II. DEL:
PREGLED HIDROLOŠKIH RAZMER V LETU 2009

PART II:
REVIEW OF HYDROLOGICAL CONDITIONS IN THE YEAR 2009

PODNEBNE ZNAČILNOSTI LETA 2009

mag. Florjana Ulaga

V letu 2009 so podnebje zaznamovali izdatne februarske snežne padavine in marca močno deževje v zahodni Sloveniji, dve večji neurji v maju, sušen julij na Obali in izrazito močne padavine v zadnji tretjini decembra, ki so ob sočasnem taljenju snega v zahodni, osrednji in južni Sloveniji povzročile poplave. Leto 2009 se uvršča med deset najtoplejših let, odkar v Sloveniji opravljamo meritve. Večina mesecev je bila nadpovprečno topla razen zimskih mesecev v visokogorju.

Podrobneje so podnebne značilnosti leta 2009 opisane v mesečnih biltenih Naše okolje Agencije RS za okolje, v nadaljevanju predstavljamo splošen letni pregled.

Padavine

V letu 2009 je bilo dolgoletno povprečje padavin preseženo v Julijskih Alpah in severovzhodnem delu Slovenije. Presežek je bil največji v Murski Soboti, največ padavin pa so namerili na Kredarici, 2259 mm. V osrednjem, južnem in zahodnem delu države je bila letna količina padavin pod dolgoletnim povprečjem. Največji primanjkljaj padavin je bil na Bizeljskem, kar 17 odstotkov (sliki 1 in 2).

2009 CLIMATE CONDITIONS

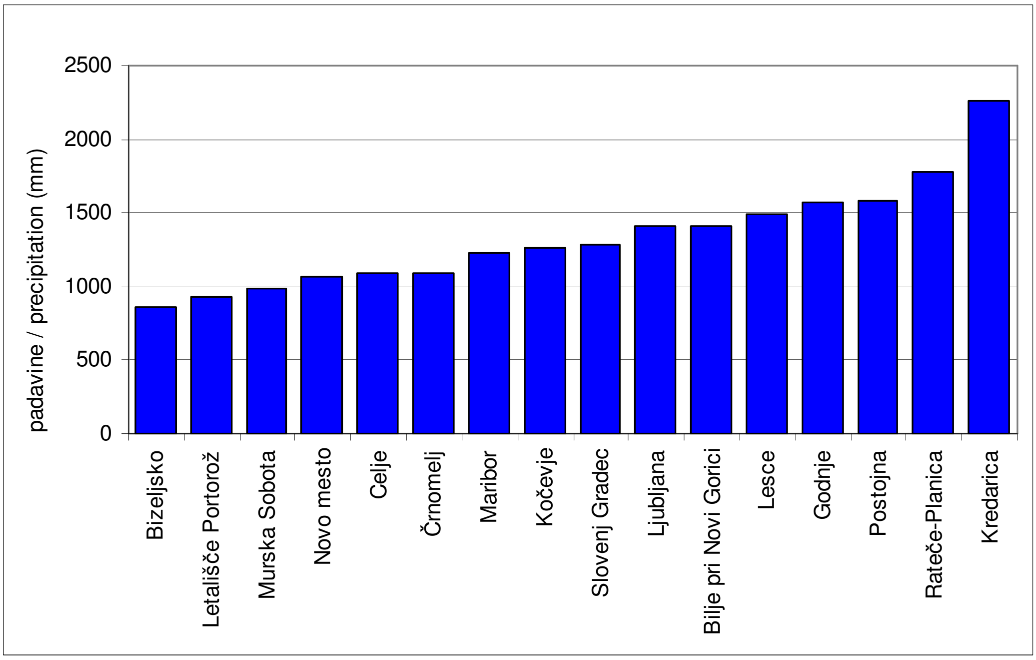
Florjana Ulaga, MSc

In 2009, the climate was marked by excessive snowfalls in February and excessive rainfalls in March in western Slovenia, two severe thunderstorms in May, a dry July in the coastal area and by excessively strong precipitation in the last third of December, which together with the melting snow, caused floods in western, central and southern Slovenia. The year 2009 is classified among the ten warmest years since the introduction of hydrological measurements in Slovenia. Most months had above average temperatures, with the exception of the winter months in the high mountain area.

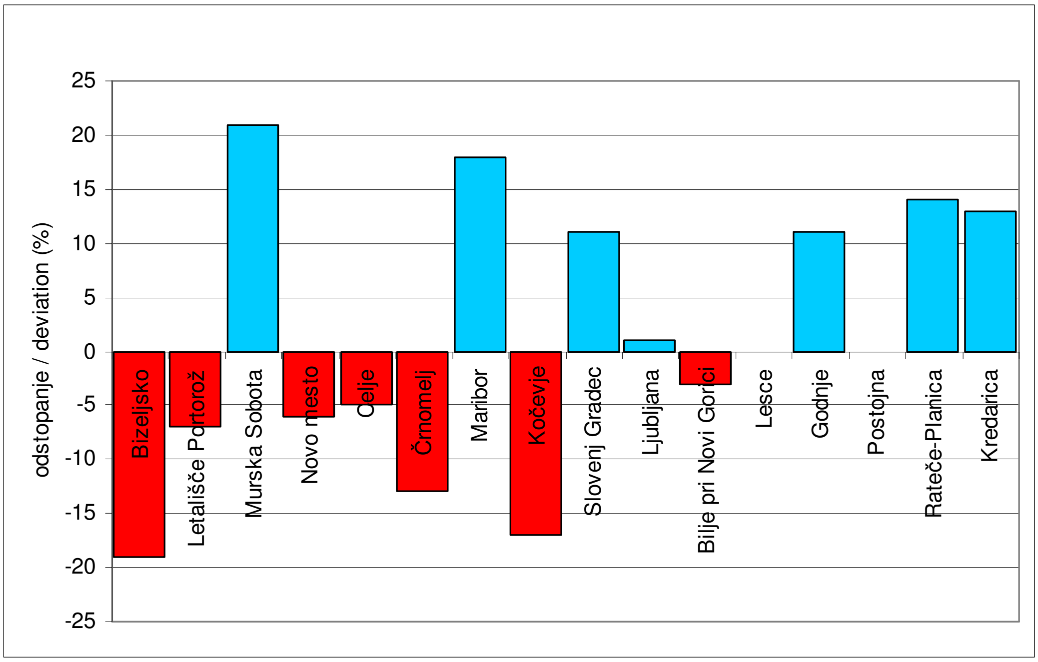
The climate conditions in the year 2009 are described in detail in the monthly bulletin of the agency, Naše okolje. Hereinafter only a general annual overview is presented.

Precipitation

In 2009, the multi-annual average of precipitation was exceeded in the Julian Alps and in north-eastern Slovenia. The precipitation surplus was the largest in Murska Sobota, while the highest precipitation level was recorded on Krederica, i.e. 2 259 mm. In the central, southern and western parts of the country, the annual precipitation volume was below the multi-annual average. The biggest deficit of precipitation was recorded in Bizeljsko with only 17 % of the multi-annual average (Figures 1 and 2).



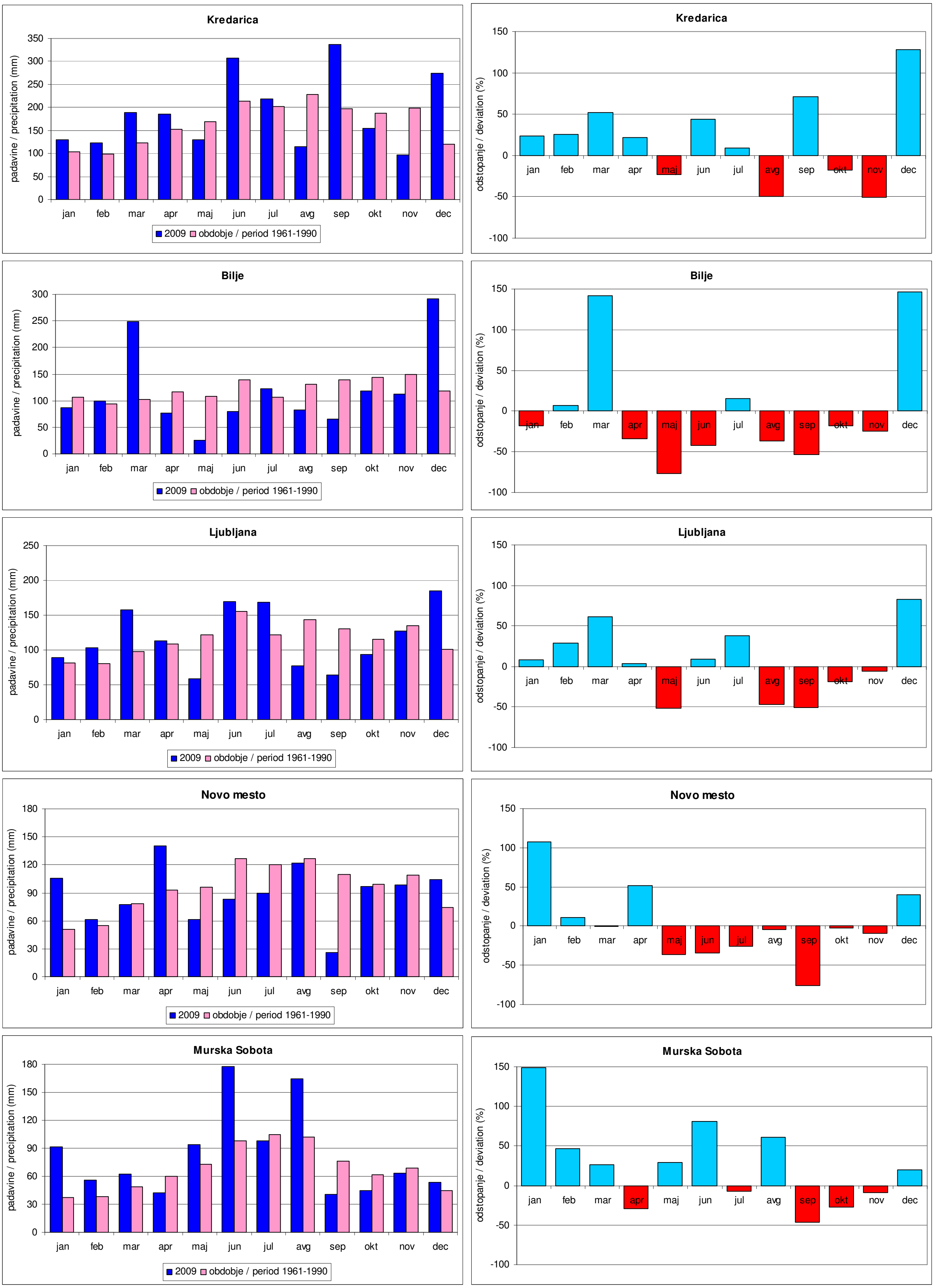
Slika 1: Višina padavin v letu 2009 na izbranih padavinskih postajah
Figure 1: The precipitation level in 2009 at selected precipitation stations



Slika 2: Odstopanje višine padavin v letu 2009 od povprečja obdobja 1961–1990 na izbranih postajah
Figure 2: Deviation of the precipitation level in 2009 from the 1961–1990 reference period average at selected stations

Januarja in februarja je bilo skoraj povsod po Sloveniji preseženo dolgoletno povprečje padavin. Januarja je bil največji presežek padavin izmerjen na vzhodu in severovzhodu države. Še posebno je bila obilna snežna odeja v zahodnem delu Julijskih Alp. Na Kredarici so februarja izmerili 487 cm snega. Marca je na zahodu padla dobra dvakratna količina običajnih padavin, temu so sledile obsežne poplave v zahodni, južni in tudi osrednji Sloveniji. Poplavljena so bila kraška polja Notranjske in Ljubljansko barje. Aprila so bile padavine izdatnejše le v severozahodnem delu, na Kredarici so celo izmerili največ snega (555 cm). Maja sta državo prizadeli večji neurji, med katerima so na Lisci izmerili rekordnih 51 mm dežja v 10 minutah, sicer pa je bil mesec podpovprečno namočen. V juniju in juliju je bilo padavin malo, na Obali so se celo spopadali s sušo. Tudi avgust je bil še topel in suh, kar je povzročilo daljše obdobje nizkih voda rek. Podpovprečna namočenost se je nadaljevala v septembru, oktobru in novembru. Septembra je povsod razen v visokogorju padlo zelo malo padavin, v Novem mestu so izmerili celo 76-odstotni primanjkljaj glede na dolgoletno povprečje. Decembra so bile padavine povsod po državi nad dolgoletnim povprečjem. V zadnji tretjini meseca so v zahodni polovici države močno presegle dolgoletno povprečje, saj jih je bilo kar 2- do 3-krat toliko kot v dolgoletnem povprečju. 19. decembra je sneg pobelil celo Obalo, kjer je težave večkrat povzročala tudi visoka plima.

In January and February, the multi-annual average was exceeded in most parts of Slovenia. In January, the highest precipitation surplus was recorded in the east and northeast of the country. The highest levels of snowfall were recorded in the western part of the Julian Alps. On Kredarica, a snow depth of 487 cm was recorded in February. In March, the precipitation level was twice as high in the west compared to the usual precipitation level, which resulted in extensive floods in western, southern and central Slovenia. Floods occurred on karstic fields of the Notranjska region and the Ljubljansko barje. In April, excessive precipitation was only recorded in the north-west; on Kredarica, for example, the snow cover was as deep as 555 cm. In May, the country was hit by two thunderstorms, during which Lisca recorded a record value of rainfall, i.e. 51 mm of rain in 10 minutes, whereas in general, below average precipitation was recorded during that month. In June and July, low precipitation was recorded. The coastal area even had to cope with drought. August, too, was still warm and dry, which caused a longer period of low water levels in Slovenian rivers. Below average precipitation also continued in September, October and November. In September, the precipitation level was very low, except for the high mountain area. In Novo mesto, a 76 % deficit in precipitation was recorded compared to the multi-annual average. In December, precipitation was above the multi-annual average across the country. In the last third of the month, precipitation strongly exceeded the multi-annual average in the western part of the country, which received two to three times its multi-annual average. On 19 December, snowfalls were even recorded on the coast, where problems were often also caused by high tides.



Slika 3: Mesečna višina padavin v letu 2009 v primerjavi z obdobnim povprečjem 1961−1990 in odstopanje od obdobnega povprečja

Figure 3: Monthly volume of precipitation in 2009 compared to the multi-annual 1961–1990 reference period and deviation from the periodical average

Izredni padavinski dogodki

Leto 2009 si bomo zapomnili predvsem po izrednih padavinah marca v porečjih Soče in Vipave, izrazitih junijskih in avgustovskih neurjih na severovzhodu države, suhem septembru ter po izdatnih decembrskih padavinah s poplavami v osrednji, južni in zahodni Sloveniji. Decembra je bilo dolgoletno povprečje mesečnih padavin preseženo v vseh slovenskih pokrajinah, največ padavin pa so izmerili v zahodnem delu države. Decembra je prevladovalo oblačno vreme in sonca je povsod, zlasti pa v jugovzhodnem delu države primanjkovalo. Začetek meseca je bil zmerno namočen, v srednjem delu meseca je bila količina padavin celo podpovprečna, v zadnji tretjini decembra pa so bile padavine zelo izdatne. Glavnina padavin je padla med 21. in 26. decembrom. V Posočju so dosegli celo rekordne dnevne padavine. Na Žagi so decembra izmerili kar 844 mm padavin.

V Postojni je padlo 434 mm padavin, v Biljah 291 mm, na Kredarici 274 mm, v Portorožu pa 203 mm. Tudi v Ljubljani je bil presežek padavin nad 80 odstotkov. Poleg močnega deževja so bile za zadnjo tretjino decembra značilne tudi nadpovprečno visoke temperature, ki so v nižinah ponekod presegle 10 °C. Taljenje snega zaradi visokih temperatur in obilne padavine so povzročale izredno povečanje pretokov rek in obsežne poplave, ki so imele neprijetne posledice predvsem na poplavnih ravnicah in v naseljih ob rekah.

Extreme precipitation events

The year 2009 shall be remembered mainly for heavy precipitation in March in the Soča and Vipava river basins, severe thunderstorms in June and August in the north-east of the country, a dry September, and for heavy precipitation in December with floods in central, southern and western Slovenia. In December, the multi-annual average of precipitation was exceeded in all Slovenian regions. The highest levels were recorded in the western part of the country. December was overcast most of the time, and there was a lack of sunshine across the country, in particular in the south-east of Slovenia. At the beginning of the month, moderate precipitation was recorded, in the middle of the month the precipitation level was below the average, while in the last third of the month precipitation was abundant. The majority of precipitation fell from 21 to 26 December. Posočje reached record values of daily precipitation. During that month, the Žaga gauging station recorded as much as 844 mm of precipitation.

Postojna received 434 mm of precipitation, Bilje 291 mm, Kredarica 274 mm and Portorož 203 mm. In Ljubljana, too, the precipitation surplus exceeded 80 %. In addition to strong winds, the last third of December had also above-average temperatures, which even exceeded 10 °C in some lowland areas. The melting of snow due to high temperatures and abundant precipitation caused an extreme increase in the discharge of rivers and extensive floods with negative consequences, in particular in wetlands exposed to flood and in settlements along rivers.

Preglednica 1: Višina decembrskih padavin 2009 in odstopanje od dolgoletnega povprečja
Table 1: December 2009 precipitation levels and deviation from the multi-annual average

Postaja / Station	Padavine / *Precipitation* (mm)	Odstopanje od povprečja / *Precipitation anomaly* (%)
Portorož	203	150
Bilje	291	147
Kredarica	274	128
Ljubljana	185	83
Novo mesto	104	40
Murska Sobota	54	20

Temperatura zraka in sončno obsevanje

Večina mesecev v letu 2009 je bila nadpovprečno topla. Najbolj so izstopali april, maj, avgust in november, v zahodni Sloveniji pa tudi september. Povprečna temperatura leta 2009 je bila nad dolgoletnim povprečjem, saj je bilo povsod po državi topleje od dolgoletnega povprečja (slika 4). V Ljubljani je povprečna letna temperatura znašala 11,7 °C, v Murski Soboti 10,2 °C, na Kredarici –0,8 °C, na Obali pa 14,1 °C. Odkloni mesečnega povprečja temperature so bili razen zimskih mesecev v zahodni Sloveniji opazno nad dolgoletnim povprečjem. Največji odklon je bil aprila v Murski Soboti (3,6 °C), najhladnejši v

Air temperature and solar radiation

In 2009, most months were unusually warm. April, May, August and November stood out especially, and also September in western Slovenia. The 2009 average temperatures exceeded the multi-annual average across the country (Figure 4). The average annual temperature recorded in Ljubljana was 11.7 °C, in Murska Sobota 10.2 °C, on Kredarica -0.8 °C, and at the coast 14.1 °C. The monthly average temperature deviations, save for the winter months, were significantly above the multi-annual average. The greatest deviation was recorded in April in Murska Sobota (3.6 °C), while the coldest month compared to primerjavi z dolgoletnim povprečjem pa je bil februar na Kredarici (slika 5).

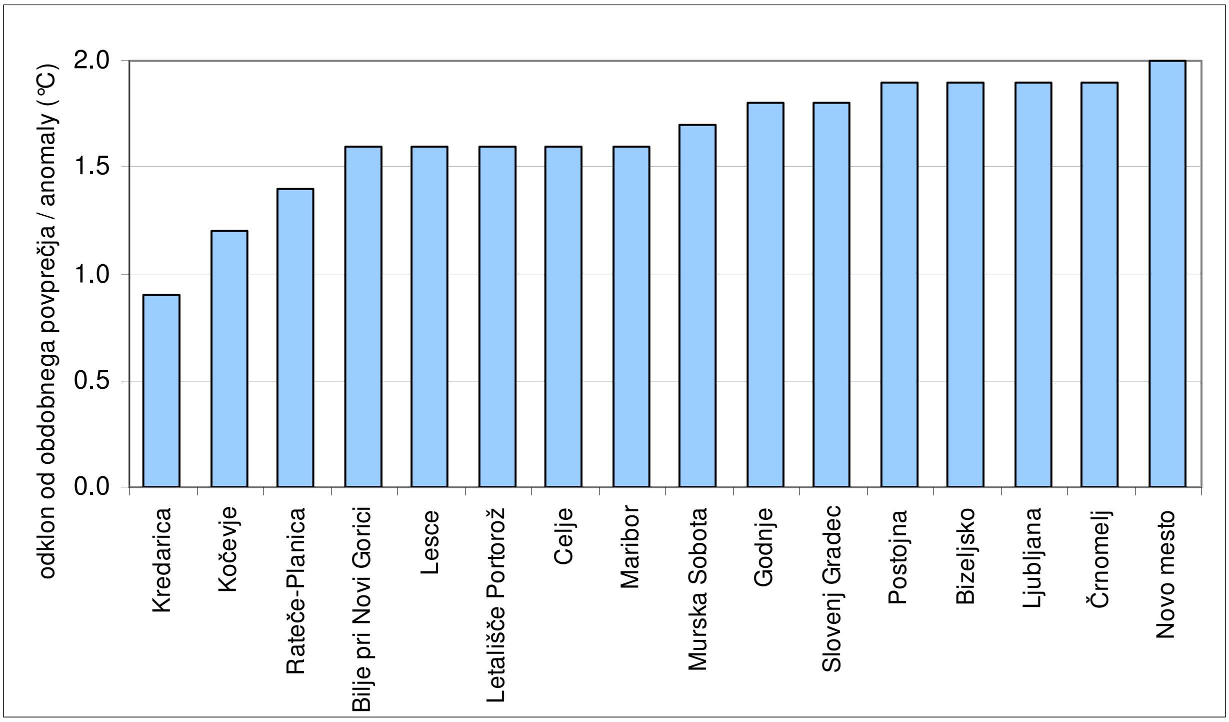
Povprečna najnižja temperatura zraka je prav tako presegla dolgoletno povprečje. Največji odklon je bil dosežen na Krasu (2,6 °C), najmanjši pa v Črnomlju (1 °C). Nad dolgoletnim povprečjem je bila tudi povprečna najvišja temperatura. V večini krajev so izmerili 1 do 2 °C višje temperature kot v dolgoletnem povprečju. Največji odklon je bil na Krasu in Bizeljskem, najmanjši pa na Kredarici. Najvišja temperatura je bila v letu 2009 izmerjena v Biljah pri Novi Gorici (35,4 °C) ter v Črnomlju, na Bizeljskem in v Mariboru (35 °C). Najnižjo temperaturo so izmerili na Kredarici (–23,1 °C) ter v Radečah, Črnomlju, Celju in Murski Soboti (–21 °C).

Pri trajanju sončnega obsevanja podobno kot pri temperaturah v dolgoletnem obdobju opazimo trend naraščanja. Leto 2009 je bilo sončnejše kot običajno. Dolgoletno povprečje je bilo preseženo v vseh pokrajinah, najbolj pa v osrednji Sloveniji. V Ljubljani dosegamo že trinajsto leto zapored nadpovprečno trajanje sončnega obsevanja; sonce je sijalo 1970 ur, kar je za 15 odstotkov več od dolgoletnega povprečja. Največji primanjkljaj sončnega obsevanja se je junija pokazal v visokogorju, novembra na Primorskem in decembra na Dolenjskem.

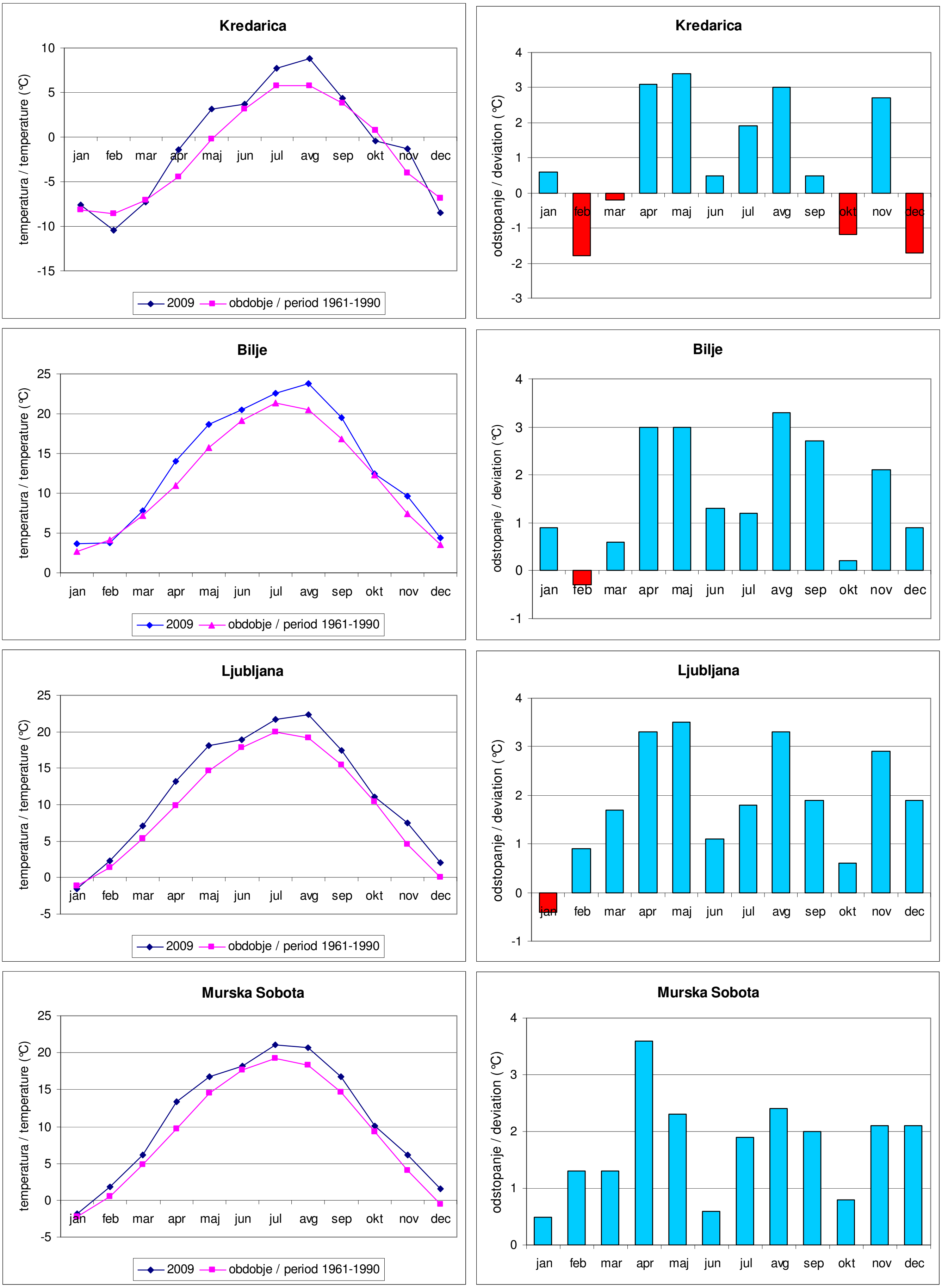
the multi-annual average was recorded in February on Kredarica (Figure 5).

The average lowest air temperature also exceeded the multi-annual average. The greatest deviation was recorded in the Karst (2.6 °C), whereas the lowest in Črnomelj (1 °C). The average highest temperature also exceeded the multi-annual average. The temperatures recorded at most places were 1 to 2 °C higher than the multi-annual average. The highest deviation was recorded in the Karst and in Bizeljsko, while the lowest deviation was recorded on Kredarica. In 2009, the highest temperatures were recorded in Bilje pri Novi Gorici (35.4 °C) and in Črnomelj, Bizeljsko and Maribor (35 °C).) The lowest temperatures were recorded on Kredarica (-23.1 °C) and in Radeče, Črnomelj, Celje and Murska Sobota (-21 °C).

An increased duration of solar radiation could be observed, which was similar to the temperature tendencies in the multi-annual reference period. The year 2009 had more sunny days than usual. The multi-annual average was exceeded in all regions and particularly in central Slovenia. The year 2009 has been the thirteenth consecutive year with above-average duration of solar radiation in Ljubljana, recording 1 970 hours of sunlight, which is 15 % more than the multi-annual average. The lowest level of solar radiation was recorded in June in the high mountain area, in November in the coastal region and in December in the Dolenjska region.



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



Slika 5: Povprečna mesečna temperatura zraka v letu 2009 v primerjavi s povprečjem obdobja 1961–1990 in mesečno odstopanje temperature v letu 2009 od povprečja obdobja 1961–1990
Figure 5: Average monthly air temperature in 2009 compared to the 1961–1990 reference period average and monthly temperature deviation in 2009 from the 1961–1990 reference period average

A.POVRŠINSKE VODE

VODOSTAJI IN PRETOKI REK

Igor Strojan

Opis hidrološkega stanja v letu 2009 je narejen na podlagi analize preverjenih podatkov petnajstih izbranih reprezentativnih vodomernih postaj. Te so nekako enakomerno porazdeljene po celotnem območju države. Izbor vključuje večje in manjše vodotoke, reke s hudourniško in kraško naravo ter tudi reke, pri katerih je naravni režim spremenjen zaradi obratovanja hidroelektrarn. Uporabljeni podatki so skupaj s podatki o merilnih postajah ter dodatnimi statističnimi podatki, kot so npr. povratne dobe pretokov, objavljeni v preglednicah površinskih voda v drugem delu te publikacije. V poglavju o primerjavi značilnih pretokov z dolgoletnim obdobjem se primerjave pretokov nanašajo na dolgoletni niz podatkov 1971–2000. V poglavju o mesečnih deležih letnih pretokov in pretočnih režimih so obravnavana odstopanja od splošno znanih pretočnih režimov posameznih rek, ki so sicer v Sloveniji dokaj različni. Značilen primer je npr. pretočni režim reke Mure, ki se napaja v avstrijskem visokogorju in je zato njena vodnatost v primerjavi z večino drugih rek, katerih vodnatost je največja pomladi in jeseni, največja v poletnem obdobju. V zadnjem poglavju, v katerem je opisan kronološki pregled razmer na rekah v posameznih mesecih leta, je opis razmer povzet iz prispevkov o pretokih rek, ki so objavljeni v mesečnih biltenih Agencije Republike Slovenije za okolje Naše okolje (http://www.arso.gov.si/). Fotografije so večinoma delo sodelavcev ARSO, ki opravljajo dodatne hidrološke meritve ali vzdržujejo merilno opremo na vodomernih postajah.

Leto 2009 je v celoti nadpovprečno vodnato leto. V povprečju je bila vodnatost rek leta 2009 za 11 odstotkov večja kot v dolgoletnem primerjalnem obdobju. Značilni za to leto so večja vodnatost v prvih štirih mesecih, izostanek vodnatosti v jesenskih mesecih in izredno vodnat december, v katerem so reke tudi močno poplavljale. Padavine in delno taljenje v dneh od 23. do 27. decembra so povzročili eno večjih povodenj v zadnjih letih. Hidrološke razmere ob poplavah so podrobneje opisane v naslednjem prispevku.

Geografsko je bila celotna letna vodnatost porazdeljena na dva dela, na bolj vodnat severni in zahodni del države vključno z reko Muro ter na manj vodnati južni in jugozahodni del države. V prvem delu so bili povprečni letni pretoki od 20 do 30 odstotkov večji od dolgoletnega povprečja, v drugem delu pa od 10 do 20 odstotkov manjši (slika 1). Največ vode je preteklo po Muri, 43 odstotkov več kot navadno,

A. SURFACE WATERS

WATER LEVELS AND RIVER DISCHARGES

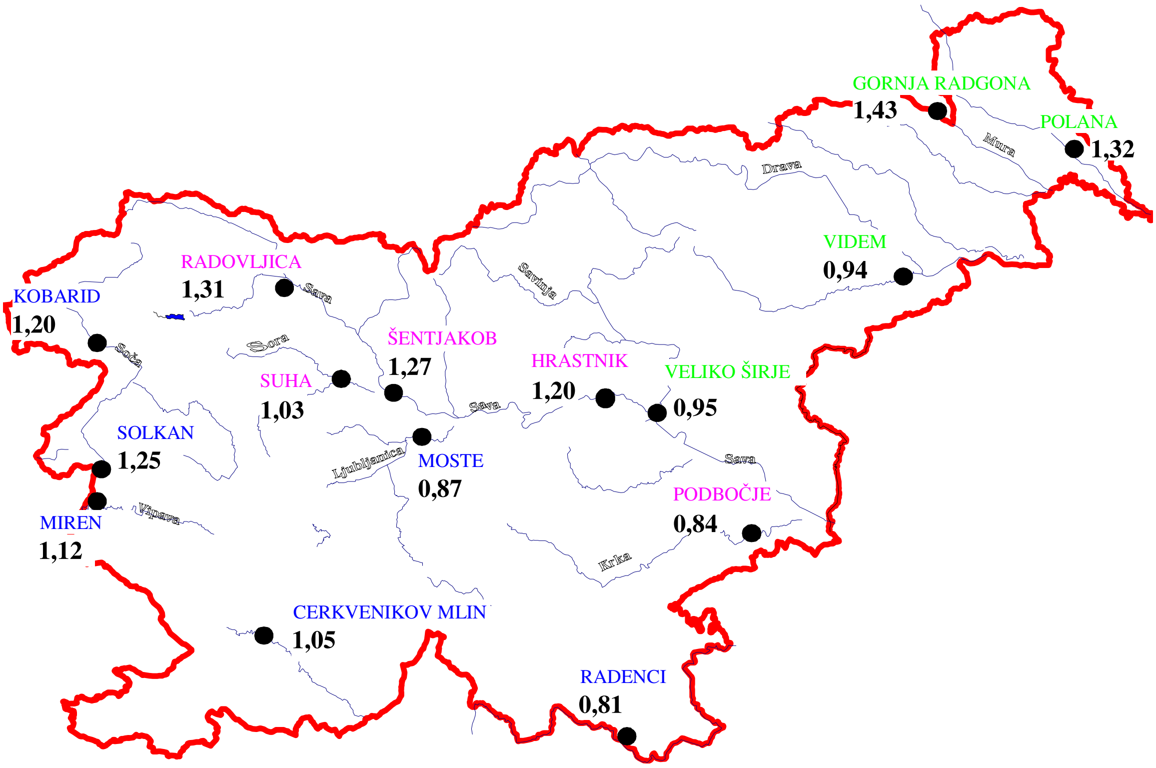
Igor Strojan

This description of hydrological conditions for 2009 was prepared on the basis of the data analysis for 15 selected representative water gauging stations, which are more or less evenly distributed on the entire territory of the Republic of Slovenia. The selection includes major and minor watercourses, rivers with torrential and karstic characteristics, as well as rivers for which the natural regime was changed due to the operation of hydroelectric power plants. The data used, along with the data on gauging stations and additional statistical data, such as return periods of discharges, are presented in the surface water tables in the second part of this publication. In the chapter on the comparison of characteristic discharges with the multi-annual reference period, the comparisons of discharges refer to the multi-annual data series covering the 1971–2000 period. The chapter on monthly shares of annual discharges and discharge regimes describes deviations from generally known discharge regimes of individual rivers, which are quite diverse in Slovenia. A characteristic example is the discharge regime of the Mura river, which is supplied by water from the Austrian high mountain range and thus its water stage is the highest in the summer period. The majority of other rivers has the water stages the highest in spring and autumn. In the last chapter, containing a chronological overview of conditions on rivers in individual months of the year, the description of the conditions is summarised from contributions on river discharges published in the monthly bulletins of the agency, Naše okolje (http://www.arso.gov.si). The photographs are mainly the work of the experts from the agency performing additional hydrological measurements or maintaining the gauging equipment at the water gauging stations.

In 2009, above average water levels were recorded. The average annual river stage in 2009 was 11 % higher if compared to the average stage during the multi-annual reference period. The year 2009 was characterised by higher water stages in the first four months, a shortage in water stages in the autumn months and abundant river stages in December, when the rivers flooded extensively. Precipitation and snow melting from 23 to 27 December caused one of the most extensive floods of Slovenian rivers in history. Hydrological conditions during floods are described in more detail in the following contribution to the yearbook.

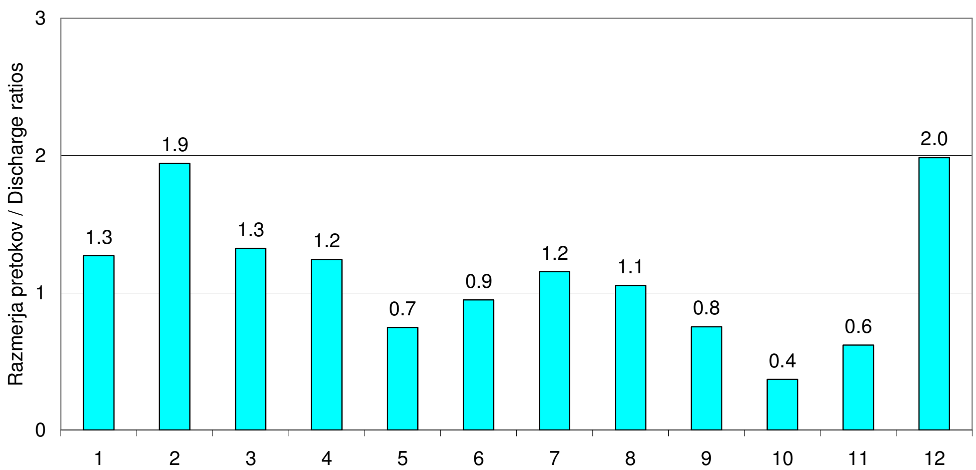
Geographically, the total annual river stage was distributed as follows: higher river stages were najmanj pa po Kolpi, 19 odstotkov manj kot navadno.

recorded in the northern and western parts of the country including the Mura river and lower river stages were recorded in the southern and south-western parts of the country. In the northern and western parts of the country the average annual river discharge was 20 % to 30 % higher in comparison to the multi-annual average, while in the southern and south-western parts it was 10 % to 20 % lower in comparison to the multi-annual average (Figure 1). The highest river discharge was recorded on the Mura river, which was 43 % above the usual average, while the lowest river discharge was recorded on the Kolpa river, i.e. 19 % below the usual average.



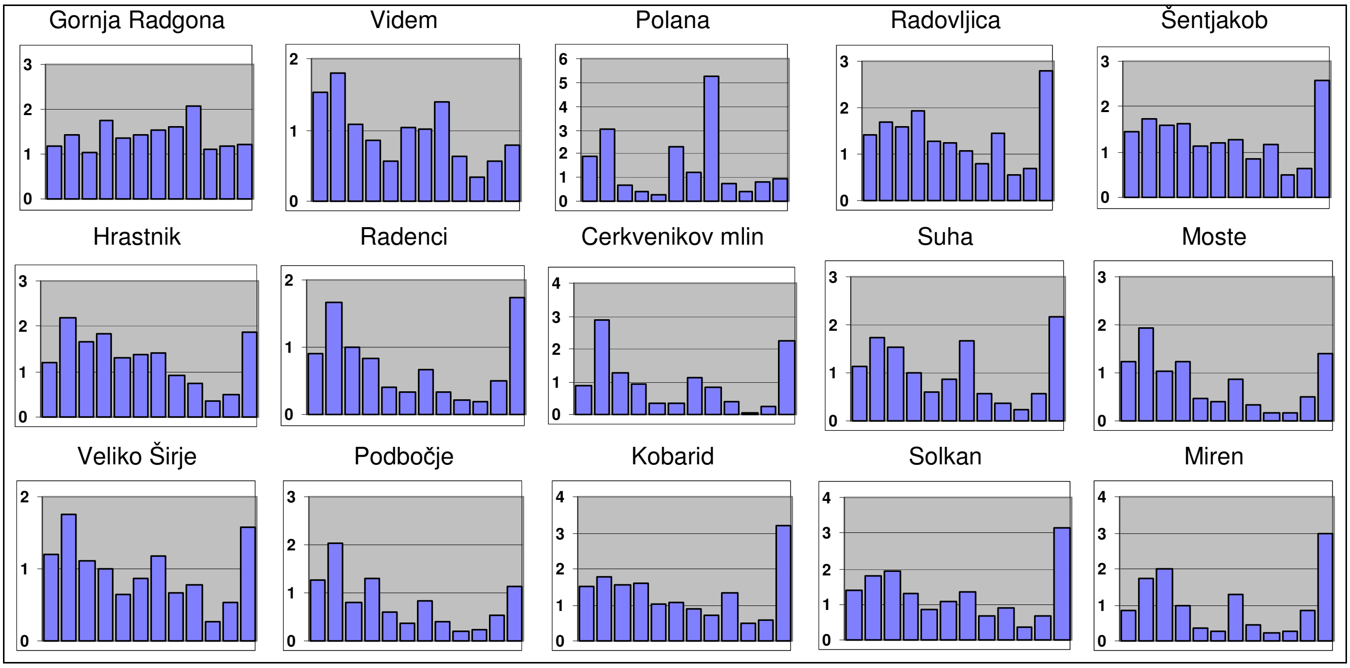
Slika 1: Razmerja med srednjimi letnimi pretoki leta 2009 in srednjimi letnimi pretoki v dolgoletnem obdobju 1971–2000 na slovenskih rekah

Figure 1: Ratios between mean annual discharges in 2009 and mean annual discharges in the multi-annual period (1971–2000) on Slovenian rivers

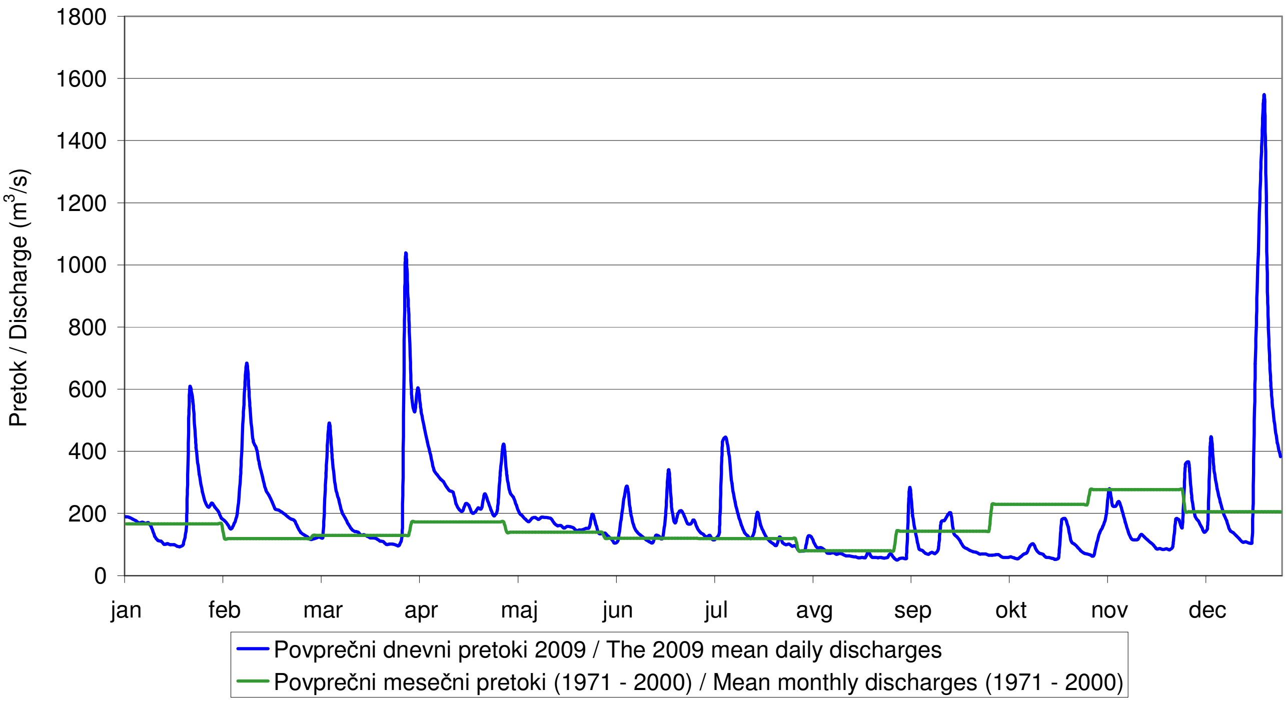


Slika 2: Razmerja med srednjimi mesečnimi pretoki v letu 2009 in obdobnimi srednjimi mesečnimi pretoki. Razmerja so izračunana kot povprečja razmerij na izbranih postajah (glej sliko 1)

Figure 2: Ratios between mean monthly discharges in 2009 and periodical mean monthly discharges. The ratios are calculated as an average of ratios at selected stations (see Figure 1)



Slika 3: Razmerja med srednjimi mesečnimi pretoki rek v letu 2009 in obdobju 1971–2000. Vrednost razmerja 1 pomeni, da je bil v določenem mesecu leta 2009 srednji mesečni pretok enak povprečju srednjih mesečnih pretokov v dolgoletnem obdobju.
Figure 3: Ratios between mean monthly river discharges in 2009 and in the 1971–2000 reference period. Ratio value 1 means that the mean monthly discharge in a certain month in 2009 is equivalent to the average mean monthly discharges in the multi-annual reference period.



Slika 4: Srednji dnevni pretoki v letu 2009 in srednji mesečni pretoki v dolgoletnem obdobju 1961–2000 na reki Savi v Hrastniku. Sava je bila v letu 2009 med bolj vodnatimi rekami. Na merilnih postajah Radovljica, Šentjakob in Hrastnik je bilo dolgoletno povprečje vodnatosti preseženo za 31, 27 in 20 odstotkov.
Figure 4: Daily mean discharges in 2009 and monthly mean discharges in the multi-annual reference period (1961–2000) on the Sava river in Hrastnik. In 2009 the Sava river was among the rivers with the highest discharges. The gauging stations Radovljica, Šentjakob and Hrastnik recorded discharge values that exceeded the multi-annual average by 31 %, 27 % and 20 % respectively.

Primerjava značilnih pretokov z dolgoletnim obdobjem

Največji pretoki vseh obravnavanih merilnih mest so bili v povprečju 34 odstotkov večji kot v dolgoletnem primerjalnem obdobju (slika 5 in preglednica 1). Pretoki so bili večinoma največji od 23. do 26. decembra, ko so reke močneje poplavljale. V zgodnjem pomladanskem času 30. marca so imele največje pretoke reke Dravinja, Ljubljanica, Krka in Vipava. Mura je imela skladno s svojim vodnim režimom največji pretok 25. junija.

Srednji letni pretoki rek so v povprečju 11 odstotkov večji od dolgoletnega povprečja. Celoletna vodnatost na Muri, Savi Soči je bila med najvišjimi v primerjalnem obdobju.

Najmanjši pretoki v letu so bili za tri odstotke manjši od srednjih malih obdobnih pretokov iz dolgoletnega primerjalnega obdobja. Pretoki so bili najmanjši avgusta, septembra in oktobra. Mura je imela najmanjši pretok 11. januarja. Najmanjši pretoki v letu 2009 so bili izmerjeni na merilnih mestih Podbočje na Krki, Polana na Ledavi in Cerkvenikov mlin na reki Reki, kjer so bili pretoki 56, 55 in 47 odstotkov manjši od srednjih malih obdobnih pretokov.

Mesečni deleži letnih pretokov leta 2009 in pretočni režimi

Mesečni deleži letnih pretokov so bili v prvih štirih mesecih leta večji od mesečnih deležev pretokov v obdobju 1971–2000. Od maja do novembra so bili deleži večinoma manjši kot navadno, pri čemer so bila odstopanja najmanjša v poletnih mesecih. Decembra, ko so bile reke zelo vodnate, je bil mesečni delež pretokov nekoliko manj kot enkrat večji od dolgoletnega povprečja (slika 6).

Primanjkljaji niso bili nikjer večji od 11 odstotkov. Gibali so se med 6 in 9 odstotki, na Muri so bili 2 odstotka in na Reki 11. Presežki so bili večji, in sicer od 2 odstotkov na Muri do 21 odstotkov na Vipavi (slika 7).

Comparison of characteristic discharges with the multi-annual reference period

On average, **the highest river discharges** at the selected gauging sites were 34% higher compared to the multi-annual reference period (Figure 5 and Table 1). The discharges were mostly the highest from 23 to 26 December, when the rivers flooded excessively. In early spring (30 March), the highest discharges were recorded on the Dravinja, Ljubljanica, Krka and Vipava rivers. The Mura river recorded the highest discharge on 25 June, which corresponded to its water regime.

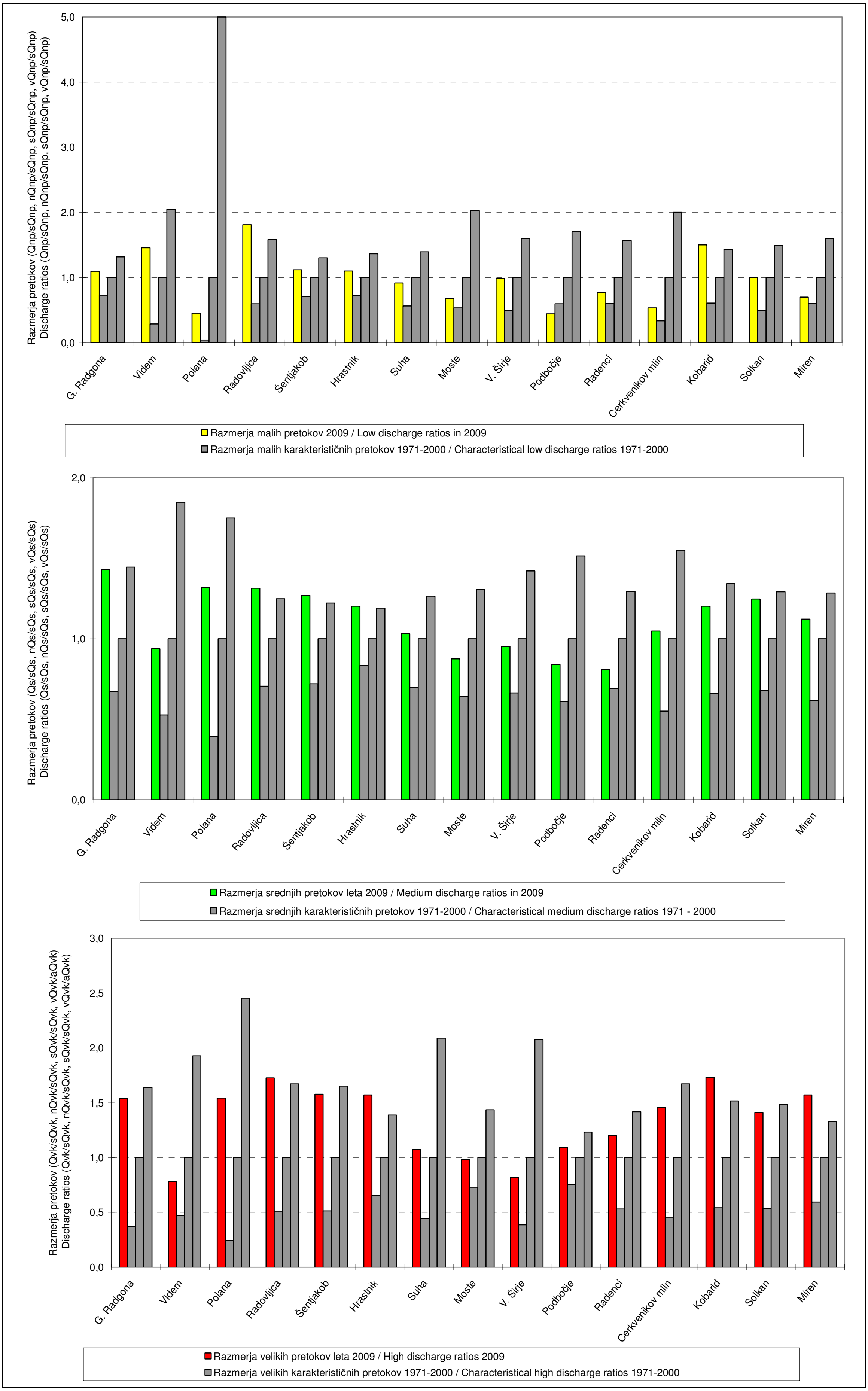
The mean annual river discharges exceeded the multi-annual average by 11%. Throughout the year, the river stages of the Mura, Sava and Soča rivers were among the highest in the reference period.

The lowest annual discharges were 3% lower compared to the mean low periodical discharges in the multi-annual reference period. The lowest discharges were recorded in August, September and October. The lowest discharge on the Mura river was recorded on 11 January. The lowest discharges in 2009 were recorded at the following gauging sites: Podbočje on the Krka river, Polana on the Lendava river, and Cerkvenikov Mlin on the Reka river. They were 56%, 55% and 47% lower than the mean low periodical discharges.

Monthly shares of annual discharges in 2009 and discharge regimes

In the first four months of the year the monthly shares of annual discharges exceeded the monthly shares recorded in the 1971–2000 reference period. From May to November the shares were in most cases lower than usual. The smallest deviations were recorded in the summer months. In December, with the rivers at a high water stage, the monthly share of discharges exceeded the multi-annual average slightly less than twice (Figure 6).

The shortages did not exceed 11% anywhere. They ranged from 6% to 9% on average, on the Mura river 2% and on the Reka river 11%. Surpluses were higher, i.e. from 2% (on the Mura river) up to 21% (on the Vipava river) (See Figure 7).

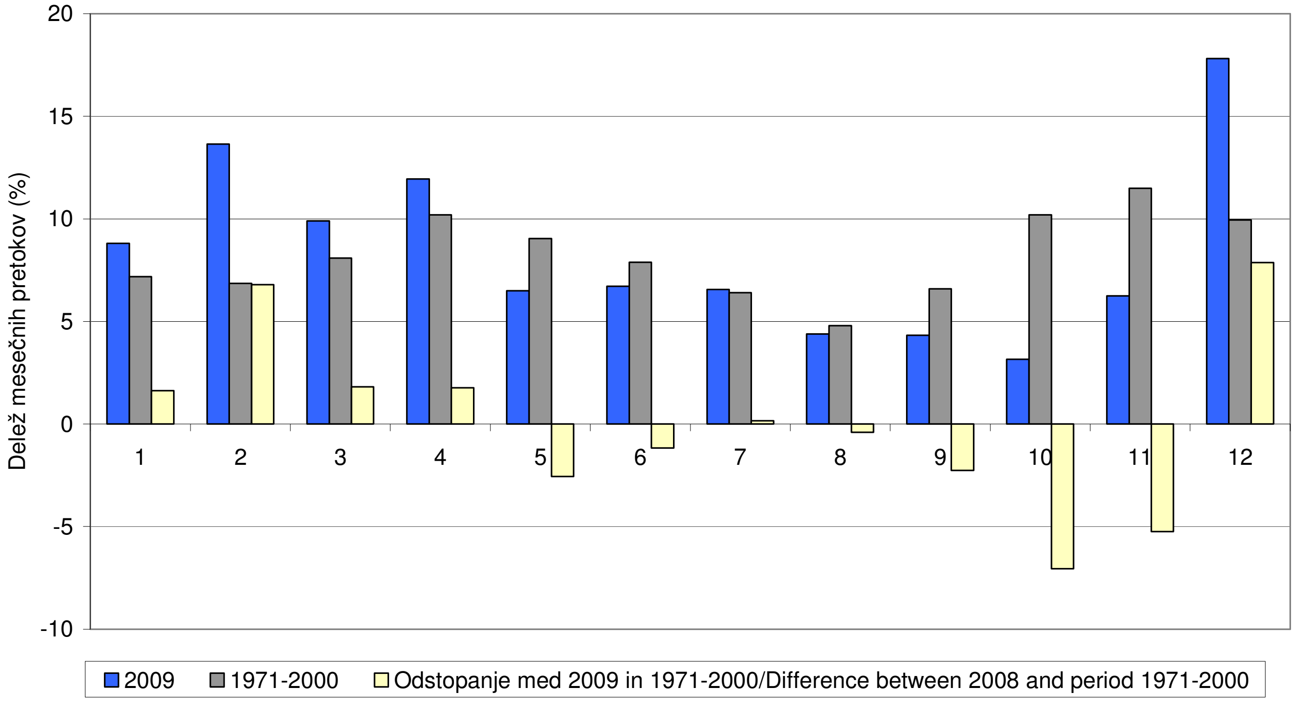


Slika 5: Razmerja malih, srednjih in velikih pretokov v letu 2009 ter razmerja značilnih pretokov obdobja 1971–2000. Vrednosti so prikazane relativno glede na srednje vrednosti malih, srednjih in velikih obdobnih pretokov.
Figure 5: Ratios of low, mean and high discharges in 2009 and ratios of characteristic discharges during the 1971–2000 reference period. The values are relative with regard to the average values of low, mean and high periodical discharges.

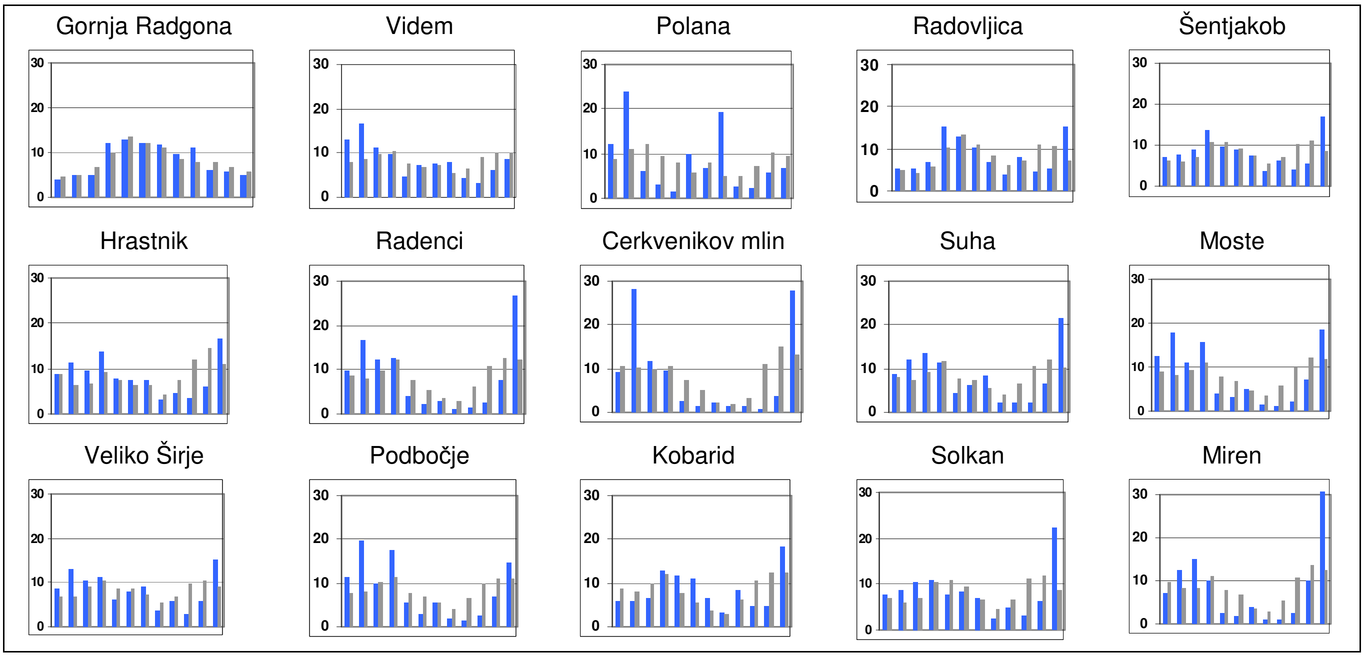
Preglednica 1: Značilni pretoki v letu 2009 in obdobju 1971–2000
Table 1: Characteristic discharges in 2009 and in the 1971–2000 reference period

Reka *River*	**Postaja** *Station*	**2009** **Qnp** m^3/s	Dan	**1971 – 2000** **nQnp** m^3/s	**sQnp** m^3/s	**vQnp** m^3/s
Mura	Gornja Radgona	68,1	11.1.	45,3	62,1	81,7
Dravinja	Videm	3,1	9.10.	0,6	2,1	4,3
Ledava	Polana	0,05	1.10.	0,004	0,1	0,5
Sava	Radovljica	15,2	30.8.	5,0	8,4	13,3
Sava	Šentjakob	30,3	1.9.	19,1	27,1	35,3
Sava	Hrastnik	50,2	1.9.	32,8	45,6	62,2
Sora	Suha	3,5	8.10.	2,14	3,8	5,3
Ljubljanica	Moste	5,2	1.10.	4,1	7,7	15,6
Savinja	Veliko Širje	9,3	29.8.	4,7	9,5	15,2
Krka	Podbočje	4,6	22.10.	6,2	10,4	17,7
Kolpa	Radenci	4,4	29.8.	3,5	5,8	9,1
Reka	Cerkvenikov mlin	0,3	8.10.	0,2	0,6	1,2
Soča	Kobarid	11,4	21.10.	4,6	7,6	10,9
Soča	Solkan	19,5	21.8.	9,6	19,6	29,3
Vipava	Miren	1,4	7.9.	1,2	2	3,2
		Qs		**nQs**	**sQs**	**vQs**
Mura	Gornja Radgona	219		103	153	221
Dravinja	Videm	10,5		5,9	11,2	20,7
Ledava	Polana	1,6		0,47	1,2	2,1
Sava	Radovljica	56,6		30,4	43,1	53,8
Sava	Šentjakob	108		61,2	85,1	104
Sava	Hrastnik	190		132	158	188
Sora	Suha	19,9		13,5	19,3	24,4
Ljubljanica	Moste	48,6		35,7	55,6	72,5
Savinja	Veliko Širje	41,9		29,2	44	62,5
Krka	Podbočje	43,5		31,7	51,9	78,6
Kolpa	Radenci	41,0		35,1	50,7	65,6
Reka	Cerkvenikov mlin	8,2		4,3	7,8	12,1
Soča	Kobarid	39,8		21,9	33,1	44,4
Soča	Solkan	112		60,9	89,8	116
Vipava	Miren	19,4		10,7	17,3	22,2
		Qvk		**nQvk**	**sQvk**	**vQvk**
Mura	Gornja Radgona	1130	25.6.	273	735	1205
Dravinja	Videm	118	30.3.	71.1	151	291
Ledava	Polana	51	4.8.	8	32.8	80.5
Sava	Radovljica	709	25.12.	208	411	687
Sava	Šentjakob	1358	25.12.	442	861	1422
Sava	Hrastnik	1888	25.12.	786	1202	1668
Sora	Suha	353	25.12.	147	329	687
Ljubljanica	Moste	277	30.3.	206	282	405
Savinja	Veliko Širje	588	26.12.	278	717	1490
Krka	Podbočje	315	3.4.	217	289	356
Kolpa	Radenci	804	23.12.	355	669	949
Reka	Cerkvenikov mlin	266	3.2.	83.3	183	305
Soča	Kobarid	759	25.12.	237	438	664
Soča	Solkan	2290	23.12.	747	1391	2066
Vipava	Miren	377	30.3.	143	240	319

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



Slika 6: Mesečni deleži letnih pretokov v odstotkih v letu 2009 in obdobju 1971–2000. Na grafu je prikazano tudi odstopanje mesečnih deležev pretokov v letu 2009 od mesečnih deležev v obdobju 1971–2000.
Figure 6: Monthly shares of annual discharges in percentages for 2009 and the 1971–2000 reference period. The graph also shows deviations of monthly discharge shares in 2009 from monthly discharge shares in the 1971–2000 reference period.



Slika 7: Deleži mesečnih pretokov v letu 2009 (modri stolpci) in obdobju 1971–2000 (sivi stolpci) kot ponazoritev odstopanj od ustaljenih režimov pretokov rek na izbranih reprezentativnih merilnih mestih v letu 2009
Figure 7: Shares of monthly discharges in 2009 (blue columns) and in the 1971–2000 reference period (grey columns) to illustrate deviations from the normal river discharge regimes at selected representative gauging sites in 2009

Kronološki pregled hidroloških razmer na rekah v posameznih mesecih leta

V povprečju so bili pretoki rek **januarja** le nekoliko večji kot navadno v tem obdobju. Večji prvi del meseca so bili pretoki majhni, pozneje so se zaradi obilnejših padavin in taljenja snega povečali. V manjšem obsegu

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

On average, in **January** the river discharges slightly exceeded the discharges that are usual during that period. At the beginning of the month small discharges so poplavljale reke Ljubljanica, Krka, Mestinjščica, Sotla in Dravinja. Večjih odstopanj od mesečnih značilnih pretokov ni bilo. Najmanjši pretoki v mesecu so bili v povprečju deset odstotkov manjši kot v primerjalnem dolgoletnem obdobju. Visokovodne konice so bile le nekoliko nadpovprečne za januar.

were recorded, whereas later during the month they increased due to abundant precipitation and snow melting. Minor floods were caused by the Ljubljanica, Krka, Mestinjščica, Sotla and Dravinja rivers. There were no major deviations from the typical monthly discharges. The lowest monthly discharges were on average 10 % lower compared to the multi-annual reference period. The high-water peaks were slightly above the January average.

Meritev pretoka na Radoljni 7. januarja 2009 (foto: arhiv ARSO)
Discharge measurement on the Radoljna stream on 7 January 2009 (Photo: Agency archives)

Vodnatost rek je bila **februarja** obilna. Pretoki so bili v povprečju 84 odstotkov večji kot navadno. K obilni vodnatosti so največ prispevala povečanja pretokov od 7. do 9. februarja. Pretoki so bili veliki v večjem delu države. Na pojav velikih pretokov je močno vplivalo taljenja snega. Več rek je prestopilo bregove. Poplavljale so Ljubljanica, Krka in večina manjših rek v severovzhodnem delu države (Ščavnica, Rogatnica, Pesnica), katerih pretoki so imeli ob visokovodnih konicah tudi 10- in večletno povratno dobo. **Marca** je bila vodnatost rek 30 odstotkov večja kot v dolgoletnem primerjalnem obdobju. Sicer so bili pretoki večji del meseca majhni, vendar sta dva porasta pretokov, od katerih je bil predvsem drugi 30. in 31. marca zelo velik, povprečno mesečno vodnatost povečala nad dolgoletno povprečje. Visokovodne konice pretokov ob koncu meseca so bile v povprečju skoraj enkrat večje kot navadno v tem mesecu. Od 40 do 200 mm padavin, katerih količina je bila manjša v najbolj vzhodnih delih države, je povzročila močan porast pretokov rek. Od večjih rek so poplavljale Vipava, Ljubljanica, Gradaščica, Dravinja v spodnjem toku, Rogatnica in Kolpa. Najbolj je poplavljala Vipava. Povratna doba visokovodne konice pretoka na Vipavi v Mirnu 378 m^3/s je imela 50- do 100-letno povratno dobo. Največ škode so poplave naredile na Vipavskem in Goriškem.

In **February** the river stages were abundant. On average, discharges were 84 % higher than usual. The increase of discharges from 7 to 9 February mostly contributed to the increased water stages. The discharges were high in most parts of the country. The occurrence of high discharges was mainly the result of the snow cover melting. Many rivers breached their banks. The Ljubljanica and Krka rivers and most of the small rivers in the northeast of the country (Ščavnica, Rogatnica, Pesnica) flooded. At high-water peaks, their discharges achieved a 10-year and multi-annual return period. In **March** the water stages were 30 % above the multi-annual reference period. For most of the month, the discharges were low; however, they increased two times, in particular on 30 and 31 March, which caused the average monthly water stage to exceed the multi-annual average. By the end of the month, high-water peaks were almost twice as high as the usual high-water peaks in March; 40 to 200 mm of precipitation, of which the lowest quantity was recorded in the eastern-most parts of the country, caused a strong increase in the discharge of the rivers. Floods were caused by larger rivers, such as the Vipava, Ljubljanica, Gradaščica, the Dravinja in its lower reach, Rogatnica and Kolpa. The strongest flood was caused by the Vipava river. The high-water peak discharge on the Vipava river in Miren reached 378 m^3/s, which means a discharge level with a 50- to 100-year return period. The flood caused most damage in the Vipava valley and the Goriška region.

Poplavljanje Vipave pri Dornberku 30. marca 2009 (foto: ARSO)
The flood caused by the Vipava river near Dornberk on 30 March 2009 (Photo: Agency archives)

V celoti gledano je bil **april** nadpovprečno vodnat mesec. Pretoki so bili 24 odstotkov večji kot navadno v aprilu. K nekoliko večji aprilski vodnatosti so prispevali visoki pretoki rek v začetku meseca in večja vodnatost rek, ki se napajajo v visokogorju. Vodnatost je povečevalo tudi taljenje snega. Pretoki rek v vzhodnem delu države so bili manjši kot drugje. Po zvišanju pretokov v začetku **maja** se je vodnatost večji del meseca zmanjševala. Pretoki so bili maja v povprečju 20 odstotkov manjši od povprečnih majskih pretokov primerjalnega obdobja. Največ vode je preteklo po Dravi in Muri ter Savi v zgornjem in srednjem toku. Pretoki v južnem delu države so bili tudi več kot polovico manjši kot navadno v maju.

Junija so bili pretoki rek manjši kot v primerjalnem obdobju. V južnem delu države so bili pretoki polovico manjši kot navadno, v severnem delu države pa povprečni ali večji kot navadno. Mura je poplavljala znotraj visokovodnih nasipov. Večkrat so se močneje povečali pretoki manjših vodotokov. **Julija** ni bilo večjih odstopanj od dolgoletnih povprečnih pretokov. Po rekah je v celoti preteklo 11 odstotkov več vode kot navadno v juliju. Najmanjši pretoki v mesecu so bili povprečni, kar kaže na to, da večdnevnih sušnih obdobij ni bilo. Porasti pretokov so bili večinoma majhni. **Avgusta** se je vodnatost rek zmanjšala. Pretoki rek so bili najmanjši na kraških rekah Ljubljanici in Krki. Več kot polovico manj vode kot navadno je preteklo po koritih Soče in Vipave. V severovzhodnem delu države so bili pretoki večji kot v dolgoletnem avgustovskem obdobju. **September** je bil hidrološko suh mesec. Po strugah slovenskih rek je v povprečju preteklo 30 odstotkov manj vode kot navadno. **Oktober** je bil zelo malo vodnat. V povprečju je po rekah preteklo le 35 odstotkov tiste količine vode, ki je sicer

Overall, **April** had above average water stages. The discharges were 24 % higher than the usual discharges in April. High river discharges at the beginning of the month and higher water stages of rivers recharged in the high mountain area, contributed to slightly higher river stages. The river stages also increased due to the melting of the snow cover. River discharges in the eastern part of the country were smaller than in other parts. After the increase in the river discharges **in May**, the water stages decreased for most of the month. On average, discharges were 20 % lower compared to the multi-annual reference period in May. The highest water discharges were recorded on the Drava and Mura rivers, and on the Sava river in its upper and middle reaches. In the southern part of the country, the discharges were more than 50 % lower than usual in May.

In **June**, the river discharges were lower than in the reference period. In the southern part of the country, the discharges were 50 % lower than usual, whereas the northern part of the country had average discharges or higher discharges than usual. The Mura river flooded within the flood embankments. The discharges of smaller rivers and streams strongly increased. In **July**, there were no major deviations from the multi-annual discharges. The total river discharge was 11 % higher than usual in July. The lowest discharges were average, which indicates that there were no draught periods lasting several days. The discharges increased slightly. In **August**, the river stages decreased. The lowest river discharges were recorded on the Ljubljanica and Krka karst rivers. The river discharges on the Soča and Vipava rivers were more than 50 % lower than usual. In the north-eastern part of the country, the discharges were higher običajna v mesecu oktobru. Pretoki so se večinoma zmanjševali, povečanja pretokov so bila majhna. **November** je bil četrti zaporedni hidrološko suh mesec. Po rekah je preteklo le 55 odstotkov običajne količine vode za november. **Decembra** so padavine in delno taljenje v dneh od 23. 12. 2009 do 27. 12. 2009 povzročili eno večjih povodenj v zadnjih letih. Poplavljale so reke in jezera. Pojavljali so se zemeljski zdrsi in plazovi. Povodenj je prizadela večji del države, izvzet je bil le njen severovzhodni del. V petih dneh je ponekod padlo nad 500 mm, v alpskem svetu in na dinarski pregradi pa večinoma nad 200 mm padavin. Na območju Kobarida, Bovca, Vogla in Soče je 24-urna višina padavin 25. decembra presegla 200 mm. Poplavne konice na rekah so se pojavljale v dveh povezanih poplavnih obdobjih. V prvem obdobju 23. 12. 2009, ko se je stalila tudi snežna odeja v nižinah, debela do 15 cm, so poplavljale predvsem reke v zahodnem in osrednjem delu, v drugem obdobju 25. 12. 2009, ko so bile poplavne konice najvišje, pa tudi v južnem delu države. Rekordni pretok v dolgoletnem primerjalnem obdobju je imela Soča v Solkanu 2290 m^3/s. Pretoki Save v celotnem toku, Vipave, Save Bohinjke in Save Dolinke, Kolpe, Selške Sore, Tržiške Bistrice so imeli pet- in večletne povratne dobe pretokov. Izredno visoka je bila tudi gladina Bohinjskega jezera, ki je bila s 332 cm le 58 cm nižja od najvišje do tedaj izmerjene višine.

Podrobneje so hidrološke razmere na rekah po posameznih mesecih leta 2009 opisane v mesečnih biltenih Agencije Republike Slovenije za okolje.

Soča v maju (foto: Janez Polajnar)
Soča in May (Photo: Janez Polajnar)

compared to the multi-annual reference period (August). **September** was a hydrologically dry month. The average discharges of Slovenian rivers were 30 % lower than usual. In **October**, the river stages were very low. On average, the discharges recorded were only 35 % lower compared to the quantities of water, which are usual for October. Discharges, however, mostly decreased and only increased to a small extent. **November** was the fourth successive hydrologically dry month. The recorded river discharges reached only 55 % of the quantities that are usual for November. In **December**, precipitation and the melting of snow (in particular from 23 December to 27 December) caused one of the major floods in Slovenian history. Rivers and lakes flooded. Landslips and landslides occurred. The flood affected most part of the country, with the exception of its north-eastern part. During five days, some parts of the country received 500 mm of precipitation, while in the Alps and on the Dinaric barrier 200 mm of precipitation were recorded. In the area of Bovec, Kobarid, Vogel and Soča the 24-hour precipitation level exceeded 200 mm on 25 December. Flood peaks on rivers occurred during two connected flooding periods. In the first period, i.e. from 23 December 2009 onwards, when the up to 15 cm thick snow cover in the lowland areas melted, mostly the rivers in the western and central parts of the country flooded, whereas in the second period, i.e. from 25 December to 27 December 2009, when the flood peaks were the highest, floods also occurred in the south of the country. A record discharge in the multi-annual reference period was recorded on the Soča river in Solkan with 2290 m^3/s. The discharges of the Sava river in its upper, middle and lower reaches, the discharges of Vipava, Sava Bohinjka and Sava Dolinka, Kolpa, Selška Sora and Tržiška Bistrica had five- to multi-annual return periods. The level of Lake Bohinj was also extremely high. With its level of 332 cm, it was only 58 cm lower than the highest recorded level to date.

The hydrological conditions on rivers in individual months of the year 2009 are described in detail in the monthly bulletins of the agency.

Poplavljanje reke Save 25. in 26. decembra v spodnjem toku
The flooding of the Sava river on 25 and 26 December in its lower reach

VISOKE VODE REK IN POPLAVE

Janez Polajnar

Dve leti po katastrofalni hudourniški povodnji smo v Sloveniji med božičnimi prazniki leta 2009 doživeli obsežnejšo povodenj, ki je na srečo povzročila le gmotno škodo. Leta 2009 so bile visoke vode razporejene čez vse leto. Zaradi taljenja snega in izdatnih padavin so bile visoke vode že marca, obsežnejša povodenj je bila konec decembra. V poletnih mesecih so nastale hudourniške poplave. Reke so poplavile tudi na območjih, na katerih je ta pojav redek. Leta 2009 so Reka, Vipava, Pesnica, Soča, Sava v Zasavju in Bistrica v Bohinjski Bistrici ter gladina Bohinjskega jezera dosegle do zdaj najvišje izmerjene vrednosti pretokov in vodostaja v opazovalnem obdobju ali se jim približale, kar dokazuje silovitost vremenskih pojavov in poplav v tem letu.

Leta 2009 je bilo skupno 107 pojavov visokih voda, ko so reke na vodomernih postajah presegle opozorilne pretoke, gladina morja na mareografski postaji pa opozorilne vodostaje, ter ob tem poplavile. Leta 2009 je bilo število teh pojavov večje kot običajno, razporejeni so bili čez vse leto. Največ visokih voda na vodotokih je bilo ob božični povodnji decembra (18), obsežnejše poplave so bile marca (14), hudourniške poplave avgusta (12), februarja (11), junija, julija in januarja (6), septembra (3), aprila (2), maja (1), le oktobra in novembra ni bilo visokih voda. Morje je poplavilo nižje dele obale osemindvajsetkrat: decembra osemkrat (8), februarja sedemkrat (7), novembra petkrat (5), marca trikrat (3), junija dvakrat (2), po enkrat pa januarja, aprila in septembra (slika 1). Leta 2009 so bili na vodomernih postajah na Reki, Pesnici, Savi, Bistrici in Soči izmerjeni rekordni pretoki v opazovalnem obdobju.

Leta 2009 so po podatkih oddelka za hidrološko prognozo in Republiškega centra za obveščanje na območju Slovenije reke, potoki, hudourniki in morje skupno 107-krat prestopili bregove in morsko obalo. Morje se je 28-krat razlilo po nižjih delih obale, večje reke potoki in hudourniki 79-krat. Reke so poplavljale na območjih vsakoletnih poplav, pa tudi na območjih, na katerih poplave niso pogoste. Obsežnejše poplave kot navadno so bile februarja ob Reki v okolici Ilirske Bistrice, marca ob Vipavi med Dornberkom in Mirnom, junija ob reki Muri in njenih pritokih, avgusta ob Pesnici, decembra pa ob Soči, Idrijci, Vipavi, Savi Bohinjki s pritoki in ob Bohinjskem jezeru, Savi v srednjem in spodnjem toku, zaradi poplavljanja morja tudi ob slovenski obali.

Lata 2009 je poplavljanje rek in morja povzročilo gmotno škodo na stanovanjskih in gospodarskih objektih, prometnicah, vodni infrastrukturi in na kmetijskih površinah. V preglednici 1 so prikazani reke in nekateri potoki, ki so poplavljali leta 2009, ter poplavljanje morja ob slovenski obali. Poplavljanje manjših potokov in hudournikov v preglednici ni prikazano.

RIVER HIGH WATERS AND FLOODS

Janez Polajnar

Two years after the catastrophic torrential flood, Slovenia faced another extensive flood during the 2009 Christmas holidays which, however, only caused material damage. In 2009 high waters were distributed throughout the year. The snow melting and abundant precipitation caused high waters in March; another extensive flood occurred at the end of December. During the summer months, torrential floods occurred. Rivers also flooded in areas in which floods usually do not occur. In 2009 the rivers: Reka, Vipava, Pesnica, Soča, Sava in the Zasavje region, Bistrica in Bohinjska Bistrica and the level of the Bohinj Lake reached the highest or nearly the highest discharges and water stages in the reference period. This proves the extremeness of weather phenomena and floods during that year.

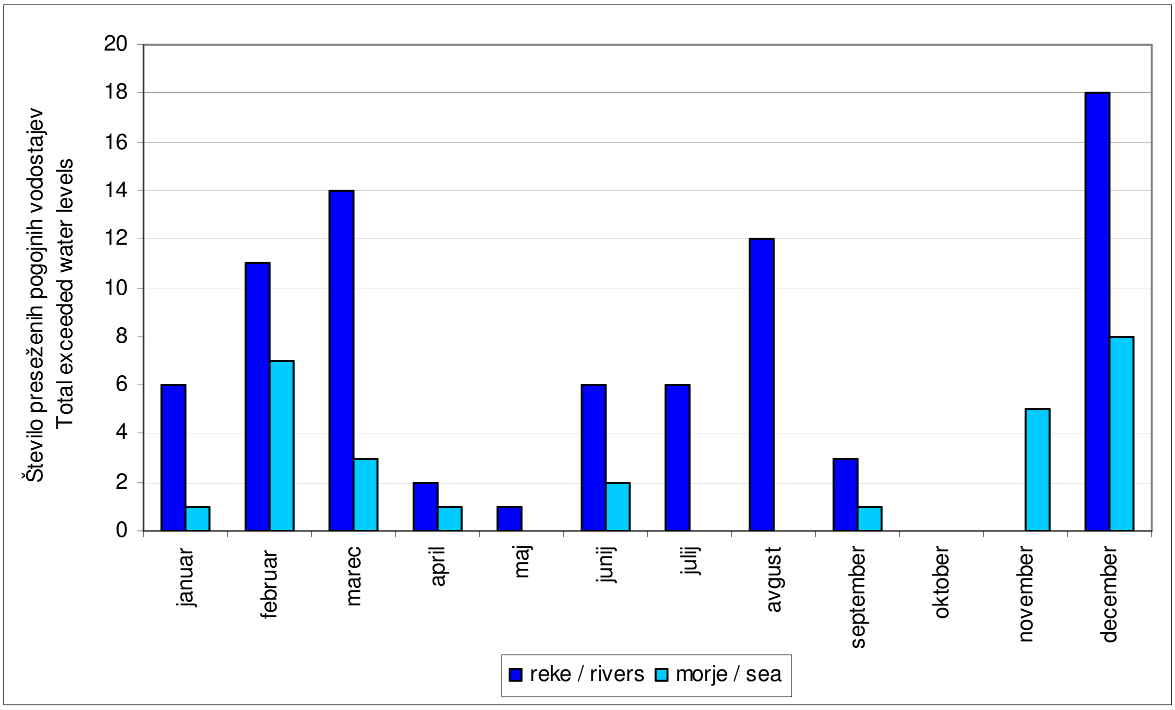
In 2009, high waters were recorded on a total of 107 occasions, when the rivers at water gauging stations exceeded critical discharge levels and the sea level at the mareographic station exceeded critical water levels and in most cases flooded. In 2009, the number of these occurrences was higher than usual, and they were equally distributed throughout the year. Most high waters occurred during the Christmas flood in December (18), extensive floods also occurred in March (14) and torrential floods in August (12); in February, high waters were recorded on 11 occasions, in June, July and January on six occasions, in September on three occasions, in April on two occasions and in May on one occasion. Only in October and November did no high waters occur. The sea flooded the low-lying parts of the coast twenty-eight times: 8 times in December, 7 times in February, 5 times in November, 3 times in March, 2 times in June and once in January, April and September (Figure 1). In 2009, the water gauging stations on the Reka, Pesnica, Bistrica and Soča rivers recorded record values of discharges in the reference period.

According to the statistics of the hydrological forecasting service and the Notification Centre of the Republic of Slovenia, the rivers, streams, torrents and the sea flooded on 107 occasions. The sea spilled over the low-lying parts of the coast 28 times, while larger rivers and streams flooded 79 times. The rivers flooded in the areas of the usual annual floods, but also in the areas where foods are not common. More extensive floods than usual occurred in February along the Reka river in the region of Ilirska Bistrica, in March along the Vipava river between Dornberk and Miren, in June along the Mura river and its tributaries, in August along the Pesnica river, in December on the Soča, Idrijca, Vipava rivers, on Sava Bohinjka and its tributaries and along Lake Bohinj, the Sava river in its mid- and lower reaches, and also along the Slovenian coast due to the flooding of the sea.

Preglednica 1: Visoke vode in njihovo razlitje leta 2009 (ARSO, CORS, razlitje manjših potokov in hudournikov ni upoštevano)
Table 1: High water levels and their spillage in 2009 (the Agency, CORS, the spillage of smaller streams and torrents was not taken into account)

	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec
Rogatnica	x	x	x									
Mestinjščica	x	x										
Ljubljanica	x	x	x	x								x x
Krka	x	x	x	x								x
Dravinja	x	x	x					x				
Sotla	x	x										
Reka		x										x
Bistrica, Ilirska Bistrica		x										
Kolpa		x	x									x
Ščavnica		x				x		x				
Pesnica		x				x	x	x				
Vipava			x									x x
Lijak												x
Branica												x
Gradaščica			x									x
Ižica			x									
Horjulščica			x									
Sava			x									x
Sava Dolinka									x			x
Sava Bohinjka												x
Tržiška Bistrica												x
Savinja												x
Branica			x									
Sora												x
Poljanska Sora			x									
Idrijca			x									x
Logaščica			x									
manjši hudourniki na Štajerskem *smaller torrents in Štajerska*					x							
Mura						x	x	x	x			
Drava												x
Kučnica						x						
Ledava						x		x				
potok Bistrica *Bistrica stream*						x						
hudourniki na Koroškem *torrents in Koroška*							x	x	x			
Grušena							x					
hudourniki v okolici Ljubljane *torrents in Ljubljana area*							x					
hudourniki v Podravju *torrents in Podravje*							x					
Žitečki potok								x				
Hočki potok								x				
Vokarski potok								x				
Jakovski potok								x				
Kučnica								x				
Gobovščica								x				
morje ob slovenski obali *sea at Slovenian coast*	x	xxxx xxx	xxx	x		xx			x		xxxx x	xxxx xxxx

Rivers and sea flooding caused major material damage on residential and commercial buildings, traffic routes, water infrastructure and farmland. Table 1 shows the rivers and streams that flooded in 2009 and the sea flooding in Slovenian coastal areas. The table does not show the flooding of smaller streams and torrents.



Slika 1: Število preseženih opozorilnih pretokov slovenskih rek na opazovanih vodomernih postajah in gladine morja ob slovenski obali leta 2009

Figure 1: Number of exceeded critical water levels of Slovenian rivers at the observed water gauging stations and sea levels at the Slovenian coast in 2009

Opis nekaterih najvišjih in rekordno visokih vod leta 2009

Visoka voda Reke 3. februarja 2009

Zaradi močnega južnega vetra v višinah in juga na Jadranu je na območju Gorskega kotarja, Snežnika in na območju Ilirske Bistrice 2. in 3. februarja močno deževalo, drugod po državi pa snežilo. Na območju Ilirske Bistrice je v 24 urah padlo približno 150 mm dežja, v zaledju Reke krajevno še več.

Reka je 3. februarja že dopoldan močno narasla in sredi dneva začela poplavljati v zgornjem toku v okolici Trpčan. Čez dan se je visokovodni val pomaknil v spodnji tok, Reka je poplavljala na območjih vsakoletnih poplav in območjih, na katerih poplave niso pogoste.

Na vodomerni postaji Trnovo je 3. februarja 2009 ob 17. uri višina vode dosegla 652 cm in pretok 205 m^3/s. Izmerjen vodostaj na tem mestu je bil drugi najvišjih v zadnjih 20 letih. Leta 1992 je dosegel 665 cm.

Visoka voda Vipave 30. marca 2009

V dveh dneh med 29. in 30. marcem 2009 je v Sloveniji padlo od 40 mm do več kot 200 mm padavin. Največ padavin je bilo v zahodnem delu države, na Vojskem 180 mm, vendar so reke povsod po državi močno narasle.

Največji pretok je imela reka Vipava. V zgornjem toku je 30. marca na vodomerni postaji Vipava ob 13. uri dosegla vodostaj 230 cm in pretok 58,5 m^3/s z dveletno

Description of some highest and record high waters in 2009

High waters on the Reka river on 3 February 2009

Due to the strong south wind blowing in higher regions and the Sirocco wind blowing on the coast, in the regions of Gorski Kotar, Snežnik and Ilirska Bistrica, heavy rainfalls occurred on 2 and 3 February. Other parts of the country received snowfalls. Around Ilirska Bistrica, approximately 150 mm of rain fell within 24 hours and even more locally in the interland of the Reka river.

On 3 February the water level of the Reka river strongly increased. In midday, it started to flood in the upper reach near Trpčane. During the day, the high-water wave moved to the lower reach and the Reka river flooded in the area of the usual annual floods as well as in areas where floods are not common.

On 3 February 2009 at 17.00, the water level at gauging station Trnovo reached 652 cm and a discharge of 205 m^3/s. The measured water level at that station was the highest water level in the last 20 years. In 1992, it reached 665 cm.

High waters on the Vipava river on 30 March 2009

Within two days, i.e. on 29 and 30 March 2009, Slovenia received from 40 mm to more than 200 mm of precipitation. The highest level of precipitation was recorded in the western part of the country (Vojsko povratno dobo. Nekaj nižje, pri Ajdovščini, je zaradi močnega dotoka potoka Hubelj na vodomerni postaji Dolenje ob 14. uri dosegla najvišji vodostaj 353 cm in pretok 211 m^3/s z 10-letno povratno dobo. V spodnjem toku na vodomerni postaji v Mirnu sta bila 30. marca izmerjena vodostaj 671 cm in pretok 377 m^3/s s 50- do 100-letno povratno dobo. Voda je pri tem preplavila hišico vodomerne postaje za 30 cm in na tem mestu dosegla rekordno višino v opazovanem obdobju (slika 2).

Visoka voda Pesnice 4. in 5. avgusta 2009

Med 3. in 4. avgustom je na območju Slovenskih goric in Maribora ob krajevnih neurjih padlo med 130 mm in 185 mm padavin, na območju Goričkega in Ptuja do 108 mm padavin.

Reke so močno narasle, med njimi najbolj Pesnica in Ščavnica s pritoki. Pesnica je na vodomerni postaji Ranca dosegla pretok s 50-letno povratno dobo 57,5 m^3/s (slika 3). V Gočavi je zjutraj 4. avgusta presegla oznako do zdaj najvišje izmerjene vode na tej vodomerni postaji, ki je 520 cm. Na območju med Juršinci in Kungoto je bil zalit večji del doline Pesnice. Poplavljali so tudi številni manjši vodotoki na tem območju, ki jih je narasla Pesnica zajezila. Poplavna voda je segla tudi na območja, na katerih ta pojav ni pogost. Omenjeno območje je bilo 5. avgusta še vedno poplavljeno.

received 180 mm of precipitation), and in general, the rivers strongly increased throughout the country.

The highest discharge was recorded on the Vipava river. On 30 March at 13.00, the Vipava river reached in its upper reach at the Vipava water gauging station; a water level of 230 cm and a discharge of 58.5 m^3/s with a two-year return period were recorded. At 14.00, further downstream, near Ajdovščina, it reached the highest water level 353 cm and a discharge of 211 m^3/s with a 10-year return period, mainly due to the strong inflow of the Hubelj stream. In the lower reach, at water gauging station Miren, the water level reached 671 cm and a discharge of 377 m^3/s with a 50- to 100-year return period. The river flooded the water gauging station, which was 30 cm under water, and on that site it reached a record water level in the reference period (Figure 2).

High waters on the Pesnica river between 4 and 5 August 2009

Between 3 and 4 August 2009, the regions of Slovenjske Gorice and Maribor received 130 mm to 185 mm of precipitation during local storms, while the Goričko and Ptuj region received up to 108 mm.

The rivers rose rapidly. The most rapid water growth was recorded on the Pesnica and Ščavnica rivers and their tributaries. At the Ranca water gauging station, the Pesnica river reached a discharge of 57.5 m^3/s, i.e. a discharge level with a 50-year return period (Figure 3). In the morning of 4 August, the water level recorded in Gočava exceeded the highest level measured to date at that station: 520 cm. In the area between Juršinci and Kungota, the major part of the Pesnica valley was covered by the flood water. Many other smaller rivers and streams in the area also flooded, which was the result of the impoundment of the Pesnica river. The flooding water also reached the areas where such occurrences are not common. On 5 August, this area was still flooded.

Slika 2: Vipava, vodomerna postaja Miren, levo ob majhni vodnatosti 25. aprila 2007, desno ob poplavi 30. marca 2009 (foto: arhiv ARSO)
Figure 2: Vipava, water gauging station Miren, on the left: low river stage on 25 April 2007; on the right: flood on 30 March 2009 (Photo: Agency archives).

Slika 3: Pesnica, vodomerna postaja Ranca, levo ob običajni vodnatosti 10. marca 2009, desno ob poplavi 4. avgusta 2009 (foto: arhiv ARSO)
Figure 3: Pesnica, water gauging station Ranca, on the left: usual water level on 10 March 2009, on the right: during the flood on 4 August 2009 (Photo: Agency Archives).

Visoke vode Soče, Save Bohinjke, Save v Zasavju, visoka gladina Bohinjskega jezera 25. decembra 2009

Ob božični povodnji med 25. in 26. decembrom so zaradi taljenja snega in obilnih padavin najbolj narasle reke s povirji v Julijskih in Kamniško-Savinjskih Alpah. Nekatere med njimi Soča (sliki 4 in 5) v spodnjem toku (vodomerna postaja Solkan, pretok 2290 m^3/s), Sava v Zasavju (vodomerna postaja Hrastnik, pretok 1888 m^3/s), Bistrica pri Bohinjski Bistrici (vodomerna postaja Bohinjska Bistrica, vodostaj je bil višji kot 220 cm) so dosegle rekordne, do zdaj največje pretoke ali vodostaje v opazovanem obdobju. Gladina Bohinjskega jezera (vodomerna postaja sv. Duh, vodostaj 332 cm) je narasla za 3 m in se približala do zdaj najvišji izmerjeni gladini 390 cm. Več o hidroloških razmerah med povodnjijo preberite v že navedenih člankih.

High waters of the rivers: Soča, Sava Bohinjka and Sava in the Zasavje region, and the high water level of the Bohinj Lake on 25 December 2009

During the Christmas flood between 25 and 26 December 2009, the water levels increased most on the rivers with their headwaters in the Julian Alps and the Kamnik–Savinja Alps due to snow melting and abundant precipitation. Some of them, i.e. the Soča (Figures 4 and 5) in its lower reach (Solkan water gauging station, discharge 2 290 m^3/s), Sava in Zasavje (Hrastnik water gauging station, discharge 1888 m^3/s), Bistrica near Bohinjska Bistrica (Bohinjska Bistrica water gauging station, the water level exceeded 220 cm) reached record water levels and discharges, the highest to date in the reference period. The level of Lake Bohinj (Sv. Duh water gauging station, water level 332 cm) rose by 3 m and reached the highest level measured to date, i.e. 390 cm. Please find more information on hydrological conditions in other articles of this yearbook.

Soča pri Trnovem, levo ob običajni vodnatosti julija 2009, desno ob poplavi 25. decembra 2009 (foto: J. Polajnar, T. Trobec)
Soča at Trnovo, on the left: usual water level in July 2009, on the right: water level during the flood on 25 December 2009 (Photo: J. Polajnar, T. Trobec).

Soča pri Kobaridu, levo ob običajni vodnatosti julija 2009, desno ob poplavi 25. decembra 2009 (foto: J. Polajnar, T. Trobec)
Soča at Kobarid, on the left: usual water level in July 2009, on the right: water level during the flood on 25 December 2009 (Photo: J. Polajnar, T. Trobec)

NIZKE VODE REK IN HIDROLOŠKA SUŠA

dr. Mira Kobold

Leto 2009 je bilo v primerjavi z dolgoletnim povprečjem povprečno namočeno, gledano po mesecih pa so bile precejšne razlike. Prvo polovico leta in decembra je bila vodnatost v splošnem nadpovprečna, v poletnih in jesenskih mesecih pa podpovprečna. V teh mesecih je bila količina padavin v večjem delu države pod obdobnim povprečjem, zato so bile v tem času na območjih, kjer je bil primanjkljaj padavin največji, nizkovodne razmere. Hidrološko sušno obdobje je trajalo od avgusta do novembra.

Analiza mesečnih pretokov

V prvi tretjini leta so bili srednji mesečni pretoki (Qs) in najmanjši mesečni pretoki (Qnp) večinoma v mejah srednjih obdobnih vrednosti (slika 1). V maju in juniju se je vodnatost razen Drave in Mure zmanjšala pod obdobna povprečja, najbolj v vzhodnem in južnem delu države. Julija ni bilo večjih odstopanj od dolgoletnih povprečnih pretokov. Od avgusta do novembra pa so bili skoraj povsod po državi pretoki razen Drave in Mure pod obdobnimi povprečji. Srednji mesečni pretoki so bili marsikje manjši od srednjih malih obdobnih pretokov (sQnp), najmanjši mesečni pretoki pa so se ponekod približali najmanjšim obdobnim mesečnim pretokom (nQnp). V decembru so padavine, ki so tudi do dvakrat presegle običajne decembrske padavine, povzročile visoke vode in poplave, ki so prizadele večji del države, izvzet je bil le njen severovzhodni del.

Avgust in oktober sta bila v najbolj suha meseca v letu 2009. Po slovenskih rekah je v teh dveh mesecih v povprečju preteklo le med 30 in 50 odstotkov običajne količine vode.

Časovni potek srednjih dnevnih pretokov

Iz časovnega poteka srednjih dnevnih pretokov (slika 2) je razvidno, da so bila krajša obdobja z malimi pretoki konec januarja, drugi polovici februarja in začetku marca ter deloma v maju in juniju. Daljše obdobje z malimi pretoki je trajalo od avgusta do konca oktobra, krajše nizkovodno stanje pa še konec novembra. Pretoki niso nikjer dosegli najmanjših obdobnih pretokov.

RIVER LOW FLOWS AND HYDROLOGICAL DROUGHT

Mira Kobold, PhD

In comparison to the multi-annual average, 2009 was an above-average water abundant year. There were, however, considerable differences between individual months. In the first half of the year and in December, in general, the water yield exceeded the average, while in the summer and autumn months it was below the average. During these months, the precipitation level was below average in most parts of the country; therefore, low flow conditions were recorded in regions with the biggest deficit of precipitation. The hydrologically dry period lasted from August to November.

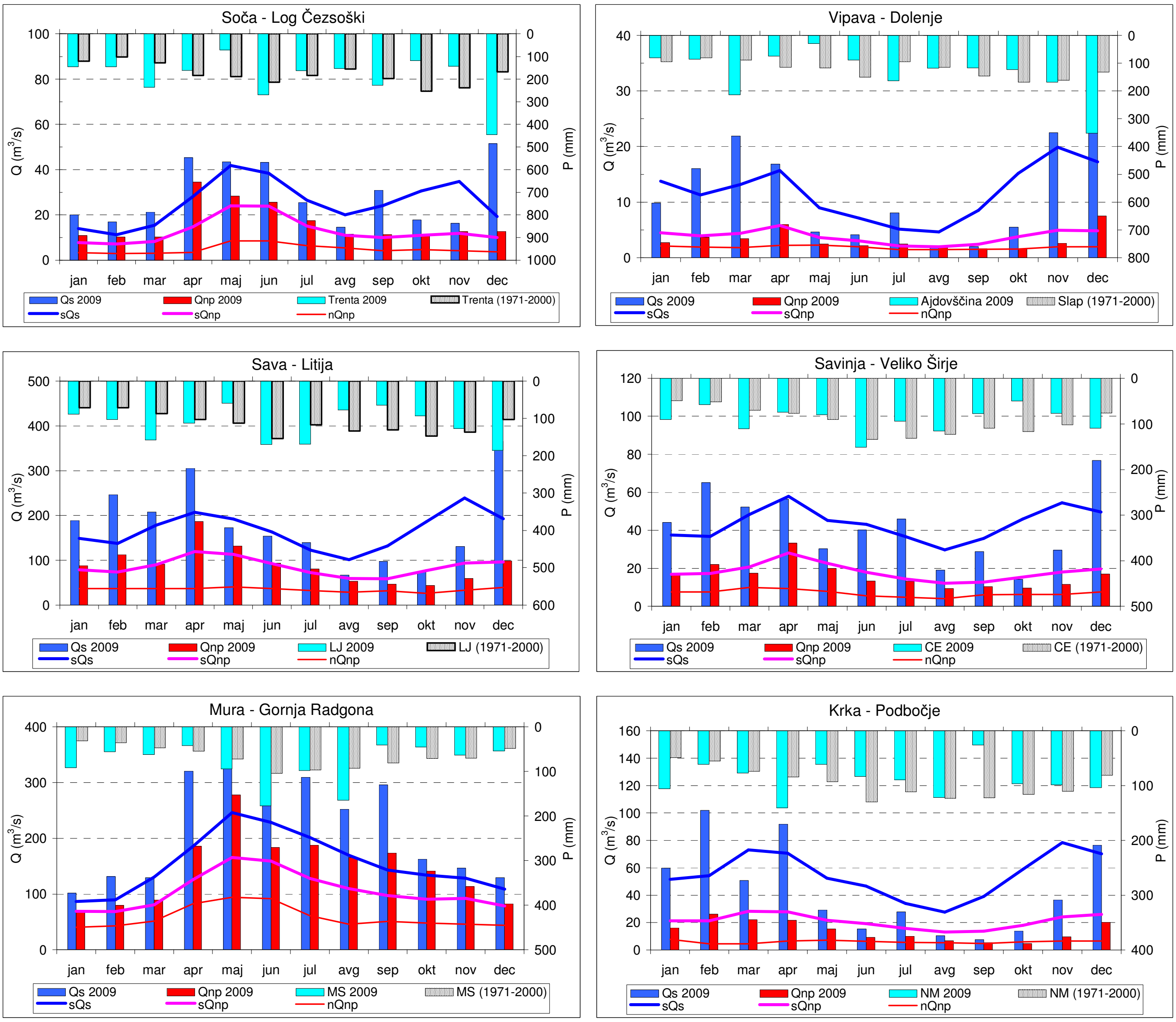
Analysis of monthly discharges

In the first third of the year, the mean monthly discharges (Qs) and the minimum monthly discharges (Qnp) were within the limits of the mean periodical values (Figure 1). In May and in June, with the exception of the Drava and Mura rivers, the water levels were below the periodical averages, in particular in the eastern and southern parts of the country. In July, there were no major deviations from the multi-annual average discharges. From August to November, the discharges were below the periodical average in most parts of the country, except for the Drava and Mura rivers. In certain parts, the mean monthly discharges were lower than the mean low periodical discharges (sQnp), while in other parts the minimum monthly discharges almost reached the minimum periodical monthly discharges (nQnp). In December, the precipitation levels, exceeding twice the usual December precipitation levels, resulted in high waters and floods causing damages in most parts of the country, except for the north-eastern part.

August and October were the driest months in 2009. In these two months, the Slovenian rivers recorded on average approximately 30 % to 50 % of the usual water levels.

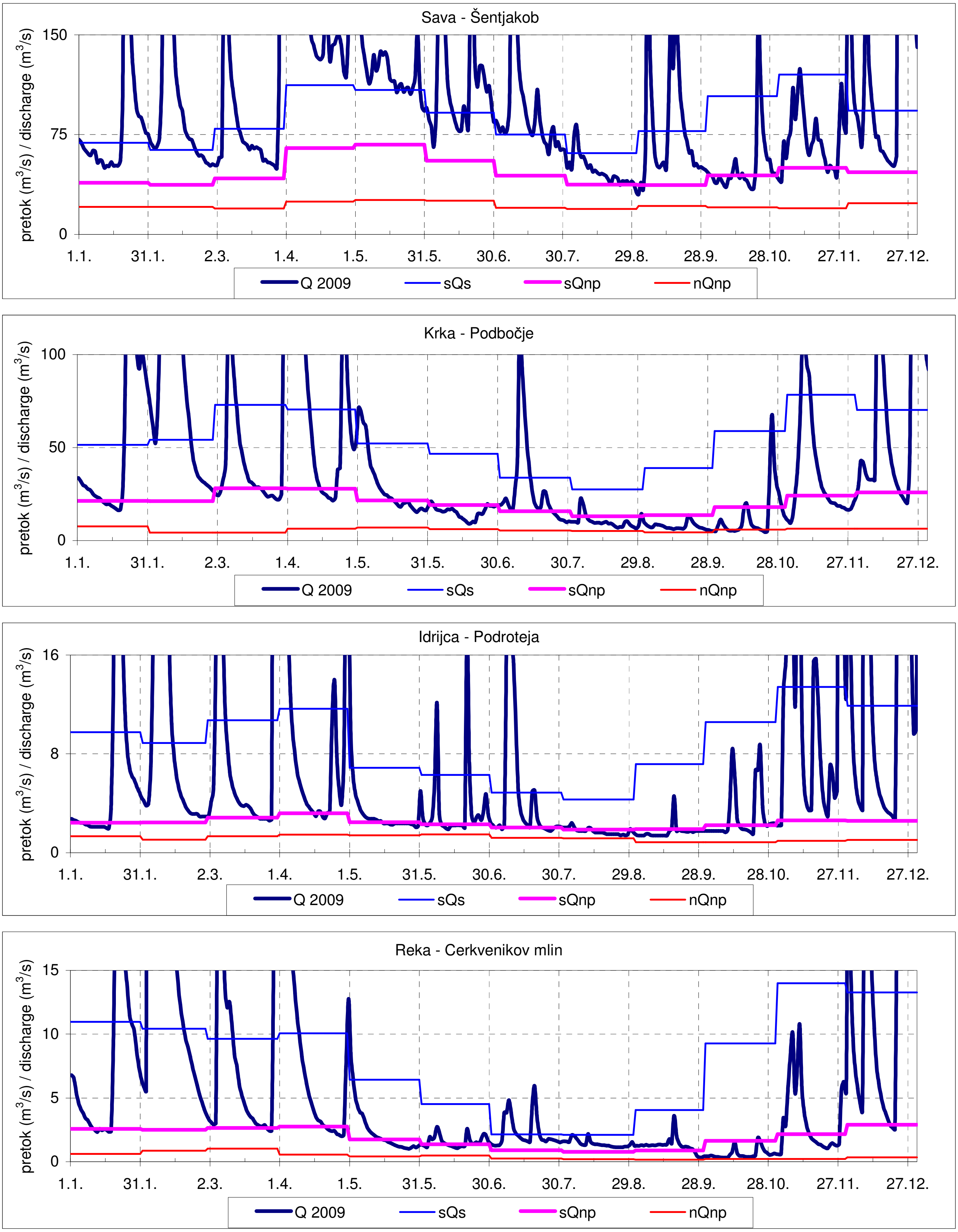
Timeline of mean daily discharges

From the timeline of the mean daily discharges (Figure 2), it is evident that shorter periods with low discharges occurred at the end of January, in the second half of February and at the beginning of March and partly in May and June. Longer periods with low discharges lasted from August to the end of October, while shorter low flow conditions occurred at the end of November. The discharges did not reach the minimum periodical discharges anywhere.



Slika 1: Srednji (Qs) in najmanjši mesečni pretoki (Qnp) v letu 2009 ter obdobne mesečne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) mesečni pretoki, obdobne mesečne količine padavin obdobja 1971–2000 in mesečne količine padavin v letu 2009 z reprezentativnih padavinskih postaj

Figure 1: Mean (Qs) and minimum monthly (Qnp) discharges in 2009 and periodical monthly values of discharges: mean periodical (sQs), mean low (sQnp) and minimum low (nQnp) monthly discharges, periodical monthly amount of precipitation in the 1971–2000 period and monthly amount of precipitation in 2009 from representative precipitation stations



Slika 2: Srednji dnevni pretoki na izbranih vodomernih postajah za leto 2009 ter obdobne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) obdobni pretok

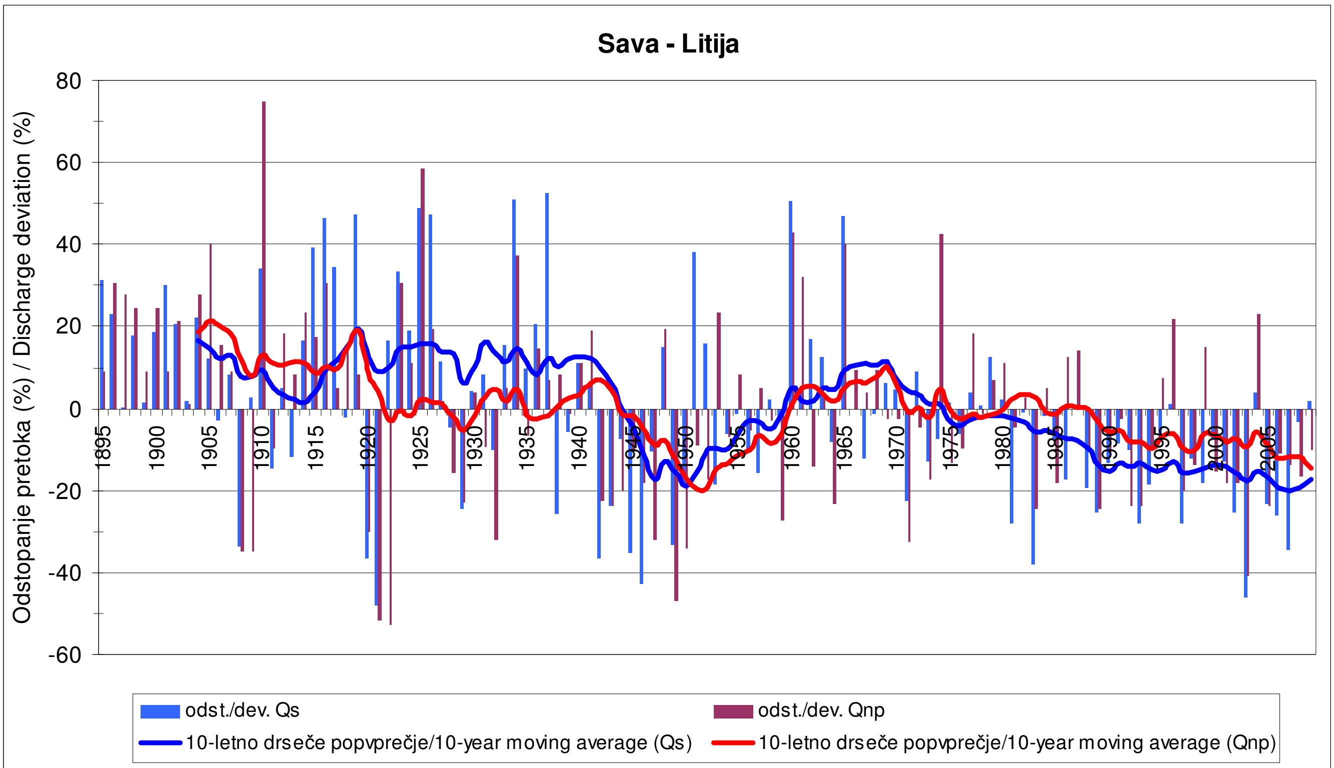
Figure 2: The mean daily discharges at selected water gauging stations for 2009 and the periodical discharge values: mean periodical (sQs), mean low (sQnp) and minimum low (nQnp) periodical discharges

Analiza časovne spremenljivosti pretokov razpoložljivega obdobja podatkov

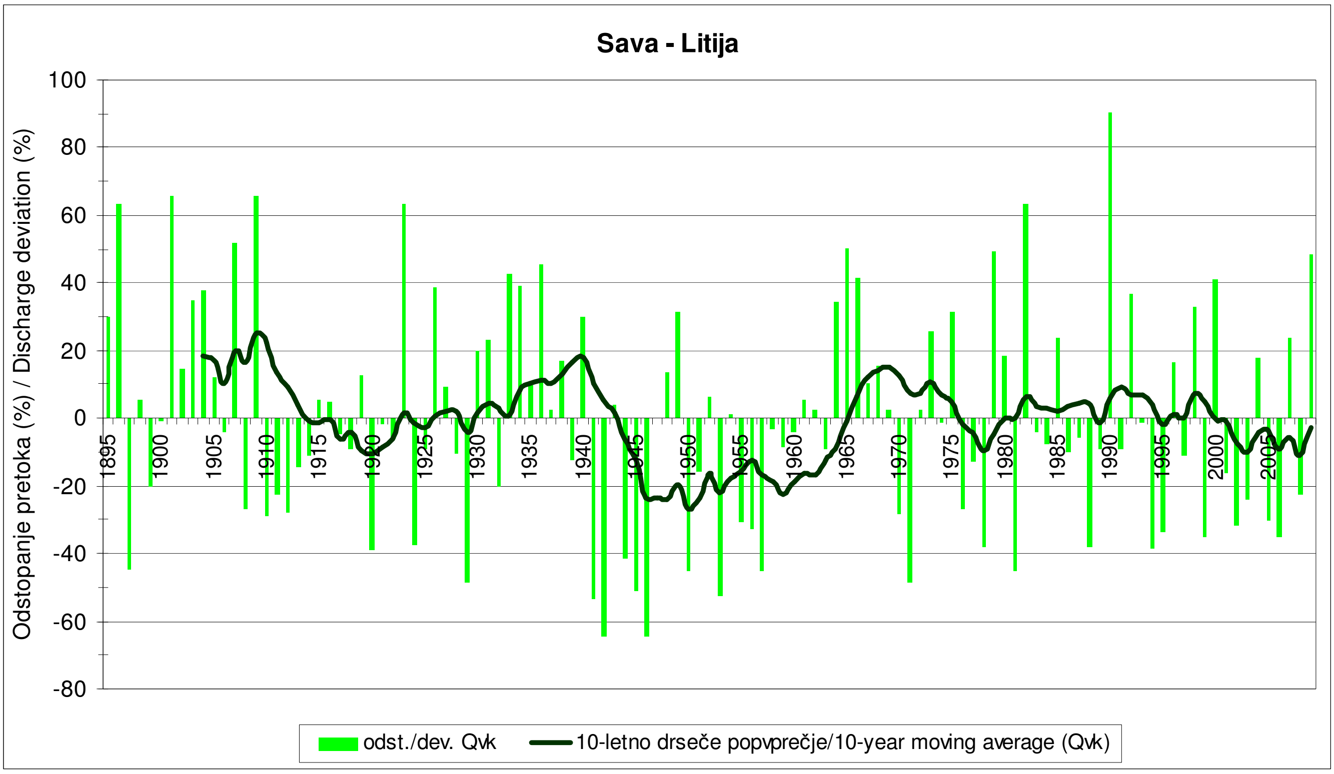
Z analizo časovne spremenljivosti pretokov razpoložljivih zgodovinskih podatkov lahko prikažemo spremembe pri hidrološkem vedenju rek. Zelo nazoren prikaz hidrološkega dogajanja je odstopanje značilnih pretokov (srednjega in najmanjšega letnega pretoka ter letnih visokovodnih konic) od srednjih obdobnih vrednosti. Analizo smo izvedli za vodomerno postajo Litija, ki ima neprekinjen niz podatkov od leta 1895. S slike 3 lahko razberemo, da so bila pretežno mokra leta konec 19. in v prvi polovici 20. stoletja do leta 1940. Srednji in najmanjši letni pretoki so bili močno nad obdobnim povprečjem, izjema so bila le posamezna leta (1908, 1909, 1920, 1921, 1929, 1932). Med 1940 in 1960 je bilo izredno suho obdobje, letu 1960 pa je sledilo skoraj 20-letno obdobje z nadpovprečno vodnatostjo. Letu 1980 sledi skoraj neprekinjeno obdobje s podpovprečno vodnatostjo, ki je trajalo vse do leta 2009. To je tudi obdobje, ko se je začelo zavedanje o podnebnih spremembah. Srednji letni pretoki v letu 2009 so le malo odstopali od dolgoletnih povprečij, najmanjši pretoki v 2009 pa so bili za dobrih 10 odstotkov manjši od obdobnih povprečij.

Analysis of the time changeability of discharges in the periods of data availability

The analysis of data changeability of discharges based on historically available data may serve to present changes in the hydrological behaviour of rivers. A highly indicative presentation of hydrological occurrences is the deviation of typical discharges (mean and minimum annual discharge and the annual high peaks) from the mean periodical values. The analysis was carried out for the Litija water gauging station at which uninterrupted data series recorded since 1985 are available. Figure 3 shows that the wettest years were recorded mainly at the end of the 19th and in the first half of the 20th century, i.e. until 1940. The mean and minimum annual discharges were highly above the periodical average, with the exception of the years 1908, 1909, 1920, 1921, 1929 and 1932. The period between 1940 and 1960 was extremely dry, and 1960 was followed by an almost 20-year period with an above average water yield. The year 1980 was followed by an almost uninterrupted period with below average water levels which lasted up until 2009. This was also the period in which people became aware of climate change. The mean annual water discharges in 2009 only slightly deviated from the multi-annual averages; the lowest discharges in 2009 were only 10 % lower than the periodical averages.



Slika 3: Odstopanje srednjega in najmanjšega letnega pretoka od povprečnih obdobnih vrednosti
Figure 3: Deviation of the mean and minimum annual discharges from the average periodical values



Slika 4: Odstopanje letnih visokovodnih konic od povprečnih obdobnih vrednosti
Figure 4: Deviation of the annual high water peaks from the average periodical values

Razporeditev visokovodnih konic je v primerjavi s srednjimi in malimi pretoki precej enakomernejša (slika 4). Izrazito podpovrečne so bile visokovodne konice v obdobju 1940–1960, ki kaže po vseh treh značilnih pretokih na obdobje z izrazito hidrološko sušo. Za obdobje po letu 1980 pa so za posamezno leto značilni podpovprečna količina srednjega letnega odtoka, dolga nizkovodna stanja in hidrološka suša, po drugi strani pa visoke vode in poplave. Razporeditev visokovodnih konic v zadnjih treh desetletjih ustreza obdobnemu povprečju. To kaže na neenakomerno porazdelitev padavin med letom. Večina padavin pade v obliki kratkotrajnih in močnih nalivov.

In comparison to the medium and low discharges the distribution of high water peaks was relatively even (Figure 4). In the 1940–1960 period, the high water peaks were greatly below the average, which according to all three typical discharges indicates a period of extreme hydrological drought. Individual years in the period after 1980 recorded below-average levels of mean annual discharges, long low flow periods and hydrological drought on the one hand, and high waters and floods on the other hand. The distribution of high-water peaks in the past three decades has complied with the periodical average. This indicates an uneven distribution of precipitation during the year. Most precipitation has fallen as short-term and heavy rain showers.

TEMPERATURE REK IN JEZER V LETU 2009

dr. Peter Frantar

Pregled temperatur vode leta 2009 temelji na pregledu temperatur vode v rekah ob 7. uri na 13 delujočih postajah na rekah in dveh postajah na jezerih. Postaje smo mesečno obravnavali tudi v mesečnih poročilih Agencije za okolje, podatki, uporabljeni v letopisu, pa so v primerjavi z mesečnimi poročili preverjeni. Leta 2009 je bilo povprečje srednjih letnih temperatur Mure, Savinje, Save, Idrijce, Kamniške Bistrice, Ljubljanice, Krke, Sore in Reke 9,9 °C, kar je za 0,3 °C več kot v večletnem primerjalnem obdobju (9,6 °C). Povprečna temperatura Blejskega jezera je znašala 13,3 °C, kar je za 0,3 °C° več kot v primerjalnem obdobju, povprečna temperatura Bohinjskega jezera pa je bila 10,1 °C, kar je 0,7 °C več kot v dolgoletnem obdobju.

Letni potek temperatur na izbranih rekah je bil skladen z letnim temperaturnim nihanjem podnebja. Od začetka leta do konca avgusta so temperature na rekah bolj ali manj enakomerno naraščale, od septembra pa so temperature v nekaj večjih skokih razmeroma hitro upadle. Temperaturna nihanja so bila najmanj izrazita na Kamniški Bistrici v Kamniku in Idrijci v Podroteji. Vzrok za to je velik vpliv kraškega zaledja na obeh postajah. Najnižje temperature na teh postajah so bile v januarju ali decembru. Oba minimuma sta podobno izrazita na vseh opazovanih postajah. Najnižje temperature so bile od 0 °C na Reki pri Cerkvenikovem mlinu in na Savinji v Velikem Širju, pa vse do nad 7 °C na Idrijci pri Podroteji. Na večini izbranih rek smo izmerili najvišje temperature vode v drugi polovici avgusta. Na obeh rekah z vplivom krasa so bile temperature vode od 11,5 °C na Kamniški Bistrici v Kamniku do 12,1 °C na Idrijci pri Podroteji. Na preostalih rekah pa so bili maksimumi od 15,2 °C na Savi pri Radovljici do 23,1 °C na Krki pri Podbočju.

Letni potek temperatur obeh alpskih jezer je bil podoben povprečnemu poteku temperatur vode. Najnižje temperature so bile konec januarja in v februarju, ko je bilo Bohinjsko jezero tudi zamrznjeno. Temperature so potem na obeh jezerih naraščale do druge polovice avgusta, od takrat pa je sledilo ohlajanje proti koncu leta. Najnižja temperatura Bohinjskega jezera je bila 0 °C med njegovo zaledenitvijo (januarja in februarja), Blejskega jezera pa 3,0 °C, ki je bila dosežena 16. januarja. Najvišja temperatura je bila na obeh jezerih dosežena 22. avgusta ko je bilo Bohinjsko jezero segreto na 23,2 °C, Blejsko pa na 25,0 °C.

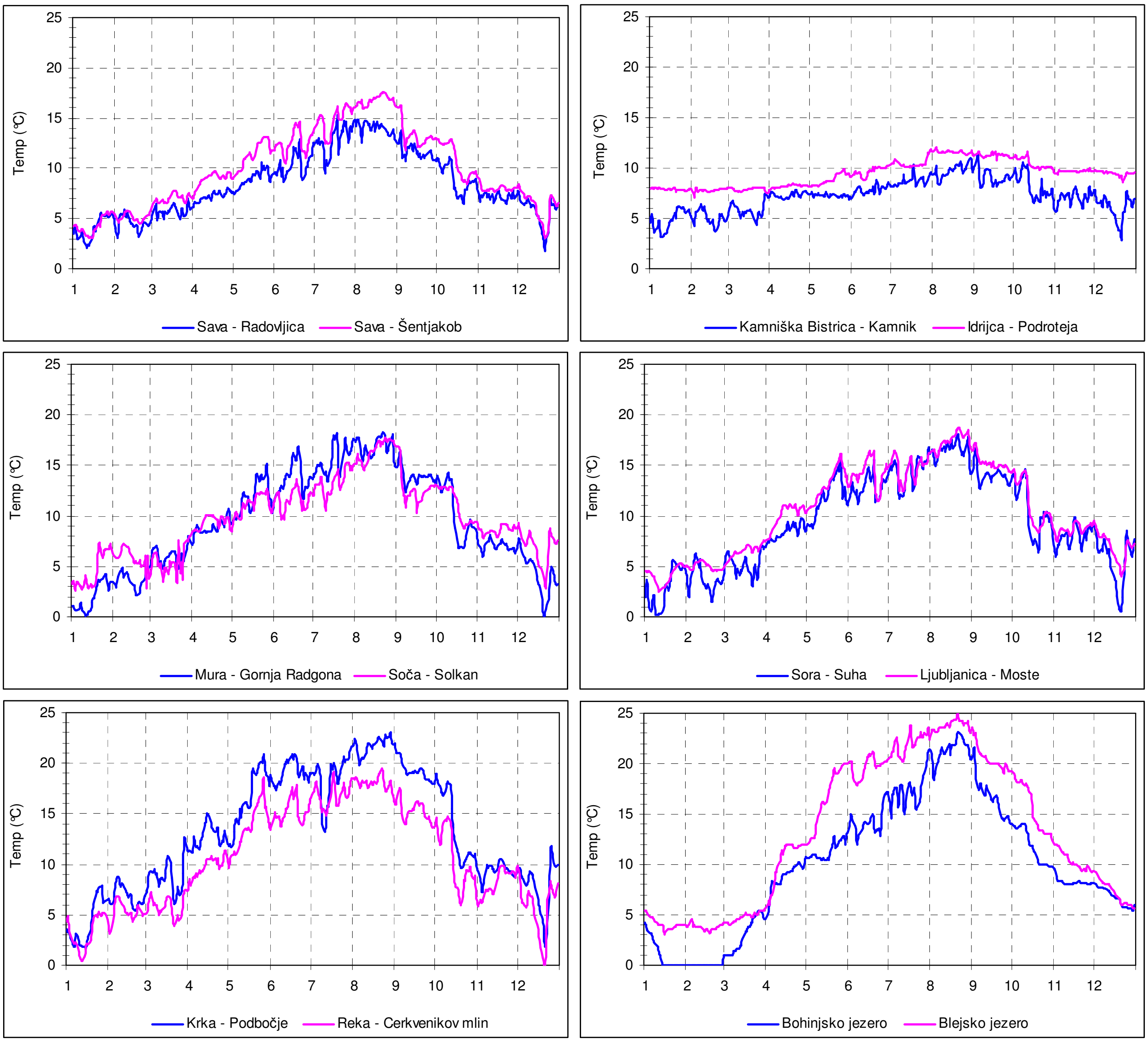
TEMPERATURES OF RIVERS AND LAKES IN 2009

Peter Frantar, PhD

The overview of water temperatures for the year 2009 is based on the overview of temperatures of Slovenian rivers at 7.00 at 13 operational water gauging stations located on rivers and two gauging stations located on lakes. The situations at the stations were also described in the monthly reports of the agency and the data used in the yearbook were checked by comparing them to those from the monthly reports. In 2009, the average mean annual temperature of the Mura, Savinja, Sava, Idrijca, Kamniška Bistrica, Ljubljanica, Krka and Sora rivers was 9.9 °C, which is 0.3 °C higher than the temperature of the multi-annual reference period (9.6 °C). The average temperature of Lake Bled was 13.3 °C, which is 0.3 °C higher than the temperature of the multi-annual reference period, while the average temperature of Lake Bohinj was 1.10 °C, which is 0.7 °C higher than the temperature recorded in the multi-annual reference period.

The annual flow of temperatures at selected rivers complied with the annual climate temperature fluctuations. From the beginning of the year until the end of August, the river temperatures were gradually rising, while from September to the end of the year, they dropped relatively quickly in a few major stages. Temperature fluctuations were the least extreme in the Kamniška Bistrica river in Kamnik and in the Idrijca river in Podroteja. The reason for that is the high impact of the karstic hinterland at both stations. The lowest temperatures at these two stations were recorded in January and December. Both minima were similarly intense at all stations at which the observations were carried out. The lowest temperatures ranged from 0 °C on the Reka river at Cerkvenikov Mlin and the Savinja river in Veliko Širje up to above 7 °C on the Idrijca river near Podroteja. On most selected rivers the highest temperatures were recorded in the second half of August. On both rivers influenced by karst features, the water temperatures ranged from 11.5 °C (the Kamniška Bistrica river in Kamnik) to 12.1 °C (the Idrijca river at Podroteja). The maximum temperatures of other rivers ranged from 15.2 °C (on the Sava river near Radovljica) up to 23.1 °C (on the Krka river near Podbočje).

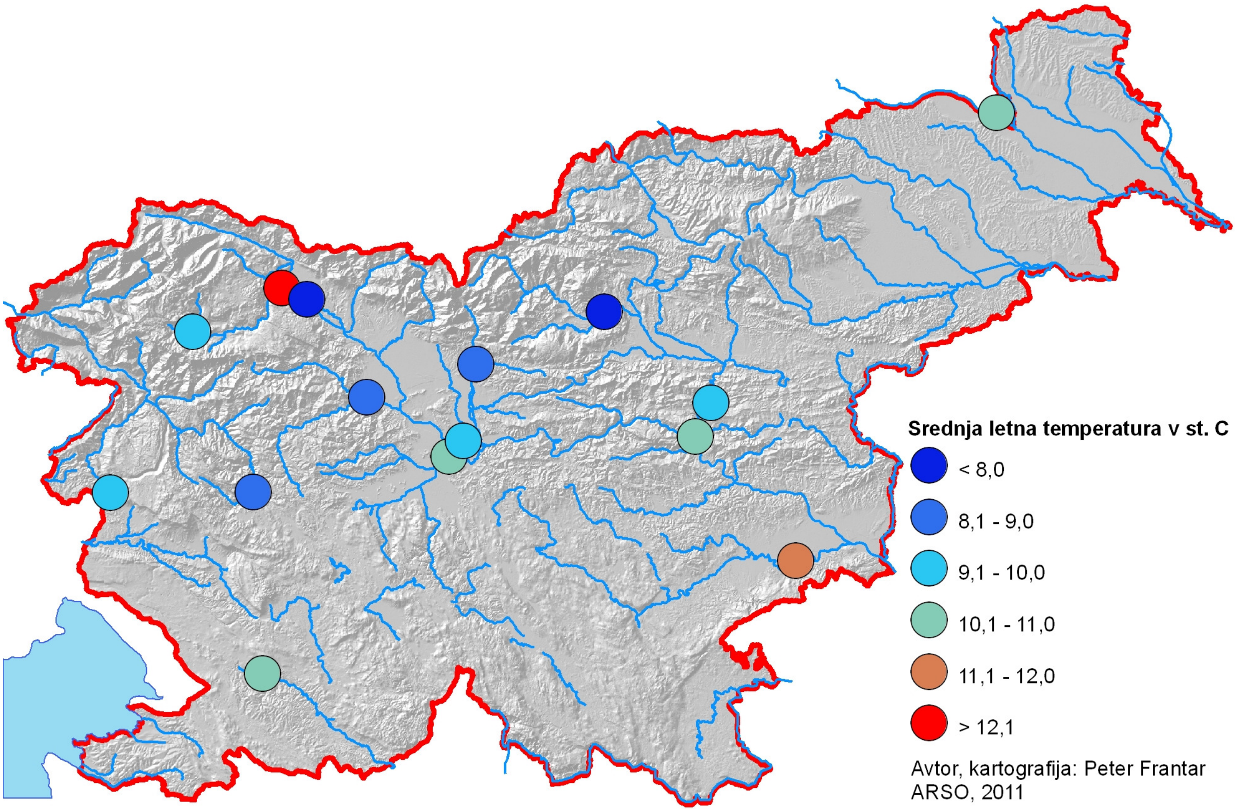
The annual temperature trend recorded in both Apline lakes was similar to the average water temperature trend. The lowest temperatures were recorded at the end of January and in February, when Lake Bohinj was also frozen. Then, the temperatures of both lakes were gradually rising until the second half of August, and toward the end of the year they dropped again. Lake Bohinj reached its lowest temperature (0 °C) in the period when it was frozen (January and February), while the lowest temperature of Lake Bled (3.0 °C) was



Slika 1: Letni potek temperatur vode ob 7. uri zjutraj na izbranih vodomernih postajah
Figure 1: Annual water temperature trend at 7.00 at selected water gauging stations

Preglednica 1: Povprečne mesečne temperature vode na izbranih vodomernih postajah
Table 1: Average monthly water temperatures at selected water gauging stations

	1	2	3	4	5	6	7	8	9	10	11	12	leto / year
Mura - Gornja.Radgona	2,0	3,6	6,1	8,8	11,9	13,6	15,5	16,8	13,9	10,3	7,0	4,2	9,5
Sava - Radovljica	4,1	4,6	5,8	7,2	9,0	10,4	12,9	14,0	11,7	8,9	7,2	5,6	8,5
Sava – Šentjakob	4,3	5,2	7,0	8,9	11,4	12,6	14,9	16,8	13,3	10,8	8,0	6,2	10,0
Sora - Suha	2,9	3,6	5,1	8,4	11,9	12,8	14,4	16,6	14,1	10,5	8,0	5,6	9,5
Kamniška Bistrica - Kamnik	4,9	5,1	5,8	7,3	7,3	7,8	8,7	9,8	9,2	8,2	7,0	6,0	7,3
Ljubljanica – Moste	4,1	5,0	6,5	10,0	13,0	14,2	14,7	17,4	15,3	11,3	8,7	6,9	10,6
Savinja - Nazarje	3,1	4,1	5,3	7,8	9,6	11,3	12,4	14,3	11,9	9,5	7,1	5,7	8,5
Savinja - Laško	2,6	4,0	6,0	9,6	13,2	14,7	16,3	18,6	14,9	11,2	7,7	5,2	10,4
Savinja – Veliko Širje	2,2	4,1	6,4	10,1	14,6	15,1	16,3	19,9	15,8	12,1	7,8	4,5	10,8
Krka - Podbočje	4,2	6,9	8,9	12,7	16,6	19,1	18,6	21,8	19,3	13,8	9,4	7,8	13,3
Soča - Solkan	4,5	5,8	5,5	9,3	11,1	11,6	13,4	16,4	12,8	11,1	8,6	6,9	9,8
Idrijca - Podroteja	7,9	7,8	7,9	8,2	8,9	9,7	10,5	11,6	11,3	10,5	9,7	9,5	9,4
Reka – Cerkvenikov mlin	3,2	5,3	5,8	9,7	13,7	15,1	16,8	18,1	15,3	10,6	8,2	5,6	10,6
Bohinjsko jezero	1,1	0,0	3,0	8,6	11,3	14,1	17,2	21,3	16,8	11,8	8,3	7,1	10,1
Blejsko jezero	4,1	3,8	4,7	10,2	16,4	19,7	21,9	23,8	20,5	15,7	10,4	7,2	13,3



Slika 2: Povprečna letna temperatura vode v reki ob 7. uri zjutraj na izbranih vodomernih postajah
Figure 2: Average annual river temperature at 7.00 at selected water gauging stations

Primerjava temperature vode izbranih rek z dolgoletnim obdobjem

Odstopanje temperature rek od obdobnega povprečja je bilo v letu 2009 na večini postaj pozitivno. Negativni so bili praviloma zgolj meseci januar, junij in julij, vsi preostali meseci pa so imeli nadpovprečne mesečne temperature vode. Največje negativno odstopanje temperature rek v državi je bilo v avgustu, ko so bile temperature vode za stopinjo nižje kot po navadi v tem mesecu. Julijska in januarska temperatura rek pa je bila za okrog pol stopinje pod običajnim mesečnim povprečjem. Nadpovprečne temperature na rekah lahko razdelimo na pomladno in jesensko obdobje. V pomladnem obdobju so bile temperature rek višje za okrog pol stopinje Celzija, v jesenskem pa za okrog stopinjo. Na nekraških rekah je bilo odstopanje najvišje v avgustu in decembru, ko so bile reke v povprečju toplejše za več kot stopinjo Celzija. Reke, pri katerih na temperaturo močno vpliva kras (Ljubljanica, Kamniška Bistrica, Podroteja), so imele v tem letu zelo različno odstopanje, kar je mogoče pripisati tudi spremembi mikrolokacije postaje oz. senzorja ali spremembi naprave.

Pregled po posameznih regijah kaže, da so imele reke v osrednji Sloveniji skoraj vse leto pozitivno odstopanje. Tudi kraška Krka je imela prav tako 10 mesecev pozitivno odstopanje, največje pri Krki je bilo v septembru 2009 za skoraj 4 °C. Mura je bila skoraj vse leto »podhlajena«, izjema je konec leta

recorded on 16 January. The highest temperature of both lakes was recorded on 22 August when Lake Bohinj warmed up to 23.2 °C and Lake Bled to 25.0 °C.

Comparison of temperatures of selected rivers with multi-annual reference period temperatures

In 2009, the deviation of river temperatures from the reference period temperatures was positive at most stations. As a rule, only January, June and July were negative, while all other months had above average monthly water temperatures. The largest negative deviation of river temperatures in the country was recorded in August, when the water temperatures were higher by 1 °C in comparison to the usual August temperatures. The river temperatures in July and January were by approximately 0.5 °C below the usual monthly average. Above average river temperatures may be divided into spring and autumn temperatures. In the spring period, river temperatures were higher by approximately 0.5 °C, while in the autumn period by approximately 1 °C. The largest deviation of temperatures of non-karstic rivers was recorded in August and December, when the temperatures were on average higher by more than 1 °C. The rivers (the temperatures of which are strongly influenced by the Karst, i.e. Ljubljanica, Kamniška Bistrica, Podroteja) recorded different deviations, which can also be ascribed to the change in the microlocation of the station or sensor or to the modification of the

2009, Soča in Notranjska Reka pa sta imeli precej spremenljivi odstopanji v obe smeri.

Tudi odstopanje temperature jezer od obdobnega povprečja je bilo v letu 2009 večinoma pozitivno. Na Blejskem jezeru smo imeli izenačenje števila mesecev s pozitivnim ali negativnim odstopanjem, v skupnem pa je bilo odstopanje višje v pozitivnih mesecih. Največje pozitivno odstopanje na Bledu je bilo v avgustu in septembru za okrog +1 °C. Na Bohinjskem jezeru smo imeli le prve tri mesece negativno mesečno odstopanje (januarja in februarja več kot 1,5 °C manj kot povprečno, marca pa zgolj 0,1 °C), preostali del leta pa je bilo odstopanje pozitivno. Največje odstopanje je bilo avgusta (več kot +3 °C) ter decembra in aprila (+2 °C).

measurement instruments.

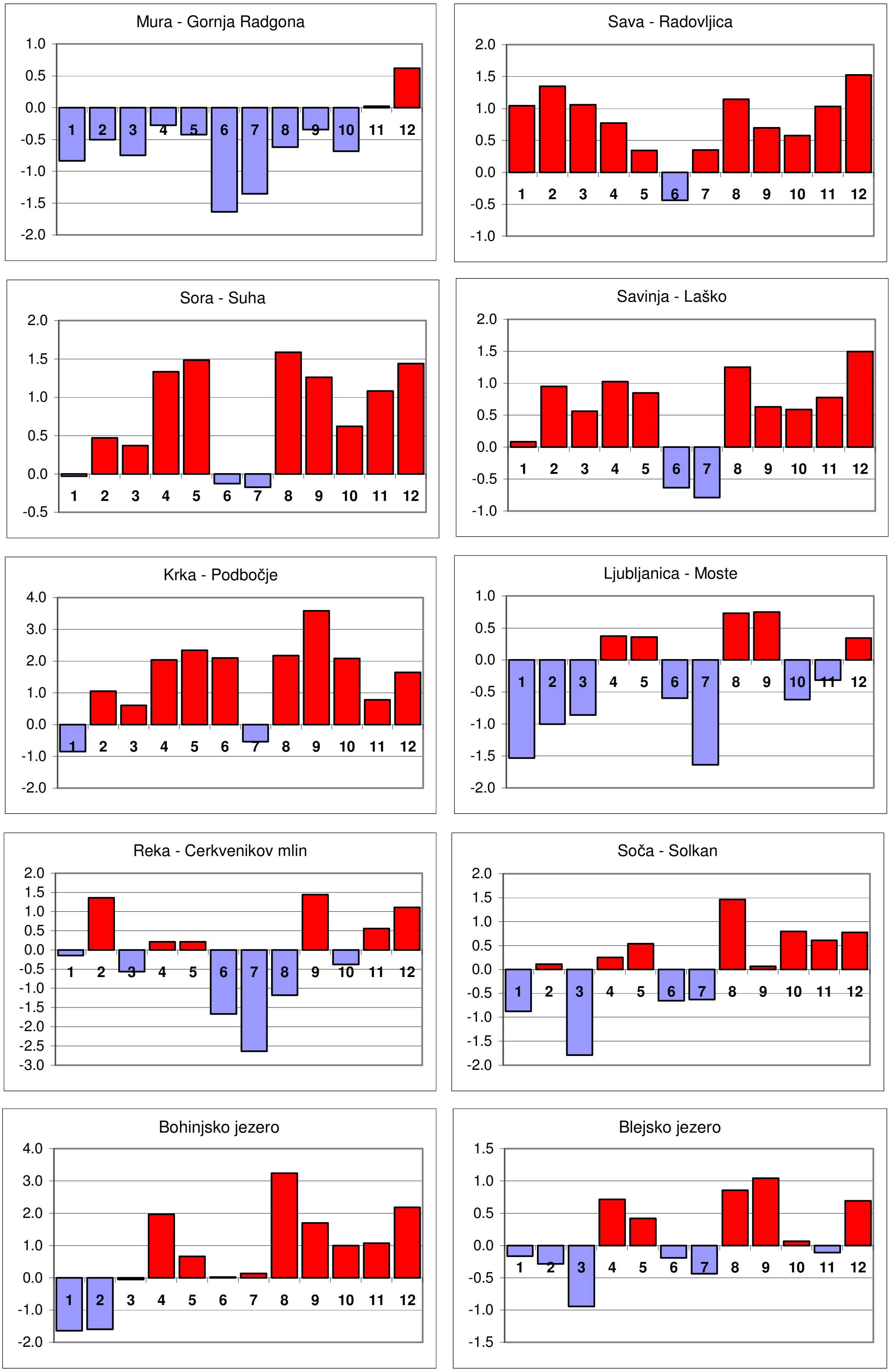
An overview by individual regions shows that the rivers in central Slovenia deviated positively almost throughout the entire year. The karstic Krka river recorded positive deviations for 10 months, the largest in September 2009 by almost 4 °C. The Mura river was 'supercooled' almost throughout the year, with the exception of the end of 2009, while variable deviations in both directions were recorded on the Soča and Reka rivers.

The deviation of lake temperatures from the periodical average was in most cases also positive. The negative and positive deviations of temperatures of Lake Bled were balanced; overall, the deviations were larger in the positive months. The largest deviation of Lake Bled was recorded in August and September by approximately +1 °C. The deviations of the temperatures of Lake Bohinj were negative in the first three months (in January and February by more than 1.5 °C below the average, in March by only 0.1 °C) while during the rest of the year the deviations were positive. The largest deviation was recorded in August (more than +3 °C), and in December and April (+2 °C).

Preglednica 2: Odstopanje povprečne mesečne temperature vode leta 2009 od obdobnih povprečnih vrednosti na izbranih vodomernih postajah

Table 2: Deviation of average monthly temperatures of water in 2009 from the periodical average at selected water gauging stations

	1	2	3	4	5	6	7	8	9	10	11	12	leto / year
Mura - Gornja.Radgona	-0,8	-0,5	-0,7	-0,3	-0,4	-1,6	-1,4	-0,6	-0,3	-0,7	0,0	0,6	-0,6
Sava - Radovljica	1,0	1,3	1,1	0,8	0,3	-0,4	0,4	1,1	0,7	0,6	1,0	1,5	0,8
Sava – Šentjakob	0,0	0,5	0,7	0,7	0,4	-0,3	0,3	2,0	0,7	0,8	0,7	1,1	0,7
Sora - Suha	0,0	0,5	0,4	1,3	1,5	-0,1	-0,2	1,6	1,3	0,6	1,1	1,4	0,8
Kamniška Bistrica - Kamnik	0,0	0,0	-0,5	-0,7	-1,5	-1,6	-2,0	-1,6	-1,1	-0,6	-0,2	0,5	-0,7
Ljubljanica – Moste	-1,5	-1,0	-0,9	0,4	0,4	-0,6	-1,6	0,7	0,7	-0,6	-0,3	0,3	-0,3
Savinja - Nazarje	0,7	1,3	0,8	0,8	0,3	-0,2	-0,8	0,6	0,3	0,6	0,9	2,0	0,6
Savinja - Laško	0,1	1,0	0,6	1,0	0,8	-0,6	-0,8	1,3	0,6	0,6	0,8	1,5	0,6
Savinja – Veliko Širje	-0,6	0,2	0,1	0,8	1,0	-1,5	-2,4	0,7	0,3	0,7	0,6	0,5	0,0
Krka - Podbočje	-0,8	1,1	0,6	2,0	2,3	2,1	-0,5	2,2	3,6	2,1	0,8	1,6	1,5
Soča - Solkan	-0,9	0,1	-1,8	0,3	0,5	-0,7	-0,6	1,5	0,1	0,8	0,6	0,8	0,1
Idrijca - Podroteja	0,3	0,2	0,0	0,0	0,2	0,5	0,9	1,6	1,9	1,7	1,4	1,6	0,8
Reka – Cerkvenikov mlin	-0,1	1,4	-0,6	0,2	0,2	-1,7	-2,6	-1,2	1,4	-0,4	0,6	1,1	-0,1
Bohinjsko jezero	-1,6	-1,6	-0,1	2,0	0,7	0,0	0,1	3,2	1,7	1,0	1,1	2,2	0,7
Blejsko jezero	-0,2	-0,3	-0,9	0,7	0,4	-0,2	-0,4	0,9	1,0	0,1	-0,1	0,7	0,3



Slika 3: Odstopanje povprečnih mesečnih temperatur vode v ℃ od obdobnega povprečja na izbranih vodomernih postajah
Figure 3: Deviation of average monthly water temperatures in ℃ from the periodical average at selected water gauging stations

VSEBNOST IN PREMEŠČANJE SUSPENDIRANEGA MATERIALA V REKAH

mag. Florjana Ulaga

Ob izrednih hidroloških razmerah se poleg povečanega pretoka rek in rinjenih plavin močno poveča tudi vsebnost suspendiranega materiala v vodi. Iz meritev vsebnosti suspendiranega materiala in izmerjenega pretoka izračunamo količino premeščenega materiala po vodotoku. Večina materiala se premesti ob visokih vodah, zaradi česar je potrebno pogosto vzorčenje prav med visokimi vodami.

V monitoring suspendiranega materiala je bilo v letu 2009 vključenih 11 merilnih mest: na Muri v Gornji Radgoni, Savi v Hrastniku, Savinji v Velikem Širju, Vipavi v Mirnu, Soči v Kobaridu, Idrijci v Hotešku, Bači v Bači pri Modreju, Reki v Cerkvenikovem mlinu, Rižani v Kubedu in na Dragonji v Podkaštelu. Na vseh merilnih mestih je monitoring potekal le ob izrednih hidroloških razmerah. Vzorci se niso odvzemali redno, torej vsak dan, pač pa le ob izrednih razmerah. Med visokimi vodami je bilo v istem dnevu lahko odvzetih tudi več vzorcev, saj se vsebnost suspendiranih snovi ob visokih vodah zelo hitro spreminja. Vzorci s prostornino enega litra so bili odvzeti ročno in analizirani v laboratoriju po klasični filtracijski metodi. Rezultati analiz so izmerjene vsebnosti suspendiranega materiala (c), izražene v g/m^3 vode. Mreža vodomernih postaj, na katerih so se v letu 2009 odvzemali vzorci, je prikazana na karti v IV. delu publikacije.

Rezultati meritev vsebnosti suspendiranega materiala v letu 2009

V letu 2009 smo največje vsebnosti suspendiranega materiala izmerili v vzorcih, odvzetih decembra v Savi, Sori, Savinji, Soči, Vipavi, Reki in Dragonji, septembra v Bači ter v pomladnih mesecih v Muri in Rižani. V Idrijci so bile največje vsebnosti izmerjene junija (preglednica 1).

Vsebnost je bila 25. decembra najbolj povečana v Sori, saj smo na vodomerni postaji v Suhi izmerili kar 2363 g/m^3. Istega dne je bil odvzet vzorec tudi v Savinji, vsebnost je bila močno povečana in je znašala 1108 g/m^3, v Soči v Kobaridu pa 1202 g/m^3. Naslednji dan smo v Savi v Hrastniku izmerili 1368 g/m^3 (slika 1). Ob decembrskih visokih vodah smo izmerili povečano vsebnost suspendiranih snovi tudi v Vipavi, Reki in Dragonji. Na sliki 2 so prikazane vsebnosti v vzorcih, odvzetih ob 8. uri.

Kljub visokim vodam decembra in povečani vsebnosti suspendiranih snovi v rekah na večini postaj nismo izmerili izrednih vsebnosti, ki bi presegale obdobne vrednosti. Izjema je le vodomerna postaja Kubed na Rižani, kjer smo ob visokih vodah konec marca izmerili

CONCENTRATION AND TRANSPORT OF SUSPENDED MATERIAL IN RIVERS

Florjana Ulaga, MSc

During extraordinary hydrological conditions, the concentration of suspended material in the water also increases significantly in addition to the increased river discharge and bed load. The quantity of transported material down the watercourse is calculated based on the measurements of suspended material concentration and the measured discharge. The majority of material is transported during high waters, thus frequent sampling is necessary precisely during this period.

Eleven water gauging stations were involved in the monitoring of suspended material in 2009: Gornja Radgona on the Mura River, Hrastnik on the Sava River, Veliko Širje on the Savinja River, Miren on the Vipava River, Kobarid on the Soča River, Hotešek on the Idrijca River, Bača pri Modreju on the Bača River, Cerkvenikov Mlin on the Reka River, Kubed on the Rižana River, and Podkaštel on the Dragonja River. Monitoring was performed at all monitoring stations only during extraordinary hydrological conditions. The samples were not taken regularly, i.e. daily, but only in extreme conditions. During the period of high waters, several samples were sometimes taken daily as the suspended material concentration changes rapidly when waters are high. One-litre samples were taken manually and analysed in laboratories using a classic filtration method. The results of analyses are measured concentrations of suspended material (c) expressed in g/m^3 of water. The network of water gauging stations at which sampling was performed in 2009 is shown on the map in Part IV of this publication.

The results of monitoring the suspended material concentration in 2009

In 2009, the maximum concentration of suspended material was measured in samples taken in December on the Sava, Sora, Savinja, Soča, Vipava, Reka and Dragonja rivers, in September on the Bača River and in the months of spring on the Mura and Rižana rivers. The maximum concentration in the Idrijca River was measured in June (Table 1).

The highest concentration was measured on 25 December in the Sora River, as the sample taken at the water gauging station at Suha showed a value as high as 2 363 g/m^3. Samples were also taken on the same day on the Savinja River, also demonstrating a considerable increase in concentration (1 108 g/m^3), and in the Soča River in Kobarid (1 202 g/m^3). On the following day we measured 1 368 g/m^3 in the Sava River near Hrastnik (Figure 1). During the period of high waters in December, a higher concentration of suspended material was measured also in the Vipava, največjo vsebnost v štiriletnem obdobju opazovanj (vzorčenje na Rižani poteka od leta 2006).

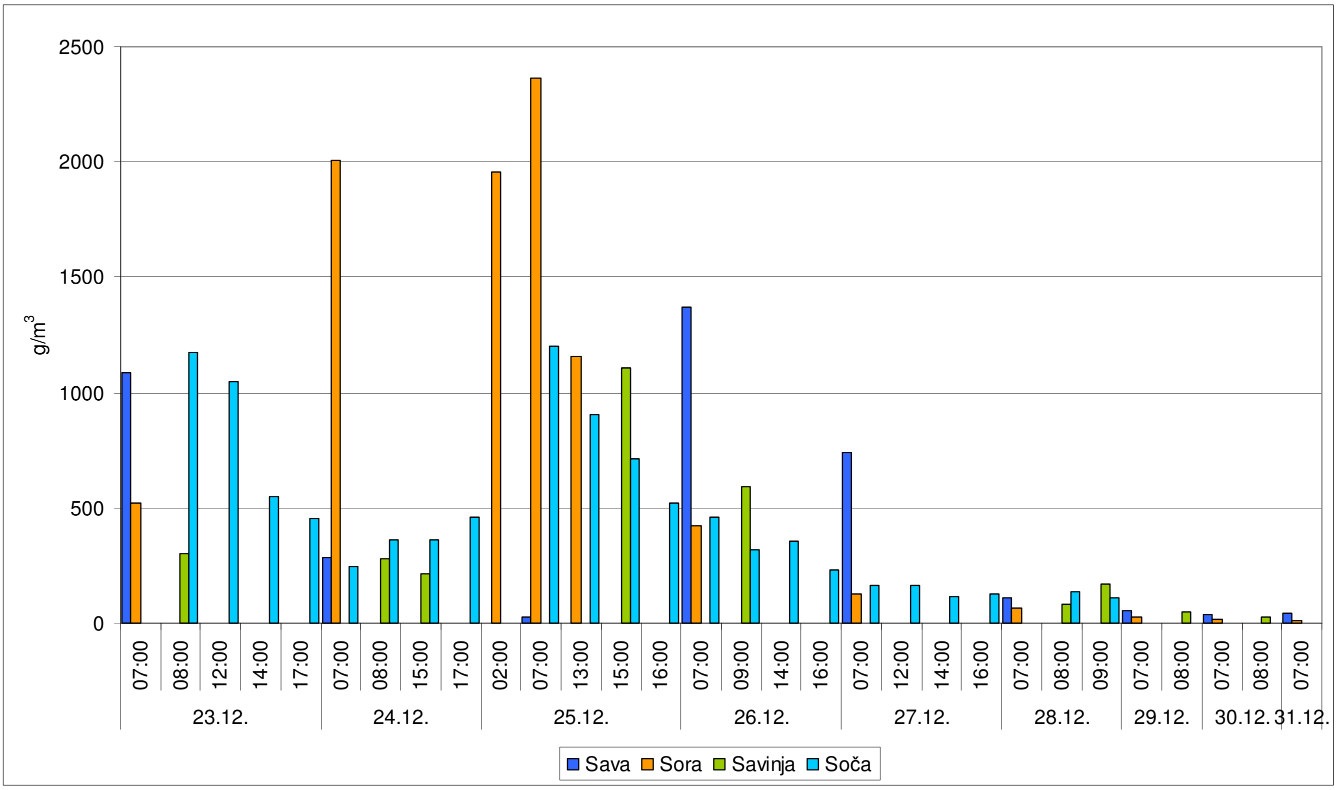
Reka and Dragonja rivers. Figure 2 shows the concentrations in samples taken at 8.00.

Preglednica 1: Največje vsebnosti suspendiranega materiala v vzorcih leta 2009 in največje izmerjene vsebnosti v obdobju 1977–2008
Table 1: Maximum concentrations of suspended material in the samples in 2009 and the maximum measured concentrations in the period from 1977 to 2008

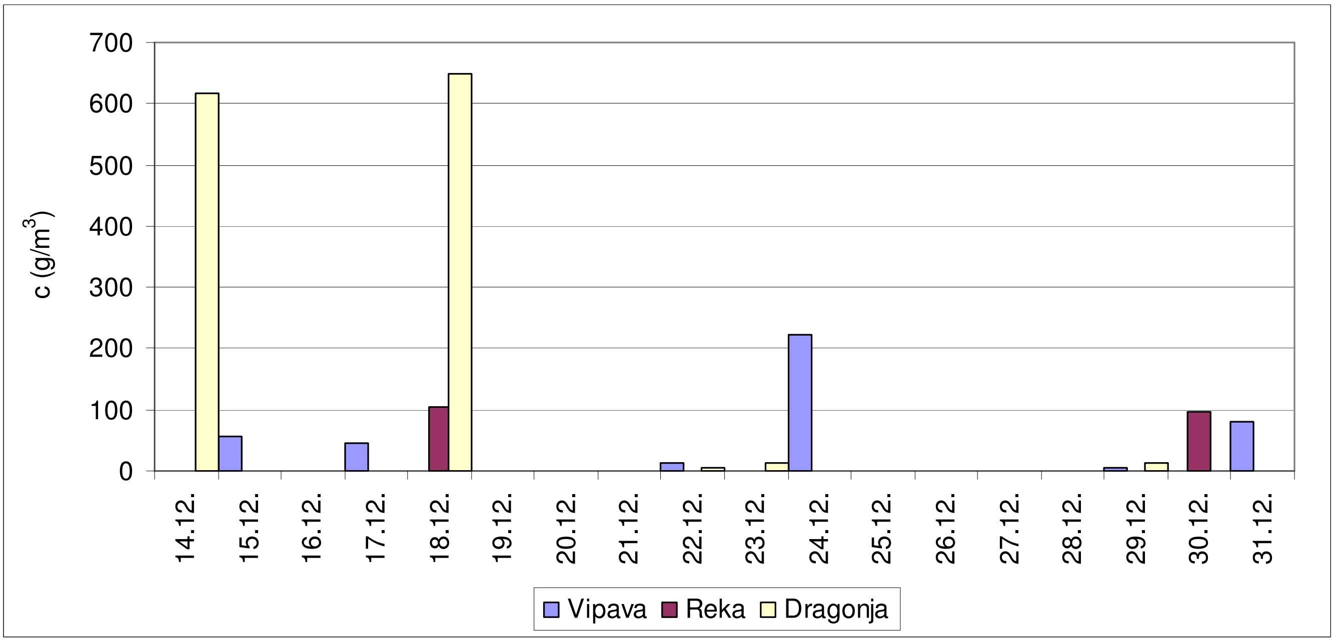
Vodotok *Stream*	Vodomerna postaja *Gauging station*	2009		1977 - 2008	
		Vsebnost c (g/m^3) *Concentration c (g/m^3)*	Datum vzorčenja *Date of sampling*	Največja obdobna vsebnost c (g/m^3) *The highest concentration in the period c (g/m^3)*	Datum največje obdobne vsebnosti *Date of the highest concentration in the period*
Mura	Gornja Radgona	1100	23.05.	2364	16.5.1996
Sava	Hrastnik	1368	26.12.	6405	19.9.2007
Sora	Suha	2363	25.12.	8120	28.2.1977
Savinja	Veliko Širje	1108	25.12.	9574	14.4.1994
Soča	Kobarid	1202	25.12.	8112	17.11.2000
Bača	Bača pri Modreju	2699	04.09.	5125	21.8.1988
Idrijca	Hotešk	886	17.06.	3743	9.10.1993
Vipava	Miren	222	24.12.	1105	27.10.2004
Reka	Cerkvenikov mlin*	105	18.12.	280	12.11.2001
Rižana	Kubed**	288	29.03.	189	14.8.2006
Dragonja	Podkaštel**	648	18.12.	1362	13.2.2007

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

Visoka voda in povečana vsebnost suspendiranega materiala v Savi v Hrastniku, 26. 12. 2009 (foto: arhiv ARSO)
High water and increased concentration of suspended material in the Sava River near Hrastnik, 26 December 2009 (photo: Agency Archives)



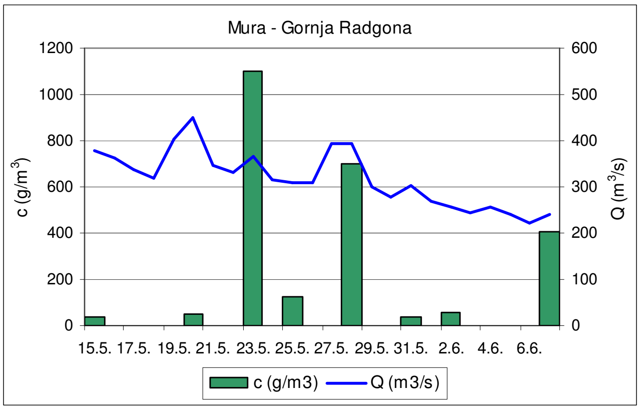
Slika 1: Povečana vsebnost suspendiranega materiala decembra 2009 odvzetih vzorcev vode v Savi, Sori, Savinji in Soči
Figure 1: Increased concentration of suspended material in samples taken from the Sava, Sora, Savinja and Soča rivers in December 2009



Slika 2: Povečana vsebnost suspendiranega materiala decembra 2009 v Vipavi, Reki in Dragonji
Figure 2: Increased suspended material concentration in December 2009 in the Vipava, Reka and Dragonja rivers

Največjo vsebnost suspendiranega materiala med vsemi odvzetimi vzorci v letu 2009 smo izmerili v reki Bači, ko smo ob visokih vodah septembra izmerili kar 2699 g/m^3, kar je četrta največja izmerjena vsebnost v dolgoletnem obdobju opazovanj na tej postaji. Na postaji Hotešk na Idrijci smo največjo vsebnost

Despite the high waters and increased concentration of suspended materials in rivers, the results of most stations did not show any extraordinary concentrations exceeding periodical values. The only exception was the Kubed water gauging station on the Rižana River, where the highest concentration in the four years of suspendiranih snovi v vodi izmerili junija, ob decembrskih visokih vodah vzorec ni bil odvzet, na postaji Gornja Radgona na Muri pa maja, 1100 g/m^3, kar je za 22-krat preseženo obdobno povprečje, ki znaša 49 g/m^3 (slika 3).



Slika 3: Povečana vsebnost suspendiranega materiala v Muri in povečan pretok v maju 2009
Figure 3: Increased suspended material concentration in the Mura River and increased discharge in May 2009

Premeščanje suspendiranega materiala

Iz vsebnosti suspendiranega materiala in izmerjenega pretoka izračunamo količino premeščenega suspendiranega materiala. Največje količine suspendiranega materiala sta glede na analize odvzetih vzorcev v letu 2009 prenesli reki Sava in Sora (slika 4). Sava v Hrastniku je 26. decembra prenesla kar 2086,95 kg/s, to je dobrih 7500 ton na uro. Sora je skozi profil v Suhi 25. decembra prenesla 675,88 kg/s. V podobnih visokovodnih razmerah bi to pomenilo v povprečju 2433 ton na uro.

V preglednici 2 so zbrani podatki o največjem premeščanju suspendiranega materiala v letu 2009 in obdobju 1977–2008. Vrednosti v Savi, Savinji, Sori, Soči, Bači, Idrijci, Vipavi in Rižani izkazujejo izredno premeščanje suspendiranega materiala med decembrskimi visokimi vodami. V Reki in Dragonji je bilo največ suspendiranih snovi premeščenih marca ob poletnih visokih vodah, v Muri pa julija. V Sori in Rižani je bilo doseženo največje premeščanje suspendiranega materiala v celotnem obdobju opazovanj. Vrednosti se nanašajo na rezultate odvzetih vzorcev, ki pa niso bili nujno odvzeti ob najvišjih vodah oziroma med največjim premeščanjem snovi v reki.

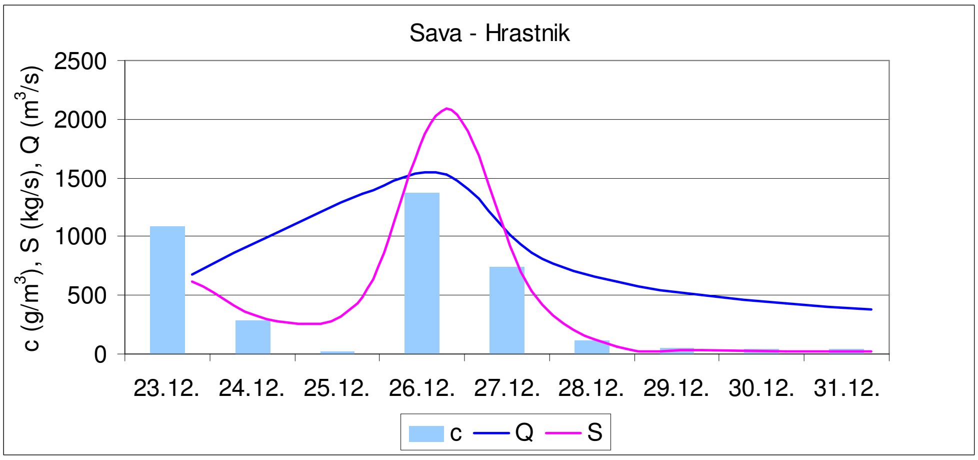
monitoring was measured at the end of March (sampling on the Rižana River has been carried out since 2006).

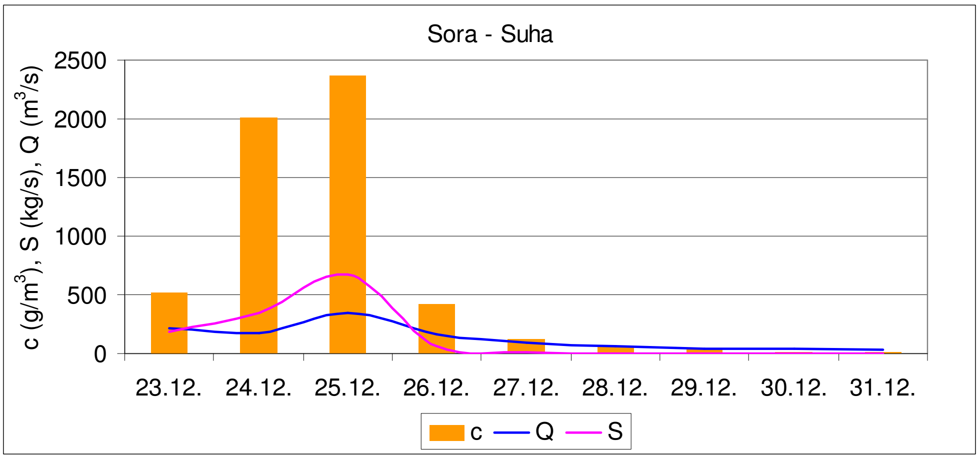
The highest concentration of suspended material in all samples taken in 2009 was measured in the Bača River, where the concentration in the period of high waters in September was as high as 2 699 g/m^3, which is the fourth highest measured concentration in a long period of monitoring at this station. The highest concentration at the Hotešk station on the Idrijca River was measured in June while the sample was not taken in the December period of high waters; the highest concentration at Gornja Radgona on the Mura River was measured in May: the value of 1 100 g/m^3 exceeds the periodical average of 49 g/m^3 by 22 times (Figure 3).

Transport of suspended material

The quantity of transported material is calculated on the basis of the suspended material concentration and the measured discharge. According to the analyses of samples taken in 2009, the largest volumes of suspended materials were transported by the Sava and Sora rivers (Figure 4). On 26 December, the Sava River at Hrastnik transported as much as 2 086.95 kg/s, which is over 7 500 tons per hour. On 25 December, the Sora River transported 675.88 kg/s through the profile at Suha. This would constitute the average of 2 433 tons per hour in similar high water circumstances.

Table 2 shows the data on maximum volumes of transported suspended material in 2009 and in the 1977–2008 period. The values in the Sava, Savinja, Sora, Soča, Bača, Idrijca, Vipava and Rižana rivers show exceptional transportation of suspended material during the high waters of December. The Reka and Dragonja rivers recorded maximum levels of transported suspended material in March and during the summer high water levels, while the Mura River recorded such levels in July. The Sora and Rižana rivers recorded maximum levels of transported suspended material in the entire period of monitoring. The values refer to the results of samples that were not necessarily taken at highest waters or during the maximum transport of material in the river.





Slika 4: Izjemno povečano premeščanje suspendiranega materiala v Savi in Sori decembra 2009
Figure 4: Exceptional increase in transportation of suspended material in the Sava and Sora rivers, December 2009

Preglednica 2: Največje premeščanje suspendiranega materiala med odvzetimi vzorci v letu 2009 in največje vrednosti premeščenega suspendiranega materiala v obdobju 1977–2008
Table 2: Maximum volume of transport of suspended material among samples taken in 2009, and maximum values of transported suspended material in the 1977–2008 period.

		2009		1977 - 2008	
Vodotok *Stream*	Vodomerna postaja *Gauging station*	Premeščanje S (kg/s) *Transport S (kg/s)*	Datum vzorčenja 2009 *Date of sampling 2009*	Največje obdobno premeščanje S (kg/s) *The highest transport in the period S (kg/s)*	Datum največjega obdobnega premeščanja *Date of the highest transport in the period*
Mura	Gornja Radgona	551,44	19.07.	1681	13.8.2002
Sava	Hrastnik	2086,95	26.12.	7500	19.9.2007
Sora	Suha	675,88	25.12.	280	28.2.1977
Savinja	Veliko Širje	370,82	25.12.	2311	5.11.1998
Soča	Kobarid	484,33	25.12.	2271	17.11.2000
Bača	Bača pri Modreju	84,53	23.12.	332	10.10.2004
Idrijca	Hotešk	263,99	23.12.	1062	1.11.1990
Vipava	Miren	55,24	24.12.	223	14.9.1997
Reka	Cerkvenikov mlin*	2,80	05.03.	32	12.12.2008
Rižana	Kubed**	7,43	23.12.	5,4	13.2.2007
Dragonja	Podkaštel**	3,45	30.03.	32	13.2.2007

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

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

B. PODZEMNE VODE

B. GROUNDWATER

STANJE ZALOG PODZEMNIH VODA V ALUVIALNIH VODONOSNIKIH V LETU 2009

Urška Pavlič

Za leto 2009 so bile značilne običajne in nadpovprečne zaloge podzemnih voda. Nadpovprečno visoke gladine so zaradi velikih količin padavin in povišanih vodostajev rek prevladovale predvsem na območju vodonosnika Ljubljanskega polja ter v delih Dravske in Murske depresije. Od običajnih in visokih gladin je izraziteje odstopalo območje vodonosnika Vipavske doline, na katerem so bile večji del leta vodne gladine zaradi neugodnih podnebnih razmer, ki se močneje izražajo že od leta 2003, v območju zelo nizkih vodnih zalog. Podpovprečne zaloge podzemnih voda so bile po pričakovanjih tudi v vodonosnikih Kranjskega in Sorškega polja, kjer je vodno stanje povzročeno z zajezitvijo Save pri Mavčičah leta 1986. V smislu zalog podzemnih voda je bil najugodnejši čas leta od januarja do aprila, najbolj sušni pa so bili razen predelov Dravskega in Prekmurskega polja jesenski meseci med septembrom in novembrom.

GROUNDWATER STORAGE IN ALLUVIAL AQUIFERS IN 2009

Urška Pavlič

Typical of 2009 were average and above-average reserves of groundwater. As a result of large volume of precipitation and increased river levels, high levels of groundwater were prevalent especially in the area of Ljubljana field aquifer and in parts of Drava and Mura depressions. A significant deviation from average and high levels was observed in the Vipava valley aquifer, whose water levels were very for most of the year as a result of unfavourable climate conditions prominent since 2003. The groundwater reserves were also below average in the aquifers of the Kranj and Sora fields, which was due to the impoundment of the Sava river at Mavčiče in 1986. In terms of groundwater reserves, the most favourable period was that from January to April, while the autumn months from September to November were the driest, except for parts of the Drava and Prekmurje fields.

Pogled na zahodni del Ljubljanskega polja, kjer se vodonosnik v veliki meri napaja z infiltracijo vode iz reke Save; april 2009
View on the western part of the Ljubljana Field, where the aquifer is largely fed by infiltration from the Sava River, April 2009

Na stanje zalog podzemnih voda vpliva količina padavin, ki posredno ali neposredno pronica v vodonosnik. V letu 2009 je bilo napajanje aluvialnih vodonosnikov s pronicanjem padavin na severu države večje kot običajno, na območju vodonosnikov južnega dela Slovenije pa dolgoletno padavinsko povprečje ni bilo doseženo. Največ padavin, ki so pripomogle k celotnemu letnemu obnavljanju zalog podzemnih voda, je prejelo območje Murske kotline, najmanj pa območje vodonosnikov Krško-Brežiške kotline. V Vipavsko-Soški dolini in Ljubljanski kotlini je bil najbolj sušen mesec maj, največ padavin pa so imeli decembra in marca. Drugje po Sloveniji je bil najbolj vodnat januar, najbolj sušen pa je bil v Krško-Brežiški in Murski kotlin september, v spodnji Savinjski dolini oktober, na območju vodonosnikov Dravske kotline pa je najmanj dežja padlo v aprilu.

Aluvialni vodonosniki se napajajo tudi s pronicanjem vode iz rek, pri čemer mora obstajati hidravlična povezava med vodotokom in podzemno vodo. Vodnatost rek je bila v letu 2009 nadpovprečna predvsem v prvih štirih mesecih in decembra, ko so padavine in raztaljen sneg razen v severovzhodnem delu države povzročili eno večjih povodenj zadnjih let. Jesen je bila podpovprečno vodnata.

Prostorska spremenljivost zalog podzemne vode v letu 2009

V letu 2009 so na območju medzrnskih vodonosnikov prevladovale normalne vrednosti zalog podzemnih voda. Značilne so bile za Mirensko-Vrtojbensko polje, Kranjsko in Vodiško polje, dolino Kamniške Bistrice, Celjsko in Krško-Brežiško kotlino ter večje predele Dravskega in Prekmurskega polja. Zelo nizke gladine so leta 2009 prevladovale v Vipavski dolini in ponekod na območju Sorškega polja, nadpovprečne vrednosti zalog pa so bile značilne za vodonosnike Ljubljanskega in Murskega polja, Vrbanskega platoja ter nekatere predele Prekmurskega, Apaškega in Dravskega polja (preglednica 1 in sliki 1 in 4).

Nadpovprečne količine letnih padavin, pa tudi povišani vodostaji rek na odsekih, ki so hidravlično povezani z gladino podzemnih voda, so bili v letu 2009 vzrok za nadpovprečno stanje zalog podzemnih voda na območjih vodonosnikov Murske in Dravske kotline. Izjema je zelo visoko vodno stanje Vrbanskega platoja, ki je pod režimom umetnega napajanja vodonosnika z vodo iz reke Drave.

Kljub normalnim letnim količinam napajanja Ljubljanskega polja s pronicanjem padavin je bilo stanje zalog podzemnih voda v tem vodonosniku leta 2009 nadpovprečno. Visoke do zelo visoke zaloge vodne gladine so prevladovale predvsem v prvih dveh tretjinah leta, k čemur je pripomogla predvsem velika vodnatost reke Save, ki v zahodnem in osrednjem delu svojega toka po Ljubljanskem polju napaja ta aluvialni vodonosnik (slika 4). Dolgoročno pa naraščajoč trend nihanja gladin v vodonosniku Ljubljanskega polja delno pripisujemo tudi vse manjšim odvzemom podzemnih voda zaradi izboljšav v vodovodni infrastrukturi in manjšim potrebam po podzemni vodi za industrijske

The quantity of precipitation that is directly or indirectly infiltrated in the aquifer influences the volume of groundwater reserves. In 2009, the feeding of alluvial aquifers through infiltration from precipitation was above average in the north of the country, while the area of aquifers of the southern part of Slovenia did not reach the multi-annual precipitation average. Most precipitation that contributed to the overall recovery of groundwater reserves fell in the area of the Mura basin, while the quantity was lowest in the area of aquifers of the Krško–Brežice basin. The driest month in the Vipava and Soča valleys and in the Ljubljana basin was May, while precipitation was highest in December and March. Elsewhere in Slovenia, the precipitation level was highest in January, while the driest months were September in the Krško–Brežice and Mura basins, October in the lower Savinja valley and April in the area of the aquifers of the Drava basin.

Alluvial aquifers are fed through infiltration from rivers, provided that a hydraulic link between the watercourse and the groundwater exists. In 2009, the river stage was above average, especially in the first four months, and in December, when precipitation and melting snow caused one of the major floods of the last years; the only exception was the north-eastern part of the country. The river stages of autumn were under average.

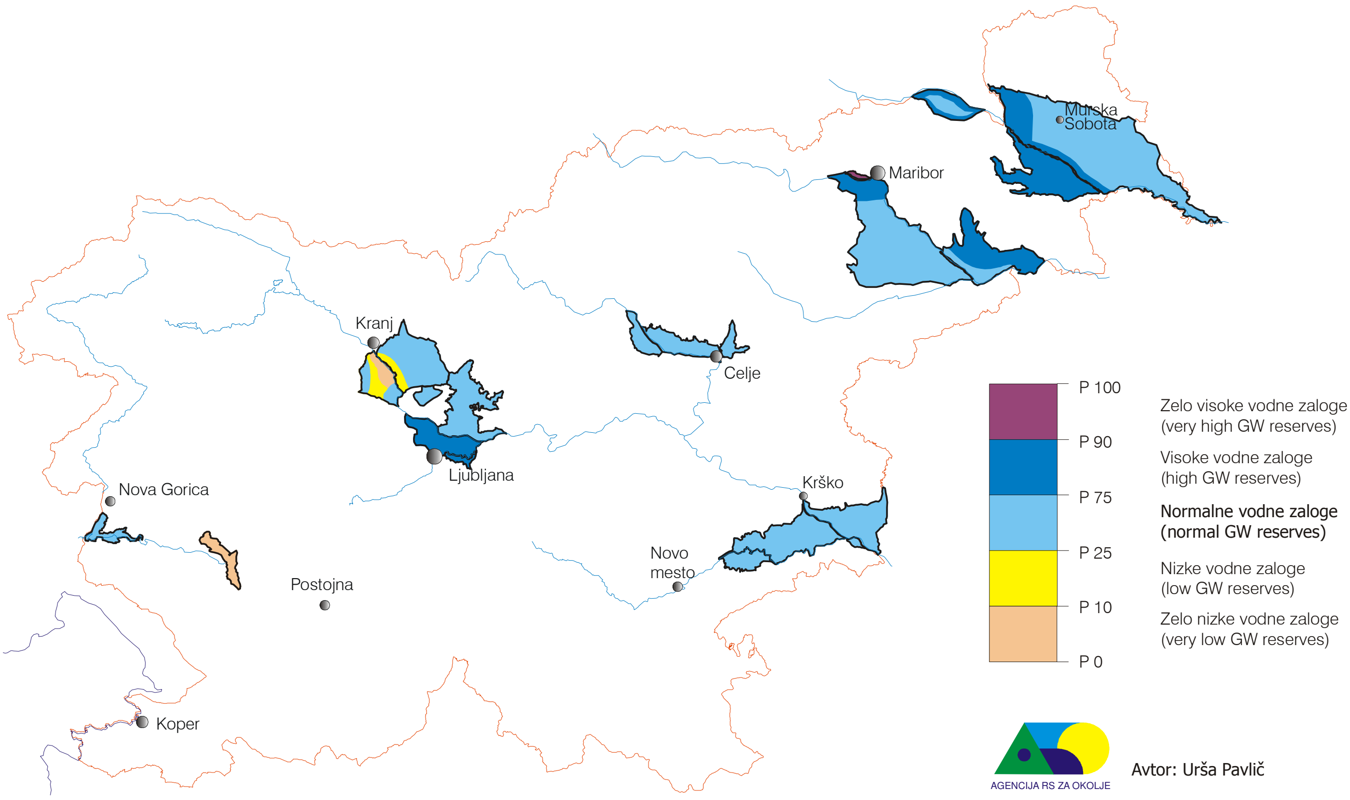
Spatial variability of groundwater reserves in 2009

In 2009, normal values of groundwater reserves prevailed in the area of intergranular aquifers. These reserves were typical of the Miren–Vrtojba field, Kranj and Vodice fields, Kamniška Bistrica valley, Celje and Krško–Brežice basins and major parts of the Drava and Prekmurje fields. In 2009, very low levels prevailed in the Vipava valley and in parts of the Sora field, while above-average reserve values were typical of the aquifers of the Ljubljana and Mura fields, the Vrbanski plateau and parts of Prekmurje, Apače and Drava fields (Table 1 and Figures 1 and 4).

Above-average quantities of annual precipitation as well as increased river levels in parts hydraulically connected to the groundwater level resulted in above-average groundwater reserves in the areas of aquifers of the Mura and Drava basins in 2009. The only exception was the very high water levels at Vrbanski plateau, which is subject to the regime of artificial feeding of the aquifer from the Drava river.

The groundwater reserves in the aquifer of the Ljubljana field in 2009 were above average despite normal annual feeding through infiltration by precipitation. The groundwater reserves were high or very high, especially in the first two thirds of the year, which was mostly because of a high water stage of the Sava feeding this alluvial aquifer in the western and central parts of its stream on the Ljubljana field (Figure 4). In the long run, the growing trend of fluctuation of levels in the aquifer of the Ljubljana field is partly ascribed to the decreasing abstraction of groundwater because of improved water supply infrastructure and to namene (slika 1).

the decreasing needs for groundwater for industrial purposes (Figure 1).



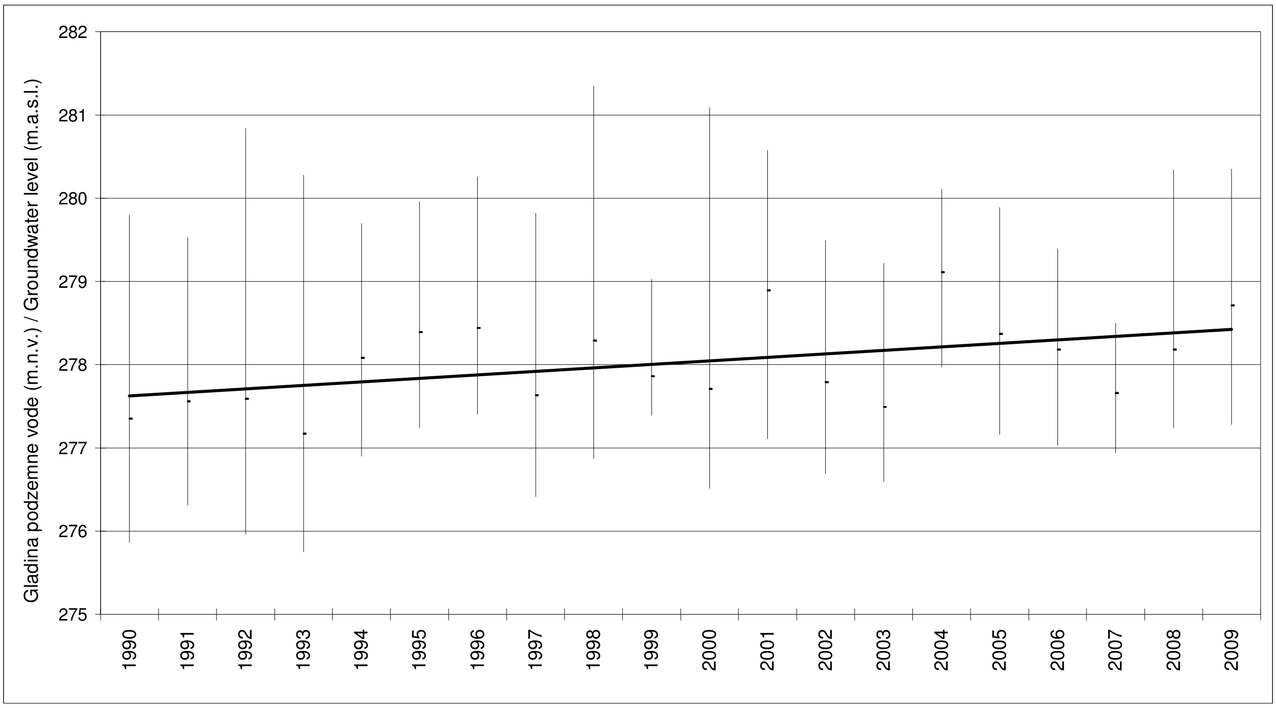
Slika 1: Srednje letne gladine leta 2009 v večjih aluvialnih vodonosnikih
Figure 1: Mean annual water levels in 2009 in larger alluvial aquifers

Povprečne letne vrednosti zalog na območju vodonosnika Vipavske doline že peto leto zapored odstopajo od normalnih količin. Zelo nizko vodno stanje, ki je prevladovalo med letoma 2005 in 2007, se je zaradi povečanega napajanja vodonosnika s pronicanjem padavin nekoliko obnovilo v letu 2008, vendar kljub temu ni doseglo običajnih gladin podzemne vode. V letu 2009 so se povprečne letne vrednosti ponovno znižale do ravni zelo nizkih vodnih zalog (slika 1). Glavni vzrok za zniževanje zalog podzemnih voda v tem vodonosniku je upadajoč trend skupnih letnih padavin in vse večja stopnja evapotranspiracije (slika 3).

Normalnih vrednosti zalog podzemnih voda v letu 2009 prav tako niso dosegla območja Kranjskega in Sorškega polja, na katerih se že dolga leta kažejo posledice zajezitve Save pri Mavčičah. Zaradi zamuljevanja rečnih brežin se zmanjšuje hidravlična povezanost med površinsko in podzemno vodo. Kljub temu so gladine podzemnih voda na teh območjih še vedno višje od stanja pred zajezitvijo, saj se je ob zajezitvi Save gladina podzemnih voda ponekod zvišala za več kot 8 metrov.

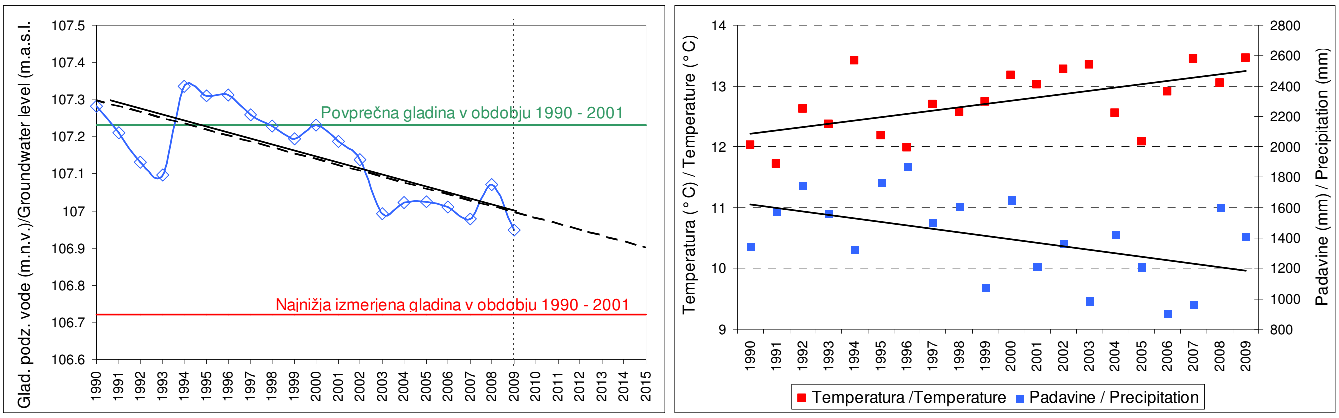
Average annual values of reserves in the field of the Vipava valley aquifer have declined from normal quantities for the fifth year in a row. Although very low water levels prevalent between 2005 and 2007 slightly improved in 2008 because of increased feeding of the aquifer through the infiltration of precipitation, they did not reach the normal groundwater levels. In 2009, the average annual values dropped again to the level of very low water reserves (Figure 1). The principal reason for the decrease of groundwater reserves in this aquifer is the decreasing trend of total annual precipitation and a growing level of evapotranspiration (Figure 3).

The areas of the Kranj and Sora fields did not reach the normal values of groundwater in 2009 either, which is the long-term consequence of the impoundment of the Sava near Mavčiče. The silting up of the river escarpments has reduced the hydraulic connection between surface water and groundwater. Nevertheless, the groundwater levels in these areas are still higher than before the impoundment, as the groundwater levels sometimes rose by more than eight metres when the Sava was impounded.



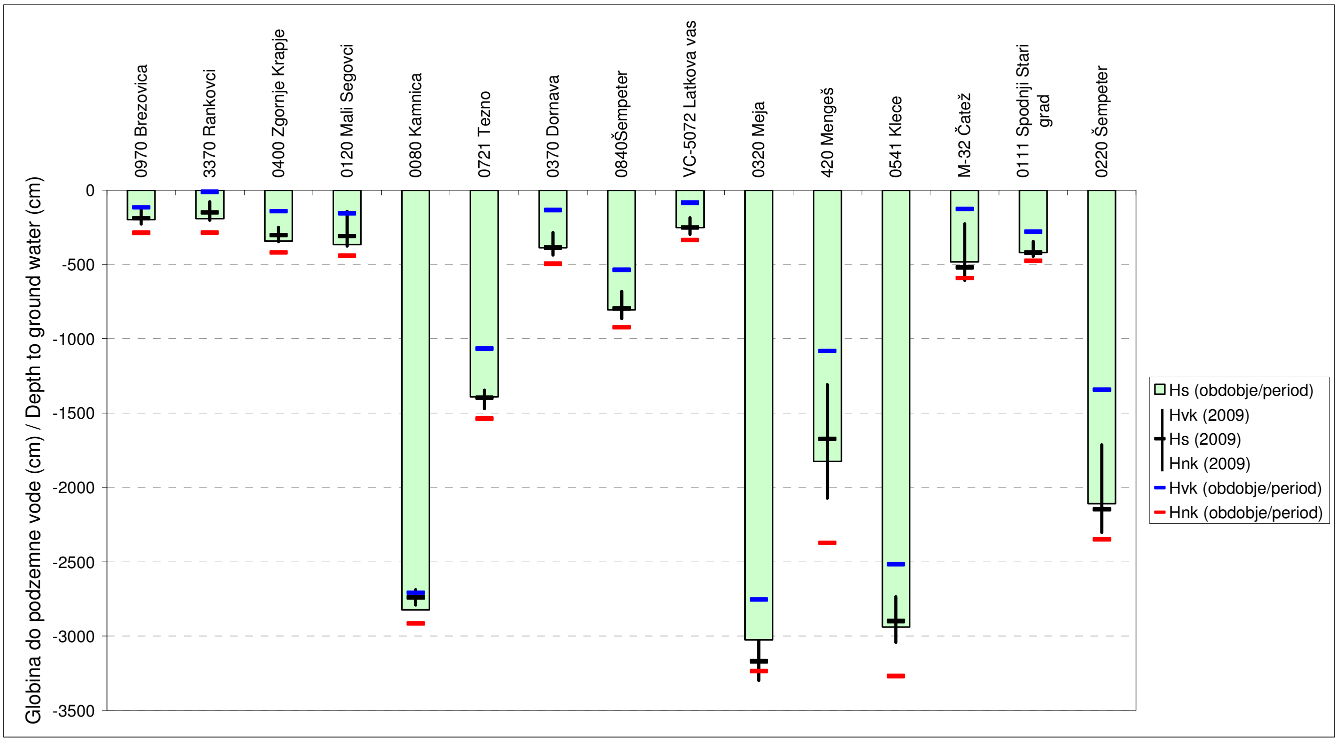
Slika 2: Nihanje značilnih letnih gladin podzemnih voda na merilnem mestu v Klečah na zahodnem delu vodonosnika Ljubljanskega polja in trend povprečnih letnih vrednosti v obdobju 1990–2009

Figure 2: Fluctuation in typical annual groundwater levels at the gauging station at Kleče in the western part of the aquifer of the Ljubljana field, and the trend of average annual values in the 1990–2009 period



Slika 3: Časovni trend nihanja povprečne letne gladine podzemne vode na merilnem mestu v Vipavskem Križu glede na povprečno in najmanjšo vrednost primerjalnega obdobja (levo) ter trenda spreminjanja povprečne letne temperature zraka in vsote letnih padavin na merilnem mestu v Biljah (desno)

Figure 3: Time trend of fluctuation of the average annual groundwater level at the gauging station at Vipavski Križ in view of the average and lowest value of the reference period (left) and the trend of variation of average annual air temperature and total amount of precipitation at Bilje gauging station (right)



Slika 4: Primerjava značilnih globin do podzemne vode v letu 2009 z značilnimi gladinami za primerjalno obdobje (preglednica 1) (Hs – srednja letna/obdobna gladina, Hnk – najnižja letna/obdobna gladina, Hvk – najvišja letna/obdobna gladina)
Figure 4: Comparison of characteristic depths to groundwater in 2009 with characteristic water levels for the reference period (Table 1) (Hs – mean annual/periodical level, Hnk – lowest annual/periodical level, Hvk – highest annual/periodical level)

Preglednica 1: Primerjava značilnih globin do podzemne vode v letu 2009 z značilnimi globinami dolgoletnega primerjalnega obdobja
Table 1: The comparison of characteristic depths to groundwater in 2009 with characteristic depths of the multi-annual reference period

Postaja *Station*	Vodonosnik *Aquifer*	2009			Obdobje / *Period*		
		Hnk (cm)	Hs (cm)	Hvk (cm)	Hnk (cm)	Hs (cm)	Hvk (cm)
0970 Brezovica	PREKMURSKO POLJE	229	190	135	287	199	116
3370 Rankovci	PREKMURSKO POLJE	203	151	78	286	191	12
0400 Zgornje Krapje	MURSKO POLJE	347	303	250	420	343	142
0120 Mali Segovci	APAŠKO POLJE	377	310	141	441	366	157
0080 Kamnica	VRBANSKI PLATO	2790	2739	2687	2915	2822	2709
0721 Tezno	DRAVSKO POLJE	1470	1397	1345	1537	1391	1066
0370 Dornava	PTUJSKO POLJE	438	386	285	496	388	135
0840Šempeter	SP. SAVINJSKA DOL.	864	796	680	923	804	537
VC-5072 Latkova vas	DOLINA BOLSKE	298	253	186	335	253	85
0320 Meja	SORŠKO POLJE	3298	3170	3028	3236	3026	2753
420 Mengeš	D. KAMNIŠKE BISTRICE	2071	1673	1308	2373	1825	1082
0541 Klece	LJUBLJANSKO POLJE	3042	2899	2735	3269	2939	2516
M-32 Čatež	ČATEŠKO POLJE	608	520	227	592	483	127
0111 Sp. Stari grad	BREŽIŠKO POLJE	445	421	345	476	419	279
0220 Šempeter	VIPAVSKO-SOŠKA DOLINA	2302	2148	1712	2350	2109	1343

Časovna spremenljivost zalog podzemne vode v letu 2009

Zaloge podzemnih voda se v aluvialnih vodonosnikih med letom spreminjajo počasneje kot izdatnost površinskih vodotokov. Časovna zakasnitev glede na napajanje vodonosnikov je večja v globokih

Temporal variability of groundwater reserves in 2009

During the year, the groundwater reserves in alluvial aquifers change more slowly than the yield in surface watercourses. The time lapse in aquifer feeding is greater in deep aquifers, which include the Kranj, Sora vodonosnikih, kamor v Sloveniji spadajo območja Kranjskega, Sorškega in Ljubljanskega polja, kot pa v plitvih aluvialnih naplavinah. V splošnem je v prvem štirimesečju leta 2009 prevladovalo ugodno vodno stanje zaradi nadpovprečnih padavin, ki se zaradi dovolj visokih temperatur niso pojavljale v obliki snega, in visokih vodostajev rek, ki so v posameznih odsekih napajale vodonosnike. Če izvzamemo severovzhodni del države, je aprilu sledilo daljše obdobje upadanja zalog podzemnih voda, k čemur sta poleg primanjkljaja padavin pripomogla tudi izhlapevanje in večja poraba vode za rast rastlin. September, oktober in november so bili hidrološko najbolj sušni meseci. Sledila je izrazita podnebna sprememba v zadnjem mesecu leta, ko so obilne padavine in taljenje snega povzročili obilno povodenj, kar se je kazalo tudi v polnjenju zalog podzemnih voda. Nihanje mesečnih gladin podzemnih voda prikazujejo preglednica 2 ter sliki 5 in 6.

Visoke in zelo visoke gladine podzemnih voda so bile j**anuarja** posledica obilnih padavin v decembru 2008, ki so se ponekod podaljšale tudi v prvi mesec leta 2009. Zelo visoke vodne gladine so bile dosežene na večini merilnih mest Krško-Brežiške kotline, spodnje Savinjske doline in Ptujskega polja ter v delih Mirensko-Vrtojbenskega, Ljubljanskega, Murskega, Prekmurskega in Apaškega polja. Zelo nizko vodno stanje na Dravskem polju je bilo januarja izraz počasnejšega obnavljanja vodonosnika od hidrološke suše preteklega leta. **Februarja** se je podzemna voda v osrednjem delu Dravskega polja sicer dvignila, vendar še ni dosegla običajnega vodnega stanja. V drugih vodonosnikih se stanje zalog podzemnih voda iz meseca januarja ni dosti spremenilo. Še vedno so prevladovale nadpovprečne in zelo visoke gladine. Izjema je bila le del Kranjskega polja in vodonosnik Vipavske doline, kjer je bilo stanje nižje od običajnega. **Marca** je bilo stanje zalog podzemnih voda v aluvialnih vodonosnikih še vedno ugodno. Vodonosniki so se tedaj napajali z nadpovprečnim pronicanjem padavin in povišanimi vodostaji rek, ki so hidravlično povezani z gladino podzemne vode. Presežek padavin je bil na območju Vipavsko-Soške doline, zaradi česar se je vodonosnik Vipavske doline obnovil do normalnega vodnega stanja, na Mirensko-Vrtojbenskem polju pa so bile dosežene zelo visoke vodne gladine. V **aprilu** je bila porazdelitev padavin neenakomerna. Žal jih je najmanj padlo ravno na območju jugozahodne Slovenije, zaradi česar so se v Vipavski dolini gladine ponovno spustile do zelo nizkih vrednosti. Tako vodno stanje se je v tem vodonosniku ohranilo vse do novembra. Od aprila so se v medzrnskih vodonosnikih vodne gladine zniževale. K slabšanju vodnega stanja je pripomogla tudi povečana stopnja evapotranspiracije, značilna za pozno pomlad in poletje. Le v vodonosnikih severovzhodne Slovenije je večji del leta prevladovalo nadpovprečno vodno stanje zaradi visokih gladin Mure in Drave ter nadpovprečnih padavin. **Maja** so bile podpovprečne zaloge podzemnih voda v dolini Bolske in na Čateškem polju ter v delih Sorškega polja in spodnje Savinjske doline, zelo nizke gladine pa so prevladovale v Vipavski dolini in zgornjem delu doline Kamniške Bistrice. Zelo nizkim zalogam podzemnih voda v Vipavski dolini se je **junija** pridružil tudi večji del Sorškega polja. Presežek padavin na severovzhodu je

and Ljubljana fields, than in shallow alluvia. In general, the first four months of 2009 had favourable water levels, because of above-average precipitation that was not in the form of snow owing to high temperatures, and because of high levels of rivers feeding aquifers in certain sections. Except in the north-eastern part of the country, April was followed by a lengthy period of dropping groundwater reserves caused by lack of precipitation, evaporation and increased water consumption for plant growth. September, October and November were the driest months in hydrological terms. This was followed by a marked climate change in the last month of the year, when extensive precipitation and melting snow caused heavy floods also evident in higher groundwater reserves. The fluctuation of monthly groundwater levels is shown in Table 2 and in Figure 5 and Figure 6.

High and very high groundwater surfaces in **January** were the result of heavy precipitation in December 2008, which continued in the first month of 2009 in some parts. Very high water levels were reached in most of the gauging stations of the Krško-Brežice basin, the lower Savinja valley and Ptuj field and in parts of the Miren–Vrtojba, Ljubljana, Mura, Prekmurje and Apače fields. Very low water levels in the Drava field in January were the result of the slower recovery of the aquifer from the hydrological drought of the previous year. Although the groundwater in the central part of the Drava field rose in **February**, it did not reach the normal water level. The groundwater reserve values in other aquifers did not differ considerably from the values of January. Most levels were still above average or very high. The only exceptions were a part of the Kranj field and the aquifer of the Vipava valley, where the levels were below average. In **March**, the groundwater reserves in alluvial aquifers were still favourable. In this period, aquifers were fed from above-average precipitation infiltration and raised river levels hydraulically connected with the groundwater level. The Vipava-Soča valley experienced excessive precipitation, which helped the aquifer of the Vipava valley recover to its normal water level, while very high water levels were reached on the Miren–Vrtojba field. The precipitation pattern in **April** was uneven. Unfortunately the precipitation was lowest in the area of the south-western Slovenia, which made the levels in the Vipava valley drop to very low values. This aquifer remained at this level until November. The water levels of intergranular aquifers were dropping since April. The water levels were further lowered by an increased rate of evapotranspiration typical of late spring and summer. Only the aquifers of the north-eastern Slovenia had above-average water levels for most of the year, which was the result of high levels of the Mura and the Drava and above-average precipitation. **May** brought under-average groundwater reserves in the Bolska valley, on the Čatež field and in parts of the Sora field and lower Savinja field; very low levels prevailed in the Vipava valley and in the upper part of the Kamniška Bistrica valley. In **June**, very low groundwater reserves prevailed in the Vipava valley as well as in the major part of the Sora field. As this month again saw excessive precipitation in the north-east, the levels of groundwater in the major parts of the Apače, bil dosežen tudi v tem mesecu, zaradi česar so se gladine podzemnih voda na večini Apaškega, Prekmurskega in Murskega polja dvignile do zelo visokih vrednosti. Napajanju iz padavin se je tedaj pridružila tudi staljena snežnica iz visokogorja v povirju reke Mure, kar je ugodno vplivalo na napajanje aluvialnih vodonosnikov, ki so hidravlično povezani z reko. **Julija** in **avgusta** je bila porazdelitev količin podzemnih voda v aluvialnih vodonosnikih regionalno neenakomerna. Na eni strani so v vodonosnikih Apaškega, Ptujskega in Prekmurskega polja ter v delih Dravskega polja prevladovale zelo visoke vodne gladine, na jugozahodu in v delih Ljubljanske in Krško-Brežiške kotline pa so bile zaloge nizke do zelo nizke. Do tega so privedle predvsem prostorsko neenakomerno porazdeljene padavine ter počasnejše obnavljanje nizkovodnega stanja iz preteklih mesecev. Od **septembra** pa vse do novembra je na območju aluvialnih vodonosnikov padlo manj padavin, kot je značilno za te mesece. Gladine podzemnih voda so se zaradi tega postopoma zniževale. Septembra so bile zelo nizke gladine podzemnih voda v vodonosnikih Vipavsko-Soške doline, v delih Kranjskega in Sorškega polja ter v vodonosnikih Krško-Brežiške kotline. V vodonosnikih ob Muri in Dravi so bile tedaj ponekod še vedno dosežene nadpovprečne vodne zaloge. Podobno vodno stanje se je nadaljevalo tudi v **oktobru**. Kljub padavinskemu primanjkljaju so se zaloge podzemnih voda v **novembru** nekoliko obnovile v delih aluvialnih vodonosnikov osrednje in zahodne Slovenije, saj se je z začetkom jeseni znižala tudi stopnja evapotranspiracije in se s tem povečala učinkovita količina padavin. **December** je bil eden od najbolj vodnatih mesecev v letu, zato je bil konec leta podobno kot v letu 2008 v znamenju izobilja podzemnih voda na večini aluvialnih vodonosnikov. Izjema so bili deli Ptujskega, Krškega in Sorškega polja, na katerih so vodne zaloge nihale v območju zelo nizkih vrednosti.

Prekmurje and Mura fields rose to very high values. The infiltration was both from precipitation and from the melting snow in the high mountains region of the Mura headwaters, which had a favourable effect on the feeding of alluvial aquifers hydraulically connected with the river. The regional distribution of groundwater quantities in alluvial aquifers was uneven in **July** and **August**. Most aquifers of the Apače, Ptuj and Prekmurje fields and in parts of the Drava field had very high water levels, while the reserves in the south-west and in parts of the Ljubljana and Krško–Brežice basins were low or very low. This was principally the result of unequally distributed precipitation and slow recovery of the low water condition from the previous months. From **September** to November, the area of alluvial aquifers received less precipitation than typical of these months. Thus the groundwater levels gradually lowered. In September, very low groundwater levels predominated in the aquifers of the Vipava–Soča valley, in parts of the Kranj and Sora fields, and in the aquifers of the Krško–Brežice basin. The water reserves in some aquifers by the Mura and Drava rivers were still above average. A similar water situation continued in **October**. Despite a lack of precipitation in **November**, the groundwater reserves somewhat recovered in parts of alluvial aquifers of the central and western Slovenia, as the beginning of autumn brought a lower level of evapotranspiration, thus increasing the efficient quantity of precipitation. **December** was one of the wettest months of the year, so the end of the year was, as in 2008, marked by abundant groundwater reserves in most alluvial aquifers. Exceptions were parts of the Ptuj, Krško and Sora fields, where water reserves fluctuated in the area of very low values.

Preglednica 2: Srednje mesečne globine do podzemne vode v letu 2009 (nm – ni meritev)
Table 2: Mean monthly depths to groundwater in 2009 (nm – measurements not available)

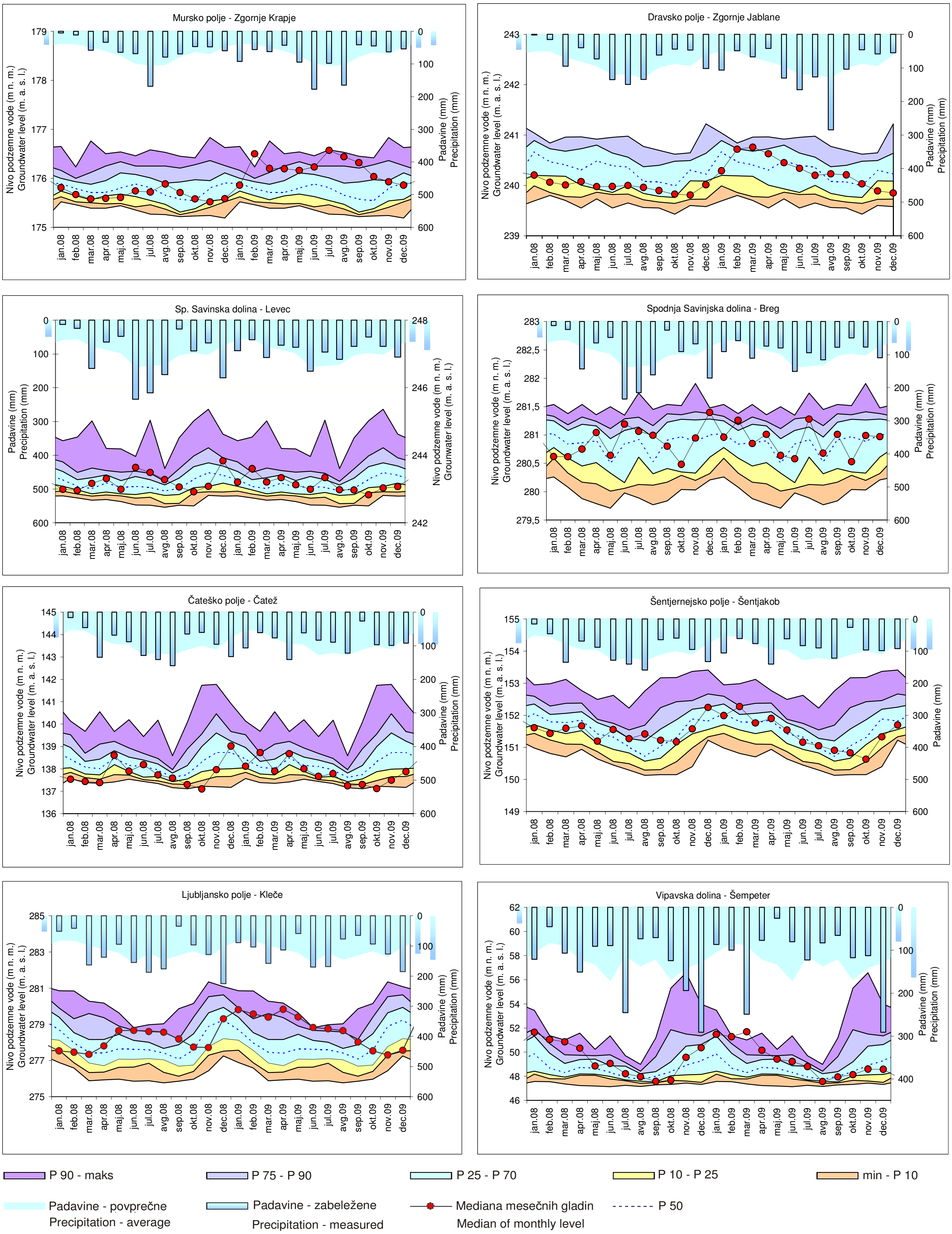
Postaja / *Station*	**Vodonosnik /*Aquifer***	**jan**	**feb**	**mar**	**apr**	**maj**	**jun**	**jul**	**avg**	**sep**	**okt**	**nov**	**dec**
0970 Brezovica	PREKMURSKO POLJE	185	158	175	185	202	199	180	198	214	221	191	178
3370 Rankovci	PREKMURSKO POLJE	188	113	128	147	156	nm	nm	nm	nm	167	159	153
0400 Zgornje Krapje	MURSKO POLJE	336	277	303	305	304	296	262	277	294	318	329	338
0120 Mali Segovci	APAŠKO POLJE	368	259	297	318	335	339	283	225	285	324	338	347
0080 Kamnica	VRBANSKI PLATO	2779	2783	2771	2733	2716	2725	2716	2710	2699	2724	2749	2766
0721 Tezno	DRAVSKO POLJE	1460	1420	1381	1379	1392	1404	1406	1390	1346	1364	1397	1426
0370 Dornava	PTUJSKO POLJE	393	322	344	363	394	402	386	367	384	417	428	433
0840Šempeter	SP. SAVINJSKA DOL.	754	718	796	779	821	849	751	796	808	839	826	814
VC-5072 Latkova vas	DOLINA BOLSKE	216	206	245	238	265	287	240	265	262	287	269	259
0320 Meja	SORŠKO POLJE	3076	3084	3097	3066	3121	3174	3171	3188	3238	3279	3296	3255
420 Mengeš	D. KAMNIŠKE BISTRICE	1480	1418	1416	1319	1533	1732	1546	1722	1926	2001	2045	1934
0541 Klece	LJUBLJANSKO POLJE	2793	2814	2832	2797	2834	2897	2895	2911	2972	3014	3031	3000
M-32 Čatež	ČATEŠKO POLJE	497	430	512	429	509	545	529	586	579	595	557	477
0111 Sp. Stari grad	BREŽIŠKO POLJE	401	360	407	416	425	434	430	438	442	444	435	421
0220 Šempeter	VIPAVSKO-SOŠKA D.	1958	1907	2039	2029	2153	2223	2258	2260	2274	2292	2284	2101

Slika 5: Odstopanja srednjih mesečnih gladin podzemne vode v letu 2009 glede na srednje mesečne gladine za dolgoletno primerjalno obdobje

Figure 5: Deviations from the mean monthly groundwater levels in 2009 with regard to the mean monthly water levels for the multi-annual reference period

Povprečne letne vrednosti zalog podzemnih voda v aluvialnih vodonosnikih so bile v letu 2009 ponekod na severovzhodu države nadpovprečne zaradi obilnejšega napajanja vodonosnikov s pronicanjem padavin in vode iz prepustnih strug rek. Tudi v tem letu smo bili priča umetnim posegom v vodonosnike, ki pa so bili glede na stanje pred posegom za stanje zalog podzemnih voda ugodni. Tako so bile gladine podzemnih voda v Vrbanskem platoju zaradi umetnega napajanja vodonosnika večji del leta zelo visoke, v Ljubljanskem polju so bile razmere ugodne zaradi visokih vodostajev reke Save in postopnega zniževanja črpanja podzemne vode iz vodonosnika, na območju Sorškega in v delu Kranjskega polja pa se je kot običajno gladina podzemne vode zniževala, vendar še ni dosegla nižjega vodnega stanja, merjenega pred zajezitvijo v Mavčičah. V vodonosniku Vipavske doline smo bili že več let zapored priča nizkim do zelo nizkim povprečnim vrednostim vodnih zalog, ki nastajajo zaradi vse večjega primanjkljaja padavin in povečane evapotranspiracije tega območja. Najbolj vodnati meseci so bili od januarja do aprila in december, jeseni pa je bilo napajanje vodonosnikov zaradi primanjkljaja padavin nižje kot običajno v tem času.

In 2009, the mean annual values of groundwater reserves in alluvial aquifers were above average in some areas in the north-east of Slovenia as a result of abundant feeding of aquifers by infiltration of precipitation and water from permeable riverbeds. This year, too, witnessed artificial interventions with aquifers, which were, however, favourable for the groundwater reserves in view of the conditions before the interventions. Thus the groundwater levels on the Vrbanski plateau were very high for the most of the year as a result of artificial feeding, the Ljubljana field had favourable conditions because of high levels of the Sava river and a gradual reduction of extraction of groundwater from the aquifer, while the groundwater level on the Sora field and part of the Kranj field lowered than usual, but did not reach the lower water level measured before the impoundment at Mavčiče. For several years, the aquifer of the Vipava valley showed low or very low water reserve levels, caused by an increasing lack of precipitation and evapotranspiration from this area. The wettest months were the months from January to April and December, while the feeding of aquifers in autumn was lower than usual because of a lack of precipitation.



Slika 6: Mediane mesečnih gladin podzemnih voda (m n. v.) v letih 2008 in 2009 – rdeči krogci, v primerjavi z značilnimi percentilnimi vrednostmi gladin primerjalnega obdobja 1990–2001

Figure 6: Medians of monthly groundwater levels (in m above sea level) in 2008 and 2009 – red circles in comparison to characteristic percentile values of water levels of the 1990–2001 reference period

C. IZVIRI

MONITORING IZVIROV V LETU 2009

Niko Trišić

V letu 2009 je program hidrološkega monitoringa izvirov zajemal skupno 17 opazovalnih mest, aktivnih oz. delujočih je bilo 15 merskih profilov (preglednica C.1.). Na profilu Mošenik pri Podljubelju opazovanja niso potekala zaradi spremembe profila in zasutja vodomera, na izviru Rakitnice pa zaradi izpada delovanja aparata. Med letom so bili pogosti izpadi tudi v profilu Letošč, na Jezernici pa je aparat pokvarjen od julija. V vseh merskih profilih spremljamo parametra vodostaj (H cm) in temperaturo (T °C), na nekaterih pa še specifično električno prevodnost (SEP µS/cm). Obnovljen je bil vodomer v profilu Idrijca nad Podrotejo.

Podatkovni nizi so v podatkovni zbirki Hidrolog preverjeni za leti 2008 in 2009, preverjajo pa se tudi starejši podatki. V letopisu za leto 2009 predstavljamo nekaj mest, na katerih poteka monitoring izvirov, ki kažejo značilnosti posameznih tipov hidrogeoloških zaledij v Sloveniji.

Izviri na območju Podroteje (visoki dinarski kras)

Na območju Podroteje, na območju zgornjega toka Idrijce, smo še naprej opazovali izvira Podroteja in Divje jezero. Za oceno hidroloških značilnosti posameznega izvira ter oceno medsebojnih odnosov površinskega in kraškega dela zaledja zgornjega toka Idrijce smo opravljali še meritve pretokov v profilu Idrijca nad Podrotejo, v kanalu Idrijce in na Jezernici.

Podatkovni nizi nihanj vodostajev (H), specifične električne prevodnosti (SEP), temperatur (T) in izvedene meritve pretokov so dragocena podlaga za spoznavanje razmer in analizo odnosov, ki prej niso bili niti znani. Poleg količinskih se spoznavajo tudi medsebojni hidravlični vplivi med posameznimi hidrogeološkimi sistemi. Izvir Divje jezero po hidrogeoloških značilnostih uvrščamo med kraške izvire vokliškega tipa. Voda izteka pod tlakom iz velikih globin v zaledju kraškega vodonosnika po sistemu dobro prepustnih kanalov. Izvir Podroteja pa je stalni bazni iztok iz celotnega kraškega zaledja, voda pa se izteka med plastmi apnenca in dolomita v omejenih oz. zadušenih količinah. Divje jezero je preliv kraških voda iz zaledja, ki je aktiven prek profila Jezernice, ob nizkih hidroloških stanjih pa celoten iztok iz kraškega zaledja zgornje Idrijce poteka prek iztoka izvira Podroteja.

C. SPRINGS

SPRING MONITORING IN 2009

Niko Trišić

In 2009, the programme of hydrological monitoring of springs consisted of 17 monitoring spots and 15 active measurement profiles (Table C.1.). Observation at the Mošenik profile in Podljubelj was not carried out due to the changing of the measurement profile and filling, while the observation at the Rakitnica spring was not carried out because of a device malfunction. Frequent malfunctions also occurred in the Letošč profile, while the device at Jezernica had been broken since July. All measurement profiles monitor water stage parameters (H cm) and the temperature (T °C), while some also monitor the specific electrical conductivity (SEP µS/cm). The water meter in the Idrijca profile above Podroteja was renovated.

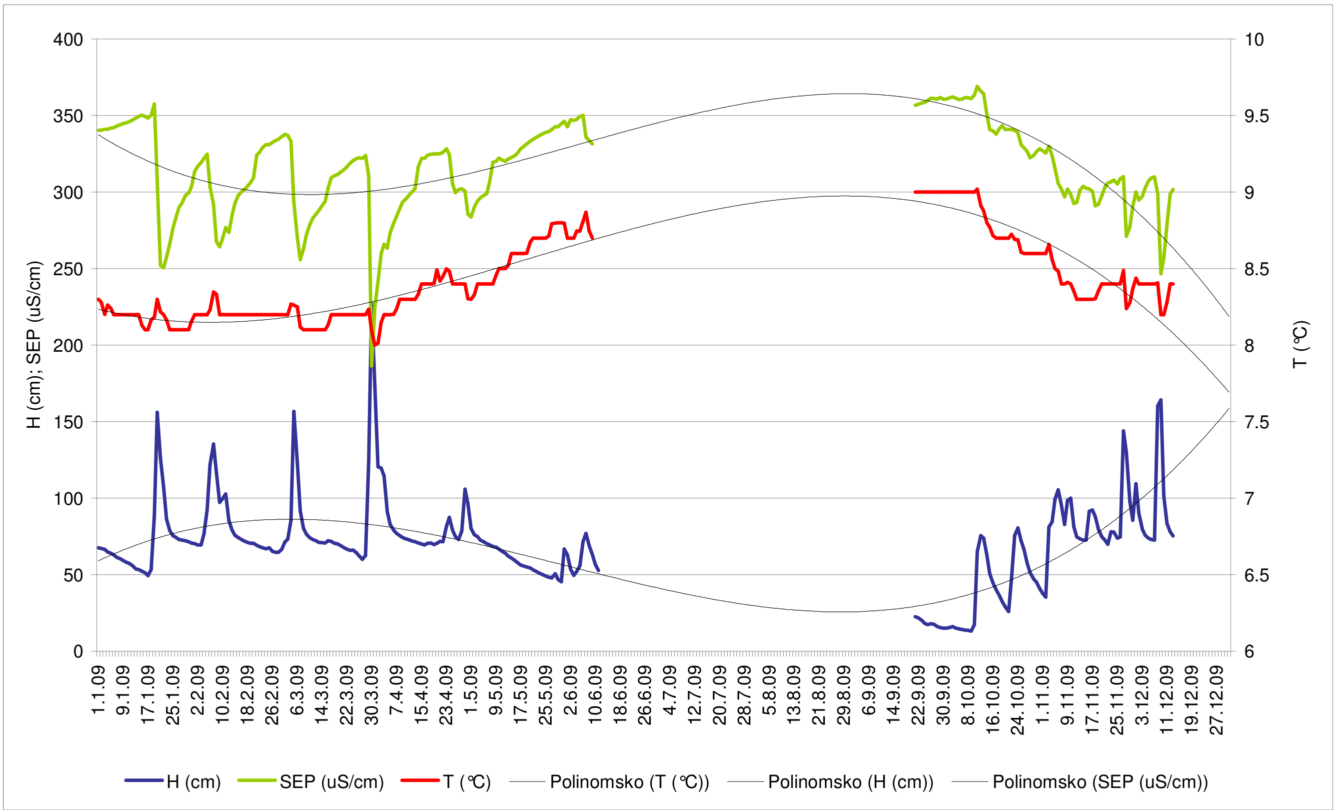
The data sets in the *Hidrolog* data collection have been checked for 2008 and 2009, and older data are also being checked. The 2009 yearbook outlines some spring monitoring spots, which show the characteristics of individual types of hydro-geological backgrounds in Slovenia.

Springs in the area of Podroteja (high Dinaric karst)

The monitoring of Podroteja and Divje jezero springs continued in the area of Podroteja, on the territory of the upper stream of the Idrijca. In order to assess hydrological characteristics of individual springs and the relation between the surface and the karstic hinterland of the upper stream of the Idrijca, we also measured the discharges in the Idrijca profile above Podroteja, in the Idrijca channel and on the Jezernica river.

The data sets of water level fluctuation (H), specific electrical conductivity (SEP), temperatures (T) and discharge measures are a valuable basis for the identification of conditions and analysis of relations not fully known before. Besides quantitative influences, we have discovered mutual hydraulic influences between individual hydro-geological systems. In terms of hydro-geological characteristic, the Divje jezero spring ranks among karstic springs of the Vaucluse type. The water is pressed from great depths in the background of the karstic aquifer through the system of well-permeable channels. The Podroteja spring is a constant base flow from the entire karstic aquifer with water running from among the layers of limestone and dolomite in limited or stifled quantities. Divje jezero is a flow of karstic waters from the background active through the Jezernica profile; at low hydrological conditions, the entire outflow from the karstic background of the upper

Idrijca runs through the outflow of the Podroteja spring.



Slika 1: Časovni potek vodostajev (H), specifične električne prevodnosti (SEP) in temperature (T) na izviru Podroteja v letu 2009

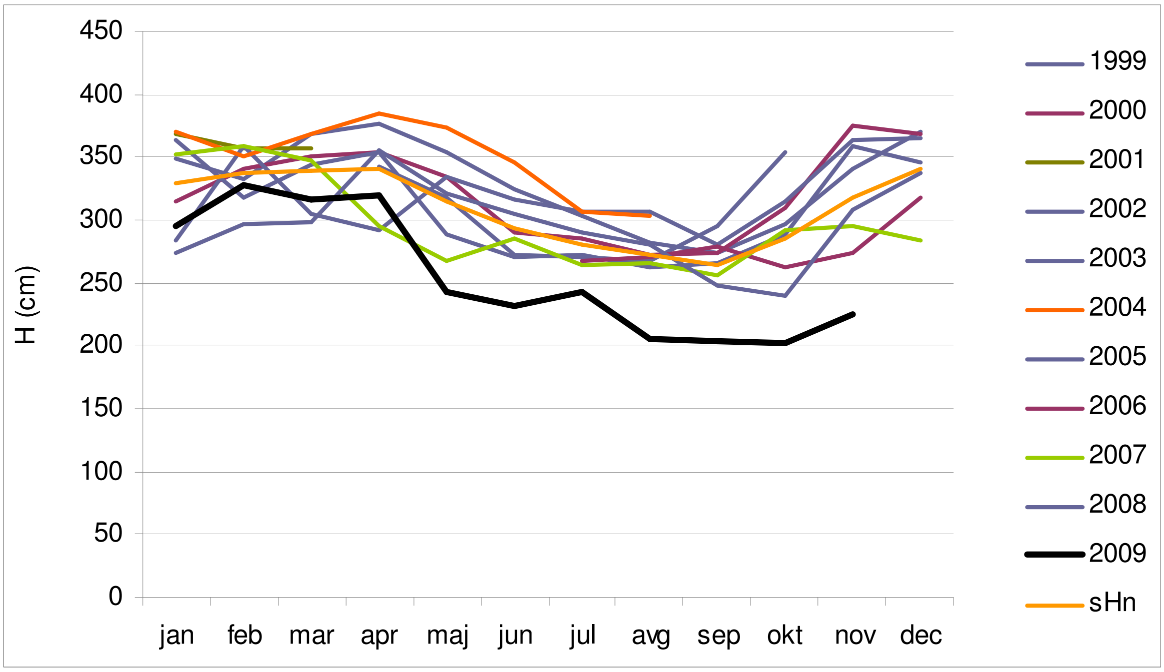
Figure 1: Timeline of water levels (H), specific electrical conductivity (SEP) and temperatures (T) on the Podroteja spring in 2009

V objektu črpališča spremljamo in zapisujemo na enem od izvirov Podroteje tri parametre: vodostaj (H), specifično električno prevodnost (SEP) in temperaturo vode (T) s 15-minutno frekvenco. Žal je bil niz v letu 2009 prekinjen zaradi izpada delovanja aparata v poletnih mesecih. Vseeno podatkovni nizi zapisanih parametrov kažejo značilne časovne razporeditve, ki so s trendnimi linijami posameznih parametrov jasno predstavljene. Parametra temperatura in specifična prevodnost sta premo soodvisna, vodostaji pa obratno soodvisni glede na druga dva parametra (slika 1). Najvišji vodostaji so bili 30. marca, ko so izdatne padavine v zahodni Sloveniji v zaledjih Soče, Idrijce in Vipave povzročile visokovodni poplavni val. Na iztoku Jezernica je bil 30. 3. 2009 ob 9. uri dosežen vodostaj 326 cm.

Sledilo je dolgotrajno, do začetka oktobra trajajoče obdobje upadanja vodostajev, ki je bilo prekinjeno le s kratkotrajnimi valovi, ki upadanja niso mogli ustaviti. Letni najnižji vodostaj na izviru Podroteja je bil dosežen 7. 10. in je hkrati absolutni doseženi minimum v obdobju opazovanj 1999–2009. Najnižji vodostaj na izviru Divje jezero je bil dosežen 1. 10. 2009. To je tudi obdobni minimum in je nižji kot minimum v letu 2003.

At the water extraction facility on one of the Podroteja springs, we monitor and record three parameters: the water stage parameter (H), specific electrical conductivity (SEP) and water temperature (T), with a 15-minute frequency. Unfortunately the data series was interrupted in 2009 because of a device malfunction in the summer months. Nevertheless, the data series of recorded parameters provide characteristic timetables clearly represented with trend lines of individual parameters. The temperature and specific electrical conductivity parameters are linearly proportionate, while the water stages are inversely proportionate with regard to the other two parameters (Figure 1). Water levels were highest on 30 March when abundant precipitation in western Slovenia caused a high water flood wave in the catchment areas of the Soča, Idrijca and Vipava rivers. The water level on the Jezernica outflow was 326 cm on 30 March 2009 at 9.00.

This was followed by a prolonged period of water level drop, which lasted until the beginning of October and was interrupted only by short-term waves, which could not stop the drop. The lowest water level recorded at the Podroteja spring on 7 October was also the absolute minimum recorded in the monitoring 1999–2009 period. The lowest water level at the Divje Jezero spring was recorded on 1 October 2009. It constitutes a periodical minimum lower than the minimum in 2003.



Slika 2: Divje jezero – mesečni najnižji vodostaji (H) v obdobju 1999–2009

Figure 2: Divje Jezero – lowest monthly water levels (H) in the period 1999–2009

Izviri na območju Podroteje skupaj z izviri Vipave, Hublja in Mrzleka reprezentativno prikazujejo hidrogeološke značilnosti visokega krasa Trnovskega gozda in Nanosa. Glavne značilnosti tega območja so razvita brezna in pretakanje podzemne vode v velikih globinah tudi na večje razdalje. Temperature podzemne vode nihajo v razponu med 8 in 9 °C, vrednosti SEP pa med 220 do 370 µS/cm.

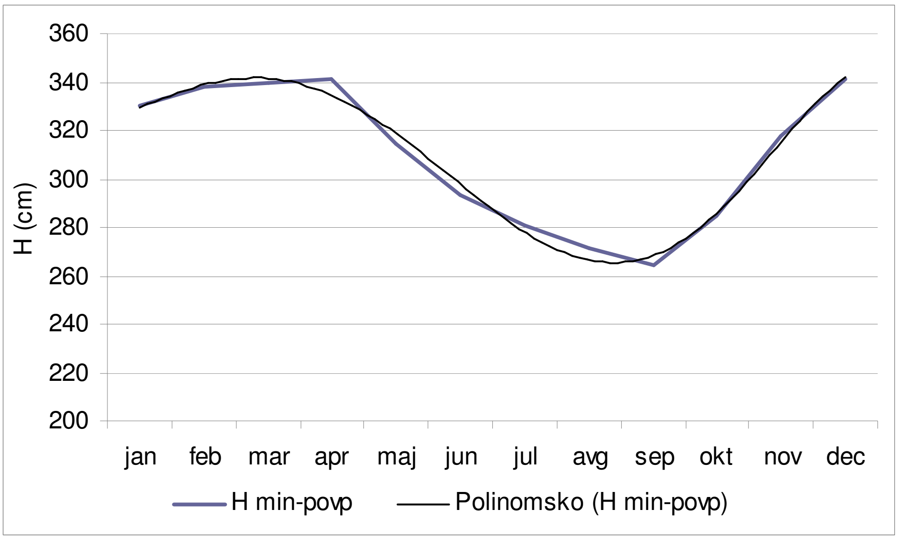
Izrazito značilen razpored mesečnih nizkih baznih vodostajev ponazarja tudi stanje mesečnih zalog podzemne vode v kraškem vodonosniku (slika 3). Temu razporedu sledijo srednji mesečni vodostaji in visoke konice, saj njihov značilni razpored sloni na nivojih baznih vodostajev (slika 4). Ta značilni razpored se jasno kaže predvsem na območju Divjega jezera, ki je dejanski odraz hidroloških razmer v osrednjem delu kraškega vodonosnika. Amplitude nihanj značilnih baznih nivojev dosegajo 0,8 m, povprečje pri 300 cm presega 7 mesecev v letu (jan.–maj, nov.–dec.), preostalih 5 mesecev (jun.–okt.) so zaloge podzemne vode v kraškem vodonosniku običajno pod povprečjem.

Opazovanje nivojev podzemne vode s tako jasno in značilno časovno razporeditvijo, kot je v izviru Divjega jezera, je le redko mogoče. Mogoče je v vrtinah ali v vodnih jamah v zaledju vodonosnika. Na območju izvirov, ki predstavljajo izlivni profil v nivoju lokalne erozijske baze, ni tako izrazitega učinka sezonskih nihanj vodostajev.

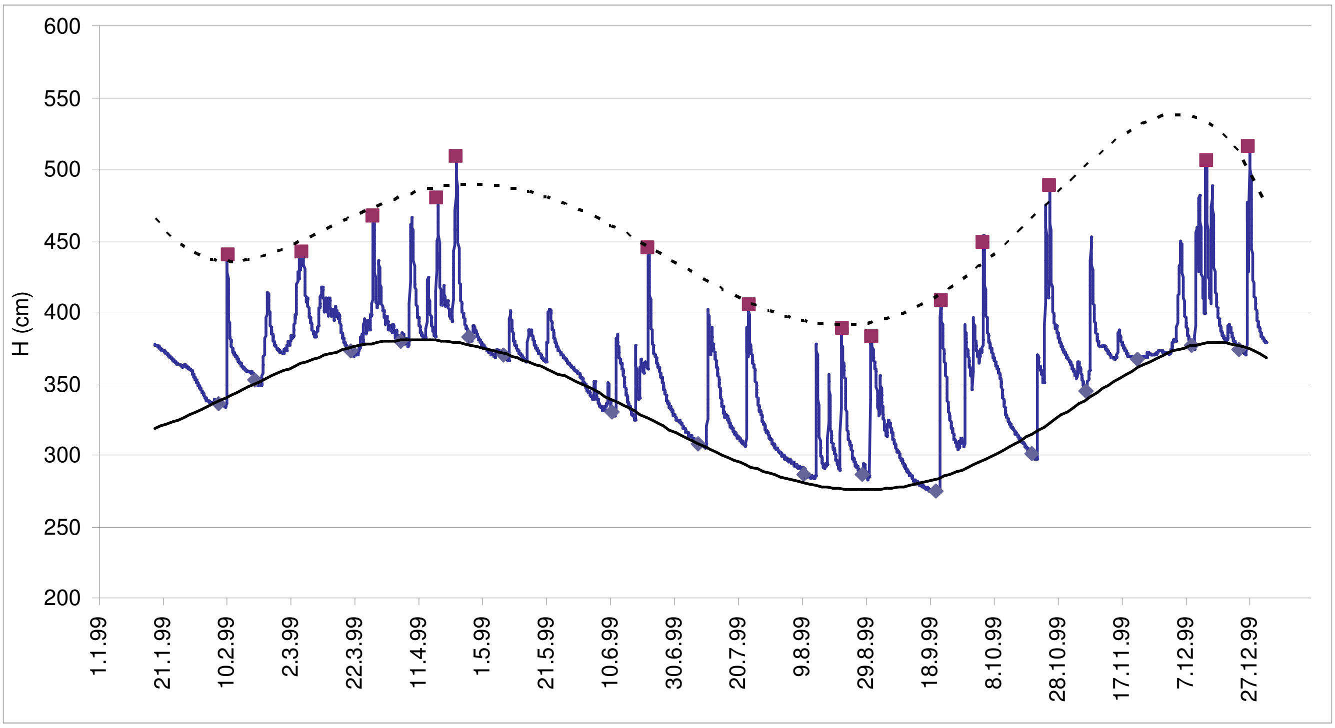
The Podroteja springs together with the Vipava, Hublelj and Mrzlek springs provide representative characteristics of the high karst of Trnovski gozd (Trnovo forest)and Nanos. The principal characteristics of this region are developed chasms and the flowing of groundwater in great depths, also to distant areas. Groundwater temperatures fluctuate from 8 to 9 °C, while SEP values range from 220 to 370 µS/cm.

The prominently typical monthly low base water stage timeline also shows the monthly groundwater reserves in the karst aquifer (Figure 3). This timeline is also followed by mean monthly water stages and high peaks, as their characteristic timeline abides by the base water stage levels (Figure 4). This typical timeline is evident especially in the area of Divje jezero, which actually reflects hydrological conditions in the central part of the karstic aquifer. The fluctuation amplitudes of typical base levels reach 0.8 m, the average of 300 cm is exceeded for seven months of the year (January to May, November and December), while the groundwater reserves in the karstic aquifer are usually below average for the other five months (June to October).

The monitoring of groundwater levels with such clear and typical timeline as that of the Divje jezero spring is only rarely possible. It may be carried out in wells or in water caves in the aquifer background. The area of springs constituting the outflow profile at the level of the local erosion basis does not have such a prominent effect of seasonal fluctuation of water levels.



Slika 3: Divje jezero – razpored povprečnih mesečnih obdobnih (1999–2009) najnižjih vodostajev H
Figure 3: Divje jezero – timeline of average lowest monthly water levels (H) in the 1999–2009 period

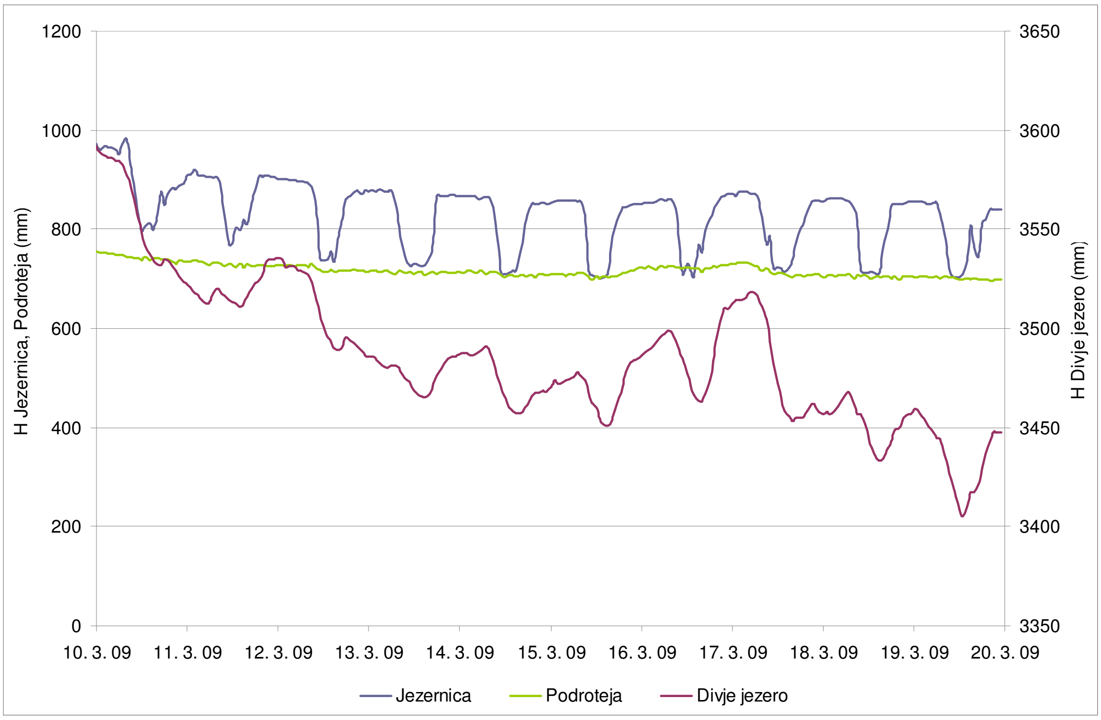


Slika 4: Divje jezero – urni vodostaji H ter shematizirani ovojnici nizkih in visokih konic v letu 1999
Figure 4: Divje Jezero – hourly water levels (H) and schematised envelopes of low and high peaks in 1999

Ob zapisovanju vodostajev na profilih Jezernice, Divjega jezera, Podroteje in kanala Idrijce pa se opazi tudi vpliv ravnanja z zapornico na jezu Kobila. Ta vpliv je na merilnem mestu Jezernice jasen, opazen je tudi v Divjem jezeru, v izviru Podroteja pa le ob ustrezni primerjavi nihanj vodostajev. To dokazuje, da se del vode površinskega toka Idrijce pod jezom Kobila medplastovno pretaka proti profilu Jezernice in na območje izvira Divje jezero ter naprej proti izviru Podroteja. V samem črpališču je opazen tudi vpliv črpanj. Ta opažanja dokazujejo vpliv površinskega toka Idrijce na izvir Podroteja, s tem pa se odpira vprašanje, kolikšen delež Idrijce bogati pretok izvira. Izmerjeni iztok iz vodonosnika v Idrijco na potezu med Divjim

The recorded water levels at the Jezernica, Divje Jezero, Podroteja and Idrijca indicate the influence of gate handling on Lake Kobila. This influence is clear at the Jezernica gauging station and also evident in Divje jezero, while the Podroteja spring reflects it only at an appropriate comparison of water level fluctuation. This proves that a part of water of the Idrijca surface stream under the Kobila dam flows between the layers towards the Jezernica profile and over the area of the Divje jezero spring towards the Podroteja spring. The water extraction facility also shows the influence of extraction. These observations confirm the influence of the Idrijca surface flow on the Podroteja spring, but also raise the question of the share of the Idrijca jezerom in profilom Idrijce, AMP Podroteja, ki ob nizkih stanjih dosega 1 m^3/s, ne pomeni količine iztoka samega izvira. V tem podatku je zajeta tudi količina zatekanja površinskega dela Idrijce v kraški vodonosnik, katerega delež še ni znan.

enhancing the rate of flow at the spring. The measured outflow from the aquifer to the Idrijca on the relation between the Divje jezero and the Idrijca profile, AMP Podroteja, which reaches 1 m^3/s at low stages, does not denote the quantity of the outflow of the spring itself. This information encompasses the quantity of the outflow of the surface part of the Idrijca to the karstic aquifer, whose share is yet unknown.



Slika 5: Nihanja vodostajev Jezernice, Divjega jezera in Podroteje

Figure 5: Fluctuations of water levels of the Jezernica, Divje jezero and Podroteja

Slika 6: Primerjava nihanj vodostajev Divjega jezera in izvira Podroteja

Figure 6: Comparison of fluctuation of water levels of the Divje jezero and Podroteja springs

Divje jezero 30. marca 2009 (foto: P. Souvent)
Divje jezero on 30 March 2009 (Photo: P. Souvent)

Dotoki v Idrijco iz izvirnega območja Podroteje 30. marca 2009 (foto: P. Souvent)
Inflows to the Idrijca River from the Podroteja spring area on 30 March 2009 (Photo: P. Souvent)

Izvir Kamniške Bistrice (alpski kras)

Režim izvira Kamniške Bistrice kaže hidrogeološke značilnosti alpskega krasa, za katerega sta značilna prevladujoča velika vertikalna komponenta pretakanja v globokih breznih in kratek zadrževalni čas podzemne vode v vodonosniku. Režim izvira se kaže v nizkih vodostajih pozimi in povečanih iztokih poleti, ko se

Kamniška Bistrica spring (Alpine Karst)

The regime of the Kamniška Bistrica spring shows hydro-geological characteristics of the Alpine karst with a large vertical flow element and short retention time of groundwater in the aquifer. The spring regime is reflected through low water stages during the winter and increased outflow in the summer, when the water iztekajo vodne zaloge iz snežne odeje v visokogorju. Pozimi je voda izvira toplejša, saj izteka t. i. bazni tok, ki se v vodonosniku pretaka počasneje in se ne bogati s hladnejšimi zimskimi padavinami. Poletni iztok vzdržuje večinoma snežnica, ki je zato tudi hladnejša. Podoben časovni razpored, kot je razpored temperatur, kaže tudi parameter SEP, saj je zimski bazni tok zaradi daljšega zadrževalnega časa v podzemlju bolj mineraliziran kot poletna hitra komponenta pretakanja.

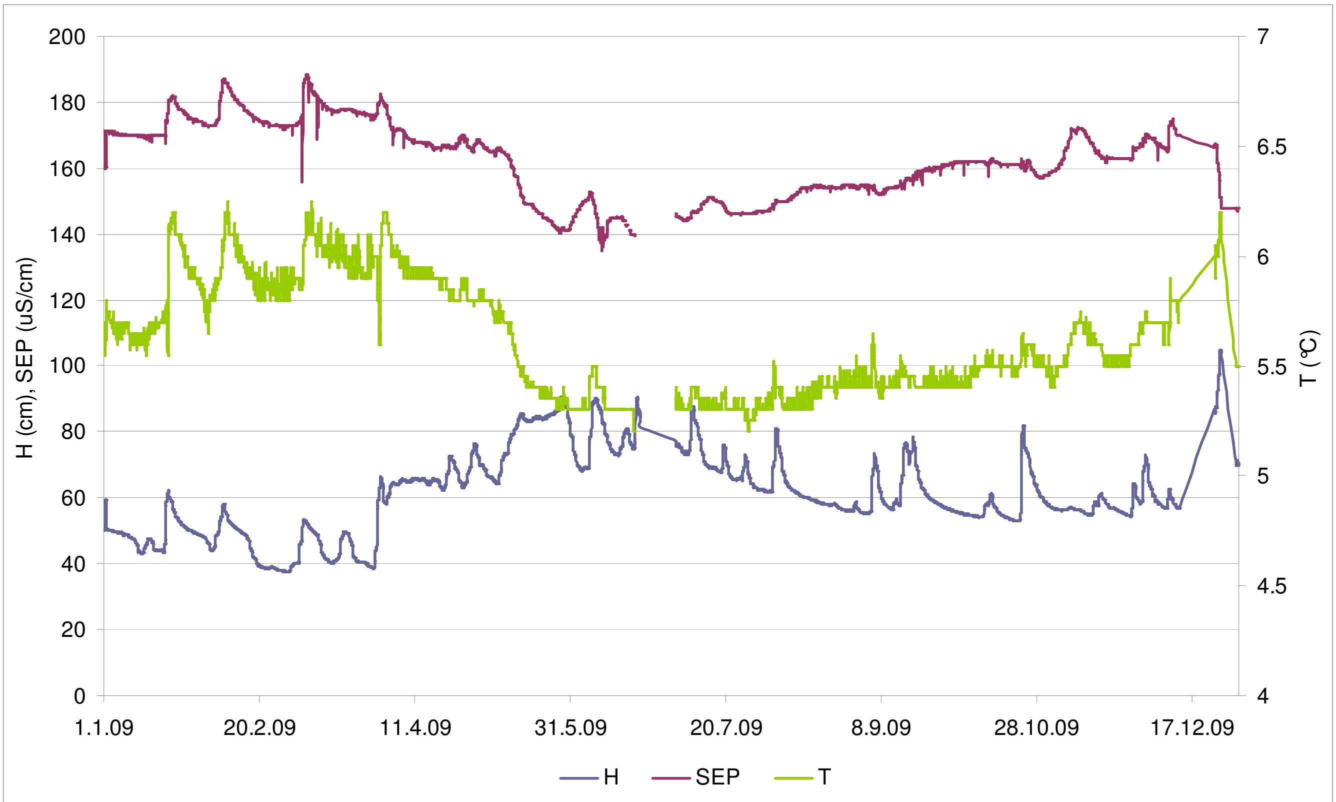
Poleg za alpski kras značilnega režima iztoka so zanj glede na druga kraška območja v Sloveniji značilne tudi nizke temperature in nizka mineralizacija vode. Vrednosti posameznih parametrov v letu 2009 ne odstopajo od obdobnih vrednosti.

Zaradi značilnega režima na območju alpskega krasa letni minimum ni dosežen v jeseni, kar je sicer značilno za režim iztoka v letu 2009 na drugih kraških območjih Slovenije.

reserves flow out from the snow cover melting in the high mountain range. In the winter, the spring water is warmer as the outflow is the so-called base flow, which runs slower in the aquifer and is not recharged with the colder winter precipitation. The summer outflow is mostly maintained by snow-water, which is colder. A timeline similar to temperature timeline is indicated by the SEP parameter, as the winter base flow, which stays underground for longer periods, is more mineralised than the rapid summer flow component.

Besides the outflow regime characteristic of the Alpine karst, the spring differs from those in the other karstic regions in Slovenia for its low temperatures and low mineralisation of water. The values of individual parameters in 2009 do not deviate from the periodical values.

Because of the typical regime in the Alpine karst area, the annual minimum is not reached in autumn, as is characteristic of the outflow regime in other karstic areas of Slovenia in 2009.



Slika 7: Časovni potek vodostaja (h), specifične električne prevodnosti (SEP) in temperature (T) na izviru Kamniške Bistrice
Figure 7: Timeline of water levels (H), specific electrical conductivity (SEP) and temperatures (T) on the Kamniška Bistrica spring

Poltarica

Izvir Poltarica je eden od izvirov Krke, ki izdanja na območju vasi Gradiček pri Krki na stiku triasnih dolomitov v podlagi in jurskih dobro prepustnih apnencev. Zaledji obeh glavnih izvirov Poltarice in Krke se prepletata in ju je nemogoče ločiti. Skupna velikost zaledja obeh izvirov se ocenjuje na 290 km^2, iz razmerja vodnobilančnih členov pa se velikost zaledja

Poltarica

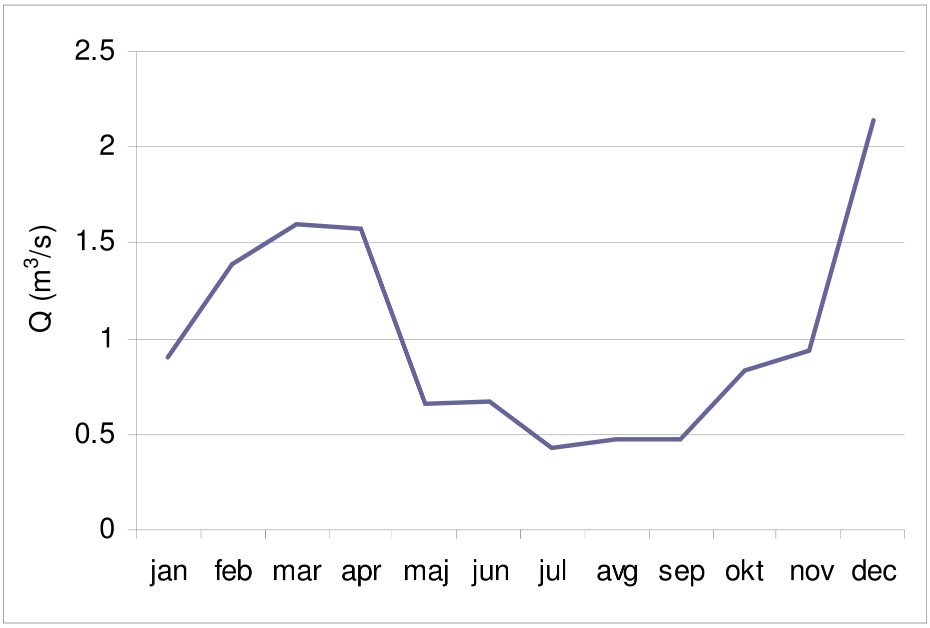
The Poltarica spring is one of Krka's springs, rising from the ground in the village of Gradiček pri Krki at the contact of Triassic dolomites in the base and Jurassic highly permeable limestones. The backgrounds of both primary springs of Poltarica and Krka are intertwined and thus impossible to distinguish from one another. The total area of the background of both springs is

Poltarice ocenjuje na 57 km^2. Zaledje izvirov Krke zajema območje ponikalnice Rašice, območje Dobrepolja in Radenskega polja pri Grosupljem. Izvir predstavlja značilnosti območja dela dinarskega krasa na Dolenjskem, kjer so izviri Krke najizdatnejši odtočni sistem.

Režim nihanja vodostajev kaže na maksimuma v marcu in decembru. Najvišji vodni val je bil tudi na Dolenjskem dosežen konec marca in v začetku aprila, visoki konici pa sta bili doseženi tudi v februarju in decembru 2009. Najnižji mesečni pretoki upadejo pod 0,1 m^3/s in so bili doseženi v obdobju od junija do oktobra 2009.

estimated at 290 km^2, while the size of the Poltarica background is estimated at 57 km^2, derived from the ratio of water balance elements. The background of the Krka springs covers the area of the Rašica sinking stream, Dobrepolje and Radensko Polje neari Grosuplje. The spring represents the characteristics of the part of the Dinaric karst in Dolenjska, where the Krka springs are the most abundant runoff system.

The water level fluctuation regime indicated maximums in March and December. The highest water wave in Dolenjska was reached at the end of March and in the beginning of April, while high peaks were also reached in February and December 2009. The lowest monthly rates of flow drop below 0.1 m^3/s and were reached in the period from June to October 2009.



Slika 8 : Potek srednjih mesečnih pretokov(Q) na izviru Poltarica za obdobje 2007–2009
Figure 8: Timeline of mean monthly discharges (Q) for the period 2007-2009 on the Poltarica spring

Težka voda

Iz sklenjenega dobro prepustnega telesa podzemne vode Gorjanci se vode iztekajo pretežno v izvire Težka voda, Kostanjeviški Obrh, Krupa in Metliški Obrh. Med izviri Težka voda, Metliški Obrh in Krupa so obširna razvodna območja v njihovem zaledju, ki napajajo vse tri izvire, zaledje izvira Kostanjeviški Obrh pa tudi še ni raziskano.

Izvir Težke vode je že bil vključen v hidrološko merilno mrežo v letih 1955–1985. S ponovnim aktiviranjem merskega profila želimo preveriti in točneje oceniti režim in količine iztoka izvira ter oceniti vplive odvzemov za oskrbo z vodo.

Srednje letni pretoki so v novejšem obdobju nižji. Najnižjih vodostajev pod 30 cm, ki so kratkotrajni ob umetnih posegih, ne moremo pretvoriti v pretok, ker meritev ob teh dogodkih nimamo.

Najnižji dosežen vodostaj v letu 2009 26,2 cm 19. 9. ob 12. uri je trenutni dogodek in posledica umetnih

Težka voda

From the closed highly permeable groundwater body of Gorjanci, waters run off mainly only into the Težka voda, Kostanjeviški Obrh, Krupa and Metliški Obrh springs. Situated between the Težka voda, Metliški Obrh and Krupa springs are extensive catchment areas in their background, feeding all three springs; the background of the Kostanjeviški Obrh spring has not been explored yet.

The Težka voda spring was already integrated in the hydrological gauging network from 1955 to 1985. By reactivating the measurement profile, we wish to verify and accurately estimate the regime and outflow quantity of the spring and estimate the influences of abstracted water on water supply.

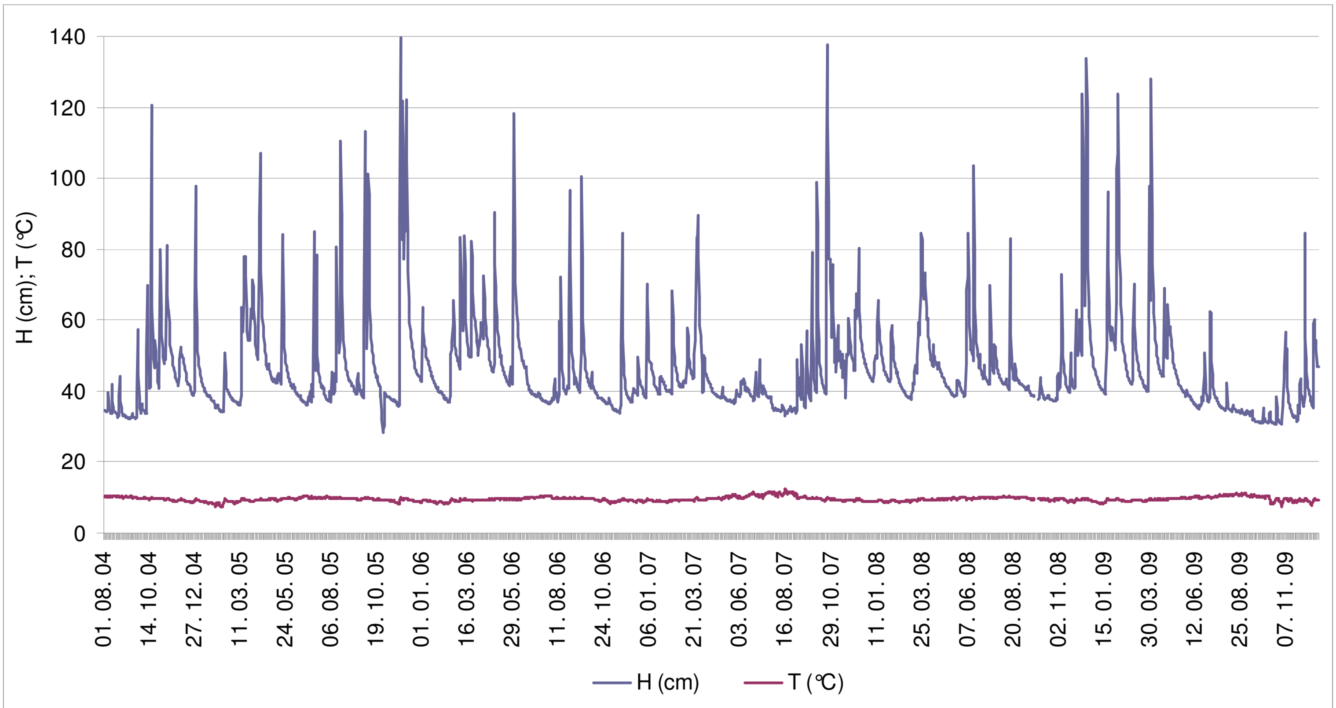
The mean annual discharges are lower in recent times. The lowest water levels are below 30 cm, which are short-term results of artificial interventions, cannot be transformed to the rate of flow as such events are not posegov, prav tako tudi najnižji novembrski vodostaji 28. 11. Pretočno krivuljo za leto 2009 smo izdelali za območje vodostajev med 30 cm in 180 cm. Visoka konica 176 cm je bila dosežena 2. 4. 2009 ob visokem valu konec marca 2009.

measured.

The lowest recorded water level in 2009 (26.2 cm on 19 September at 12.00) is a one-off event and a consequence of artificial interventions, the same applies to the lowest water levels of November, recorded on 28 November. The rating curve for 2009 was made for the area of water levels between 30 cm and 180 cm. The peak of 176 cm was reached on 2 April 2009 as a part of the high wave that occurred at the end of March 2009.

Preglednica 1: Značilni mesečni in letni pretoki (Q v m^3/s) v obdobjih 1955–1985 in 2004–2009 za izvir Težka voda
Table 1: Characteristic monthly and annual discharge (Q in m³/s) during the 1955–1985 period and 2004–2009 for the Težka voda spring

Q	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Qs	Q max	Q min
2004								0,114	0,088	0,631	0,747	0,580	0,421	7,530	
2005	0,281	0,215	0,763	0,975	0,550	0,231	0,473	0,727	0,439	0,659	0,620	1,129	0,525	7,025	
2006	0,489	0,447	1,100	0,864	0,747	0,627	0,200	0,511	0,588	0,236	0,262	0,274	0,519	8,487	0,044
2007	0,466	0,420	0,778	0,350	0,205	0,282	0,228	0,091	0,381	1,083	0,707	0,768	0,470	6,961	
2008	0,580	0,444	0,754	0,629	0,292	0,892	0,523	0,452	0,290	0,218	0,448	1,430	0,573	7,178	0,093
2009	0,664	1,180	0,808	1,090	0,473	0,204	0,268	0,122	0,083	0,076	0,211	0,490	0,456	7,200	0,050
Qs	0,496	0,541	0,840	0,782	0,453	0,447	0,338	0,336	0,312	0,484	0,499	0,778	0,494	8,487	0,044
1955-1985	0,617	0,608	0,795	0,894	0,654	0,552	0,399	0,344	0,406	0,545	0,753	0,794	0,613	10,700	0



Slika 9: Časovni potek dnevnih vodostajev (H cm) in temperatur (T) v merskem profilu Težka voda v letih 2004–2009
Figure 9: Timeline of daily water levels (H cm) and temperatures (T) in the Težka voda measurement profile from 2004 to 2009

Krupa

Trenutno je na izviru Krupe edina merilna postaja v okviru monitoringa izvirov v Beli krajini. S srednjim letnim pretokom več kot 3 m^3/s je Krupa najmočnejši vodni vir v Beli krajini ter skupaj z Lahinjo in Dobličico drenira bazne odtoke obsežnega kraškega

Krupa

The gauging station at the Krupa spring is currently the only station for monitoring the springs of Bela Krajina. The Krupa spring with a mean annual discharge exceeding 3 m³/s represents the most powerful water source in Bela Krajina; together with Lahinja and vodonosnika. Za merski profil Krupe v Dolencih prikazujemo značilne vodostaje, dosežene v obdobju delovanja postaje od 2004 do 2009.

V obdobju opazovanj je opazen dvig najnižjih letnih vodostajev po letu 2006, potem ko je bila dvignjena pregrada na izviru Krupe. Dvig znaša več kot 20 cm, njegov vpliv pa sega še v vodonosnik v zaledju izvira.

Podobno kot v drugih predelih Slovenije je bil tudi v Beli krajini visokovodni val dosežen konec marca in v začetku aprila. Najvišjega vodostaja v letu (301 cm) pa ne moremo neposredno pretvoriti v pretok, ker sega vpliv visokih valov Lahinje tudi še v merski profil Krupe. Po tem visokovodnem valu se je začelo obdobje upadanja vodostajev, ki se je končalo šele v oktobru2009.

Za realno primerjavo in analizo podatkov moramo upoštevati spremembe v profilu Krupe ter obravnavati dve ločeni obdobji, pred spremembami v profilu in po njih.

Bilpa

Izvir Bilpe je podzemno povezan s ponikalnico Rinžo, katere tok ponikuje na območju Zajčjega polja pri Livoldu. Poleg izvira Bilpa so najizdatnejši iztoki iz vodonosnega sistema Kočevje – Goteniška gora še izviri Čabranke, Kotnice, Rakitnice in Ribnice.

Tudi izvirno območje Bilpe je zajezeno z umetno pregrado, zaradi česar so nizki vodostaji izravnani in nihajo v območju 82–83 cm, sunki pod 80 cm pa so posledica občasnega ravnanja z zapornico na jezu.

Dobličica, it drains the base outflows of the extensive karstic aquifer. We provide characteristic water levels for the measurement profile of Krupa in Dolence recorded in the period of 2004–2009.

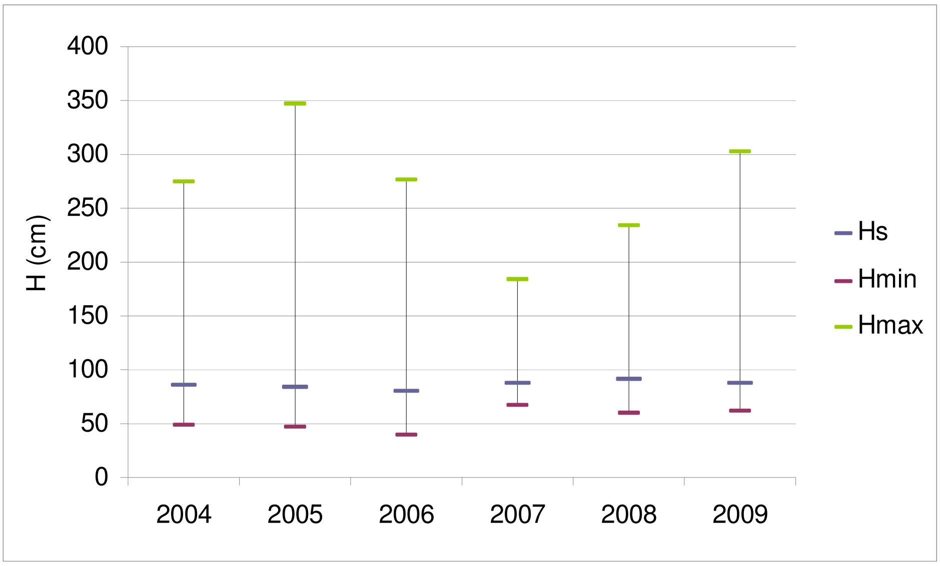
The monitoring period shows the increase of the lowest annual water levels after 2006, after the barrier at the Krupa spring was lifted. The increase was over 20 cm and its influence reaches as far as the aquifer in the spring background.

As in other parts of Slovenia, the high water wave in Bela Brajina was reached at the end of March and in the beginning of April. The highest water level of the year (301 cm), however, cannot be directly transformed to the rate of flow as the influence of the high waves of the Lahinja reaches as far as the Krupa measurement profile. After this high water wave came a period of dropping water levels, which ended only in October 2009.

In order to obtain a realistic comparison and analysis of data, we must take into account the changes in the profile of the Krupa and consider two separate periods, before and after the changes in the profile.

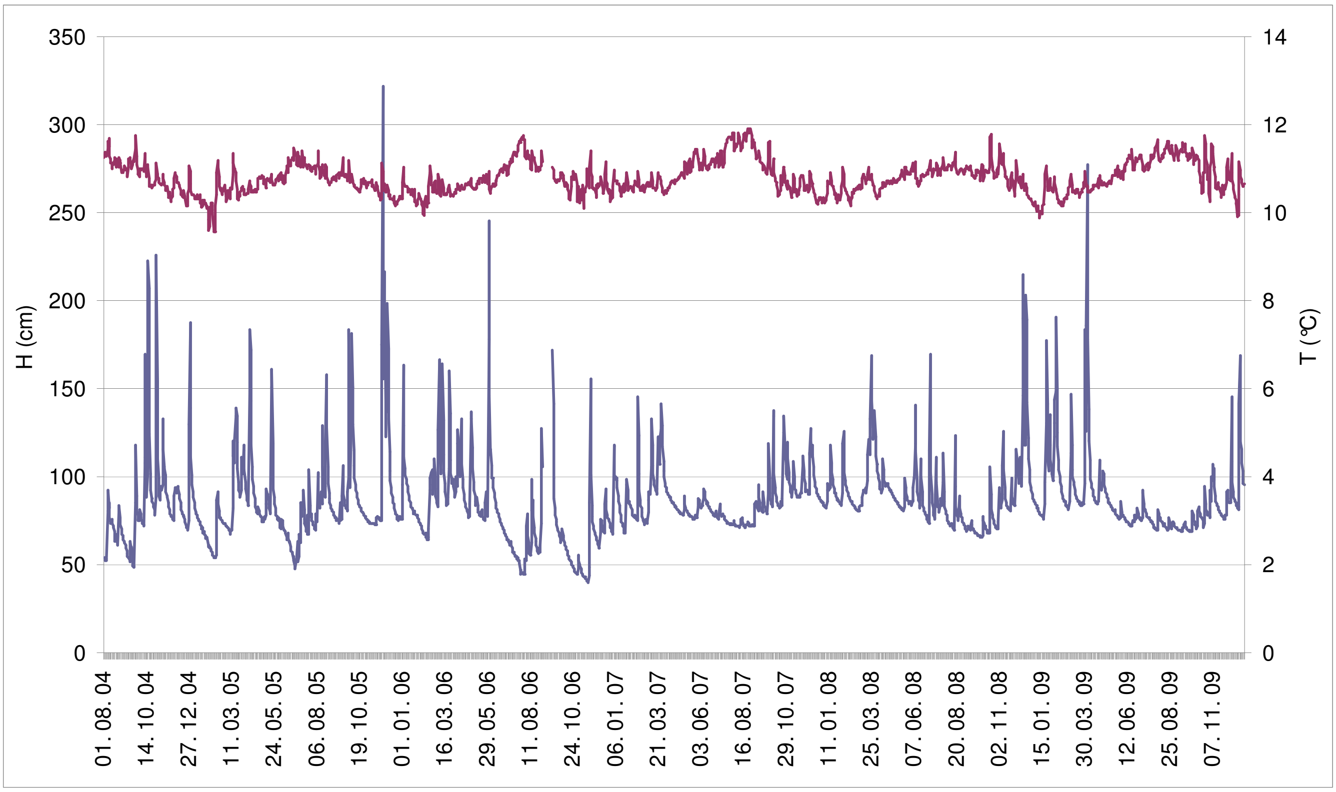
Bilpa

The Bilpa spring is connected underground with the Rinža sinking river, the stream of which sinks in Zajčje Polje at Livold. Beside the Bilpa spring, the most abundant outflows of the Kočevje–Goteniška gora aquifer system include the springs of the Čabranka, Kotnica, Rakitnica and Ribnica rivers.

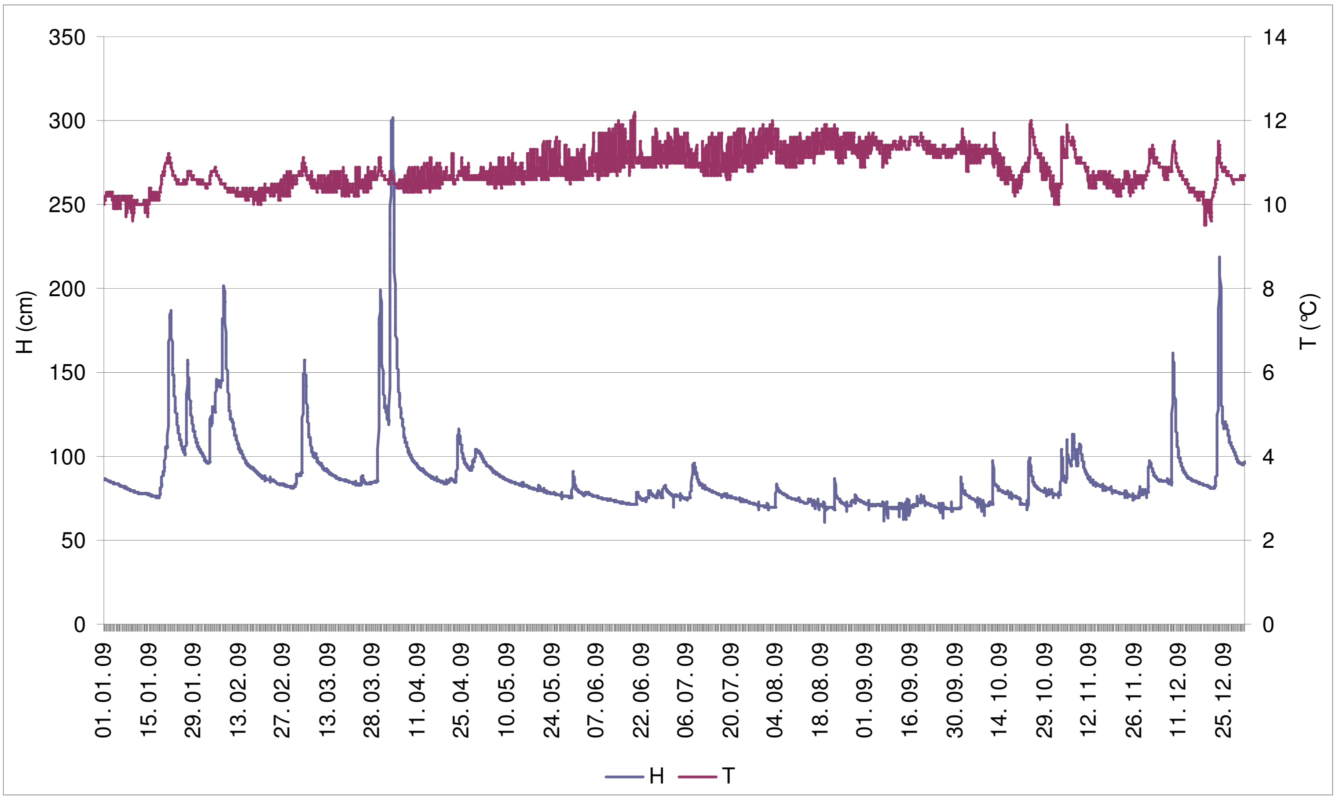


Slika 10: High-low diagram značilnih letnih vodostajev (H cm) na izviru Krupe

Figure 10: High-low diagram of characteristic annual water levels (H cm) at the Krupa spring



Slika 11: Razporeditev dnevnih vodostajev (H cm) in temperatur (T °C) v obdobju 2004–2009 na izviru Krupe
Figure 11: Timeline of daily water levels (H cm) and temperatures (T °C) at the Krupa spring in the 2004–2009 period



Slika 12: Razporeditev urnih vrednosti vodostajev (H cm) in temperatur (T °C) na izviru Krupe v letu 2009
Figure 12: Timeline of hourly values of water levels (H) and temperatures (T °C) at the Krupa spring in 2009

Vrednosti SEP se gibljejo v razponu med 350–500 µS/cm, povprečje pa je v območju 400 µS/cm. Te vrednosti kažejo na daljše zadrževalne čase v

As the spring area of Bilpa is also impounded with an artificial barrier, low water stages are levelled and stand at 82–83 cm, while thrusts below 80 cm are a vodonosniku, kot je to značilno za območja visokega krasa. Povprečna letna temperatura izvira je v območju 9 °C. Visoka valova z vodostaji nad 200 cm sta se pojavila konec marca in v decembru.

V letu 2009 so bile v merskem profilu opravljene 4 meritve pretoka v razponu med 0,175 in 3,37 m^3/s. Ob upoštevanju tudi teh meritev smo izdelali novo pretočno krivuljo v območju veljavnosti vodostajev od 77 do 310 cm.

Veliki Obrh

Za spremljanje režima izvirnega območja Ljubljanice smo izbrali profil Veliki Obrh na Vrhniki v Loški dolini, ki je skupaj z Malim Obrhom in izviri pri gradu Snežnik prvo izvirno območje Ljubljanice na območju Slovenije. Združeni tok Obrha na koncu Loške doline pri Danah ponikne in podzemno odteka proti Cerkniškemu polju.

Prispevno območje Loške doline se razteza na povodje Trbuhovice na Hrvaškem, Babnega polja, Retja in Racne gore ter na jugu na obsežen masiv Snežnika. Na tem območju so bili v 2009 visokovodni valovi doseženi v začetku leta od januarja do aprila, mesečne konice na izvirih pa so pomenile tudi obdobne mesečne maksimume. Tudi julijski val je dosegel obdobno ekstremno vrednost, jesenski pa obdobnih ekstremov niso dosegli.

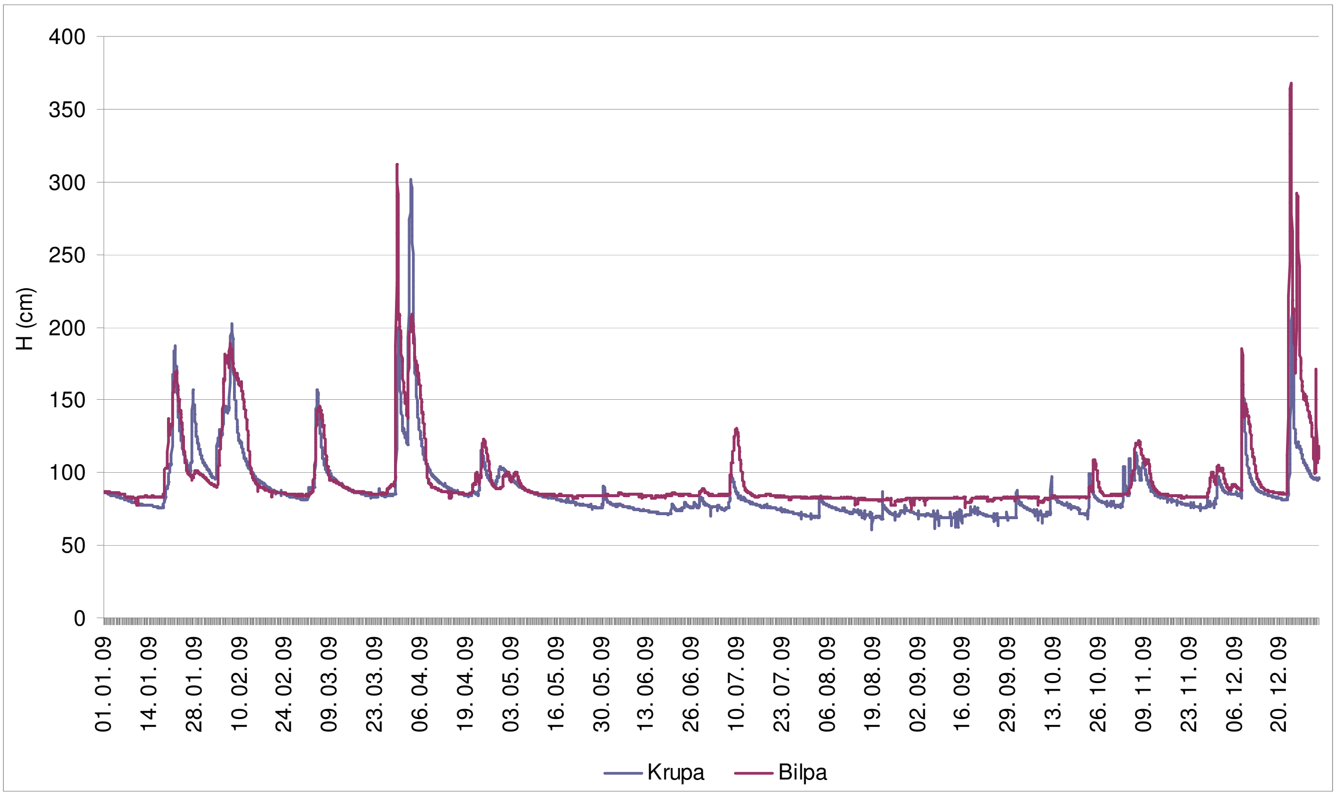
result of occasional gate handling on the dam.

The SEP values range from 350 and500 µS/cm, the average being around 400 µS/cm. These values indicate longer retention periods in the aquifer than are characteristic for the region of the high karst. The average annual temperature of the spring is in the range of 9 °C. High waves with the levels over 200 cm occurred at the end of March and in December.

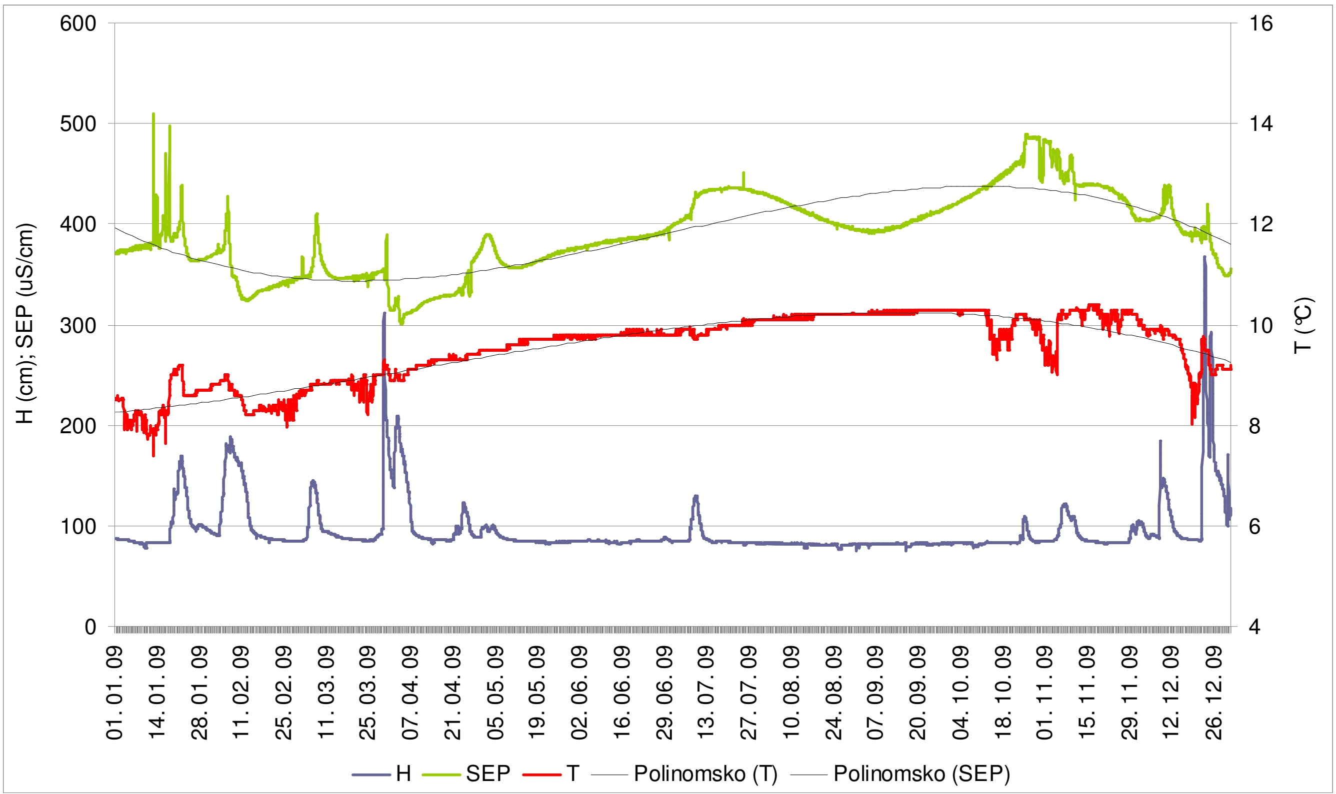
Four outflow measurements were carried out in the measurement profile in 2009, ranging from 0.175 to 3.37 m^3/s. With the consideration of these measurements, we made a new rating curve in the area of water level validity from 77 to 310 cm.

Veliki Obrh

The Veliki Obrh spring at Vrhnika on the Lož valley represents the first spring area of the Ljubljanica river in Slovenia, together with Mali Obrh and springs at Snežnik Castle; thus Veliki Obrh was selected for the monitoring of the regime of the Ljubljanica spring area. The united Obrh stream sinks at the end of the Lož valley near Dane and runs off underground towards the Cerknica field.



Slika 13: Primerjava nihanj vodostajev (H) Bilpe in Krupe v 2009
Figure 13: Comparison of fluctuation of water levels (H) of the Bilpa and Krupa in 2009



Slika 14: Časovni potek vodostajev, SEP in temperature v letu 2009 na izviru Bilpa

Figure 14: Timeline of water levels, SEP and temperature in 2009 at the Bilpa spring

Značilnost hidrološkega stanja na tem območju v letu 2009 je najnižji obdobni srednji letni vodostaj in doseganje najnižjih srednjih mesečnih obdobnih vrednosti v mesecih junij, avgust, september in oktober. Vodni val v juliju je prekinil upadanje vodostajev, ki se je začelo v maju 2009 in nato nadaljevalo še do sredine oktobra (slika 15).

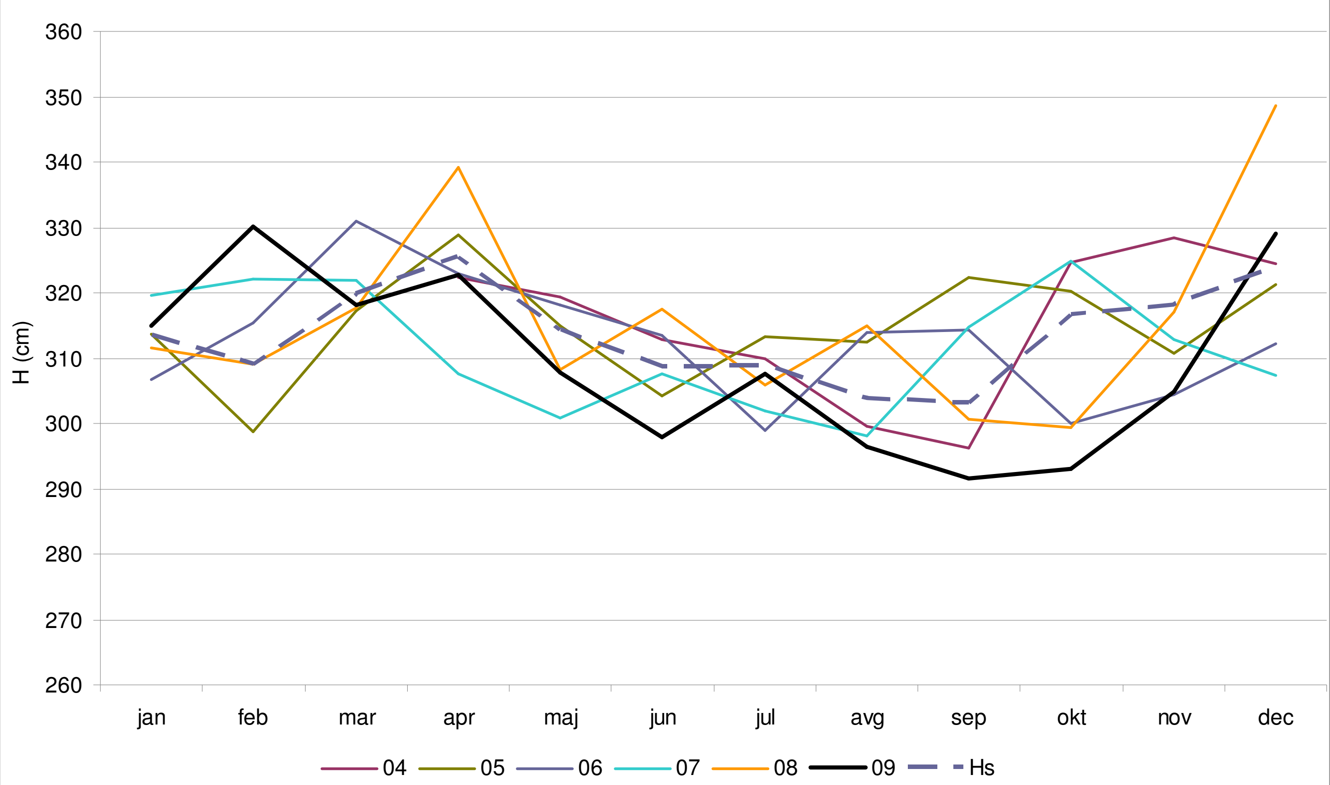
The catchment area of the Lož valley extends to the drainage basin of Trbuhovica in Croatia, Babno field, Retje and Racna gora and in the south to the extensive Snežnik mass. The high water waves in this area were reached in the beginning of 2009, from January to April, with monthly peaks at springs constituting periodic monthly maximums. The July wave also reached a similar extreme value, while the autumn waves did not reach any periodical extremes.

The characteristic of the hydrological conditions in this area in 2009 is the lowest periodical mean annual water level, and the lowest mean monthly periodical values reached in June, August, September and October. The water wave in July interrupted the water level drop, which began in May 2009 and continued until mid-October (Figure 15).

Preglednica 2: Najvišji mesečni vodostaji v obdobju 2004–2009 na izviru Veliki Obrh

Table 2: Highest monthly water levels in the 2004–2009 period at the Veliki Obrh spring

H max	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	vHmax
2004				332	355	348	350	320	304	411	413	417	417
2005	342	308	353	373	348	331	359	351	368	366	388	377	388
2006	328	363	378	337	406	389	303	359	363	301	360	365	406
2007	383	357	364	327	315	334	321	301	382	384	346	321	384
2008	345	354	360	378	314	370	340	386	308	357	375	407	407
2009	377	407	382	380	327	312	361	300	301	330	340	398	407
vHmax	383	407	382	380	406	389	361	386	382	411	413	417	417



Slika 15: Srednji mesečni vodostaji (H cm) v obdobju 2004–2009 na izviru Veliki Obrh
Figure 15: Mean monthly water levels (H cm) in the period 2004-2009 at the Veliki Obrh spring

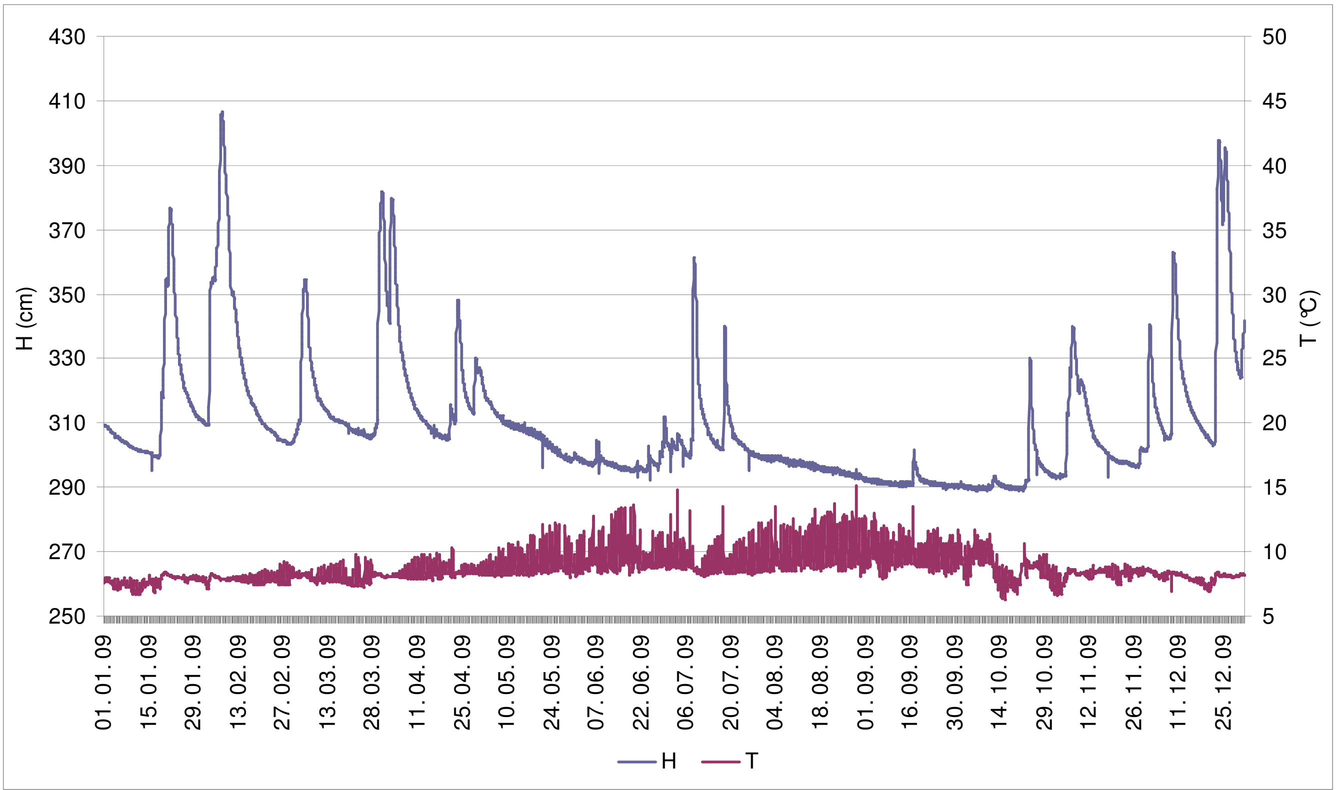


Figure 16: Timeline of hourly water levels (H) and temperatures (T) at the Veliki Obrh spring in 2009
Slika 16: Potek urnih vodostajev (H) in temperatur (T) na izviru Veliki Obrh v letu 2009

Loški potok

Izvir Loškega potoka je na območju vodonosnega sistema Kočevje – Goteniška gora položajno najvišji (700 m n. m) in predstavlja značilnosti območja dinarskega krasa Dolenjske. Razvodnica proti kraški Ljubljanici je tudi razvodnica med povodji Jadrana in Črnim morjem. Območje Loškega potoka pripada v tektonskem pogledu racnogorski brahisinklinali, ki jo sestavljajo zgornjetriasni dolomiti ter jurski in spodnjekredni skladi, z značilno dinarsko usmeritvijo. Večji prelom poteka v dinarski smeri od Nove vasi na Blokah čez Loški potok, ob tem prelomu poteka tudi podolje, kjer Loški potok po krajšem površinskem toku ponikne. Dokazana je povezava ponikalnice z izviri Rakitnice v Ribniški dolini. Izvir je kot eden redkih vodnih virov na tem območju zajet za vodno oskrbo naselij Retje, Hrib - Loški Potok in Travnik.

Izvir je bil uvrščen v program monitoringa v letu 2004, po 6 letih delovanja postaje smo opazovanja v 2009 končali.

Režim izvira Loškega potoka je soroden režimu izvira Veliki Obrh, saj se povodji stikata na potezu razvodnice na območju Racne gore. V merskem profilu smo v 6 letih pridobili podatkovni niz, ki kaže glavne značilnosti hidrološkega režima s časovnim razporedom mesečnih vodostajev (slika 18) in značilnimi letnimi vrednostmi vodostajev (slika 19).

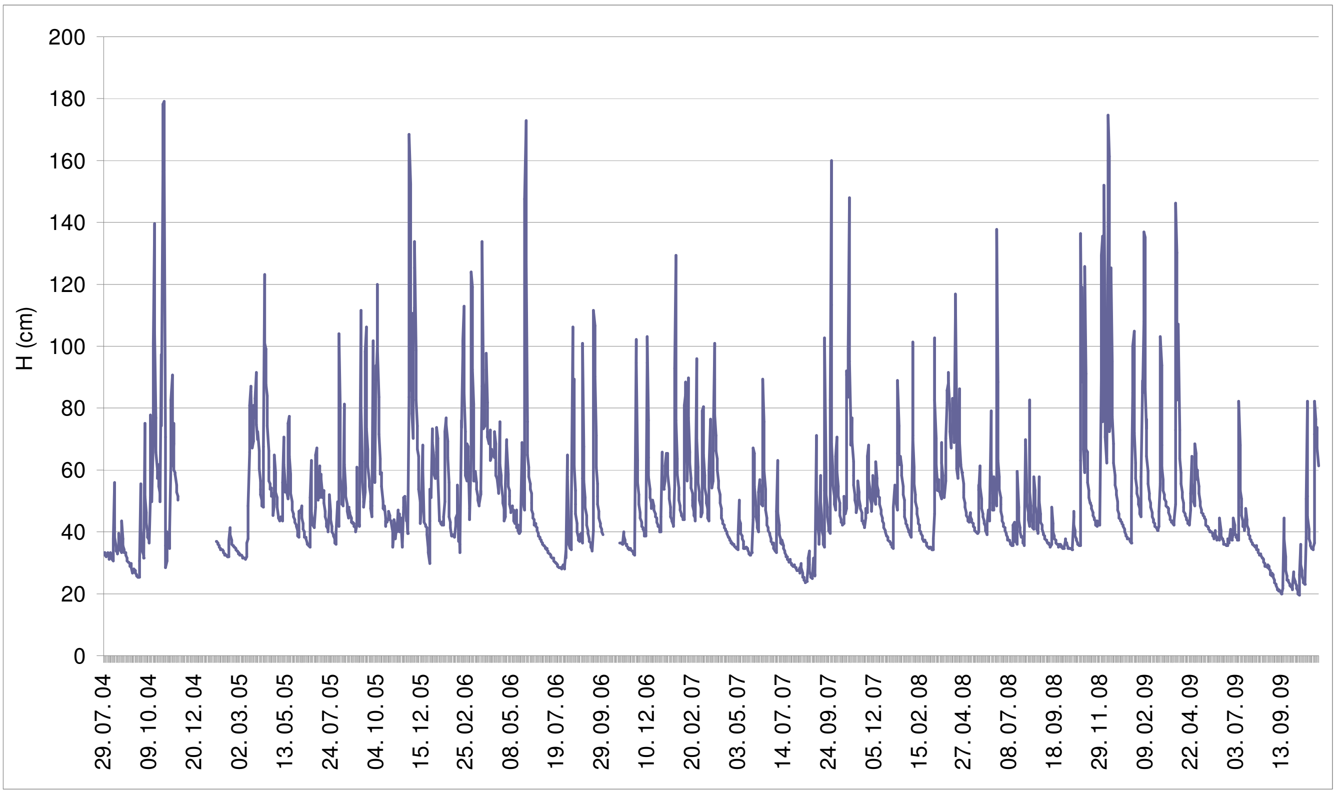
V merskem profilu smo izvajali tudi meritve pretokov. Izvedene so bile v razponu od 0,036 do 0,224 m^3/s, pri vodostajih pod 30 cm pa pretoka ni več mogoče meriti oz. ga praktično ni.

Loški potok

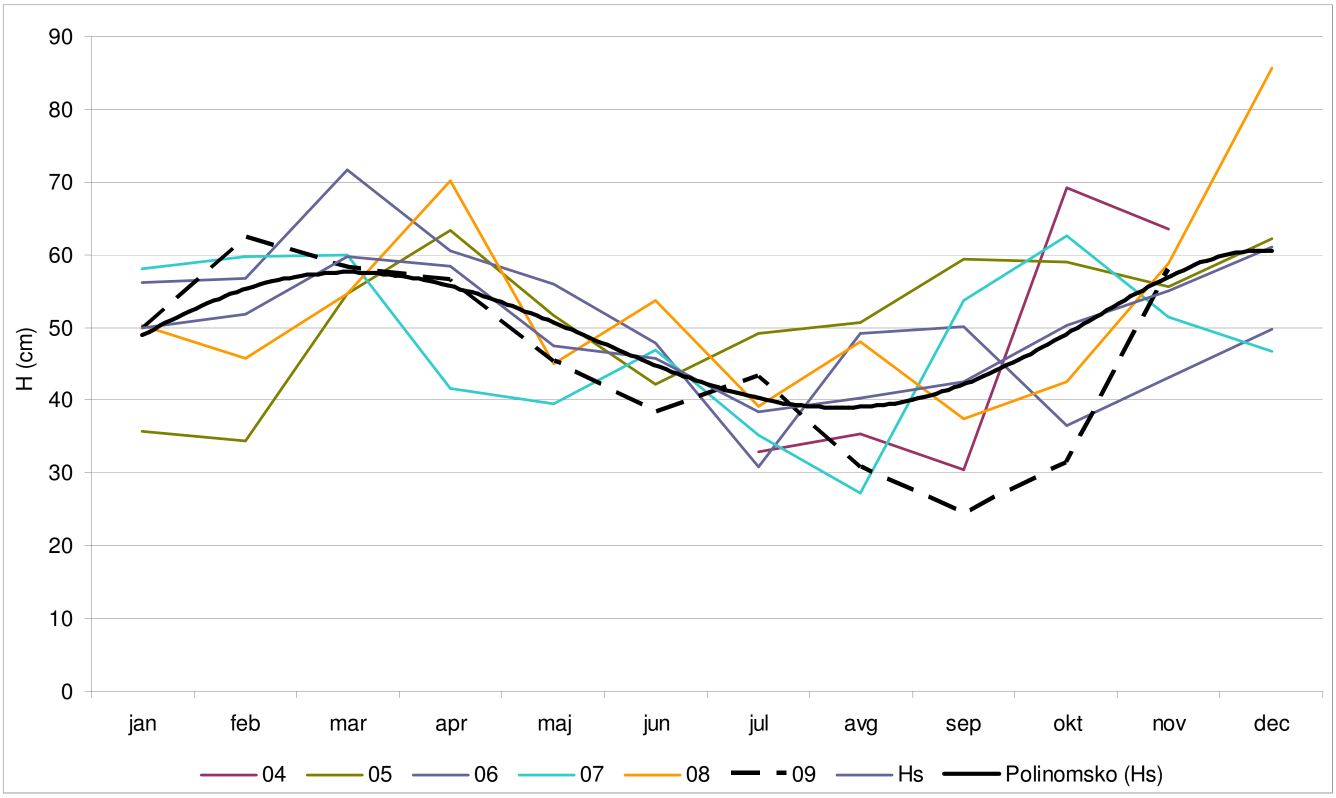
The Loški potok spring is located at the highest altitude in the area of the Kočevje–Goteniška gora aquifer (700 m above the sea level) and represents the characteristics of the area of the Dinaric karst of Dolenjska. The watershed divide toward the karstic region of the Ljubljanica river is also the watershed between the Adriatic and Black Sea basins. In the tectonic aspect, the Loški potok area belongs to the Racna gora brachysincline consisting of the Upper Triassic dolomite and Jurassic and Lower Cretaceous stacks with a typical Dinaric orientation. A major rupture runs in the Dinaric direction from Nova vas na Blokah over Loški potok; along this rupture runs a system of valleys where Loški potok sinks after a short surface stream. There is a proven connection of the sinking stream with the Rakitnica springs in the Ribnica valley. As one of the few water sources in this area, the spring is captured as a reservoir for the water supply of settlements Retje, Hrib–Loški Potok and Travnik.

The spring was included in the monitoring programme in 2004, which ended in 2009 after six years of station operation.

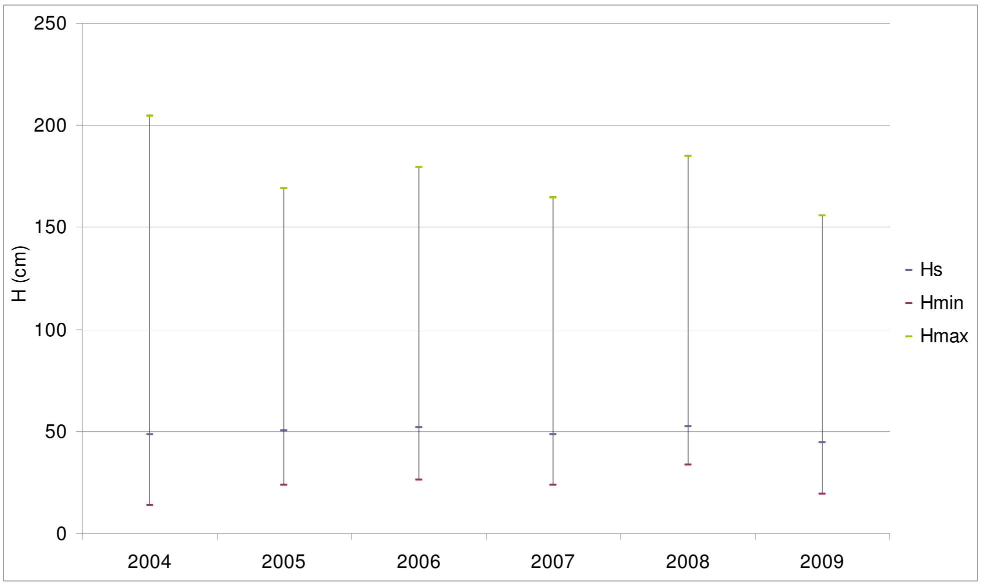
The regime of the Loški potok spring is similar to the regime of the Veliki Obrh spring, as the catchment areas are joined at the watershed divide in the Racna gora area. In six years, the measurement profile developed a data series indicating the main characteristics of the hydrological regime with the timeline of monthly water levels (Figure 18) and characteristic annual values of water levels (Fig. 19).



Slika 17: Potek dnevnih vrednosti vodostajev (H) na izviru Loški potok v obdobju opazovanj 2004–2009
Figure 17: Timeline of daily water level values (H) at the Loški potok spring in the 2004–2009 monitoring period



Slika 18: Potek mesečnih vodostajev (H) v letih opazovanj na izviru Loški potok (2004–2009)
Figure 18: Timeline of monthly water levels (H) in the monitoring period at Loški potok spring (2004–2009).



Slika 19: Značilni letni vodostaji Hmin, Hs, Hmax na izviru Loški potok v obdobju 2004–2009
Figure 19: Characteristic annual water levels Hmin, Hs, Hmax at the Loški potok spring in the 2004–2009 period

Brestovica, vrtina B-2

Na območju Klaričev pri Brestovici na Krasu v vrtini B-2, ki je le nekaj km oddaljena od iztoka podzemne vode v morje, niha gladina podzemne vode v kraškem vodonosniku. Nizki vodostaji kažejo frekvenco nihanj plimovanja morja, visoki valovi pa so posledica hidroloških razmer v povodjih Reke, Vipave in tudi Soče, ter padavin na območju matičnega Krasa. V letu

The periodical minimum reached in 2004 (16 November 2004 at 11.00; H = 13.9 cm) is the result of an artificial intervention (extraction). The actual minimum was reached in 2009 after the period of water level drop had been prolonged until September or, after a short interruption when groundwater reserves were not filled, even until October.

The measurement profile included the measurements of discharges. These were carried out in the range

2009 je bil najvišji vodni val dosežen konec marca zaradi izdatnih padavin in hitrega porasta vodostajev na vodotokih v zahodni Sloveniji. Za tem vodnim valom se je začelo dolgotrajno obdobje nizkih vodostajev, ki se je končalo šele po 6 mesecih v začetku novembra. Nivoje nizkih gladin podzemne vode v vodonosniku vzdržuje nivo morske gladine.

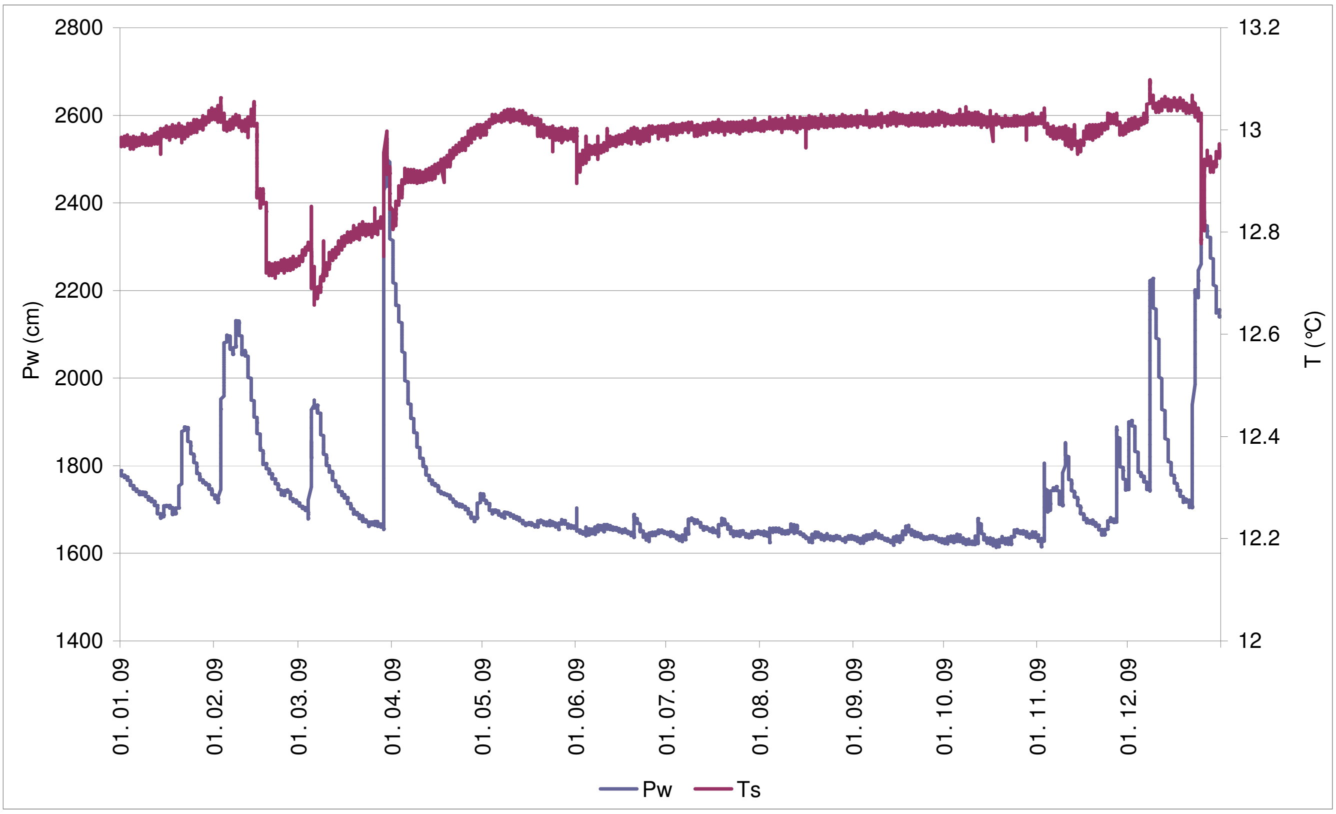
Temperature podzemne vode se sicer komaj opazno znižajo le ob vplivih vodnih valov v hladnejših mesecih, celoletni razponi temperatur pa dosegajo le 0,4 °C. Nizke gladine podzemne vode so v objektu B-2 25 m pod površjem, na območju Pliskovice pa že več kot 200 m. Temperaturni vplivi s površja so s tem zabrisani in opazni le ob izrazitejših dogodkih, zapisovanje pa zahteva relativno natančnost, večjo kot 0,1 °C.

from 0.036 to 0.224 m³/s, while the discharge cannot be measured at water levels below 30 cm as it practically disappears.

Brestovica, borehole B-2

We recorded fluctuation of the ground water levels in the karstic aquifer in the area of Klariči at Brestovica in the Karst region in the B-2 borehole, only a few kilometres from the outflow of the groundwater into the sea. The low water levels reflect the fluctuation frequency of the sea tides, while the high-water waves are a result of hydrological conditions in the drainage basins of the Reka, Vipava and Soča rivers, and precipitation in the area of the classical Karst. The highest water wave in 2009 was reached at the end of March as a result of abundant precipitation and rapid growth of water levels on watercourses in the western Slovenia. After this wave came a long period of low water levels, which ended only after six months, in early November. The levels of low groundwater levels in the aquifer are maintained by the sea level.

Groundwater temperatures record a hardly perceptible drop only under the influence of water waves in colder months, while the temperature ranges over the year reach only 0.4 °C. Low groundwater levels are 25 m below the surface in the B-2 facility, and over 200 m below the surface in the area of Pliskovica. Thus the temperature influences from the surface are vague and noticeable only at major events, while their recording requires relative accuracy of over 0.1 °C.



Slika 20: Potek urnih nekompenziranih vodostajev (H) in temperatur (T) v vrtini B-2 Brestovica

Figure 20: Timeline of hourly uncompensated water levels (H) and temperatures (T) in the B-2 Brestovica bore

D. MORJE

PLIMOVANJE MORJA

Mojca Robič

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

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

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

Podobno velja za nizke vode, pri katerih določimo nižjega od obeh ekstremov (NNV) in iz tega računamo povprečje (SNNV v preglednici D.2.). Srednja nizka voda (SNV v preglednici D.2.) je povprečje vseh nizkih voda v dnevu, mesecu ali letu. Najnižja gladina morja v mesecu ali letu je označena z NNNV in jo najdemo v preglednicah D.2. in D.4.

Preglednice s podatki so objavljene v drugem delu letopisa.

Višine morja v primerjavi z dolgoletnim povprečjem

Morje je bilo v letu 2009 zelo visoko. Srednja letna višina morja je bila z 226,6 cm celo najvišja v opazovalnem obdobju (slika 1).

Srednje mesečne višine morja so bile zelo visoke, prav vse so bile višje od srednje obdobne vrednosti (slika MR_2). Močno navzgor so izstopale mesečne vrednosti za februar, junij, oktober, november in december, ki so vse segale nad 230 cm. Najvišja je bila srednja mesečna višina morja v decembru, ki je bila z 243,9 cm izjemno visoka, najvišja izmerjena v

D. SEA

SEA TIDES

Mojca Robič

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

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

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

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

The tables with the data are published in the second part of the yearbook.

Sea levels in comparison with the multi-annual average

The sea level in 2009 was very high. The mean annual sea level was 226.6 cm, which is the highest value in the entire monitoring period (Figure 1).

The mean monthly sea levels were very high, all of them exceeding the mean periodical value (Figure MR_2). There was a strong positive deviation of monthly values of February, June, October, November and December, all reaching over 230 cm. The mean monthly sea level was the highest in December; with celotnem opazovalnem obdobju. Najnižja je bila srednja mesečna višina v maju, 220 cm.

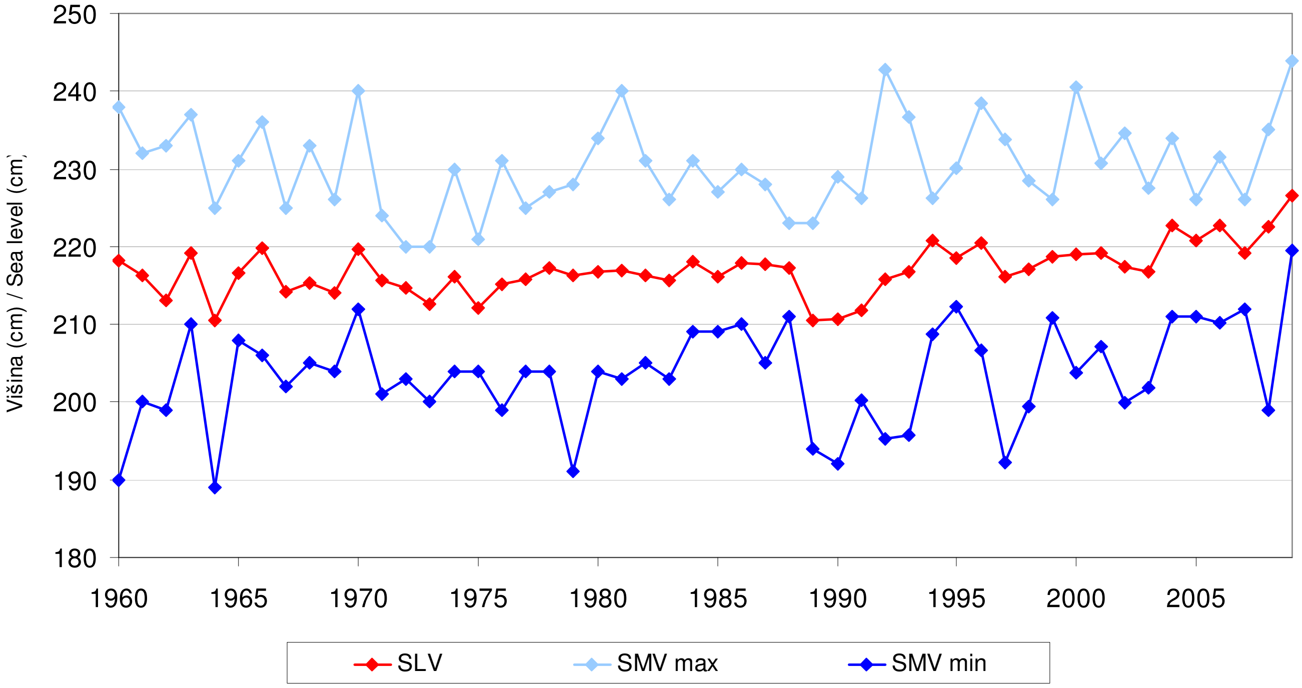
V letu 2009 je morje pogosto poplavljalo niže ležeče dele obale. Kar devet mesecev je imelo najvišjo mesečno vrednost višjo od 300 cm. Najvišja višina morja 342 cm je bila izmerjena ob koncu decembra. To je zelo visoka, vendar ne izjemna višina.

Najnižja letna višina morja 128 cm je bila dosežena v januarju in je v primerjavi z obdobjem nekoliko nadpovprečna.

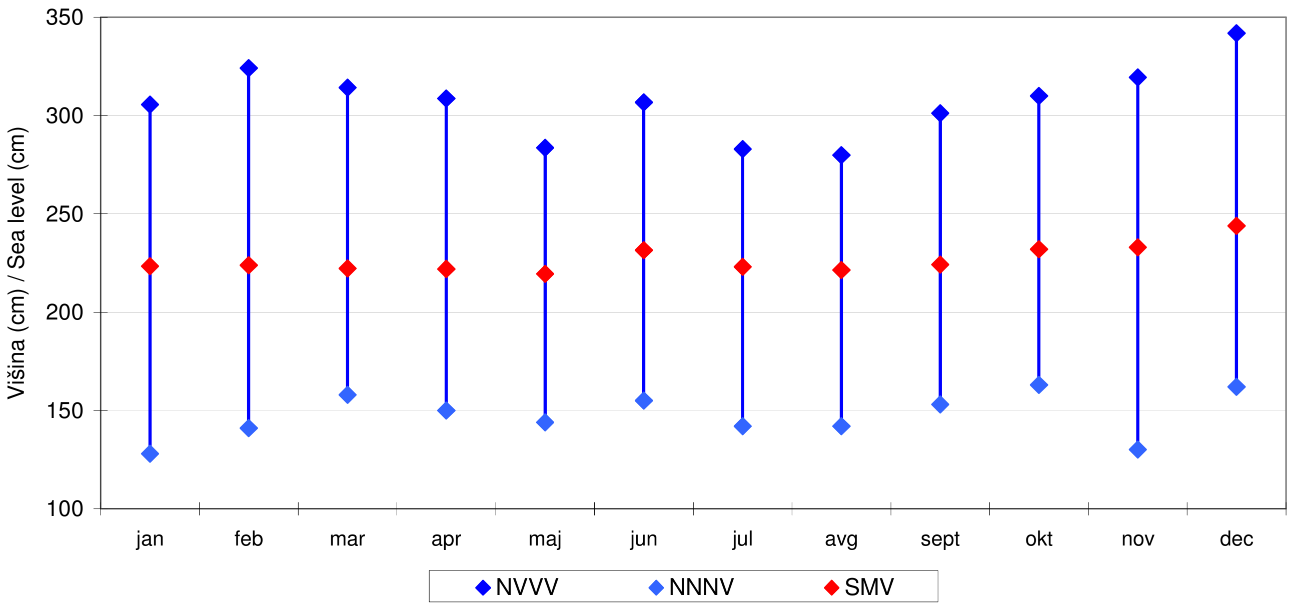
the value of 243.9 cm, it was the highest value measured in the entire monitoring period. The mean monthly level was lowest in May: 220 cm.

Lower parts of the coast were often flooded in 2009. The mean monthly value was over 300 cm for as long as nine months. The highest sea level (342 cm) was measured at the end of December. This level is very high but not exceptional.

The lowest annual sea level (128 cm) was reached in January and is slightly above average in comparison with the period.



Slika 1: Srednje letne višine morja (SLV) ter najvišja in najnižja srednja mesečna višina vode (SMV) v dolgoletnem obdobju
Figure 1: The mean annual sea level (SLV) and the highest and lowest mean monthly sea levels (SMV) in the multi-annual period



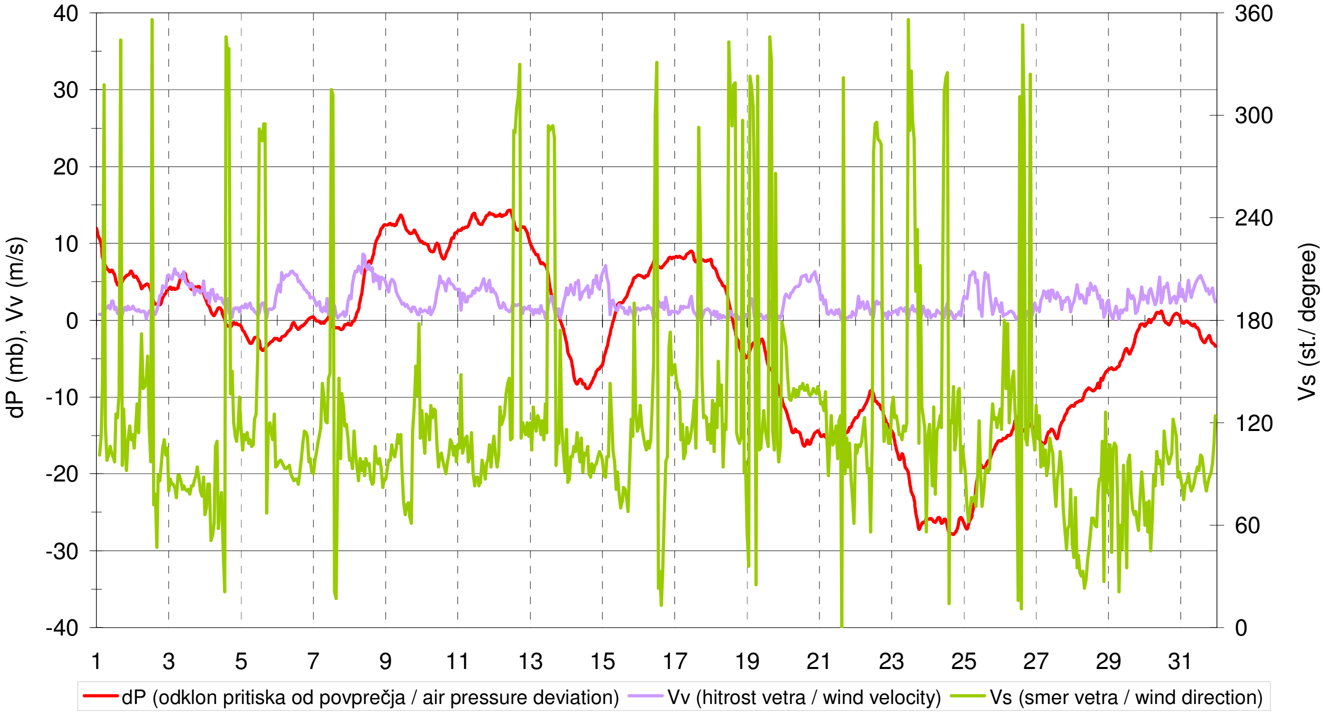
Slika 2: Srednje mesečne višine morja (SMV) z najnižjimi (NNNV) in najvišjimi (NVVV) mesečnimi višinami za leto 2009
Figure 2: The mean monthly sea level (SMV) with the lowest (NNNV) and the highest (NVVV) monthly sea levels in 2009

Kronološki pregled po mesecih

V prvih dneh **januarja** je bilo morje povprečno visoko, sredi meseca podpovprečno, ob koncu meseca pa precej nadpovprečno. 12. januarja ob 16.30 je bila dosežena najnižja letna višina morja, 128 cm. Glavni vzrok za pojav najnižje letne oseke so nizka astronomska višina in nekaj dni trajajoča burja ter visok zračni tlak.

Chronological monthly review

The sea level was average in the first days of **January,** below average in the middle of the month and considerably above average at the end of the month. On 12 January at 16:30, the lowest annual sea level was recorded: 128 cm. The principal reasons for the lowest tide of the year are low astronomical height, the Bora wind, and high pressure, which lasted for a few days.



Slika 3: Hitrost in smer vetra ter odklon zračnega tlaka od povprečja v januarju 2009. Vremenske razmere so bile v prvi polovici meseca ugodne za znižanje, v drugi polovici pa za zvišanje gladine morja
Figure 3: Speed and direction of wind and deviation of air pressure from average in January 2009. The weather conditions were favourable for sea level drop in the first half of the month and for sea level rise in the second half of the month

V prvi polovici **februarja** se je nadaljevalo pestro vremensko dogajanje, ki je močno vplivalo na višine morja. Morje je bilo v tem času močno povišano, kar desetkrat je doseglo višino, ko začne poplavljati niže ležeče dele obale. 8. februarja ob 8.30 je bila izmerjena druga najvišja gladina morja, 324 cm. Drugi del meseca so bile višine morja povprečne.

Tudi v **marcu** je bila višina morja nadpovprečna. Najnižja mesečna gladina 158 cm je bila v primerjavi z obdobnimi vrednostmi zelo visoka, v primerjavi z drugimi mesečnimi minimumi v letu 2009 pa šele tretja najvišja. Najvišja višina morja 314 cm je bila izmerjena ob koncu meseca, ko je bilo vremensko dogajanje znova zelo pestro. Ob najvišji plimi v mesecu so bili vremenski vplivi najmočnejši nekaj ur prej, med oseko in naraščanjem morja, tako da do izjemnih višin ni prišlo.

Višina morje v **aprilu** je bilo nadpovprečna, vendar ne izjemna.

The first half of **February** saw the continuation of diverse weather situation strongly influencing the sea levels. The sea level rose significantly in this period; as many as ten times, it reached the level when it started flooding the low lying parts of the coast. The second highest sea level (342 cm) was measured on 8 February at 8:30. In the second part of the month, the sea levels were average.

In **March**, the sea level was also above average. The lowest sea level of 158 cm was very high in comparison with the periodical values, but only the third highest in comparison with other monthly minimums in 2009. The highest sea level (314 cm) was measured at the end of the month when the weather situation was again very diverse. On the highest tide of the month, the weather influences were strongest a few hours earlier, between the low tide and the rising sea, so exceptional levels did not occur.

The sea level in **April** was above average, but not

Tudi v **maju** je bilo morje nadpovprečno visoko, čeprav je srednja mesečna vrednost najnižja v letu. V primerjavi z obdobjem je bila visoka najnižja oseka, najvišja plima pa je bila podpovprečna.

V **juniju** je bilo morje močno povišano. Srednja mesečna vrednost je bila z 232 cm tretja najvišja v letu, vendar daleč višja od najvišje junijske srednje vrednosti, izmerjene v obdobju 1960–1990. Zgodnje poletje navadno ni čas, ko bi morje dosegalo izjemne višine. K visoki srednji vrednosti je največ pripomogel nizek zračni tlak, ki je bil podpovprečen ves mesec, ob nastopu najvišje gladine morja 307 cm pa se je znižal celo pod 1000 mb.

V začetku **julija** je bilo morje še nekoliko povišano, ob koncu meseca pa se je približalo povprečnim vrednostim.

Podobno nekoliko nadpovprečno je bilo stanje **avgusta** in **septembra**.

V zadnjih treh mesecih leta je bilo morje zelo visoko. V **oktobru** je bilo morje povišano, posebej visoko je bilo ob najvišji mesečni višine morja 310 cm 22. oktobra dopoldan, ko je znova za krajši čas poplavilo obalo. Residualna višina, to je razlika med izmerjeno in napovedano astronomsko plimo, je bila večja od pol metra, kar kaže na močan vpliv vremenskih dejavnikov.

Novembra sta bili srednja in najvišja višina morja nadpovprečni, medtem ko je bila najnižja višina morja podpovprečna, s 130 cm celo druga najnižja v letu. Velika razlika med najvišjo in najnižjo mesečno višino morja nakazuje zelo pestro vremensko dogajanje. V prvi polovici meseca razen prvih treh dni je bila obala pod vplivom ciklona z izrazito nizkim zračnim tlakom ter močnim južnim in jugovzhodnim vetrom. Morje je v tem času trikrat preseglo opozorilno vrednost. Take razmere so se v še močnejši obliki ponovile v zadnjih dveh dneh in povzročili povišanje višine morja. 30. novembra je bila izmerjena najvišja mesečna višina, 319 cm.

December je bil vremensko izjemno pester mesec. Nizek zračni tlak zadnjih novembrskih dni se je nadaljeval tudi v prvih devetih dneh decembra. Že prvi dan je višina morja prvič presegla 300 cm. V tem času so bile višine morja višje od napovedanih tudi do 50 cm. Sledilo je petdnevno obdobje povprečnega zračnega tlaka in majhnega astronomskega plimovanja ter le rahlo povišanih gladin morja. To je bil najbolj umirjeni del meseca.

Med 20. in 27. decembrom pa je bila slovenska obala pod močnim ciklonskim vplivom, zračni tlak se je znižal celo na 996 mb. Morje je bilo močno povišano. Med 21. in 25. decembrom je večkrat poplavljalo, kar je sovpadalo tudi z velikimi poplavami rek po vsej državi. V tem času je morje kar trikrat preseglo vrednost 320 cm. Residualne višine so dosegale tudi do 100 cm. V tem času je bilo astronomsko plimovanje nizko, sicer bi lahko prišlo do izjemnih višin in poplav morja. Srednje dnevne višine morja so bile v tem obdobju izredno visoke, najvišja 25. decembra je dosegla celo 280 cm. Najvišja decembrska in hkrati najvišja letna višina morja v letu 2009 je bila izmerjena 23. decembra

exceptional.

The sea level continued to be above average in **May**, although the mean monthly level is the lowest of the year. In comparison with the period, the lowest low tide was high while the highest tide was below average.

The sea level increased significantly in **June**. The mean monthly average of 232 cm was third highest of the year, but far from the highest mean value of June measured in the 1960–1990 period. Early summer is usually not a time of extremely high sea levels. The high mean value was mostly the result of the air pressure, which was below average for the whole month and dropped as low as under 1 000 mb at the highest sea level of 307 cm.

At the beginning of **July**, the sea levels were still somewhat raised, while they approached the average values at the end of the month.

The levels were again somewhat above average in **August** and **September**.

The sea was very high in the last three months of the year. The sea level was higher in **October**, especially at the highest monthly sea level of 310 cm on 22 October in the afternoon, when it flooded the coast again for a while. The residual level, i.e. the difference between the measured and forecast astronomical tide, exceeded half a metre, which indicates a strong influence of weather factors.

While the mean and maximum sea levels were above average in **November**, the lowest sea level was below average, even the second lowest of the year, at 130 cm. The great difference between the highest and lowest monthly sea levels indicates a very diverse weather situation. In the first half of the month, except for the first three days, the coast was under the influence of a cyclone with prominently low air pressure and a strong southern and south-western wind. In this period, the sea exceeded the limit value three times. Such conditions were repeated in an even stronger form in the last two days and caused the raised sea level. The highest monthly value (319 cm) was measured on 30 November.

December was a month of extremely diverse weather. The low barometric pressure of the last days of November continued in the first nine days of December. The sea level was over 300 cm already on the first day. The sea levels in this period exceeded the forecast values by as much as 50 cm. This was followed by a five-day period of average barometric pressure, mild astronomical tides and only slightly raised sea levels. This was the most placid part of the month.

Between 20 and 27 December, the Slovenian coast was under a strong cyclone influences; the air pressure dropped as low as 996 mb. The sea rose significantly. It flooded several times between 21 and 25 December, which coincided with major river floods throughout the country. In this period, the sea exceeded the level of 320 cm for as many as three times. Residual heights reached as much as 100 cm. The astronomic tide was low in this period, which prevented the extraordinary ob 2.50 ponoči in je dosegla 342 cm.

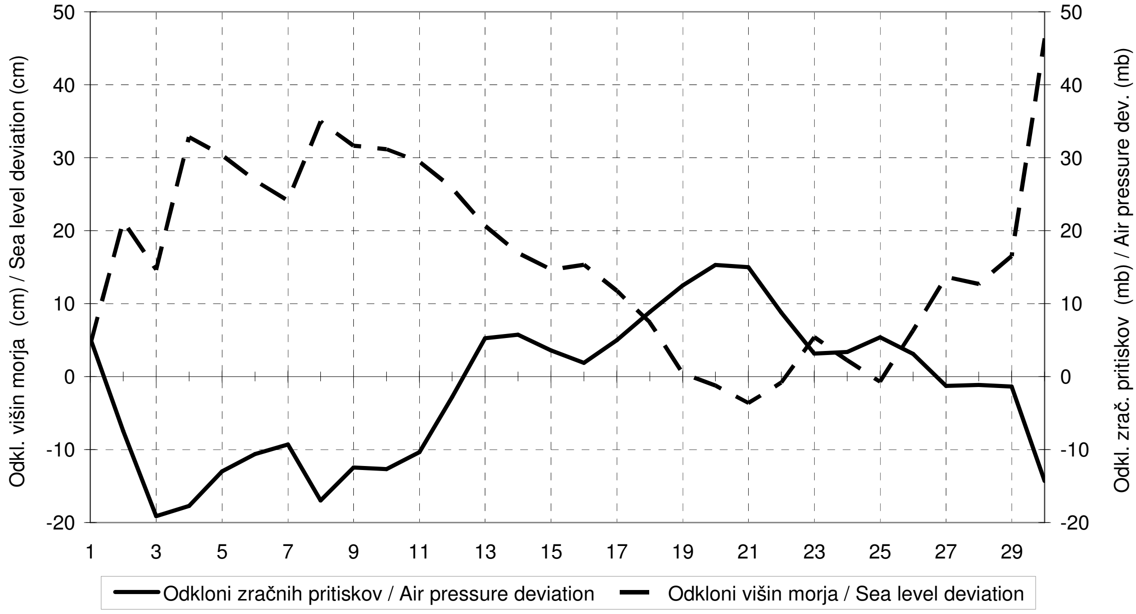
V zadnjih dneh leta so se vremenske razmere nekoliko omilile, vendar je bilo astronomsko plimovanje višje, tako da so bile višine morja še vedno zelo visoke.

Morje je v decembru desetkrat preseglo opozorilno vrednost in večkrat poplavljalo obalo. Srednja mesečna višina je z 243,9 cm izjemno visoka in je najvišja v letu. To je hkrati do zdaj najvišja izmerjena srednja mesečna višina morja (slika 1).

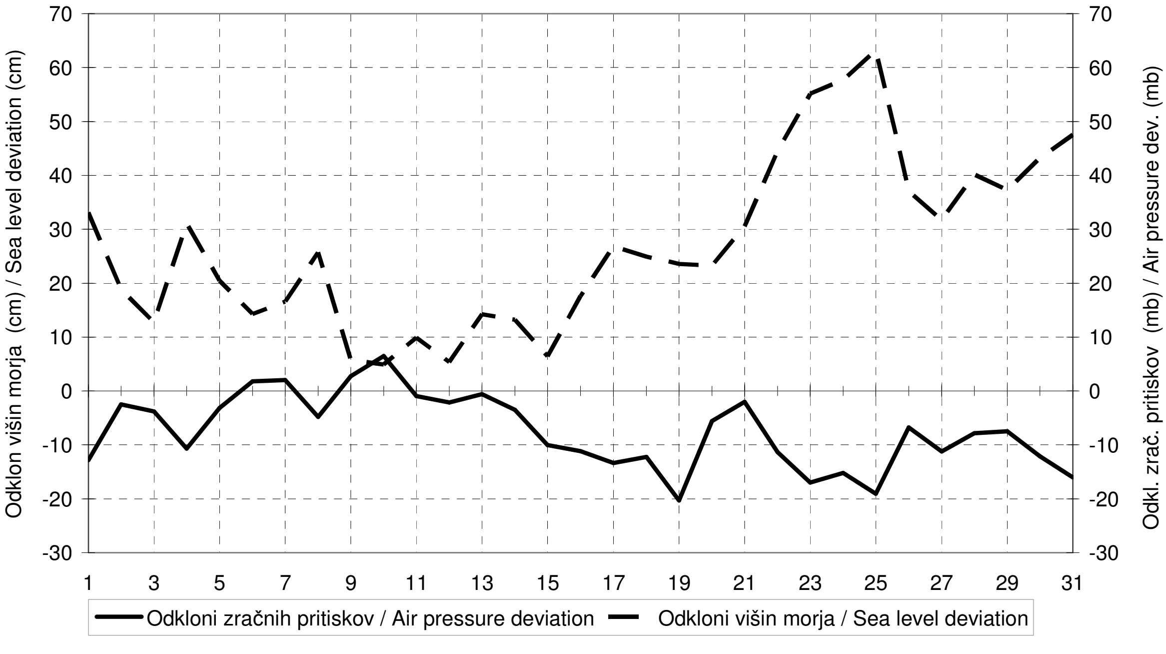
levels and sea floods. The mean sea levels were extremely high in this period, reaching, as high as 280 cm on 25 December. The highest sea level of December, which was also the highest sea level of 2009, was measured on 23 December at 2:50 and reached 342 cm.

Although the weather conditions somewhat stabilised in the last days of the month, the astronomical tide was higher, so the sea levels were still very high.

In December, the sea exceeded the limit value for ten times and flooded the coast several times. Its mean monthly level of 243.9 cm is extremely high and the highest of the year. It constitutes the highest mean monthly sea level measured to this day (Figure 1).



Slika 4: Višine morja so bile v novembru večinoma nadpovprečne
Figure 4: The sea levels in November were mostly above average



Slika 5: Višine morja so bile v decembru močno nadpovprečne
Figure 5: The sea levels in December were high above average

TEMPERATURA MORJA V LETU 2009

Igor Strojan

Značilnosti temperatur morja v letu 2009 so bile nekoliko višja povprečna letna temperatura morja kot v celotnem primerjalnem obdobju meritev od leta 1957, visoka povprečna temperatura morja v maju ter več hitrih in večjih sprememb temperature morja.

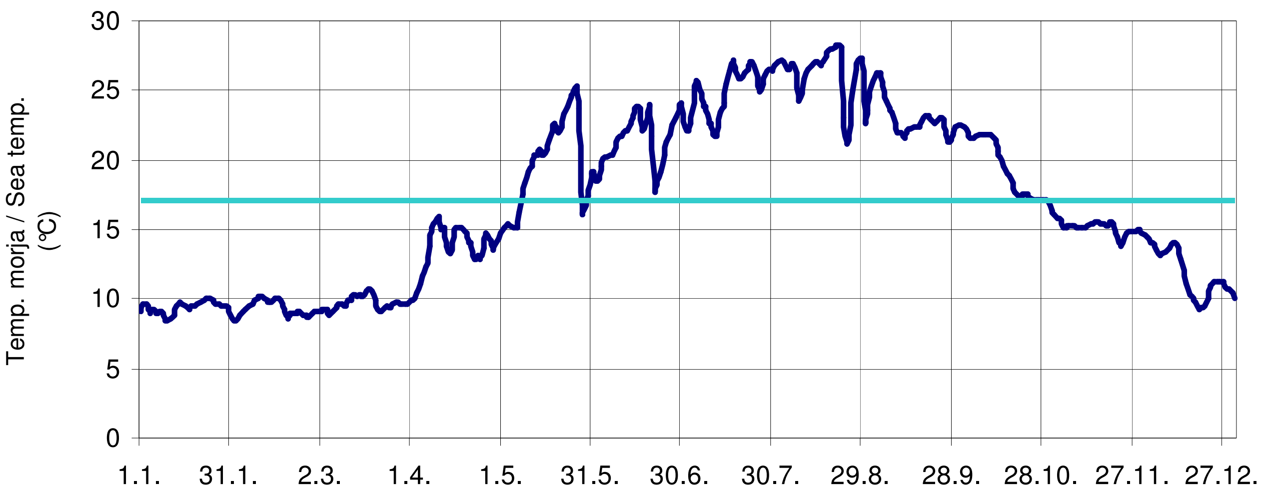
V prvih treh mesecih leta je bilo morje najhladnejše (slika 1). Povprečna temperatura morja v tem času je bila 9,5 °C, kar je dokaj običajno za to letno obdobje. V tem času se temperature morja blizu površine in v globini med seboj le malo razlikujejo. Temperatura zraka je bila v tem času večinoma občutno nižja od temperature morja. V začetku aprila se je temperatura dokaj hitro dvignila, tako da se je morje v sedmih dneh ogrelo za več kot 5 °C. Sledilo je nekaj temperaturnih odstopanj okoli srednje mesečne temperature 13,6 °C, ki je bila sicer aprila nekoliko višja kot v dolgoletnem primerjalnem obdobju. Morje se je do kopalne temperature 18 °C ogrelo že maja. Maj je bil izredno topel, vendar se je konec maja in nato še junija morje tudi hitro in močno shladilo. Pri tem se je temperatura morja konec maja v dveh dneh znižala za 9 °C. Prave poletne temperature so se začele od sredine julija in so trajale do zadnjih deset dni v avgustu. V tem času so bile povprečne dnevne temperature morja večinoma višje od 25 °C. V naslednjih mesecih do konca leta se je morje postopno ohlajalo. Temperature morja so bile od septembra občutno višje od temperatur zraka (slika 2). Zadnje dni leta je bila povprečna dnevna temperatura morja 10 °C.

SEA TEMPERATURES IN 2009

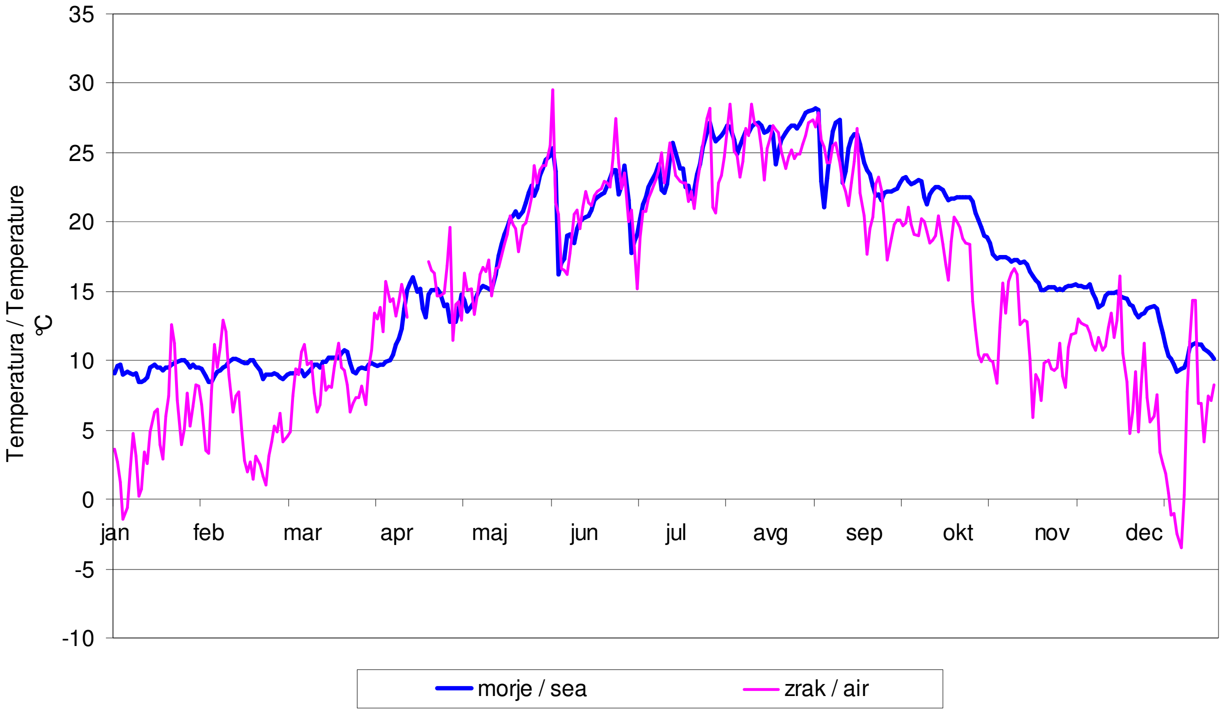
Igor Strojan

The characteristics of sea temperatures in 2009 were a slightly higher average sea temperature than in the entire comparative monitoring period since 1957, a high average sea temperature in May and several rapid and major changes in se temperature.

The sea was coldest in the first three months of the year (Figure 1). The mean sea temperature in this period was 9.5 °C, which is quite average for this period of the year. At this stage, the sea temperatures near the surface and in the depths do not differ considerably. The air temperature was mostly considerably lower than the sea temperature. The temperature rose quite rapidly in early April, so the sea warmed by more than 5 °C. This was followed by some temperature deviations around the mean monthly temperature of 13.6 °C, which was slightly higher than in the multi-annual comparative period. The sea reached the bathing temperature of 18 °C as early as in May. Although May was extremely warm, the sea cooled rapidly and dramatically at the end of May and in June. At the end of May, the sea temperature dropped by 9 °C in two days. The true summer temperatures began in mid-July and lasted until the last ten days in August. The average daily temperatures of the sea in this period mostly exceeded 25 °C. In the months until the end of the year, the sea cooled gradually. The sea temperatures in September were considerably higher than the air temperatures (Figure 2). In the last days of the year, the mean daily sea temperature was 10 °C.



Slika 1: Srednje dnevne temperature morja in srednja letna temperatura morja v letu 2009
Figure 1: Mean daily sea temperatures and mean annual sea temperature in 2009



Slika 2: Srednja dnevna temperatura zraka in morja v letu 2009
Figure 2: Mean daily temperature of air and sea in 2009

Primerjava z dolgoletnim obdobjem

Povprečna temperatura morja v letu 2009 je bila 17 °C, kar je nekoliko nadpovprečno glede na celotno opazovano obdobje od leta 1957 in povprečno, če jo primerjamo s podatki zadnjih desetih let.

Srednja mesečna porazdelitev temperatur morja kaže, da je bila le novembra srednja mesečna temperatura morja nekoliko podpovprečna. V vseh drugih mesecih so bile srednje temperature morja višje kot v dolgoletnem primerjalnem obdobju. Tako je bilo morje razmeroma najtoplejše maja, ko je bila srednja mesečna temperatura 19,7 °C. Tudi najvišja dnevna 25,3 °C in najvišja trenutna temperatura morja 26,2 °C sta bili 26. maja med najvišjimi majskimi temperaturami morja v dolgoletnem primerjalnem obdobju. Maj 2009 je bil tako med najtoplejšimi v celotnem opazovalnem obdobju in skoraj tri stopinje toplejši kot v dolgoletnem povprečju.

Porazdelitev najvišjih in najnižjih temperatur v posameznih mesecih (slika 4) kaže, da so bila največje mesečne amplitude temperature morja 10,6 °C maja in avgusta 7,1 °C. Najmanj so se najvišje in najnižje mesečne temperature razlikovale januarja in februarja 1,6 °C ter marca 1,8 °C in novembra 2,3 °C.

Najvišja srednja dnevna temperatura morja 28,2 °C je bila 28. avgusta, najmanjša 8,5 °C pa 9. in 10. januarja ter 1. in 2. februarja. Najnižja izmerjena temperatura morja je bila 8,1 °C 19. februarja ob 6.20 zjutraj. 21. avgusta ob 16.10 je bila temperatura morja najvišja 28,8 °C.

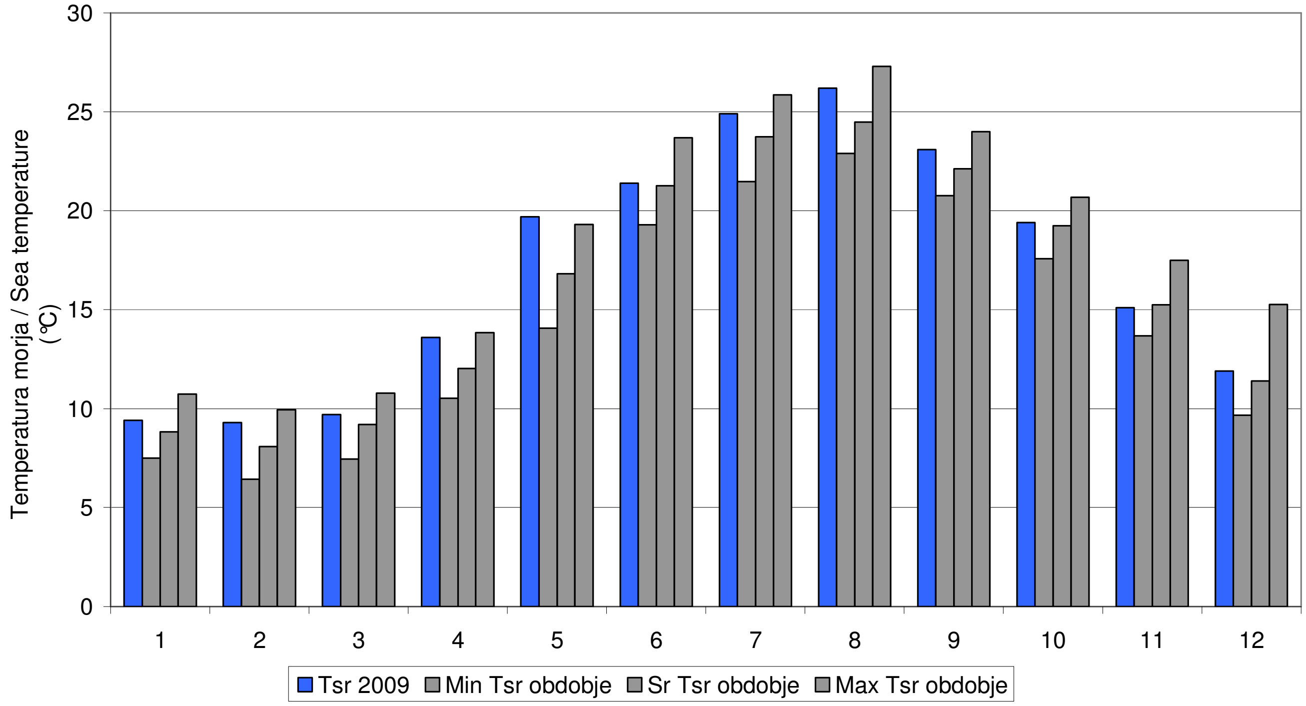
Comparison with the multi-annual period

The mean sea temperature in 2009 was 17 °C, which is slightly above average in comparison with the entire monitoring period since 1957 and average if compared to the data of the previous ten years.

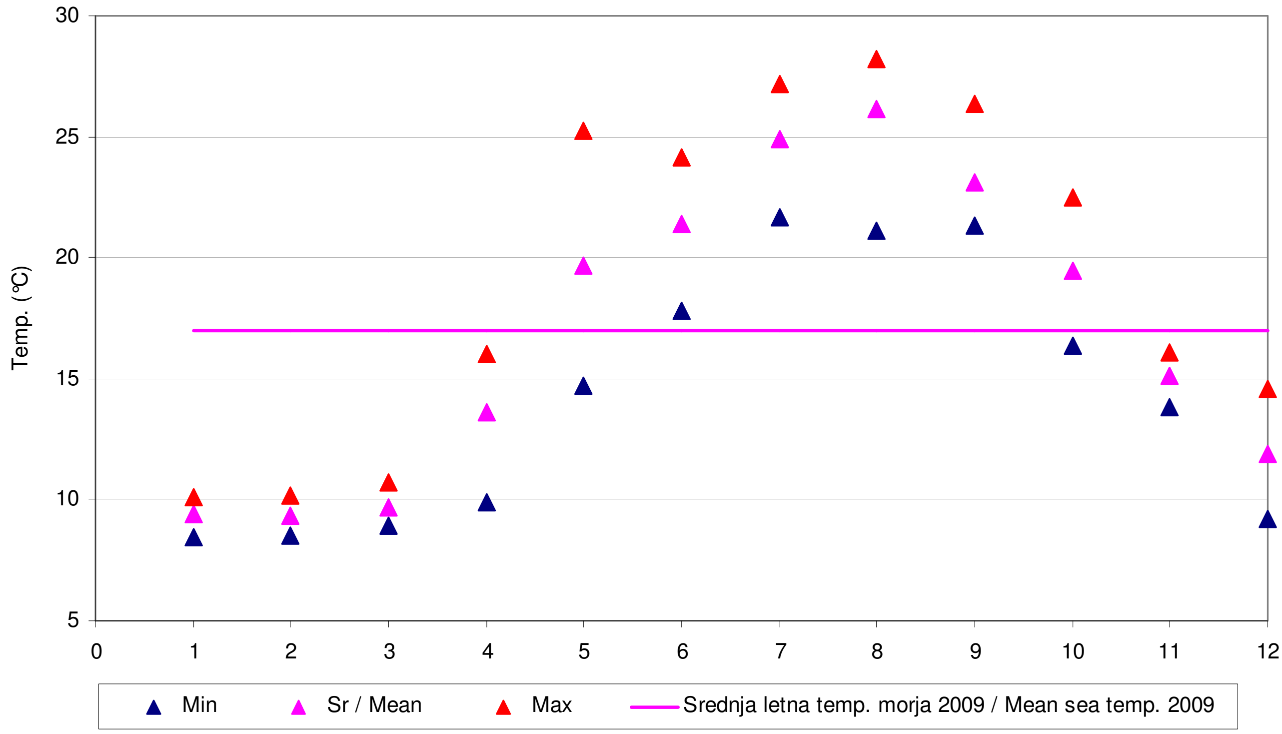
The mean monthly distribution of sea temperatures indicates that the mean monthly sea temperature was slightly below average only in November. In all other months, the mean sea temperatures were slightly higher than in the multi-annual reference period. Thus the sea was relatively warmest in May when the mean monthly temperature was 19.7 °C. The highest daily temperature of 25.3 °C and the highest momentary sea temperature of 26.2 °C measured on 26 May were also among the highest May sea temperatures in the multi-annual reference period. May 2009 was thus among the warmest in the entire monitoring period and warmer than the multi-annual average by almost three degrees.

The distribution of highest and lowest temperatures in individual months (Figure 4) indicates than the greatest monthly amplitudes of sea temperature were 10.6 °C in May and 7.1 °C in August. The difference between the lowest and the highest monthly temperatures was smallest in January and February (1.6 °C), in March (1.8 °C) and in November (2.3 °C).

The highest mean daily sea temperature (28.2 °C) was recorded on 28 August, and the lowest (8.5 °C) on 9 and 10 January and on 1 and 2 February. The lowest sea temperature (8.1 °C) was recorded on 19 February at 6:20. The sea temperature was highest on 21 August at 16:10 at 28.8 °C.



Slika 3: Srednje mesečne temperature morja leta 2009 in srednje mesečne temperature v dolgoletnem obdobju1981–2000 (najnižje, srednje in najvišje vrednosti v dolgoletnem obdobju)
Figure 3: Mean monthly sea temperatures in 2009 and mean monthly temperatures in the 1981–2000 period (lowest, mean and highest values in the multi-annual period)



Slika 4: Srednje, najmanjše in največje mesečne temperature morja v letu 2009
Slika 4: Mean, lowest and highest monthly sea temperatures in 2009

Kronološki pregled

Kronološki pregled je povzet po prispevkih o temperaturah morja v mesečnem biltenu Agencije RS za okolje Naše okolje. Od objave v mesečnem biltenu

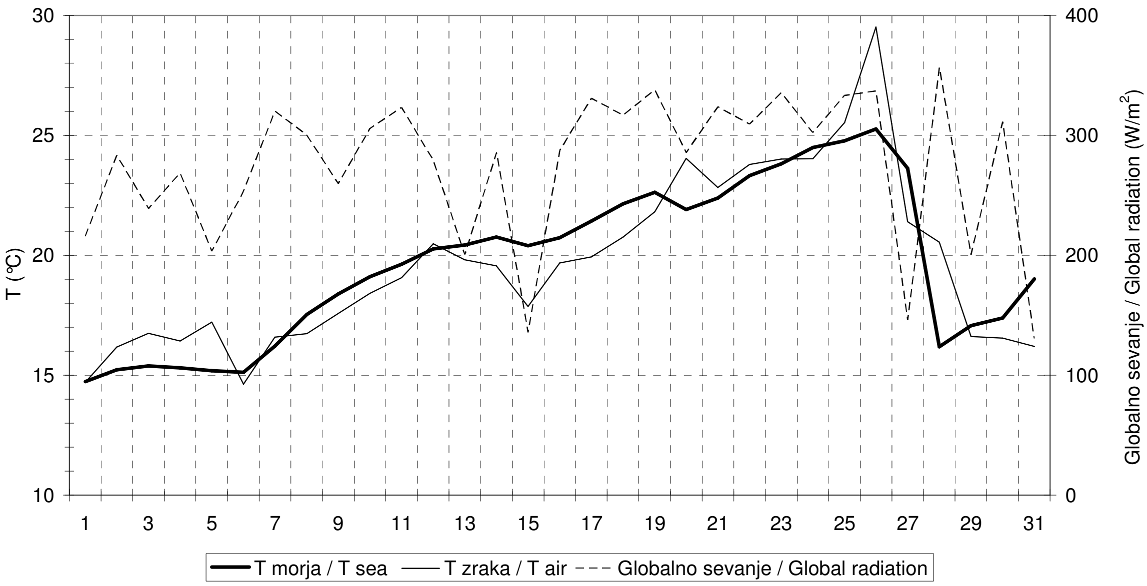
Chronologic overview

The chronologic overview has been summarised from the contributions about sea temperatures in the monthly bulletin of the agency, *Naše okolje* (Our do objave v hidrološkem letopisu so bili podatki meritev ponovno kontrolno obravnavani in vneseni v informacijski sistem Hidrolog, zato se nekateri podatki v hidrološkem letopisu razlikujejo od podatkov, objavljenih v mesečnem biltenu oz. so drugače obravnavani.

Povprečna temperatura morja v **januarju** 9,4 °C je bila nekoliko nadpovprečna glede na obdobje 1981–2000. Temperatura se je prvih deset dni nekoliko zniževala, nato pa do 24. januarja naraščala. Razlika med najvišjo in najnižjo temperaturo je bila le 1,6 °C. Povprečna temperatura morja v **februarju** je bila spet nekoliko nadpovprečna glede na primerjalno. Temperatura se je tokrat prvih deset dni zviševala, nato se ni več spreminjala ter se med 15. in 19. februarjem spustila za stopinjo in pol. Do konca meseca se nato ni več dosti spreminjala. Razlika med najvišjo in najnižjo temperaturo je bila spet le 1,6 °C. Povprečna temperatura morja v **marcu** 9,7 °C je bila 0,5 °C višja kot običajno. Temperatura se je zviševala do 19. marca, nato pa v dveh dneh padla za 1,6 °C. Do konca meseca se je temperatura nato le še nekoliko zvišala. Mesečna amplituda je bila zelo majhna in ni dosegla 2 °C. Najnižja temperatura morja je bila višja, najvišja pa nižja kot običajno. **Aprila** je bilo morje 1,6 °C toplejše kot navadno v tem času. Temperatura morja se je zviševala do 11. aprila, nato so sledila tri krajša obdobja zviševanja in zniževanja temperature. Mesečna amplituda 6,1 °C je bila velika. Najnižja mesečna temperatura je bila aprila podpovprečna, najvišja pa nekoliko podpovprečna. Temperatura morja je **maja** večino meseca hitro naraščala. Najnižja je bila prvi dan v mesecu 14,7 °C, najvišjo dnevno vrednost 25,3 °C pa je dosegla 26. maja. Ta vrednost je med najvišjimi v dolgoletnem primerjalnem obdobju. Sledilo je dvodnevno obdobje hitre ohladitve, ko se je temperatura morja znižala za 9 °C. Zadnje dni maja se je temperatura morja znova nekoliko zvišala (slika 5).

Environment). Between the publication in the monthly bulletin and the publication in the hydrology yearbook, the data were subject to another control and entered in the *Hidrolog* information system, so certain data in the hydrology yearbook differ from the data published in the monthly bulletin or were treated differently.

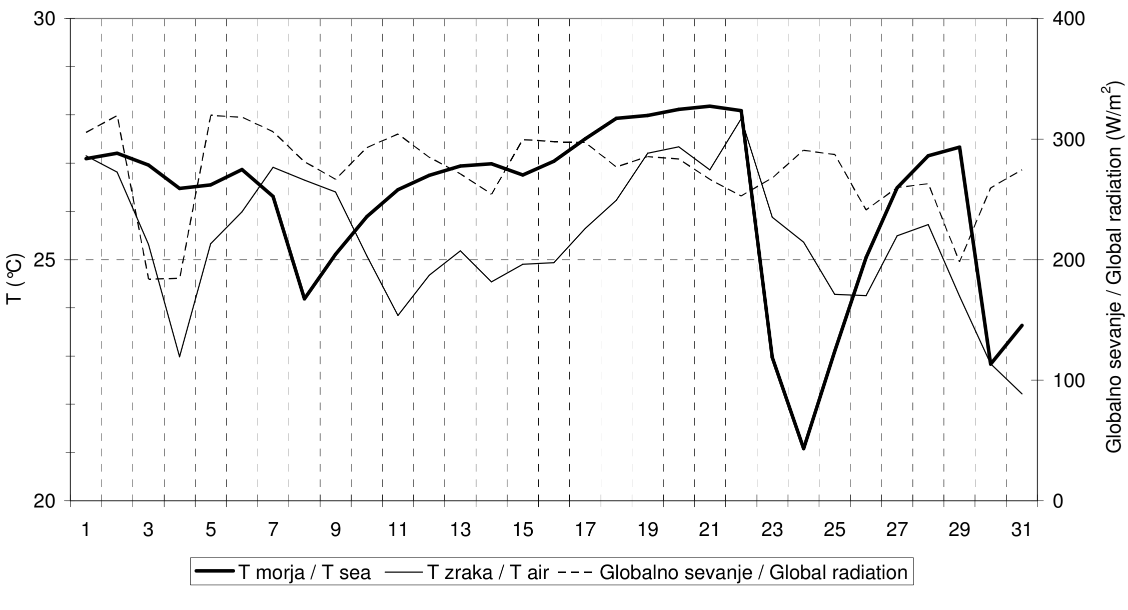
The mean sea temperature in **January** (9.4 °C) was slightly above average in comparison with the 1981–2000 period. The temperature was decreasing slightly for the first ten days and then increasing until 24 January. The difference between the highest and the lowest temperature was only 1.6 °C. The mean sea temperature in **February** was again somewhat above average in comparison to the reference values. The temperature rose for the first ten days, and then remained unchanged and dropped by a degree and a half between 15 and 19 February. It did not vary considerably until the end of the month. The difference between the highest and the lowest temperature was again only 1.6 °C. The mean sea temperature in **March** (9.7 °C) exceeded the average by 0.5 °C. The temperature rose until 19 March, and then dropped by 1.6 °C in two days. The temperature rose slightly by the end of the month. The monthly amplitude was very small, under 2 °C. The lowest sea temperature was higher than usual while the highest was lower than usual. In **April**, the sea was 1.6 °C warmer than usually at this time. The sea temperature rose until 11 April, which was followed by three short periods of temperature rising and falling. The monthly amplitude of 6.1 °C was great. The lowest monthly temperature of April was below average, while the highest was slightly below average. The sea temperatures of **May** grew rapidly for most of the month. It was lowest on the first day of the month (14.7 °C) while the highest daily value (25.3 °C) was reached on 26 May. This value ranks among the highest in the multi-annual reference period. It was followed by a period of rapid cooling when the sea temperature dropped by 9 °C. The sea temperature slightly rose again in the last days of May (Figure 5).



Slika 5: Srednja dnevna temperatura zraka, globalno sevanje in temperatura morja v maju 2009
Figure 5: Mean daily air temperature, global radiation and sea temperature of May 2009

Temperatura morja se je v prvi polovici **junija** zviševala. Morje se je v tem času ogrelo z 18,5 °C na 23,5 °C. V drugi polovici meseca je sledila hitra in močna ohladitev. Med 19. in 21. junijem se je morje ohladilo na 17,8 °C, kar je bila najnižja temperatura v mesecu. Temperatura se je po tej ohladitvi hitro zviševala in ob koncu meseca dosegla najvišjo mesečno vrednost 24,1 °C. To je manj od najnižje povprečne dnevne temperature morja, izmerjene v juniju v dolgoletnem obdobju. Tudi srednja in najvišja temperatura morja v juniju sta bili podpovprečni. **Julija** je temperatura morja večkrat močno zanihala. Najnižjo vrednost je dosegla 11. julija, ko je bila srednja dnevna temperatura morja 21,7 °C, najvišjo pa 17. julija 27,2 °C. V prvi polovici meseca je bila temperatura morja večinoma nižja od 25 °C, v drugi polovici pa višja. Značilne vrednosti so bile vse malo višje od obdobnih povprečij. Srednja mesečna temperatura morja v **avgustu** 2009 je bila s 26,2 °C nekoliko nadpovprečna. Najnižja temperatura morja v avgustu je bila podpovprečna in najvišja mesečna temperatura morja nadpovprečna. Amplituda 7,1 °C je bila velika. Zanimivo je, da sta bili najvišja in najnižja temperatura izmerjeni v presledku le treh dni. Za temperaturo morja v avgustu so bili značilni trije močnejši padci: prvi, najblažji med 6. in 9. avgustom, drugi najmočnejši 7 °C med 22. in 24. avgustom ter zadnji v zadnjih dneh meseca (slika 6).

The sea temperature was growing in the first half of **June**. In this period, the sea warmed from 18.5 °C to 23.5 °C. A rapid and strong cooling followed in the second half of the month. Between 19 and 21 June, the sea cooled to 17.8 °C, which was the lowest temperature of the month. After this cooling, the temperature rose quickly and reached the highest monthly value of 24.1 °C at the end of the month. This is less than the lowest mean daily sea temperature measured in June during a multi-annual period. The mean and highest sea temperatures in June were below average, too. In **July** the sea temperature fluctuated strongly several times. It reached the lowest value on 11 July, when the mean daily sea temperature was 21.7 °C, and the highest value on 17 July, when it was 27.2 °C. The sea temperature was mostly below 25 °C in the first half of the month and above 25 °C in the second half. All typical values were slightly above the periodical averages. The mean monthly sea temperature in **August** 2009 (26.2 °C) was slightly above average. The lowest sea temperature in August was below average while the highest was above average. The amplitude of 7.1 °C was great. An interesting fact is that the highest and the lowest temperatures were recorded in the time interval of three days. The sea temperature in August was characterised by three considerable drops: the first and mildest occurred between 6 and 9 August, the second and strongest (7 °C) took place between 22 and 24 August, while the last one came in the last days of the month (Figure 6).

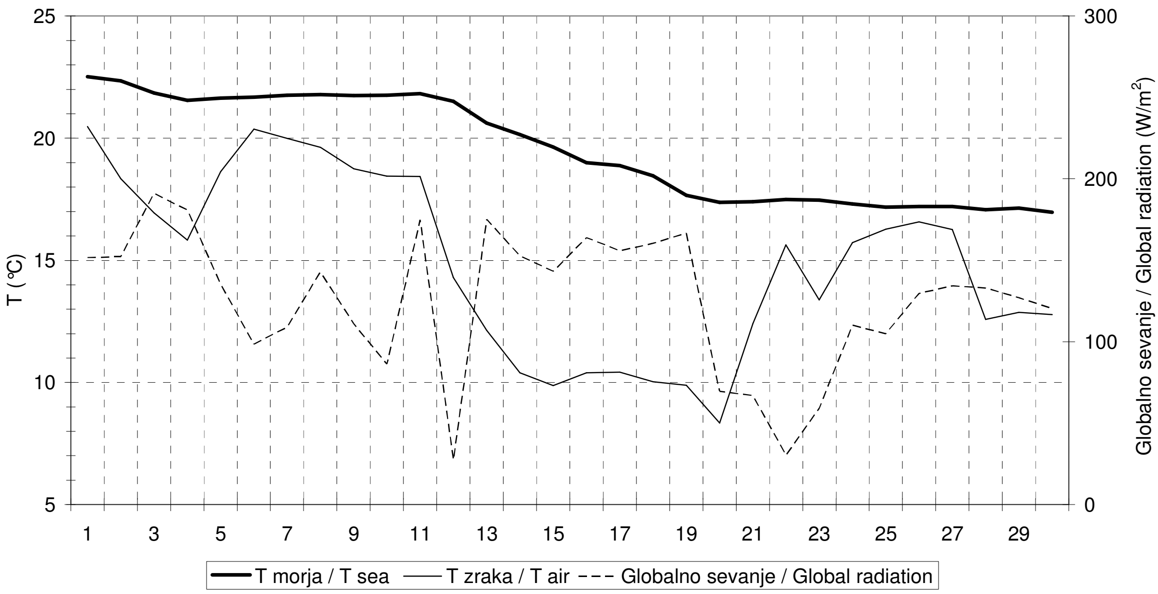


Slika 6: Srednja dnevna temperatura zraka, globalno sevanje in temperatura morja v avgustu 2009
Figure 6: Mean daily air temperature, global radiation and sea temperature of August 2009

Vse značilne temperature morja v **septembru** so bile nadpovprečne in nobena izjemna. Mesec se je začel z nekajdnevnim obdobjem naraščanja temperature, ki mu je sledila močna ohladitev. V desetih dneh se je morje ohladilo za 4,4 °C. V nadaljevanju meseca se je temperatura le malo spreminjala in je bila običajna za september. Gibala se je med 22 in 23 °C. Vse značilne temperature morja v **oktobru** so bile nadpovprečne in

All typical sea temperatures in **September** were above average and none was exceptional. The month began with a few days of temperature growth followed by strong cooling. The sea cooled by 4.4 °C in ten days. As the month continued, the temperature changed only slightly and was typical of September. It was between 22 and 23 °C. All typical sea temperatures in **October** were above average and none was exceptional. The spet nobena izjemna. Temperatura morja se je zniževala od prvega do zadnjega dne v oktobru. Razlika med najvišjo in najnižjo mesečno temperaturo je bila 6,1 °C (slika 7). **Novembra** je bila srednja temperatura morja povprečna in se je skoraj ves mesec gibala okoli 15 °C. Navzgor so odstopali prvi štirje dnevi, navzdol pa dnevi med 20. in 25. novembrom. Najnižja temperatura je bila višja od najvišje obdobne vrednosti. Razlika med najvišjo in najnižjo mesečno temperaturo je bila le 2,3 °C. Srednja temperatura morja v **decembru** 11,9 °C je bila nekoliko višja kot v dolgoletnem primerjalnem obdobju. Najvišja temperatura morja v decembru je bila nižja kot navadno. V prvi tretjini meseca se je temperatura le malo spreminjala, sledilo je desetdnevno obdobje ohlajanje morja, preostali del meseca pa se je temperatura morja spet le malo spreminjala. Najnižja temperatura je bila višja od najvišje obdobne vrednosti. Razlika med najvišjo in najnižjo mesečno temperaturo je bila 5,4 °C.

sea temperature was decreasing from the first to the last day of October. The difference between the highest and the lowest monthly temperature was only 6.1 °C (Figure 7). The mean sea temperature in **November** was average, around 15 °C for the whole month. There was a positive deviation in the first four days and a negative deviation from 20 to 25 November. The lowest temperature was higher than the highest periodical value. The difference between the highest and the lowest monthly temperature was only 2.3 °C. The mean sea temperature in **December** (11.9 °C) was slightly higher than in the multi-annual reference period. The highest sea temperature in December was lower than usual. In the first third of the month, the temperature varied only slightly; this was followed by a ten-day period of sea cooling, while the temperature varied only slightly again for the remaining part of the month. The lowest temperature was higher than the highest periodical value. The difference between the highest and the lowest monthly temperature was 5.4 °C.



Slika 7: Ohlajanje morja v oktobru 2009
Figure 7: Cooling of the sea in October 2009

E. VODNA BILANCA

VODNA BILANCA POREČIJ

dr. Peter Frantar

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

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

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

Členi vodne bilance

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

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

Vodna bilanca po glavnih slovenskih porečjih

Pomurje je hidrogeografska regija s površino 1390 km^2 in z najmanjšo povprečno količino padavin v Sloveniji. Leta 2009 je v Pomurju padlo v povprečju 1115 mm padavin (v obdobju 1971–2000 897 mm), kar je enako 49,2 m^3/s. Padavin je bilo za četrtino več od povprečja. Bilančno izhlapevanje je bilo 975 mm oz. 43 m^3/s. Najmanj padavin je leta 2009 padlo na

E. WATER BALANCE

WATER BALANCE OF THE RIVER BASINS

Peter Frantar, PhD

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

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

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

Water balance elements

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

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

severovzhodu Pomurja v porečju Velike Krke v okolici Hodoša, kjer je bilo padavin nekaj pod 900 mm. Okrog 1000 mm padavin je bilo v širši okolici Hodoša in okolici Lendave. Na Goričkem je bilo padavin med 1050 na vzhodu do dobrih 1200 mm na zahodu gričevja. Na Prekmurskem polju je bilo padavin od 1000 mm na vzhodu do slabih 1200 mm na zahodnem delu polja. V Slovenskih goricah je bil najbolj namočen severozahodni del, kjer je bilo do 1350 mm padavin, od tod proti jugovzhodu Goric pa so padavine upadle na okrog 1100 mm. Pri vtoku površinskih voda v Slovenijo smo upoštevali Muro in dela porečij Kučnice in Ledave, ki ležita zunaj Slovenije. Pri odtoku iz države smo upoštevali Muro, Veliko Krko, Ledavo, Ščavnico in odtok s preostalega območja, ki ga ne zajamemo z našimi vodomernimi postajami. Vsi dotoki v Pomurje so leta 2009 prispevali 221 m^3/s, z območja Pomurja pa je odteklo 227 m^3/s. Količina vode, ki je leta 2009 odtekla s površine Pomurja, je bila v povprečju 6,2 m^3/s.

Podravje meri 3265 km^2, čezenj pa teče naša največja prehodna reka Drava. Podravje je imelo leta 2009 nekoliko več padavin, kot je obdobno povprečje. Leta 2009 je bilo tu v povprečju 1418 mm padavin (v obdobju 1971–2000 1244 mm), kar je 147 m^3/s. Najmanj padavin v Podravju je bilo leta 2009 na posameznih območjih Dravsko-Ptujskega polja in v osrednjem delu porečja Pesnice – okrog 1100 mm. Jugovzhodni predeli Slovenskih goric so prejeli okrog 1150 mm, severni pa do 1350 mm padavin. Količina padavin raste proti višjim predelom in proti zahodu. Haloze so prejele okrog 1200 mm padavin, najvišji predeli Haloz (Donačka gora) pa okrog 1300 mm padavin. V pogorju Boča je količina padavin dosegla 1350 mm. Osrednji deli Dravsko-Ptujskega polja so imeli med 1150 in 1200 mm padavin, predel okrog Maribora pa do 1300 mm. Na Kozjanskem je bilo do 1350 mm padavin. Na Pohorju je količina padavin rasla skladno z nadmorsko višino in na najvišjih predelih v letu 2009 dosegla 2150 mm. Vzhodni predeli Karavank, ki segajo v Podravje, dobijo zaradi zavetrne lege manj padavin in tako jih je leta 2009 na Uršlji gori padlo do 2150 mm, na Olševi pa do 2200 mm. Na Olševi je bil padavinski presežek Podravja v letu 2009. Dravska dolina ter dolini Meže in Mislinje so prejele okoli 1400 mm padavin, na pogorju Kozjaka pa je v najvišjih predelih padlo 1800 mm padavin. Količino dotoka vode iz Avstrije smo določili s pretoki na Dravi v Dravogradu, na Bistrici v Muti ter na povirju Pesnice. Skupni odtok vsega Podravja je Drava na iztoku iz Slovenije pri Ormožu. V Podravje je leta 2009 v povprečju priteklo dobrih 307 m^3/s vode, iz njega pa odteklo 385 m^3/s. Neto prispevek Podravja k odtoku Drave je bil 77,6 m^3/s. Z upoštevanjem padavin in neto odtoka dobimo, da je iz Podravja bilančno izhlapelo 69,4 m^3/s vode.

Posavje zajema dobro polovico (11.750 km^2) Slovenije. Leta 2009 je bilo na območju slovenskega Posavja v povprečju 1605 mm (v obdobju 1971–2000 1589 mm) padavin oz. za 598 m^3/s, kar je skoraj enako kot v dolgoletnem obdobju.

V porečju imamo velik razpon v količini padavin, ki je bil leta 2009 od 900 do 1000 mm v Brežiški kotlini in spodnjem Posotelju, pa vse do 4500 mm na pobočjih

Water balance by principal Slovenian river basins

Pomurje (the Mura river Basin) is a hydrogeographical region with an area of 1,390 km^2 and the lowest average precipitation level in Slovenia. In 2009, the average precipitation level of Pomurje was 1 115 mm (897 mm in the 1971–2000 period) equalling 49.2 m^3/s. The precipitation level exceeded the average value by a quarter. Balance evaporation was 975 mm or 43 m^3/s. In 2009, the precipitation level was lowest in the south-eastern part of Pomurje in the Velika Krka basin around Hodoš: slightly under 900 mm. The precipitation level in the broader surroundings of Hodoš and Lendava was about 1 000 mm. The Goričko ridge had 1 050 mm of precipitation in the east and slightly over 1 200 mm in the west. The Prekmurje field had 1 000 mm of precipitation in the east and slightly under 1 200 mm in the west. The wettest part of Slovenske gorice was the north-western part with up to 1 350 mm of precipitation; towards the south-east of Slovenske gorice the quantity dropped to about 1 100 mm. With regard to the inflow of surface waters to Slovenia, we considered the Mura river and parts of the Kučnica and Ledava river basins located outside of Slovenia. With regards to the outflow from Slovenia, we considered the Mura, Velika Krka, Ledava, Ščavnica rivers and the outflow from the remaining area not covered by our gauging stations. All inflows to Pomurje in 2009 contributed 221 m^3/s, while the outflow from the Pomurje area represented 227 m^3/s. The average quantity of water flowing from the surface of Pomurje in 2009 amounted to 6.2 m^3/s.

Podravje (the Drava river Basin) covers an area of 3 265 km^2 and is a part of the biggest transitional river in Slovenia, the Drava river. In 2009, the precipitation level of Podravje was slightly higher than the periodical average. In 2009, the average precipitation level of Podravje was 1 418 mm (1 244 mm in the 1971–2000 period) equalling 147 m^3/s. The precipitation in Podravje in 2009 was lowest in individual parts of the Drava–Ptuj field and in the central part of the Pesnica river basin: about 1 100 mm. The south-eastern parts of Slovenske gorice had about 1 150 mm of precipitation, while the level in the northern parts was up to 1 350 mm. The quantity of precipitation rose towards higher areas and towards the west. Haloze received about 1 200 mm of precipitation and its highest parts (Donačka gora) about 1 300 mm. The Boč mountain area reached 1 350 mm of precipitation. The central part of the Drava–Ptuj field received between 1 150 and 1 200 mm of precipitation, while the area around Maribor recorded around 1 300 mm. Kozjansko recorded around 1 350 mm of precipitation. In 2009, the level of precipitation grew in line with the altitude and reached 2 150 mm in the higher areas. The eastern areas of the Karavanke mountain range, which extend to Podravje, received less precipitation due to their lee side, receiving 2 150 mm on Uršlja gora and 2 200 mm on Olševa in 2009. Olševa marked the annual precipitation surplus of Podravje in 2009. The Drava valley and the Meža and Mislinja valleys received around 1 400 mm of precipitation, while the južnih in zahodnih bohinjskih gora v Julijcih. Količina padavin raste od vzhoda proti zahodu in z nadmorsko višino. Predeli Posavja na območjih vzhodno od Bele krajine na jugu, Suhe krajine, Kuma, vzhodnega dela Posavskega hribovja, Celjske in Šaleške kotline so imeli pod 1300 mm padavin. Zahodni del Posavskega hribovja in vzhod Ljubljanske kotline sta prejela do 1500 mm padavin. Od tod je količina padavin rasla na vse strani. Na jugu so jih predeli Kočevskega roga, Kočevske Male in Velike gore prejeli do 1700 mm, najvišji predeli Snežnika pa dobrih 2400 mm. Na zahodu je bilo v Škofjeloškem hribovju med 1800 in 2700 mm padavin, v Polhograjskem hribovju med 1700 mm in 2300 mm, v Idrijskem hribovju do 2400 mm padavin. Nanos in Javorniki so dobili okrog 1800 mm padavin, na Hrušici pa jih je bilo do okoli 2200 mm. V porečju Pivke je bilo padavin med 1600 in 1700 mm. Vsi Julijci so tega leta dobili več kot 3000 mm padavin, južne bohinjske gore več kot 4000 mm s presežkom okrog 4500 mm. Dobro namočeni so bili tudi grebeni Karavank, kjer je padlo od 2800 do 3200 mm padavin, nekoliko manj pa so bile tega leta namočene Kamniško-Savinjske Alpe – najvišji predeli so dobili med 2600 in 2700 mm padavin.

Pritoki v slovensko Posavje iz hrvaškega dela porečja Ljubljanice, Kolpe, Krke in Sotle so prispevali 30 m^3/s, skupen iztok iz Slovenije pa je bil 342 m^3/s. Neto odtok iz slovenskega Posavja je bil 312 m^3/s. Po bilančni enačbi izračunano izhlapevanje je bilo 286 m^3/s.

Posočje meri 2320 km^2 in je po specifičnih odtokih naše najbolj vodnato porečje. Tudi leta 2009 je tu padlo največ padavin v Sloveniji, 2597 mm oz. 191 m^3/s. Letna količina padavin je bila za desetino nad dolgoletnim povprečjem obdobja 1971–2000 z 2386 mm. Največ padavin je bilo v Julijcih. Severno od Bače jih je bilo večinoma povsod nad 2800 mm. Grebeni južnih bohinjskih gora so dobili do 4500 mm padavin, pogorje Mangarta do 3600 mm, Kaninsko pogorje do 4200 mm, Breginjske gore do 4100 mm, Krnsko pogorje do 3800 mm. Visoke dinarske planote Banjšice in Trnovski gozd so dobili med 2500 in 3200 mm padavin, Nanos do 2400 mm. Doline v zaledju planot so prejele zaradi zavetrne lege manj padavin – najmanj v okolici Cerkna – nad 1850 mm. V Vipavski dolini je bilo padavin med 1500 in 1700 mm, v Goriških brdih pa jih je bilo med 1600 in 2000 mm. Najmanj padavin v Posočju, slabih 1500 mm, je bilo v okolici Vrtojbe. Nadpovprečno visoka količina padavin ni prinesla enakega povečanja odtoka iz porečja. Skoraj vse Posočje pripada Sloveniji. Izjeme so povirja Učje, Nadiže in deloma Idrije, ki so dodala v Slovenijo 8,8 m^3/s. Iz slovenskega Posočja voda odteka predvsem po Soči, Vipavi in Nadiži, nekaj pa tudi po Idriji, Reki (v Goriških brdih) in Korenu. Skupaj je odteklo dobrih 133 m^3/s. Bilančno izhlapevanje je bilo v Posočju leta 2009 slabih 67 m^3/s, neto odtok v Posočju pa 124,4 m^3/s.

Povodje preostalih jadranskih rek zajema 1530 km^2, največji vodotok je (Notranjska) Reka. Tu je padlo leta 2009 nekoliko več padavin od dolgoletnega povprečja. Bilo jih je 1666 mm (v obdobju 1971–2000 1619 mm), kar je slabih 80,8 m^3/s. Najmanjše količine padavin so bile v Koprskem primorju na območju Sečoveljskih solin in Pirana, in sicer okoli 1100 mm. Drugod po

Kozjak mountain range received 1 800 mm of precipitation at the highest altitudes. The quantity of the water inflow from Austria was determined through discharges on the Drava river in Dravograd, on the Bistrica river in Muta and at the headwaters of the Pesnica river. The total runoff of the entire Podravje area is the Drava river at the outflow from Slovenia near Ormož. In 2009, the average inflow was slightly over 307 m^3/s, while the outflow amounted to 385 m^3/s. The net contribution of Podravje to the Drava river runoff was 77.6 m^3/s. By taking the precipitation and the net runoff into account, it is possible to calculate the balance evaporation from Podravje, which amounted to 69.4 m^3/s.

Posavje (the Sava river Basin) covers over half (11 750 km^2) of Slovenia. In 2009, the average precipitation level of Posavje was 1 605 mm (in the 1971–2000 period: 1 589 mm) equalling 598 m^3/s, which is almost the same as in the multi-annual period.

The basin has a broad span in terms of precipitation quantity, which ranged in 2009 from 1 000 mm in Brežice basin and the lower Sotla area to 4 500 mm on the slopes of the southern and western Bohinj mountains in the Julian Alps. The quantity of precipitation also increased from east to west with the rise in altitude (above sea level). Parts of Posavje east of Bela Krajina in the south, Suha Krajina, Kum, the eastern part of the Posavje hills, and the Celje and Šalek basins had under 1 300 mm of precipitation. The western part of the Posavje Hills and eastern part of the Ljubljana Basin received up to 1 500 mm of precipitation. From there, the quantity of precipitation grew everywhere. The precipitation level in some parts of Kočevski Rog, Kočevska Mala and Velika gora amounted to 1 700 mm, and to almost 2 400 mm in the highest parts of Snežnik. The precipitation level in the west in the Škofja Loka Hills was between 1 800 and 2 700 mm, in the Polhov Gradec Hills between 1 700 mm and 2 300 mm, and in the Idrija Hills up to 2 400 mm. While Nanos and Javorniki received around 1 800 mm of precipitation, Hrušica received up to 2 200 mm. Precipitation in the Pivka river basin ranked from 1 600 to 1 700 mm. All the Julian Alps received more than 3 000 mm of precipitation, while southern Bohinj mountains received more than 4 000 mm with the surplus of 4 500 mm. The ridges of Karavanke were quite wet, too, as they received from 2 800 to 3 200 mm of precipitation; slightly drier were the Kamnik and Savinja Alps with 2 600 to 2 700 mm of precipitation in the highest parts.

The inflows to Slovenian Posavje from the Croatian parts of the basins of the Ljubljanica, Kolpa, Krka and Sotla contributed 30 m^3/s, while the total outflow from Slovenia was 342 m^3/s. The net outflow from the Slovenian Posavje was 312 m^3/s. The evaporation calculated by the balance equation was 286 m^3/s.

Posočje (the Soča river Basin) covers an area of 2 320 km^2 and is the most water abundant river basin in Slovenia in terms of the specific runoffs. In 2009 as well, it had the highest precipitation level in Slovenia: 2 597 mm or 191 m^3/s. This is a tenth above the multi-annual average of the 1971–2000 period, i.e.

Koprskem gričevju je bilo padavin med 1200 in 1400 mm, od tod pa je bilo padavin več proti vzhodu in severu. Pogorje Slavnika je prejelo do 2000 mm padavin, Brkini okrog 1700 mm, Snežnik pa do 2600 mm. Okolica Ilirske Bistrice je prejela okoli 1500 mm padavin, v dolini (Notranjske) Reke in Košanski dolini jih je bilo okoli 1600 mm, na Vremščici pa do 1900 mm. Planota Krasa je prejela povsod med 1500 in 1800 mm padavin.

Tekoče vode v Slovenijo pritečejo po povirjih Rižane, (Notranjske) Reke in Dragonje. Skupaj je priteklo v Slovenijo 1 m^3/s vode. Iztokov je več: poleg večine Krasa (s podzemnim odtokom) in obale se v Italijo odtaka tudi Osapska reka, na Hrvaško pa teče voda iz povirja porečja Mirne. Skupni odtok leta 2009 je bil 27 m^3/s, neto odtok pa 26 m^3/s. Leta 2009 je po bilančni metodi izhlapelo 55 m^3/s.

Primerjava z obdobno vodno bilanco

Vse člene vodne bilance leta 2009 smo primerjali z obdobno vodno bilanco 1971–2000, in sicer za črnomorsko in jadransko povodje (Vodna bilanca Slovenije 1971–2000). **V slovenskem delu črnomorskega povodja** je bilo leta 2009 za 4 odstotke več padavin, kot jih je bilo v obdobnem povprečju. V obdobju 1971–2000 je bila povprečna količina padavin 1462 mm, leta 2009 pa jih je padlo 1526 mm. Leta 2009 je bilančno izhlapelo 766 mm vode, v obdobju 1971–2000 pa 713 mm. V obdobju 1971–2000 smo z ozemlja Slovenije v črnomorsko povodje prispevali 390 m^3/s vode oz. 749 mm, v letu 2009 je bila ta količina podobna, 396 m^3/s oz. 760 mm.

V slovenskem delu **jadranskega povodja** je v letu 2009 padlo 7 odstotkov več padavin kot v dolgoletnem obdobju. V tem letu je bila količina padavin 2227 mm, obdobno povprečje pa je 2081 mm. Izhlapevanja je bilo po letnem vodnobilančnem izračunu 996 mm, kar je 35 odstotkov več kot v obdobju 1971–2000. V letu 2009 je bil povprečni odtok v Jadran 150 m^3/s (1232 mm), dolgoletni povprečni odtok pa je dobrih 164 m^3/s (1346 mm). Odtok v letu 2009 je bil od povprečja manjši predvsem zaradi povečanega izhlapevanja.

Leta 2009 je bilo v **Sloveniji** v primerjavi z obdobjem 1971–2000 padavin več za 5 odstotkov, izhlapevanja je bilo več za 13 odstotkov, odtok pa je bil manjši za 1 odstotek. V Podonavju je bilo tega leta 4 odstotke, v jadranskem povodju pa 7 odstotkov več padavin. Glede na izmerjene odtoke se je tega leta povečalo zlasti izhlapevanje, v Podonavju za 7 odstotkov, v jadranskem povodju pa kar za 35 odstotkov v primerjavi z obdobnim povprečjem 1971–2000. Odtoki so bili v Podonavju za 2 odstotka večji kot v obdobnem povprečju, v povodju Jadrana pa so bili za 9 odstotkov manjši.

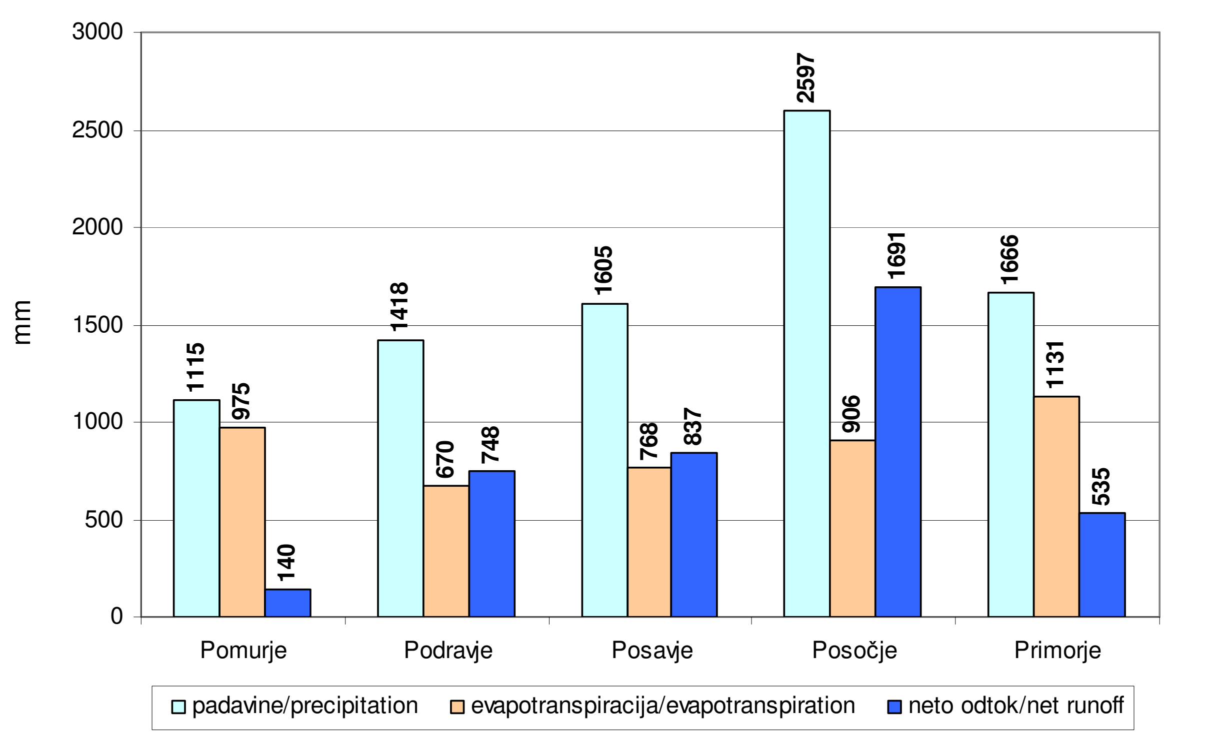
2 386 mm. The highest level of precipitation was in the Julian Alps. The precipitation level exceeded 2 800 mm in most parts north of Bača. The ridges of the South Bohinj Mountains received up to 4 500 mm of precipitation, the Mangart mountain range up to 3 600 mm, the Breginj mountains up to 4 100 mm, the Kanin mountains up to 4 200 mm and the Krn mountain range up to 3 800 mm. The high Dinaric plateaus Banjšice and Trnovski Gozd received between 2 500 mm and 3 200 mm of precipitation compared to Nanos, which received up to 2 400 mm. The valleys in the hinterland of the plateaus due to their lee side received less precipitation (the least in the area surrounding Cerkno) more than 1 850 mm. Vipava valley received between 1 500 and 1 700 mm, while Goriška Brda received between 1 600 and 2 000 mm of precipitation. The lowest amount of precipitation in Posočje, less than 1 500 mm, was recorded in the surroundings of Vrtojba. The above-average quantity of precipitation did not contribute significantly to the runoff from the river basin. Almost the entire area of Posočje is located in Slovenia. The exceptions are the headwaters of the Učja, Nadiža and partly the Idrija rivers, which contributed 8.8 m^3/s to Slovenia. For the most part, the water of the Slovenian Posočje runs off through the Soča, Vipava and Nadiža rivers, and some also through the Idrija, Reka (in Goriška Brda) and Koren rivers. The total runoff was over 133 m^3/s. In 2009, the balance evaporation in Posočje was 67 m^3/s, while the net runoff amounted to 124.4 m^3/s.

The basin of other Adriatic rivers encompasses 1 530 km^2, with the (Notranjska) Reka river as the largest watercourse. In 2009, the precipitation level was slightly higher compared to the multi-annual average. It amounted to 1 666 mm (in the 1971–2000 period: 1 619 mm) equalling slightly less than 80.8 m^3/s. The lowest precipitation level, around 1 100 mm, was recorded in the Koper littoral in the area of the Sečovlje saltpans and Piran. In other areas in the Koper Hills between 1 200 and 1 400 mm of precipitation was recorded, increasing towards the east and north. The Slavnik Mountains received up to 2 000 mm, Brkini around 1 700 mm and Snežnik up to 2 600 mm of precipitation. The area of Ilirska Bistrica received about 1 500 mm of precipitation, the (Notranjska) Reka and the Košana valleys around 1 600 mm and the Vremščica Mountain up to 1 900 mm. The Karst plateau received between 1 500 and 1 800 mm in the whole area.

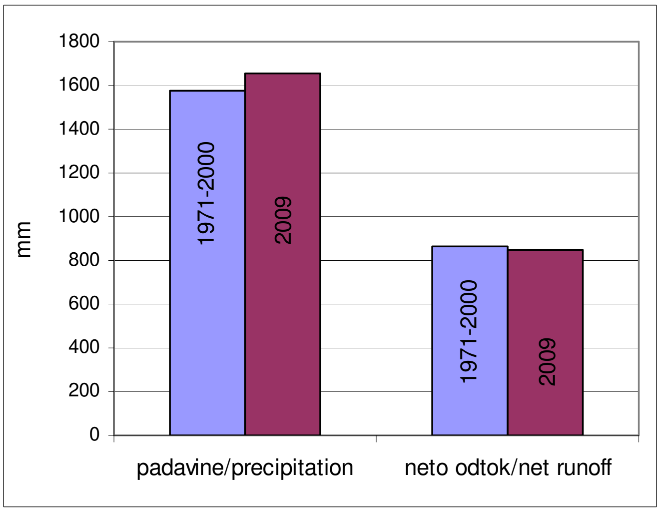
Running waters enter Slovenia through the headwaters of the Rižana, (Notranjska) Reka and Dragonja rivers. In total, 1 m^3/s of water entered Slovenia. There are several outflows: besides the waters from most of the Karst area (with underground runoff) and the coast, the Osp river flows to Italy while Croatia receives water from the source of the Mirna river basin. In 2009, the total runoff was 27 m^3/s, while the net runoff amounted to 26 m^3/s and the evaporation calculated using the balance method was 55 m^3/s.

Preglednica 1: Členi vodne bilance leta 2009 po glavnih porečjih Slovenije v mm
Table 1: Terms of water balance of 2009 by main river basins of Slovenia in mm

(mm)	Pomurje	Podravje	Posavje	Posočje	Primorje
padavine / precipitation	1115	1418	1605	2597	1666
izhlapevanje / evapotranspiration	975	670	768	906	1131
neto odtok / net runoff	140	748	837	1691	535
odtočni količnik / runoff coeficient	0.13	0.53	0.52	0.65	0.32



Slika 1: Členi vodne bilance leta 2009 po glavnih porečjih Slovenije v mm
Figure 1: Terms of water balance of 2009 by main river basins of Slovenia in mm



Slika 2: Padavine v Sloveniji in odtok z ozemlja Slovenije v primerjalnem obdobju 1971–2000 in letu 2009 v mm
Figure 2: Precipitation in Slovenia and the runoff from the Slovenian territory in the 1971–2009 reference period and in 2009 in mm

Comparison with the reference period water balance

All elements of the 2009 water balance for the Black Sea and Adriatic Sea basins were compared to the water balance of the 1971–2000 reference period (Water Balance of Slovenia, 1971–2000). **In the Slovenian part of the Black Sea basin**, the precipitation in 2009 exceeded the reference period average by 4 %. Between 1971 and 2009, the average precipitation amount was 1 462 mm, while the amount in 2009 was 1 526 mm. In 2009, the balance evaporation level was 766 mm, while in the period of 1971–2000 it amounted to 713 mm. In the period of 1971–2000, the contribution to the Black Sea catchment area from the territory of Slovenia was 390 m³/s of water or 749 mm, while the quantity was similar in 2009: 396 m³/s, or 760 mm.

In the Slovenian part of the **Adriatic Sea basin** the precipitation in 2009 exceeded the multi-annual reference period by 7 %. The quantity of precipitation amounted to 2 227 mm compared to the periodical average of 2 081 mm. According to the annual water balance calculation, evaporation amounted to 996 mm,

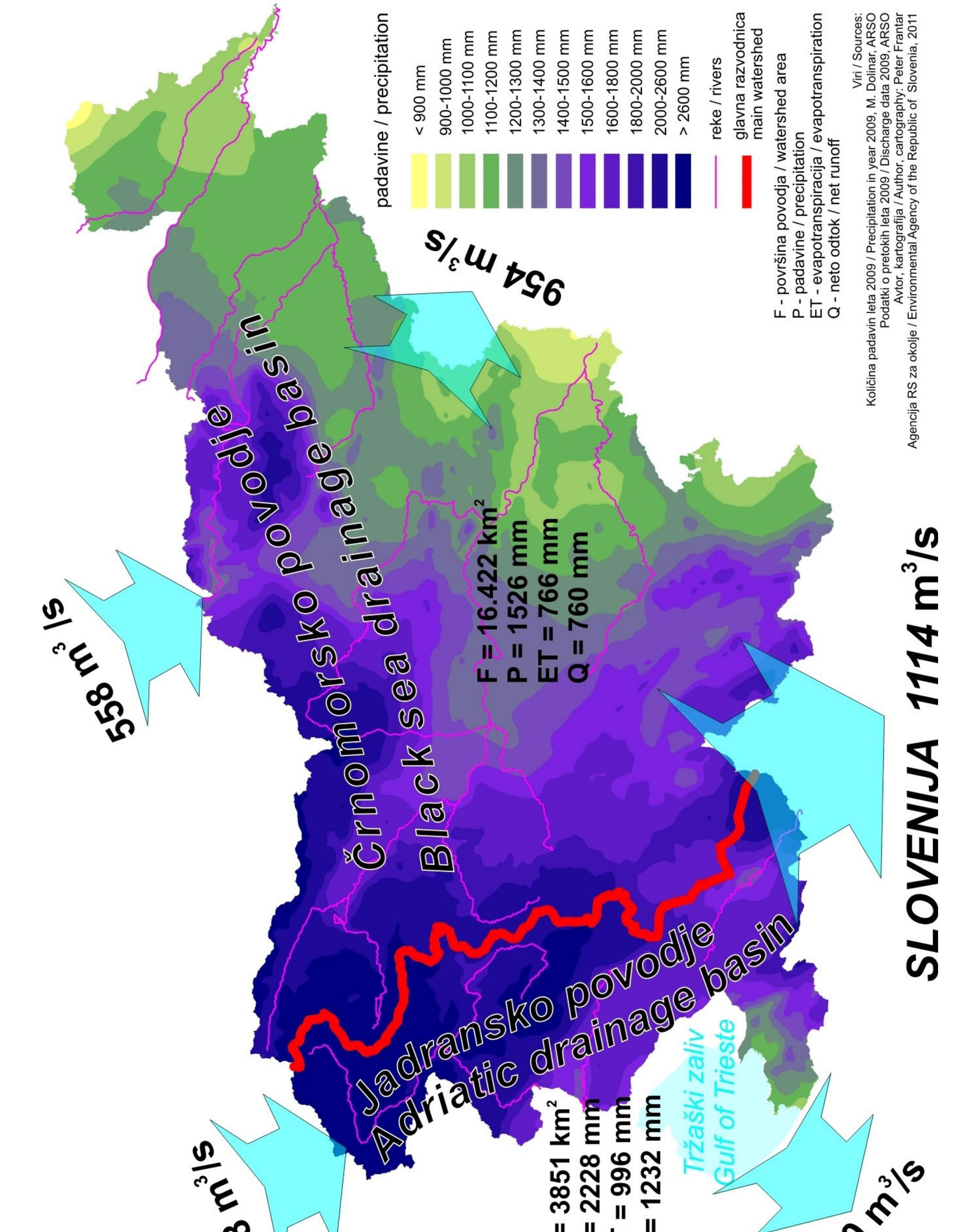
Jezero je naravni rezervoar, ki blaži pretočni režim odtoka iz pojezerja. Bohinjsko jezero 19. novembra 2009 (foto: P. Frantar)
Lake is a natural water buffer that softens the outflow discharge regime. Bohinj lake on 19th of November 2009 (photo: P. Frantar)

which is 35 % more than in the 1971–2000 period. The average runoff into the Adriatic Sea in 2009 was 150 m^3/s (1 232 mm), while the multi-annual average runoff slightly exceeds 164 m^3/s (1 346 mm). The runoff in 2009 was lower than the average mainly due to the increased evaporation.

In comparison with the 1971–2000 period, **Slovenia** received 5 % more precipitation in 2009, evaporation increased by 13 %, and the runoff was lower by 1 %. In Podonavje (the Danube river basin) and in the Adriatic Sea basin there was 4 % and 7 % more precipitation, respectively. With regard to the recorded runoffs mainly evaporation increased this year, in Podonavje by 7 % and in the Adriatic Sea basin by no less than 35 % compared to the periodical average in the 1971–2000 period. The runoffs were higher in Podonavje by 2 % and lower in the Adriatic basin by 9 %.

Preglednica 2: Primerjava členov vodne bilance 2009 z dolgoletnim obdobjem 1971–2000
Table 2: Comparison of the water balance elements in 2009 with the 1971-2000

(mm)	Podonavje *Danube river Basin*		Jadran *Adriatic*		Slovenija *Slovenia*	
	1971–2000	2009	1971–2000	2009	1971–2000	2009
padavine / precipitation	1462	1526	2081	2227	1579	1659
izhlapevanje / evapotranspiration	713	766	735	996	717	809
neto odtok / net runoff	749	760	1346	1232	862	850
odtočni količnik / runoff ratio	0,51	0,50	0,65	0,55	0,55	0,51



Slika 3: Vodnobilančni členi po povodjih v Sloveniji leta 2009
Figure 3: Water balance elements by river basins in Slovenia in 2009