be stored in digital form. Setting up the automatic station at Luka Koper in 1991 enabled a leap in the quality of data. This meant that the tide gauge station at Luška kapitanija lost its status as primary station and it operated only as a supplementary station for several years (data processing took place only in the event of a shortfall of data from Luka Koper). In 1999, a data logger was set up at Luška kapitanija, meaning another leap in the quality

Mareografska postaja Koper do leta 2005 (levo), nova nadgrajena mareografska postaja Koper po letu 2005 (sredina) in oceanografska boja Piran.

The old tide gauge station in Koper until 2005 (left), upgraded tide gauge Koper after 2005 and oceanographic buoy Piran.

različnih globinah. Merilnik je bil nameščen na oceanografsko bojo v Piranskem zalivu.

Višine morja glede na dolgoletno povprečje

Morje je bilo v letu 2005 zelo visoko. Srednja letna višina (SLV) morja je bila 220,8 cm, kar je druga najvišja vrednost obdobja 1960–2000. Le leta 2004 je bila srednja letna višina morja višja (slika 44).

Najvišja srednja mesečna višina morja (SMVmax) je bila 225,5 cm in je bila podpovprečna. Najnižja srednja mesečna vrednost je bila januarska, 211,2 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 14,3 cm.

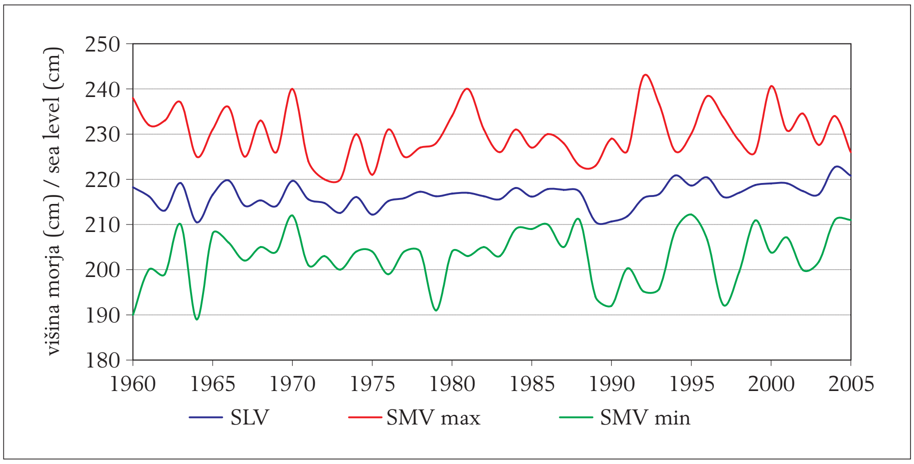
Najvišja je bila srednja mesečna višina v avgustu. Močno nadpovprečne so bile tudi srednje mesečne višine v septembru, novembru, aprilu in maju. Najnižja mesečna vrednost je bila zabeležena v januarju, glede

of data gathering. New proposals for the renovation of the station were being put forward at that time.

Within the scope of the ESEAS-RI project in 2005 (the project is described on the Website of the Environmental Agency of the Republic of Slovenia: **http://www.arso.gov.si/vode/morje/projekti/ESEASnet3.pdf**), it was agreed that the analyses of sea levels at the station in Koper required associated measurements of wave action and the sea current. This is why a portion of the project funds was allocated to the acquisition of an ADCP instrument for measuring wave action and the sea current at various depths. The profiler was set up on an oceanographic buoy in the Bay of Piran.

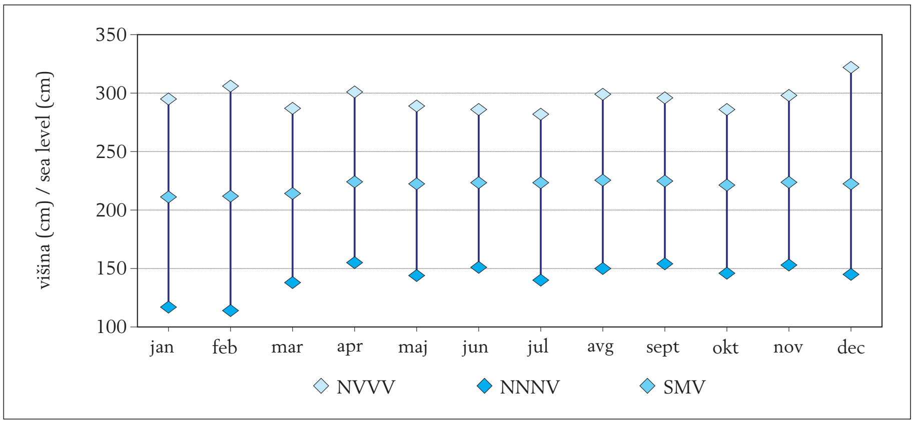
The Sea Levels with Respect to the Multi-Annual Mean

The sea was very high in 2005. The mean annual sea level (SLV) was 220.8 cm, which is the second highest



Slika 44: Srednje letne višine morja (SLV) ter najvišja in najnižja srednja mesečna višina vode (SMV) v dolgoletnem obdobju. Srednja letna višina morja leta 2005 je bila ena najvišjih v opazovalnem obdobju.

Figure 44: *The mean annual sea levels (SLV) and the highest and lowest mean monthly sea level (SMV) in the multi-annual period. The mean annual sea level in 2005 was one of the highest in the period of monitoring.*



Slika 45: Srednje mesečne višine morja (SMV) z najnižjimi (NNNV) in najvišjimi (NVVV) mesečnimi višinami za leto 2005.

Figure 45: *The mean monthly sea levels (SMV) with the minimum (NNNV) and maximum (NVVV) monthly levels for 2005.*

na obdobje pa so bile podpovprečne še mesečne vrednosti februarja in marca (slika 45).

Najvišja (NVVV) in najnižja (NNNV) gladina morja v letu 2005 nista bili izjemni. V primerjavi z obdobjem sta bili obe nekoliko podpovprečni. Najvišja letna gladina morja, 322 cm, je bila izmerjena 3. decembra ob prvi plimi, najnižja letna višina morja, 114 cm, pa 9. februarja ob popoldanski oseki.

Srednja visoka voda (SVV) je bila v letu 2005 nadpovprečna. Po višini je izstopala tudi srednja nizka voda (SNV), ki je bila s 186,5 cm le za pol cm nižja od obdobnega (1961–2000) maksimuma.

Kronološki pregled po mesecih

Morje je bilo v prvih dneh leta nizko. **Januarja** je bila zabeležena ena najnižjih osek v letu, 117 cm. To je nekaj nižje od srednje obdobne vrednosti. V drugi polovici meseca pa je bilo morje nekoliko povišano. Posledica je druga največja mesečna amplituda v letu.

Februar je bil vremensko zelo pester. Najnižja letna višina morja, 114 cm, je bila izmerjena v prvi polovici februarja. Ob močni astronomski plimi je burja še nekoliko znižala gladino morja in 9. februarja povzročila nastop najnižje vode v letu. V drugem delu meseca je bilo morje ob prevladi nizkega zračnega pritiska in južnega vetra glede na astronomske višine morja povišano. Najvišja gladina morja v tem mesecu, 306 cm, je presegla opozorilno vrednost, to je višino, ko že pride do poplavljanja nižje ležečih delov obale. Ker sta se v istem mesecu zvrstili tako najnižja letna oseka kot tudi ena

value in the 1960–2000 reference period. The mean annual seal level was only higher in 2004 (Figure 44).

The highest mean monthly sea level (SMVmax) was 225.5 cm and was below-average. The lowest mean monthly value was that recorded in January of 211.2 cm and this was higher than the average when compared to the multi-annual period. What is characteristic is the small amplitude – the difference between the highest and lowest monthly sea level was only 14.3 cm.

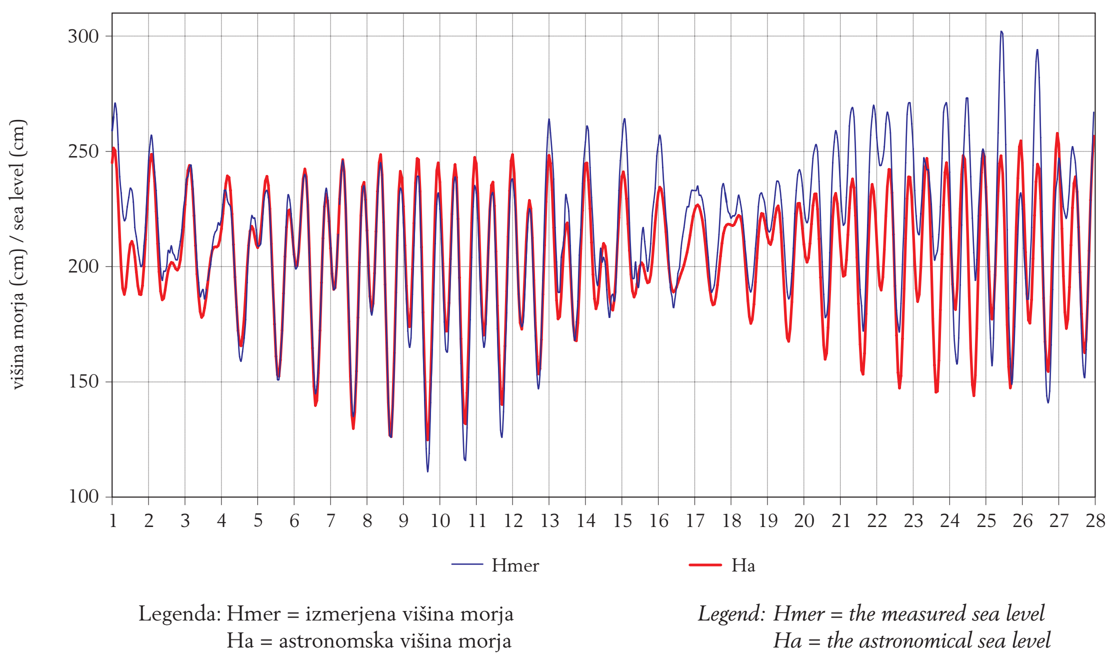
The mean monthly level was highest in August. The mean monthly values were also considerably above-average in September, November, April and May. The lowest monthly value was recorded in January, while the monthly values in February and March were below-average with respect to the multi-annual period (Figure 45).

The maximum (NVVV) and minimum (NNNV) sea levels in 2005 were not exceptional. Both were slightly below-average in comparison with the multi-annual period. The highest annual sea level of 322 cm was measured on 3 December during the first high tide and the lowest annual sea level of 114 cm was on 9 February during the afternoon low tide.

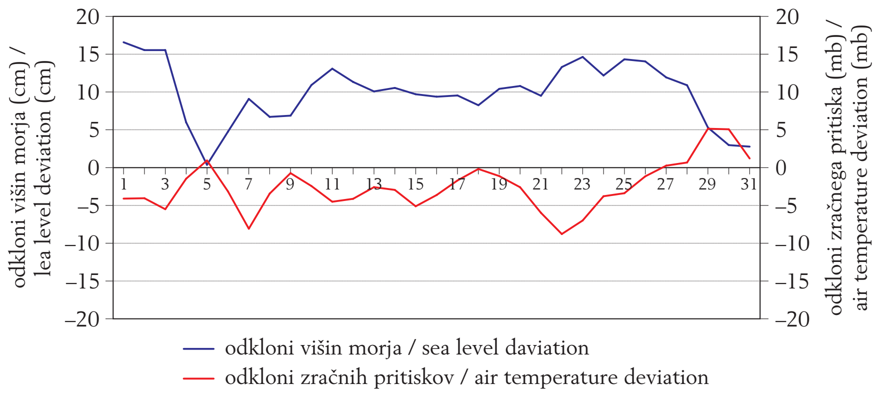
The mean high water (SVV) was above-average in 2005. The mean low water (SNV) stood out in terms of height as, with 186.5 cm, it was only half a centimetre lower than the reference period (1961–2000) maximum.

Chronological Overview by Month

In the first days of the year, the sea was very low. **In January,** one of the lowest low tides of the year was



Slika 46: Morje je bilo v prvi polovici februarja nizko, v zadnjih dneh pa povišano.
***Figure 46:** The sea was low in the first half of February and elevated in the final days.*



Slika 47: Odkloni zračnega pritiska in višine morja od dolgoletnega povprečja v avgustu.
Figure 47: *The deviations of the air pressure and the sea level from the multi-annual mean in August.*

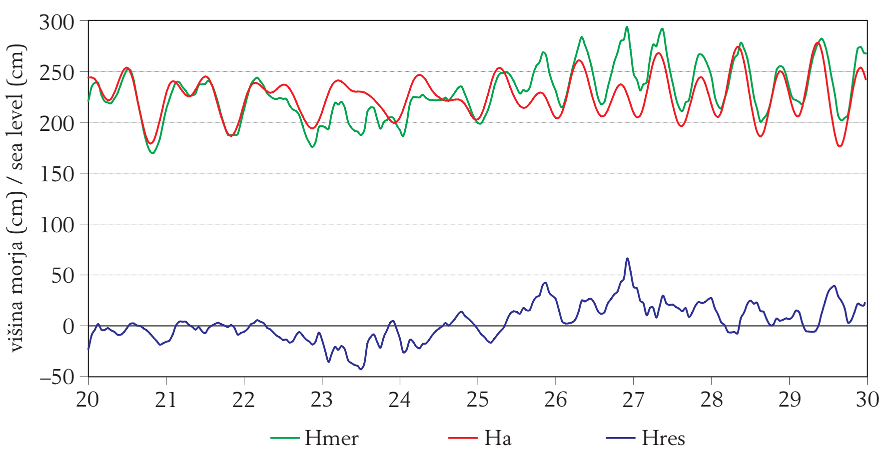
najvišjih voda v letu, je posledica najvišja mesečna amplituda v letu 2005, ki znaša 192 cm.

Povišano plimovanje morja se je nadaljevalo tudi v prvih dneh **marca**. Srednja mesečna višina marca je bila podpovprečna, če jo primerjamo z dolgoletno obdobno letno vrednostjo, v primerjavi z obdobnimi višinami marca pa je nekoliko nadpovprečna. Nobena karakteristična vrednost ni bila izstopajoča.

Aprila je bilo vremensko dogajanje zelo pestro, residualne višine so bile nekajkrat zelo velike, tudi preko 40 cm. Vendar pa vremenske situacije, ki povzročijo povišanje morja, večinoma niso sovpadale z visokim astronomskim plimovanjem. Le ob koncu aprila je bilo morje nekoliko povišano in je dvakrat doseglo opozorilno vrednost.

recorded at 117 cm. This is somewhat lower than the mean reference period value. In the second half of the month, the sea level was slightly elevated. The result was the second largest monthly amplitude in the year.

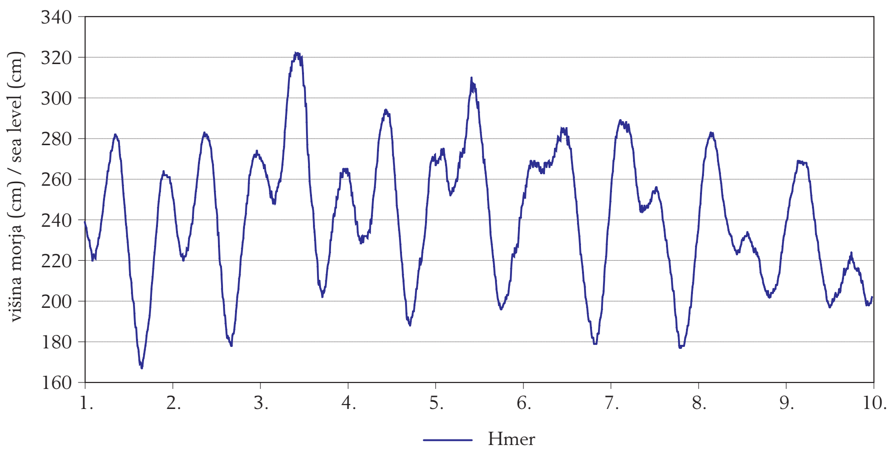
February was highly diverse in terms of weather conditions. The lowest sea level of the year – 114 cm – was measured in the first half of February. In addition to the strong astronomical tide, the bora wind additionally decreased the sea level and caused the occurrence of the lowest water in the year on 9 February. In the second half of the month, the sea was elevated with respect to the astronomical sea levels because of the prevalence of low air pressure and a southern wind. The highest sea level in that month of 306 cm exceeded the value at which warnings are issued – the level when



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

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

Slika 48: Izmerjena, astronomska in residualna višina morja od 20. do 30. novembra.
Figure 48: *Measured, astronomical and residual sea level between 20. and 30. November.*



Slika 49: Višina morja izmerjena v začetku decembra na novi avtomatski postaji v Kopru.
Figure 49: *Sea level measured on new automatic station at Koper in first days of December.*

Višina morja v **maju**, **juniju** in **juliju** je bila visoka, ne pa izjemna. Srednje mesečne vrednosti so uvrščale med srednje in najvišje obdobne. Najvišje mesečne višine morja so bile blizu dolgoletnega povprečja, najnižje mesečne pa večinoma nadpovprečne.

Srednja mesečna višina morja je bila v **avgustu** najvišja v celem letu. Morska gladina je bila vse dni v letu višja od povprečja (slika 47). Poletje ni običajen čas za tako povišano gladino morja, saj takrat največkrat prevladuje anticiklonalno vreme z visokim zračnim pritiskom. Toda v avgustu leta 2005 je bil zračni pritisk ves mesec podpovprečen in je zato pripomogel k zvišanju gladine morja. Najvišja mesečna višina morja je bila nadpovprečna za avgust, 299 cm, ne pa izjemno visoka.

Tudi **septembra** se je nadaljevalo obdobje nekoliko povišanih višin morja. Visoke so bile oseke (nizke vode), plime (visoke vode) pa niso dosegale zelo visokih vrednosti.

Jesensko obdobje velike vremenske spremenljivosti se je začelo v **oktobru**, ki je bil glede na letne obdobne vrednosti sicer visok, v primerjavi z oktobrskim povprečjem pa povsem povprečen.

V začetku **novembra** je bilo morje povprečno visoko, v drugem delu meseca pa so se izmerjene vrednosti močno razlikovale od izračunanih astronomskih (slika 48). Najvišja residualna višina je presegla 60 cm, vendar se je to zgodilo v času, ko astronomsko plimovanje ni bilo najbolj izrazito. Nekaj dni pred tem je bilo zelo veliko odstopanje navzdol, ki je prav tako skoraj doseglo 50 cm.

V **decembru** je bila izmerjena najvišja letna višina morja. Višina 322 cm je bila izmerjena 3. decembra ob 9:40 uri (slika 49). Ob precej visoki astronomski plimi je gladino poviševal tudi južni veter. Vtis poplav je okrepilo še močno deževje. Morje je dva dni kasneje še enkrat poplavilo nižje ležeče dele obale.

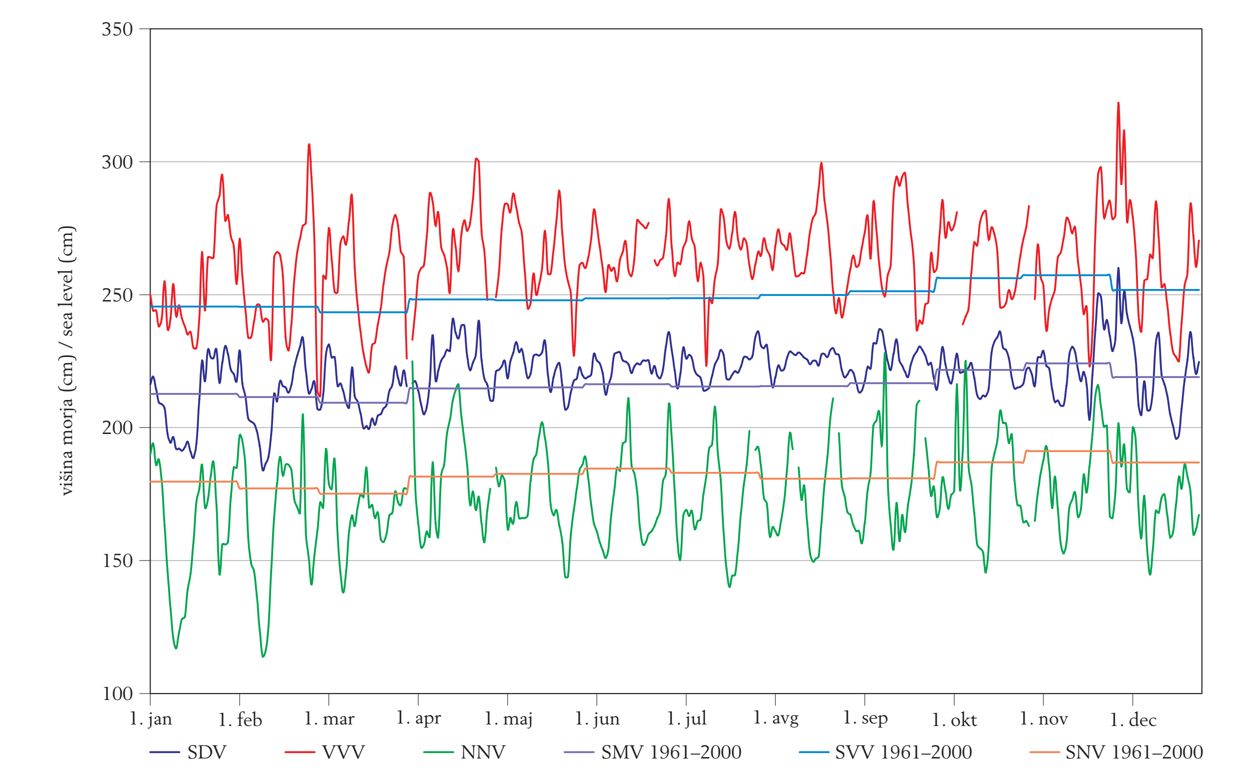
lower-lying parts of the coast begin to flood. Because both the lowest annual low tide and one of the highest waters of the year occurred in the same month, this resulted in the highest monthly amplitude in 2005, amounting to 192 cm.

The increased tidal action of the sea also continued in the first days of **March**. The mean monthly sea level in March was below-average if we compare it to the multi-annual reference period annual value, though it was slightly above-average when compared to the reference period levels for the month of March. None of the characteristic values stood out.

In **April,** the weather situation was highly diverse, with very high residual sea levels on several occasions, even exceeding 40 cm. However, the weather situations that cause the rising of the sea did not coincide with high astronomical tidal action for the most part. It was only at the end of April that the sea was somewhat elevated and twice reached the value when warnings are issued.

The sea levels in **May**, **June** and **July** were high but not exceptional. The mean monthly values ranked among the mean and maximum reference period values. The highest monthly sea levels were close to the multi-annual mean, while the lowest monthly values were for the most part above-average.

The mean monthly sea level in **August** was the highest in the year. The sea level was higher than the average in all days in the year (Figure 47). The summer is not the usual time for such an elevated sea level, as anticyclonic weather with high air pressure prevails at this time. However, in August of 2005, the air pressure was below-average throughout the month, thus contributing to the elevation of the sea level. The highest monthly sea level of 299 cm was above-average for the month of August, but was not extremely high.



Slika 50: Povprečne dnevne višine morja, povprečne dnevne plime in oseke v letu 2005 s pripadajočimi mesečnimi vrednostmi obdobja 1961–2000.

Figure 50: *The average daily sea levels and average daily high and low tides in 2005 with the associated monthly values of the 1961–2000 reference period.*

The period of slightly elevated sea levels continued in **September** as well. The low tides (low waters) were high, while the high tides (high waters) did not reach very high values.

The autumn period of great weather variability began in **October**, which had high values when compared to the annual reference period values, but was entirely average in comparison with the October average.

In the beginning of **November,** the sea level was average, though in the second half of the month the measured values differed significantly from the calculated astronomical values (Figure 48). The highest residual level exceeded 60 cm, though this occurred during a time when the astronomical tidal action was not at its most prominent. A few days prior to this, there was a great deviation downwards, which almost reached 50 cm.

The highest annual sea level was measured in **December**. The level of 322 cm was measured on 3 December at 9:40 a. m. (Figure 49). In addition to the high astronomical high tide, the sea level was elevated by a southern wind as well. The floods were boosted by heavy rain. The sea flooded the lower-lying parts of the coast again two days later.

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 in izhlapevanja smo izračunali iz rastrskih kart Slovenije z velikostjo celice 100 m × 100 m. Osnova so bili podatki merilnih mest za padavine in podatki o izračunanem potencialnem izhlapevanju. Za karto padavin so bile uporabljene korigirane padavine (v letih 2002 in 2003 nekorigirane, v letu 2004 pa že korigirane vrednosti). Padavine smo korigirali s temperaturo, vetrom in intentizeto padavin. Za karto izhlapevanja smo izračunali potencialno in realno izhlapevanje za isto leto. Realno izhlapevanje smo dobili s prostorsko porazdelitvijo izračunane potencialne evapotranspiracije ter z uporabo korekcijskih faktorjev. V prejšnjih letnih vodnih bilancah smo uporabljali potencialno izhlapevanje. S prekrivanjem poligonov (porečij) smo tako dobili skupno količino padavin in izhlapevanja v posameznem porečju. Tako določeno izhlapevanje smo primerjali z »bilančno« vrednostjo, izračunano po enačbi P – Q = ET. Izračunano realno izhlapevanje smo uporabili za boljšo opredelitev prostorske porazdelitve.

Odtoki so praviloma najzanesljivejši člen vodne bilance porečij. Na reprezentativnih vodomernih postajah se odtok določenega območja zbere na enem vodomer-

E. Water balance

The water balances of the river basins

Peter Frantar

The calculation of the water balance is based on the water cycle concept – on comparison of the runoff, precipitation, evaporation and changes in the water reserves. We cannot quantify the changes in the water reserves from the available data, which is why this data are not taken into account. However, we must keep this data in mind when interpreting the water balance components. We therefore used a simplified water balance equation for the calculation, which represents a balance between precipitation and the runoff and evaporation:

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

We produced a balance for the Adriatic and Black Sea basins, which we divided internally when calculating runoffs. We divided the Adriatic Sea Basin into the Soča River Basin – which encompasses the tributaries of the Soča and Vipava rivers – and the basin of the Adriatic Sea rivers, which encompasses the remainder of the Adriatic Sea Basin. We divided the Black Sea Basin into Pomurje, Podravje and Posavje. The calculated precipitation and evaporation quantities are based on analysis of the individual units of the main basins using geoinformation technology. Evaporation is equated with the term evapotranspiration in the text. Evapotranspiration includes evaporation (evaporation from water surfaces) and transpiration (evaporation from plant life).

The Components of the Water Balance

We calculated the annual amount of precipitation and evaporation from the raster maps of Slovenia with a cell size of 100 m × 100 m. The basis for the calculation was data from the precipitation gauging sites and the data on the calculated potential evaporation. Corrected precipitation values were used for the precipitation map (uncorrected values were used in 2002 and 2003 and corrected in 2004). Precipitation was corrected with the temperature, the wind and the intensity of precipitation. We calculated the potential and real evaporation for the same year in order to produce the evaporation map. We obtained the real evaporation from the spatial distribution of the calculated potential evapotranspiration and with the use of correction factors. We used potential evaporation in the previous annual water balances. By overlapping polygons (river basins), we obtained the total quantity of precipitation and evaporation in an individnem 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.

Vodna bilanca po glavnih slovenskih porečjih

Pomurje je hidrogeografska regija s površino 1390 km^2 in z najmanjšo povprečno količino padavin v Sloveniji. Leta 2005 je v Pomurju padlo v povprečju 994 mm padavin (v obdobju 1971–2000: 897 mm), kar je enako 43,9 m^3/s. Padavin je bilo v tem porečju za 10 % več kot v dolgoletnem obdobju. Količina izhlapele vode je bila po izračunu realne evapotranspiracije dobrih 20 % manjša od »bilančnega izhlapevanja« (izračunano po formuli ET = P – Q). Domnevni vzroki so najverjetneje plitvi vodonosni sistemi, ki ob zadostni količini padavin dobro skrbijo za vodnatost rastlinja. Bilančno izhlapevanje je bilo 804 mm oz. 35,5 m^3/s. Najmanj padavin je leta 2005 padlo na skrajnem vzhodnem delu Pomurja, v porečju Velike Krke, okrog 870 mm in na skrajnem Lendavskem delu, okrog 850 mm; največ padavin pa je padlo na jugovzhodnem delu Slovenskih goric in sicer okoli 1100 mm. Prav tako je bilo med 1000 in 1100 mm padavin na osrednjem delu Goričkega in na severnem delu Goric. Po ravninah in v dolinah je bilo padavin med 950 in 1000 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 2005 doprinesli 178,9 m^3/s, iz območja Pomurja pa je odteklo skupaj 187,3 m^3/s. Količina vode, ki je leta 2005 odtekla iz Pomurja, je bila v povprečju 8,4 m^3/s.

Podravje meri 3265 km^2 in skozenj teče naša največja tranzitna reka – Drava. Tudi Podravje je imelo padavin nekaj več kot je obdobno povprečje. Leta 2005 je bilo tu v povprečju 1309 mm padavin (v obdobju 1971–2000: 1244 mm) kar je 135,7 m^3/s. Najmanj padavin v Podravju je bilo leta 2005 na vzhodnem delu – v osrednjem delu Slovenskih Goric v okolici Lenarta, kjer je bilo padavin nekaj čez 1000 mm. Od tod je količina rasla proti višjim predelom in proti zahodu. Vrhovi Haloz so tako imeli okrog 1300 mm padavin. Največ padavin pa je bilo na Pohorju in v predelu Karavank, ki sega v Podravje – okrog 1800 mm na najvišjih predelih. 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 2005 v povprečju priteklo dobrih 229 m^3/s vode, odteklo pa je 286 m^3/s. Neto prispevek Podravja k odtoku

ual river basin. We compared the resulting evaporation with the »balance« value calculated according to the equation P – Q = ET. We used the calculated real evaporation for the improved definition of spatial distribution.

As a rule, runoffs are the most reliable component of the water balance of river basins. At representative hydrometric stations, the runoff of a particular area is gathered in one single hydrometric cross-section. When doing the calculation, we took into account the discharges at hydrometric stations encompassing the majority of inflows and outflows from the country as well as the assessments of discharges for streams that only have headwaters in Slovenia. We determined the discharges for areas without measurements by taking into consideration the specific discharges q (l/km^2/s) of hydrologically comparable hydrometric stations.

The Water Balance by Major Slovenian River Basins

Pomurje (the river basin of the Mura River) is a hydrogeographical region with a surface area of 1,390 km^2, which experiences the least amount of precipitation in Slovenia on average. In 2005, there was an average of 994 mm of precipitation in Pomurje (in the 1971–2000 reference period: 897 mm), which equals 43.9 m^3/s. There was 10% more precipitation in this river basin than the normals. According to the calculation of real evapotranspiration, the quantity of evaporated water was a good 20% lower than the »balance evaporation« (calculated according to the equation: ET = P – Q). The presumable causes were most probably the shallow aquifer systems, which provide enough water for plant life if there is a sufficient quantity of precipitation. The balance evaporation was 804 mm or 35.5 m^3/s. The least precipitation in 2005 was in the easternmost part of Pomurje and in the river basin of the Velika Krka River – around 870 mm – as well as in the farthest lying Lendava area with around 850 mm. The most precipitation fell in the south-eastern part of Slovenske gorice, namely around 1100 mm. There was also between 1000 and 1100 mm of precipitation the central part of Goričko and in the northern part of Gorice. There was between 950 and 1000 mm of precipitation in the plains and valleys. The inflow of the Mura River into Slovenia and inflows from a part of the river basin of the Kučnica and Ledava rivers lying outside Slovenia were taken into consideration. At the outflow from the country, the Mura, Velika Krka, Ledava and Ščavnica rivers and the runoff from the remaining part of the area not covered by hydrometric stations was also taken into consideration. All the inflows into Pomurje in 2005 contributed 178.9 m^3/s, while a total of 187.3 m^3/s flowed out. The quantity of water that flowed out of Pomurje in 2005 amounted to 8.4 m^3/s on average.

Podravje (the river basin of the Drava River) measures 3265 km^2 and is our largest transit river – the Drava

Drave je bil torej skoraj 56,9 m^3/s. Z upoštevanjem padavin ter neto odtoka dobimo, da je iz Podravja bilančno izhlapelo 78,7 m^3/s vode. Izračunano realno izhlapevanje je bilo 11 % manjše od bilančnega.

Posavje zajema dobro polovico (11.750 km^2) Slovenije. Leta 2005 je bilo na območju slovenskega Posavja v povprečju 1598 mm (v obdobju 1971–2000: 1589 mm) padavin oz. za 595,9 m^3/s. To je praktično enaka količina kot v dolgoletnem obdobju. V porečju je velik razpon v količini padavin, ki je bil leta 2005 od okoli 1200 mm v Posotelju do 2600 mm na pobočjih južnih in zahodnih Bohinjskih gora v Julijcih. Od vzhoda količina padavin raste proti zahodu. Ljubljanska kotlina je imela tako med 1400 in 1600 mm padavin, Kamniške Alpe so jih prejele do 2000 mm, nad 2000 mm pa jih je bilo na dinarskem robu, od Goteniške Gore preko Snežnika, Nanosa pa do Julijcev. Območje Snežnika je imelo leta 2005 skoraj enak višek padavin kot Julijci – okrog 2600 mm. Pritoki v slovensko Posavje iz hrvaškega dela porečja Ljubljanice, Kolpe, Krke in Sotle so prispevali 36,4 m^3/s, skupen iztok iz Slovenije pa je bil 338,8 m^3/s. Neto odtok iz slovenskega Posavja je bil 302,4 m^3/s. Po bilančni enačbi izračunano izhlapevanje je bilo 293,5 m^3/s, realnega izhlapevanja pa smo izračunali za 9 % manj.

Posočje meri 2320 km^2 in je po specifičnih odtokih naše najbolj vodnato porečje. Tudi leta 2005 je tu padlo največ padavin v Sloveniji: 1858 mm oz. 136,7 m^3/s. Količina je precej pod dolgoletnim povprečjem obdobja 1971–2000 z 2386 mm. Leta 2005 je bilo v Posočju največ padavin v Julijcih, kjer je bilo padavin preko 2200 mm, kar je precej manj napram prejšnjim letom in tudi obdobju. Najbolj namočene južnobohinjske gore so tako dobile le do 2500 mm padavin (leta 2004 preko 3500 mm). Visoki dinarski planoti Nanos in Trnovski gozd sta dobili nad 2000 mm padavin, Javorniki med 1800 in 1900 mm, v Vipavski dolini pa je bilo padavin med 1400 in 1500 mm. V dnu doline Soče je bilo padavin med 1600 in 1700 mm. Najmanj padavin je bilo v okolici Mirna v spodnjem delu Vipavske doline – nekaj nad 1200 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 3,27 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 72,7 m^3/s. Bilančno izhlapevanje je bilo v Posočju leta 2005 67,3 m^3/s, izračunano realno je bilo za 13 % manjše od bilančnega, neto odtok v Posočju pa je bil 69,4 m^3/s.

Povodje preostalih Jadranskih rek zajema 1530 km^2, največji vodotok je reka Reka. Tu je padlo leta 2005 manj padavin od dolgoletnega povprečja. Bilo jih je 1425 mm (v obdobju 1971–2000: 1619 mm), kar je slabih 69,1 m^3/s. Najmanjše količine padavin so bile koprskem primorju, 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,

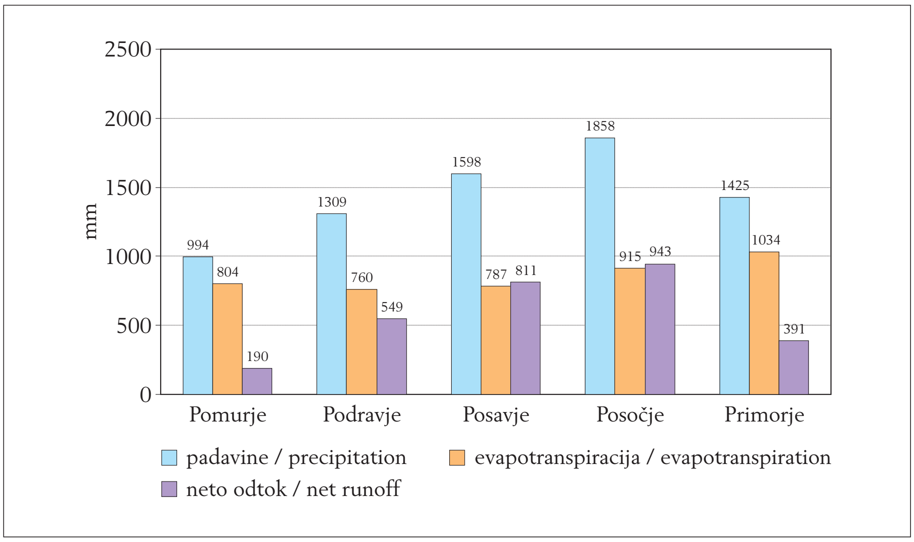
runs through it. Podravje also had somewhat more precipitation than the reference period mean. There was 1309 mm of precipitation in 2005 on average (in the 1971–2000 reference period: 1244 mm), which is 135.7 m^3/s. The least precipitation in Podravje in 2005 was in its eastern part – in the central part of Slovenske Gorice in the area of Lenart, where there was somewhat more than 1000 mm of precipitation. From there, the quantity increased in the direction of the higher-lying parts and towards the west. The peaks of Haloze thus had around 1300 mm of precipitation. The most precipitation fell on Pohorje and in the part of the Karavanke Mountains that stretches into Podravje – around 1800 mm in the highest-lying parts. The quantity of water inflow from Austria was determined using the discharges of the Drava River at Dravograd, the Bistrica River at Muta and in the headwaters of the Pesnica River. The Drava River at Ormož is the common outflow of the entire Podravje river basin from Slovenia. On average, there was 229 m^3/s of water flowing in and 286 m^3/s of water flowing out of Podravje in 2005. The net contribution of Podravje to the discharge of the Drava River was therefore almost 56.9 m^3/s. By considering the precipitation and the net runoff, we find that there was 78.7 m^3/s of balance evaporation of water from Podravje. The calculated real evaporation was 11% lower than the balance evaporation.

Posavje (the river basin of the Sava River) encompasses more than half (11,750 km^2) of Slovenia. In 2005, the territory of the Slovenian Posavje had, on average, 1598 mm of precipitation or 595.9 m^3/s (1,589 mm in the 1971–2000 reference period). This is practically the same quantity as in the multi-annual period. The river basin is known for the great variation in the amount of precipitation and, in 2005 this was from 1200 mm in Posotelje to 2600 mm on the slopes of southern and western Bohinj Mountains and in the Julian Alps. The quantity of precipitation increases from east to west. The Ljubljana Basin thus had between 1400 and 1600 mm of precipitation and the Kamniške Alps had 2000 mm, while there was more than 2000 mm on the Dinaric Ridge from Mount Goteniška gora over Mount Snežnik, Mount Nanos and all the way to the Julian Alps. The area of Mount Snežnik had almost the same precipitation peak as the Julian Alps in 2005 – around 2600 mm. Inflows into the Slovenian Posavje from the Croatian part of the river basin of the rivers Ljubljanica, Kolpa, Krka and Sotla contributed 36.4 m^3/s, while the total outflow from Slovenia was 338.8 m^3/s. The net outflow from the Slovenian Posavje was 302.4 m^3/s. Evaporation calculated according to the water balance equation was 293.5 m^3/s, though we calculated 9% less real evaporation.

Posočje (the river basin of the Soča River) measures 2,320 km^2 and is the most water-abundant river basin in terms of specific discharges. In 2005, the river basin had the most precipitation in Slovenia: 1858 mm or 136.7 m^3/s. However, the quantity is significantly below the normals of the 1971–2000 reference peri-

Preglednica 22: Členi vodne bilance leta 2005 po hidrogeografskih enotah Slovenije.
Table 22: *The components of the water balance in 2005 according to the hydrogeographical units of Slovenia.*

(mm)	Pomurje	Podravje	Posavje	Posočje	Primorje
padavine / *precipitation*	994	1309	1598	1858	1425
izhlapevanje / *evapotranspiration*	804	760	787	915	1034
neto odtok / *net runoff*	190	549	811	943	391
odtočni količnik / *runoff coeficient*	0,19	0,42	0,51	0,51	0,27



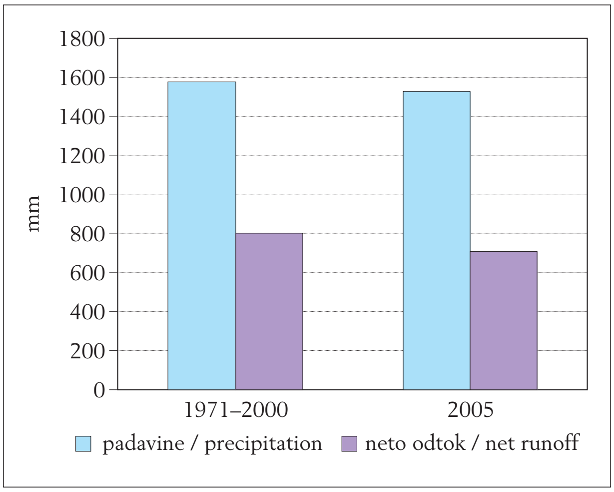
Slika 51: Členi vodne bilance leta 2005 po hidrogeografskih enotah Slovenije v mm.
Figure 51: *The components of the water balance in 2005 according to the hydrogeographical units of Slovenia, in mm.*

Brkini in okolica okoli 1500 mm, največ pa pogorje Snežnika – preko 2000 mm. Kot že omenjeno je bilo leta 2005 na območju Snežnika padavin prav toliko kot v Julijcih, v ožji okolici vrhov Snežnika in Zatrepa celo preko 2600 mm. Tekoče vode v Slovenijo pritečejo preko povirij Rižane, Reke ter Dragonje. Skupaj je priteklo v Slovenijo manj kot 0,69 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 2005 19,7 m^3/s, neto odtok pa je 19 m^3/s. Leta 2005 je po bilančni metodi izhlapelo 50,2 m^3/s, 22 % več kot smo izračunali realnega izhlapevanja.

Primerjava z obdobno vodno bilanco

Vse člene vodne bilance leta 2005 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 2005 padlo le nekoliko več padavin kot je obdobno povprečje. Med leti 1971–2000 je bila povprečna količina padavin 1462 mm, leta 2005 pa jih je padlo 1489 mm. Tudi izhlapevanje je bilo leta 2005 večja kot v povprečju obdobja 1971–2000. Leta 2005 je bilančno izhlapelo 783 mm vode, v obdobju 1971–2000 pa 713 mm. V obdobju 1971–2000 smo iz ozemlja Slovenije v črnomorsko povodje pris-od, which is 2,386 mm. In 2005, the most precipitation in Posočje fell in the Julian Alps, where there was in excess of 2200 mm – significantly less in comparison with the previous years and the reference period. The most water-abundant South Bohinj Mountains thus received only up to 2500 mm of precipitation (in 2004 they got more than 3500 mm). The high Dinaric plateaus of Nanos and Trnovski gozd had more than 2000 mm of precipitation and Javorniki between 1800 and 1900 mm, while in the Vipava Valley there was between 1400 and 1500 mm of precipitation. At the bottom of the Soča River valley there was between 1600 and 1700 mm of precipitation. The least precipitation occurred in the surroundings of Miren, in the lower part of the Vipava Valley – somewhat more than 1200 mm. This smaller quantity of precipitation was also reflected in the outflow from the river basin. Almost the entire Posočje belongs to Slovenia. Exceptions to this are the headwaters of the Učja and Nadiža rivers and partly also the Idrija, which contributed 3.27 m^3/s to Slovenia. The water flows out of the Slovenian Posočje predominantly through the Soča, Vipava and Nadiža rivers, though some of it also flows out through the Idrija, Reka (in the Goriška Brda) and Koren rivers. The total outflow was 72.7 m^3/s. In 2005, the balance evaporation in Posočje was 67.3 m^3/s, while the calculated real evaporation was 13% lower than the balance evaporation, and the net runoff in Posočje was 69.4 m^3/s.

Izhlapevanje po nevihti (foto: Peter Frantar).
Evapotranspiration after the storm (photo: Peter Frantar).



Slika 52: Padavine v Sloveniji in odtok z ozemlja Slovenije v referenčnem obdobju 1971–2000 ter letu 2005 v mm.

Figure 52: *Precipitation in Slovenia and the outflow from the Slovenian territory in the reference period of 1971–2000 and in 2005 in mm.*

pevali 390 m^3/s vode oz. 749 mm, v letu 2005 je bila ta količina nekoliko manjša: 368 m^3/s oz. 706 mm. V primerjavi z dolgoletnim obdobjem je bilo leto 2005 v tem povodju bolj namočeno na vzhodnem delu v Pomurju in Podravju, in manj na zahodnem delu (v Alpah in predgorju). Skupno pa je bilo leto 2005 povprečno leto pri padavinah, manj je bilo odtoka in več izhlapevanja.

V slovenskem delu **Jadranskega povodja** je v letu 2005 padlo znatno manj padavin kot v dolgoletnem obdobju. V tem letu je bila količina padavin zgolj 1686 mm, obdobno povprečje pa je 2081 mm. Izhlapevanja je bilo po letnem vodnobilančnem izračunu 962 mm, kar je skoraj tretjino več kot v obdobju 1971–2000. V letu 2005 je bil povprečni odtok v Jadran 88 m^3/s (724 mm), medtem ko je dolgoletni povprečni odtok preko 164 m^3/s (1346 mm). Odtok v letu 2005 je bil od povprečja manjši tako zaradi manjše količine padavin kot tudi zaradi večjega izhlapevanja. Največje odstopanje od povprečja je bilo v Posočju.

The water catchment area of the rest of the Adriatic Sea rivers encompasses 1,530 km^2, its largest stream being the Reka. There was less precipitation here in 2005 than the normals as it amounted to 1425 mm (in the 1971–2000 reference period: 1619 mm), or somewhat less than 69.1 m^3/s. The lowest quantities of precipitation occurred in the Koper littoral area – even below 900 mm in the surroundings of Kaštel. Elsewhere in the Koper littoral area, there was between 900 and 1000 mm of precipitation. There was more precipitation towards the east and north. The Karst Plateau received between 1100 and 1300 mm of precipitation and Brkini and the surrounding areas received around 1500 mm, with the most precipitation occurring in the Snežnik mountain chain (in excess of 2000 mm). As already mentioned, there was as much precipitation in the area of Mount Snežnik in 2005 as in the Julian Alps. In the immediate vicinity of the peaks of Snežnik and Zatrep it even exceeded 2600 mm. Running water flows into Slovenia through the headwaters of the Rižana, Reka and Dragonja rivers. The total inflow into Slovenia was less than 0.69 m^3/s of water. There are several outflows: in addition to the majority of the Karst (with underground runoff) and the Coast, there is the Osapska River that flows into Italy, while the water from the headwaters of the Mirna River flows out into Croatia. The total runoff in 2005 was 19.7 m^3/s and the net runoff was 19 m^3/s. According to the water balance method, 50.2 m^3/s of water evaporated in 2005, which is 22% more than the calculated real evaporation.

Comparison with the Reference Period Water Balance

All the components of the 2005 water balance for the Black Sea and Adriatic Sea basins were compared with the water balance of the 1971–2000 reference period (Bat et al., 2008).

In the Slovenian part of the Black Sea Basin, there was more precipitation in 2005 than the mean of the reference period. Between 1971 and 2000, the average precipitation amount was 1462 mm, while the amount in 2005 was 1489 mm. There was also more evaporation in 2005 than the mean of the 1971–2000 reference period. In 2005, balance evaporation amounted to 783 mm of water compared to 713 mm in the 1971–2000 reference period. The Slovenian territory contributed 390 m^3/s or 749 mm of water into the Black Sea Basin in the 1971–2000 reference period, while in 2005 this amount was somewhat lower: 368 m^3/s or 706 mm. In this catchment basin, the year 2005 was more water abundant in the eastern part of Pomurje and Podravje in comparison with the multi-annual reference period and less so in the western part (in the Alps and in the foothills). In total, 2005 was an average year in terms of precipitation, with less runoff and more evaporation.

Preglednica 23: Primerjava členov vodne bilance 2005 z dolgoletnim obdobjem 1971–2000.
***Table 23:** A comparison of the components of the water balance for 2005 with the multi-annual reference period of 1971–2000.*

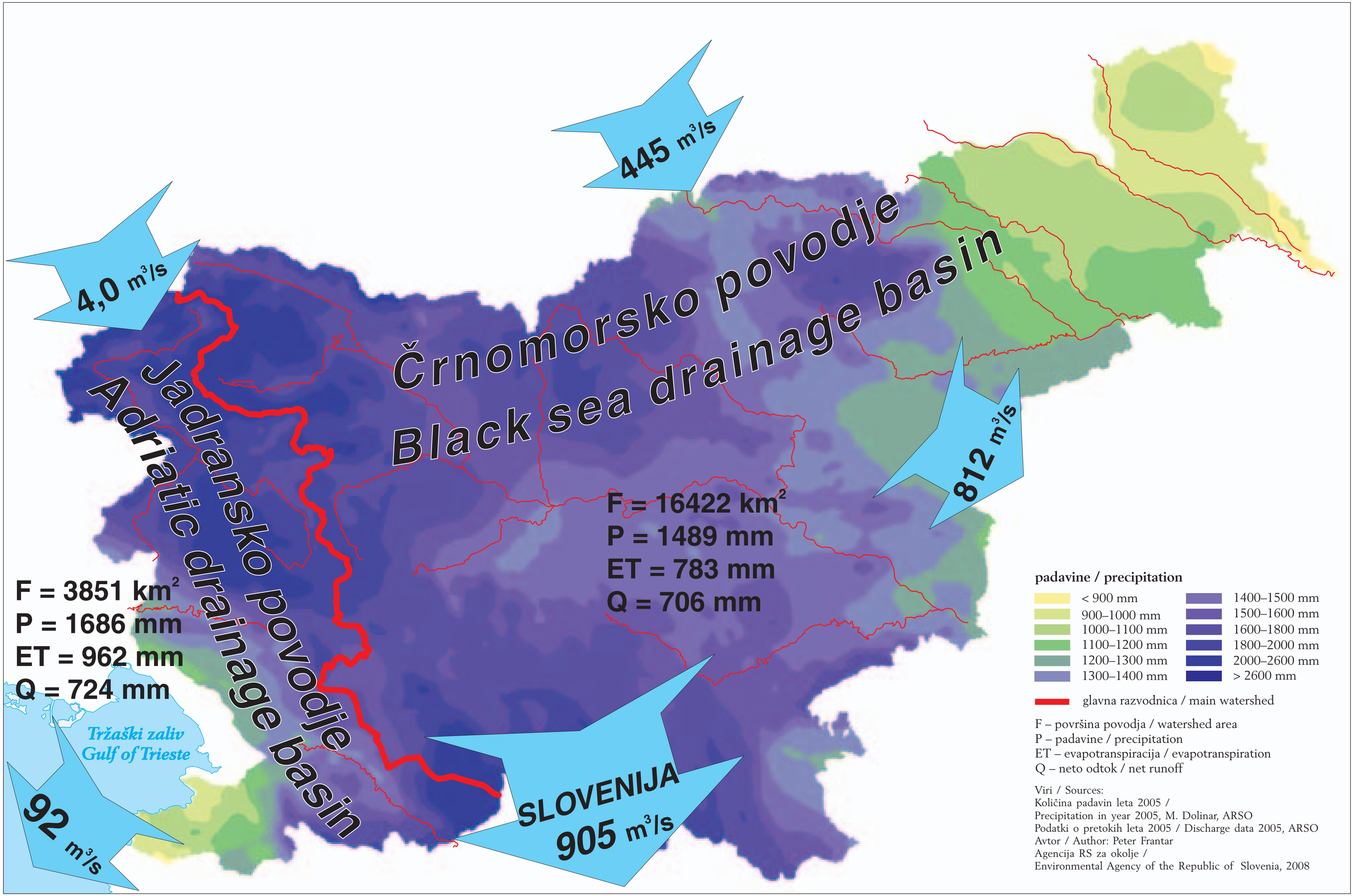
(mm)	Podonavje		Jadran		Slovenija	
	1971–2000	2005	1971–2000	2005	1971–2000	2005
padavine / *precipitation*	1462	1489	2081	1686	1579	1527
izhlapevanje / *evapotranspiration*	713	783	735	962	717	817
neto odtok / *net runoff*	749	706	1346	724	862	709
odtočni količnik / *runoff coefficient*	0,51	0,47	0,65	0,43	0,55	0,46

Leto 2005 je bilo v **Sloveniji** v primerjavi z referenčnim obdobjem 1971–2000 v okviru povprečja le po količini padavin. Izhlapevanje je bilo leta 2005 v Sloveniji večje za 14 %, odtok pa manjši za 18 %. V Podonavju je bil vodni cikel leta 2005 dokaj povprečen, v Jadranskem povodju pa je bilo manj padavin, še manj pa odtoka vode.

In the Slovenian part of the **Adriatic Sea Basin,** there was significantly less precipitation in 2005 than in the multi-annual reference period. The quantity of precipitation was merely 1686 mm, while the reference period mean was 2081 mm. According to the water balance calculation, evaporation was 962 mm, which is almost a third more than in the 1971–2000 period. The average runoff into the Adriatic Sea in 2005 was 88 m^3/s (724 mm), while the multi-annual reference period mean runoff exceeded 164 m^3/s (1346 mm). The runoff in 2005 was lower than the average because of the lower quantity of precipitation and the greater evaporation. The greatest deviation from the average occurred in Posočje.

In comparison with the 1971–2000 reference period, 2005 in Slovenia was within the scope of the average only in terms of precipitation. Evaporation in 2005 was greater by 14% and the runoff was lower by 18%. In Podonavje (the river basin of the Danube), the water cycle in 2005 was rather average, while there was less precipitation in the Adriatic Sea Basin and even less runoff.

Slika 53: Karta vodnobilančnih členov v Sloveniji leta 2005.
***Figure 53:** Map of water balance components in Slovenia in 2005.* ➤



Črnomorsko povodje
Black sea drainage basin
Jadransko povodje
Adriatic drainage basin
4,0 m³/s
445 m³/s
812 m³/s
92 m³/s
SLOVENIJA
905 m³/s
Tržaški zaliv
Gulf of Trieste
F = 16422 km²
P = 1489 mm
ET = 783 mm
Q = 706 mm
F = 3851 km²
P = 1686 mm
ET = 962 mm
Q = 724 mm
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
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 2005 /
Precipitation in year 2005, M. Dolinar, ARSO
Podatki o pretokih leta 2005 / Discharge data 2005, ARSO
Avtor / Author: Peter Frantar
Agencija RS za okolje /
Environmental Agency of the Republic of Slovenia, 2008