I. DEL: PREGLED HIDROLOŠKIH RAZMER V LETU 2001

PART I: A REVIEW OF HYDROLOGICAL CONDITIONS IN THE YEAR 2001

A. POVRŠINSKE VODE

VODOSTAJI IN PRETOKI REK

Igor Strojan

V letu 2001 je po slovenskih rekah v celoti preteklo okoli deset odstotkov manj vode kot v dolgoletnem primerjalnem obdobju. Pretoki se preko leta niso spreminjali skladno z ustaljenimi pretočnimi režimi rek. Običajnih visokih voda v aprilu in v oktobru ni bilo.

Povprečni mesečni pretoki rek so bili z redkimi izjemami, največji januarja, marca ter septembra. V vseh ostalih mesecih so bili povprečni mesečni pretoki manjši od obdobnih (karta 1 in graf 3). Izjema so bili pretoki na Muri, kjer so bila mesečna odstopanja pretokov od povprečja veliko manj izrazita kot na ostalih slovenskih rekah.

Visokovodne konice so bile največje večinoma konec januarja. Ob tem so reke poplavljale večinoma območja 2- do 5-letnih poplav, izjemoma pa tudi območja 5-letnih poplav. Visokim pretokom je botrovalo taljenje snega. V splošnem se je vodnatost v tem času zmanjševala od zahoda oz. severozahoda, kjer je bila največja, proti vzhodu oz. severovzhodu, kjer je bila najmanjša.

Hidrološke sušne razmere leta 2001 so bile dokaj izrazite. Vodnatost rek se je pričela zmanjševati aprila, ko so bili mesečni pretoki rek že nekoliko manjši kot v dolgoletnem primerjalnem obdobju. Pomanjkanje padavin je hidrološke sušne razmere postopno stopnjevalo vse do julija in avgusta, ko so se neugodnim padavinskim razmeram pridružile visoke temperature zraka, ki so dodatno vplivale na izredno majhno vodnatost rek. Pretoki rek so bili med najmanjšimi v obdobju, dosegali so pet- in večletne povratne dobe malih pretokov (graf 3 in 4). Nekatere manjše reke in potoki so začasno presahnili. Po hidrološko mokrem deževnem septembru so se pretoki ponovno zmanjševali vse do konca leta.

Podrobneje so nizkovodne in visokovodne razmere v letu 2001 opisane v posebnih poglavjih letopisa.

Dnevno spreminjanje pretokov na sloven-

A. SURFACE WATERS

WATER LEVEL AND RIVER DISCHARGE

Igor Strojan

On the whole, river discharge in Slovenia in the year 2001 was 10% lower than in the multiannual comparative period. During the year, the discharges did not change in accordance with the stable discharge regimes of rivers. The usual high waters in April and October did not occur.

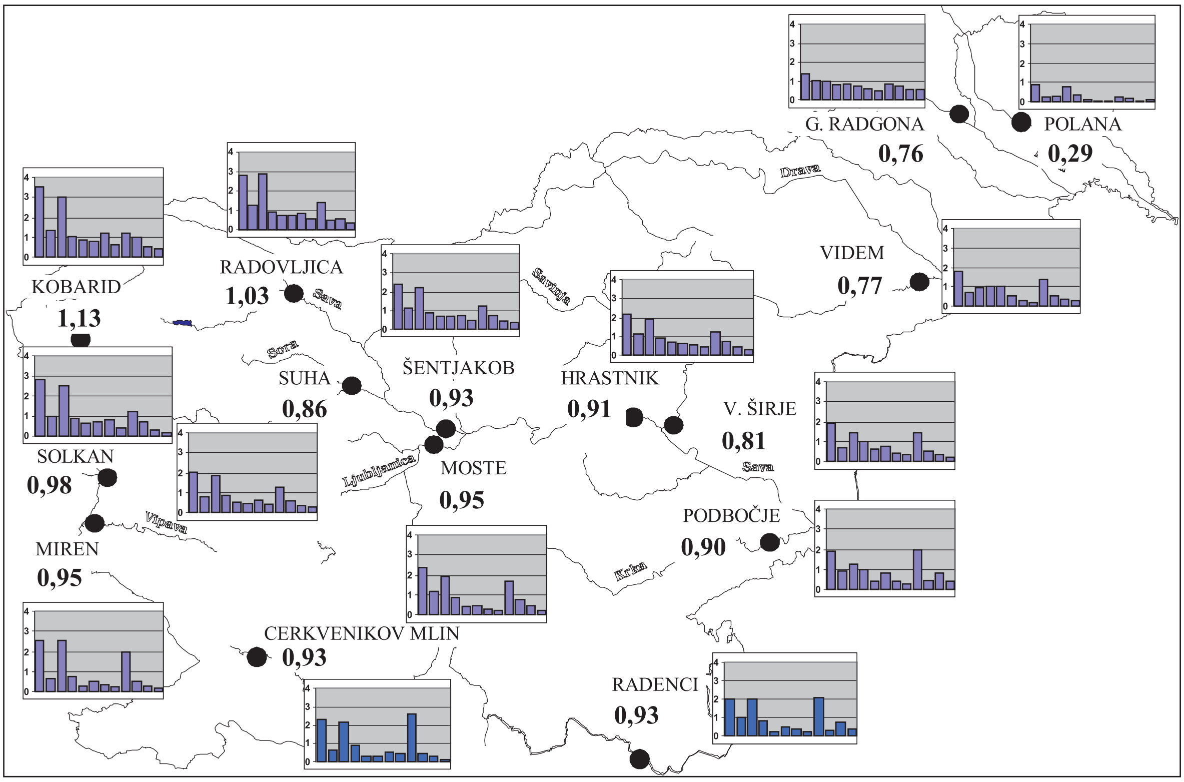
The mean monthly river discharges were, with rare exceptions, the highest in January, March and September. The mean monthly discharges in all other months were lower than that of the period (Map 1 and Graph 3). An exception was the Mura River where monthly deviations from the mean discharge values were less evident than on other Slovene rivers.

The yearly high water peaks were mainly reached at the end of January. Rivers mainly flooded 2- to 5- year flooding areas, and exceptionally also 5- year flooding areas. Snow melting was the cause of high discharges. Generally, the quantity of water decreased from west or north-west, where it reached its peak, towards east or north-east, where it was lowest.

The dry period in 2001 was rather explicit. The quantity of water in rivers began to decrease in April when the monthly discharges of rivers were somewhat lower than in the comparative period. The lack of precipitation gradually intensified the dry period, which lasted from July to August, when we registered high air temperatures as well, which was an additional reason for the extremely low quantity of water in rivers. River discharges were the lowest in this period, they reached 5 or more year return period of low discharges (Graph 3 and 4). Some small rivers and streams have temporarily run dry. After a hydrologically wet September the discharges have started decreasing again up till the end of the year.

The low and high flows in 2001 are described in greater detail in the additional chapters of this yearbook.

Daily changes of discharges on Slovene rivers in 2001 are presented with mean daily di-



Karta 1: Razmerja med srednjimi letnimi pretoki leta 2001 in obdobja 1961-1990 ter grafični prikazi razmerij med srednjimi mesečnimi pretoki leta 2001 in obdobja 1961-1990. Vrednost razmerja 1 pomeni, da je bil pretok leta 2001 enak povprečju dolgoletnega obdobja.
Map 1: The ratios between the mean annual discharges in 2001 and the period 1961-1990 along with graphic presentations of ratios between mean annual discharges in 2001 and the period 1961-1990. Ratio value 1 means that discharge in 2001 was the same as the average multiannual mean.

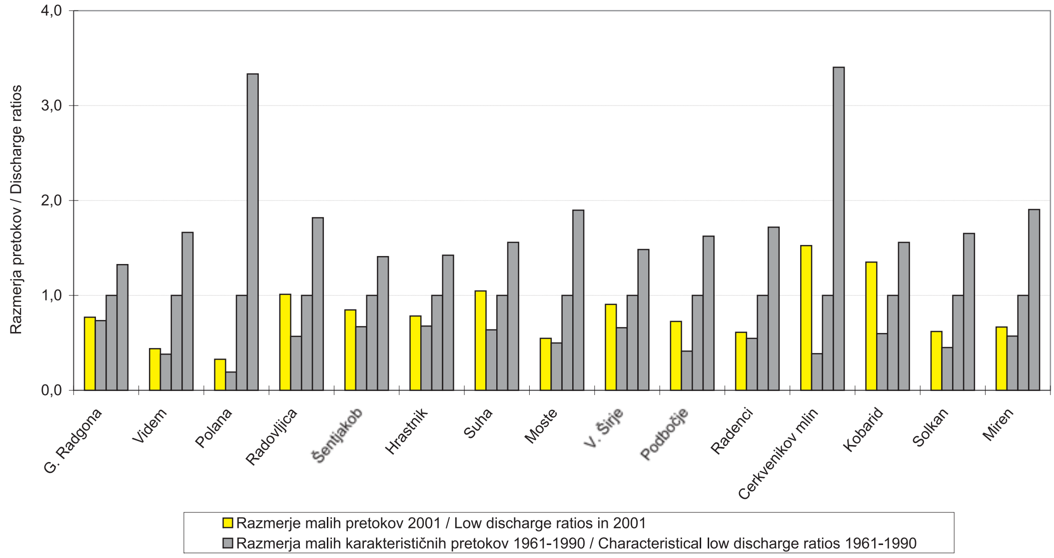
skih rekah leta 2001 je predstavljeno s srednjimi dnevnimi pretoki Save na vodomerni postaji v Hrastniku (graf 4). Odstopanja od prikazanih pretokov so se tudi v letu 2001 pojavljala predvsem na rekah z drugačnim pretočnim režimom, od katerih je najbolj izrazit primer Mure, ki ima snežni pretočni režim z obilnimi pretoki pomladi in poleti. V letu 2001 so na Muri veliko manj kot na drugih slovenskih rekah izstopali hidrološko mokri meseci januar, marec in september.

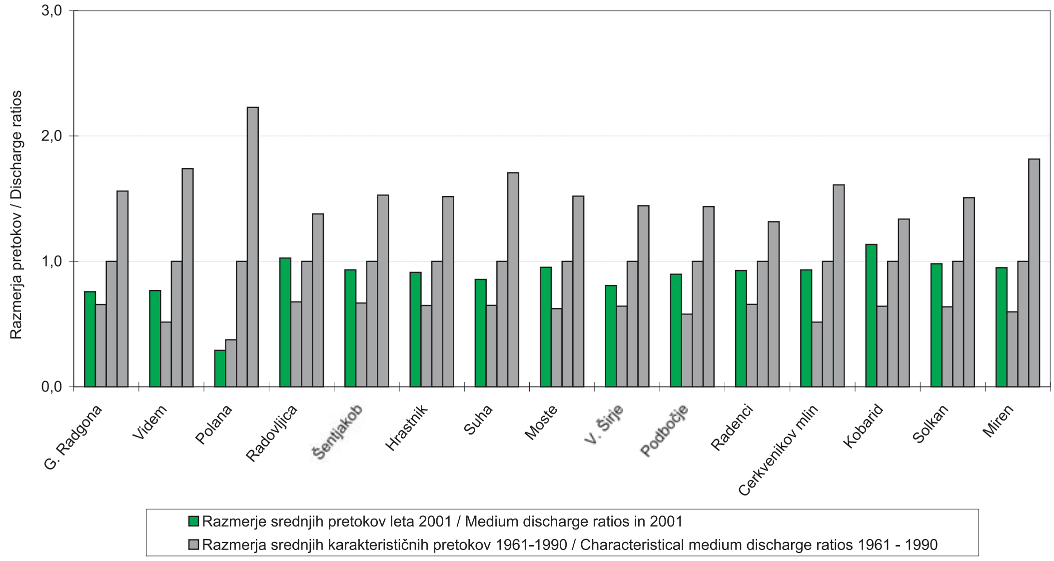
Podrobnejši pregled hidroloških razmer prikazuje obdobje mesecev januarja, februarja in marca kot hidrološko zelo mokro. Pretoki so bili januarja in marca v povprečju dvakrat večji kot navadno v tem obdobju (graf 3), februar pa je bil povprečen. V prvih treh mesecih leta so bile najbolj vodnate reke v severozahodni Sloveniji, kjer so bili mesečni pretoki tudi trikrat večji kot v primerjalnem obdobju. Pretok Mure je bil v tem času le nekoliko večji kot navadno. Januarja in marca, so se pretoki dvakrat močneje povečali. Ob tem so reke tudi poplavljale.

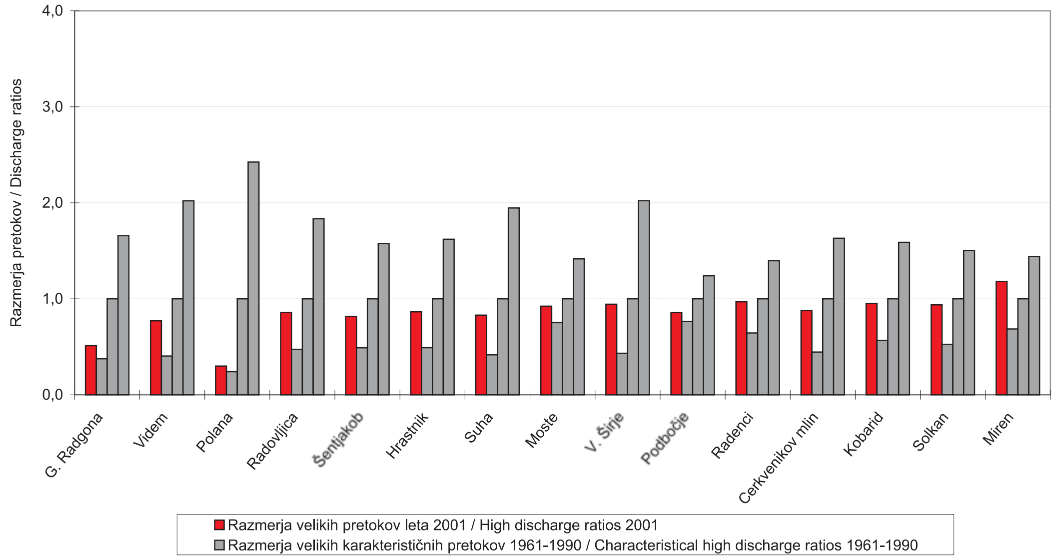
Aprila, maja, junija, julija in avgusta so se

scharges of the Sava River on the gauging station in Hrastnik (Graph 4). Deviations from the displayed discharges have appeared in 2001 mainly on rivers with different discharge regime, the most distinctive example being the Mura River, which has a snow discharge regime with high discharge in spring and summer. In 2001, the Mura River had an exceptionally hydrologically wet January, March and September, however not as wet as other Slovene rivers.

A detailed review of hydrological conditions show the first three months (January, February and March) as hydrologically very wet. On average, the discharges were twice the normal size in January and March (Graph 3), but they reached average values in February. Rivers in the north-west of Slovenia had the largest quantity of water in the first three months with monthly discharges three times higher in comparison with the comparative period. The Mura River discharge was a little higher than usual. In January and March a substantial increase in the discharges was noticed twice, which caused the rivers to flood.







Graf 3: Razmerja med srednjimi mesečnimi pretoki v letu 2001 in obdobnimi srednjimi mesečnimi pretoki. Razmerja so izračunana kot povprečja razmerij na izbranih postajah (glej karto 1).
Graph 3: The Ratios between the mean monthly discharges in the year 2001 and between the mean monthly discharges of the period. The ratios are calculated as mean values of ratios on selected stations (see Map 1).

pretoki rek postopoma zmanjševali. Hitrejše zmanjševanje pretokov so občasno prekinjale manjše padavine. Glede na primerjalne mesece v dolgoletnem obdobju je preteklo po koritih rek aprila 10, maja in junija 40, julija 50 in avgusta 60 odstotkov manj vode. Ob koncu sušnega obdobja so bile sušne razmere najbolj izrazite, nekatere manjše reke in potoki so presahnili, najmanjši pretoki so bili blizu najmanjšim pretokom iz dolgoletnega primerjalnega obdobja.

V septembru so se pretoki močneje povečali in končalo se je večmesečno poletno sušno obdobje. Drugače od pričakovanj so bile padavine tudi po septembru manj izdatne kot navadno in vodnatost rek se je ponovno zmanjševala, tokrat vse do konca leta. V oktobru je bila vodnatost 40 odstotkov, novembra 60 in v decembru celo 70 odstotkov manjša kot v primerljivih mesecih dolgoletnega obdobja (graf 3). Zadnje decembrske dni so bili pretoki nekaterih rek najmanjši v letu (preglednica 1).

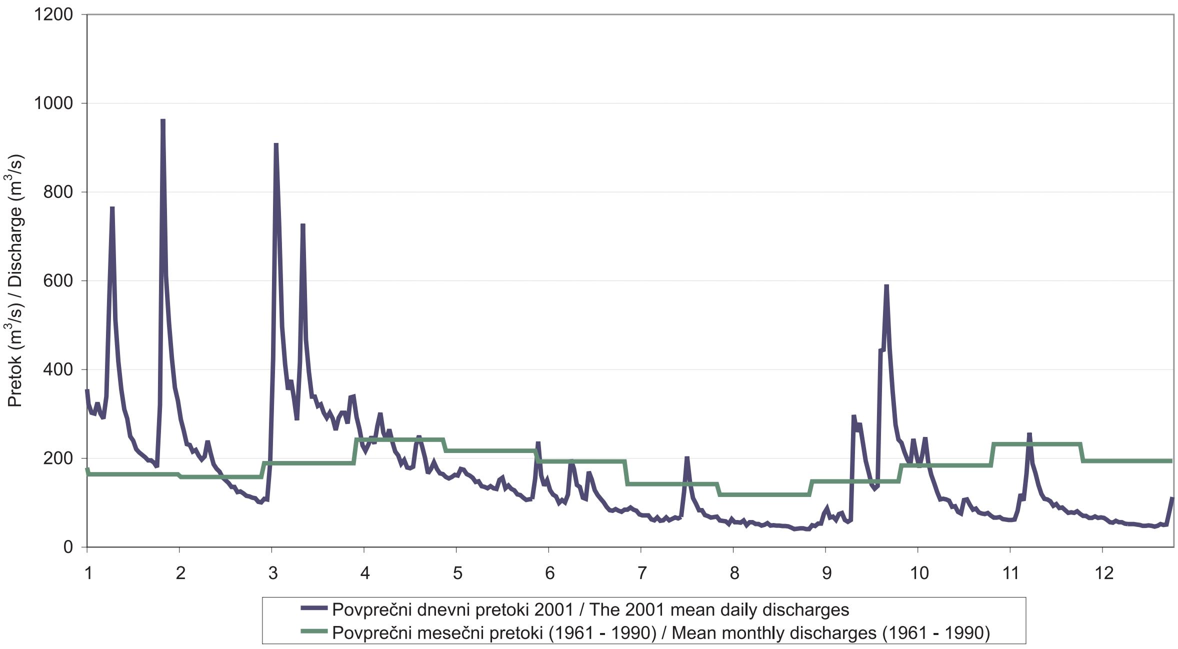
Podrobneje so hidrološke razmere na rekah v letu 2001 opisane v Mesečnih biltenih Agencije Republike Slovenije za okolje.

Primerjava značilnih pretokov v letu 2001 z značilnimi pretoki v primerjalnem ob-

The river discharges have gradually decreased in April, May, June, July and August. A faster decrease of discharges was at times interrupted by smaller precipitation. With regard to the comparative months there was 10% less water in rivers in April, 40% less in May and June, 50% less in July and 60% less in August. Dry conditions were most explicit at the end of the dry period. Some small rivers and streams have run dry and the smallest discharges were close to the smallest values from the multiannual comparative period.

The discharges have increased substantially in September and the dry period of several months has ended. However, the precipitation was less excessive than usual even after the wet September and the water quantity has been decreasing until the end of the year. The water quantity in October was 40%, in November 60% and in December even 70% lower than in the comparative months of the multiannual period (Graph 3). The discharges of some rivers were lowest in the last days of December (Table 1).

The hydrological conditions in 2001 are described in greater detail in the Monthly Bulletin of the Environmental Agency of the Republic of Slovenia.



Graf 4: Srednji dnevni pretoki v letu 2001 in srednji mesečni pretoki v dolgoletnem obdobju 1961 – 1990 na reki Savi v Hrastniku.
Graph 4: Mean daily discharges in the year 2001 and mean monthly discharges in the multiannual period 1961 – 1990 on the Sava River in Hrastnik.

Preglednica 1: Značilni pretoki v letu 2001 in obdobju 1961–1990.
Table 1: Characteristic discharges in the year 2001 and in the period 1961–1990.

VODOTOK STREAM	POSTAJA GAUGING STATION	**Qnp** 2001 m^3/s	**Qnp** 2001 dan/day	nQnp 1961-1990 m^3/s	sQnp 1961-1990 m^3/s	vQnp 1961-1990 m^3/s
MURA	G. RADGONA	47,5	26. 12.	45,3	61,7	81,7
DRAVINJA	VIDEM	0,9	28. 08.	0,78	2,05	3,41
LEDAVA	POLANA	0,05	24. 07.	0,03	0,15	0,52
SAVA	RADOVLJICA	8,9	26. 12.	5	8,8	16
SAVA	ŠENTJAKOB	24,9	30. 08.	19,7	29,4	41,4
SAVA	HRASTNIK	40,7	26. 08.	35,2	52,0	74,0
SORA	SUHA	4,0	16. 08.	2,44	3,83	5,97
LJUBLJANICA	MOSTE	4,5	30. 08.	4,1	8,22	15,6
SAVINJA	V. ŠIRJE	8,2	25. 12.	6,0	9,1	13,5
KRKA	PODBOČJE	7,9	30. 08.	4,5	10,9	17,7
KOLPA	RADENCI	3,9	22. 08.	3,5	6,4	11
REKA	CERKVENIKOV MLIN	0,9	02. 08.	0,22	0,57	1,94
SOČA	KOBARID	10,4	28. 12.	4,6	7,7	12,0
SOČA	SOLKAN	13,2	26. 10.	9,6	21,3	35,2
VIPAVA	MIREN	1,4	28. 08.	1,2	2,1	4,0

VODOTOK STREAM	POSTAJA GAUGING STATION	**Qs** 2001 m^3/s	nQs 1961-1990 m^3/s	sQs 1961-1990 m^3/s	vQs 1961-1990 m^3/s
MURA	G. RADGONA	119	103	157	245
DRAVINJA	VIDEM	9,1	6,14	11,9	20,7
LEDAVA	POLANA	0,4	0,51	1,36	3,03
SAVA	RADOVLJICA	46,1	30,4	44,9	61,9
SAVA	ŠENTJAKOB	85,4	61,2	91,6	140
SAVA	HRASTNIK	166	118	182	276
SORA	SUHA	17,8	13,5	20,8	35,5
LJUBLJANICA	MOSTE	54,6	35,7	57,3	87,1
SAVINJA	V. ŠIRJE	37,3	29,7	46,2	66,7
KRKA	PODBOČJE	49,1	31,7	54,7	78,6
KOLPA	RADENCI	49,5	35,1	53,4	70,3
REKA	CERKVENIKOV MLIN	7,7	4,26	8,26	13,3
SOČA	KOBARID	38,7	21,9	34,1	45,6
SOČA	SOLKAN	93,7	60,9	95,5	144
VIPAVA	MIREN	17	10,7	17,9	32,5

VODOTOK STREAM	POSTAJA GAUGING STATION	**Qvk** 2001 m^3/s	**Qvk** 2001 dan/day	nQvk 1961-1990 m^3/s	sQvk 1961-1990 m^3/s	vQvk 1961-1990 m^3/s
MURA	G. RADGONA	372	09. 01.	273	727	1205
DRAVINJA	VIDEM	111	26. 01.	58,2	144	291
LEDAVA	POLANA	10	08. 04.	8	33,2	80,5
SAVA	RADOVLJICA	377	08. 01.	208	439	805
SAVA	ŠENTJAKOB	737	26. 01.	442	902	1422
SAVA	HRASTNIK	1126	26. 01.	639	1302	2110
SORA	SUHA	293	25. 01.	147	353	687
LJUBLJANICA	MOSTE	264	26. 01.	215	286	405
SAVINJA	V. ŠIRJE	689	26. 01.	316	730	1476
KRKA	PODBOČJE	250	18. 09.	223	292	362
SOČA	KOBARID	689	26. 01.	237	418	664
KOLPA	RADENCI	164	26. 01.	458	711	993
REKA	CERKVENIKOV MLIN	398	07. 01.	83,3	187	305
SOČA	SOLKAN	1331	05. 03.	747	1420	2134
VIPAVA	MIREN	289	26. 01.	168	245	353

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

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

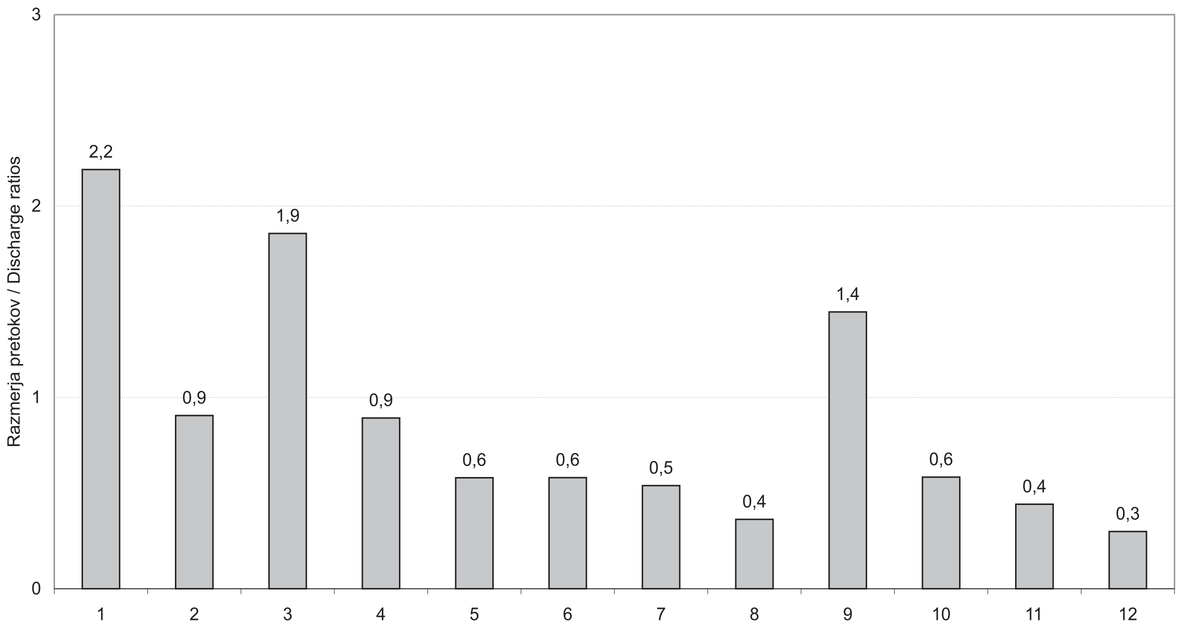
dobju 1961-1990. Mura, Sava v zgornjem toku, Soča v Kobaridu in Savinja v Velikem Širju so imele v letu 2001 **najmanjši pretok** decembra. Najmanjši pretok na Soči v Solkanu je bil konec oktobra. Na vseh ostalih rekah so bili pretoki najmanjši avgusta. Na Ledavi v Polani je bil najmanjši pretok 5 l/s že julija (preglednica 1 in graf 5). V povprečju so bili najmanjši pretoki 19 odstotkov manjši kot v primerjalnem obdobju. Pretoki so bili najmanjši v severovzhodni Sloveniji. Na severozahodu, kjer je bila pred poletno sušo vodnatost največja, so bili najmanjši pretoki manj izraziti.

Srednji letni pretoki rek, ki so prikazani na karti 1, grafu 5 in v preglednici 1, so bili v povprečju 12 odstotkov manjši kot v dolgoletnem primerjalnem obdobju. Pretoki v severovzhodni Sloveniji so bili med najmanjšimi v primerjalnem obdobju (preglednica 1 in graf 5). Srednji letni pretok Mure je bil 24 odstotkov manjši kot v dolgoletnem primerjalnem obdobju.

V povprečju so bili **največji pretoki** v letu 2001 16 odstotkov manjši kot v dolgoletnem obdobju. Nekoliko večja kot navadno je bila visokovodna konica na Vipavi v kraju Miren, občutno podpovprečne pa so bile visokovodne

The comparison of characteristic discharges in 2001 with characteristic discharges in the comparative period 1961-1990. The Mura and Sava rivers in the upper reach, the Soča River in Kobarid and the Savinja River in Velike Širje had **the lowest discharge** in December 2001. The lowest discharge on the Soča River in Solkan was recorded at the end of October. We recorded the lowest discharges on all other rivers in August. The lowest discharge of the Ledava River in Polana, 5 l/s, was recorded as early as in July (Table 1 and Graph 5). The lowest discharges were on average 19% lower than in the comparative period. The lowest discharges were recorded in the north-east of Slovenia. The lowest discharges were less significant in the north-west, where the quantity of water was the highest before the summer drought.

Mean annual discharges of rivers presented on Map 1, Graph 5 and Table 1 were on average 12 % lower than in the multiannual comparative period. The discharges in the north-east of Slovenia were among the lowest in the comparative period (Table 1 and Graph 5). The mean annual discharge of the Mura River was 24 % lower than in the multiannual comparative period.



Graf 5: Razmerja malih, srednjih in velikih pretokov v letu 2001 (po mesecih) ter razmerja karakterističnih pretokov obdobja 1961-1990. Vrednosti so podane relativno glede na srednje vrednosti malih, srednjih in velikih obdobnih pretokov.
Graph 5: Ratios of low, medium and high discharges in the year 2001 (by months) and ratios of characteristic discharges in the period 1961-1990. The values are relative, regarding the mean values of low, medium and high discharges of the period.

konice v severovzhodni Sloveniji ter na Muri. Pretoki so bili v veliki večini največji januarja, kar je glede na primerjalno obdobje redkost (preglednica 1 in graf 5).

The **maximum discharges** in 2001 were on average 16% lower than in the multiannual period. The high-water peak in the Vipava River in Miren was somewhat higher than usual, the high-water peaks in the north-east of Slovenia and on the Mura River were substantially below average. The discharges were highest in January, which is a rarity if the comparative period is taken into consideration. (Table 1 and Graph 5).

Struga Kobiljskega potoka je bila pri vodomerni postaji Kobilje suha ves avgust (foto: Peter Frantar, 30. avgust 2001).
The riverbed of the water course Kobiljski potok at the gauging station was dry whole August (photo: Peter Frantar, August 30, 2001).

TEMPERATURE REK IN JEZER

Igor Strojan

Leta 2001 so bile temperature Mure, Save, Kamniške Bistrice, Ljubljanice, Krke in Soče ter Blejskega in Bohinjskega jezera povprečno nekaj manj kot pol stopinje Celzija (°C) višje kot v večletnem primerjalnem obdobju. Predvsem so bile nadpovprečne temperature januarja in februarja. Nekoliko višje kot navadno so bile temperature voda tudi v sušnem obdobju leta, julija in avgusta. Občutna je bila ohladitev voda v začetku septembra in v decembru.

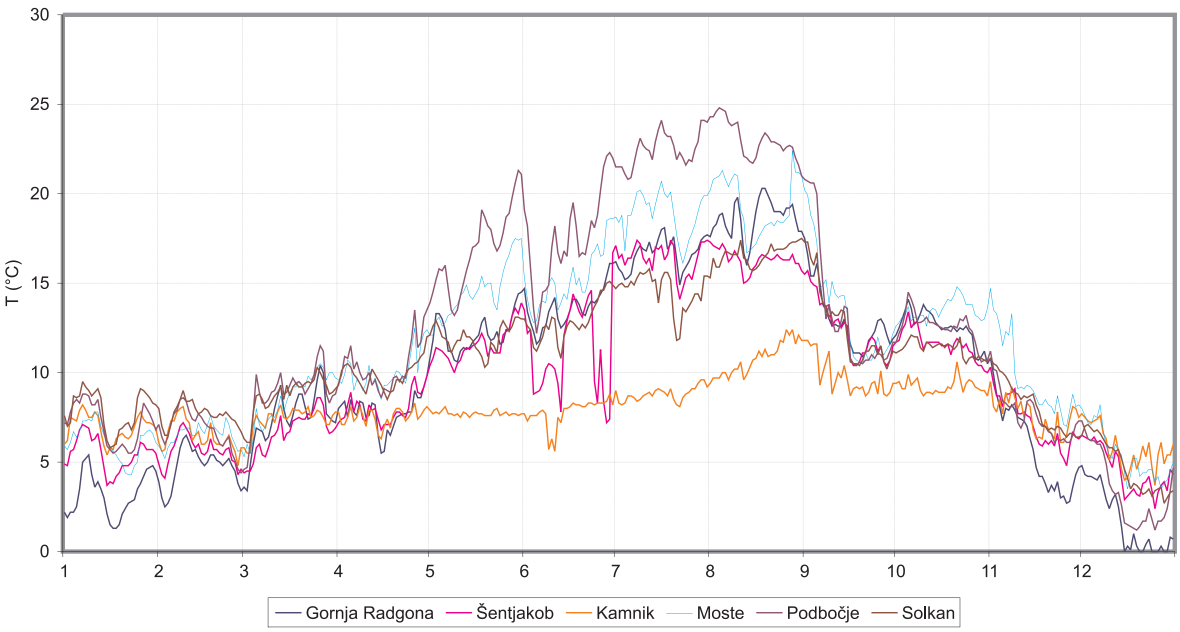
Leto 2001 se je pričelo z občutno višjimi temperaturami voda kot navadno. Januarja in februarja so imele vode povprečno temperaturo 6 °C, kar je za reke 1,9 °C in za jezera 1,5 °C več kot v primerjalnem obdobju. Naslednja dva meseca so se temperature voda približale povprečnim obdobnim vrednostim, v maju pa so bile vode zopet toplejše kot so navadno v tem mesecu. V najbolj sušnem obdobju leta, v juliju in avgustu, so imele reke povprečno temperaturo 17,3 °C, jezera pa 18,6 °C, kar je 0,4 °C oz. 0,8 °C več kot v večletnem primerjalnem obdobju. Septembra pa so se temperature voda izrazito znižale. Ohladile so se za 1,3 °C pod povprečno obdobno septembrsko vrednost. Oktobra so bile vode zopet nadpovprečno tople. November je bil temperaturno

TEMPERATURES OF RIVERS AND LAKES

Igor Strojan

The temperatures of the Mura, Sava, Kamniška Bistrica, Ljubljanica, Krka and Soča rivers as well as lakes Bled and Bohinj in 2001 were on average less than half a degree (°C) higher than in the multiannual comparative period. January and February had high temperatures, which were above average. Water temperatures in the dry season of the year (July and August) were somewhat higher than usual. There was a considerable cooling of water at the beginning of September and December.

The temperatures at the beginning of 2001 were considerably higher than usual. The mean water temperature in January and February was 6 °C which is 1.9 °C higher for rivers and 1.5 °C for lakes when compared to the comparative period. In the next two months the temperatures were close to the mean values of the period, but the waters were warmer again in May as it is usually the case. The mean temperature in the driest period of the year (July and August) was at rivers 17.3 °C and lakes 18.6 °C. That was 0.4 °C and 0.8 °C higher than in multiannual comparative period. However, in September the water temperature dropped considerably. The water was 1.3 °C below the mean September value of the



Graf 6: Temperaturna nihanja slovenskih rek Mure, Save, Kamniške Bistrice, Ljubljanice, Krke in Soče leta 2001 (po mesecih).
Graph 6: Temperature fluctuations of the Mura, Sava, Kamniška Bistrica, Ljubljanica, Krka and Soča rivers in 2001 (by months).

podoben obdobnemu povprečju, decembra pa so bile vode najbolj hladne v letu, temperature vode so bile podpovprečne (graf 8).

V izbranih primerih poteka temperaturnih nihanj na rekah na grafu 6 izstopata reka Krka (vodomerna postaja Podbočje) kot najtoplejša in Kamniška Bistrica (vodomerna postaja Kamnik) kot najbolj hladna reka. Razvidne so relativno visoke temperature voda januarja in februarja ter najnižje temperature decembra. Povišanim majskim temperaturam sledi znižanje temperatur junija, nato pa povišanje temperatur v sušnem obdobju julija in avgusta. Zelo izrazito je znižanje temperatur septembra.

V Blejskem in Bohinjskem jezeru je bil potek temperaturnih sprememb podoben kot na rekah, le da sta se jezeri pričeli bolj izrazito ogrevati nekoliko kasneje kot reke (graf 7). Manjša temperaturna nihanja so na obeh jezerih večinoma manj izrazita kot na rekah. Bohinjsko jezero je bilo kot običajno vse leto hladnejše kot Blejsko, v povprečju celega leta za 3,4 stopinje Celzija.

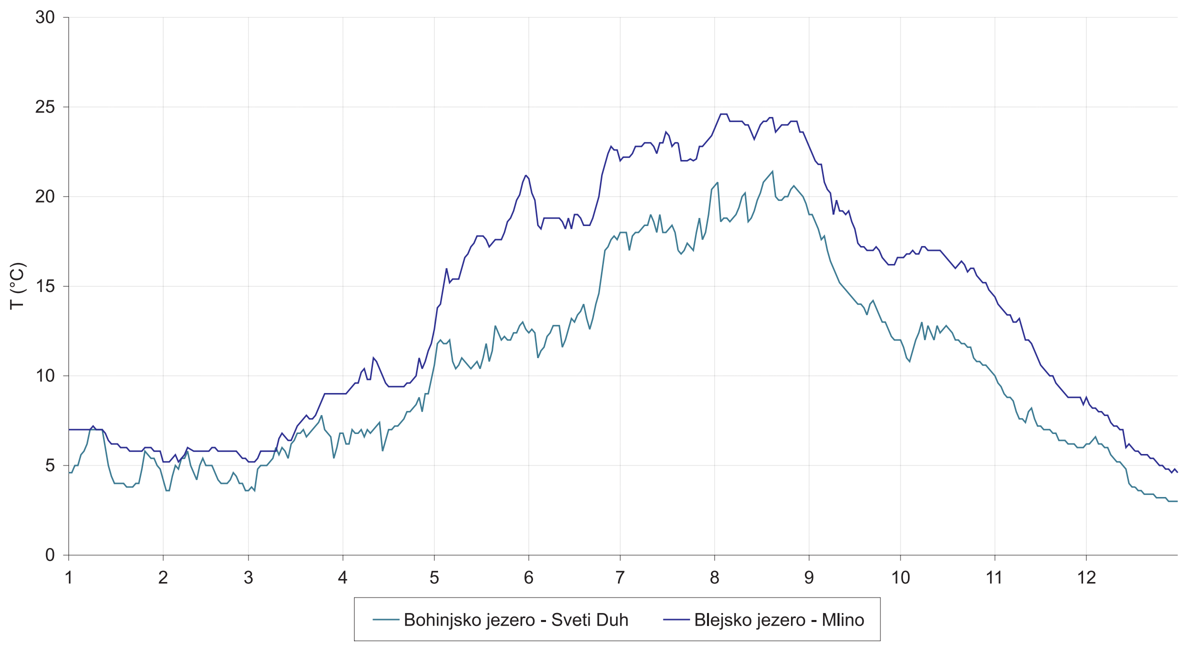
Primerjava značilnih temperatur voda z večletnim obdobjem. Reke in obe jezeri so bili najbolj hladni ob koncu leta. To je bilo izrazito odstopanje od običajnega temperaturnega režima voda, saj so vode običajno najbolj hladne januarja ali februarja. Najnižje temperature rečnih voda v letu 2001 so bile večinoma nekoliko nižje

period. The temperature of water in October was above average. November was similar to the value of the period as far as temperature is concerned, but December saw the lowest temperatures of the year (Graph 8).

In the chosen examples of temperature fluctuations in rivers (Graph 6), the following rivers stand out: the Krka River (gauging station Podbočje) as the warmest river and the Kamniška Bistrica River (gauging station Kamnik) as the coldest river. Obvious are the relatively high water temperatures in January and February and the lowest temperatures in December. High temperatures in May are followed by a decrease in temperature in June and by an increase in the dry period of July and August. The decrease in temperature is extremely evident in September.

The temperature change in Lake Bled and Lake Bohinj was similar to that of the rivers. However, the temperature of both lakes has started to increase a little later (Graph 7). Minor temperature fluctuations in both lakes were less noticeable than in rivers. Lake Bohinj was colder than Lake Bled throughout the year as it is usually the case, by 3.4 °C on yearly average.

Comparison of characteristic water temperatures in the multiannual period. The rivers and both lakes were the coldest at the end of the year. This was a marked deviation from



Graf 7: Temperaturna nihanja Blejskega in Bohinjskega jezera leta 2001 (po mesecih).
Graph 7: Temperature fluctuations of Lake Bled and Lake Bohinj in 2001 (by months).

kot v primerjalnem obdobju. Najnižji temperaturi obeh jezer, 4,6 °C Blejskega in 3 °C Bohinjskega jezera, ki sta navadno najbolj hladni v drugi polovici zime, sta bili okoli 2 °C višji od povprečja.

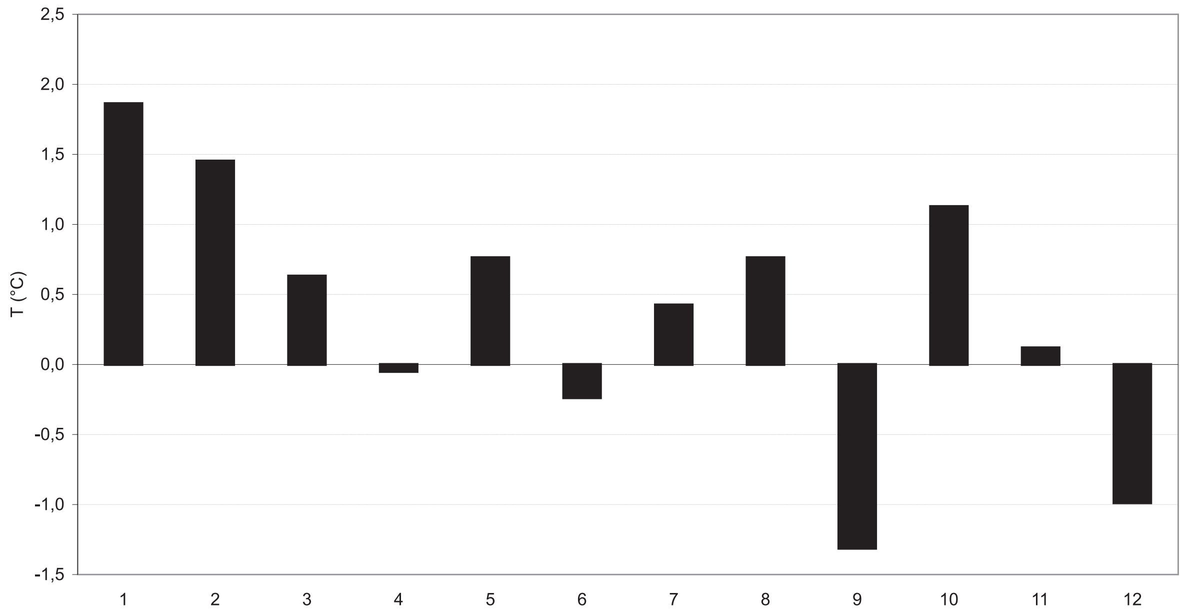
Srednje temperature izbranih rek in obeh jezer so bile 0,4 °C višje od povprečja. Srednja letna temperatura rek na izbranih postajah je bila 10,4 °C, jezer pa 12,1 °C. Srednje mesečne temperature so bile glede na primerjalno obdobje najvišje januarja, februarja in oktobra, najnižje pa septembra in decembra (graf 8).

Najvišje temperature rek in obeh jezer so bile v splošnem nadpovprečne. Vode so bile najbolj tople avgusta. Četrtega avgusta je izstopala temperatura Krke v Podbočju s 24,8 °C. Le dve desetinki stopinje hladnejše je bilo Blejsko jezero 3. avgusta.

the usual temperature regime of water, since waters reach the lowest temperature in January and February. The lowest temperature of river waters in 2001 was predominantly lower than in the comparative period. The lowest temperature of both lakes, Lake Bled 4.6 °C and Lake Bohinj 3 °C which are usually coldest in the second half of winter, were around 2 °C higher than average.

Mean temperatures of chosen rivers and both lakes were 0.4 °C higher than average. In comparison with the comparative period, the mean yearly river temperature on chosen stations was 10.4 °C, and lake temperature was 12.1 °C. Mean monthly temperatures were highest in January, February and October and lowest in September and December (Graph 8).

The highest temperatures of rivers and both lakes were generally average. The waters were warmest in August. On August 4 the temperature of the Krka River in Podbočje stood out with its 24.8 °C. Lake Bled was only two-tenths of a degree colder on August 3.



Graf 8: Odstopanja srednjih mesečnih temperatur v letu 2001 od srednjih mesečnih temperatur obdobja na izbranih rekah in jezerih. Odstopanja so izračunana kot povprečja odstopanj na šestih rečnih in dveh jezerskih merilnih postajah (glej graf 6 in 7).
Graph 8: Temperature deviations of mean monthly temperatures from the monthly temperatures on chosen rivers and both lakes in the year 2001. The deviations are calculated as mean values of deviations on six water gauge stations on the rivers and on two stations on the lakes (see Graphs 6 and 7).

VSEBNOST SUSPENDIRANEGA MATERIALA V REKAH

Florjana Ulaga

Hitrost premeščanja plavin, količina suspendirane snovi, velikost zrn, mineraloška sestava, vsebnost mikroorganizmov in motnost vode so osnovni parametri za ugotavljanje lastnosti reke z vidika kalnosti. Material, ki zaradi spiranja preperine ali erodiranja brežin v povirju, lahko pa tudi kot posledica umetnih vplivov v bližini struge, potuje po reki, znatno pripomore k njenemu spreminjanju. Delci se dolvodno ob zmanjšani transportni sposobnosti reke usedajo na rečno dno. Posledice dinamike premeščanja snovi so spremembe v in ob rečni strugi, zapolnjevanje vodnih zadrževalnikov, zablatenje rečnega dna zaradi usedanja drobnih zrn in s tem povezane spremembe v vodnem krogu, predvsem pri povezavi površinskih in podzemnih voda.

Premeščanje trdnih delcev v strugi. V celoti pod vplivom turbulence premeščen rečni material imenujemo rečni nanos. Glede na velikost delcev in hitrost prenosa ga delimo na lebdeče plavine v celotnem rečnem prerezu v suspendirani obliki in na prod, ki se premika po rečnem dnu s kotaljenjem. Med tema dvema oblikama ni ostre meje. Istočasno, ko se premikajo drobni delci v vodi, se po rečnem dnu valijo večji delci oz. prodniki. S povečanjem hitrosti vode prehaja material z rečnega dna v suspenz, s tem se povečuje količina lebdečega nanosa. Ob visokovodnih stanjih je tudi vsebnost suspendiranega materiala močno povečana. Splošno znano je dejstvo, da usedlina izhaja iz povirja reke, se po reki prenaša in na koncu odlaga. Zato lahko govorimo o treh območjih rečnega sistema. Z vidika hitrosti prenosa usedline je tako najbolj zanimiv osrednji del reke, z vidika celotnega prenosa materiala na določenem porečju pa je bolj pomembno poznavanje geoloških in hidroloških značilnosti povirnega območja ter dejanska količina odloženega materiala v spodnjem delu reke.

Mreža postaj monitoringa suspendiranega materiala. Cilj spremljanja je izračun skupne količine materiala, ki se premesti prek izbranega mesta v vodotoku v določeni časovni enoti. Dinamiki gibanja plavin v vodi sledimo z merjenjem vsebnosti suspendiranega materiala, iz katere pri izmerjenem pretoku izračunamo prenos materiala. Pogostost odvzema vzorcev je

THE CONCENTRATION OF SUSPENDED MATERIAL IN RIVERS

Florjana Ulaga

The speed of solids transporting, the amount of suspended material, the size of particles, mineralogical structure, the content of microorganisms and water opacity are the basic parameters in establishing river characteristics regarding turbidity. The material which travels down the river can contribute to its changing due to the washing down of weathered debris or eroding of river banks in headwaters or as a consequence of outside interference in the vicinity of river channels. With a diminished transporting capacity of the river the particles can then sink downstream to the river bottom. The consequences of transport dynamics are the changes in and by the river channel, the filling of water reservoirs, mudding the river bottom because of small particles sinking and corresponding changes in the water cycle, mainly in connection of surface waters and groundwaters.

Transport of solid particles in the river channel. The river material wholly transported under the influence of turbulence is called river alluvium. According to the size of particles we divide it into floating solids (found in the whole of the river cross section in suspended form) and into gravel, which moves along the bottom of the river. There is no great distinction between the two. At the same time, when the small particles move in water, bigger particles or pebbles move along the bottom of the river. When the speed of the water increases the material proceeds from the river bottom to the sediments and the amount of floating material increases. High-water situations cause a substantial increase in the concentration of suspended material. It is a common fact that the sediments come from the headwaters of the river, are transported through the river and finally deposited in the river. Therefore, we can speak of three areas of the river system. If taking into consideration the speed of the sediment transfer, the most interesting part of the river is the middle part. Nevertheless, if taking the whole material transfer in the specific area into consideration, it is the knowledge of geological and hydrological characteristics of the headwater area and the actual quantity of deposited material in the lower part of the river that is essential.

odvisna od značilnosti prispevnega območja in od pretočnega režima. Dosedanje analize suspendiranega materiala so pokazale, da se približno 70 odstotkov celotnega materiala premesti ob visokovodnih dogodkih. Zaradi tega je potrebno pogosto vzorčenje v času visokih valov.

Redna merjenja vsebnosti suspendiranega materiala izvajamo na štirih vodomernih postajah: na Muri v Gornji Radgoni, na Savi v Hrastniku, na Savinji v Velikem Širju in na Vipavi v Mirnu. Enkrat dnevno se odvzame vzorec 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. Ob tem se nekajkrat letno opravljajo tudi profilne meritve suspendiranega materiala: vzorci se odvzamejo v posameznih točkah prečnega prereza. Na podlagi vsebnosti snovi v odvzetih vzorcih izračunamo srednjo vsebnost v prerezu, s pomočjo izmerjenega pretoka pa tudi trenutni prenos suspendirane snovi.

Poleg rednega odvzema in analiziranja vzorcev poteka tudi odvzem vzorcev ob izrednih hidroloških razmerah na devetih vodomernih postajah. S pomočjo analiz teh vzorcev do-

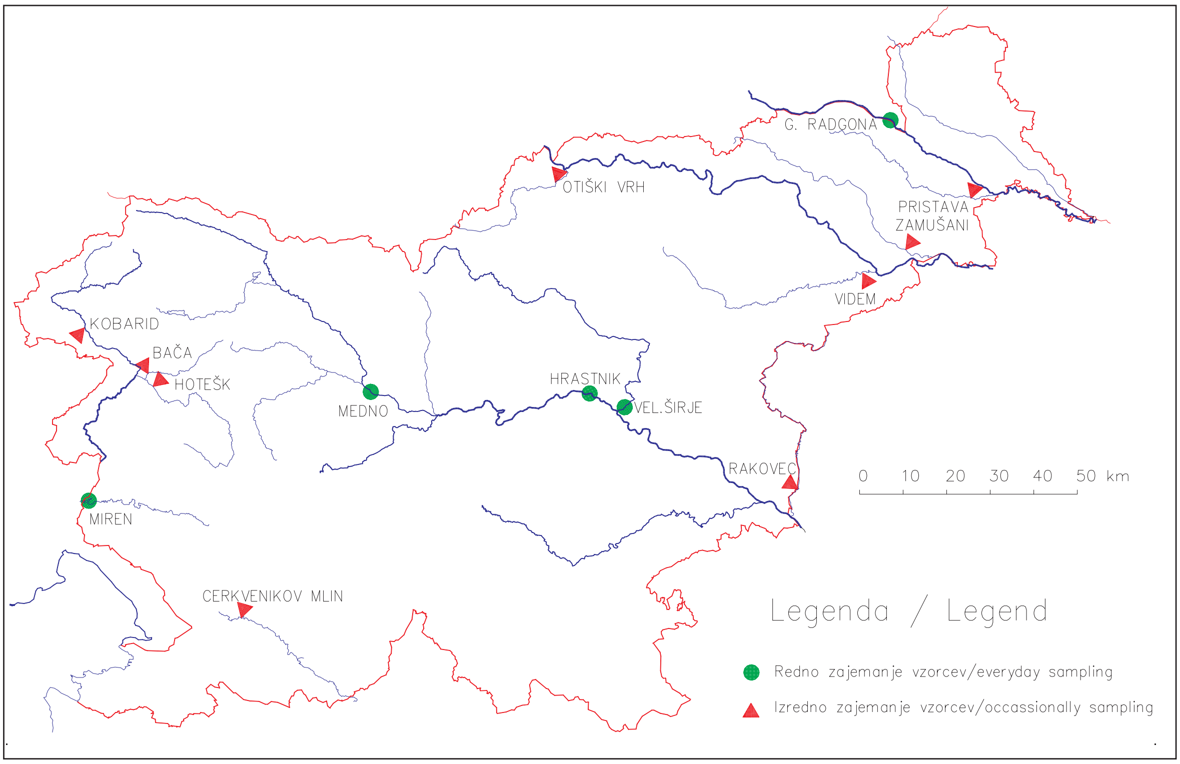
The monitoring network for suspended material. The aim of monitoring is the calculation of the total quantity of material, transported through a chosen place in the stream in a specific time unit. The dynamics of solids movement in water can be traced by measuring the concentration of suspended material. When the measured discharge value is gained, we can calculate the transfer of the material. The frequency of samples taking depends on the characteristics of the area in question and on the discharge regime. The analyses of the suspended material made so far, showed that approximately 70% of the entire material is transferred during high water occurrences. Thus, frequent sampling during high waves is necessary.

Regular measurements of suspended material are carried out on four gauging stations: on the Mura River in Gornja Radgona, on the Sava River in Hrastnik, on the Savinja River in Veliko Širje and on the Vipava River in Miren. Once a day, a 1 litre sample is taken and analysed in a laboratory according to the classical filtration method. The results are the measured concentrations of suspended material (c) in g/m^3 of water. Several times a year profile measuremen-

Vzorčevanje z batometrom (foto: Tomaž Haller).
Suspended material water sampling (photo: Tomaž Haller).

polnilne mreže lažje in pravilneje vrednotimo podatke rednih meritev, hkrati pa rezultati predstavljajo pregled stanja ob visokovodnih razmerah po vsej Sloveniji. Izredni odvzemi vzorcev so bili leta 2001 na Ščavnici v Pristavi, na Pesnici v Zamušanih, na Meži v Otiškem Vrhu, na Dravinji v Vidmu, na Sotli v Rakovcu, na Soči v

ts of suspended material are performed as well: the samples are taken at individual points of a sectional view. On the basis of substance concentration in the samples the mean concentration in the cross section is calculated. By using the discharges measurements, a momentary transfer of suspended material is calculated.



Karta 2: Postaje z rednim in izrednim odvzemom vzorca v letu 2001.
Map 2: Stations with every day and occasionally sampling in 2001.

Kobaridu, na Idrijci v Hotešku, na Bači v Bači pri Modreju in na Reki v Cerkvenikovem mlinu.

Mreža postaj za spremljanje vsebnosti suspendiranega materiala se je v Sloveniji zelo spreminjala. Začetki segajo v leto 1955, ko so pričeli z odvzemanjem vzorcev v porečju Savinje. Redno spremljanje vsebnosti suspendiranega materiala na rekah Mura in Vipava poteka od leta 1985. Odvzemna mesta na Savi pa se spreminjajo.

Rezultati meritev vsebnosti suspendiranega materiala v letu 2001. Ob pregledu izmerjenih vsebnosti suspendiranega materiala na postajah z dnevnim odvzemom vzorcev ugotovimo, da leto 2001 ni bilo izjemno glede količine drobnih delcev v vodi, pač pa bolj glede časa nastopa povečanih vsebnosti. Za snežni pretočni režim, kakršnega ima reka Mura, je značilen

Along with regular taking and analysing of samples, a sample taking in exceptional hydrological situations on nine gauging stations takes place. With the help of sample analysis of the supplementary network, the data of regular measurements are easier and more accurately evaluated and at the same time the results present an overview of the high-water condition all over Slovenia. Exceptional sample takings took place in 2001 on the Ščavnica River in Pristava, on the Pesnica River in Zamušani, on the Meža River in Otiški Vrh, on the Dravinja River in Videm, on the Sotla River in Rakovec, on the Soča River in Kobarid, on the Idrijca River in Hotešek, on the Bača River in Bača near Modrej on the Reka River in Cerkvenikov mlin (mill).

The network of stations for monitoring the concentration of suspended material has been

Preglednica 2: Največje vsebnosti suspendiranega materiala vzorcev postaj z enkrat dnevnim odvzemom v letu 2001 in v obdobju 1985–2000.
Table 2: The highest concentration of suspended material in samples with one daily taking in 2001 and in the period 1985–2000.

Postaja Gauging station	datum odvzema vzorca date of sampling	vsebnost c (g/m^3) concentration c (g/m^3)	datum največje obdobne vsebnosti date of the highest concentration	največja obdobna vsebnost the highest concentration	srednja obdobna vsebnost mean concentration
Gornja Radgona na Muri	12. 01. 2001	346	16. 05. 1996	364	50,6
Veliko Širje na Savinji	26. 01. 2001	949	07. 11. 2000	6026	51
Miren na Vipavi	25. 01. 2001	305	14. 09.1997	1066	17,3

pretočni višek ob prehodu pomladi v poletje, torej maja. Obdobna najvišja vsebnost suspendiranega materiala je bila prav tako izmerjena v maju leta 1996, ko je kar 43-krat presegla srednjo obdobno vsebnost v Muri. V letu 2001 je višek nastopil že januarja, kar lahko pripišemo izrednim vremenskim razmeram in obilnim padavinam v vodozbirnem zaledju vodomerne postaje Gornja Radgona. Največje letne vsebnosti smo izmerili januarja tudi v Savinji in Vipavi, čeprav bi jih glede na dežno-snežni pretočni režim, za katerega je značilen pretočni višek pomladi in jeseni, pričakovali kasneje. Prav tako januarja smo izmerili največjo vsebnost suspendiranega materiala v Savi. Vzorec, ki je bil odvzet 26. januarja 2001 v Hrastniku, je vseboval 610 g/m^3 suspenza. Rezultat hkrati predstavlja najvišjo vsebnost izmerjeno na tem mestu od leta 1998 dalje.

Analiza vzorcev, odvzetih ob izrednih hidroloških razmerah, odraža hidrološko suho leto 2001. Vsebnosti suspendiranega materiala nikjer, z izjemo Dravinje, niso bile velike gleda na dolgoletna spremljanja. Analiza vzorca odvzetega v Dravinji je prikazala izredno velike vsebnosti suspendiranega materiala, saj je teža drobnih zrnc v vodi presegla 4,5 kg/m^3. Večje vsebnosti smo v preteklih 17-ih letih spremljanja izmerili le še v Pesnici leta 1997, v Dravinji 1999 in v Savinji ter Soči novembra 2000.

Prenos suspendiranega materiala. Odnos med spreminjanjem pretoka in vsebnostjo suspendiranega materiala v določenem času ni povsem linearen. Največja vsebnost suspenza v vodi nastopi pogosto nekoliko pred viškom visokovodnega vala. Zato je tudi predvidevanje količin suspenza zelo težavno. Upoštevati je potrebno, v katerem delu vodozbirnega zaledja so bile pada-

changing in Slovenia. The beginnings date back to 1955, when we started with the sample taking in the catchment area of the Savinja River. A regular monitoring of suspended material concentration on the Mura and Vipava rivers has been taking place since 1985. The sampling points on the Sava River are changing.

The results of the suspended material concentration measurements in 2001. By examining the measured concentrations of suspended material on stations where daily sample taking is carried out, it can be seen that 2001 was not an exceptional year as regards the quantity of small particles in the water, but it was exceptional because of the time of the increased concentration of material. A discharge surplus, characteristic of the snow discharge regime (the Mura River), occurs in the transition from spring to summer, i.e. in May. The highest concentration of suspended material of the period was measured in May 1996 and it exceeded the mean concentration of the period by 43 times. In 2001, the culmination was reached already in January, which can be ascribed to exceptional weather conditions and abundant precipitation in water-collecting hinterland of gauging station Gornja Radgona. The highest yearly concentrations were measured in January in the Savinja and Vipava rivers, although we would expect them to appear later according to the rain-snow discharge regime, a characteristic of which is a discharge peak in spring and autumn. The highest concentration of suspended material in the Sava River was measured in January as well. The sample taken on January 26 in Hrastnik contained 610 g/m^3 of sediment. This result presents the highest measured concentration in this place since 1998.

Preglednica 3: Največje vsebnosti suspendiranega materiala vzorcev odvzetih ob izrednih hidroloških razmerah.
Table 3: The highest concentration of suspended material in samples taken in exceptional hydrological conditions.

Postaja Gauging station	vodotok stream	vsebnost c (g/m^3) concentration c (g/m^3)	datum odvzema vzorca 2001 date of sampling in 2001	največja vsebnost obdobja 1990-2000 / the highest concentration in the period 1990-2000 max c1	datum date	max c2	datum date
Pristava	Ščavnica	338	09. 04.	2623	29. 11. 1990	1730	22. 10. 1991
Zamušani	Pesnica	246	09. 04.	4780	25. 06. 1997	3729	25. 04. 1999
Otiški Vrh	Meža	480	17. 06.	1606	08. 11. 1997	1388	10. 07. 1999
Videm	Dravinja	4627	26. 01.	4832	22. 05. 1999	3582	07. 11. 1998
Kobarid	Soča	886	13. 03.	8112	17. 11. 2000	1536	04. 10. 1999
Hotešk	Idrijca	354	25. 01.	3743	09. 10. 1993	2988	01. 11. 1990
Bača pri Modreju	Bača	252	13. 03.	1959	27. 10. 1990	1088	07. 11. 1997

vine, kakšna je geološka zgradba območja, predhodna namočenost tal pa tudi čas od zadnjega visokovodnega vala.

Zmnožek vsebnosti suspendiranega materiala in pretoka vode skozi rečni prerez je prenos suspendiranega materiala S (kg/s). Ta podatek je tudi cilj vsakodnevnega odvzema vzorcev, laboratorijskih analiz in neprekinjenih spremljanj pretokov v izbranih rečnih prerezih. Iz preglednice 4 so razvidne razlike med letnimi vrednostmi prenešene snovi. Na podlagi poznavanja velikosti porečja lahko ocenimo zniževanje zemeljskega površja v zaledju posamezne postaje. Tako lahko ocenimo, da bi se ob podobnih hidroloških in erozijskih razmerah, kot smo jih zabeležili v 10-letnem obdobju, površje porečja Mure v tisočih letih znižalo za 12 mm, Vipave za 16 mm, Savinje pa za 106 mm. Pri interpretaciji teh vrednosti pa ne smemo pozabiti na dejstvo o geološki raznolikosti zaledja, na selektivnost erozije, na korozijo na kraških območjih ter na kratek niz podatkov in dolgo dobo, ki je potrebna za večino geomorfoloških sprememb.

The analysis of the samples taken in exceptional hydrological conditions reflects a hydrologically dry year 2001. The concentration of suspended material was never high (with the exception of the Dravinja River) according to the many years of monitoring. The analysis of the sample taken in the Dravinja River showed exceptional high concentrations of suspended material, since the weight of the particles exceeded 4.5 kg/m^3. Such concentrations were measured only in the Pesnica River in 1997 (in the 17 years of monitoring), in the Dravinja River in 1999 and in the Savinja River and in the Soča River in November 2000.

The transfer of suspended material. The relation between the discharge change and the concentration of suspended material in a specific time is not entirely linear. The highest concentration of sediment frequently appears just before the peak of the high-water wave. Hence, it is difficult to foresee the quantity of sediment. The part of catchmentwhere the precipitation occurs has to be taken into consideration as well as the geological structure of the area, previous ground wetness and the time passed since the last high-water wave.

The product of the concentrations of suspended material and water discharge through

Preglednica 4: Letne vrednosti prenesenega suspendiranega materiala (tisoč ton).
Table 4: Yearly values of transported suspended material (thousand tons).

Postaja Gauging station	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	vsota sum	F (km^2)	(t / km^2)
Mura	561	428	154	116	661	255	211	670	275	96	3426	10197	336,01
Savinja			525	136	283	1322	381	244	269	109	3269	1853	1764,32
Vipava	54	49	29	16	25	37	20	9	32	24	295	593	497,43

cross section equals to the transfer of suspended material S (kg/s). The data acquired is the aim of the daily sample taking, laboratory analysis and constant discharge monitoring in chosen river cross sections. Table 4 shows the differences between yearly values of transferred substances. On the basis of the catchment area knowledge, the decrease of earth surface in the hinterland of individual stations can be estimated. In this way, the following estimate is possible: in similar hydrological and erosion conditions as were registered in the 10-year period, the surface of the Mura River catchment area would erode for 12 mm, the catchment area of the Vipava River for 16 mm and the catchment area of the Savinja River for 106 mm. When interpreting these values we must not forget the geological variety of thecatchment, the selectivity of erosion, the corrosion in karstic areas, the short set of data and the long period necessary for most of the geomorphologic changes.

Odvzem vzorcev (foto: Florjana Ulaga).
Water sampling (photo: Florjana Ulaga).

NIZKE VODE IN HIDROLOŠKA SUŠA

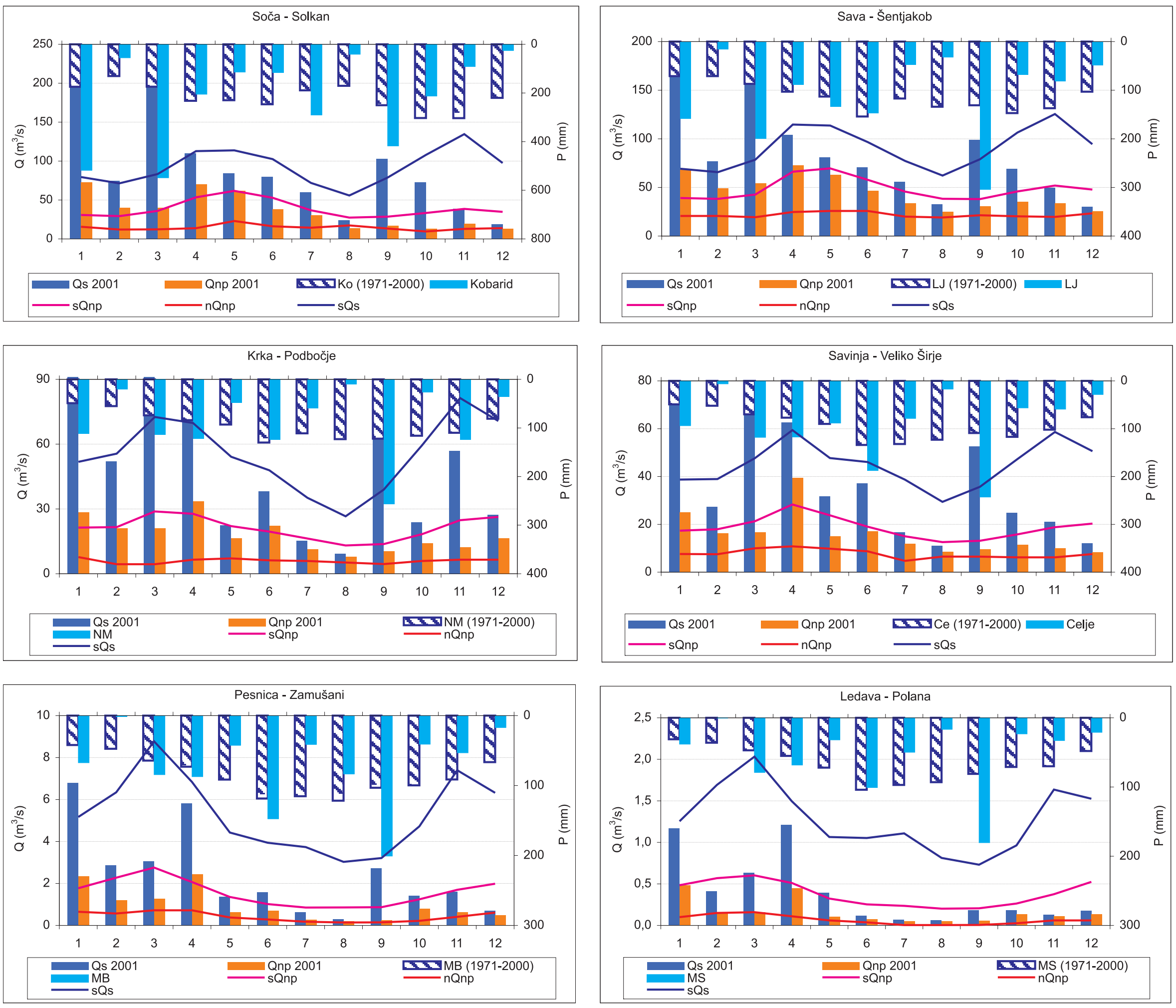
Mira Kobold

V letu 2001 so bili srednji mesečni pretoki v prvi tretjini leta povečini v mejah srednjih obdobnih mesečnih pretokov (sQs), potem pa vse do konca leta, z izjemo septembra, pod srednjimi obdobnimi mesečnimi pretoki, v mejah srednjih malih pretokov (sQnp). Najmanjši mesečni pretoki so bili v prvi polovici leta v mejah srednjih malih obdobnih pretokov, v drugi polovici leta pa pod srednjimi malimi pretoki. V poletnih mesecih so se ponekod približali najmanjšim izmerjenim obdobnim pretokom (nQnp), vendar najmanjši obdobni pretoki v letu 2001 niso bili doseženi (graf 9). Nizkovodno stanje je povzročila majhna količina padavin. V januarju, marcu in septembru je bila zlasti v zahodni in osrednji Sloveniji znatno večja od obdobnih mesečnih

LOW FLOWS AND HYDROLOGICAL DROUGHT

Mira Kobold

The mean monthly discharges in the first third of 2001 were mainly within the limits of mean monthly discharges of the period (sQs). Afterwards, until the end of the year (with the exception of September), the mean monthly discharges were below the mean monthly discharges of the period and within the limits of mean low discharges (sQnp). The lowest monthly discharges were within the limits of mean low discharges of the period in the first half of the year. In the second half of the year, they were below the mean low discharges. In some places in summer they approached the lowest measured discharges of the period (nQnp), however the lowest discharges of the period in 2001 were not reached (Graph 9). The low flows were caused by



Graf 9: Srednji in minimalni mesečni pretoki v letu 2001, mesečna količina padavin ter obdobne mesečne vrednosti.
Graph 9: Mean and minimal monthly discharges in 2001, monthly quantity of precipitation and monthly values of the period.

vrednosti, v ostalih mesecih pa je bila v mejah srednjih obdobnih mesečnih vrednosti ali manjša. Količina padavin, ki je bila najnižja v severovzhodni Sloveniji, je povzročila hidrološko sušo v tem delu države že v prvi tretjini leta.

Nizkovodno stanje smo v večjem delu države začeli beležiti v maju, ko so se pretoki rek po državi zmanjšali pod srednje pretoke in dosegli vrednosti srednjih malih pretokov. V juniju so bili prehodi vremenskih front dokaj enakomerno porazdeljeni. Zaradi tega so bili pretoki večine rek v juniju v mejah srednjih obdobnih pretokov. Šele proti koncu meseca, ko se je ustalilo lepo vreme, so se pretoki rek ponekod približali srednjim malim obdobnim junijskim pretokom.

Hidrološka suša se je pričela v juliju in se nadaljevala v avgustu, ko so bili na večini rek doseženi najnižji pretoki v letu 2001. Julij in avgust sta bila najbolj suha meseca v letu. Z izjemo Posočja je količina padavin v teh dveh mesecih dosegla le od 30% do 50% padavin povprečja 1971-2000. Padavine v juliju so bile prostorsko neenakomerno razporejene. Julijska temperatura zraka je bila nad dolgoletnim povprečjem. Povprečna dnevna temperatura zraka v Ljubljani je v juliju znašala 21,9 °C in je bila za 2 °C nad povprečjem primerjalnega obdobja. Prvi pojavi hidrološke suše segajo v drugo polovico julija, ko so bili pretoki v mejah srednjih malih obdobnih pretokov za mesec julij. Tudi na Muri, ki ima snežni režim in je običajno najbolj vodnata v poletnih mesecih, smo od junija naprej beležili male pretoke. Izjema je bila le Soča v zgornjem toku, kjer smo v juliju še beležili srednje pretoke. Vodnatost rek se je zaradi pogostih neviht v juliju prostorsko in časovno neenakomerno zmanjševala. Ob koncu julija pa so se vremenske razmere ustalile in takrat smo že beležili izrazito zmanjševanje pretokov. Relativno najmanjši pretoki so bili zabeleženi na rekah v osrednji Sloveniji (Gradaščici, Ljubljanici, Savinji v spodnjem toku), na Primorskem ter v vzhodni in severovzhodni Sloveniji. Najmanjši pretoki niso dosegli najmanjših malih julijskih obdobnih pretokov. Na večini opazovanih rek v juliju pretoki niso presegli vrednosti dveletne povratne dobe malih pretokov.

Avgustovska količina padavin je bila manjša od julijske in precej pod dolgoletnim povprečjem. Pretoki rek so se vseskozi zmanjševali in so padli pod srednje obdobne male pretoke ter

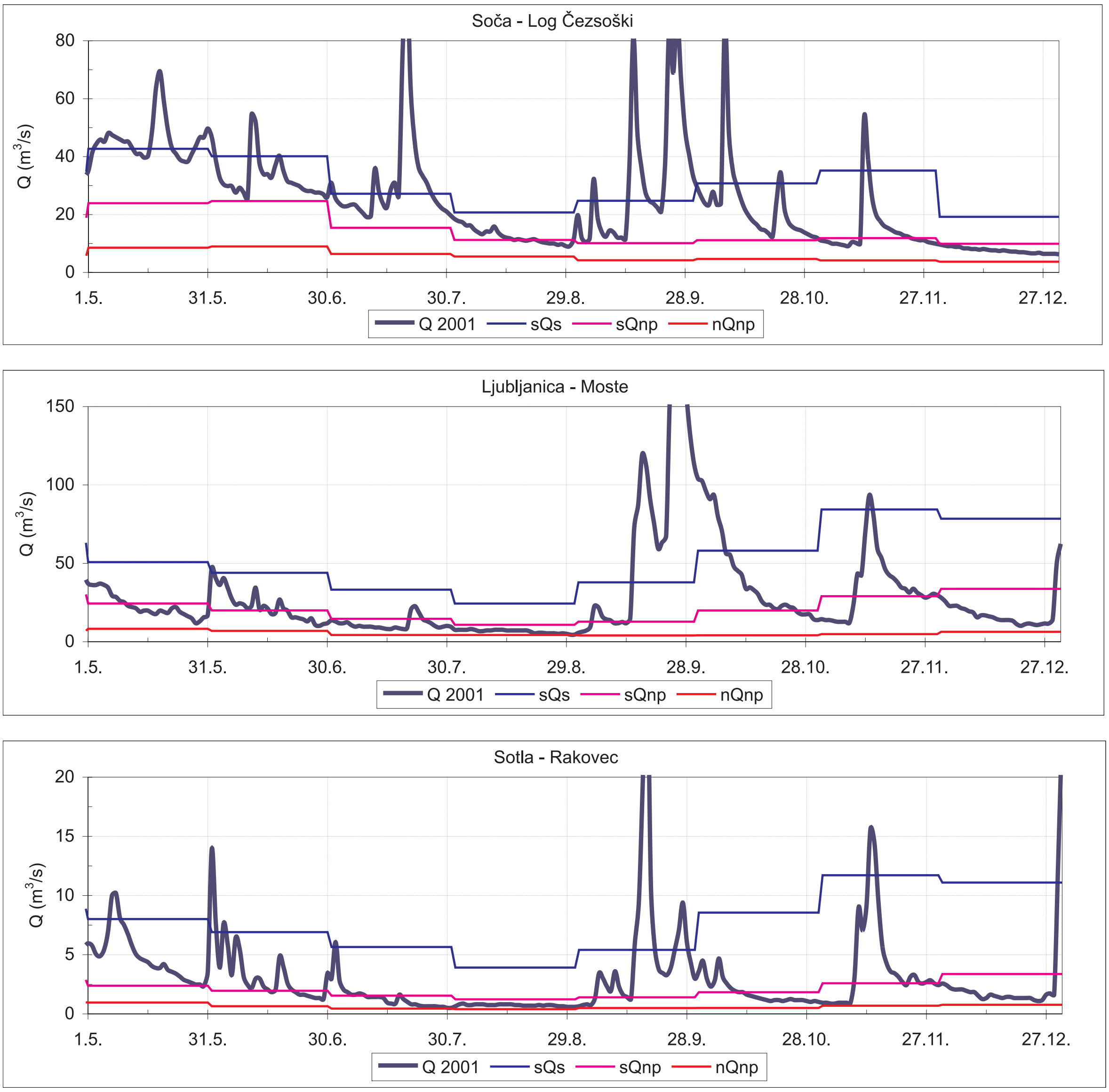
small quantity of precipitation. Especially in the western and the central part of Slovenia it was considerably higher than the monthly values of the period in January, March and September. During the rest of the months it was within the limits of mean monthly values of the period or lower. The quantity of precipitation, which was lowest in the north-east of Slovenia, caused hydrological drought in the first third of the year in this part of the country.

Low flows were recorded in most parts of the country in May, when river discharges across the country decreased below mean discharges and reached the values of mean low discharges. The cold fronts were evenly distributed in June. Thus, the discharges of most of the rivers in June were within the limits of mean discharges of the season. It was not until the end of the month when the weather stabilized that the discharges approached mean low discharges for June.

Hydrological drought occurred in July and continued in August, when most of the rivers reached the lowest discharges in 2001. July and August were the driest months of the year. With the exception of the Posočje region, the amount of precipitation in these two months reached only 30% to 50% of the yearly precipitation average in 1971-2000. The precipitation in July was spatially unequally distributed. The air temperature in July was above the multiannual mean. The mean daily air temperature in Ljubljana in July was 21.9 °C, which was 2 °C above the average of the comparative period. First occurrences of hydrological drought were recorded in the second half of July, when the discharges were within the limits of mean low discharges for July. Even on the Mura River with its nival regime and usually the greatest quantity of water in summer months, we have recorded low discharges from June onwards. The Soča River in the upper reach was the only exception, where mean discharges were still recorded in July. The quantity of water in July was spatially as well as temporally unevenly decreasing due to frequent storms. At the end of July, the weather conditions became stable again and the discharges began decreasing rapidly. Relatively low discharges were recorded on rivers in central Slovenia (in lower reaches of the Gradaščica, Ljubljanica and Savinja rivers), in Primorska region, Notranjska region, in the east and north-east of se proti koncu avgusta približali najmanjšim avgustovskim obdobnim pretokom. Relativno najmanjši pretoki so bili zabeleženi na manjših rekah v osrednji in južni Sloveniji, na notranjsko kraškem območju, na Primorskem, širšem območju Dravskega polja, v Slovenskih Goricah in Prekmurju. Največjo vodnatost rek smo beležili na povirnih delih alpskih rek (Soča). Pretoki so na večini opazovanih rek dosegli vrednosti dve- do pet-letne povratne dobe malih pretokov. Na Ljubljanici, Savinji v spodnjem toku, Rižani, Sotli in Ledavi so bili izmerjeni mali pretoki s pet- do deset-letno povratno dobo, na Pesnici in Kolpi pa mali pretoki z deset- do dvajset-letno povratno

Slovenia. The lowest discharges did not reach the lowest low discharges for July. The discharges on most of the observed rivers in July did not exceed the 2-year return period for low discharges.

The amount of precipitation in August was lower than in July and considerably below the multiannual mean. The river discharges were constantly decreasing and fell below mean low discharges of the period. Towards the end of August they approached the lowest discharges for August. Relatively lowest discharges were recorded on small rivers in central and southern Slovenia, in the areas of Notranjska and Kras,



Graf 10: Srednji dnevni pretoki (Qs) za obdobje od maja do konca decembra 2001 in obdobni mesečni pretoki (sQs, sQnp, nQnp).
Graph 10: Mean daily discharges (Qs) for the period from May to the end of December 2001 and periodical monthly discharges (sQs, sQnp and nQnp).

dobo. Najmanjši pretoki tudi v avgustu niso dosegli najmanjših obdobnih pretokov.

Padavine so v septembru, ko je skoraj po celi državi padla več kot dvakratna količina padavin primerjalnega obdobja 1971-2000, vplivale na povečanje vodnatosti rek. V zahodni, osrednji in južni Sloveniji so se pretoki rek dvignili tudi do visokih voda, vendar le za krajši čas. Že v drugi polovici oktobra so se pretoki rek zopet približali in kasneje tudi padli pod srednje male oktobrske pretoke. Na grafu 10 je za nekaj postaj iz različnih delov Slovenije prikazan potek srednjih dnevnih pretokov od maja naprej. Za primerjavo so dodani obdobni pretoki: srednji mesečni (sQs), srednji mali (sQnp) in najmanjši mesečni pretoki (nQnp).

Primanjkljaj padavin v juliju in avgustu je povzročil neprestano upadanje pretokov, ki je trajalo nepretrgoma skoraj dva meseca. Neprekinjeno obdobje z malimi pretoki je bilo v letu 2001 daljše kot v letu 2000, ko smo tudi beležili pojav hidrološke suše. Količina in razporeditev padavin v poletnih mesecih je bila manj ugodna kot v letu 2000, ko je v juliju padlo več padavin glede na julij 2001. Analiza primanjkljaja odtoka za leto 2001 je dala, z izjemo zgornjega Posočja, v splošnem višje vrednosti primanjkljajev odtoka glede na leto 2000. Tudi maksimalni primanjkljaji odtoka neprekinjenega trajanja so v glavnem presegli vrednosti iz leta 2000. Za pretok praga smo vzeli 95 odstotni pretok (Q95) iz krivulje trajanja, ki se v hidrološki praksi običajno uporablja za pretok praga. Primeri izračunanih vrednosti so prikazani na grafu 11.

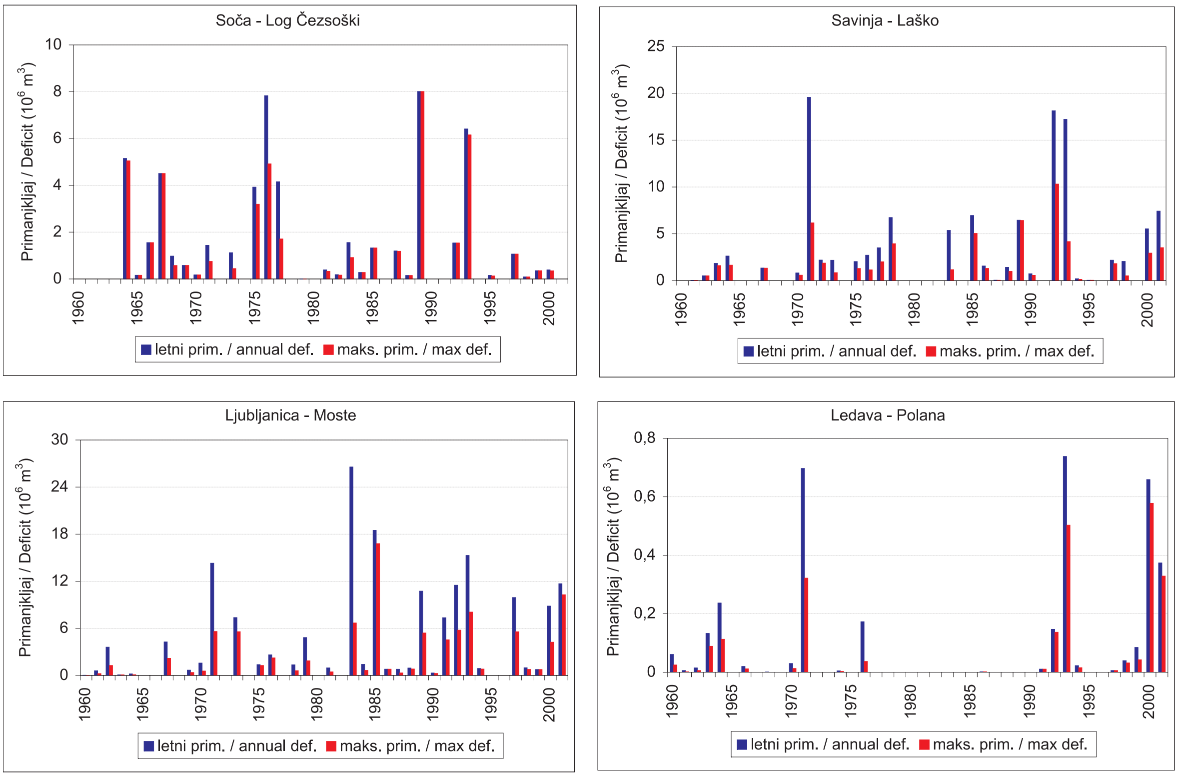
Analiza nazorno prikazuje leta z največjimi primanjkljaji, ki jih uvrščamo med hidrološko sušna leta. Primerjava zadnjih dveh let z obdobjem od leta 1960 naprej kaže, da so se na območjih, kjer je bila hidrološka suša v letih 2000 in 2001 najhujša (Prekmurje in južna Slovenija), primanjkljaji približali največjim obdobnim vrednostim. Hidrološka suša v letu 2001 torej ni bila ekstremen pojav v obdobju izvajanja meritev. Tudi najmanjši pretoki v tem obdobju niso bili zabeleženi. Je pa suša regionalen pojav in ne zajame enakomerno cele Slovenije. V letu 2001 se je suša najbolj odražala v severovzhodni Sloveniji, kjer je povprečna letna količina padavin najnižja, hkrati pa je bil primanjkljaj padavin največji.

the Primorska region, a greater area of the Drava Plain, Slovenske gorice and the Prekmurje region. The highest water levels were recorded in the headwaters of Alpine rivers (the Soča River). The discharges on most of the observed rivers reached 2- to 5-year return period values of low discharges. Low discharges with 5- to 10-year return period were measured on the Ljubljanica River, in the lower reach of the Savinja, Rižana and Ledava rivers. Low discharges with 10- to 20-year return period were measured on the Pesnica and Kolpa rivers. The lowest discharges in August did not reach the lowest discharges of the period.

Precipitation in September, when there was almost twice as much precipitation across the country as in the comparative period of 1971-2000, influenced the increase of water quantity in rivers. The discharges in the western, central and southern Slovenia rose to the level of high waters, but only temporarily. Already in the second half of October the river discharges approached and later dropped below the mean low discharges for October. Graph 10 presents the mean daily discharges from May onwards for some gauging stations from different parts of Slovenia. Period discharges were added for comparison: mean monthly discharges (sQs); mean low discharges (sQnp) and lowest monthly discharges (nQnp).

The precipitation deficit in July and August caused a constant decrease of discharges, which lasted successively for almost two months. A continuous period with low discharges lasted longer in 2001 than in 2000, when hydrological drought was also recorded. The amount and distribution of precipitation in summer months was less favourable than in 2000, because of more precipitation in July 2000. The analysis of the runoff deficit for 2001 (with the exception of the upper Posočje region) showed higher runoff deficit values in comparison with 2000. Even maximum run-off deficits of continuous duration largely exceeded the values in 2000. The discharge threshold was 95% (Q95) taken from the duration curve, in hydrology commonly used as a discharge threshold. Examples of calculated values are shown in Graph 11.

The analysis clearly shows the years with the largest deficits, which are placed in the group of hydrologically dry years. The comparison of the last two years with the period from 1960



Graf 11: Prikaz letnih primanjkljajev odtoka in maksimalnih primanjkljajev odtoka neprekinjenega trajanja za obdobje od leta 1960 naprej.
Graph 11: The presentation of the yearly run-off deficits of continuous duration for the period from 1960 onwards.

Krka je imela na vodomerni postaji Dvor najmanjši letni pretok ob koncu avgusta (foto: Jože Uhan).
The Krka river reached the lowest annual discharge at the gauging station Dvor at the end of August (photo: Jože Uhan).

onwards shows that the deficits in the area with the worst cases of hydrological drought in 2000 and 2001 (the Prekmurje region and southern Slovenia) approached the highest values of the period. The hydrological drought in 2001 was thus not extreme in the period of taking measurements. The lowest discharges in this period were not recorded as well. Drought is a regional phenomenon and does not equally affect all parts of Slovenia. The worst affected area in 2001 was the north-east of Slovenia where the average yearly amount of precipitation is lowest and at the same time the precipitation deficit is the worst.

VISOKE VODE V SLOVENIJI LETA 2001

Janez Polajnar

V letu 2001 ni bilo obsežnejših poplav, kot smo jih bili vajeni v prejšnjih letih. Nekoliko neobičajna je bila porazdelitev visokih voda preko leta, saj se v jesenskem času niso pojavile značilne visoke vode. Reke so poplavljale v manjšem obsegu, večinoma na območjih vsakoletnih poplav.

Prve visoke vode so se pojavile že januarja, predvsem v zahodni in osrednji Sloveniji. Sledile so visoke vode v marcu, ko so zaradi obilnih padavin in taljenja snega najbolj narasle reke v zahodni in južni, kasneje pa tudi v osrednji Sloveniji. V preostalem delu leta, razen v septembru, ni bilo visokih voda. Poletje je bilo suho z zelo majhno vodnatostjo rek. Predvsem v južni Sloveniji, na notranjsko kraškem območju, Primorskem in širšem območju Dravskega polja so nekatere manjše reke in potoki presahnili. V tem času je Agencija RS za okolje seznanjala in opozarjala javnost o škodljivih vplivih poseganja v vodni prostor.

Služba za spremljanje hidroloških stanj, napovedi in poročanje Agencije RS za okolje je leta 2001 zaznala 51 visokovodnih dogodkov, ko

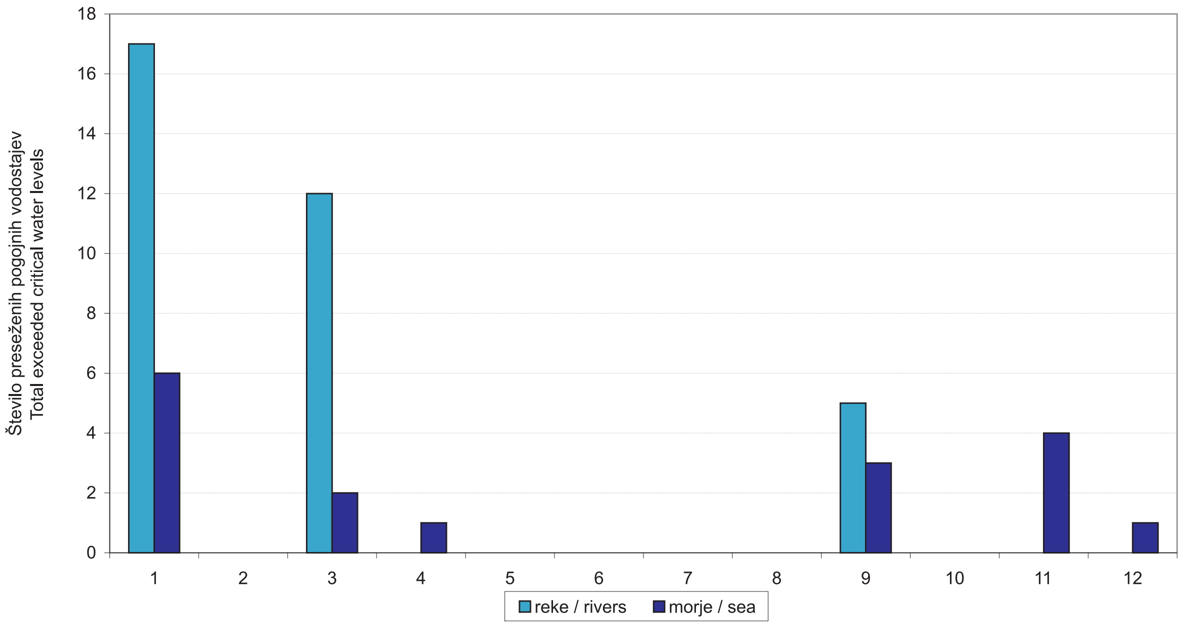
HIGH WATERS IN SLOVENIA IN 2001

Janez Polajnar

The year 2001 did not witness any major floods, as did the previous years. A slight deviation occurred in the distribution of high waters during the year, since there were no typical high waters in autumn. The rivers flooded to a smaller extent, mainly in the areas of yearly floods.

First high waters occurred already in January, mainly in the western and central Slovenia. High waters in March followed, when waters increased in the western, southern and later in the central Slovenia due to abundant precipitation and snow melting. With the exception of September, the rest of the year witnessed no high waters. Summer was dry, with low water levels. Small rivers and streams ran dry in southern Slovenia, the areas of Notranjska and Kras, the Primorska region, and a greater area of the Drava Plain. During this time, the Environmental Agency of the Republic of Slovenia pointed out and warned the public about the bad influences of intervention in water environment.

The Service for Monitoring Hydrological Conditions, Forecasts and Reports of the Environmental Agency of the Republic of Slo-



Graf 12: Število preseženih pogojnih vodostajev slovenskih rek na opazovanih vodomernih postajah in gladine morja ob slovenski obali leta 2001 (po mesecih).
Graph 12: The number of exceeded conditional water levels of the Slovene rivers at the monitored gauging stations in the year 2001 (by months).

so reke na vodomernih postajah in gladina morja ob slovenski obali presegle pogojne vodostaje. To so vodostaji, pri katerih se začneta izredno spremljanje in obveščanje. Največ visokih voda je bilo januarja (23), marca (14) in septembra (8). Preostale mesece je le gladina morja večkrat presegla vrednosti, pri katerih se začneta izredno spremljanje in obveščanje (več v prispevku o plimovanju morja). Februarja, v obdobju med majem in avgustom ter oktobra te vrednosti niso bile presežene (graf 12).

Po podatkih Službe za spremljanje hidroloških stanj, napovedi in poročanje Agencije RS za okolje in Republiškega centra za obveščanje so leta 2001 reke, potoki in morje 40-krat prestopili bregove rek ali morsko obalo ter se v manjšem obsegu razlili. Poplavna voda v tem letu ni povzročila večje gmotne škode na stanovanjskih in gospodarskih objektih, prometnicah in kmetijskih površinah, kot jo je v prejšnjih letih. Voda se je v večini primerov razlivala na območjih vsakoletnih poplav (preglednica 5).

Visoke vode januarja in marca 2001. Visoke vode v januarju niso pogoste, tokrat pa so zajele večji del države, kar je prav tako dokaj redek pojav. Prve visoke vode in visoko plimovanje morja so bili med 6. in 10. januarjem, drugič ob koncu meseca med 25. in 26. januarjem. Takrat so največji pretoki nekaterih rek dosegli 5-letno povratno dobo in reke so ponekod poplavljale. Zaradi obilnih padavin 7. in 8. januarja so reke zelo narasle sprva na zahodu države, kasneje tudi v osrednji Sloveniji. Najbolj so se povečali pretoki rek v Posočju, zgornjem toku Save in na

venia recorded 51 high-water occurrences in 2001, when rivers at the gauging stations and the sea level on Slovene coast exceeded the critical water levels. This is when emergency monitoring and notification begin. High waters were most frequent in January (23), March (14) and September (8). During the rest of the months, only the sea level exceeded the values at which the emergency monitoring and notification begin (more in the sea levels section). These values were not exceeded in February, the period between May and August and in October (Graph 12).

In the year 2001, there were 40 overflows and floods registered (rivers, streams and the sea) according to the Service for Monitoring Hydrological Conditions, Forecasts and Reports of the Environment Agency of Republic of Slovenia and the National Information Centre. The floods did not cause extensive material damage on housing and economic facilities, traffic routes and agricultural areas as they did in the previous years. In most cases, the floods occurred in the usual flood prone areas (Table 5).

High waters in January and March 2001. High waters are not very common in January; however, they have affected most of the country in January and March, which is a rather rare event. First high waters and high tide occurred between January 6 and 10, the second time at the end of the month between January 25 and 26. At that time, the highest discharges of some rivers reached a 5-year return period and the rivers flooded in some places. The increase in water levels was substantial due to abundant precipita-

Preglednica 5: Visoke vode in njihovo razlitje leta 2001 (po mesecih) (ARSO, CORS, razlitja manjših hudournikov niso upoštevana).
Table 5: High waters and overflowing in 2001 (by months) (ARSO, CORS, overflows of smaller torrents have not been included).

	J	F	M	A	M	J	J	A	S	O	N	D
Sava	1		1									
Vipava	1		1									
Reka	1		1									
Ljubljanica	1		1						1			
Unica	1											
Mali Obrh			1									
Idrijca	1		1									
Krka									1			
Kolpa	1		1									
Gradaščica	1											
Dravinja	1											
Ložnica	1											
Rogoznica	1											
kraška polja Notranjske	1		1									
morje ob slovenski obali	6		2	1					3		4	1

Notranjskem, kjer je reka Reka pri Trpčanah v manjšem obsegu poplavljala. Na Ljubljanskem barju se je na območju vsakoletnih poplav začela razlivati Ljubljanica.

Veliki pretoki rek so bili v zahodnih predelih države vse do 24. januarja, ko so se padavine ponovno okrepile in zajele večji del Slovenije. 25. in 26. januarja so bile visoke vode v vsej državi. Reke so sprva najbolj narasle na zahodu. Taljenje snega je dodatno povečalo vodnatost rek na teh območjih. Najbolj so narasle reke s povirji ob gorskih pregradah zahodne Slovenije, predvsem tiste s povirji v kraškem Trnovskem gozdu. Idrijca in Vipava sta dosegli največje pretoke z 2- do 5-letno povratno dobo in na izpostavljenih mestih poplavljali. Največji pretok kraškega izvira Hubelj nad Ajdovščino je s 40 m^3/s dosegel 5-letno povratno dobo. Ponoči 26. januarja so bile visoke vode tudi na rekah osrednje in vzhodne Slovenije. Med njimi sta najbolj narasli Gradaščica in Poljanska Sora, ki je v Žireh s pretokom 72 m^3/s dosegla 2- do 5-letno povratno dobo. Obe reki sta na izpostavljenih mestih tudi poplavljali. Poplavljeno območje ob Ljubljanici na zahodnem delu Ljubljanskega barja se je ponovno povečalo. V tem času je naraščala Savinja. Ponoči je v zgornjem toku dosegla pretok z 2- do 5-letno povratno dobo. Velik pretok Savinje je dodatno povečal vodnatost narasle Save, ki je že poplavljala v Zasavju. To noč je poplavljala tudi Dravinja. V zgornjem toku v Ločah je dosegla največji pretok z 2- do 5-letno povratno dobo, proti jutru pa je že poplavljala v srednjem toku, v okolici Poljčan in Majšperka. Tudi Rogoznica pri Ptuju in Ložnica pri Polzeli sta poplavljali v manjšem obsegu. V tem času je poplavljala tudi Kolpa. Največji pretok v Radencih je znašal 686 m^3/s, in ni presegel 2-letne povratne dobe.

Med 3. in 5. marcem so bile v večjem delu države ponovno visoke vode. Najdlje, vse do konca meseca, so bile na kraških poljih Notranjske, kar za ta letni čas ni običajno. Največji pretoki nekaterih rek so dosegli 5-letno povratno dobo. Reke so ponekod poplavljale.

V tem času je bil večji del države prekrit s snežno odejo. Odjuga in obilne padavine so med 2. in 5. marcem povzročile naglo taljenje snega od nižin do visokogorja. Te dni je bilo največ padavin v zahodni, osrednji in južni Sloveniji. Ob toplem dežju se je sneg naglo talil, na Notranjskem in Kočevskem tudi do 10 cm na dan.

tion on January 7 and 8, at first in the western part of the state and later in the central part of Slovenia. The discharges of rivers in the Posočje region, upper reach of the Sava River and in the Notranjska region have increased the most due to the flooding of the Reka River near Tripče. The Ljubljanica River overflowed in the area where the floods occur every year.

River discharges have stayed high until January 24, when the precipitation increased again and spread across the greater part of Slovenia. High waters could be found across the country on January 25 and 26. At first, rivers increased in the west. Snow melting additionally increased the water quantity in these areas. Rivers with headwaters in mountain chains of the western Slovenia increased the most, mostly those with headwaters in the karstic Trnovski gozd. The Idrijca in Vipava rivers reached their highest discharges with 2- to 5-year return period and flooded in exposed areas. The highest discharge of the karstic spring Hubelj has reached 5-year return period with 40 m^3/s. On the night of January 26, high waters occurred in central and western Slovenia. The Gradaščica and Poljanska Sora rivers (the Poljanska Sora River reached 2- to 5- year return period in Žiri with 72 m^3/s) increased the most. Both rivers flooded in exposed areas as well. The flooded area by the Ljubljanica River in the western part of the Ljubljansko barje (Marshland) has increase again. At this time, the Savinja River increased as well. It reached the discharge of 2- to 5-year return period in the upper reach. The high discharge of the Savinja River additionally increased the water quantity in the Sava River, which flooded in Zasavje as well. The Dravinja River flooded in the same night. In the upper reach of Loče, it reached the highest discharge with 2- to 5-year return period and in the morning it flooded in its central reach in the vicinity of Poljčane and Majšperk. The Rogoznica River near Ptuj and the Ložnica River near Polzela flooded to a lesser extent. The Kolpa River flooded at the same time. Its highest discharge in Radenci was 686 m^3/s and did not exceed the 2-year return period.

Between March 3 and 5, high waters again occurred in most parts of Slovenia. They stayed the longest (until the end of the month) in the karstic fields of the Notranjska region, which is not usual for this time of the year. The highest river discharges reached a 5-year return period. Rivers flooded in some areas.

Predvsem na porečjih kraških rek na Notranjskem, porečju Kolpe in na porečjih rek v alpskem in predalpskem hribovju je delež snežnice izdatno povečal vodnatost rek in obseg poplavljenih površin na kraških poljih.

Že ponoči 3. marca so se začeli povečevati pretoki rek na zahodu in jugu države. Največji pretoki rek ta dan niso presegli 2-letne povratne dobe, le Reka je v okolici Ilirske Bistrice poplavljala v manjšem obsegu. Ponoči 4. marca je ob ponovnih padavinah silovito narasla Kolpa in v zgodnjih jutranjih urah dosegla v Radencih največji pretok 758 m^3/s z 2- do 5-letno povratno dobo. Na izpostavljenih mestih je poplavljala. Ta dan se je poplavno območje ob Ljubljanici na Ljubljanskem barju še povečalo, prav tako so se povečevale poplavljene površine na kraških poljih Notranjske. V drugem delu dneva in ponoči 5. marca so reke v zahodnem, južnem in osrednjem delu države po nekajurni prekinitvi začele ponovno močneje naraščati. Najbolj so narasle Idrijca, Vipava, Soča, Sava v zgornjem in srednjem toku, Savinja v zgornjem toku, Ljubljanica in Krka. V jutranjih urah 5. marca je poplavljala Idrijca v spodnjem toku. Preplavila je cesto med Slapom ob Idrijci in Dolenjo Trebušo. V zgornjem toku, na vodomerni postaji v Podroteji, je dosegla največji pretok 204 m^3/s z 2- do 5-letno povratno dobo. V tem času je poplavljala tudi reka Vipava v srednjem toku pri Velikih Žabljah. Na vodomerni postaji Dolenje je bil zabeležen največji pretok 143 m^3/s. Narasla Idrijca in izdaten dotok vode kraških izvirov na zahodnem delu Trnovsko-Banjške planote, so to jutro povečali pretok Soče, predvsem v srednjem in spodnjem toku. Na vodomerni postaji Solkan je bil zabeležen največji pretok 1280 m^3/s z 2- do 5-letno povratno dobo. Čez dan so se povečali tudi pretoki rek v osrednji Sloveniji, vendar niso presegli 2-letne povratne dobe. Le Sava je v popoldanskih urah ob pretoku 1000 m^3/s poplavljala na izpostavljenih mestih v Zasavju. Na meji s Hrvaško je največji pretok, okoli 1450 m^3/s, dosegla v poznih večernih urah.

V prihodnjih dneh so se poplavljene površine na kraških poljih Notranjske še povečevale. Med drugimi je Mali Obrh v Loški dolini 7. marca poplavil ceste na območju Šmarate in Kozarišča. Visoke gladine vode na kraških poljih so se zadržale do konca meseca. V zahodni in osrednji Sloveniji so se 13. marca pretoki rek ponovno povečali. Najbolj v spodnjem toku Soče,

Most of the country was covered in snow at that time. Thaw and abundant precipitation have caused a rapid snow melting from lowlands to mountains. Most of the precipitation occurred in the western, central and southern part of Slovenia. Warm precipitation caused the snow to melt rapidly, in the Notranjska region and in Kočevje even 10 cm a day. The snow water substantially increased water quantity in rivers. It also increased the extent of flooded areas on karstic fields in the catchment areas of karstic rivers in the Notranjska region, the catchment area of the Kolpa River and catchment areas of rivers in the Alpine and pre-Alpine highlands.

In the night of March 3, the discharges of rivers in the east and south of the country started increasing. The highest discharges did not exceed a 2-year return period; the Reka River was the only one to flood in the vicinity of Ilirska Bistrica. In the night of March 4, the Kolpa River increased substantially and in the early morning reached its highest discharge in Radenci with 758 m^3/s and a 2- to 5-year return period. It flooded in exposed areas. The flooded area by the Ljubljanica River in the Ljubljana barje (Marshland) increased. At the same time, the flooded areas on karstic fields of the Notranjska region increased as well. The rivers started increasing heavily in the western, southern and central part of the country in the afternoon and in the night of March 5. The Idrijca, Vipava, Soča and Sava rivers increased the most in their upper and central reach, the Savinja, Ljubljanica and Krka rivers in its upper reach. The Idrijca River flooded in the lower reach in the early hours of March 5. It flooded the road connecting Slap ob Idrijci and Dolenja Trebuša. It reached its highest discharge, 204 m^3/s with a 2- to 5-year return period in its upper reach, at the gauging station Podroteja. The Vipava River flooded as well in its central reach near Velike Žablje. The highest discharge, 143 m^3/s, was recorded at the gauging station Dolenje. The high waters of Idrijca and the inflow of karstic springs in the western part of Trnovsko-Banjška plateau increased the discharge of the Soča in its central and lower reach. The highest discharge, the value of which was 1280 m^3/s and a 2- to 5-year return period, was recorded at the gauging station in Solkan. The Sava was the only river in the Zasavje region, which flooded in the afternoon in exposed areas with the discharge of 1000 m^3/s. It reached its highest kjer je največji pretok znašal 1178 m^3/s. Pretoki ostalih naraslih rek v osrednji Sloveniji ta dan niso dosegli 2-letne povratne dobe.

discharge late in the afternoon at the Croatian border, the value of which was 1450 m^3/s.

The flooded areas in the karstic fields of the Notranjska region have increased in the following days. The Mali Obrh spring flooded the roads in the Šmarata and Kozarišče area on March 7. High water levels in karstic fields stayed there till the end of the month. River discharges have increased on March 13 in the western and central part of Slovenia. The greatest increase occurred in the lower reach of the Soča, the value of which was 1178 m^3/s. The discharges of other flooding rivers did not reach a 2-year return period.

Poplava na Ljubljanskem barju (foto: Janez Polajnar).
Flood on the Ljubljansko barje (photo: Janez Polajnar).

B. PODZEMNE VODE

PODZEMNA VODA V ALUVIALNIH VODONOSNIKIH

Zlatko Mikulič

Trend zniževanja gladin je bila prevladujoča značilnost režima podzemnih voda v aluvialnih vodonosnikih Slovenije v letu 2001. Praviloma so bile zaloge podzemnih voda povsod manjše na koncu leta kot v prvih mesecih. Poletje je zaznamovala huda hidrološka suša, ki je zajela vse opazovane vodonosnike, razen tistih v Ljubljanski in Celjski kotlini. V vodonosnikih severovzhodne Slovenije je suša trajala celo leto. Zaradi neugodnega vodnega režima so bile v letu 2001 povprečne gladine podzemnih voda povečini pod letnim povprečjem (Hs) dolgoletnega primerjalnega obdobja (graf 13, preglednica 6 in karta 3). V Ljubljanski in Celjski kotlini so bile zaradi večje vodnatosti srednje gladine nad dolgoletnim povprečjem, v vodonosnikih severovzhodne Slovenije pa zaradi hude suše celo pod nizkim dolgoletnim povprečjem (Hnp).

Višine gladin podzemnih voda v aluvialnih vodonosnikih na Slovenskem so v splošnem odvisne od ravnovesja med dotoki vode na eni strani, ter odtoki, izgubami in odvzemi na drugi strani. Viri napajanja vodonosnikov so padavine na samih poljih in v neposrednem padavinskem zaledju na obrobju ravnin, kakor tudi pronicanje iz rek: Ledave, Mure, Drave, Savinje, Kamniške Bistrice, Kokre, Save, Vipave in Soče ter ostalih manjših vodotokov na območju vodonosnikov. Odtoki podzemnih voda so posledica dreniranja v vodotoke, izgube pa so posledica evapotranspiracije, ki je posebej pomemben dejavnik v plitvih vodonosnikih severovzhodne Slovenije. Odvzemi so predvsem s črpanjem za oskrbo z vodo, v širšem pomenu pa tudi odvajanje podzemnih voda z melioracijskimi posegi. Za ocenjevanje vodnih razmer podzemnih voda je potrebno upoštevati prostorsko in časovno spremenljivost količine padavin, evapotranspiracije in višino vode v rekah, ki mejijo na vodonosnike.

Klimatski dejavniki, ki so najbolj vplivali na režim podzemnih voda, so bili v splošnem primanjkljaj padavin in nadpovprečno visoke temperature, od posameznih dogodkov pa obilne

B. GROUNDWATERS

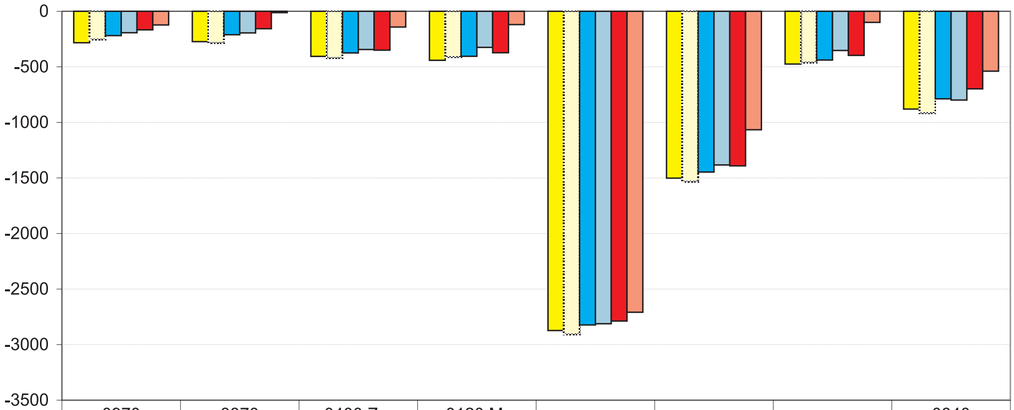
GROUNDWATER IN ALLUVIAL AQUIFERS

Zlatko Mikulič

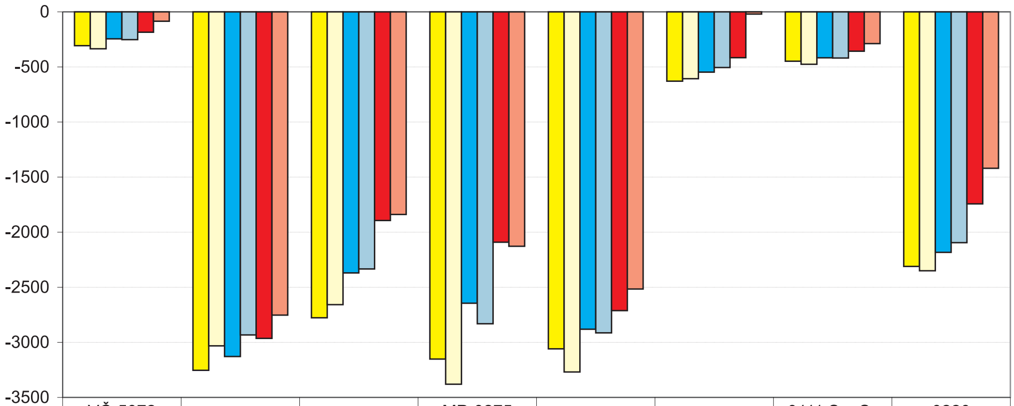
The decrease of water levels was a prevailing characteristic of the groundwater regime in Slovene alluvial aquifers in 2001. The groundwater reserves were low everywhere at the end of the year rather than at the beginning. A severe hydrological drought occurred in summer. It affected all the observed aquifers, except for those in the Ljubljana and Celje Basin. The aquifers in the north-east of Slovenia suffered drought throughout the year. The mean levels of groundwater in 2001 were largely below the annual mean (Hs) of a multiannual comparative period (Graph 13, Table 6, Map 3) due to the unfavourable water regime. The mean water levels in the Ljubljana and Celje Basin were above the multiannual mean. Nonetheless, the aquifers in the north-east of Slovenia were below the multiannual mean (Hnp) due to severe drought.

The groundwater levels in alluvial aquifers in Slovenia generally depend on the balance between the inflows on the one hand and outflows, losses and withdrawals on the other hand. The sources of aquifer recharge are precipitations on the fields themselves and in the catchment areas bordering on plains, as well as the infiltration from the following rivers: the Ledava, Mura, Drava, Savinja, Kamniška Bistrica, Kokra, Sava, Vipava, Soča and other smaller watercourses in the area of aquifers. Groundwater outflows are a consequence of drainage into watercourses; the losses are a consequence of evapotranspiration, which is a particularly important factor in the shallow aquifers of the northeastern part of Slovenia. The water is mainly withdrawn for water supply or some cases, for the reclamation of land by drainage. When estimating the condition of groundwaters the following has to be taken into consideration: spatial as well as temporal variability of the amount of precipitation, evapotranspiration and water levels in rivers bordering on aquifers.

Climatic factors influencing the groundwater regime the most were generally: precipitation deficit and temperatures above average. More



	0970 Brezovica	3370 Rankovci	0400 Zg. Krapje	0120 M. Segovci	0080 Kamnica	0721 Tezno	0370 Dornava	0840 Šempeter
Hnk-2001	-283	-273	-406	-441	-2873	-1502	-475	-880
Hnk-obdobje / Hnk-period	-254	-285	-420	-413	-2907	-1534	-461	-918
Hs-2001	-219	-211	-375	-405	-2823	-1447	-439	-788
Hs-obdobje / Hs-period	-193	-195	-344	-325	-2812	-1383	-353	-799
Hvk-2001	-167	-157	-350	-373	-2788	-1391	-397	-698
Hvk-obdobje / Hvk-period	-123	-12	-142	-120	-2709	-1066	-100	-539



	VČ-5072 Latkova vas	0320 Meja	0360 Brnik	MP-0275 Mengeš	0541 Kleče	0152 Skopice	0111 Sp. S. Grad	0220 Šempeter
Hnk-2001	-307	-3254	-2777	-3152	-3059	-629	-448	-2311
Hnk-obdobje / Hnk-period	-335	-3032	-2658	-3380	-3269	-607	-476	-2350
Hs-2001	-245	-3129	-2370	-2645	-2881	-547	-417	-2183
Hs-obdobje / Hs-period	-252	-2933	-2334	-2831	-2914	-505	-419	-2095
Hvk-2001	-185	-2964	-1894	-2091	-2712	-416	-357	-1743
Hvk-obdobje / Hvk-period	-85	-2753	-1839	-2128	-2516	-20	-288	-1420

Graf 13: Primerjava značilnih gladin podzemnih voda v letu 2001 z značilnimi gladinami za primerjalno obdobje 1961–1990 (Hs = srednja letna/obdobna gladina, Hnk = najnižja letna/obdobna gladina, Hvk= najvišja letna/obdobna gladina).
Graph 13: Characteristic groundwater levels in the year 2001 compared to multiannual characteristic levels of 1961–1990 (Hs = mean yearly/periodic level, Hnk = the lowest yearly/periodic level, Hvk = the highest yearly/periodic level).

snežne padavine pozimi in spomladi v visokogorju ter huda poletna meteorološka suša.

Celoletna količina padavin je bila manjša od dolgoletnega povprečja na območju vseh aluvialnih vodonosnikov. Primanjkovalo je od ene desetine do skoraj četrtine padavin. Za hidrološki režim podzemnih voda je bila pomembna prostorska in časovna razporeditev primanjkljajev. Izpad padavin na celoletni ravni je bil največji na območju vodonosnikov severovzhodne Slovenije, kjer je znašal okoli ene petine na območju

specifically: snow precipitation in winter and spring in the mountains and a severe meteorological drought in summer.

The yearly quantity of precipitation was below the multiannual mean on the whole area of alluvial aquifers. A deficit from one tenth to almost a quarter of precipitation could be witnessed. The spatial and temporal distribution of deficits was important for the hydrological groundwater regime. The yearly precipitation deficit was most severe in the north-east of Slo-

Maribora, do skoraj ene četrtine na območju Prekmurja. Drugod je primanjkovalo okoli ene desetine padavin. Časovno so bili primanjkljaji sklenjeno razporejeni v neugodnem letnem času od aprila do avgusta, pomemben klimatski odklon pa je bil tudi približno polovični izpad padavin v zadnjih treh mesecih leta. V poznih jesenskih mesecih je obnavljanje zalog podzemnih voda običajno največje. Več kot v obravnavanem letu utegne ta jesenska klimatska motnja vplivati na režim podzemnih voda v naslednjem letu. Izrazita meteorološka suša v poletnih mesecih je povzročila primanjkljaj podzemnih voda v tem obdobju. Izjemno obilno deževje v septembru, z več kot dvakratno običajno količino, je končalo poletno sušo v vseh opazovanih aluvijalnih vodonosnikih razen na območju severovzhodne Slovenije. Ugoden vpliv na režim podzemnih voda je imelo poleg tega deževja še obilno sneženje v visokogorju. Spomladi je snežna odeja na Kredarici dosegla debelino rekordnih sedem metrov. Taljenje snega v gorah v pomladansko poletnem obdobju je pomembno prispevalo k bogatitvi zalog podzemnih voda na območjih, kjer se vodonosniki napajajo iz rek Save, Kamniške Bistrice, Savinje in Soče.

Na območju vseh opazovanih aluvialnih vodonosnikov so bile v letu 2001 izgube vode z evapotranspiracijo nadpovprečno velike, predvsem zaradi višje temperature zraka in nadpovprečnega sončnega obsevanja. Pri večini vodonosnikov je bil odklon temperature za okoli poldrugo stopinjo Celzija, na območju Prekmurja celo nekaj več. Temu so največ prispevali nadpovprečno topli popoldnevi, kar je imelo v vegetacijskem obdobju, od pomladi naprej, za posledico nadpovprečno veliko izgubo vode. Posebej velike izgube vode so se vrstile iz meseca v mesec v vročem poletju, ko je bilo zabeleženih nadpovprečno veliko vročih dni z najvišjo dnevno temperaturo nad 30 stopinj Celzija. Vsega skupaj je bilo takih dni za en mesec, na območju aluvialnih vodonosnikov zahodne Slovenije pa celo 39. Na območju večine opazovanih vodonosnikov je bilo dni z najvišjo temperaturo zraka nad 25 stopinj Celzija vsega skupaj za dobra dva meseca, v zahodni Sloveniji celo za več kot tri mesece. V takih razmerah je povečana evapotranspiracija v poletju močno načenjala, zaradi pomanjkanja padavinske vode, že tako pičle vodne zaloge.

Opisana razporeditev padavin se je odražala tudi v prostorski in časovni porazdelitvi

venia, amounting from one fifth in the Maribor area to almost one fourth in the Prekmurje area. In other areas the deficit amounted to one tenth of precipitation. The deficits were temporally distributed in an unfavourable time of the year, from April to August. An important climatic deviation was a 50% precipitation deficit in the last three months of the year. The restoration of groundwater supplies is usually greatest in late autumn. This autumn climatic disruption is likely to have great influence on the groundwater regime in the following year. A severe hydrological drought in summer months caused groundwater deficit in this period. Abundant precipitation in September with twice as much precipitation than usual ended summer drought in all the observed alluvial aquifers except in the north-east of Slovenia. Besides the precipitation, heavy snow in the mountains was also a favourable influence for the groundwater regime. Snow cover in spring in Kredarica was seven meters thick. Snow melting in mountains in the spring-summer period contributed considerably to the increase of the groundwater supplies in areas where aquifers recharge from the Sava, Kamniška Bistrica, Savinja and Soča rivers.

Water losses in 2001 were because of evapotranspiration above average in all observed areas of alluvial aquifers, mainly due to high air temperature and the insolation, which was above average. The temperature deviation in most aquifers was about 1.5 °C, a bit larger in the Prekmurje area. The reason lies in the very warm afternoons, the consequence being the loss of water in the vegetation period from spring onwards that is above average. Water losses were especially severe in summer months, when the number of hot days was above average, with the mean daily temperature above 30 °C. There were about 30 such days altogether, and 39 in the area of alluvial aquifers in western Slovenia. There were more than 60 days with the daily temperature above 25 °C in the area of most observed alluvial aquifers. In western Slovenia, there were even more then 90 days with such temperature. Increased evapotranspiration caused even further decrease of scarce supplies of rainwater.

The described precipitation distribution was reflected in spatial and temporal distribution of discharges or water level in rivers bordering on aquifers. Long-lasting dry periods were common and this was the reason for the dischargpretokov oziroma višine vode rek, ki mejijo na vodonosnike. Značilne so bile dalj časa trajajoče sušne razmere v vodotokih, zaradi česar je bila celoletna količina pretokov okoli ene desetine manjša od dolgoletnega povprečja. Vodnatost rek je bila pod povprečjem skupno devet mesecev v letu. Najmanjša je bila v avgustu in decembru, zaradi česar je bilo tedaj najmanjše bogatenje podzemnih voda s pronicanjem iz rek. Ugoden vpliv površinskih voda na večanje zalog podzemnih voda je bil pomemben le v mesecih januarju, marcu in septembru, ko so višine vode v rekah bile nadpovprečno visoke. Opisani nenavadni režim površinskih voda je v celoti slabo vplival na stanje zalog podzemnih voda.

Nizkega vodnega stanja na Sorškem polju in na delu Kranjskega polja ne označujemo za hidrološko sušo, saj se primerjava nanaša na obdobje zvišanih gladin podzemnih voda po izgradnji HE Mavčiče leta 1986. Na tem območju se gladine zadnjih nekaj let znižujejo zaradi zamuljevanja dna zajezitvenega jezera hidroelektrarne in s tem povezanega zmanjšanja pronicanja vode iz Save v podzemlje.

Značilne letne gladine Hnk, Hs in Hvk (graf 13) so grobi pokazatelji vodnih zalog, oziroma hidrološkega režima na celoletni ravni. Ti statistični parametri omogočajo grobo oceno spremenljivosti v prostoru, ne morejo pa zajeti časovne spremenljivosti med letom. Primerjava srednjih letnih gladin Hs odraža dve pomembni

es being one tenth lower than the multiannual mean. Water quantity in rivers stayed below average for nine months. It was lowest in August and December and consequently the groundwater recharge was then lowest as well. A favourable influence of surface waters on the increase of groundwater reserves was noteworthy only in January, March and September, when the water levels were exceptionally high in the rivers. The unusual surface water regime had a bad influence on groundwater supplies.

A low water level in the Sora Plain and in a part of the Kranj Plain is not defined as hydrological drought, because the comparison refers to the period of raised groundwater levels after the construction of the hydroelectric power station Mavčice in 1986. Water levels in this area have been decreasing due to the silting-up of the bottom of the dam reservoir of the hydroelectric power station, which result in decreased infiltration from the Sava River.

Characteristic yearly groundwater levels Hnk, Hs and Hvk (Graph 13) roughly show water supplies or hydrological regime on a yearly level. Those statistical parameters allow a rough estimation of variability in space, but they cannot capture temporal variability during the year. The comparison of mean yearly groundwater levels (Hs) indicates two important characteristics of the groundwater regime in 2001. The yearly groundwater levels in the north-east of Slovenia,

Preglednica 6: Primerjava značilnih gladin podzemnih voda v letu 2001 z značilnimi gladinami primerjalnega obdobja 1961–1990.
Table 6: Characteristic groundwater levels in the year 2001 and the characteristic levels of the comparative period 1961–1990.

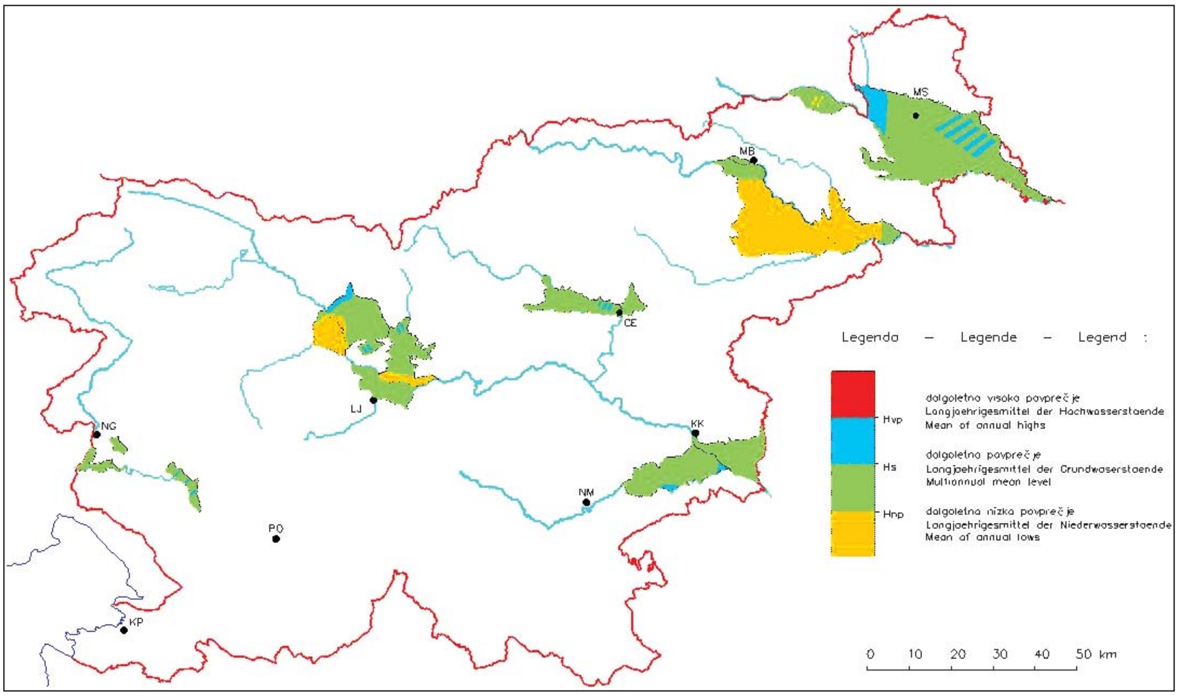
POSTAJA / LOCATION	VODONOSNIK / AQUIFER	2001 Hnk (cm)	2001 Hs (cm)	2001 Hvk (cm)	OBDOBJE / PERIOD časovni niz (leta) time series (years)	Hnk (cm)	Hnp (cm)	Hs (cm)	Hvp (cm)	Hvk (cm)
0970 Brezovica	PREKMURSKO POLJE	283	219	167	1980-1990	254	242	193	138	123
3370 Rankovci	PREKMURSKO POLJE	273	211	157	1961-1990	285	248	195	113	12
0400 Zgornje Krapje	MURSKO POLJE	406	375	350	1964-1990	420	385	344	285	142
0120 Mali Segovci	APAŠKO POLJE	441	405	373	1961-1967	413	391	325	239	166
0080 Kamnica	VRBANSKI PLATO	2873	2823	2788	1981-1990	2907	2870	2812	2747	2709
0721 Tezno	DRAVSKO POLJE	1502	1447	1391	1961-1990	1534	1476	1383	1246	1066
0370 Dornava	PTUJSKO POLJE	475	439	397	1961-1990	461	410	353	276	100
0840 Šempeter	SP. SAVINJSKA DOL.	880	788	698	1966-1990*	918	879	799	668	539
VČ-5072 Latkova vas	DOLINA BOLSKE	307	245	185	1975-1990	335	307	252	163	85
0320 Meja	SORŠKO POLJE	3254	3129	2964	1987-1990	3032	3009	2933	2827	2753
0360 Brnik	KRANJSKO POLJE	2777	2370	1894	1987-1990	2658	2559	2334	1980	1839
MP-0275 Mengeš	D. KAMNIŠKE BISTRICE	3152	2645	2091	1976-1990	3380	3168	2831	2389	2128
0541 Kleče	LJUBLJANSKO POLJE	3059	2881	2712	1974-1990	3269	3066	2914	2726	2516
0152 Skopice	KRŠKO POLJE	629	547	416	1980-1990	607	579	505	305	20
0111 Spodnji Stari grad	BREŽIŠKO POLJE	448	417	357	1971-1990	476	453	419	344	288
0220 Šempeter	VIPAVSKO-SOŠKA D.	2311	2183	1743	1961-1990	2350	2259	2095	1775	1420

* prekinjen časovni niz / interrupted time series

značilnosti režima podzemnih voda v letu 2001. V vodonosnikih severovzhodne Slovenije, Vipavsko-Soške doline in Krške kotline so bile srednje letne gladine podzemnih voda nižje od primerjalnega obdobja, kar je posledica izrazite poletne meteorološke suše in s tem povezanih večmesečnih nizkih vodnih stanj. Srednje letne gladine v vodonosnikih Ljubljanske kotline in Celjske kotline so bile višje od obdobnih, kot posledica večmesečnega obilnega napajanja vodonosnika iz rek s povirji v visokogorju. V tem primeru je snežnica iz debele snežne odeje nadomeščala primanjkljaje padavin. Na hudo sušo v severovzhodni Sloveniji kaže tudi primerjava nizkih letnih konic Hnk, saj so se tam gladine podzemnih voda v letu 2001 znižale celo pod raven najnižjih gladin primerjalnega obdobja. Kot posledica hidrološke suše na tem območju so bile najvišje letne konice Hvk daleč pod obdobnimi, v nekaj primerih so se celo približale ravni srednjih obdobnih gladin. V severovzhodni Sloveniji je bil celotni razpon nihanja gladin v letu 2001 premaknjen navzdol. Analiza visoko vodnih konic kaže še eno posebnost. V dolini Kamniške Bistrice je bil leta 2001 presežen obdobni maksimum, kar priča, kako ekstremno velika je bila zaloga vode v snežni odeji visokogorja v zaledju vodonosnika. Značilne letne gladine so podrobno prikazane v preglednici 6.

the Vipava-Soča Valley and the Krško Basin were lower than those in the comparative period, a consequence of severe meteorological drought in summer and several months of low water levels. Mean yearly water levels in the Ljubljana and Celje Basin aquifers were higher than those of the period, a consequence of several months of abundant water reserve from rivers with headwaters in the mountains. Snow water from a thick snow cover was a substitute for the precipitation deficit. The comparison of low yearly peaks (Hnk) also shows a severe drought in the northeast of Slovenia, since the groundwater levels in 2001 fell below the lowest levels of the comparative period. The consequences of hydrological drought in this area were low values of the highest yearly peaks (Hvk). In some cases they approached the mean levels of the period. The whole span of level fluctuation in 2001 in the northeast of Slovenia moved downwards. The analysis of high water peaks reveals another peculiarity. The maximum of the period was exceeded in the Kamniška Bistrica Valley, which shows the size of the water reserve in the mountain snow cover in the aquifers hinterland. Characteristic yearly levels are presented in detail in Table 6.

The regime of fluctuations of groundwater reserves levels in 2001 was not conditioned only by the previously mentioned factors but also



Karta 3: Srednje letne gladine leta 2001 v največjih slovenskih aluvialnih vodonosnikih.
Map 3: Mean yearly levels in 2001 in major Slovene alluvial aquifers.

Režim nihanja gladin oziroma zalog podzemnih voda v letu 2001 je bil poleg uvodoma opisanih dejavnikov vodne bilance pogojen tudi z režimom v predhodnem letu. V jeseni 2000 so v zadnjih treh mesecih izjemno obilne padavine povečale vodne zaloge nad povprečje v pretežnem delu države. Konec decembra 2000 so bile vodne zaloge nadpovprečne v vseh opazovanih aluvialnih vodonosnikih, razen severovzhodne Slovenije. V nekaterih delih vodonosnikov Ljubljanske kotline in Mirensko-Vrtojbenskega polja so vodne zaloge celo presegle visoko povprečje Hvp. Slabo stanje je bilo v velikem delu vodonosnikov severovzhodne Slovenije, kjer je konec leta 2000 še vedno prevladovala suša, čeprav so bile zaloge v manjših predelih vodonosnikov nad povprečjem. Tako je bilo izhodiščno stanje zalog podzemnih voda na začetku leta 2001 povsod zelo ugodno, razen v severovzhodni Sloveniji.

Glede časovne spremenljivosti hidrološkega režima v letu 2001 so bile tako velike razlike med vodonosniki severovzhodne Slovenije in vodonosniki v preostalem delu države, da ta dva prostorska sklopa opisujemo ločeno.

Glavne značilnosti režima podzemnih voda v severovzhodni Sloveniji so bile:

- sušne razmere v nekaterih predelih vodonosnikov že od začetka leta,
- med letom širitev območij zajetih s hidrološko sušo,
- razmeroma ustaljen režim z malimi amplitudami nihanja,
- tendenca zmanjševanja vodnih zalog skozi leto in
- različen režim na Vrbanskem platoju od preostalih vodonosnikov tega območja.

Od januarja do maja se je stanje vodnih zalog v severovzhodni Sloveniji močno spreminjalo. Osrednji del Prekmurskega polja in večji del Dravskega polja je pestila hidrološka suša, medtem ko so bile v večini vodonosnikov zaloge pod letnim povprečjem. Na skrajnem zahodnem in vzhodnem delu Prekmurskega polja so zaloge presegale srednje stanje. Od junija naprej so se območja hidrološke suše začela hitro širiti in dosegla največjo prostorsko razsežnost v izjemno suhem in vročem avgustu. Nadpovprečno obilno deževje v septembru je sicer prehodno prekinilo zniževaje gladin v teh vodonosnikih, vendar je sušo omililo le na omejenih manjših

by the regime of the previous year. In the autumn of 2001 (last three months) the water reserves have risen above average in most parts of the country. At the end of December 2000, the amount of water supplies was above average in all observed alluvial aquifers, except in the north-east of Slovenia. In some parts of aquifers in the Ljubljana Basin and the Mirna-Vrtojba Plain water supplies exceeded the high average (Hvp). Poor condition persisted in most aquifers in the north-east of Slovenia, where drought still continued at the end of 2000, although the reserves in smaller parts of aquifers were above average. Groundwater reserves at the beginning of 2001 were satisfactory everywhere, except in the north-east of Slovenia.

As far as temporal variability of hydrological regime in 2001 is concerned, there were great differences between aquifers of north-eastern Slovenia and other aquifers, so they are discussed separately.

The main characteristics of the groundwater regime in the north-east of Slovenia were:

- Drought in some parts of aquifers from the beginning of the year
- The areas affected by drought during the year were extended
- A relatively stable regime with low fluctuation amplitudes
- The water reserves were decreasing throughout the year
- The Vrbansko plateau had a different regime from the rest of the aquifers in the area

The state of water reserves in the north-east of Slovenia has been changing heavily from January to May. The central part of the Prekmurje Plain and a larger part of the Drava Plain suffered from hydrological drought, but at the same time the reserves in other aquifers were below the yearly mean. The reserves at the far west and east part of the Prekmurje Plain exceeded the mean state. The areas of hydrological drought have started spreading quickly from June onwards and reached its biggest spatial extent in extremely dry and hot weather in August. Abundant precipitation in September that was above average temporarily interrupted the decrease of water levels in these aquifers, but only in limited and small areas. Water levels were decreasing in the dry autumn, which only intensified the drought. Hence, groundwaters in the north-east območjih. Do konca leta so se gladine v suhi jeseni zniževale, kar je stopnjevalo sušo. Tako so koncem leta podzemne vode v severovzhodni Sloveniji praviloma upadle na najnižjo raven.

Izjema je bil vodonosnik Vrbanskega platoja, kjer je glavni vir napajanja pronicanje iz reke Drave. Gladine so bile tam od marca do junija nad letnim povprečjem, ko je bil zaradi taljenja snega v visokogorskem povirju pretok reke velik. V ostalih mesecih so bile gladine nižje od srednje letne. Le v decembru se je tudi v tem vodonosniku, kot v vseh ostalih vodonosnikih severovzhodnega dela države, pojavila suša.

V preostalih opazovanih vodonosnikih po državi se je leto začelo z ugodnimi vodnimi zalogami, glavne značilnosti režima podzemnih voda pa so bile:

– ugodne oz. zelo ugodne zaloge podzemnih voda na začetku leta,
– pretežno ugodne zaloge v prvi polovici leta,
– ugodno bogatenje s snežnico od pozne zime do začetka poletja s snežnico,
– kratkotrajna izrazita hidrološka suša v poletnih mesecih,
– izjemno obilna in hitra obnova vodnih zalog v mokrem septembru,
– zniževanje zalog v suhi pozni jeseni in
– zaloge pod povprečjem, ponekod že hidrološka suša na koncu leta.

Bogate vodne zaloge v decembru 2000 in obilne padavine v januarju so dvignile gladine podzemnih voda konec januarja nad letno povprečje Hs, ponekod celo nad visoko povprečje Hvp. Take izjemno bogate vodne zaloge, nad Hvp, so bile na celem Kranjskem polju, v zahodni polovici Ljubljanskega polja in gor vodnem delu vodonosnika doline Kamniške Bistrice pod Krvavcem. Na Kranjskem polju, v predelu pod Krvavcem, so se bogate vodne zaloge obdržale vse do začetka maja. Temu je prispeval dotok snežnice iz tega dela Kamniških Alp.

V suhem februarju so se gladine povsod zniževale, vendar so visoke januarske zaloge omogočile ohranitev zalog nad povprečjem. Pod letno povprečje so podzemne vode upadle le v nekaterih predelih Celjske kotline, Krške kotline in Mirensko-Vrtojbenskega polja.

Kljub pomanjkanju padavin so se gladine podzemnih voda vse do poletja spreminjale v

of Slovenia dropped to the lowest level at the end of the year.

The aquifer of Vrbanski plateau was an exception, because the Drava is the main source of groundwater recharge. The levels were above the yearly mean from March till June, when the discharge in the headwaters of the river was high, due to snow melting in the mountains. Water levels were lower than the mean yearly level during the rest of the months. Drought affected this aquifer in December as did every other aquifer in the north-east of the country.

The year started with favourable water reserves in the rest of the observed aquifers across the country. The principal groundwater regime characteristics were:

– Abundant groundwater reserves at the beginning of the year
– Relatively favourable groundwater reserves in the first half of the year
– Favourable snow water supply from late winter till the beginning of summer
– A short-term, but severe hydrological drought in summer
– Extremely plentiful and fast restoration of water reserves in the wet September
– Decrease of water reserves in the hot late autumn
– At the end of the year reserves below average, hydrological drought affecting some areas.

Abundant water supplies in December 2000 and abundant precipitation in January raised groundwater levels above the yearly mean (Hs) at the end of January and in some places even above the high average (Hvp). These extremely plentiful water reserves above Hvp were recorded in entrelly Kranj Plain, in the western half of the Ljubljana Plain and in the upper part of the Kamniška Bistrica aquifer below Krvavec mountain. Abundant water reserves have been retained until the beginning of May in the Kranj Plain below Krvavec. An inflow of snow water from this part of the Kamnik Alps was a valuable contribution.

Water levels were decreasing everywhere in the dry February, however, high January reserves have made it possible for the reserves to remain above average. Groundwaters fell below the yearly mean only in some parts of the Celje razponu običajnih letnih nihanj. Zaloge podzemnih voda so bile v vodonosnikih, ki dobivajo večji del vode s pronicanjem iz rek s povirji v visokogorju, vso prvo polovico leta pretežno nad povprečjem. Taljenje debele snežne odeje v visokogorju je tako omogočilo nadpovprečne zaloge v vodonosnikih ob Savi na Ljubljanskem polju in Krško-Brežiškem polju, v vodonosnikih ob Savinji v Celjski kotlini in ob Kokri na Kranjskem polju.

Pomanjkanje padavin in visoke temperature zraka v poletnem obdobju so povzročile izrazito zniževanje gladin, še posebej v vročem avgustu, ki je bil skoraj brez padavin. Količina vodnih zalog je bila pred poletjem na Ljubljanskem polju, v dolini Kamniške Bistrice in v Celjski kotlini tako ugodna, da so se ohranile v razponu normalnih vodnih zalog tudi v obdobju meteorološke suše. V avgustu, ko je bil višek poletne hidrološke suše podzemnih voda, je ta pojav zajel večji del Slovenije. Ob že prej sušni severovzhodni Sloveniji smo imeli tedaj sušo v nekaterih predelih Ljubljanske kotline, manjših predelih Celjske kotline, pretežnem delu Krške kotline in v Vipavsko-Soški dolini.

V izjemno deževnem septembru so se zaloge podzemnih voda obnovile na normalno raven, v vsej Celjski kotlini pa nad povprečje, v manjšem predelu celo na raven zelo bogatih zalog z gladinami nad visokim povprečjem Hvp. V zadnjih treh sušnih mesecih so se gladine povsod zniževale, tako je konec leta večji del Slovenije ponovno zajela hidrološka suša.

Mesečna odstopanja gladin v letu 2001 od mesečnih povprečij za primerjalno dolgoletno obdobje (graf 14) ponazarjajo opisane posebnosti režima tega leta. Izstopa celotno območje vodonosnikov severovzhodne Slovenije, kjer se je celoletna hidrološka suša odražala v negativnih odstopanjih mesečnih povprečij. Na tem območju so bila odstopanja nenavadno velika, še posebej v suhi pozni jeseni. Vodonosniki vse Slovenije kažejo nekaj skupnih posebnosti režima. V septembru so bile gladine kljub izjemno obilnemu deževju povsod pod povprečjem za ta mesec. To priča o hudi poletni suši v letu 2001 in velikem primanjkljaju podzemnih voda v avgustu. Zadnja dva meseca so bile zaradi zelo redkega pojava jesensko-zimske hidrološke suše podzemnih voda gladine povsod nižje od mesečnih povprečij. Regionalna pestrost režima se kaže kot odstopanje navzgor v prvi polovici leta na

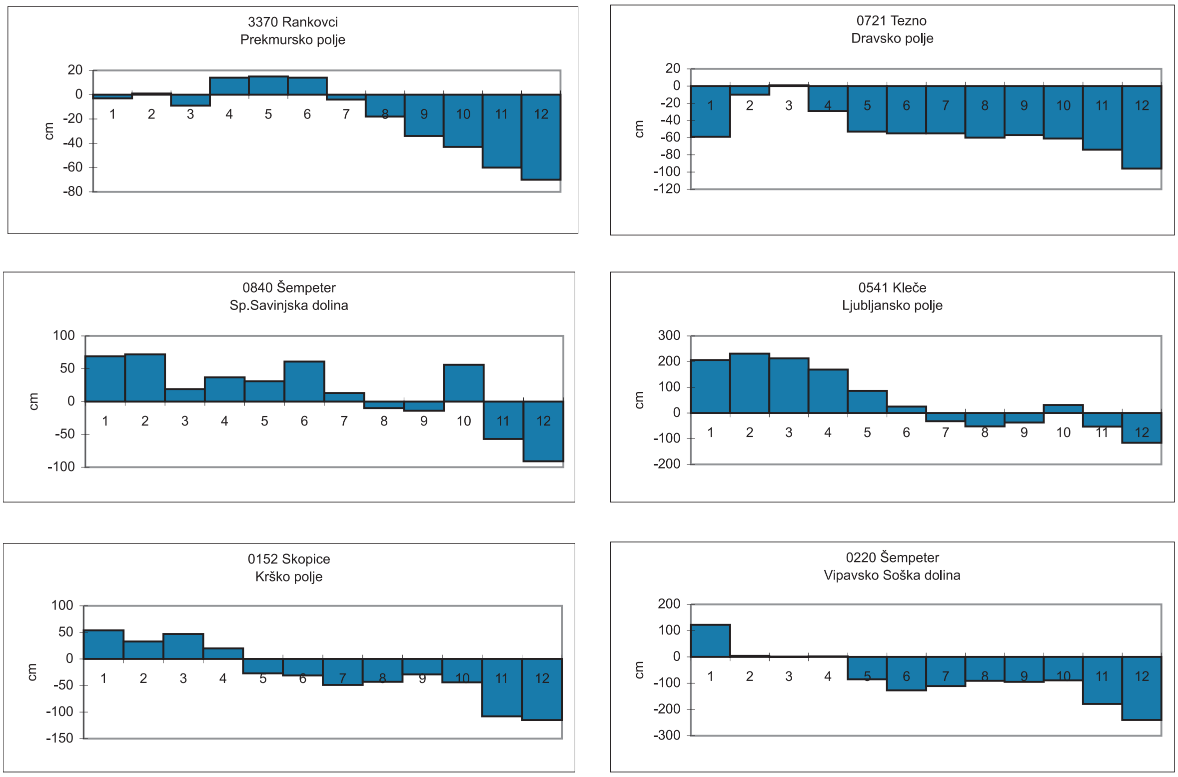
Basin, the Krško Basin and the Mirna-Vrtojba Plain.

Groundwater levels were despite the lack of precipitation fluctuating until summer in the usual way. Water levels in aquifers that receive a large share of water with infiltration from rivers with headwaters in the mountains were mainly above average in the first part of the year. The melting of a thick snow cover supplied abundant quantities of water reserves in aquifers near the Sava River in the Ljubljana Plain and the Krško Basin, near the Savinja River in the Celje Basin and near the Kokra River in the Kranj Plain aquifer.

Lack of precipitation and high air temperatures in summer caused an exceptional decrease in water levels, especially in the hot August with almost no precipitation. The quantity of water reserves in the Ljubljana Plain, the Kamniška Bistrica Valley and the Celje Basin was so favourable before the summer that there were reasonable quantities of water reserves left even in the period of meteorological drought. In August, when the hydrological drought of groundwaters was at its peak, hydrological drought affected most of Slovenia: besides already dry north- eastern Slovenia, some parts of the Ljubljana Basin, smaller parts of the Celje Basin, a large part of the Krško Basin and the Vipava-Soča Valley.

The extremely wet September saw a restoration of groundwater reserves to a normal level. Water levels in the Celje Basin rose above average and in a small part of the basin the groundwaters rose substantially with levels above the high average (Hvp). Afterwards water levels were decreasing everywhere in the last three dry months, and the hydrological drought again affected a larger part of Slovenia.

Monthly water-level deviations from monthly mean in a multiannual comparative period in 2001 (Graph 14) present the distinctive features of the regime in 2001. A whole area of aquifers in the north-east of Slovenia stands out, since this year's hydrological drought was reflected in negative deviations from monthly means. This area witnessed unusually sharp deviations, especially in the late and dry autumn. The aquifers in Slovenia show some common features. Water levels were despite abundant precipitation below average in September, which points to severe summer drought in 2001 and a consi-



Graf 14: Odstopanja srednjih mesečnih gladin podzemnih voda v letu 2001, glede na srednje mesečne gladine za primerjalno dolgoletno obdobje 1961–1990.

Graph 14: Deviations of mean monthly groundwater levels in the year 2001 from mean monthly levels in a multiannual comparative period 1961–1990.

Ljubljanskem polju, odstopanje navzdol skoraj celo leto na Mirensko-Vrtojbenskem polju, odstopanje navzdol od maja naprej na Krškem polju in raznoliko odstopanje v Spodnje Savinjski dolini, kjer je bila spremenljivost režima največja.

Pri letnem poteku nihanja gladin so bile zabeležene visoke konice leta pretežno med januarjem in aprilom, le izjemoma ponekod v maju ali juniju. Najvišje letne gladine so bile najpogosteje januarja ali marca, prav vse pa so bile v prvi polovici leta. Najnižje letne gladine so bile večinoma na prehodu iz avgusta v september, ponekod tudi konec leta. Letni minimumi so bili v poletju v večini države, konec leta pa pretežno v severovzhodni Sloveniji. Prav tam so bile v decembru na nekaj postajah zabeležene do tedaj najnižje gladine v vsem dolgoletnem opazovalnem obdobju. Severovzhodno Slovenijo je zaznamovalo celoletno zniževanje gladin, tako je kar precej primerov z najvišjo letno gladino na začetku in najnižjo na koncu leta.

Po splošnih značilnostih režima podzemnih voda je bilo leto 2001 nenavadno. Praviloma so bile gladine v prvi polovici leta višje kot v drugi. V običajnih letih so gladine najvišje v pozni jeseni ob večkratnih prehodih vremenskih front

derable groundwater deficit in August. In last two months of the year groundwater levels were below monthly mean everywhere due to a very rare phenomenon of hydrological drought of autumn – winter period. A regional regime variety is presented by deviations being above average in the first half of the year in the Ljubljana Plain and by being below average throughout the year in the Mirna-Vrtojba Plain and in the Krško Plain from May onwards and by a variable deviation in the Lower Savinja Valley where the regime changes the most.

High yearly peaks were mainly recorded between January and April, and only exceptionally in May and June. The lowest yearly water levels were mainly recorded at the turn of the month in August and at some places at the end of the year. Yearly minimum was reached in most parts of Slovenia in summer and at the end of the year, it was recorded mainly in the north-east. The lowest water levels in a multiannual observation period were recorded in December in some stations in the north-east of Slovenia. The decrease of water level was observed in the north-east of Slovenia throughout the year, and consequently several cases of the highest water level at the čez Slovenijo, ki prinašajo obilne padavine. V prvi polovici leta je v pretežnem delu vodonosnikov prevladovalo ugodno stanje vodnih zalog z gladinami nad obdobnim letnim povprečjem Hs. V drugi polovici leta so bile gladine, razen septembra, praviloma nižje od letnega povprečja.

Leto 2001 je zaznamovala suša. V nekaterih predelih vodonosnikov severovzhodne Slovenije je bila hidrološka suša skozi celo leto. V teh predelih suša traja neprekinjeno že od pomladi leta 2000. Decembra je pestila večino Slovenije huda hidrološka suša podzemnih voda, kar je redek pojav. Zadnja zimska suša pred tem je bila v zimi leta 1988/89. Izjemno nizka raven zalog podzemnih voda na koncu leta 2001 je bilo slabo izhodišče za režim nihanja zalog v letu 2002.

beginning of the year and the lowest water level at the end of the year were recorded.

The year 2001 can be described as unusual, judging by the general characteristics of groundwater regime. Water levels were generally high in the first half of the year. Normally, the water levels are highest in late autumn when weather fronts bringing abundant precipitation pass Slovenia. A favourable water reserves status generally prevailed in the first half of the year with water levels above the yearly mean of the period (Hs). Water levels were below the yearly mean in the second half of the year, with the exception of September.

The year 2001 was marked by drought. The hydrological drought lasted throughout the year in some parts of aquifers in north-eastern Slovenia. Drought has persisted in these parts since the spring of 2000. A severe hydrological drought of groundwaters affected most of Slovenia in December, which is a rare phenomenon. The last drought before that occurred in the winter of 1988/89. An exceptionally low level of groundwater supplies at the end of 2001 was not a favourable starting point for the regime of fluctuations of water supplies in 2002.

Zaraščena struga Ledave pri vodomerni postaji Čentiba 31. avgusta 2001 (foto: Peter Frantar).
Nearly overgrown channel of the Ledava River at the gauging station Čentiba on August 31, 2001 (photo: Peter Frantar).

C. IZVIRI

HIDROLOŠKI MONITORING IZVIROV

Niko Trišić

V letu 2001 se je nadaljeval hidrološki monitoring izvirov, ki se je z vgraditvijo podatkovnih zapisovalnikov na izvirih Divje jezero in Podroteja pričel v letu 1999. Srednji letni vodostaj je bil na izviru Podroteja nekaj centimetrov nižji od srednjega vodostaja v preteklih dveh letih, vendar je že v mesecu januarju 2001 nastopil visokovodni val, ki je presegel vse vrednosti v dotedanjem dvoletnem nizu izmerjene vrednosti vodostajev. Konica vala se je pojavila na obeh izvirih istočasno, 25. januarja ob 20:30. Na izviru Divje jezero je bil ob tem podatkovni zapisovalnik preplavljen in je po nekaj dneh prenehal delovati. Najvišji zabeleženi vodostaj na izviru Divje jezero (616 cm) je bil za 54 oz. 97 centimetrov višji od najvišjega vodostaja v letu 2000 oz. v letu 1999. Na podlagi sledov visoke vode smo ocenili, da je vodostaj na vodomerni postaji Divje jezero na Jezernici, ki je iztok vode izvira Divje jezero, dosegel okoli 245 cm. Ocenjeni pretok ob tem vodostaju je med 70 in 75 m^3/s.

Zaradi visokega vala je tudi srednja mesečna januarska vrednost vodostaja v letu 2001 najvišja v opazovanem nizu 1999-2001. Zaradi prekinitve delovanja merilnika v začetku februarja nimamo na razpolago primerljivega niza podatkov o Divjem jezeru za celotno leto 2001. Kljub temu je podatek o vodostaju visokega vala dragocen, saj do sedaj nismo imeli ocene visokega pretoka iz Divjega jezera.

Podatkovni zapisovalnik, ki je vstavljen v črpališče izvira Podroteja, je neprekinjeno beležil podatke o vodostaju, temperaturi in specifični

C. SPRINGS

HYDROLOGICAL MONITORING OF SPRINGS

Niko Trišić

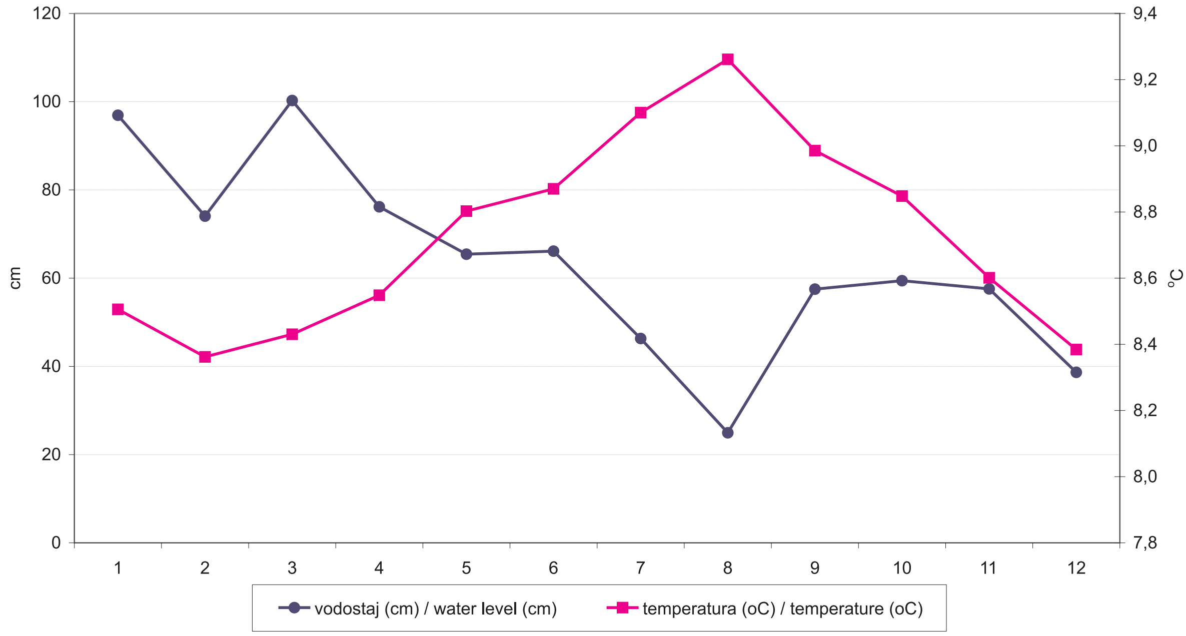
The hydrological monitoring of springs began in 1999 with the installation of data loggers on Divje jezero (Savage Lake) in Podroteja and continued in 2001. Mean yearly water level in the Podroteja spring was a few centimetres lower than the mean water level in the last two years, however a highwater wave occurred which exceeded all values in the two year series of water level measurements. The peak of the wave appeared on both springs at the same time, on January 25 at 20:30. The data logger on Divje jezero (Savage Lake) was flooded and stopped working after a couple of days. The highest recorded water level on Divje jezero (Savage Lake) (616 cm) was 54 or 97 higher than the highest water level in 2000 or 1999. On the basis of high water marks the water level on gauging station Divje jezero (Savage Lake) on Jezernica (an outflow of Divje jezero (Savage Lake) spring) was estimated to around 245 cm. An estimated discharge value on this aquifer was between 70 and 75 m^3/s.

A mean January water level in 2001 was the highest in a series of observations from 1999 till 2000 due to a high wave. We have no comparable series of data for the entire year 2001 because of the data logger disruption at the beginning of February. In spite of all that, the data about the highwave level is very important, since there was not any high discharge estimation from Divje jezero (Savage Lake) so far.

The data logger installed in the waterworks Podroteja continuously recorded data on

Preglednica 7: Primerjava značilnih nizkih, visokih (nk, vk) in srednjih (s) letnih vrednosti vodostajev, temperature in specifične električne prevodnosti na izviru Podroteja.
Table 7: Comparison of characteristic low, high (nk, vk) and mean (s) annual water levels (H), temperatures (T) and specific electric conductivity (EP) on the water gauging station Podroteja.

	vodostaj (cm) water level (cm)			temperatura (ºC) temperature (ºC)			spec. el. prevodnost (µS/cm) spec. conductivity (µS/cm)		
	Hnk	Hs	Hvk	Tnk	Ts	Tvk	EPnk	EPs	EPvk
1999	27,2	67,9	167	7,7	8,6	10,2	251	314	357
2000	20,2	67,3	187	8,0	8,6	10,1	226	310	355
2001	14	64	226	8,2	8,7	9,7	-	-	-



Graf 15: Srednji mesečni vodostaji (cm) in srednje mesečne temperature (°C) vode na izviru Podroteja v letu 2001.
Graph 15: Mean monthly water levels (cm) and mean monthly temperatures (°C) in the Podroteja spring in 2001.

električni prevodnosti. Ker imata izvira podoben režim in skupno vodozbirno zaledje, lahko iz časovnega razporeda podatkov za ta izvir sklepamo na režim izvira Divje jezero v letu 2001.

Po prvem visokem valu v januarju je sledil drugi visoki val 5. marca, ki je bil le za 6 centimetrov nižji od prvega. Temu pa je sledila vrsta nekaj nižjih vodnih valov, ki so povzročili visoko srednjo vrednost vodostajev v mesecu marcu. Kalnost ob nastopu visokih valov je verjetno vzrok za motnje v delovanju sonde za specifično električno prevodnost. Zaradi nezanesljivih podatkov te veličine za leto 2001 ne podajamo.

V juliju in avgustu je bil le en srednje visoki vodni val, sicer pa so vodostaji upadali in v avgustu in začetku septembra je bil zabeležen najnižji vodostaj v opazovanih treh letih, 14 oz. 15 centimetrov. Jesenski visoki val je 24. septembra dosegel konico 179 centimetrov, kasnejši valovi pa so bili precej nižji, kar je posledično povzročilo tudi zelo nizek zimski minimum v decembru z vrednostjo le 21 centimetrov.

water level, temperature and specific electrical conductivity. Since the two springs have a common regime and a catchment area, it is possible to establish the regime of Divje jezero (Savage Lake) in 2001 with the help of the temporal data distribution.

After the first high wave in January, a second high wave followed on March 5, which was only 6 cm lower than the first. A series of lower water waves followed. They caused high mean water level value in March. The turbidity that appears with high waves is probably the reason for interruptions in sensors for specific electric conductivity. The data for 2001 were unreliable; therefore they are not included here.

Only one middle height wave was recorded in July and August, otherwise the water level was decreasing and in August and at the beginning of September the lowest water levels in three years of observations were recorded (14 or 15 cm). The high wave in autumn reached a peak of 179 cm on September 24. The waves following were considerably lower, which consequently caused a very low winter minimum in December (21 cm).

D. MORJE

PLIMOVANJE MORJA

Igor Strojan

Leta 2001 so bile gladine morja višje kot v dolgoletnem primerjalnem obdobju od leta 1961 do 2000. Povprečna letna višina morja je bila 219,4 cm, kar je 3,3 cm višja kot navadno. Povprečna mesečna gladina morja je bila najvišja marca (232 cm), januarja (231 cm) in septembra (226 cm), kar je dokaj nenavadno, saj so praviloma višine morja v prvih treh mesecih leta najnižje, najvišje pa oktobra in novembra. Najvišja višina morja v letu 2001 (320 cm) je bila osmega januarja. Vrednost je 9 cm nižja od dolgoletnega povprečja najvišjih letnih višin. Tudi najnižja gladina morja v letu (127 cm), ki je bila drugega decembra, glede na dolgoletno obdobje ni bila ekstremna. Vrednost je bila 11 cm višja od povprečja v dolgoletnem obdobju. Preplavitve nižje ležečih predelov obale so bile manjše in manj pogoste kot navadno.

Višine morja so v prvih treh mesecih leta najpogosteje nizke. V 40-letnem obdobju meritev višin morja v Koprskem zalivu je bila gladina morja v vseh prvih treh mesecih obdobja v povprečju okoli 10 cm nižja od celoletnega povprečja obdobja, ki znaša 216,1 cm. Leta 2001 ni bilo tako. Povprečne mesečne višine gladine morja so bile v prvih treh mesecih veliko višje kot v dolgoletnem primerjalnem obdobju: januarja 25 cm, februarja 9 cm in marca celo 28 cm. Januarja (231 cm) in marca (232 cm) sta bili povprečni mesečni višini morja celo najvišji v letu 2001.

Januarja je bila gladina morja večji del meseca višja od pričakovane, le nekaj dni v sredini meseca je bila gladina nižja. Največje odstopanje je bilo v prvih desetih dneh, ko je morje šestkrat preseglo višino 300 cm in v manjši meri poplavljalo obalo. Na preseganje izračunane astronomske gladine morja je najbolj vplival južni veter, ki je bil najmočnejši od šestega do devetega januarja. V tem času so bile zabeležene velike residualne višine, najvišja (75 cm) šestega januarja pozno ponoči. Posebej visoko je bilo morje sedmega januarja, ko je srednja dnevna višina znašala 265,2 cm. Najvišja višina morja v mesecu in obenem v letu (320 cm) je bila izmerjena

D. SEA

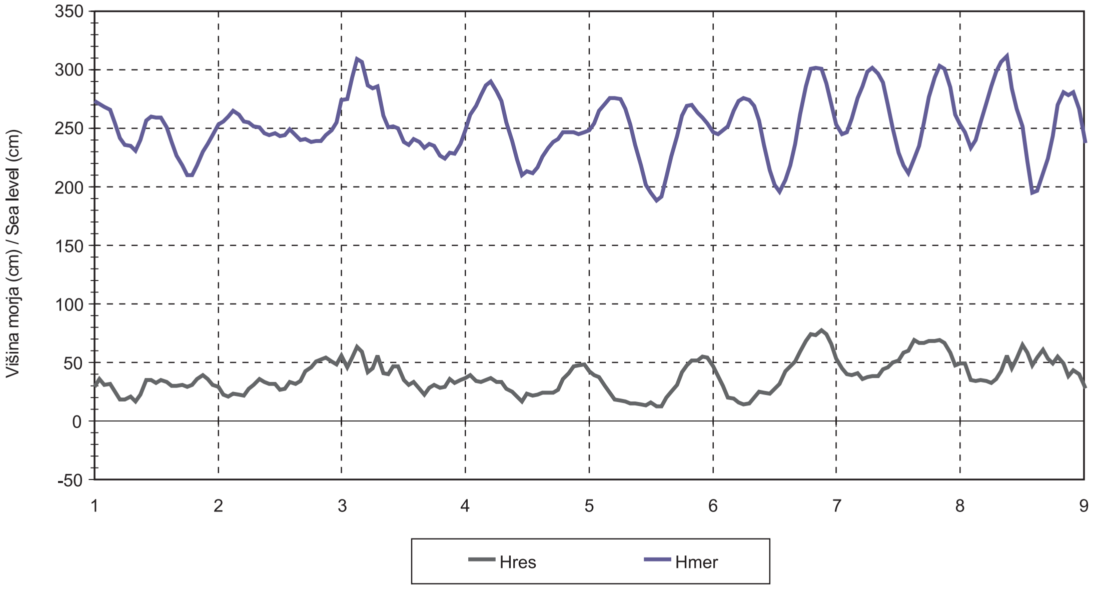
SEA LEVELS

Igor Strojan

Sea levels in 2001 were higher than in the multiannual comparative period from 1961 till 2000. The mean annual sea level reached 219.4 cm which is 3.3 cm higher than usual. The mean monthly seal level was highest in March (232 cm), January (231 cm) and September (226 cm), which is rather unusual considering that the sea level is generally lowest in the first three months and highest in October and November. The maximum sea level (320 cm) was recorded on January 8, 2001. This value is 9 cm lower than the multiannual mean of the highest yearly peaks. The minimum sea level in 2001 (127 cm) was recorded on December 2 and in comparison with the multiannual mean, it was not extreme. It was 11 cm higher than the multiannual mean. The sea did not flood the lower parts of the coast as frequently and extensively as in the previous year.

The sea level was low in the first three months. In 40 years of sea level measuring in the Gulf of Koper, the sea level was 10 cm lower in the first three months than the multiannual mean (216.1 cm). This was not the case in 2001. Mean monthly sea levels were substantially higher in the first three months than in the multiannual comparative period: 25 cm in January, 9 cm in February and 28 cm in March. Mean monthly levels in January (231 cm) and March (232 cm) were highest in 2001.

The sea level was higher than expected for most of **January**; there were only a few days with the sea level lower than expected. The highest deviation occurred in the first ten days, when the sea exceeded 300 cm and flooded the coast. The south wind that was strongest from January 6 to 9 was the cause of exceeded astronomic sea level. High residual heights were recorded during this time, the highest being 75 cm in the night of January 6. The sea level was especially high on January 7, when the mean daily height of 265.2 cm was recorded. The highest sea level of the month and of the year (320 cm) was recorded on January 8 at 8:26, and the lowest (144 cm) on January 12 at 16:58.



Graf 16: Januarja je bilo morje najvišje v prvih desetih dneh meseca, ko je šestkrat preseglo 300 cm in je poplavilo nižje ležeče predele obale. Zaradi močnega južnega vetra in znižanega zračnega pritiska so bile gladine morja zvišane tudi do 75 cm.
Legenda: Hmer – merjena višina morja, Hres – residualna višina morja.
Graph 16: The sea level reached its peak in the first ten days of January, when it exceeded 300 cm six times and flooded the lower parts of the coast. Due to strong southerly wind and low air pressure measured sea levels exceeded astronomic sea levels up to 75 cm.
Key: Hmer – measured sea level, Hres – residual sea level.

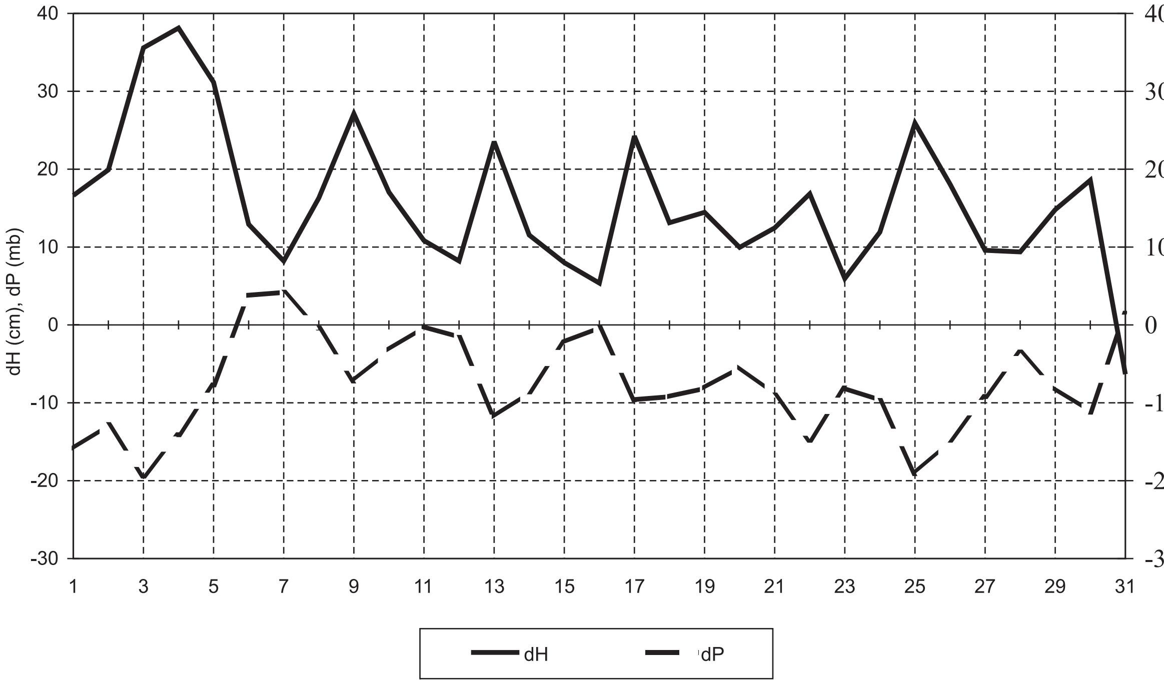
osmega januarja ob 8:26, najnižja (144 cm) pa dvanajstega januarja ob 16:58.

Prvih deset dni **februarja** je bilo morje višje od povprečja, nato je bilo deset dni nižje in v zadnjih dneh meseca, ob izrazitem znižanju zračnega pritiska, zopet višje. Najvišja višina morja v mesecu (288 cm), izmerjena osmega februarja ob 22:42, je bila nekoliko višja kot je to običajno za februar. Najnižja gladina morja 138 cm je bila zabeležena 21. februarja ob 14:54. Tudi ta vrednost je med srednjo in najvišjo obdobno vrednostjo. Morje je bilo **marca** 2001 zelo visoko. Srednja mesečna gladina morja (232 cm) je bila najvišja v letu in najvišja v marčevskem dolgoletnem primerjalnem obdobju. Gladina morja je bila ves mesec višja od srednje obdobne vrednosti. Zelo visoko je bila predvsem v prvih dneh marca. Glede na dnevna povprečja je bila gladina morja najvišja četrtega marca, ko je bila srednja dnevna višina morja 253,1 cm. Najvišja višina morja v mesecu (303 cm), ki je bila nekoliko višja od dolgoletnega marčevskega povprečja, je bila izmerjena osmega marca ob 21:44. Gladina morja je bila najnižja sedmega marca ob 14:02 (157 cm). Običajno so najnižje višine morja marca veliko nižje.

Pomladi in poleti, v mesecih od aprila do septembra, so povprečne mesečne višine morja v 40-letnem obdobju zelo malo odstopale od celoletnega povprečja obdobja. Za leto 2001 je

The sea level was above average in the first ten days of **February**, for the next ten days it was low and again high in the last days of the month when the barometric pressure dropped considerably. The highest sea level of the month (288 cm), measured on February 8 at 22:42, was slightly higher than usual. The lowest sea level (138 cm) was recorded on February 21 at 14:45. This value was also between the mean and the highest value of the period. **March** saw extremely high sea levels. The mean monthly sea level (232 cm) was the highest of the year and the highest of the multiannual comparative period for March. The sea level was higher than the mean values of the period throughout the month. It was especially high in the first days of the month. Considering the daily means, the sea level was highest on March 4, when the mean daily sea level came up to 253.1 cm. The highest monthly sea level (303 cm), which was slightly higher than the multiannual March mean, was recorded on March 8 at 21:44. The sea level was lowest on March 7 at 14:02 (157 cm). The lowest sea levels in March are generally much lower.

The mean monthly sea levels in a 40-year period deviated only slightly from the yearly value of the period in spring and summer, from April till September. In 2001 all mean monthly sea levels were generally higher than in the multiannual period, yet at the same time they were con-



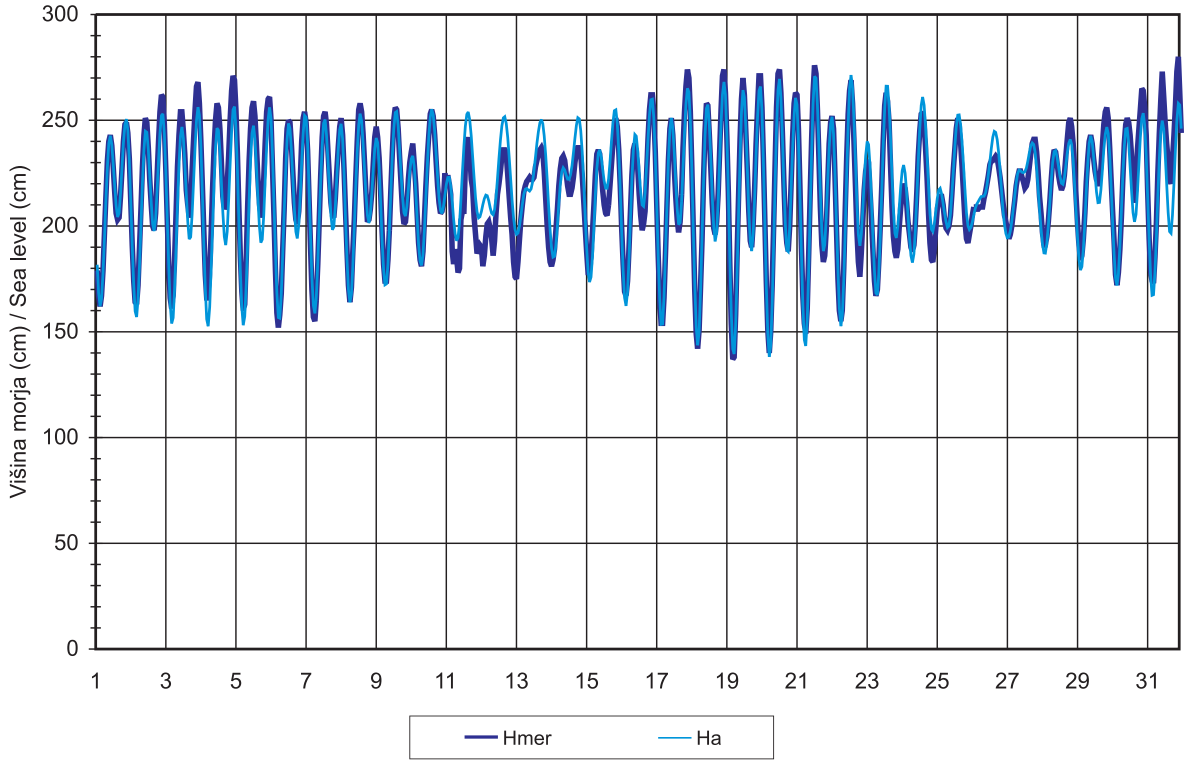
Graf 17: Marca so vremenske razmere večji del meseca zviševale gladino morja. Na sliki so prikazani odkloni srednjih dnevnih višin morja dH in odkloni srednjih dnevnih zračnih pritiskov dP od dolgoletnih povprečnih vrednosti. Dobro je razviden odnos med spremembo obeh merjenih parametrov. Ob znižanem zračnem tlaku se gladina morja zviša.
Graph 17: Sea levels got higher throughout the month due to weather conditions. The graph shows deviations of mean daily sea levels dH and deviations of mean daily air pressure dP from multiannual mean values. The relation between the changes of both parameters measured is clearly visible. When the air pressure drops, the sea level rises.

značilno, da so bile v tem delu leta vse povprečne mesečne višine morja višje kot v dolgoletnem obdobju, vendar bistveno manj kot v prvih treh mesecih, v povprečju za 5 cm.

Aprila so bile višine morja povprečne. Srednja mesečna vrednost 214 cm je bila podobna srednji obdobni vrednosti. **Maja** je bilo morje, z izjemo prvih dveh dni, nekoliko višje od pričakovanega. Posebno visoko je bilo med 14. in 18. majem, ko so se srednje dnevne vrednosti gibale med 227,9 in 237,9 cm. Povprečna mesečna višina morja (220 cm) je bila 6 cm višja kot navadno v tem mesecu. V naslednjem mesecu, **juniju**, so bile povprečne dnevne višine morja večinoma višje od srednje obdobne višine, vendar so bile v štirih krajših obdobjih tudi nekoliko nižje. Podobno kot v predhodnih mesecih so bile tudi **julija** srednje dnevne višine morja večino meseca nekoliko višje od povprečnih. Prve tri dni julija je bilo morje nižje, nato pa do 21. v mesecu precej višje od dolgoletnega povprečja. Zadnje dni julija odstopanja niso bila velika. Podobne razmere so se nadaljevale tudi **avgusta**. Povprečne dnevne višine morja so bile večino meseca nekoliko višje od povprečja. Nižje so bile le v dveh obdobjih: 11. in 12. ter od 21. do 25.

siderably lower than in the first three months, 5cm on average.

Sea levels in **April** were average. The mean monthly value (214 cm) was similar to the mean value of the period. In **May**, however, the sea level was slightly higher than expected, with the exception of the first two days. The sea was especially high between May 14 and 18, when the mean daily values ranged between 227.9 and 237.9 cm. The mean monthly sea level (220 cm) was 6 cm higher than usual. The mean daily sea levels were generally higher than the mean value of the period in **June**; yet, there were four short periods of low values. Similarly, the mean daily sea levels were slightly higher than average in **July**. The sea level was somewhat lower in the first three days of July, but from July 21 onwards, it was notably higher than the multiannual mean. There were no great deviations noticeable in the last days of July. Similar conditions continued in **August**. The mean daily sea levels were slightly higher than average for most of the month. Only two periods witnessed lower temperatures: August 11 and 12 as well as August 21 to 25. There were no considerable deviations from the average and they did not exceed 10 cm.



Graf 18: Izmerjene urne (Hmer) in izračunane astronomske (Ha) višine morja avgusta 2001. Izmerjene višine morja so le malo odstopale od izračunanih astronomskih. Izhodišče izmerjenih višin morja je mareografska »ničla« na mareografski postaji v Kopru. Srednja višina morja v dolgoletnem obdobju je 216,1 cm.
Graph 18: Measured hourly (Hmer) and calculated astronomic (Ha) sea levels in August 2001. Measured sea levels deviated only slightly from the calculated astronomic levels. The starting point for the measured sea levels is the mareographic 'zero' on the Koper mareographic station. The mean sea level of the multiannual period reached 216.1 cm.

avgusta. Odstopanja od povprečja niso bila velika in niso presegala 10 cm.

Septembra so bile višine morja najvišje v opisanem večmesečnem obdobju. Povprečne dnevne višine morja so bile ves mesec višje od povprečja septembrskega dolgoletnega povprečja. Povprečna mesečna višina morja v septembru (226 cm) je bila 11 cm višja kot navadno v tem mesecu in tako med najvišjimi v primerjalnem obdobju.

Oktobra in novembra so višine morja navadno najvišje v letu. Vremenski in drugi vplivi na višino gladine morja so v teh dveh mesecih največji. Oktobra je povprečna višina morja v dolgoletnem primerjalnem obdobju 220 cm, novembra pa 223 cm. To je obdobje, v katerem morje največkrat preplavlja nižje ležeče predele obale. Leta 2001 so bile višine morja oktobra in predvsem novembra nižje kot običajno. Novembra je bila povprečna mesečna višina morja (213 cm) 10 cm nižja kot navadno. Morje je le v nekaj primerih in v manjši meri preseglo višino 300 cm, pri kateri prične preplavljati nižje predele obale.

The sea levels in **September** were the highest in the period of several months. The mean daily sea levels were higher than the multiannual September mean throughout the month. The mean monthly sea level in September (226 cm) was 11 cm higher than usual and therefore one of the highest in the comparative period.

The sea levels in October and November are usually the highest of the year. Weather influences and other influences are usually the strongest in these two months. The mean sea level in October in a multiannual comparative period reached 220 cm and 223 cm in November. This was the period of biggest over-flows over lower parts of the coast. The sea levels in October and November 2001 were lower than usual. The mean sea level in November (213 cm) was 10 cm lower than usual. There were even some cases when the sea levels exceeded 300 cm and started flooding the lower parts of the coast.

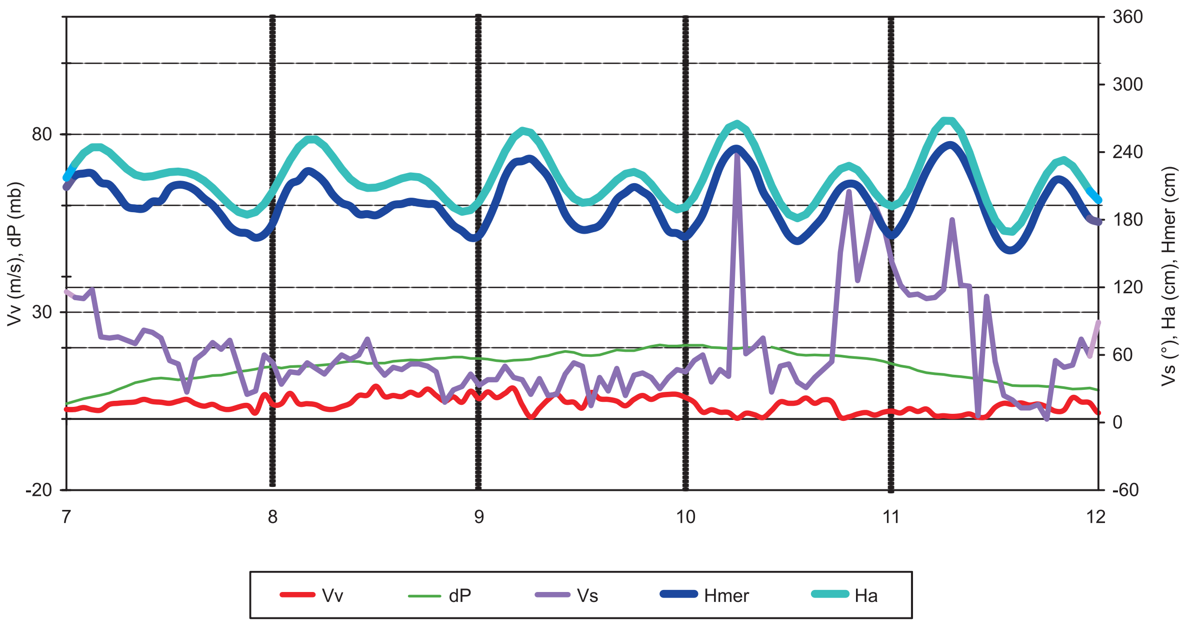
The mean sea level in **October** was only 1 cm lower than usual. Considering the expected astronomic levels, sea levels in **November** changed considerably. Lower than average sea levels

Povprečna višina morja v **oktobru** je bila le centimeter nižja kot navadno. **Novembra** so se odstopanja gladin morja, glede na pričakovane astronomske višine, zelo spreminjala. Morje je bilo prvih nekaj dni nižje od povprečja. Sledilo je desetdnevno obdobje s povišanimi gladinami. To obdobje je imelo dva viška, ob drugem je bila dosežena najvišja gladina v mesecu. V drugi polovici meseca so bile gladine spet večinoma nižje od povprečja. Najvišja gladina morja 305 cm je nastopila štirinajstega novembra ob 8:12. Meteorološka situacija je bila za povišanje morske gladine nekoliko neznačilna. Residualna višina je bila 43 cm. Pihala je burja. Hkrati pa je v južnem Jadranu pihal močan jugo, ki je vodo narival proti severu. K povišanju gladine je prispevalo tudi močno znižanje zračnega pritiska.

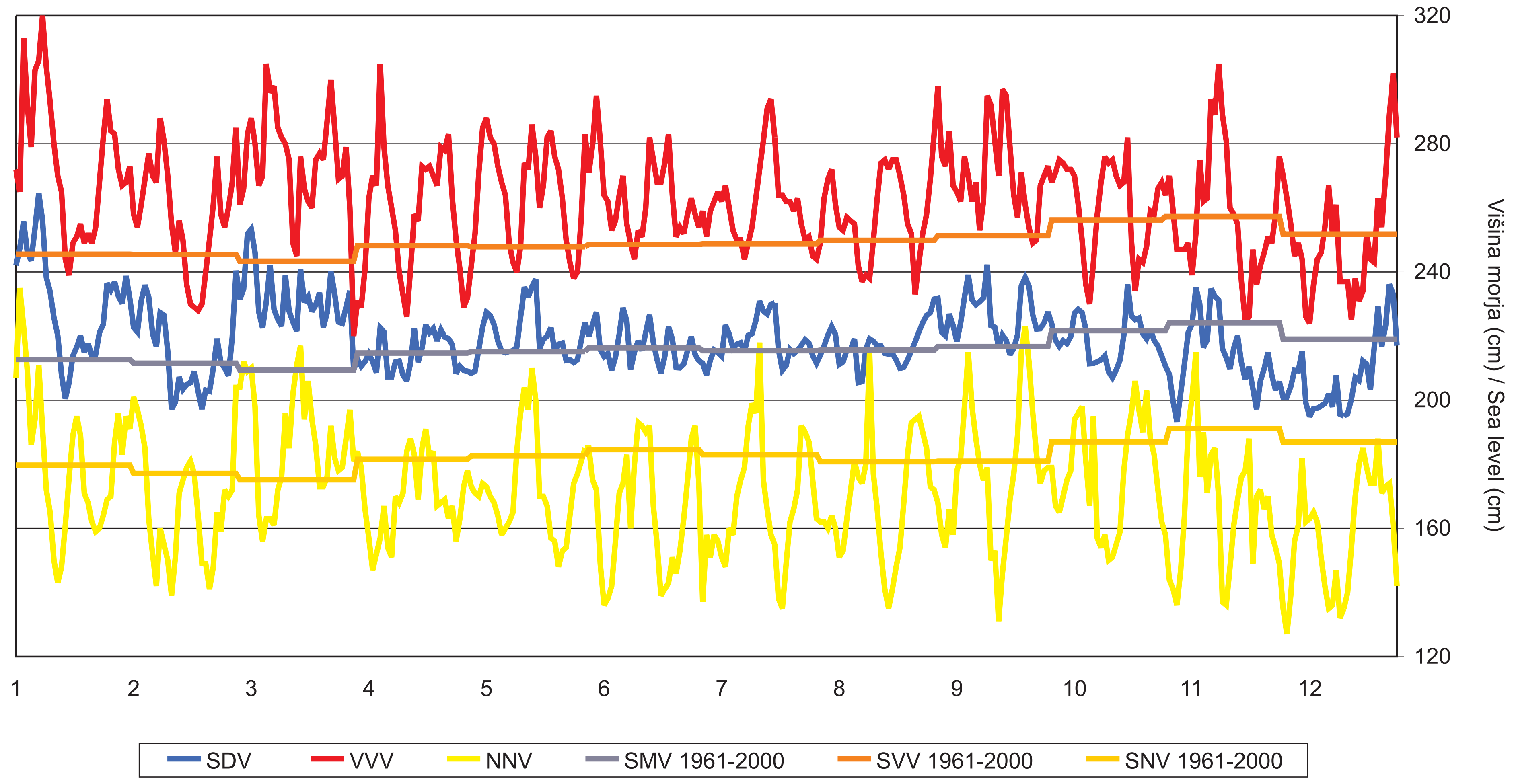
Decembra so bile višine morja, razen zadnjih dni v mesecu, nižje od dolgoletnega povprečja. Povprečna mesečna višina morja je bila 208 cm. Srednje dnevne gladine morja so bile višje od srednjih obdobnih vrednosti le v zadnjih šestih dneh decembra, ko je bila dosežena tudi najvišja mesečna vrednost. Najvišja gladina morja (302 cm) je bila zabeležena tridesetega decembra ob 8:38, najnižja (127 cm) pa drugega decembra ob 16:00.

could be observed in the first few days. A ten-day period of raised sea levels followed. This period recorded two peaks, with the highest sea level of the month during the second peak. Sea levels were lower than average in the second part of the month. The highest sea level reached 305 cm and was recorded on November 14 at 8:12. The meteorological situation was somewhat unusual considering the raised sea level. The residual height reached 43 cm. A strong northeast wind (burja) was blowing. The jugo wind (a southeastern wind of moderate strength) was blowing at the same time in the south Adriatic and pushed the water towards the north. A considerable decrease of barometric pressure contributed to the sea level rise.

With the exception of the last days of **December**, the sea levels were lower than the multiannual mean. The mean monthly sea level height reached 208 cm. The mean daily sea levels were higher than the mean values of the period only in the last six days of December, when the highest monthly value was reached. The highest sea level (302 cm) was recorded on December 30 at 8:38, and the lowest (127 cm) on December 2 at 16:00.



Graf 19: Meteorološka situacija je v začetku decembra pogojevala višine morja, ki so bile nižje od napovedanih. Burja je odrivala vodne mase od obale, visok zračni tlak pa je gladino morja še zniževal.
Legenda: dP – odstopanje od povprečnega zračnega pritiska, Vv – hitrost vetra, Vs – smer vetra, Hmer – merjena višina morja, Ha – astronomska višina morja.
Graph 19: Meteorological situation at the beginning of December influenced the sea level, which was lower than forecasted. A strong north east wind pushed the water away from the coast, and high barometric pressure caused a decrease in the sea level.
Key: dP – deviation from mean barometric pressure, Vv – wind speed, Vs – wind direction, Hmer – measured sea level, Ha – astronomic sea level.



Graf 20: Povprečne dnevne višine morja, povprečne dnevne plime in oseke v letu 2001 in pripadajoče povprečne mesečne vrednosti iz obdobja 1961–2000.
Graph 20: Mean, high and low waters in 2001 and mean montly values from 1961–2000 period.