4

Členi vodne bilance
Water Balance Elements

4.1 Padavine

Mojca Dolinar

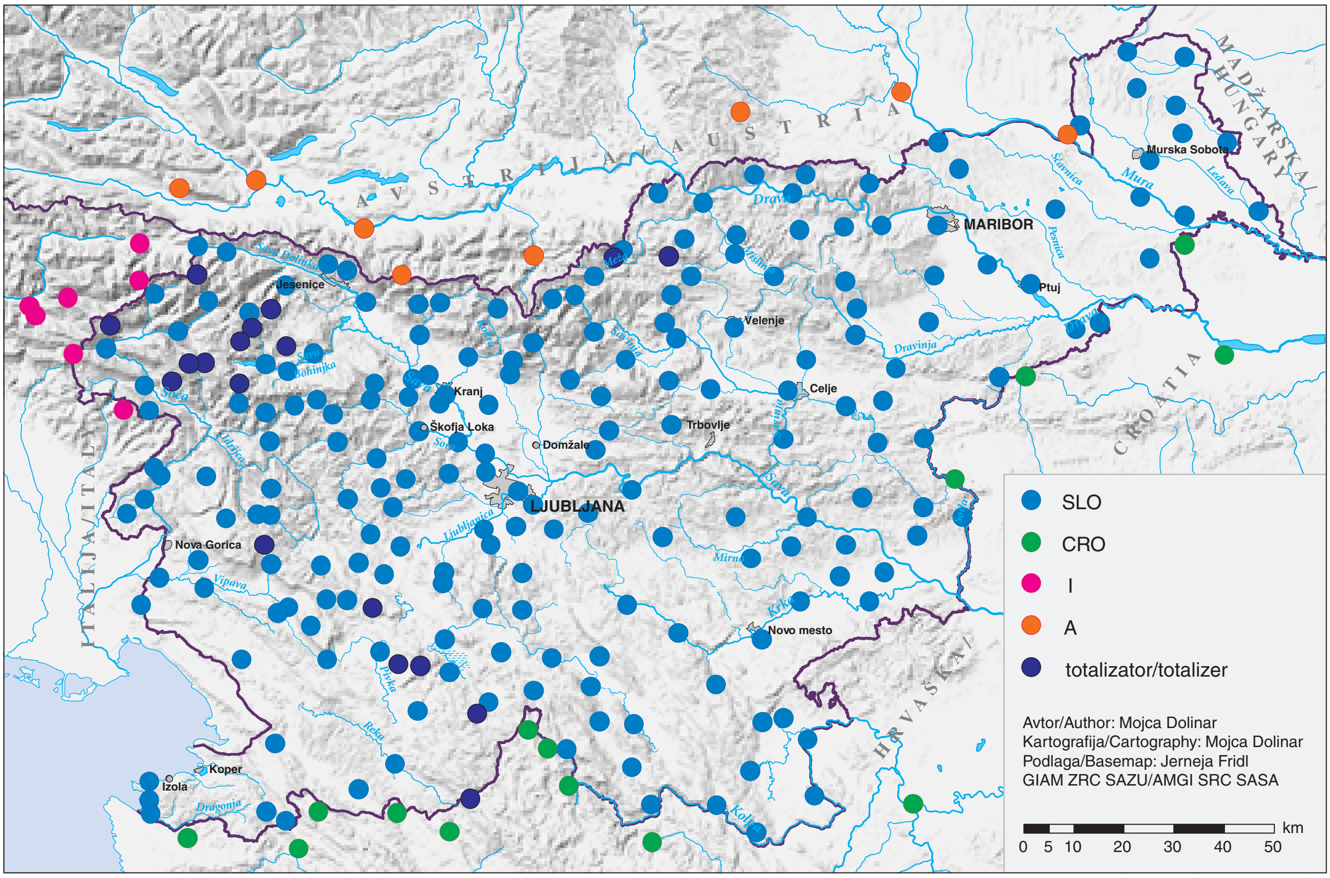
Količino padavin smo v bilančnem obdobju 1971–2000 merili na 394 postajah. Na precejšnjem številu merilnih mest so bila tudi obdobja brez meritev padavin. Posebej v zadnjem desetletju obravnavanega obdobja se je število delujočih postaj močno zmanjšalo. Ker daljša manjkajoča obdobja meritev lahko bistveno vplivajo na rezultate analize, smo pri analizi padavin za vodno bilanco uporabili le podatke merilnih mest z najmanj 25 leti delovanja znotraj obravnavanega obdobja. Zaradi boljše pokritosti površja z merilnimi mesti smo v obdelavo vključili tudi 8 meteoroloških postaj s krajšimi nizi (od 24 do 5 let). Vseh v analizo vključenih merilnih mest je bilo 201 (slika 19). Poleg postaj z meritvami dnevnih padavin smo za izračun prostorske porazdelitve padavin uporabili tudi meritve totalizatorjev, kjer količino padavin odčitamo enkrat na leto – običajno septembra ali oktobra. Te meritve so sicer obremenjene s številnimi napakami, vendar nam kljub temu dajo pomembno informacijo o količini padavin na gorskih območjih, kjer drugih meritev nimamo. Pred prostorsko analizo smo podatke totalizatorjev homogenizirali na podlagi podatkov bližnjih padavinskih postaj. Za obravnavano obdobje smo imeli na voljo podatke totalizatorjev na 18 lokacijah v Julijskih Alpah, Karavankah in Dinarskem gorstvu. Poleg podatkov s postaj na območju Slovenije smo za izračun prostorske porazdelitve padavin (mesečnih in letnih) imeli na voljo tudi podatke meritev dnevnih padavin na 29 obmejnih postajah Avstrije, Hrvaške in Italije. Posebej so bili pomembni podatki tujih postaj na območju državne meje z razgibanim reliefom, kjer je prostorska spremenljivost padavin zelo velika. Za izračun vodne bilance je namreč pomembna tudi prostorska porazdelitev padavin preko državne meje.

Za korekcijo podatkov o padavinah so pomembni tudi podatki o temperaturi zraka,

4.1 Precipitation

Mojca Dolinar

In the 1971–2000 reference period, we measured the quantities of precipitation at 394 stations. A significant number of precipitation stations had periods when precipitation measurements were not performed. The number of operational stations has diminished significantly, especially in the last decade of the reference period. Because longer periods of missing measurements can significantly affect the analysis results, we only used data from stations with at least 25 years of operation within the period treated for the analysis. To achieve a greater spatial coverage with the stations, we included 8 additional meteorological stations with shorter time series (from 24 to 5 years). Finally, there were 201 precipitation stations (Figure 19) included in the analysis. For the calculation of the spatial distribution of precipitation we also used measurements from totalizer rain gauges where the quantity of precipitation is read once a year – usually in September or October – in addition to stations with measurements of daily precipitation. These measurements are loaded with numerous errors, but nevertheless provide us with important information on the quantity of precipitation in mountainous regions where other measurements are not available. Prior to the spatial analysis, we homogenised the totalizer rain gauge data based on the data from nearby precipitation stations. We had the data from the totalizer rain gauges in 18 locations in the Julian Alps, the Karavanke Mountains and the Dinaric Alps available for the period treated. In addition to data from the stations in the territory of Slovenia, we also had at our disposal data on the daily precipitation from 29 stations located in Austria, Croatia and Italy for the calculation of the spatial distribution of precipitation (monthly and annual). The stations on complex topography in the national border areas where the



Slika 19: *Merilna mesta meritev količine padavin za vodno bilanco*

Figure 19: *Stations for the precipitation measurement used for the water balance*

vetru in intenziteti padavin. Vse navedene količine se merijo v bistveno redkejši mreži merilnih mest kot padavine. Za obravnavano obdobje smo imeli na voljo neprekinjene meritve temperature zraka in jakosti vetra na 29 lokacijah, intenziteto padavin pa smo analizirali na 11 reprezentativnih lokacijah.

V Sloveniji merimo dnevne količine padavin s Hellmanovim ombrometrom. Te meritve padavin so delno podcenjene zaradi različnih vplivov: izhlapevanja, omočenja sten ombrometra in vpliva vetra, ki padavine odnaša mimo ombrometra (WMO, 1994). Za potrebe izračuna vodne bilance smo izmerjene padavine korigirali, pri čemer smo upoštevali vpliv vetra, intenzitete padavin in omočenosti ombrometra. Popravek zaradi omočenosti se uporablja le za padavine nad 1 mm (Nespor et al., 1999). Za tekoče padavine je popravek 0,3 mm, za trdne padavine 0,15 mm. Dinamični faktor zajema vpliv vetra, odvisen pa je tudi od oblike padavin, temperature in urne intenzitete padavin. Ker se vetrne in temperaturne razmere ob posameznih padavinskih dogodkih močno razlikujejo, prav tako intenziteta padavin, smo korekcije padavin izračunali na dnevni ravni (Dolinar et al., 2006). Dinamični korekcijski faktor je močno odvisen od agregatnega stanja padavin. Ledene kristalčke z veliko površino veter bolj raznaša kot kapljice. Zato smo korekcijske faktorje za Hellmanov ombrometer računali za vsako vrsto

spatial variability of precipitation is considerable were especially important because the spatial distribution of precipitation from across the national border was also needed for the water balance calculation.

The data on air temperature, wind and precipitation intensity is also important for the correction of precipitation measurements. All the indicated quantities are measured using a significantly smaller measurement network than is the case for precipitation. For the treated period, we had uninterrupted measurements of air temperature and wind speed from 29 locations at our disposal, and we analysed the precipitation intensity at 11 representative locations.

Daily quantities of precipitation are measured in Slovenia using the Hellman rain gauge. These measurements are partially underestimated because of various effects: evaporation, the wetting of the walls of the Hellman rain gauge and the effect of the wind blowing the precipitation away from the rain gauge (WMO, 1994). For the purpose of calculating the water balance, we corrected the precipitation measured, considering the effect of the wind, the precipitation intensity and the wetting of the Hellman rain gauge. The correction for wetting is only used for precipitation in excess of 1 mm (Nespor et al., 1999). For liquid precipitation, the correction factor is 0.3 mm and 0.15 mm for solid. The dynamic factor

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Slika 20: *Mostnica*

Figure 20: *The Mostnica River*

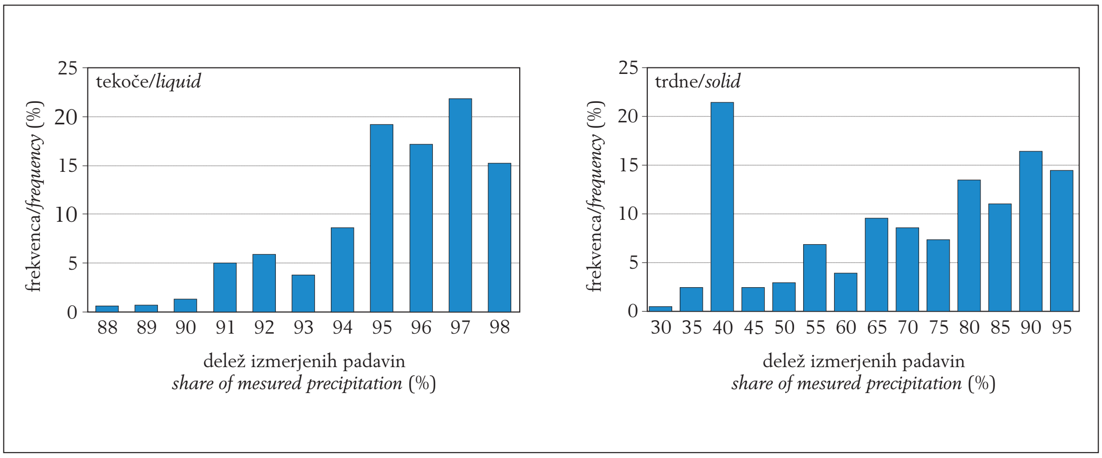
padavin posebej (Dolinar et al., 2006). Manjkajoče podatke smo na dnevni in mesečni ravni interpolirali na podlagi vrednosti na sosednjih postajah.

Povprečni korekcijski faktorji za merilne postaje (preglednica na str. 105, v prilogi) so podobni, kot so bili izračunani za obdobje 1961–1990 (Kolbezen et al., 1998). Pri nekaterih posameznih merilnih postajah se pojavljajo večje razlike, vendar sistematičnih odstopanj ni opaziti. Ustreznost modela za korekcijo količine padavin smo preverili tudi pri izračunu vodne bilance na podlagi korigiranih vrednosti padavin. V primeru napačnih korekcij bi na posameznih območjih (visokogorje, gozdovi, večje ravnine) prišlo do sistematičnih odstopanj, ki pa jih

captures the effect of the wind, but is also dependent on the form of the precipitation, the temperature and the hourly precipitation intensity. As the wind and temperature conditions during individual precipitation events differ significantly, as does the precipitation intensity, we calculated precipitation corrections on a daily basis (Dolinar et al., 2006). The dynamic correction factor is strongly dependent on the aggregate state of the precipitation. Ice crystals with a large surface area are better carried by the wind than rain drops. This is why the correction factors for the Hellman rain gauge were calculated separately for each form of precipitation (Dolinar et al., 2006). The missing data was interpolated on a daily and monthly level based on the values from neighbouring stations.

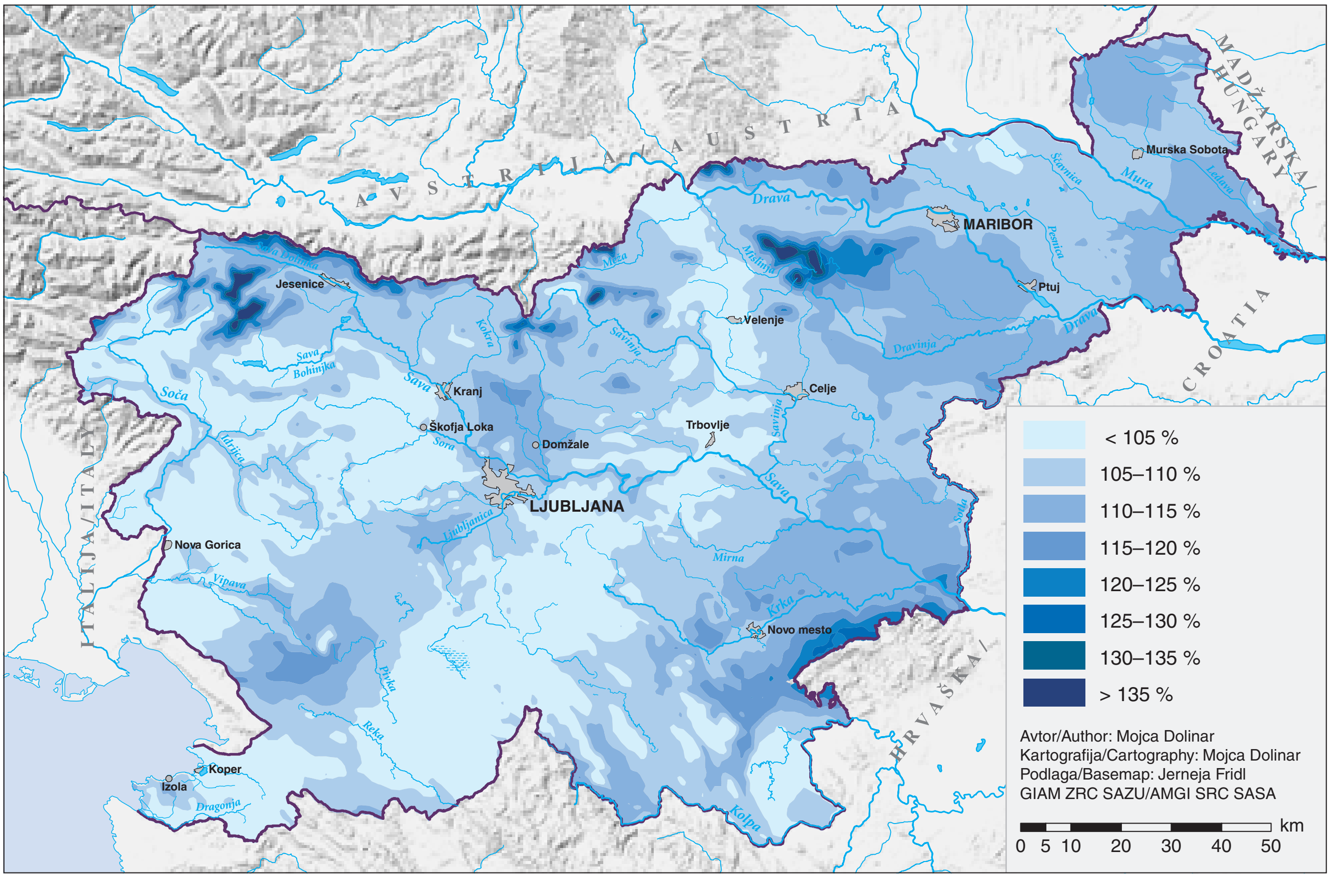
The average correction factors for the precipitation stations (table on page 105 in the appendix) are similar to those calculated for the 1961–1990 period (Kolbezen et al., 1998). Differences occurred at some of the individual precipitation stations, but no systematic deviations could be observed. The suitability of the model for the correction of precipitation quantities was also verified during the calculation of the water balance based on the corrected precipitation values. In the case of incorrect corrections, systematic deviations would occur in individual areas (high mountains, forests or larger plains), but we did not observe any. The most problematic proved to be the corrections of precipitation values for the higher-lying locations, where there is a lot of snowfall and where the winds are stronger. This is why we verified the precipitation corrections on Kredarica using measurements of the water content in the accumulated snow cover on Podi below the Triglav glacier (Dolinar et al., 2006).

The measured precipitation shares differ significantly for the liquid and solid precipitation. When precipitation occurs in the form of rain, we usually (in 99% of the measurements) measure above 90% of the real quantity of precipitation.



Slika 21: *Deleži izmerjenih padavin za tekoče in trdne padavine*

Figure 21: *The shares of measured precipitation for the liquid and solid precipitation*



Slika 22: *Prostorska porazdelitev razlik med korigiranimi in izmerjenimi padavinami (razlike so prikazane v odstotkih izmerjenih vrednosti)*

Figure 22: *The spatial distribution of differences between the corrected and measured precipitation (differences are shown in percentages of the values measured)*

v našem primeru ni bilo. Najbolj problematične so korekcije vrednosti padavin za višje lege, kjer je veliko snežnih padavin in pihajo močnejši vetrovi. Iz tega razloga smo korekcije količine padavin na Kredarici preverili z meritvami vsebnosti vode v akumulirani snežni odeji na Podih pod Triglavskim ledenikom (Dolinar et al., 2006).

Deleži izmerjenih padavin se bistveno razlikujejo za tekoče in trdne padavine. Kadar so padavine v obliki dežja, običajno (99 % meritev) izmerimo nad 90 % dejanske količine padavin. Ob sneženju pa tako količino izmerimo le v tretjini vseh meritev, pri eni tretjini pa izmerimo celo manj kot 75 % dejanske količine padavin. Povprečni korekcijski faktor se z nadmorsko višino do 1200 m bistveno ne spreminja, močno pa naraste nad to mejo, saj so v visokih legah trdne padavine, močan veter in nizke temperature pogostejši.

Razlike med korigiranimi in izmerjenimi vrednostmi padavin (slika 22) so največje (nad 35 %) v goratih območjih – na območju Julijskih in Kamniško-Savinjskih Alp, Karavank, Pohorja in Gorjancev. Najmanjše razlike (do 5 %) so v zahodni in jugozahodni Sloveniji (z izjemo visokih kraških planot) ter v pasu od jugozahoda Slovenije proti Koroški. Razlike med 5 in 15 % se pojavljajo v vzhodnih in jugovzhodnih predelih države. Razlika med vzhodnim in zahodnim delom države je predvsem posledica manj

When it snows, this percent is only measured in a third of all the measurements, while in one third we even measure less than 75% of the real precipitation quantity. The average correction factor does not change significantly with altitude up to 1200 m, but increases significantly above this limit, as solid precipitation, strong winds and low temperatures are more frequent in high-lying locations.

The differences between the corrected and measured precipitation values (Figure 22) are highest (above 35%) in the mountainous regions – in the area of the Julian and Kamniško-Savinjske Alps, the Karavanke Mountains, Pohorje and Gorjanci. The smallest differences (up to 5%) occur in western and south-western Slovenia (with the exception of the high Karst plateaus) and within the belt stretching from the south-west of Slovenia to Koroška. Differences ranging from 5 to 15% appear in the eastern and south-eastern parts of the country. The difference between the eastern and western parts of the country is the result of the less intensive precipitation in the east of the country where the correction factors are consequently slightly higher.

The spatial distribution of the precipitation was calculated separately for each month, based on the corrected precipitation values from 248 locations. The spatial distribution of annual corrected precipitation was calculated from intenzivnih padavin na vzhodu države, kjer so posledično korekcijski faktorji nekoliko višji.

Prostorsko porazdelitev padavin smo izračunali na podlagi korigiranih padavin na 248 lokacijah za vsak mesec posebej, porazdelitev povprečnih vrednosti letnih korigiranih padavin pa na podlagi zgoraj omenjenih korigiranih mesečnih padavin. Prostorsko interpolacijo padavin iz 248 točk v pravilno mrežo z ločljivostjo 100 m smo izračunali z metodo splošnega kriginga (Cressie, 1999). Pri tem smo upoštevali vpliv reliefa v ločljivosti 100 m na prostorsko porazdelitev padavin. Količina padavin je namreč v veliki meri odvisna od nadmorske višine, poleg tega pa nanjo vpliva tudi bližina gorskih pregrad v smeri proti severovzhodu, saj največ padavin v Sloveniji pade ob vlažnih jugozahodnih vetrovih. Glede na gostoto merilnih mest in njihovo reprezentativnost smo izračunane vrednosti povprečili v pravilno mrežo 1 km. Vsaka točka predstavlja povprečne mesečne ali letne padavine na območju 1 km^2. Znotraj tega območja lahko pričakujemo manjše ali večje odstopanje od izračunane vrednosti, predvsem na območjih z zelo velikim horizontalnim gradientom padavin (pred gorskimi pregradami).

4.1.1 Geografska razporeditev padavin

Geografska razporeditev padavin je močno povezana z razgibanostjo reliefa (slika str. 114–115). Zaradi orografskega učinka se količina padavin povečuje, ko gremo od morja proti notranjosti Slovenije, in doseže maksimum na dinarsko-alpski pregradi. Največ padavin (v povprečju več kot 2600 mm letno) pade na privetrni strani grebenov Julijskih Alp, na najvišjih grebenih pade celo več kot 3200 mm padavin. Nad 2600 mm padavin pade tudi na jugozahodni (privetrni) strani Snežnika. Drugod v Julijskih Alpah, Karavankah in na robnih visokih dinarskih planotah pade povprečno letno med 2000 in 2600 mm padavin. Nekoliko manjši, vendar kljub temu opazen, lokalni maksimum padavin se prav tako zaradi učinka dviganja zračnih mas pojavlja v Kamniško-Savinjskih Alpah. Za dinarsko pregrado proti severovzhodu se z oddaljenostjo od orografske pregrade količina padavin zelo hitro zmanjšuje, večja količina padavin zaradi orografskega učinka pade le še na Pohorju in na Gorjancih (do 1800 mm). V Ljubljanski kotlini količina padavin pada od severa proti jugu in se giblje med 1300 mm na jugovzhodu kotline do 1800 mm na skrajnem severu kotline. V višjih predelih Zasavskega hribovja pade do 1400 mm padavin letno, medtem ko v nižjih predelih Zasavskega hribovja, na Koroškem, Štajerskem do Maribora, na Dolenjskem in v Beli krajini pade med 1200 in 1300 mm padavin. Od

monthly spatial distributions. The spatial interpolation of the precipitation from 248 locations into a grid with a resolution of 100 m was calculated using the kriging methodology (Cressie, 1999). In the calculation, we considered the effect of the relief on the spatial distribution of precipitation with a spatial resolution of 100 m. The quantity of precipitation is to a great extent dependent on the elevation, as well as the proximity of mountain barriers to the north-east, as the majority of precipitation in Slovenia falls during moist south-westerly winds. Taking into account the number of measurement sites and their representativeness, we finally averaged the calculated values into a 1 km grid. Each point represents the average monthly or annual precipitation amounts in an area of 1 km^2. Within this area we can expect smaller or larger deviations from the calculated value, especially in areas with a high horizontal gradient of precipitation (over the mountain barriers).

4.1.1 The Geographic Distribution of Precipitation

The geographic distribution of the precipitation is strongly linked to the topography of the relief (Figure page 114–115). Because of the orographic effect, the quantity of precipitation increases as we move from the coast towards the interior of Slovenia and achieves the maximum on the Dinaric-Alpine barrier. The highest amount of precipitation (more than 2600 mm per year on average) falls on the windward side of ridges in the Julian Alps. More than 3200 mm of precipitation can fall on the highest ridges. More than 2600 mm of precipitation also falls on the south-west (windward) side of Mount Snežnik. Elsewhere in the Julian Alps, in the Karavanke Mountains and on the periphery of the high Dinaric plateaus there is between

Slika 23: *Sneg na Kobli*

Figure 23: *Snow on Kobla Mountain*

MATEJ OGRIN

Dravsko-Ptujskega polja, kjer letno dobijo med 1100 in 1200 mm padavin, se proti severovzhodu količina padavin še vedno zmanjšuje. Na skrajnem severovzhodu države (Prekmurje), kjer se že čuti močan vpliv celinskega podnebja, letna količina padavin ne preseže 900 mm. Ob obali se letna količina padavin giblje med 1100 in 1200 mm. Takšna prostorska porazdelitev padavin je posledica dejstva, da v Sloveniji največ padavin pade ob vremenskih situacijah, ko se vlažne in relativno tople zračne mase preko države pomikajo z jugozahodnim vetrom. Smer premikanja zračnih mas je pravokotna na grebene orografske pregrade, zato se ob njih zračne mase dvigajo, zrak se ohlaja in tedaj se iz njega izločajo padavine. To je vzrok, da leži maksimum letnih padavin v Julijcih, kjer pade letno nad 3200 mm padavin. To območje spada tudi med najbolj namočene v Alpah in v Evropi. Razmerje med najbolj in najmanj namočenimi območji v Sloveniji je tako skoraj 1 : 4 oz. 900 mm : 3200 mm.

4.1.2 Časovna porazdelitev padavin

V Sloveniji nimamo izrazito suhega ali mokrega dela leta, kljub temu pa med meseci oz. letnimi časi opazimo večje razlike (slika 25). Letni padavinski cikel je pogojen s podnebnim tipom, ki ima v obravnavani regiji največji vpliv. Za submediteransko podnebje (Bilje) sta značilna dva padavinska maksimuma: prvi se pojavlja konec pomladi, drugi jeseni. Za alpsko podnebje (Kre-

Slika 24: *Pa kaj, če dežuje?*

Figure 24: *It rains. So what?*

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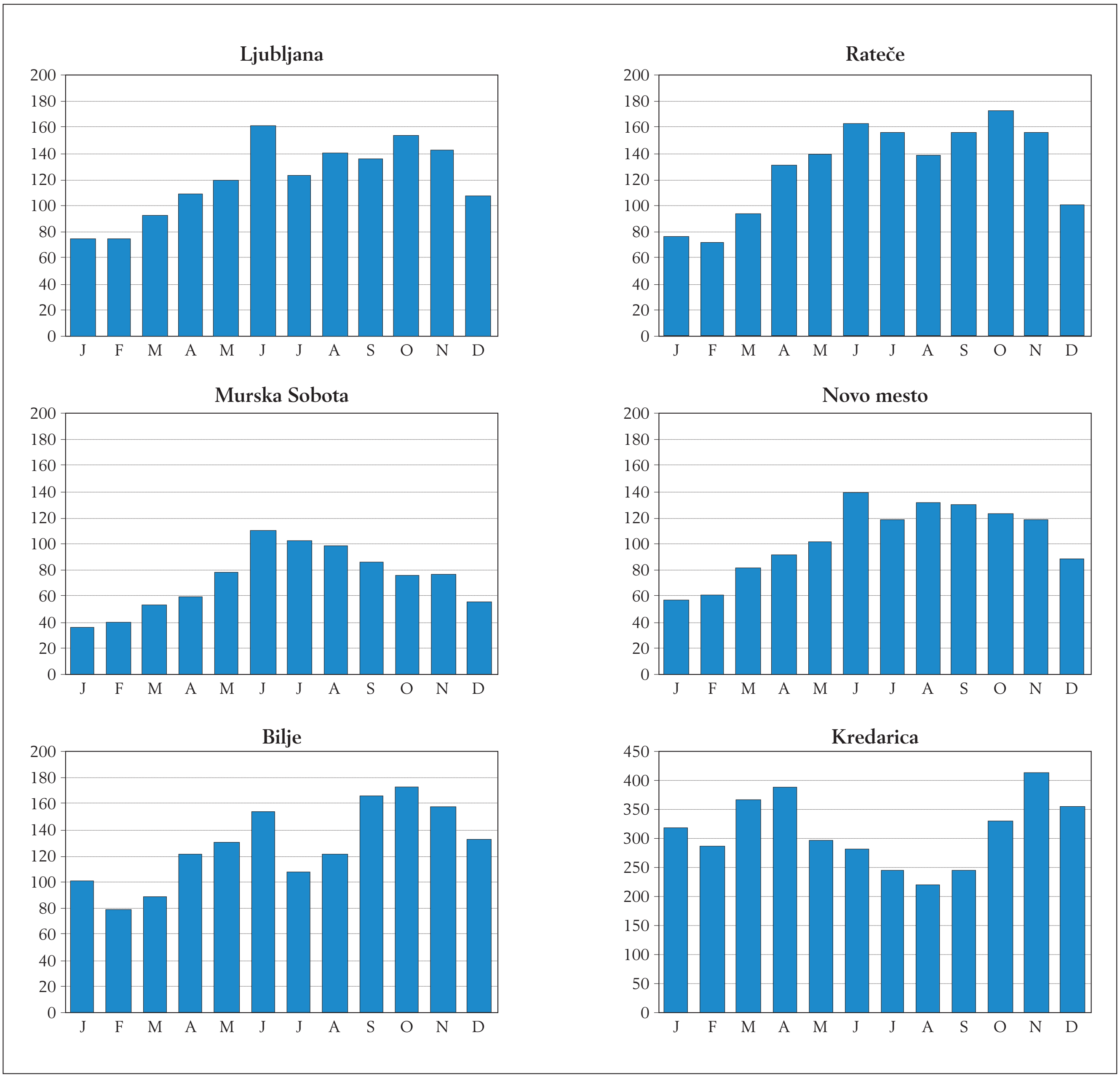
2000 and 2600 mm of precipitation annually on average. A somewhat smaller, but nevertheless noticeable local precipitation maximum is a result of the same lifting effect in the Kamniško-Savinjske Alps. Behind the Dinaric barrier and towards the north-east, the precipitation quantities diminish rapidly when moving away from the sea and the orographic barrier, while the larger quantity of precipitation on account of the orographic effect only limits on Pohorje and on Gorjanci (up to 1800 mm). In the Ljubljana Basin, the precipitation quantities diminish from north to south and ranges between 1300 mm in the south-east of the basin to 1800 mm in the northernmost part of the basin. In the higher parts of the Zasavsko hribovje hills, up to 1400 mm of precipitation fall annually, while in the lower parts of the Zasavsko hribovje hills, in Koroška and Štajerska and up to Maribor, in Dolenjska and in Bela krajina there is between 1200 and 1300 mm of precipitation. From the Dravsko-Ptujsko polje, where there is from 1100 to 1200 mm of precipitation annually, the quantity of precipitation keeps decreasing towards the north-east. In the north-easternmost part of the country (Prekmurje), where the effect of the continental climate can be felt strongly, the annual quantity of precipitation does not exceed 900 mm. On the coast, the annual quantity of precipitation fluctuates between 1100 and 1200 mm. This spatial distribution of precipitation is the result of the fact that most precipitation falls in Slovenia during weather conditions where moist and relatively warm air masses move across the country, blown by a south-westerly wind. The direction of the air mass movement is perpendicular to the ridges of the orographic barrier, which is why air masses lift along them, the air is cooled and precipitation separates from the air. This is the cause for the annual precipitation maximum lying in the Julian Alps, where in excess of 3200 mm of precipitation falls annually. This area also stands as one of the most water-abundant areas in the Alps and in Europe. The ratio between the most and least water-abundant areas in Slovenia is therefore almost 1 : 4 or 900 mm : 3200 mm.

4.1.2 The Temporal Distribution of Precipitation

We do not experience distinctive dry or wet parts of the year in Slovenia, but in spite of this we can observe considerable differences between the months or seasons (Figure 25). The annual precipitation cycle is conditioned by the climate type that exerts the greatest influence in the region treated. The sub-Mediterranean cli-



Slika 25: *Povprečna količina korigiranih padavin (mm) po mesecih za obdobje 1971–2000*

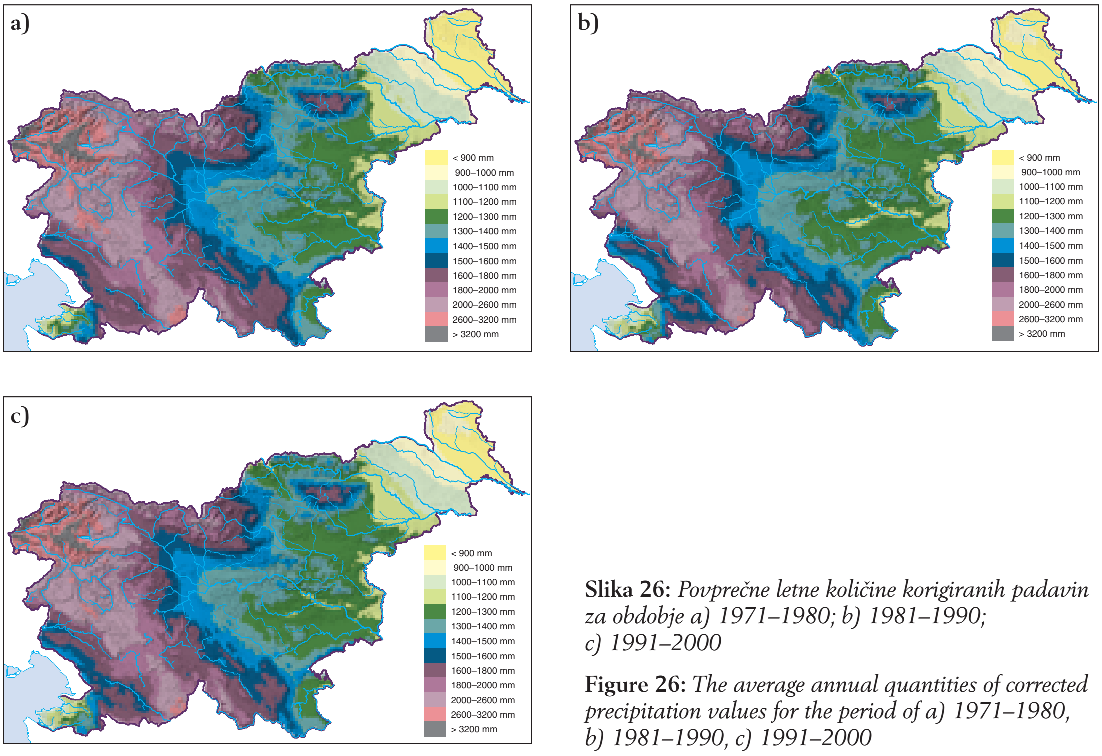
Figure 25: *The average quantity of corrected precipitation (mm) for the 1971–2000 period by month*

darica, Rateče) je značilno, da je največ padavin jeseni, nekoliko manj izrazit maksimum pa je značilen ob koncu pomladi in v začetku poletja. Na vzhodu države, kjer imamo izrazit vpliv celinskega podnebja (Murska Sobota, Novo mesto), je največ padavin ob poletnih plohah in nevihtah, najbolj suhi pa so zimski meseci.

Za vse podnebne regije v Sloveniji velja, da se količina padavin iz leta v leto lahko močno spreminja in tako tudi za obravnavano obdobje velja, da zajema tako sušna kot tudi izjemno mokra leta. Po vsej državi sta bili izrazito suhi leti 1971 in 1983 in izredno mokro leto 1979, sicer pa se kažejo večje regionalne razlike v pojavljanju suhih in mokrih let (slika 27). Posamezna desetletja znotraj obdobja se v namočenosti med seboj le malo razlikujejo (slika 26). Nekoliko odstopa le prvo desetletje (1971–1980), ko je bilo več padavin v vsej zahodni Sloveniji

mate (Bilje) is characterised by two precipitation maximums: the first occurs at the end of spring and the second in the autumn. The characteristic of the Alpine climate (Kredarica, Rateče) is that the highest amounts of precipitation occur in the autumn, while a slightly less pronounced maximum is characteristic of the end of the spring and the beginning of summer. In the east of the country, where there is a prominent effect from the continental climate (Murska Sobota, Novo mesto), the highest amounts of precipitation occur during summer downpours and storms, while the driest months are those in the winter.

In all the regions in Slovenia, the quantity of precipitation can change significantly from year to year and it is therefore also true of the period treated that it has both years of drought and extremely wet years. The years 1971

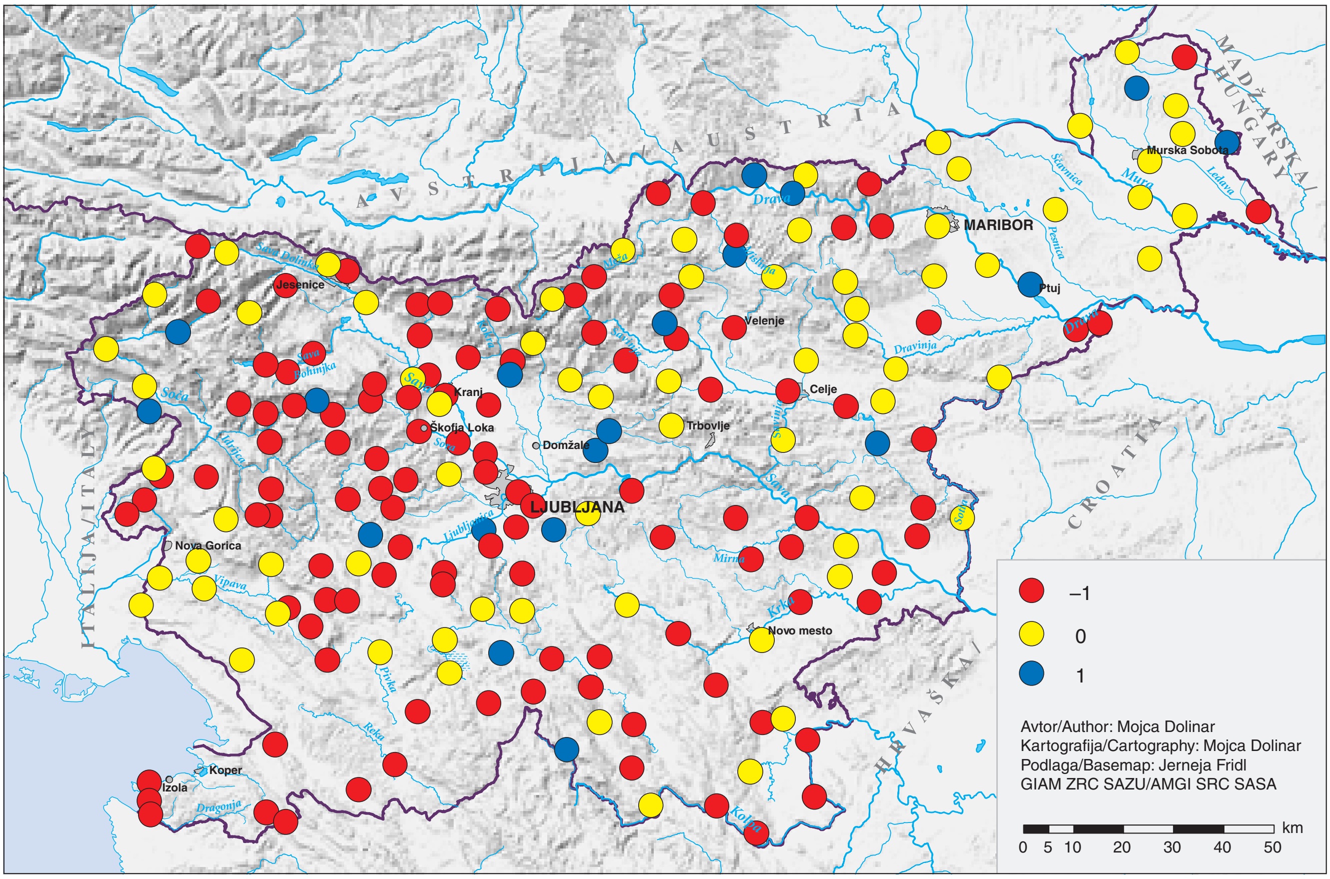


Slika 26: *Povprečne letne količine korigiranih padavin za obdobje a) 1971–1980; b) 1981–1990; c) 1991–2000*

Figure 26: *The average annual quantities of corrected precipitation values for the period of a) 1971–1980, b) 1981–1990, c) 1991–2000*

Slika 27: *Statistično značilni trendi v letni količini padavin za obdobje 1971–2000. Rdeč znak pomeni statistično značilno upadanje letne količine padavin, moder znak statistično značilno naraščanje letne količine padavin, rumen znak pa pomeni, da trend ni statistično značilen.*

Figure 27: *Statistically significant trends in the annual quantity of precipitation for the 1971–2000 period. The red symbol shows the statistically significant decrease in the annual quantity of precipitation, the blue symbol shows the statistically significant increase in the annual quantity of precipitation and the yellow symbol shows that the trend is not statistically significant.*



Avtor/Author: Mojca Dolinar
Kartografija/Cartography: Mojca Dolinar
Podlaga/Basemap: Jerneja Fridl
GIAM ZRC SAZU/AMGI SRC SASA

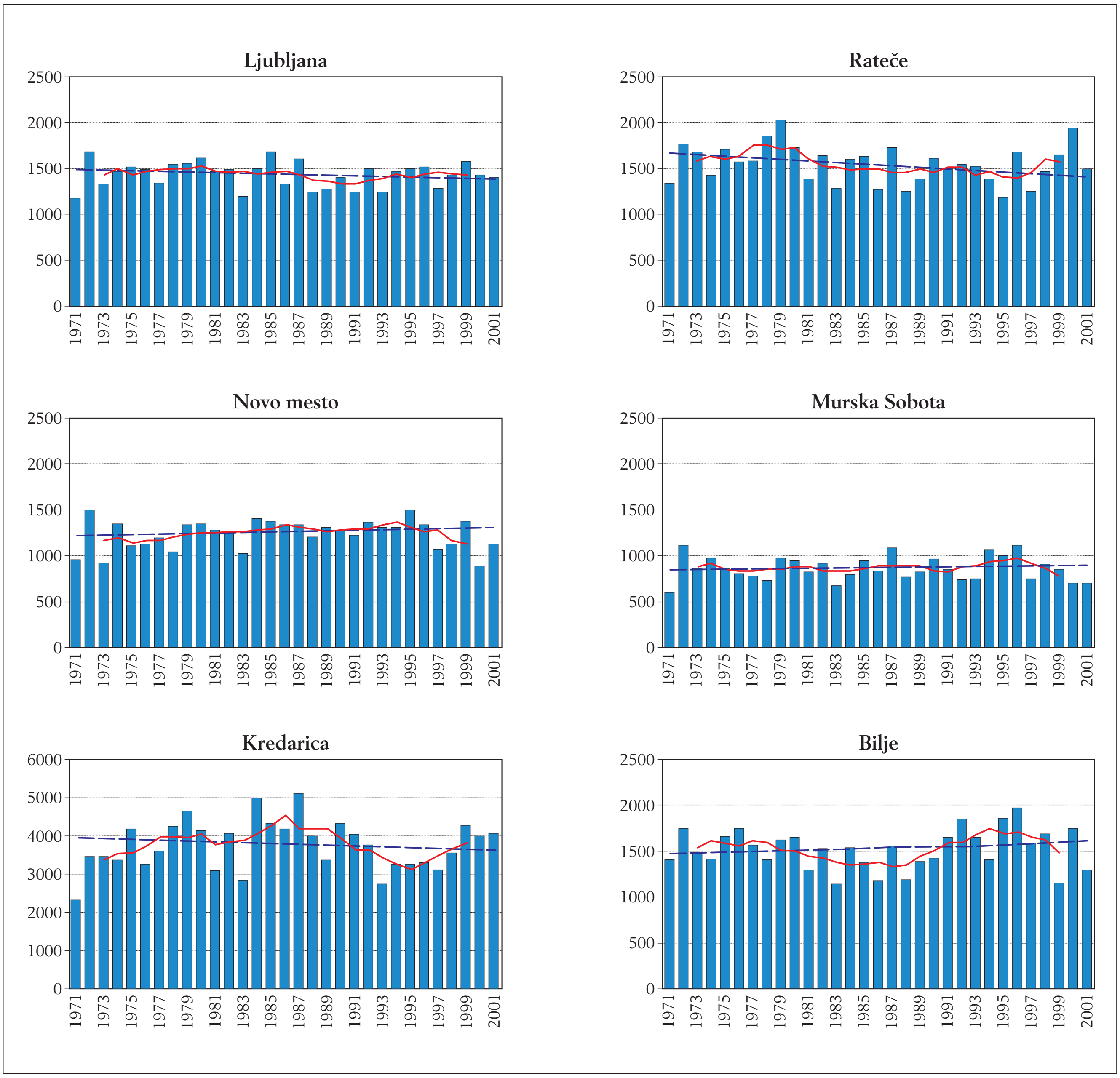
in hribovitem delu osrednje Slovenije in nekoliko bolj suho v severovzhodni Sloveniji.

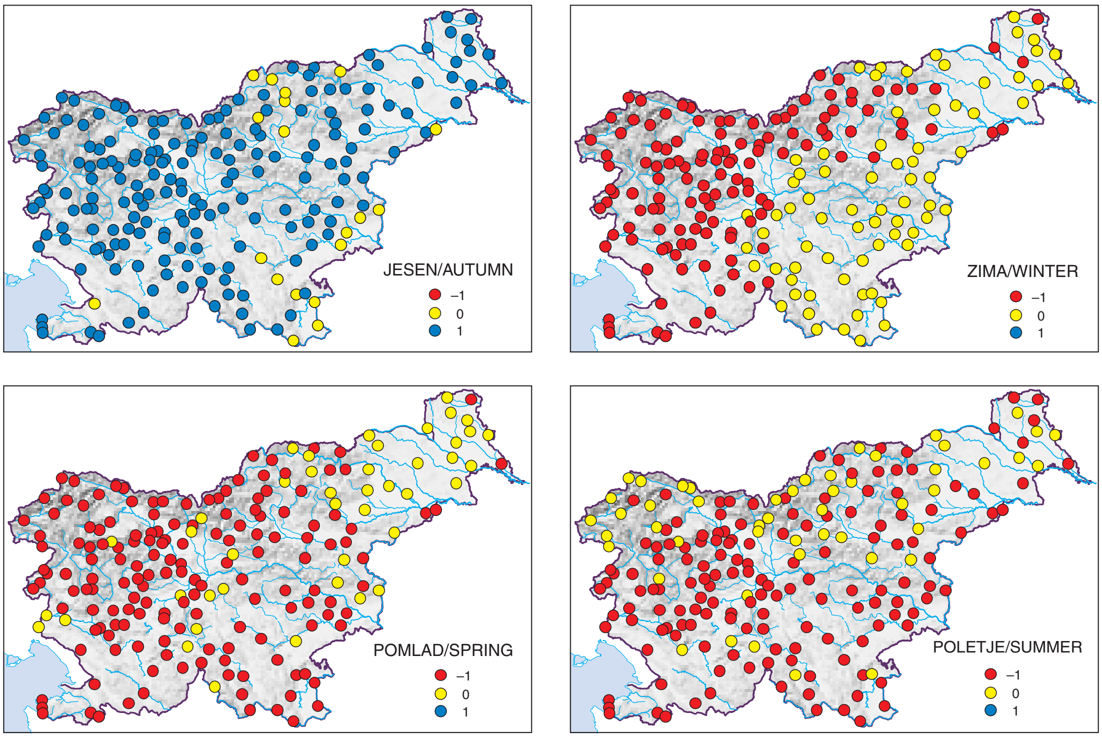
Čeprav se ob globalnih podnebnih spremembah predvidevajo tudi spremembe v količini padavin, te na letni ravni niso tako očitne (slika 28). Slika 27 prikazuje statistično značilne trende v letni količini padavin na merilnih postajah, ki so neprekinjeno delovale v obdobju 1971–2000. Na velikem številu merilnih mest sicer opazimo statistično značilen upad v letni količini padavin, vendar pa je veliko tudi takih merilnih mest, kjer sprememb v letni

and 1983 were notably dry throughout the country, while 1979 was an extremely wet year. Greater regional differences are otherwise reflected in the occurrence of dry and wet years (Figure 27). Individual decades within the reference period differ only slightly from one another in terms of water abundance (Figure 26). Only the first decade (1971–1980) departs from this slightly, when there was more precipitation across all of western Slovenia and the hilly part of central Slovenia, contrasted with somewhat less in north-eastern Slovenia.

Slika 28: *Letna vsota padavin (mm) v obdobju 1971–2000. Rdeča črta predstavlja 5-letno drseče povprečje, prekinjena črta pa trend, izračunan po podatkih za obdobje 1971–2000.*

Figure 28: *The annual sum of precipitation values (mm) in the 1971–2000 period. The red line represents the 5-year moving average and the broken line represents the trend calculated according to the data for the 1971–2000 period.*





Slika 29: *Statistično značilni trendi v količini padavin po letnih časih (obdobje 1971–2000). Rdeč znak pomeni statistično značilno upadanje letne količine padavin, moder znak statistično značilno naraščanje letne količine padavin, rumen znak pa pomeni, da trend ni statistično značilen.*

Figure 29: *Statistically significant trends in the quantity of precipitation organised by seasons (the 1971–2000 period). The red symbol shows the statistically significant decrease in the annual quantity of precipitation, the blue symbol shows the statistically significant increase in the annual quantity of precipitation and the yellow symbol shows that the trend is not statistically significant.*

količini padavin ni opaziti ali so celo pozitivne. Precej bolj enotna slika pa se pokaže, če pogledamo, kako se količina padavin spreminja znotraj posameznih sezon (slika 29). Zelo očitno je, da se jeseni količina padavin veča skoraj po vsej državi, z izjemo manjših območjih v Beli krajini, v okolici Brežic in na Koroškem, kjer ni opaziti statistično značilnih sprememb. Tudi pozimi opazimo zelo enoten prostorski vzorec spre-

Slika 30: *Strela ob nevihti*

Figure 30: *Storm lightning*


IZTOK SINJUR

Even though global climate changes are also predicting changes in the quantity of precipitation, these are not that obvious on an annual level (Figure 28). Figure 27 shows the statistically significant trends in the annual quantity of precipitation at the precipitation stations that operated without interruption in the 1971–2000 period. We can observe a statistically significant decrease in the annual quantity of precipitation at a large number of stations, though there are also many sites where changes in the annual quantity of precipitation cannot be observed or are even positive. A much more uniform picture appears if we look at how the quantity of precipitation changes within the individual seasons (Figure 29). It is quite obvious that the quantity of precipitation increases in the autumn, almost throughout the country – the exception being smaller areas in the Bela krajina region, in the area surroundings of the town of Brežice and in the Koroška region, where no statistically significant changes could be observed. Even in the winter, we can observe a very uniform spatial pattern of changes: the quantity of precipitation is diminishing across all of western Slovenia, in Koroška and on Pohorje, while there are no changes in the winter quantity of precipitation in the eastern half memb: količina padavin se zmanjšuje v vsej zahodni Sloveniji ter na Koroškem in Pohorju, medtem ko sprememb v zimski količini padavin v vzhodni polovici ni. Spomladi je opaziti dokaj enoten trend zmanjševanja padavin po vsej državi razen v vzhodni Štajerski, Prekmurju in Goričkem. Nekoliko drugačna je situacija poleti: padavin je manj povsod razen v višjih legah Alp, kjer ni opaziti sprememb. Očitno je torej, da se spreminja padavinski režim: jesenski maksimum postaja bolj izrazit, medtem ko se v ostalih mesecih količina padavin zmanjšuje.

4.2 Izhlapevanje

Peter Frantar, Blaž Kurnik, Vesna Ožura

Izhlapevanje oz. evapotranspiracija (ETP) je prehajanje vode v obliki vodne pare z vodne površine ali zemeljskega površja in skozi listne reže rastlin v ozračje (Allen, 1998). Evapotranspitacija je proces, ki povezuje evaporacijo z neporaslega zemeljskega površja in vodnih površin ter transpiracijo z rastlin. Izračunano je bilo dejansko, realno izhlapevanje za obdobje 1971–2000, ki je podano v povprečni višini vodnega stolpca v mm.

Evaporacija je odvisna od deleža dostopnosti vode v zgornjem delu tal in od poraščenosti tal. Poraščenost tal se med letom spreminja, zato se spreminja tudi evapotranspiracija. Dejanska evapotranspiracija je odvisna od vrste rastlin, fenološke faze rastlin, rastlinam dostopne talne vlage in meteoroloških pogojev, izmed katerih na izhlapevanje najbolj vpliva temperatura zraka, relativna vlaga zraka, hitrost vetra in sončno sevanje.

Izračun dejanskega izhlapevanja je izveden po modificirani Hargreasovi metodi za 37 klimatoloških postaj na osnovi minimalne in maksimalne temperature zraka in natančne geografske lege postaje. Za Slovenijo je Hargreasova metoda utežena z linearnimi regresijskimi koeficienti glede na dnevne vrednosti potencialnega izhlapevanja po Penman-Monteithovi metodi (Allen, 1998). Ta izračun velja za topli del leta in dobro namočena tla, poraščena s travo. Zaradi razlike v evapotranspiraciji pri različnih tipih pokrovnosti tal (gozd, kmetijske površine, …) so dobljene vrednosti potencialnega

Preglednica 4: *Vrednost povprečnih koeficientov izhlapevanja pri posamezni skupini rastlin glede na referenčno potencialno izhlapevanje*

Table 4: *The value of the average coefficients of evaporation for individual types of vegetation with respect to the reference potential evaporation*

Rastlina ***Plant***	**Koeficient** ***Coefficient***
mešan gozd / *Mixed forest*	1.10
kmetijske rastline / *Farmland*	0.82
vodne površine / *Water surfaces*	0.60
urbano območje / *Urban areas*	1.00

of the country. A fairly uniform trend of decreasing precipitation across the country can be observed in the spring, except in eastern Štajerska, Prekmurje and in Goričko. The situation is somewhat different in the summer: there is less precipitation everywhere except for in the higher reaches of the Alps, where no changes can be observed. It is therefore obvious that the precipitation regime is changing: the autumn maximum is becoming more pronounced while the quantity of precipitation in the other months is decreasing.

4.2 Evaporation

Peter Frantar, Blaž Kurnik, Vesna Ožura

Evaporation or evapotranspiration (ETP) is the transfer of water in the form of water vapour from the water surface, the ground and through plant stomata into the atmosphere (Allen, 1998). Evapotranspiration is a process that combines evaporation from un-vegetated ground and water surfaces with the transpiration from plants. We have calculated the actual, real evaporation for the 1971–2000 period, which is given in the average height of the water column in mm.

Evaporation depends on the water availability in the upper layer of the ground and on the surface vegetation. The vegetation changes through the year, which is why evapotranspiration changes as well. The real evapotranspiration depends on the variety of plant, the phenological phase of the plant, the ground moisture available to the plants and the meteorological conditions, among which the air temperature affects evaporation the most, followed by relative air humidity, wind speed and solar radiation.

The calculation of the real evaporation was performed for 37 climatological stations using the modified Hargreas method based on the minimum and maximum air temperature and the precise geographical position of the station. The Hargreas method is balanced for Slovenia with linear regression coefficients concerning their daily value of potential evaporation according to the Penman-Monteith method (Allen, 1998). This calculation applies to the warm part of the year and to well-wetted ground covered with grass. Because of the difference in evapotranspiration from different types of land cover (forest, farmland, etc.), the values obtained for potential evaporation are then corrected in order to obtain the real evaporation for the entire year. The correction is performed using standard correction coefficients for individual layers of land cover with respect to the potential evaporation (Table 4).

izhlapevanja korigirane, da smo dobili dejansko izhlapevanje tekom celega leta. Korekcija je opravljena s standardnimi korekcijskimi koeficienti za posamezen sloj pokrovnosti glede na potencialno izhlapevanje (preglednica 4).

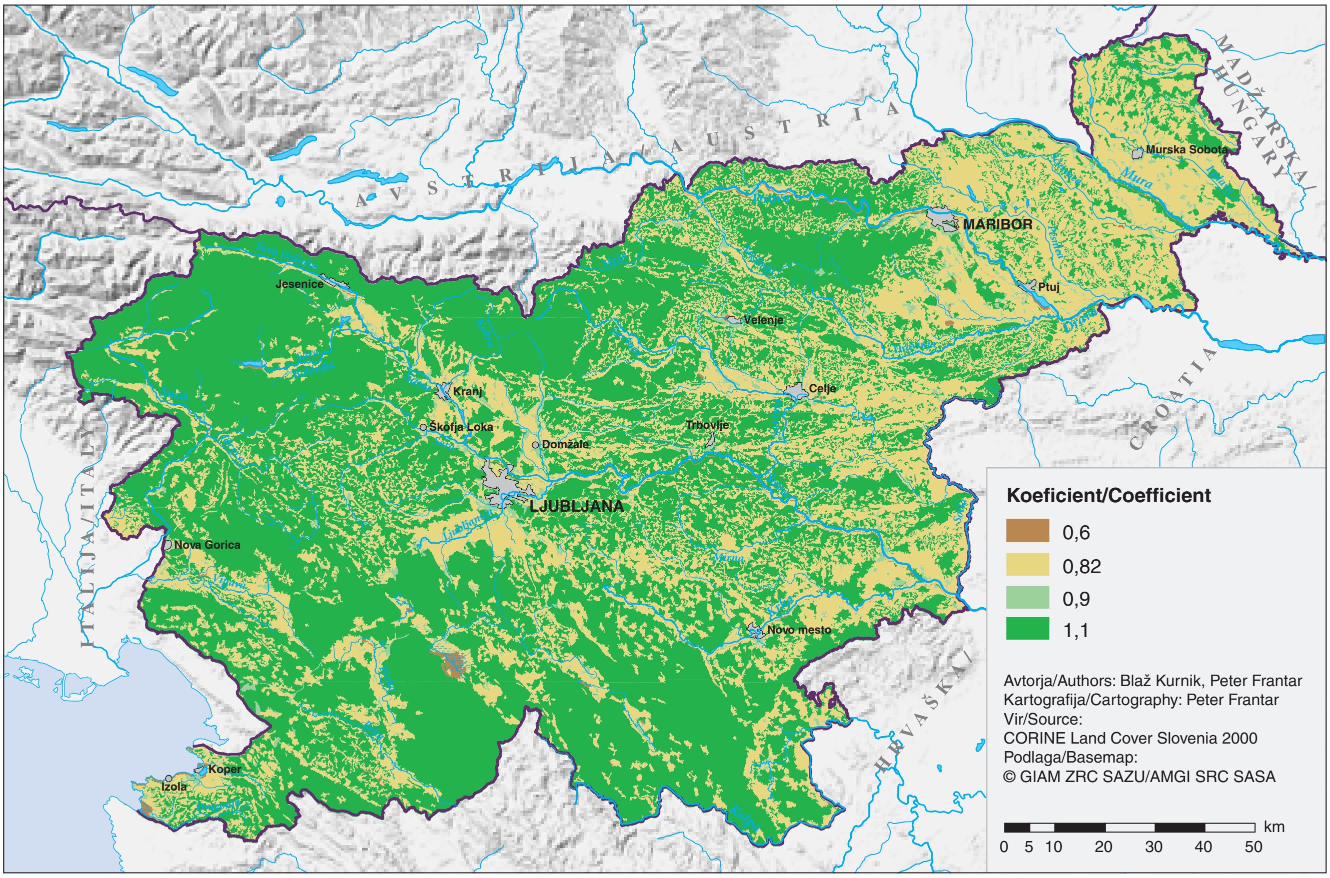
Izračunane povprečne letne vrednosti dejanskega izhlapevanja za posamezno meteorološko

The calculated average annual values of the real evaporation for individual meteorological stations vary from 355 mm at the station on Kredarica to 845 mm at the Bilje pri Novi Gorici station. Evaporation is strongly affected by elevation, so it also depends on the geographical position of the station. Using interpo-

Preglednica 5: *Vrednost dejanskega izhlapevanja na posamezni meteorološki postaji*

Table 5: *The value of the real evaporation at individual meteorological stations*

Postaja ***Station***	**Koordinata X** ***X coordinate***	**Koordinata Y** ***Y coordinate***	**Nadmorska višina** ***Elevation*** (m)	**ETp** (mm)
Bilje	393.617	84.389	55	845
Bizeljsko	554.176	96.995	179	789
Brnik	459.693	119.393	364	765
Celje	519.469	122.286	244	793
Črnomelj	511.774	46.206	157	795
Gor. Radgona	575.863	170.429	232	765
Godnje	410.437	68.508	320	784
Ilirska Bistrica	441.012	47.584	424	798
Jeruzalem	591.622	148.693	345	703
Kočevje	488.634	55.651	467	755
Kredarica	411.847	137.865	2.514	355
Krvavec	463.136	128.546	1.558	488
Lendava	613.251	158.045	190	773
Ljubljana	462.645	102.486	299	757
Maribor	549.167	155.240	275	741
Murska Sobota	591.549	168.258	188	772
Nanos	424.221	75.241	915	655
Nova Gorica	395.903	91.028	113	799
Nova vas na Blokah	462.091	69.955	722	716
Novo mesto	514.163	73.066	220	765
Planina pod Golico	427.624	147.445	970	657
Podgradje	594.145	151.109	272	699
Polički vrh	581.619	135.860	280	726
Postojna	437.588	69.412	533	722
Radenci	580.649	166.971	203	765
Rateče	401.574	151.142	864	705
Sevno	494.556	93.086	545	648
Sl. Konjice	532.860	133.333	330	749
Slap	417.519	77.765	130	797
Stara Fužina	415.080	127.569	547	742
Starše	559.215	147.302	240	766
Šmartno pri S. Gradcu	508.908	149.509	455	735
Velenje	509.574	135.506	410	740
Veliki Dolenci	598.579	188.854	308	716
Vojsko	415.450	98.448	1.067	578
Zavrč	553.603	166.608	280	755



Avtorja/Authors: Blaž Kurnik, Peter Frantar
Kartografija/Cartography: Peter Frantar
Vir/Source:
CORINE Land Cover Slovenia 2000
Podlaga/Basemap:
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Slika 31: *Koeficienti rastlin, uporabljeni pri izračunu potencialne evapotranspiracije v 100 m resoluciji*

Figure 31: *The plant coefficients applied in the calculation of potential evapotranspiration in a resolution of 100 m*

postajo se gibljejo med 355 mm na postaji Kredarica do 845 mm na merilni postaji Bilje pri Novi Gorici. Izhlapevanje je močno pogojeno z nadmorsko višino, zato je odvisno od geografske lege postaje. Z interpolacijo smo izdelali karto prostorske porazdelitve povprečnega izhlapevanja z upoštevanjem pokrovnosti tal in rastlin.

4.2.1 Geografska razporeditev izhlapevanja

Naravnogeografska pestrost Slovenije se odraža tudi pri izhlapevanju. Vrednosti povprečnega letnega izhlapevanja po hidrometričnih zaledjih nihajo med 458 in 879 mm. Povprečno letno izhlapevanje v obravnavanih zaledjih je bilo 755 mm. Razmerje med najmanjšo in največjo povprečno količino izhlapevanja je le 1 : 2. Spremembe izhlapevanja v prostoru so relativno najmanjše od vseh elementov vodnega kroga.

Najvišje vrednosti dejanskega izhlapevanja so na območju jugozahodne in jugovzhodne Slovenije. Visoke vrednosti so posledica predvsem visoke povprečne temperature zraka v vegetacijskem obdobju in precejšnje gozdnatosti, ki pomeni visok koeficient rastlin na tem območju.

Največje izhlapevanje, nad 850 mm, imamo iz posameznih območij v Pomurju, Krško-Brežiškega polja in Bele krajine ter na zahodu v južnejših in nižinskih legah Primorske in dolini Soče vse do Tolmina. Površina tega pasu je 440 km^2.

lation, we produced a map of the spatial distribution of the average evaporation, taking into account the land cover and vegetation.

4.2.1 The Geographical Distribution of Evaporation

The natural and geographic diversity of Slovenia is also reflected in its evaporation. The value of the average annual evaporation in different hydrometric catchment areas fluctuates between 458 and 879 mm. The average annual evaporation in the catchment areas treated was 755 mm. The ratio between the minimum and maximum average quantities of evaporation is only 1 : 2. The spatial changes of evaporation are, relatively, the smallest of all the elements in the water cycle.

The highest values for real evaporation are reached in the areas of south-western and south-eastern Slovenia. High values are primarily a consequence of the high average air temperature in the vegetation period and of

Preglednica 6: *Razredi izhlapevanja na območju Slovenije*

Table 6: *Evaporation grades in the territory of Slovenia*

ETP (mm)	**Površina** *Surface area* **(km^2) (%)**
< 500	195 (1 %)
500–650	4.961 (24 %)
650–800	10.038 (51 %)
> 800	4.986 (24 %)

MILAN ROBIČ

Slika 32: *V dolini Save*

Figure 32: *In the Sava Valley*

Na okrog 4700 km^2 Slovenije izhlapi med 800 in 850 mm vode letno. Lege s tolikšnim izhlapevanjem so zelo razdrobljene, zavzemajo pa prisojne lege v jugozahodni Sloveniji, pojavljajo se tudi na prisojnih pobočjih dolin in kotlin v pasu nekje 50 do 100 m nad dnom. Večja sklenjena območja so v Suhi krajini, Beli krajini in v zgornjem delu porečja Kolpe. Na vzhodu so v Halozah in gozdnih predelih Slovenskih goric in na Goričkem.

Na 4240 km^2, na petini Slovenije, izhlapi med 750 in 800 mm. Pretežno se območja s takim povprečnim izhlapevanjem nahajajo v južni polovici države, kjer je pas razdrobljen med Posočjem in Gorjanci. Na severovzhodu imajo takšno izhlapevanje predeli Kozjaka in nižji predeli Pohorja.

700 do 750 mm vode izhlapi v letnem povprečju na 1885 km^2 Slovenije. V severnem delu Slovenije so to območja med 150 in 300 m nad dolinami in kotlinami od severnega Posočja do Pohorja. Na jugu so taki višji predeli visokih dinarskih planot, okolica Snežnika in Koprsko primorje.

V pasu izhlapevanja med 650 in 700 mm so najvišji deli Snežnika in Trnovskega gozda na jugu, posamezna območja na Primorskem, alpske planote ter najvišji predeli Pohorja. Pas obsega 1370 km^2.

Kar 5765 km^2 pa obsega pas med 600 in 650 mm izhlapevanja letno – dobro četrtino Slovenije. To so višji gorski predeli, posamezni predeli Primorske, Barje in kotline v osrednji Sloveniji. Večje površine zavzema na vzhodu – od Dolenjske do Prekmurja.

Med 550 in 600 mm izhlapevanja ima zgolj 1600 km^2 Slovenije. Pas tolikšnega izhlapevanja je raztresen po vsem alpskem in predalpskem svetu.

Najmanjše izhlapevanje v Sloveniji je v povprečju pod 550 mm vode na leto. Območja s tako majhnim izhlapevanjem zavzemajo vsega 1 %

significant land cover with forests that results in a high plant coefficient in this area.

The greatest evaporation, in excess of 850 mm, occurs in individual areas in Pomurje, the Krško-Brežice Basin, the Bela krajina region and, in the west, in the southern and low-lying locations of Primorska and the valley of the Soča River up to Tolmin. This evaporation level is characteristic of an area of 440 km^2.

Between 800 and 850 mm of annual evaporation occurs in around 4700 km^2 of Slovenia. The locations with this level of evaporation are highly dispersed and fragmented, mostly covering sunny slope aspect areas in south-western Slovenia, but are also appearing in the sunny slopes of valleys and basins 50 to 100 m above the base. Larger, contiguous areas are in Suha krajina, Bela krajina and in the upper part of the Kolpa River basin. In the east, these areas are located in Haloze and in the forested parts of Slovenske gorice and in Goričko.

Between 750 and 800 mm evaporate from a surface area of 4240 km^2, which is a fifth of the territory of Slovenia. The areas exhibiting this average evaporation levels are located predominantly in the southern half of the country, where they are fragmented and lie between Posočje and Gorjanci. In the north-east, parts of Kozjak and the lower parts of Pohorje also exhibit these evaporation levels.

On average, 700 to 750 mm of water evaporate annually from 1885 km^2 of Slovenia. In the northern part of Slovenia, these are areas lie between 150 and 300 m and are located above valleys and basins stretching from northern Posočje to Pohorje. In the south, these areas are higher lying parts of the high Dinaric plateaus, the surroundings of Snežnik and the Koper littoral area.

The belt with evaporation of between 650 and 700 mm covers the highest parts of Snežnik and Trnovski gozd in the south, individual regions in Primorska, Alpine plateaus and the highest parts of Pohorje. The area encompasses 1370 km^2.

The range of annual evaporation of between 600 and 650 mm covers 5765 km^2 – well over a quarter of Slovenia. These are the higher mountain regions, individual parts of Primorska, Barje and the basins in central Slovenia. Larger areasare found in the east – from Dolenjska to Prekmurje.

Only 1600 km^2 of Slovenia exhibit evaporation between 550 and 600 mm. These values are scattered across the entire Alpine and pre-Alpine area.

The lowest evaporation level in Slovenia is below 550 mm of water per year. Areas with such a small evaporation cover a mere 1% of the country – 200 km^2. The largest part lies in the države – 200 km^2. Največji del tega pasu pripada najvišjim predelom Julijskih Alp, posamezna območja pa so še na najvišjih predelih ostalih slovenskih gora in hribovij ter ozek pas v dnu večjih rečnih dolin.

4.3 Pretoki

Odtok je pojem, ki opisuje oz. predstavlja premikanje določenega dela padavinske vode do kanaliziranega vodotoka oz. pretok vode v njem (Davie, 2004; Van Abs. et al. 2000). Višek padavin, ki ne izhlapi oz. se ga ne porabi za transpiracijo, odteče, je odtok. V primerih, ko je ta presežek dovolj velik, se odtok zbere v vodotokih, ki predstavljajo večino odtoka z določenega vodozbirnega zaledja. Na mestih, kjer se torej večina odtoka zbere, lahko odtok merimo kot pretok.

Izmerjeni pretoki so praviloma najzanesljiveje izmerjeni element vodnega kroga. Na primerno postavljenih vodomernih postajah namreč voda določenega vodozbirnega območja odteče skozi profil vodomerne postaje. Pretoki so osnovni podatki za večino hidroloških analiz.

Značilnosti pretoka na določeni točki so odraz celotnega vodozbirnega zaledja (WMO, 1994). Zaradi tega je ključnega pomena poznavanje fizičnogeografskega prostora, zlasti merilnih profilov in razvodnic med posameznimi merilnimi mesti, saj le tako lahko dobimo medsebojno primerljive podatke in analiziramo manjše enote porečij.

Vsi podatki o pretokih so vezani na prostor, na hidrometrična zaledja, ki so osnovna prostorska enota pri izdelavi vodne bilance. Vodnobilančne člene lahko primerjamo na območju enega ali več hidrometričnih zaledij.

Težave pri analizi hidroloških podatkov povzročajo podatkovne vrzeli. Pri pregledu podatkov o pretokih za obdobje 1971–2000 ima popolne podatkovne nize 65 vodomernih postaj. Podatkovne vrzeli preostalih vodomernih postaj smo dopolnili z uporabo statistične metode – s pomočjo Pearsonovega koeficienta linearne korelacije na podlagi srednjih mesečnih povprečij obdobja 1961–2001.

4.3.1 Pretočni režimi

Peter Frantar, Mauro Hrvatin

Pretočni režim je pokazatelj povprečnega kolebanja pretoka reke preko leta. Dejavniki, ki oblikujejo pretočni režim so številni in raznovrstni, med pomembnejšimi so: podnebje, relief, kamninska podlaga, prst, rastlinstvo in človek. V Sloveniji je najpomembnejši dejavnik podnebje, saj

highest parts of the Julian Alps, though certain areas also lie in the highest parts of the rest of the Slovenian mountains and hills as well as a narrow belt at the bottom of larger river valleys.

4.3 Discharges

Runoff is the term that describes or represents the movement of a certain part of precipitated water into channelled streams or the discharge of water within it (Davie, 2004; Van Abs. et al. 2000). The surplus precipitation that does not evaporate or is not used for transpiration, which instead flows away, is the runoff. When this surplus is large enough, the runoff is collected into streams, which represent the majority of the runoff from a certain catchment area. In places where the majority of the runoff is collected the runoff can be measured as the discharge.

In general, measured discharges are the most reliably measured elements of the water cycle. In suitably located water gauging stations, water from a certain catchment area runs through the cross-section of the water gauging station. Discharges are the basic data for the majority of the hydrological analyses.

The characteristics of a discharge at a certain point are a reflection of the entire catchment area (WMO, 1994). Because of this, knowledge of the physical-geographical space, especially of the gauging profiles and divides is of key importance, as it is only in this way that we can obtain comparable data and analyse smaller river basin units.

Discharge data are linked to the space, to the hydrometric catchment areas, which are the basic spatial unit in the production of the water balance where the water balance elements can be compared.

Data gaps cause difficulties in the analysis of hydrological data. When reviewing the data

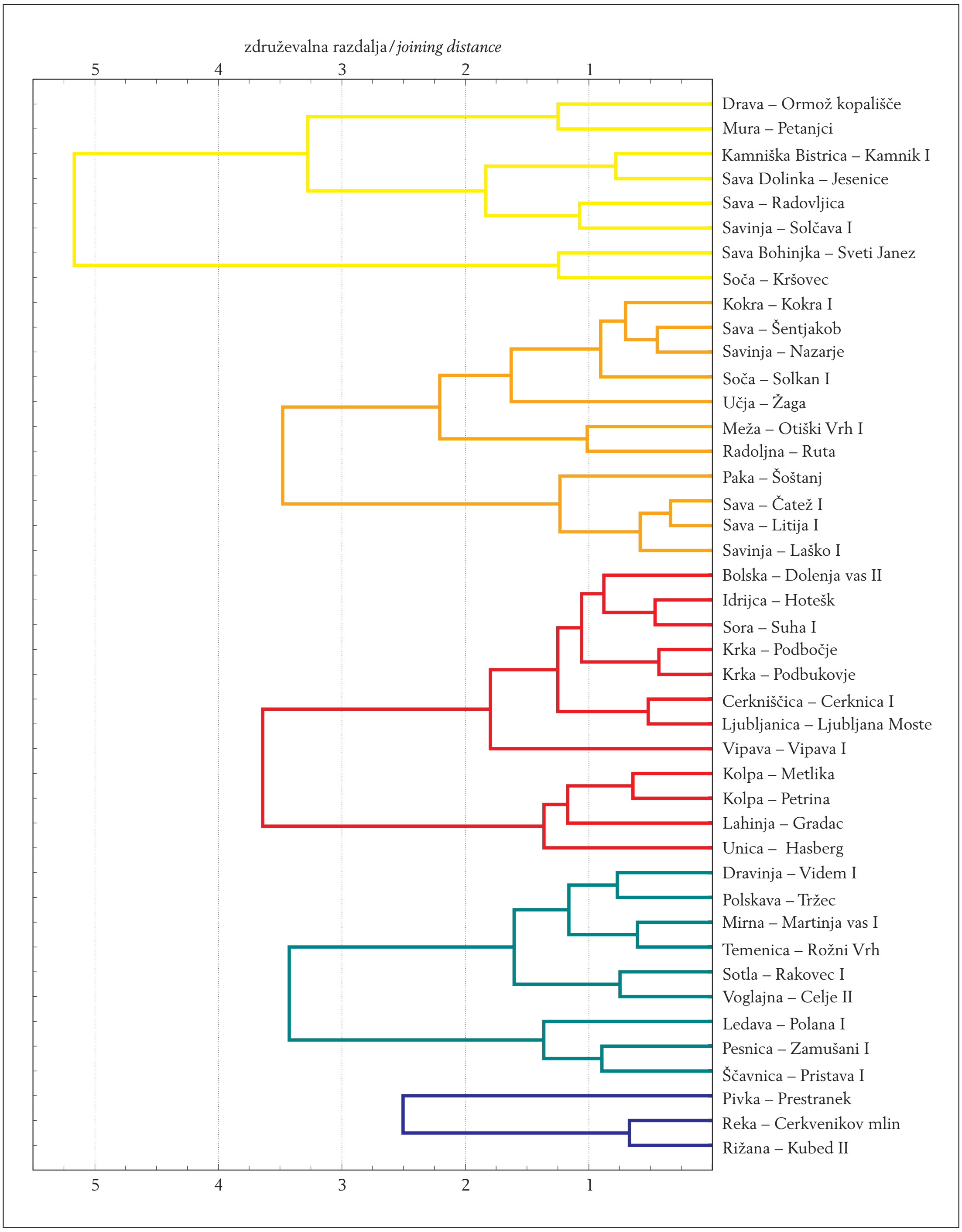
Slika 33: *Sava Dolinka*

Figure 33: *The Sava Dolinka River*

PETER FRANTAR

Slika 34: *Drevo združevanja rek glede na pretočni režim, kjer barva pomeni isto skupino pretočnega režima*

Figure 34: *The tree of river clustering with respect to the discharge regime, where the same colour implies the same discharge regime group*



so pretočni režimi odvisni predvsem od letne razporeditve padavin in temperatur ter od trajanja snežne odeje.

Pri izbiri merilnih mest smo se omejili na 43 vodomernih postaj na 35 slovenskih rekah, enakomerno razporejenih po celotni državi. Vse imajo sklenjen časovni podatkovni niz o srednjih mesečnih pretokih v obdobju med letoma 1971 in 2000. Niz je okrnjen le pri Dravi, za katero manjkajo pretočni podatki med letoma 1978 in 1990. Pri razvrščanju v skupine smo uporabili Wardovo metodo hierarhičnega združevanja in v Sloveniji ugotovili pet tipov pretočnih režimov. Poimenovali smo jih glede na pokrajinsko enoto, za katero so

on discharges for the 1971–2000 period, it was found that 65 water gauging stations had complete data sets. On other stations, data gaps were supplemented with the use of a statistical method – with the Pearson linear correlation coefficient based on the mean monthly averages of the 1961–2001 period.

4.3.1 Discharge Regimes

Peter Frantar, Mauro Hrvatin

A discharge regime is an indicator of the average fluctuation of the river discharge during the year. The factors that shape the discharge regime are numerous and diverse, the most important značilni ter glede na vodni vir, s katerim se reke napajajo:

- alpski snežno-dežni režim,
- alpski dežno-snežni režim,
- dinarski dežno-snežni režim,
- panonski dežno-snežni režim in
- sredozemski dežni režim.

Reke z **alpskim snežno-dežnim režimom** so Drava, Kamniška Bistrica, Mura, Sava Bohinjka, Sava Dolinka, Sava pri Radovljici, Savinja pri Solčavi ter Soča pri Kršovcu. Režim se pojavlja pri rekah, katerih pomembni delež porečja sega v visokogorje in je zaradi tega pri njih posebej izrazit vpliv taljenja snega. Glavni pretočni višek, ki je posledica taljenja snega, nastopi maja ali celo junija, ko se vrednosti mesečnih pretočnih količnikov gibljejo od 1,43 na Savinji pri Solčavi do 2,16 na Savi Bohinjki. Drugotni višek, kot posledica padavinskega maksimuma, nastopi oktobra ali novembra, z mesečnimi pretočnimi količniki med 1,16 na Dravi in 1,60 na Savinji pri Solčavi. Najmanj vode je februarja, ki je padavinsko med bolj sušnimi in se velik del padavin nabira v snežni odeji, ko se mesečni pretočni količniki spustijo na vrednosti od 0,27 na Savi Bohinjki do 0,63 na Kamniški Bistrici. Ob drugem nižku avgusta ali septembra (poletno visoko izhlapevanje) mesečni pretočni količniki kolebajo od 0,63 na Soči pri Kršovcu do 0,88 na Savi Dolinki. Nadpovprečna količina vode je običajno med aprilom in julijem ter oktobra in novembra, podpovprečna pa avgusta in septembra ter od decembra do marca.

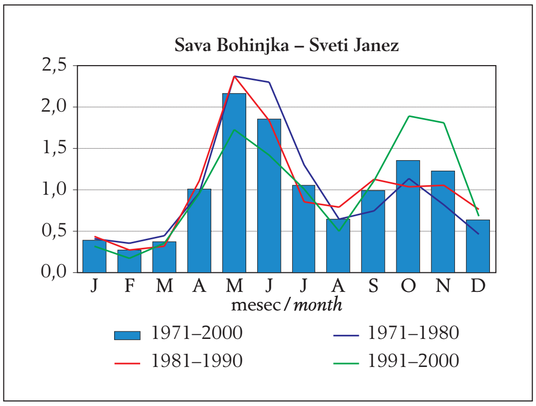
Od opisanih razmer nekoliko odstopata režima Mure in Savinje pri Solčavi. Režim Mure je še vedno z enim samim izrazitim viškom maja in enim izrazitim nižkom januarja, se pa v zadnjih desetletjih vse bolj krepijo jesenske vode, ki so pri Dravi že ustvarile drugotni jesenski višek.

being: the climate, the relief, the geology, soil, vegetation and anthropogenic activities. The most important factor in Slovenia is the climate, as the discharge regimes are primarily dependent on the annual distribution of precipitation and temperature as well as on the duration of the snow cover.

When selecting the stations, we limited ourselves to 43 water gauging stations on 35 Slovenian rivers, evenly distributed across the entire country. All the stations have continuous time series on the mean monthly discharges in the period between 1971 and 2000. The series is only incomplete for the Drava River, for which the discharge data is missing for the years between 1978 and 1990. When classifying these into groups, we used the Ward method of hierarchical clustering and established that there were five types of discharge regimes in Slovenia. We named them based on the landscape unit they are characteristic of and with respect to the water source recharging the rivers:

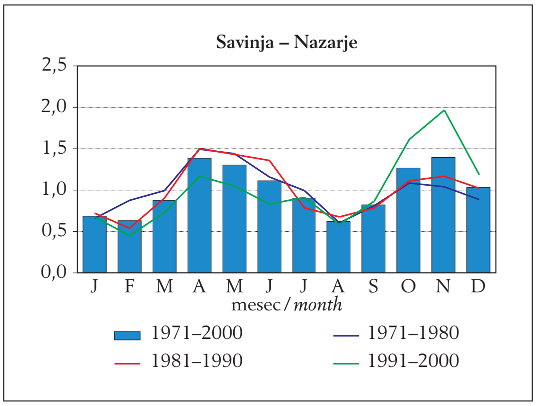
- Alpine nival-pluvial regime,
- Alpine pluvial-nival regime,
- Dinaric pluvial-nival regime,
- Pannonian pluvial-nival regime and
- the Mediterranean pluvial regime.

Rivers in the **Alpine nival-pluvial regime** are the Drava, Kamniška Bistrica, Mura, Sava Bohinjka, Sava Dolinka, the Sava at Radovljica, the Savinja at Solčava and the Soča at Kršovec. The regime occurs in rivers where an important part of the river basin reaches up into the high mountains and where the effect of snow melt is therefore especially pronounced. The main discharge peak occurs in May or even June as a result of the snow melt, when the monthly discharge coefficient values range between 1.43 on the Savinja River at Solčava and 2.16 on the Sava Bohinjka River. The secondary peak, arising



Slika 35: *Mesečni pretočni količniki Save Bohinjke na vodomerni postaji Sveti Janez – alpski snežno-dežni režim*

Figure 35: *The monthly discharge coefficient of the Sava Bohinjka River at the Sveti Janez water gauging station – the Alpine nival-pluvial regime*



Slika 36: *Mesečni pretočni količniki Savinje na vodomerni postaji Nazarje – alpski dežno-snežni režim*

Figure 36: *The monthly discharge coefficient of the Savinja River at the Nazarje water gauging station – the Alpine pluvial-nival regime*

Nenavaden je tudi režim Savinje pri Solčavi, pri kateri jesenski višek nekoliko presega spomladanskega. Razlog je v pičlih zimskih padavinah, zaradi katerih je vpliv snežnega zadržka skromen. V zadnjem desetletju se je sušnost med decembrom in februarjem še stopnjevala, medtem ko so se oktobrske in novembrske pretežno dežne padavine še okrepile.

Alpski dežno-snežni režim imajo Kokra, Meža, Paka, Radoljna, Sava pri Šentjakobu, Litiji in Čatežu, Savinja pri Nazarjah in Laškem, Soča pri Solkanu ter Učja. Režim je značilen predvsem za reke, ki imajo večji delež porečja v alpskem sredogorju, deli nekaterih pa segajo deloma tudi še v visokogorje.

Spomladanski in jesenski višek sta dokaj izenačena, zato imajo reke Meža, Radoljna in Učja glavni višek aprila in drugega v novembru, ostale pa ravno obratno. Vrednosti pretočnih količnikov se ob glavnem višku gibljejo od 1,24 na Radoljni do 1,53 na Učji, ob drugem višku pa od 1,19 na Radoljni do 1,40 na Učji. Tudi oba nižka, zimski in poletni, sta močno izenačena. Ob glavnem nižku se mesečni pretočni količniki spustijo na vrednosti od 0,51 na Učji do 0,73 na Meži, ob drugem nižku pa kolebajo med 0,58 na Učji in 0,87 na Savi pri Čatežu. Nadpovprečna količina vode je običajno od aprila do junija ter od oktobra do decembra, podpovprečna pa od januarja do marca ter od julija do septembra.

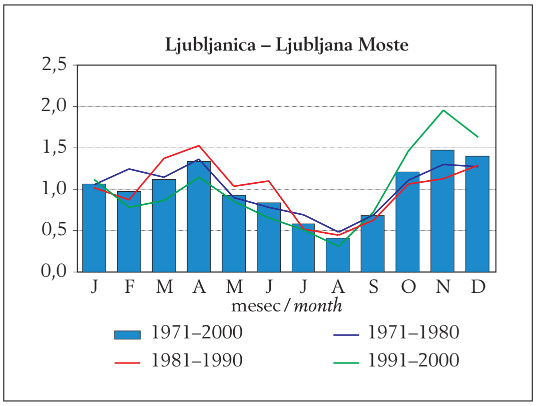
V skupino rek z **dinarskim dežno-snežnim režimom** so se uvrstile Bolska, Cerkniščica, Idrijca, Kolpa, Krka, Lahinja, Ljubljanica, Sora, Unica ter Vipava. Režim je značilen za reke dinarskega sveta, ki so se jim pridružile reke Bolska, Idrijca in Sora. Spomladanski in jesenski viški so pri tej skupini dokaj izenačeni, razlike med zimskimi in poletnimi nižki pa zelo izrazite. Ob glavnem višku se vrednosti pretočnih količnikov gibljejo od 1,35 na Krki pri Podbočju do 1,58 na

from the precipitation maximum, occurs in October or November, with monthly discharge coefficients of between 1.16 on the Drava River and 1.60 on the Savinja River at Solčava. The water is at its lowest in February, which is the driest month in terms of precipitation as a great part of precipitation accumulates as snow cover. Here, the monthly discharge coefficients drop to between 0.27 on the Sava Bohinjka River to 0.63 on the Kamniška Bistrica River. During the second low in August or September (caused by the high level of evaporation in the summer), the monthly discharge coefficients fluctuate between 0.63 on the Soča River at Kršovec and 0.88 on the Sava Dolinka River. There is usually an above-average quantity of water between April and July and October and November, and the below-average quantity occurs between August and September and from December to March.

Only the regimes of the Mura River and the Savinja at Solčava deviate from the conditions described. The regime of the Mura River still exhibits a single prominent peak in May and one prominent low in January, but the autumn waters have been strengthening over the last decades and have already created the secondary autumn peak on the Drava River.

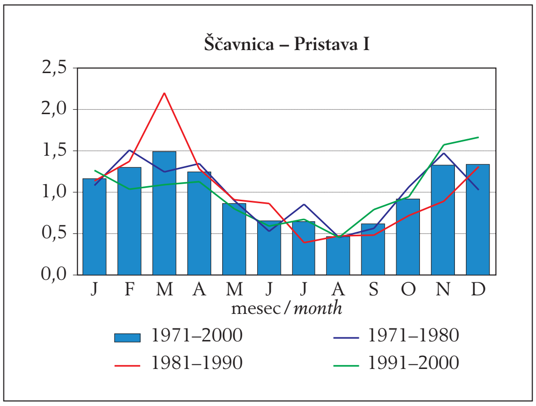
The regime of the Savinja River at Solčava is also unusual because the autumn peak slightly exceeds the spring one. The reason for this is the scarce winter precipitation, leading to only a moderate effect from the snow residence time. In the last decade, the drought during December and February has been intensifying, while the precipitation in October and November – predominantly of rain – has strengthened.

Rivers exhibiting the **Alpine pluvial-nival regime** are the Kokra, Meža, Paka, Radoljna, the Sava at Šentjakob, Litija and Čatež, the Savinja at Nazarje and Laško, the Soča at Solkan and the



Slika 37: *Mesečni pretočni količniki Ljubljanice na vodomerni postaji Moste – dinarski dežno-snežni režim*

Figure 37: *The monthly discharge regimes of the Ljubljanica River at the Moste water gauging station – the Dinaric pluvial-nival regime*



Slika 38: *Mesečni pretočni količniki Ščavnice na vodomerni postaji Pristava I – panonski dežno-snežni režim*

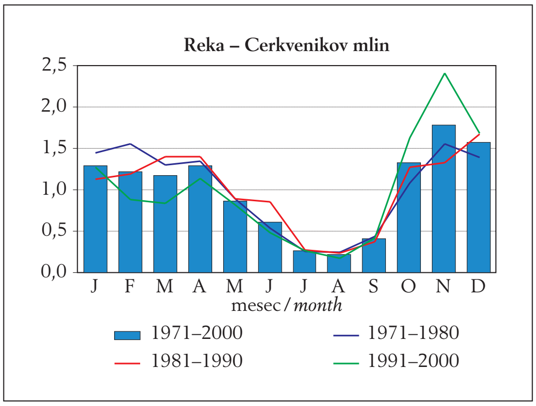
Figure 38: *The monthly discharge coefficients of the Ščavnica River at the Pristava I water gauging station – Panonnian pluvial-nival regime*

Kolpi pri Petrini, ob drugotnem višku pa od 1,23 na Bolski do 1,46 Kolpi pri Petrini. Najmanj vode je avgusta, ko se mesečni pretočni količniki spustijo na vrednosti od 0,32 na Unici do 0,54 na Bolski. Ob januarskem ali februarskem drugem nižku so pretoki blizu povprečja, zato se mesečni pretočni količniki gibljejo od 0,87 na Sori do 1,01 na Kolpi pri Metliki. Nadpovprečna količina vode je običajno med oktobrom in decembrom ter marca in aprila, podpovprečna med majem in septembrom. Januarja in februarja se pretoki močno približajo letnemu povprečju.

Panonski dežno-snežni režim imamo na Dravinji, Ledavi, Mirni, Pesnici, Polskavi, Sotli, Ščavnici, Temenici ter Voglajni. Režim je sicer značilen za reke po gričevjih in ravninah panonskega sveta, vključuje pa tudi Temenico in Mirno.

Zgodnjepomladanski in poznojesenski viški so močno izenačeni, glavni nižki so povsod poleti, drugi nižki pa pozimi in se nikjer ne spustijo bistveno pod povprečje. Ob glavnem pretočnem višku se vrednosti mesečnih pretočnih količnikov gibljejo od 1,27 na Dravinji do 1,49 na Ščavnici, ob drugem pa od 1,19 na Temenici do 1,38 na Pesnici. Najmanj vode je avgusta, ko se mesečni pretočni količniki znižajo na vrednosti od 0,44 na Sotli do 0,73 na Polskavi, ob drugem, neizrazitem nižku pa kolebajo od 0,94 na Voglajni do 1,16 na Ščavnici. Nadpovprečna količina vode je običajno med februarjem in aprilom ter med oktobrom in decembrom, podpovprečna pa med majem in septembrom. Januarski pretoki le malo odstopajo od letnega povprečja.

V skupini rek s **sredozemskim dežnim režimom** so Pivka, Reka in Rižana. Režim je značilen za jugozahodni, sredozemski svet Slovenije. Skupina rek s sredozemskim dežnim režimom je najmanjša in hkrati najbolj prostorsko homogena. Glavni pretočni višek nastopi novembra ali decembra, ko se vrednosti mesečnih pretočnih količnikov gibljejo od 1,61 na Rižani do



Slika 39: *Mesečni pretočni količniki Reke na vodomerni postaji Cerkvenikov mlin – sredozemski dežni režim*

Figure 39: *The monthly discharge coefficients of the Reka River at the Cerkvenikov mlin water gauging station – Mediterranean pluvial regime*

Učja. The regime is primarily characteristic of rivers with a larger portion of their river basin in the medium-height Alpine mountains, while parts of certain river basins also partially reach into the high mountains.

The spring and autumn peaks are fairly equal, which is why the Meža, Radoljna and Učja rivers experience their main peaks in April and the secondary ones in November, while the opposite is true for the others. The values of the discharge coefficients during the main peak range from 1.24 on the Radoljna to 1.53 on the Učja and, during the second peak, from 1.19 on the Radoljna to 1.40 on the Učja. Both lows, winter and summer, are also very much equal. During the main low, the monthly discharge coefficients drop to between 0.51 on the Učja to 0.73 on the Meža and, during the second low, they range between 0.58 on the Učja and 0.87 on the Sava River at Čatež. Above-average water quantities usually occur between April and June and from October to December. Below-average water quantities occur from January to March and from July to September.

The rivers with the **Dinaric pluvial-nival regime** are the Bolska, Cerkniščica, Idrijca, Kolpa, Krka, Lahinja, Ljubljanica, Sora, Unica and Vipava. This regime is characteristic of the Dinaric area rivers that are joined by the rivers Bolska, Idrijca and Sora. The spring and autumn peaks are fairly equalised in this group, though differences between the winter and summer lows are very pronounced. During the main peak, the discharge coefficient values range between 1.35 on the Krka River at Podbočje and 1.58 on the Kolpa at Petrina and, during the second peak, between 1.23 on the Bolska and 1.46 on the Kolpa at Petrina. The lowest water quantities occur in August when the monthly discharge coefficients drop to between 0.32 on the Unica and 0.54 on the Bolska. During the second low in January or February, the discharges are close to the average, which is why the monthly discharge coefficients range from 0.87 on the Sora to 1.01 on the Kolpa at Metlika. Above-average quantities of water usually occur between October and December and between March and April, while below-average quantities occur between May and September. In January and February, the discharges strongly approximate the annual average.

The Panonnian pluvial-nival regime is exhibited by the Dravinja, Ledava, Mirna, Pesnica, Polskava, Sotla, Ščavnica, Temenica and Voglajna rivers. The regime is characteristic of the rivers flowing in the hills and plains of the Pannonian area, but also includes the Temenica and Mirna rivers.

The early summer and late autumn peaks are strongly equalised, with the main lows occurring

ARSO

Slika 40: *Učja*

Figure 40: *The Učja River*

1,97 na Pivki. Količina vode se v naslednjih mesecih bistveno ne zmanjša, zato je drugi višek v aprilu samo nakazan. Najmanj vode je avgusta, ko se mesečni pretočni količniki spustijo na vrednosti od 0,05 na Pivki do 0,21 na Rižani. Nadpovprečna količina vode je običajno med oktobrom in aprilom, podpovprečna pa med majem in septembrom.

Primerjava pretočnih režimov obdobja 1971–2000 z režimi v preteklih obdobjih kaže številne razlike. Predvsem se je marsikje močno zmanjšal vpliv taljenja snega, kar se odraža v neizrazitem zimskem snežnem zadržku in v skromnem spomladanskem višku, ki je v veliki meri odvisen od taljenja snežne odeje. V zadnjih dveh desetletjih 20. stoletja se je močno skrajšalo trajanje snežne odeje na visokih dinarskih planotah ter v alpskih hribovjih in kotlinah (Dolinar et al., 2000). Na Trnovskem gozdu in Snežniku se je snežna doba skrajšala za več kot 30 dni. Trajanje snežne odeje se ni bistveno spremenilo le na najvišjih gorskih območjih Slovenije, zato ostaja sneg najpomembnejši dejavnik pretočnega režima le na peščici rečnih odsekov ob vznožju alpskega visokogorja. Celo Mura in Drava, ki so ju vsi dosedanji raziskovalci prištevali med reke z enostavnim snežnim režimom, sta se pri novi klasifikaciji uvrstili med reke z mešanim snežno-dežnim režimom.

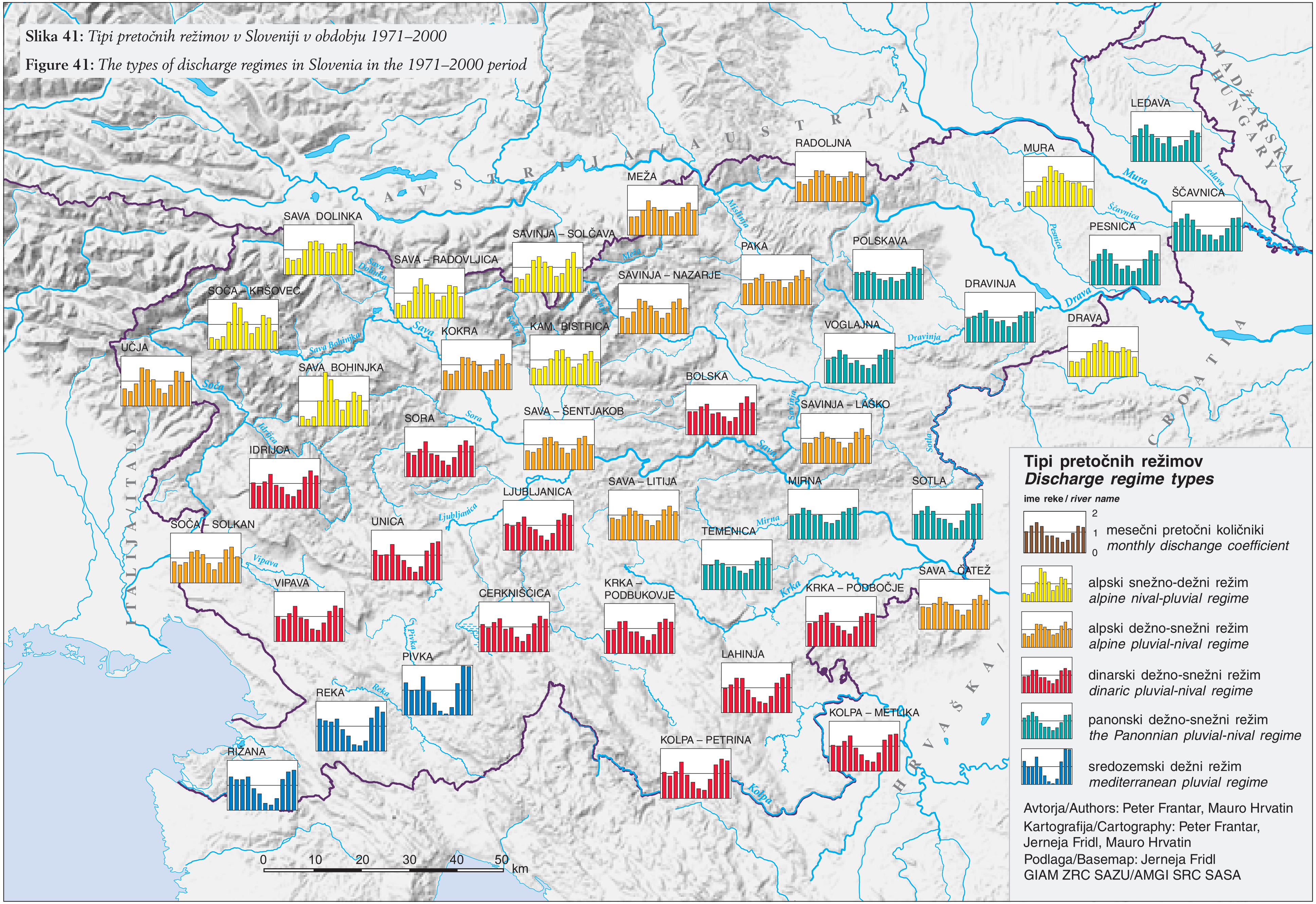
in the summer on all the rivers. The second low occur in the winter and do not drop significantly below the average anywhere. During the main discharge peak, the values of the monthly discharge coefficients range between 1.27 on the Dravinja and 1.49 on the Ščavnica and, during the second peak, between 1.19 on the Temenica and 1.38 on the Pesnica. The lowest water quantities occur in August, when the monthly discharge coefficients drop to between 0.44 on the Sotla and 0.73 on the Polskava and, during the second non-prominent low, they fluctuate between 0.94 on the Voglajna and 1.16 on the Ščavnica. Above-average quantities of water usually occur between February and April and between October and December, while the below-average quantities occur between May and September. The January discharges deviate only slightly from the annual average.

The group of rivers with the **Mediterranean pluvial regime** consists of the Pivka, Reka and Rižana. The regime is characteristic of the south-western, Mediterranean area of Slovenia. The group of rivers with the Mediterranean pluvial regime is the smallest and also the spatially most homogenous one. The main discharge peak occurs in November or December when the values of the monthly discharge coefficients range between 1.61 on the Rižana and 1.97 on the Pivka. The quantity of water does not decrease significantly in the following months, which is why only the second peak in April is indicated. The lowest water quantities occur in August, when the monthly discharge coefficients drop to between 0.05 on the Pivka and 0.21 on the Rižana. Above-average water quantities occur between October and April and below-average levels between May and September.

A comparison of the discharge regimes in the 1971–2000 period with the regimes in other periods shows numerous differences. In many places the effect of melting snow has decreased significantly, which is reflected in the less prominent winter snow residence period and in the modest spring peak dependent, to a large extent on the melting of the snow cover. In the last two decades of the 20th century, the duration of the snow cover has decreased significantly on the high Dinaric plateaus and in the Alpine hills and basins (Dolinar et al., 2000). On the Trnovski gozd and Snežnik, the snow period has decreased by more than 30 days. Only in the highest mountain regions of Slovenia has the duration of the snow cover not changed much, which is why the snow remains the main factor of the discharge regime in only a few sections at the foot of the high Alpine mountains. Even the Mura and Drava rivers, which were considered by

Slika 41: *Tipi pretočnih režimov v Sloveniji v obdobju 1971–2000*

Figure 41: *The types of discharge regimes in Slovenia in the 1971–2000 period*



Avtorja/Authors: Peter Frantar, Mauro Hrvatin
Kartografija/Cartography: Peter Frantar, Jerneja Fridl, Mauro Hrvatin
Podlaga/Basemap: Jerneja Fridl
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ARSO

Slika 42: *Idrijca*

Figure 42: *The Idrijca River*

Globalno naraščanje temperatur zraka (Ogrin, 2004) pospešuje predvsem poletno izhlapevanje vode, zaradi katerega vseskozi narašča delež vode rek, ki imajo sredi poletja glavni pretočni nižek. Porast temperature zraka posredno nedvomno spada med najpomembnejše dejavnike hitrega upadanja povprečnih letnih pretokov slovenskih rek.

Zaradi zmanjšane vloge zimskega snežnega zadržka in povečane vloge poletnega izhlapevanja se razlike med posameznimi pretočnimi režimi postopoma zmanjšujejo. Pretočna kolebanja slovenskih rek so si vse bolj podobna, zato je tudi število tipov pretočnih režimov manjše – hidrološka raznolikost Slovenije se zmanjšuje.

Primerjava pretočnih režimov med obdobjem 1961–1990 ter obdobjem 1971–2000 je pokazala, da se vplivi podnebnih sprememb vse bolj izrazito kažejo tudi v pretokih vodotokov. Posebej izstopajo naslednje podnebne razlike:

- višja povprečna temperatura zraka (npr. Brnik v obdobju 1961–90 8,4 °C, v obdobju 1971–2000 pa 8,7 °C),
- izdatnejše izhlapevanje (v obdobju 1961–90 650 mm, 1971–2000 pa 717 mm),
- spremenljiva količina padavin ter
- krajše trajanje snežne odeje v sredogorju in v nižinah in posledično skromnejši snežni zadržek.

4.3.2 Trendi pretokov

Peter Frantar, Mira Kobold, Florjana Ulaga

Pri analizah povprečnih letnih pretokov slovenskih rek, ki so bile v preteklih letih opravljene na Agenciji RS za okolje, je bil statistično značilen regionalni trend odkrit predvsem pri pretokih rek v severozahodnem alpskem delu Slovenije (Ulaga, 2002; Uhan, 2002; Frantar et al., 2003; Uhan et al., 2006). Po rezultatih teh analiz se povprečni letni odtok na tem območju v zadnjih petdesetih letih zmanjšuje. Podob-

all researches up to now to belong to the simple nival regime, now need a new classification among the rivers with a mixed nival-pluvial regime.

The global increasing of air temperatures (Ogrin, 2004) is being accelerated primarily by the summer evaporation of water, because of which the share of water from the rivers with their main discharge low in the middle of summer is continuously increasing. The increase in air temperature undoubtedly belongs indirectly among the most important factors of the rapid decline in the average annual discharges of the Slovenian rivers.

Because of the diminishing role of winter snow residence time and the increase of the role of summer evaporation, the differences between individual discharge regimes are gradually diminishing. The discharge fluctuations of Slovenian rivers are becoming increasingly similar, which is why the number of discharge regimes is smaller – the hydrological diversity of Slovenia is diminishing.

A comparison of the discharge regimes between the 1961–1990 period and the 1971–2000 period has shown that the effects of climate changes are becoming increasingly pronounced and reflected in the discharges of the streams. The following climate differences especially stand out:

- higher average air temperatures (e. g. in the 1961–90 period, Brnik had 8.4 °C while in 1971–2000 it had 8.7 °C),
- higher rate of evaporation (650 mm in the 1961–90 period and 717 mm in the 1971–2000 period for the Slovenian annual average),
- variable quantity of precipitation and
- shorter duration of snow cover in the medium-height mountains and in the lowlands and, consequently, a more modest snow residence time.

4.3.2 Discharge Trends

Peter Frantar, Mira Kobold, Florjana Ulaga

In the analyses of the average annual discharges of Slovenian rivers performed in previous years by the Environmental Agency of the Republic of Slovenia, a statistically significant regional trend was established primarily in the discharges of rivers in the north-western Alpine part of Slovenia (Ulaga, 2002; Uhan, 2002; Frantar et al., 2003; Uhan et al, 2006). According to the results of these analyses, the average annual runoff in this area over the last fifty years is diminishing. A similar tendency is exhibited by the environmental indicator of the annual river balance. The analyses of extremes carried out up no tendenco nakazuje tudi kazalec okolja o letni rečni bilanci. Pri dosedanjih analizah ekstremov ni bila ugotovljena statistična značilnost regionalne ocene trendov pretokov. Rezultati nedavnih študij Globalnega centra podatkov o pretokih rek (GRDC) v katerih so analizirali časovne vrste podatkov o hidroloških ekstremih na izbranih slovenskih vodomernih postajah govorijo tudi o značilno upadajočem trendu največjih pretokov (Kundzewicz et al., 2004; Svensson et al., 2004; Uhan, 2007). Pričujoča analiza trenda pretokov predstavlja razširitev analize časovne spremenljivosti podatkovnih nizov o pretokih slovenskih rek na večjem številu reprezentativnih vodomernih postaj.

Trendi so pomembni kazalci časovne spremenljivosti pojavov (pretokov). Z analizo časovnega zaporedja pretokov ocenjujemo izrazitost in značilnost časovnega spreminjanja. V zadnjih letih, ko so poplave in suše kot posledica podnebnih sprememb, opazno pogostejše, je spremljanje in proučevanje hidroloških stanj in dogodkov vse bolj aktualno.

V analizi trendov pretokov slovenskih vodotokov smo obravnavali podatke malih, srednjih in velikih pretokov. Analizo smo izvedli na 22 vodomernih postajah, ki imajo dovolj dolge in zanesljive zvezne podatkovne nize ter so reprezentativno razporejene po Sloveniji. Pri analizi trendov kratkih podatkovnih nizov lahko na rezultate zelo vpliva podnebna spremenljivost (Kundzewicz et al., 2000), zato smo v izbor poskušali zajeti vodomerne postaje z najmanj 50 letnim podatkovnim nizom.

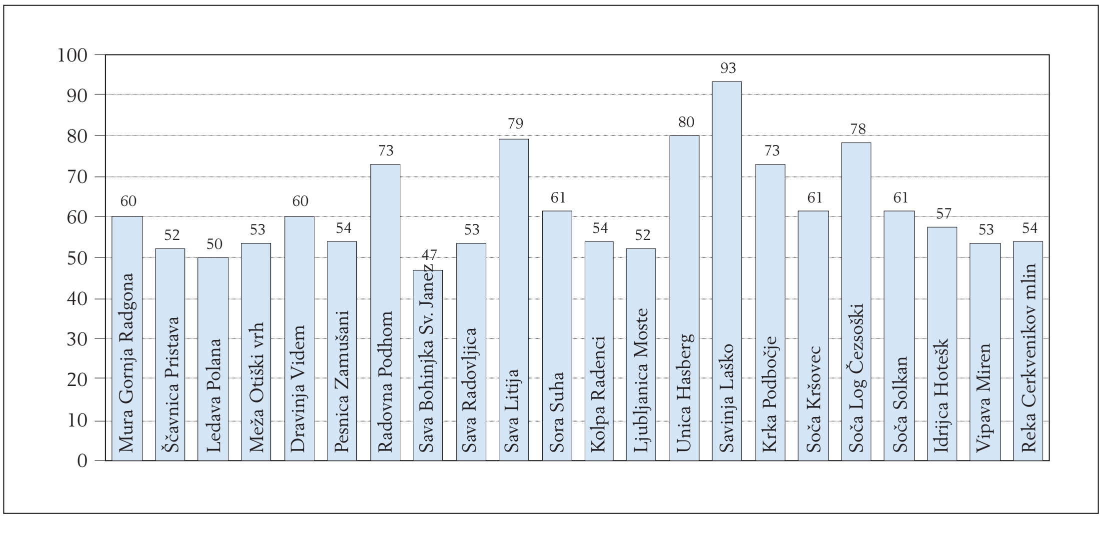
Izbrane so bile naslednje vodomerne postaje: Gornja Radgona na Muri, Pristava na Ščavnici, Polana na Ledavi, Otiški Vrh na Meži, Videm na Dravinji, Zamušani na Pesnici, Podhom na Radovni, Sveti Janez na Savi Bohinjki, Radovljica in Litija na Savi, Suha na Sori, Radenci na Kolpi, Moste na Ljubljanici, Hasberg na Unici, Laško na Savinji, Podbočje na Krki,

to now have found no statistical significance of the regional assessment of discharge trends. The results of recent studies performed by the Global Runoff Data Centre (GRDC), within the scope of which the time series of the hydrological extremes on selected Slovenian water gauging stations were analysed, are also speaking of the characteristically diminishing trend of the maximum discharges (Kundzewicz et al., 2004; Svensson et al., 2004, Uhan 2007). The present discharge trend analysis represents an expansion of the analysis of the temporal variability of data sets on the discharges of Slovenian rivers using a larger number of representative water gauging stations.

Trends are important indicators of the temporal variability of phenomena (discharges). By analysing the time sequence of the discharges, we assess the prominence and significance of the temporal variability. In recent years, when floods and droughts as a result of climate change have become more frequent, the monitoring and study of hydrological states and events is becoming increasingly topical.

In the analysis of the trends of discharges on Slovenian streams, we examined data on the low, mean and high discharges. The analysis was carried out at 22 water gauging stations with sufficiently long and reliable continuous data sets and are which are representatively distributed across Slovenia. In analysing the trends in short data sets, the results can be affected significantly by climatic variation (Kundzewicz et al., 2000), which is why we attempted to include only water gauging stations with at least 50-year data sets into the selection.

The following water gauging stations were selected: Gornja Radgona on the Mura, Pristava on the Ščavnica, Polana on the Ledava, Otiški Vrh on the Meža, Videm on the Dravinja, Zamušani on the Pesnica, Podhom on the Radovna, Sveti Janez on the Sava Bohinjka,



Slika 43: *Število let podatkov izbranih vodomernih postaj za analizo trendov*

Figure 43: *The number of years covered by the data from the water gauging stations selected for trend analysis*

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Slika 44: *Ljubljanica v Ljubljani*

Figure 44: *The Ljubljanica River in Ljubljana*

Kršovec, Log Čezsoški in Solkan na Soči, Hotešk na Idrijci, Miren na Vipavi in Cerkvenikov mlin na Reki. Uporabili smo podatke celotnega obdobja opazovanj, ki so na voljo v arhivu ARSO, do vključno leta 2005 (slika 43). Najdaljši niz podatkov med izbranimi vodomernimi postajami ima Laško na Savinji. Na tej vodomerni postaji se s presledkom v obdobju 1940–1945 merijo gladine in pretoki že od leta 1907, torej 93 let. Povprečna dolžina podatkovnih nizov izbranih vodomernih postaj je 62 let.

Spremembe v časovni vrsti so lahko kot nenadna naključna sprememba, ciklično ponavljajoča sprememba ali pa kot stalna sprememba z izrazitim trendom. Obliko trenda najlaže določimo analitično z linearno regresijsko analizo in grafičnim prikazom. Preprosta testna statistika za prikaz trenda je naklon regresijske premice, ki pove, kako močan je trend. Če ni trenda, je vrednost regresijskega gradienta blizu vrednosti 0. Če je trend znaten, je vrednost regresijskega gradienta (zelo) različna od 0, pozitivna za naraščajoči trend in negativna za upadajočega. Statistična značilnost pretočnih trendov je bila ocenjena s stopnjo značilnosti z upoštevanjem desetodstotne ravni zaupanja in s predpostavko, da je porazdelitev podatkov normalna (Kundzewicz et al., 2000). Vrednosti nad 90 % smo privzeli kot statistično značilen pojav spreminjanja pretokov oz. nekaterih izbranih hidroloških indeksov.

Analizo trendov vrednosti in indeksov pretokov smo opravili na osnovi časovnih vrst srednjih dnevnih pretokov. Z računalniškim programom Hydrospect, ki je bil razvit pod okriljem Svetovne meteorološke organizacije (Radziejewski, 2007), so bili izračunani različni indeksi, to je izvedeni časovni nizi malih, srednjih in velikih pretokov (Svensson et al., 2004; Kundzewicz et al., 2004). Trend obravnavanih indeksov smo določili z linearno regresijsko analizo, pri čemer je bil čas neodvisna spremenljivka.

Radovljica and Litija on the Sava, Suha on the Sora, Radenci on the Kolpa, Moste on the Ljubljanica, Hasberg on the Unica, Laško on the Savinja, Podbočje on the Krk, Kršovec, Log Čezsoški and Solkan on the Soča, Hotešk on the Idrijca, Miren on the Vipava and Cerkvenikov mlin on the Reka. We used the data from the entire period of observations (available in the ARSO archives), up to and including the year 2005 (Figure 43). The Laško station on the Savinja River has the longest data set of the selected water gauging stations. Here, the water stages and discharges have been measured since 1907 with the exception of an interval in 1940–1945. That is 93 years. The average length of the data sets from the selected water gauging stations is 62 years.

Changes in the time series can occur as sudden incidental changes, cyclically repetitive changes or as a continuous change with a distinct trend. The type of the trend can be most easily established analytically using linear regression analysis and graphic depiction. The simple test statistic for the depiction of a trend is the slope of the regression line that shows how distinct the trend is. If there is no trend, the value of the regression gradient is close to 0. If the trend is significant, the value of the regression gradient is (considerably) different from 0 – positive for an increasing trend and negative for a decreasing one. The statistical significance of the discharge trends was assessed with a significance rate that adopts a ten percent confidence level and the assumption that the distribution of the data is normal (Kundzewicz et al., 2000). Values above 90% were adopted as a statistically significant phenomenon for changing discharges or for some selected hydrological indexes.

The analysis of the value trends and discharge indexes was carried out based on the time series of mean daily discharges. Using the Hydrospect program, developed under the auspices of the World Meteorological Organization (Radziejewski, 2007), various indexes were calculated, such as the derived time series of low, mean and large discharges (Svensson et al, 2004; Kundzewicz et al, 2004). The trend of the indexes treated was determined using linear regression analysis, where time was the independent variable.

Index of mean annual discharges – Statistical estimates of the mean annual discharges (Qs) indicate the average annual quantity of water. By analysing the trend of these time series, we can assess the prominence and characteristics of changes in the quantity of water and the envisaged trend of this in the future.

Indeks srednjih letnih pretokov
Statistične ocene srednjih letnih pretokov (Qs) ponazarjajo povprečno letno količino vode. Z analizo trenda teh časovnih vrst lahko ocenimo izrazitost in značilnost spreminjanja količine vode in predvideni trend količine vode v prihodnosti.

Indeks malih pretokov
Na osnovi srednjih dnevnih pretokov so bili analizirani minimalni letni pretoki enodnevnega (Qmin1), 7-dnevnega (Qmin7) in 30-dnevnega (Qmin30) trajanja. Analiza najmanjših letnih pretokov različnih trajanj kaže tudi na značilnost sušnih obdobij in pojavov hidroloških suš, ki so bile v zadnjem desetletju pogoste (Kobold, 2004; Kobold et al., 2004).

Indeks velikih pretokov
Za oceno časovne spremenljivosti velikih pretokov je bilo uporabljenih pet različnih indeksov. Študije velikih pretokov so običajno osredotočene na trende največjih letnih pretokov (Qvp), kar pomeni, da vsako leto upoštevajo le po en

Index of low discharges – Based on the mean daily discharges, the minimum annual discharges lasting for 1 (Qmin1), 7 (Qmin7) and 30 (Qmin30) days were analysed. The analysis of minimum annual discharges of various durations also shows the characteristics of the drought periods and the occurrences of hydrological droughts, which were frequent over the last decade (Kobold, 2004; Kobold and Sušnik, 2004).

Index of high discharges – Five different indexes were used to assess the temporal variation in the high discharges. Studies of high discharges usually focus on the trends of the maximum annual discharges (Qvp), meaning that only one event is taken into account each year, irrespective of whether there were several high-water waves or no high-water waves at all. A more representative way of describing the frequency of high waters is the use of the threshold method (the POT – 'Peak Over Threshold'). When using this method, all events with discharges in excess of a set threshold are selected under the condition that the selected events are not

Preglednica 7: *Stopnja statistične značilnosti trendov*

Table 7: *The rate of the statistical significance of trends*

			Mali pretoki *Low discharges* *of the extreme*			Izrazitost ekstrema *Prominence* *of the extreme*		Pogostost ekstrema *Frequency*	
Vodomerna postaja ***Water gauging station***	Qsr	Qvp	Qmin1	Qmin7	Qmin30	POT1 mag	POT3 mag	POT1-f	POT3-f
Mura Gornja Radgona	–37.86	29.99	83.66	71.4	18.7	–31.14	–22.9	13.92	–0.7
Ščavnica Pristava	–99.2	55.69	55.6	27.13	–17.55	99.88	99.97	27	–75.52
Ledava Polana	–99.55	–96.55	–38	–69.3	–81.98	–38.1	–90.0	–99.15	–99.64
Meža Otiški Vrh	–98.76	–92.64	–96.9	–95.3	–98.75	18.66	–7.99	–99.38	–99.94
Dravinja Videm	–64.95	81.54	84.76	77.37	85.47	18.16	96.18	69.27	61.75
Pesnica Zamušani	–96.48	35.14	–27.4	–18.1	–18.93	44.62	94.24	10.46	–69.21
Radovna Podhom	–99.87	–99.99	–98.8	–98.3	–88.6	–99.84	–99.99	–99.99	–99.93
Sava Bohinjka Sv. Janez	–99.81	–85.9	–98.6	–98.5	–99.1	–66.73	–22.49	–28.93	–53.18
Sava Radovljica	–98.88	–7.96	–98.2	–99.9	–99.9	–62.68	6.52	65.38	64.78
Sava Litija	–99.41	–84.56	–39.9	–42.5	–82.53	59.45	–75.68	–99.87	–99.59
Sora Suha	–62.16	16.67	86.44	71.8	–18.16	–65.94	–38.6	–23.88	–36.22
Kolpa Radenci	–99.15	–97.94	–96.8	–97.5	–95.58	–73.86	65.3	–81.13	–99.99
Ljubljanica Moste	–93.2	–62.45	–86.6	–99.5	–99.54	–56.11	–92.91	–77.57	20.59
Unica Hasberg	–91.74	–99.88	88.27	92.6	71.11	–99.99	–95.6	–98.95	–99.99
Savinja Laško	–99.94	–91.1	–93.6	–94.2	–97.34	39.83	–63.13	–99.88	–99.88
Krka Podbočje	–96.79	–98.8	92.76	75.86	54.87	–93.73	–98.3	–99.83	–99.99
Soča Kršovec	–91.8	–98.9	–92.1	–95.3	–98.67	–91.22	–88.17	–98.64	–99.52
Soča Log Čezsoški	–99.81	–97.39	27.39	10.5	–63.73	–94.44	–83.36	–89.47	–98.28
Soča Solkan	–79.24	43.67	–12.6	–64.1	–94.94	32.43	69.78	53.2	–21.45
Idrijca Hotešk	–91.72	–70.21	–21.2	–61.7	–72.4	–68.21	34.83	–12.8	–83.89
Vipava Miren	–69.99	–10.83	–28.7	–49.9	–87.26	–75.38	–19.43	–18.61	49.44
Reka Cerkvenikov mlin	–92.37	6.36	97.84	99.58	96.54	–9.64	90.74	–2.66	–93.45

dogodek, ne glede na to, ali je bilo visokovodnih valov več ali pa izrazitih visokovodnih valov sploh ni bilo. Bolj reprezentativen način opisovanja pogostosti visokih voda je uporaba metode praga (POT – 'Peak Over Treshold'). Pri tej metodi izberemo iz celotnega podatkovnega niza vse dogodke s pretokom nad določenim pragom pod pogojem, da so izbrani dogodki med seboj neodvisni. Tako imamo v enem letu lahko več zabeleženih velikih pretokov, ali pa nobenega. Izbrane so bile visoke vrednosti praga s frekvenco (v povprečju) ene (POT1-mag) in treh (POT3-mag) vrednosti na leto. Poleg ocene trenda izrazitosti visokovodnega ekstrema smo ocenili tudi trend pogostosti visokih voda z računanjem števila vrednosti nad pragom (POT), torej POT 1-f in POT3-f za vsako leto in trend teh podatkovnih nizov.

Niza podatkov POT1 (POT1-mag in POT1-f) opisujeta velikost in pogostost večine ekstremnih velikih pretokov, medtem ko niza POT3 (POT3-mag in POT3-f) označujeta spremenljivost tudi zmernejših visokovodnih pretokov.

Trend srednjih letnih pretokov – Qs je na vseh analiziranih vodomernih postajah upadajoč. Z izjemo Mure, Dravinje, Sore, Soče v Solkanu in Vipave, ki ne izkazujejo statistično značilnega upadanja srednjih letnih pretokov, pa vsi ostali vodotoki, ne glede na dolžino upoštevanega niza, izkazujejo statistično značilno upadanje količin vode (slika 45). Trend srednjih letnih pretokov kaže na zmanjševanje letne količine vode v vseh pokrajinskih enotah Slovenije. Upadanje pretokov je v prvi vrsti posledica upadanja količine padavin, ki neposredno zmanjšuje odtok, in porasta temperature, ki povečuje izhlapevanje (evapotranspiracijo).

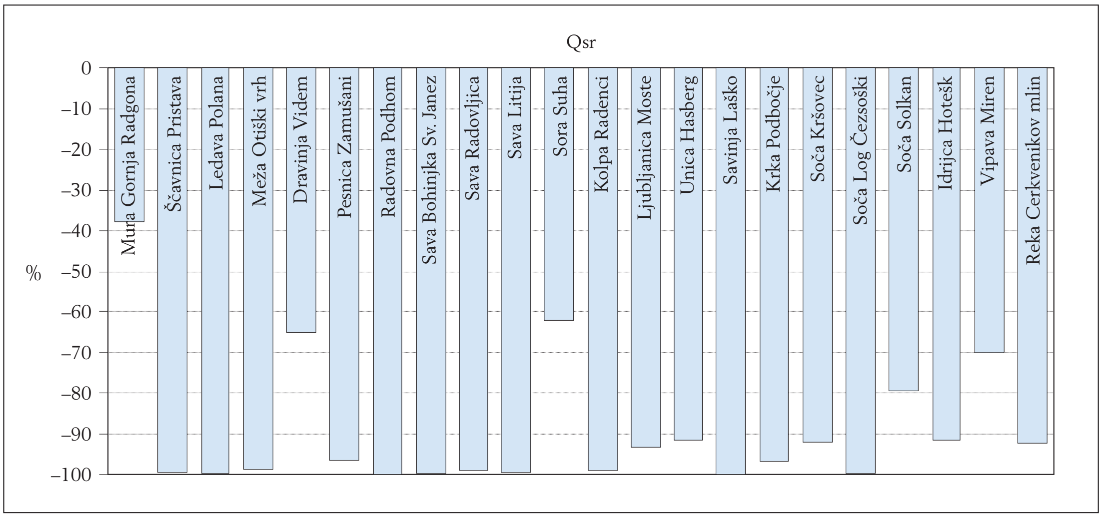
Trendi najmanjših letnih pretokov – Qmin so bili obravnavani za najmanjše letne srednje dnevne pretoke (Qmin1), najmanjše 7-dnevne

interdependent. Therefore we can have several high discharges recorded in a year or none at all. We have chosen high threshold values with a frequency (on average) of one (POT1-mag) and three (POT3-mag) values per year. In addition to assessing the trend of the prominence of the high-water extreme, we also assessed the trend of the frequency of high waters by calculating the number of values above the threshold (POT) – namely POT 1-f and POT3-f – for each year and the trend of these data sets.

The data sets POT1 (POT1-mag and POT1-f) describe the size and frequency of the extreme high discharges, while the sets POT3 (POT3-mag and POT3-f) describe the variability of more moderate high-water discharges.

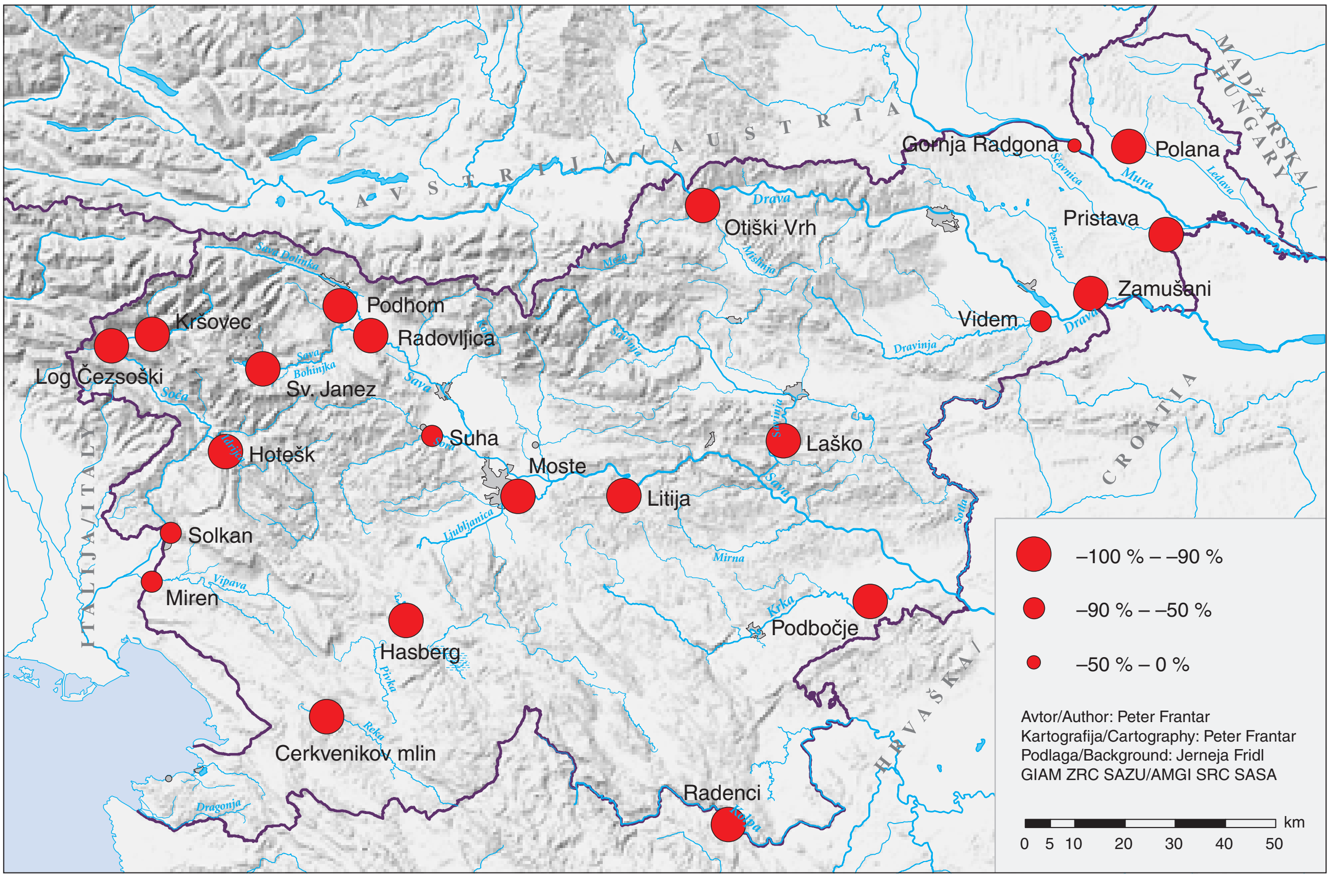
The trend of mean annual discharges – Qs is a decreasing one at all the analysed water gauging stations. With the exception of the Mura, Dravinja, Sora, Soča at Solkan and Vipava rivers, which do not exhibit a statistically significant decrease in the mean annual discharges, all the other streams exhibit a statistically significant decrease in the quantity of water (Figure 45), irrespective of the length of the set used. The trend of the mean annual discharges indicates a decrease in the annual quantity of water in all the landscape units of Slovenia. The decrease in discharges is first and foremost a result of the decrease in the precipitation, which directly reduces the runoff, and the increase in temperature, which in turn increases evapotranspiration.

The trends of the minimum annual discharges – Qmin were examined for the minimum annual mean daily discharges (Qmin1), minimum 7-day (Qmin7) and minimum 30-day (Qmin30) discharges. Analysis of the minimum mean daily discharges (Qmin1) indicates a statistically significant decreasing trend at the selected water



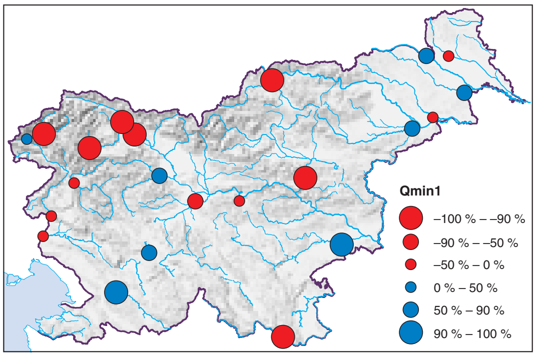
Slika 45: *Stopnja značilnosti trenda srednjih letnih pretokov*

Figure 45: *The significance rate of the trend of mean annual discharges*



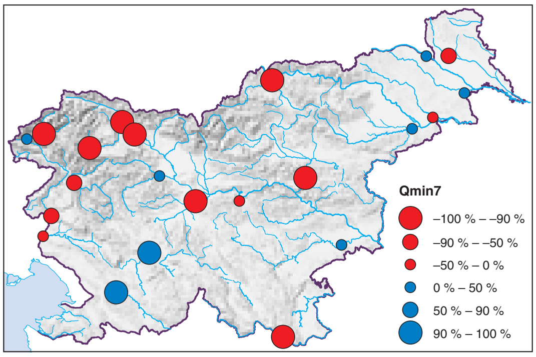
Slika 46: *Stopnja značilnosti trenda srednjih letnih pretokov*

Figure 46: *The significance rate of the trend of mean annual discharges*



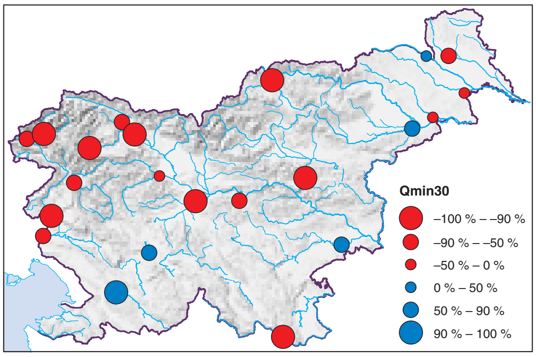
Slika 47: *Stopnja značilnosti trenda najmanjših dnevnih pretokov (Qmin1)*

Figure 47: *The significance rate of the trend of minimum daily discharges (Qmin1)*



Slika 48: *Stopnja značilnosti trenda najmanjših letnih pretokov 7-dnevnega trajanja (Qmin7)*

Figure 48: *The significance rate of the trend of the minimum annual discharges with 7-day duration (Qmin7)*



Slika 49: *Stopnja značilnosti trenda najmanjših letnih pretokov 30-dnevnega trajanja (Qmin30)*

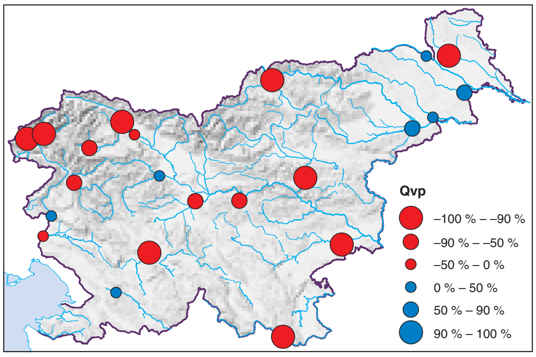
Figure 49: *The significance rate of the trend of the minimum annual discharges with 30-day duration (Qmin30)*

(Qmin7) in najmanjše 30-dnevne (Qmin30) pretoke. Analiza najmanjših srednjih dnevnih pretokov (Qmin1) kaže na statistično značilen trend upadanja na izbranih vodomernih postajah z gorskim zaledjem. Naraščajoč trend teh pretokovnih nizov je zaznan na kraškem in vzhodnem predelu Slovenije, statistično značilen je na Krki in Reki. Podobna geografska razporejenost se kaže tudi pri najmanjših pretokih daljšega trajanja (Qmin7 in Qmin30). Število vodomernih postaj z naraščajočim trendom je vse manjše, z upadajočim pa je vse večje. Radovna ima izrazito upadajoč trend najmanjših letnih pretokov Qmin1 in Qmin7, Ljubljanica pa Qmin7 in Qmin30. Pri naraščajočem trendu ima izrazite vrednosti Unica za Qmin7 in Krka za Qmin1 ter Reka za vse male pretoke, kjer pa gre najverjetneje za umetni vpliv vodnih zadrževalnikov Molja in Klivnik v njenem zaledju.

Trendi največjih letnih pretokov – Qvp izkazujejo manjšo statistično značilnost kot trendi srednjih dnevnih pretokov. Večina analiziranih vodomernih postaj izkazuje upadajoč trend, ki je statistično značilen na Ledavi in Meži, pritokih Save (na Radovni, Unici, Savinji, Krki in Kolpi) ter na vodomernih postajah zgornje Soče (Kršovec, Log Čezsoški). Neznačilen rastoč trend izkazujeta le Dravinja in Ščavnica. Trendi na ostalih rekah niso statistično značilni (slika 50).

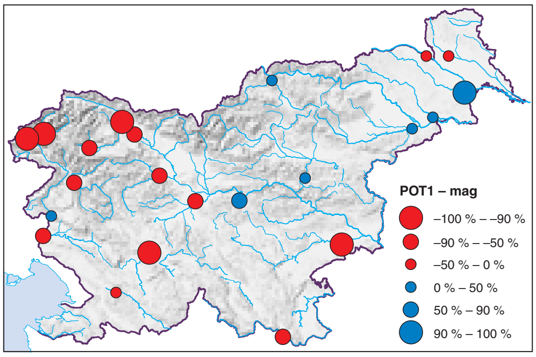
gauging stations for mountain catchment areas. An increasing trend was observed in these discharge data sets on the karstic and eastern areas of Slovenia, and is statistically significant on the Krka and Reka rivers. A similar geographical distribution is also exhibited in the longer duration minimum discharges (Qmin7 and Qmin30). The number of water gauging stations with an increasing trend is getting smaller though, while the number of those with a decreasing trend is ever greater. The Radovna River has a prominently decreasing trend in the minimum annual discharges Qmin1 and Qmin7, while these are Qmin7 and Qmin30 for the Ljubljanica. In the rivers with an increasing trend, the prominent values are exhibited by the Unica River for the Qmin7, the Krka River for the Qmin1 and the Reka River for all the low discharges, most probably caused by the artificial impact of the Molja and Klivnik water reservoirs in its catchment area.

Trends of the maximum annual discharges – Qvp indicate a lower statistical significance than the trends of the mean daily discharges. The majority of the water gauging stations analysed indicate a decreasing trend, which is statistically significant on the Ledava at Meža, on tributaries of the Sava (on the Radovna, Unica, Savinja, Krka and Kolpa rivers) as well as on the water



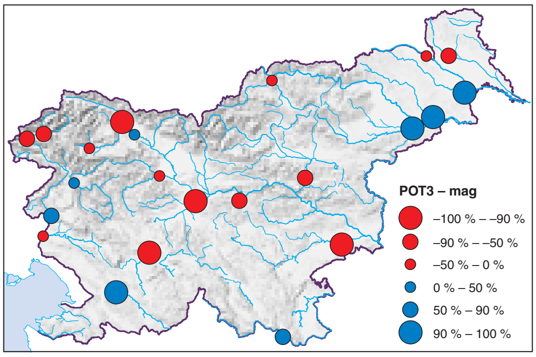
Slika 50: *Stopnja značilnosti trenda največjih letnih pretokov (Qvp)*

Figure 50: *The significance rate of the trend of the maximum annual discharges (Qvp)*



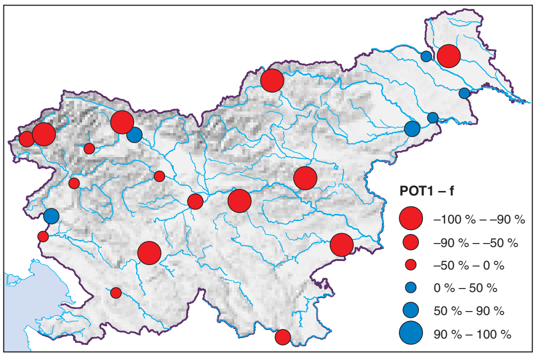
Slika 51: *Stopnja značilnosti trenda izrazitosti pojavljanja visokih ekstremov – v povprečju enkrat letno*

Figure 51: *The significance rate of the trend of the prominence of the occurrence of high extremes – on average once a year*



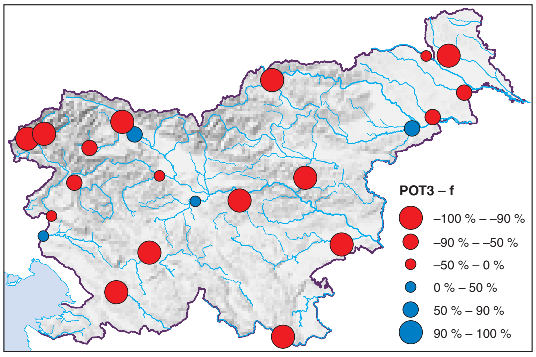
Slika 52: *Stopnja značilnosti trenda izrazitosti pojavljanja visokih ekstremov – v povprečju trikrat letno*

Figure 52: *The significance rate of the trend of the prominence of the occurrence of high extremes – on average three times a year*



Slika 53: *Trendi pogostosti pojavljanja visokih ekstremov – v povprečju enkrat letno*

Figure 53: *The trends of the frequency of the occurrence of high extremes – on average once a year*



Slika 54: *Trendi pogostosti pojavljanja visokih ekstremov – v povprečju trikrat letno*

Figure 54: *The trends of frequency of the occurrence of high extremes – on average three times a year*

Indeks izrazitosti pojavljanja visokih ekstremov (v povprečju ena vrednost na leto – POT1 mag) izkazuje podobno pokrajinsko raznolikost kot trendi največjih letnih pretokov (Qvp), z večinoma upadajočim trendom. Statistično značilen upadajoč trend imajo Radovna in Krka ter Soča v zgornjem toku, naraščajoč trend pa samo Ščavnica. Preostale lokacije ne izkazujejo značilnih trendov POT1 mag. Pri indeksu izrazitosti pojavljanja visokih ekstremov s pojavnostjo trikrat letno (POT3 mag) se slika spremeni: poveča se število vodomernih postaj z naraščajočim trendom, ki so statistično značilni za Ščavnico, Dravinjo, Pesnico in Reko. Statistično značilni upadajoči trendi pa so na Ledavi, Radovni, Ljubljanici, Unici in Krki. Ostale analizirane reke nimajo značilnih trendov izrazitosti ekstremov.

Pogostost visokih ekstremov indeksov POT1-f in POT3-f kaže v pretežni meri na upadajoč trend, ki je statistično značilen za skoraj polovico merilnih mest. Pri pojavu visokih ekstremov s pojavnostjo trikrat letno je značilnih 11, pri pojavu ekstremov z enkrat letno pojavnostjo pa 8 upadajočih trendov, kar kaže, da se število ekstremnih visokovodnih dogodkov na leto zmanjšuje.

Ob pregledu značilnosti trendov po porečjih lahko za **Pomurje** zaključimo, da so trendi pretokov največje Pomurske reke Mure statistično neznačilni. To je domnevno posledica energetske rabe vode Mure v Avstriji. Ščavnica in Ledava izkazujeta statistično značilen upadajoč trend srednjih letnih pretokov, Ledava pa nakazuje upadajoči trend največjih letnih srednjih dnevnih pretokov. Pri Ledavi so upadajoči tudi trendi izrazitosti in pogostosti pojavljanja velikih ekstremov. Pretoki Ščavnice izkazujejo statistično značilen naraščajoč trend pri časovnih vrstah statističnih indeksov POT1-mag in POT3-mag.

Med analiziranimi rekami **Podravja** ima Meža najbolj statistično značilne trende. Razen obeh indeksov izrazitosti pojavljanja visokih ekstremov (POT1-mag in POT3-mag) se pri

gauging stations of the upper Soča River (Kršovec, Log Čezsoški). A non-significant increasing trend is only exhibited by the Dravinja and Ščavnica rivers. The trends on other rivers are not statistically significant (Figure 50).

The index of the prominence of the occurrence of high extremes (on average, one value per year – POT1 mag) indicates a similar regional diversity to the trends of the maximum annual discharges (Qvp) with a predominantly decreasing trend. A statistically significant decreasing trend is exhibited by the Radovna and Krka rivers as well as the Soča in its upstream part, while only the Ščavnica exhibits an increasing trend. The remaining locations do not exhibit significant POT1 mag trends. With the significance index of the occurrence of high extremes three times a year (POT3 mag), the picture changes. The number of water gauging stations with an increasing trend increases, with the Ščavnica, Dravinja, Pesnica and Reka rivers being statistically significant. Statistically significant decreasing trends were observed on the Ledava, Radovna, Ljubljanica, Unica and Krka rivers. The other rivers analysed do not exhibit significant trends in prominent extremes.

To a considerable extent, the frequency of the high extremes of the POT1-f and POT3-f indexes indicates a decreasing trend that is statistically significant for almost a half of the stations. The phenomenon of high extremes occurring three times a year has 11 significant trends, while the phenomenon of extremes occurring once year has 8 decreasing trends, showing that the number of extreme high-water events occurring in a year is decreasing.

Overview of the trends by river basins shows us that discharge trends of the largest River Mura in the **Mura river basin**, are statistically non-significant. This is presumed to be the result of the use of the water from the Mura for energy generation in Austria. The Ščavnica and Ledava exhibit a statistically significant decreasing


BLAŽ KOŠAK

Slika 55: *Klop na Otočcu*

Figure 55: *Bench in Otočec*

Meži nakazujejo statistično značilni upadajoči trendi. Od ostalih izbranih rek tega območja ima Pesnica statistično značilen le upadajoč trend srednjih letnih pretokov (Qs) in naraščajoči trend izrazitosti visokega ekstrema nad pragom POT3-mag. Trendi ostalih hidroloških indeksov v Zamušanih niso statistično značilni. Dravinja pri Vidmu, razen naraščajočega trenda izrazitosti pojavljanja visokih ekstremov POT3-mag, ne izkazuje statistično značilnega trenda.

Analiza časovne vrste srednjih dnevnih pretokov Qs na vseh izbranih vodomernih postajah **porečja Save** izkazuje upad, ki je, razen na Sori, statistično značilen.

Na Savi je statistično značilen upadajoči trend zaznati še pri malih pretokih Qmin1, Qmin7 in Qmin30 v Radovljici. V Litiji sta neznačilni upadajoči pogostosti visokega ekstrema (POT1-f in POT3-f). Značilnost upadajočega trenda malih pretokov se zmanjšuje navzdol po Savi. Pogostost pojavljanja ekstremov visokih voda ima v Radovljici neznačilen trend, medtem ko je trend v Litiji značilno upadajoč. Trend Qvp na izbranih vodomernih postajah Save ni statistično značilen.

Pritoka Save, Radovna in Sava Bohinjka, izkazujeta v večini analiziranih hidroloških indeksov upadajoč trend. Srednji letni in mali pretoki so na obeh rekah izkazali nad 98 % statistično značilnost. Upadanje trendov Qvp, pogostosti in izrazitosti visokega ekstrema so statistično značilni na Radovni, na Savi Bohinjki pa nekoliko manj (86 %). Za alpska pritoka Save je torej značilno bolj ali manj izrazito upadanje vodnih količin in delno tudi hidroloških visokih ekstremov.

Sora z zaledjem v predalpskem svetu ne izkazuje statistično značilnih trendov spreminjanja pretokov, celo srednji letni pretok izraža le blago statistično neznačilno upadanje. Pri malih pretokih je zaznati tendenco statistično neznačilnih porastov.

trend in the mean annual discharges, while the Ledava exhibits a decreasing trend in the maximum annual mean daily discharges. In the Ledava, the trends of the prominence and frequency of high extremes are also decreasing. The discharges of the Ščavnica are exhibiting a statistically significant increasing trend in the time series of the statistical indexes POT1-mag and POT3-mag.

The Meža River has the most statistically significant trends of the rivers of the **Drava river basin** that were analysed. Except for the two indexes of the prominence of the occurrence of high extremes (POT1-mag and POT3-mag), the Meža exhibits statistically significant decreasing trends. Of the other selected rivers of this area, the Pesnica has a statistically significant decreasing trend in the mean annual discharges (Qs) and an increasing trend in the prominence of a high extreme exceeding the POT3-mag threshold. The trends of other hydrological indexes in Zamušani are not statistically significant. The Dravinja River at Videm does not exhibit a statistically significant trend, except for an increasing trend in the prominence of the occurrence of the POT3-mag high extremes.

Analysis of the time series on the mean daily discharges (Qs) for all the selected water gauging stations in the **Sava river basin** is showing a decrease that is statistically significant everywhere except on the Sora River. The Sava exhibits a statistically significant decreasing trend in its low discharges Qmin1, Qmin7 and Qmin30 at Radovljica. In Litija, the decreasing frequency trends of the high extremes (POT1-f in POT3-f) are non-significant. The significance of the decreasing trend for the low discharges decreases when moving down the Sava River. The frequency of the occurrence of high water extremes has a non-significant trend at Radovljica, though the trend at Litija is a significantly decreasing one. The Qvp trend at the selected water gauging stations on the Sava is not statistically significant.

The tributaries of Sava, Radovna and Sava Bohinjka exhibit a decreasing trend in the majority of the hydrological indexes analysed. The mean annual and low discharges of both rivers have exhibited a statistical significance exceeding 98%. The decreasing of the trends covering Qvp, frequency and the prominence of the high extreme are statistically significant on the Radovna, while they are slightly less so on the Sava Bohinjka (86%). The Alpine tributaries of the Sava are therefore characterised by more or less prominent decreases in the water quantities, especially of the hydrological high extremes.

Savinja s predalpskim zaledjem izkazuje izrazito padajoče trende srednjih, velikih in malih pretokov, kot tudi pogostost pojavljanja visokih ekstremov. Statistično neznačilen upad izkazuje izrazitost hidrološkega ekstrema. Hidrološka slika skoraj 100-letnega niza analiziranih podatkov se je v zadnjih letih potrdila ravno ob večkratnih visokih vodah v porečju Savinje.

Pritoki Save s kraškim zaledjem (razen Ljubljanice, ki izkazuje le blag neznačilen negativen trend) izkazujejo statistično značilen upad srednjih pretokov (Qs) in tudi upadanje velikih pretokov Qvp. Trend nizkih pretokov izkazuje statistično značilno upadanje na Kolpi in Ljubljanici, na Unici in Krki pa se kaže izrazito naraščajoč trend 7-dnevnih in 30-dnevnih malih pretokov. Unica in Krka izkazujeta tudi statistično značilen upadajoč trend izrazitosti in pogostosti ekstremov visokih voda. Upadajoč trend pogostosti hidroloških visokih ekstremov POT3-f je statistično značilen še na Kolpi, na Ljubljanici pa statistično značilnost izkazuje trend izrazitosti visokega ekstrema POT1-mag.

Značilnosti trendov rek **Jadranskega povodja** lahko strnemo v dve skupini. Na Soči smo analizirali hidrološke podatke treh vodomernih postaj z dolgim podatkovnim nizom. Najbolj izrazit upadajoč trend vseh analiziranih hidroloških indeksov izkazuje pretok Soče v Kršovcu, kjer lahko med vsemi analiziranimi vodomernimi postajami govorimo o najbolj izrazitem upadanju trendov srednjih, malih in velikih pretokov, kot tudi izrazitosti in pogostosti visokih


ARSO

Slika 56: *Soča*

Figure 56: *The Soča River*

The Sora, with its catchment area in the pre-Alpine area, does not exhibit statistically significant trends in changing discharges, with even the annual discharge only exhibiting a mild and statistically non-significant decrease. A tendency towards statistically non-significant increases can be observed in the low discharges.

The **Savinja**, with its catchment area in the pre-Alpine world, is exhibiting prominent decreasing trends in the mean, high and low discharges, as well as in the frequency of the occurrence of high extremes. The prominence of the hydrological extreme is exhibiting a statistically non-significant decrease. The hydrological picture given by the almost 100-year long data set has been confirmed in recent years during the high waters that occurred several times in the Savinja river basin.

The tributaries of the Sava, with their karstic catchment area (with the exception of the Ljubljanica, which is exhibiting a mild and non-significant negative trend), exhibit a statistically significant decrease in the mean discharges (Qs), as well as a decrease in the high discharges (Qvp). The trend of the low discharges is exhibiting a statistically significant decrease on the Kolpa and Ljubljanica, while the Unica and Krka are exhibiting a prominently increasing trend in the 7-day and 30-day low discharges. The Unica and Krka are also exhibiting a statistically significant decreasing trend in the prominence and frequency of the high water extremes. The decreasing trend of the frequency of the POT3-f hydrological high extremes is statistically significant on the Kolpa, while on the Ljubljanica the trend of the prominence of the POT1-mag high extreme is exhibiting statistical significance.

The significance of the trend of the **Adriatic river basin** is it possible to combine in two groups. On the Soča, we analysed the hydrological data from three water gauging stations with long data sets. The most prominent decreasing trend of all the analysed hydrological indexes is exhibited by the discharge of the Soča at Kršovec, where we can see the most prominent decreasing trends in mean, low and high discharges, as well as in the prominence and frequency of the high extremes among all the analysed water gauging stations. At Log Čezsoški, the decreasing of the trends Qs and Qvp, the prominence of the high extremes POT3-mag and the frequency of the high extremes are statistically significant. At Solkan, only the decreasing trend of the minimum discharges with a duration of 30 days exhibits statistical significance. The Qvp trend and the trends of the prominence and frequency of the occurrence of extremes are increasing, but remain statistically non-significant.

FLORIANA ULAGA

Slika 57: *Kamni pod vodo*

Figure 57: *Pebbles in the water*

ekstremov. V Logu Čezsoškem so statistično značilni le še upadanje trendov Qs, Qvp, izrazitost visokih ekstremov POT3-mag in pogostost visokega ekstrema. V Solkanu pa izkazuje statistično značilnost le še upadajoč trend najmanjših pretokov 30-dnevnega trajanja. Trend Qvp ter trenda izrazitosti in pogostosti pojavljanja ekstremov so naraščajoči, vendar še statistično neznačilni.

Idrijca v večini analiziranih hidroloških indeksih ne izkazuje visoke stopnje statistične značilnosti trendov. Statistično značilen je le upadajoč trend srednjih pretokov (Qs). Tudi reka Vipava ne izkazuje statistično značilnih trendov. Podatki vodomerne postaje Cerkvenikov mlin na Reki izražajo statistično značilen upadajoč trend pretokov Qs kot tudi izrazitost (POT3-mag) in pogostost pojavljanja visokih ekstremov (POT3-f). Na Reki je zaznan tudi statistično značilen naraščajoč trend pri malih pretokih: najmanjših letnih srednjih dnevnih, 7-dnevnih in 30-dnevnih, kjer gre najverjetneje za že omenjeni vpliv vodnih zadrževalnikov v zaledju.

Sklepna razmišljanja o trendih slovenskih vodotokov so sledeča. Pri analiziranju časovnega spreminjanja pretokov se je potrdila domneva o splošnem zmanjševanju količine vode v rekah. Pretoki imajo na večini analiziranih vodomernih postajah upadajoč trend srednjih dnevnih pretokov. Tudi pri trendih visokih voda je zaznati v pretežni meri upadajoč trend, z večjo prostorsko spremenljivostjo statistične značilnosti ugotovljenih trendov. Večja statistična značilnost upadajočih trendov podatkovnih nizov visokih voda je opažena na vodomernih postajah s pretežno visokogorskim in kraškim zaledjem. Naraščajoč trend ima le nekaj izmed analiziranih vodomernih postaj, pretežno v vzhodni Sloveniji. Prostorska razporeditev statistično značilnih trendov podatkovnih nizov malih pretokov je podobna. Severni, zahodni in osrednji del Slovenije kažejo zmanjševanje pretokov nizkih

In the majority of its indexes analysed, the Idrijca does not exhibit a high level of statistical significance in its trends. Only the decreasing trend of the mean discharges (Qs) is statistically significant. The Vipava River also does not exhibit statistically significant trends. The data from the Cerkvenikov mlin water gauging station on the Reka River exhibits a statistically significant decreasing trend in the Qs discharges as well as in the prominence (POT3-mag) and frequency of the occurrence of high extremes (POT3-f). On the Reka River, a statistically significant increasing trend was also observed in the low discharges: the minimum annual mean daily, 7-day and 30-day discharges, though this is most probably the result of the already mentioned impact of the water reservoirs in the catchment area.

Our **conclusions about discharge trends** on Slovenian rivers are as follow. When analysing the temporal variation of discharges, the assumption of a general decrease in water quantities in the rivers was confirmed. The discharges at the majority of the water gauging stations analysed have a decreasing trend in the mean daily discharges. Even in the high water trends, we can observe a decreasing trend to a large extent, though with a greater spatial variation in the statistical significance of the established trends. Decreasing trends with a greater statistical significance were seen in data sets for high waters, observed at water gauging stations with predominantly high-mountain and karstic catchment areas. An increasing trend is only exhibited by some of the water gauging stations analysed, predominantly in eastern Slovenia. The spatial distribution of statistically significant trends in the data sets for low discharges is similar. Northern, western and central parts of Slovenia exhibit decreasing low water discharges, while the western and southern parts exhibit an increasing of the same. A significant spatial variation in the statistical significance of the trends was also observed here. In general, we can confirm that the quantities of water in Slovenia are diminishing.

4.3.3 Specific Runoff in the 1971–2000 Period

Peter Frantar

The specific runoff tells us the quantity of water that runs off in a certain time interval per area unit – how many litres per second run off from one square kilometre on average. The average runoff can be estimated based on the measured values from the discharges at individual water gauging stations or using the water balance equation – precipitation minus evaporation ($Q = P - E$). The runoffs measured in Slovenia voda, vzhodni in južni pa naraščanje. Tudi tu je zaznana velika prostorska spremenljivost statistične značilnosti trendov. V splošnem lahko potrdimo, da se količina vode v Sloveniji zmanjšuje.

4.3.3 Specifični odtoki 1971–2000

Peter Frantar

Specifični odtok nam pove količino vode, ki odteče v določenem časovnem intervalu na enoto površine – koliko litrov na sekundo odteče v povprečju iz enega kvadratnega kilometra. Povprečen odtok lahko ocenimo na osnovi merjenih vrednosti preko pretokov posameznih vodomernih postaj ali z bilančno formulo – padavine minus izhlapevanje (Q = P – E). Izmerjeni odtoki v Sloveniji so zelo podobni izračunanim po bilančni formuli, kar kaže na pravilnost izračuna padavin in izhlapevanja.

Pri izračunavanju odtoka smo upoštevali pretoke vodomernih postaj na dotokih in odtokih iz posameznega hidrometričnega zaledja. Večja odstopanja posameznega območja od te sheme ter od sosednjih hidrometričnih zaledij kažejo na težavo meritev v vodomernem profilu ali na težave pri določitvi razvodnice. V Sloveniji je prevladujoča značilnost dolgoletnega specifičnega odtoka, da je največji v zgornjem toku in postopoma pada proti spodnjemu toku (Kolbezen et al., 1998).

Slovenija je dežela povirnih in tranzitnih (prehodnih) vodotokov. Naravnogeografska pestrost (razgiban relief, pestra vegetacijska sestava, pestra geologija, geomorfologija itd.) in lega pogojujeta zelo pestre podnebne razmere. Velika spremenljivost padavin določa še večjo spremenljivost odtoka. Razmerje med najmanjšim in največjim izračunanim odtokom po hidrometričnih zaledjih je tako več kot 20 : 1 (Tolminka : Velika Krka). Zaradi bilančnega neskladja v porečju Tolminke je realnejša ocena razmerja 18 : 1 (hidrometrično zaledje Soče pri Kobaridu : Velika Krka). Povprečni specifični odtok Slovenije obdobja 1971–2000 je 27.1 l/s/km^2. Najmanjši je v porečju Velike Krke – 4.3 l/s/km^2, največji pa v porečju Tolminke – 105.2 l/s/km^2. Splošna značilnost odtoka je, da se zmanjšuje od severo zahoda proti jugu in vzhodu države; odvisno je tudi od orografije – višji predeli imajo praviloma višji odtok.

Največji **specifični odtoki** v Sloveniji so na območju Julijskih Alp: v zahodnih Bohinjskih gorah, v zgornjem delu porečja Soče ter Save Bohinjke, Krnskem pogorju, Mangartskem pogorju in južnem pogorju Triglava. Za to območje lahko rečemo, da je tu hidrološko središče Slovenije. Tu odteče nad 70 l/s/km^2. Hidrometrična zaledja

are very similar to those calculated using the water balance formula, which indicates the correctness of the calculations of precipitation and evaporation.

When calculating the runoff, we took into account the discharges at water gauging stations at the inflows and outflows from individual hydrometric catchment areas. Increased deviations of an individual area from this scheme and from the neighbouring hydrometric catchment areas indicate problems with the measurements in the hydrometric cross-section or in the determination of the water divide. The prevailing characteristic of the specific discharge in Slovenia is that it is highest in the upstream part and gradually decreases downstream (Kolbezen et al, 1998, 29).

Slovenia is a country of headwater and transit streams. The natural-geographic diversity (complex topography, varied vegetation, varied geology, geomorphology, etc.) and its position cause very diverse climate conditions. The high variation in precipitation causes even higher variation in the runoff. The ratio between the minimum and maximum calculated runoffs by hydrometric catchment area is thus more than 20 : 1 (Tolminka : Velika Krka). Because of the water balance discrepancy in this part of the Tolminka river basin, a more realistic estimate of the ratio is 18 : 1 (the hydrometric catchment area of the Soča at Kobarid : Velika Krka). The Slovenian average specific runoff for the 1971–2000 period is 27.1 l/s/km^2. The minimum average runoff is that of the Velika Krka river basin – 4.3 l/s/km^2, and the maximum is the Tolminka river basin – 105.2 l/s/km^2. The general characteristic of the runoff is that it decreases as you move from the west to the south and east of the country; it also depends on the orography – as a rule, the higher areas have a higher runoff.

Slika 58: *Dvojno jezero*

Figure 58: *The Double Lake*

ALBERT KOLAR – SOKOL

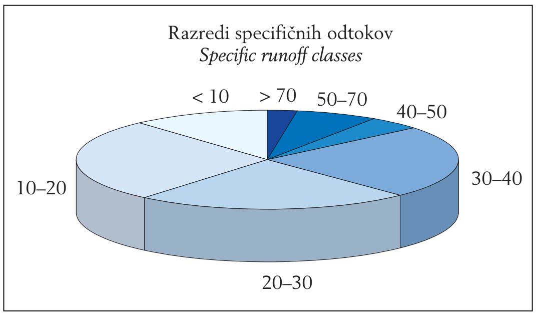
s tako velikimi povprečnimi specifičnimi odtoki zavzemajo 460 km^2, dobra 2 % površine.

V hidrometričnih zaledjih, ki obdajajo najbolj vodnate Julijske Alpe specifični odtoki še vedno presegajo 50 l/s/km^2. Večje zaključeno območje je vzhodni del naših Julijcev, visoke vrednosti izkazuje porečje Učje ter osrednje območje Idrijskega hribovja in Trnovskega gozda. V tem razredu je tudi povirje Kolpe s Čabranko, z zaledjem v pogorju Snežnika in Gorskega Kotarja. Zaledja s tolikim specifičnim odtokom merijo 1338 km^2, kar je 7 % površine.

Povprečni specifični odtok med 40 in 50 l/s/km^2 imajo območje osrednjih Kamniško Savinjskih Alp (zgornji tok Kamniške Bistrice, Lučnica), južne Bohinjske gore s predalpskim hribovjem (porečje Bače, povirje Selške Sore in Cerkniščice, Poljanska Sora) ter vzhodni in zahodni del južnega roba Trnovskega gozda in Nanosa (zaledje kraških povirij Vipave in Lijaka). Velik specifičen odtok imata tudi porečji Nadiže in Idrije, vsa ta zaledja pa zavzemajo 4,5 % površja, kar je 850 km^2.

Hidrometrična zaledja s povprečnim specifičnim odtokom med 30 in 40 l/s/km^2 zavzemajo naslednjo četrtino države – 4531 km^2. Vsa ležijo v zahodnem delu Slovenije in obsegajo pas gričevij in hribovij od severozahoda do jugovzhoda države ter pas gorskih predelov na severu. Take specifične odtoke imamo v porečju Save Dolinke in v veliki večini Kamniško-Savinjskih Alp, v predgorskem delu Julijskih Alp – območju Jelovice, spodnjem delu porečij obeh Sor, osrednje Idrijce ter delu porečja Soče od Kobarida do Solkana. V to skupino se uvršča tudi porečje kraške Ljubljanice (z okoliškimi porečji Nanoščice, Borovniščice in Gradaščice) ter osrednja dela porečij Krke in Kolpe.

Območja z odtokom »slovenskega povprečja« med 20 in 30 l/s/km^2 ležijo pretežno v osrednjem delu države. Na jugozahodnem delu je to porečje Reke v Goriških brdih, osrednje Vipave, Močilnika in povirnega dela Reke. V osrednjem delu obsega ta pas območje zahodne Ljubljanske kotline, Barja in Krimskega hribovja s pripadajočimi zaledji. Vzhodneje obsega še višje dele vzhodnih Karavank in Pohorja, osrednje dele Menine planine, Posavskega hri-



Slika 59: *Delež površine hidrometričnih zaledij s specifičnimi odtoki po razredih*

Figure 59: *The share of the surface area of hydrometric catchment areas with specific runoffs by classes*

The highest **specific runoffs** in Slovenia are in the area of the Julian Alps: in the western Bohinj mountains, in the upper reaches of the Soča and Sava Bohinjka river basin, the Krn mountain chain, the Mangart mountain chain and, in the south, the mountain chain of Mount Triglav. This area can be said to be the hydrological centre of Slovenia. In excess of 70 l/s/km^2 flow out of this area. Hydrometric catchment areas with these high average specific runoffs cover an area of 460 km^2, which is a good 2% of the surface area.

In the hydrometric catchment areas surrounding the most water-abundant Julian Alps, specific runoffs still exceed 50 l/s/km^2. A larger unbroken area here is the eastern part of the Slovenian Julian Alps, with high values exhibited by the Učja river basin and the central area of the Idrijsko hribovje hills and the Trnovski gozd. The headwaters of the Kolpa River with Čabranka, having their catchment area in the mountain chain of Snežnik and Gorski Kotar, also belong to this class. Catchment areas with this specific runoff measure 1338 km^2, which is 7% of the surface area.

An average specific runoff of between 40 and 50 l/s/km^2 is exhibited by the area of the central Kamniško-Savinjske Alps (the upstream part of the Kamniška Bistrica and the Lučnica), the southern Bohinj mountains with their pre-Alpine hills (the Bača river basin, the headwaters of the Selška Sora, Cerkniščica and the Poljanska Sora) and the eastern and western parts of the southern edge of Trnovski gozd and Nanos (the catchment area of the karstic headwaters of the Vipava and Lijak). The river basins of the Nadiža and Idrija have a high specific runoff, and all these catchment areas cover 4.5% of the surface area, or 850 km^2.

Hydrometric catchment areas with specific discharges of between 30 and 40 l/s/km^2 cover another quarter of the country – 4531 km^2. All of them lie in the western part of Slovenia and encompass a belt of hills of varying heights from the north-west to the south-east of the country and a belt of mountainous areas in the north. These discharges are observed in the Sava Dolinka river basin and in the major part of the Kamniško-Savinjske Alps, in the foothills of the Julian Alps – in the area of Jelovica, the lower part of the river basins of both the Sora rivers, central Idrijca and a part of the Soča river basin from Kobarid to Solkan. The karstic Ljubljanica river basin (with the surrounding river basins of the Nanoščica, Borovniščica and Gradaščica) belong to this class, as do the central parts of the river basins of the Krka and Kolpa rivers.

The areas with a runoff within the »Slovenian average« of between 20 and 30 l/s/km^2 lie pre-

Slika 60: *Struga reke Idrije*

Figure 60: *The riverbed of Idrija River*

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bovja in večino Bele in Suhe krajine. V tem razredu je skoraj četrtina Slovenije – 4423 km^2.

Majhen specifični odtok med 10 in 20 l/s/km^2 ima več kot 5100 km^2 območja, kar predstavlja naslednjo četrtino Slovenije. Na jugozahodu države je to osrednja Vipavska dolina, območje Reke ter Slovensko primorje, v osrednjem delu je Ljubljanska kotlina, na vzhodu pa ima take specifične odtoke območje Gorjancev, Krška kotlina in jugovzhodni del Posavskega hribovja. Večje območje je tudi v osrednjem delu porečja Savinje, Dravinje in Sotle s pritoki. Na severovzhodu je to območje zahodnega dela Slovenskih goric.

Najmanjše odtoke, pod 10 l/s/km^2, imamo na severovzhodu ter na skrajnem jugozahodu. V Primorju ima izmerjen tak specifični odtok Drnica, zagotovo ima tako majhne odtoke pretežni del obalnega Primorja ter celo Pomurje in osrednji del porečja Pesnice. Razlike so v tem pasu relativno zelo velike. V osrednjem delu Pesnice se odtaka v povprečju skoraj 10 l/s/km^2, v porečju Velike Krke pa samo dobrih 4 l/s/km^2.

Specifične odtoke lahko izrazimo tudi kot odtok izražen v mm. Geografska razporeditev seveda ostaja enaka. Izraženo v teh enotah, imamo preko 3000 mm odtoka pri Tolminki, okoliška porečja imajo v povprečju med 2000 in 2500 mm odtoka, preostali del Alp in določena predalpska območja pa imajo med 1500 in 2000 mm odtoka. Količina potem pada do majhnih odtokov pod 500 mm letno, ki ga imajo v Sloveniji posamezne reke na Primorskem,

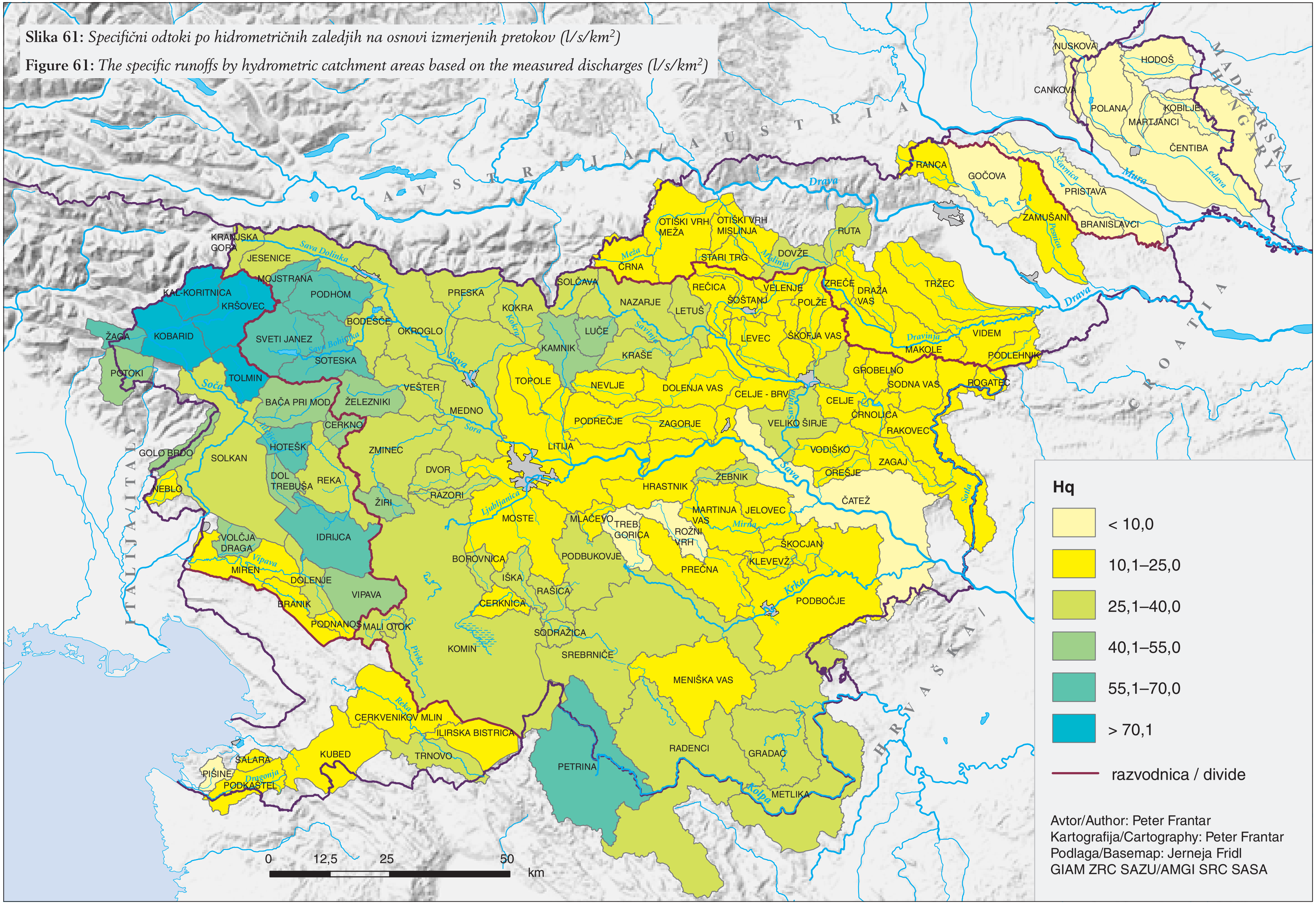
dominantly in the central part of the country. In the south-western part of the country, this is the Goriška brda region's Reka river basin, the central Vipava, Močilnik and the headwater part of the Reka. In the central part of the country, this belt encompasses the area of the western Ljubljana Basin, Barje (the Ljubljana Marshes) and the Krim highlands with appertaining catchment areas. In the eastern part, it encompasses the higher reaches of the east Karavanke Mountains and Pohorje, the central parts of Menina planina, the Posavsko hribovje hills and the majority of the Bela and Suha krajina regions. Almost a quarter of Slovenia belongs in this belt, namely 4423 km^2.

A low specific runoff of between 10 and 20 l/s/km^2 is present over more than 5100 km^2 of the area, representing another quarter of Slovenia. These specific runoffs are exhibited in the south-west of Slovenia by the central Vipava Valley, the area of the Reka and the Slovenian coast, the central part of the Ljubljana Basin and, in the east, the area of Gorjanci, the Krško-Brežice Basin and the south-eastern part of the Posavsko hribovje hills. A larger area is also present in the central part of the river basin of the Savinja, Dravinja and Sotla rivers and their tributaries. In the north-east, this area covers the western part of Slovenske gorice.

The lowest runoffs, of below 10 l/s/km^2, occur in the north-east and south-western-most part of the country. In the Primorje region, this measured runoff is characteristic of the Drnica River. Such low runoffs are present in the major part of the coastal part of Primorje, the entire Pomurje area and the central part of the Pesnica river basin. Differences in this belt are relatively high. In the central part of the Pesnica River, the average runoff is almost 10 l/s/km^2, while the Velika Krka river basin has only a good 4 l/s/km^2.

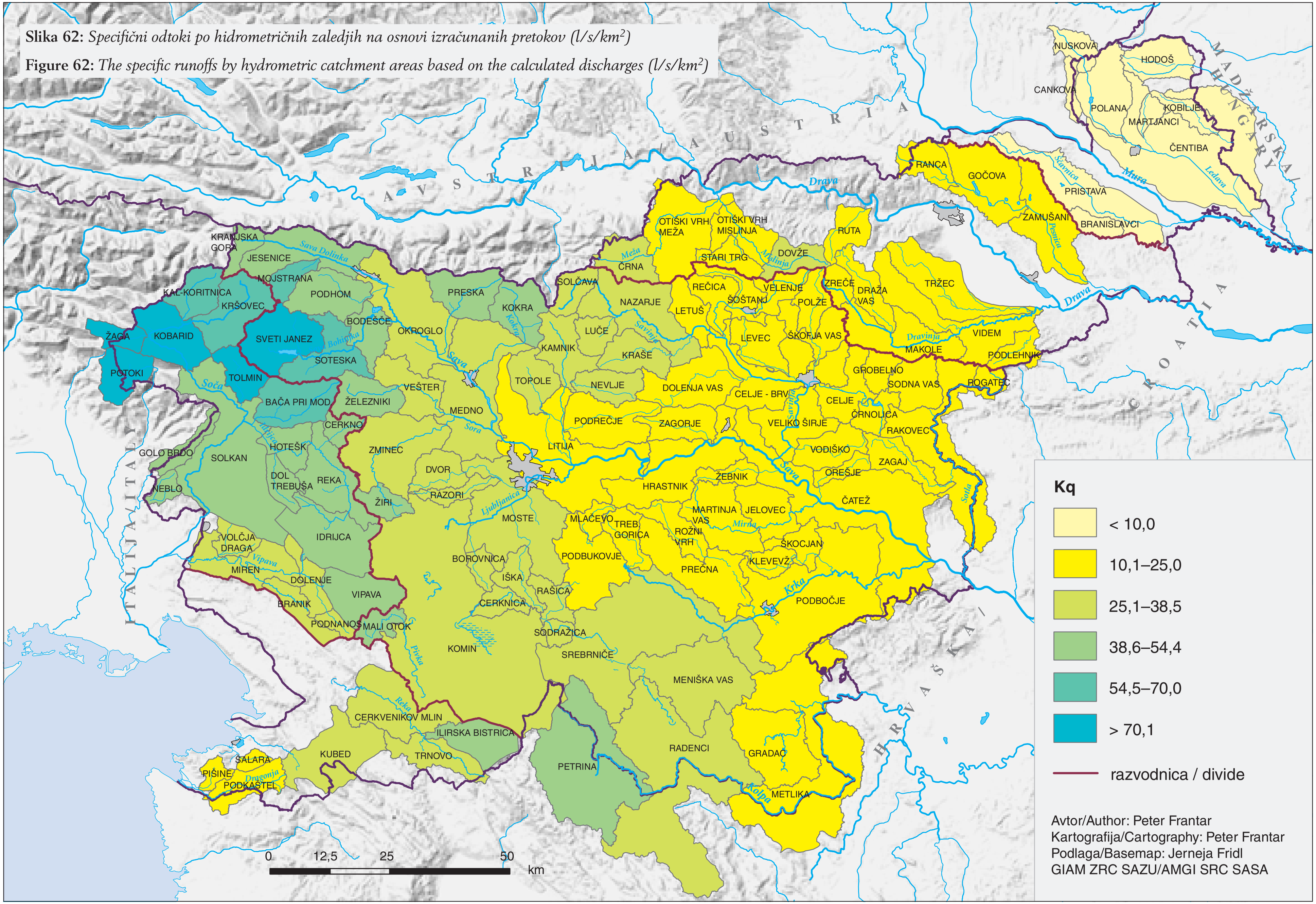
Specific runoffs can also be expressed as runoff in mm. The geographical distribution, of course, remains the same. Using these units, we have in excess of 3000 mm of runoff on the Tolminka River, while the surrounding river basins have, on average, between 2000 and 2500 mm of runoff and the remaining part of the Alps and certain pre-Alpine areas have between 1500 and 2000 mm of runoff. The quantity then drops down to lower runoffs of below 500 mm per year, which is exhibited in Slovenia by some rivers in Primorska, in the Ljubljana Basin and in eastern Slovenia. The lowest runoffs expressed in these units are below 300 mm and occur in Pomurje region.

The climate or, more precisely, the precipitation, exerts the most important effect on the specific runoff, which is also reflected in the geographical distribution. The quantity of the specific



Slika 61: *Specifični odtoki po hidrometričnih zaledjih na osnovi izmerjenih pretokov (l/s/km^2)*

Figure 61: *The specific runoffs by hydrometric catchment areas based on the measured discharges (l/s/km^2)*



Slika 62: *Specifični odtoki po hidrometričnih zaledjih na osnovi izračunanih pretokov (l/s/km^2)*

Figure 62: *The specific runoffs by hydrometric catchment areas based on the calculated discharges (l/s/km^2)*

Avtor/Author: Peter Frantar
Kartografija/Cartography: Peter Frantar
Podlaga/Basemap: Jerneja Fridl
GIAM ZRC SAZU/AMGI SRC SASA

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Slika 63: *Slap Orglice*

Figure 63: *The Orglice waterfall*

v Ljubljanski kotlini in v vzhodni Sloveniji. Najmanjši odtoki, ki merijo v teh enotah pod 300 mm, so v Pomurju.

Najpomembnejši vpliv na specifični odtok ima podnebje, in sicer padavine, kar se kaže tudi v geografski razporeditvi. Količina specifičnega odtoka se zmanjšuje od Alp in dinarskega pasu proti severovzhodu in jugozahodu, kar kaže tudi karta specifičnih odtokov, izdelana na osnovi bilančnega računa s padavinami in izhlapevanjem.

4.3.4 Odtočni količniki

Peter Frantar

Odtočni količnik je razmerje med padavinami in odtokom. Prikazuje delež odteklih padavin in je izražen v odstotkih. Odtočni količnik je odvisen od hidrogeografskih lastnosti povodja, od količine padavin, izhlapevanja, od tipa pokrovnosti tal, reliefnih in kamninskih značilnosti. Na napako izračuna nas opozorijo vrednosti količnika v bližini 100 % oz. velika odstopanja od sosednjih hidrometričnih zaledij (Kolbezen et al., 1998).

Odtočni količnik smo izračunali na dva načina. Iz izmerjenih vrednosti pretokov smo dobili »merjen odtočni količnik« KH, na podlagi rastrskih kart padavin in izhlapevanja pa »izračunan odtočni količnik« KK. Podan je pregled slednjih odtočnih količnikov, saj je pravilnost »merjenega odtočnega količnika« zelo odvisna od hidrografskih lastnosti povodja, ki so v Sloveniji zelo raznolike in zlasti na kraških predelih težko prepoznavne.

Geografska razporeditev deleža odtoka je podobna razporeditvi specifičnih odtokov. Najmanjši odtočni količniki so na severovzhodu države. V osrednjem delu Pomurja in na vzhodnem Goričkem – 20 %. Vrednosti deleža odtoka od padavin rastejo od tod proti zahodu, skladno z nadmorsko višino.

V območju Slovenskih goric so količniki med 30 (v porečju Ščavnice) ter 35 (v porečju Pesnice). Podoben delež odtoka ima tudi slovenska

runoff decreases as you move from the Alps and the Dinaric belt toward the north-east and south-west, which is also shown by the chart of specific runoffs that was produced based on the water balance equation using precipitation and evaporation data.

4.3.4 Runoff Coefficients

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The runoff coefficient is the ratio between precipitation and runoff. It shows the share of precipitation that ran off and is expressed in percentages. The runoff coefficient is dependant on the hydrogeographical properties of the catchment area, the quantity of precipitation and evaporation, the type of land cover and the topographical and geological properties. We are alerted to a calculation error by coefficient values close to 100% or by considerable deviation from the neighbouring hydrometric catchment areas (Kolbezen et al., 1998).

We calculated the runoff coefficient in two ways. We obtained the »measured runoff coefficient« (KH) from the measured discharge values and, on the basis of raster charts of precipitation and evaporation, the »calculated runoff coefficient« (KK). We also provide an overview of these runoff coefficients as the correctness of the »measured runoff coefficient« is highly dependent on the hydrographic properties of the catchment areas, which are highly diverse in Slovenia and difficult to recognise, especially in the karstic areas.

The geographical distribution of the runoff share is similar to the distribution of specific runoffs. The lowest runoff coefficients are in the north-east of the country. The coefficient is 20% in the central part of Pomurje and the eastern part of Goričko. The value of the share of runoff from precipitation increases in accordance with the elevation as you move towards the west.

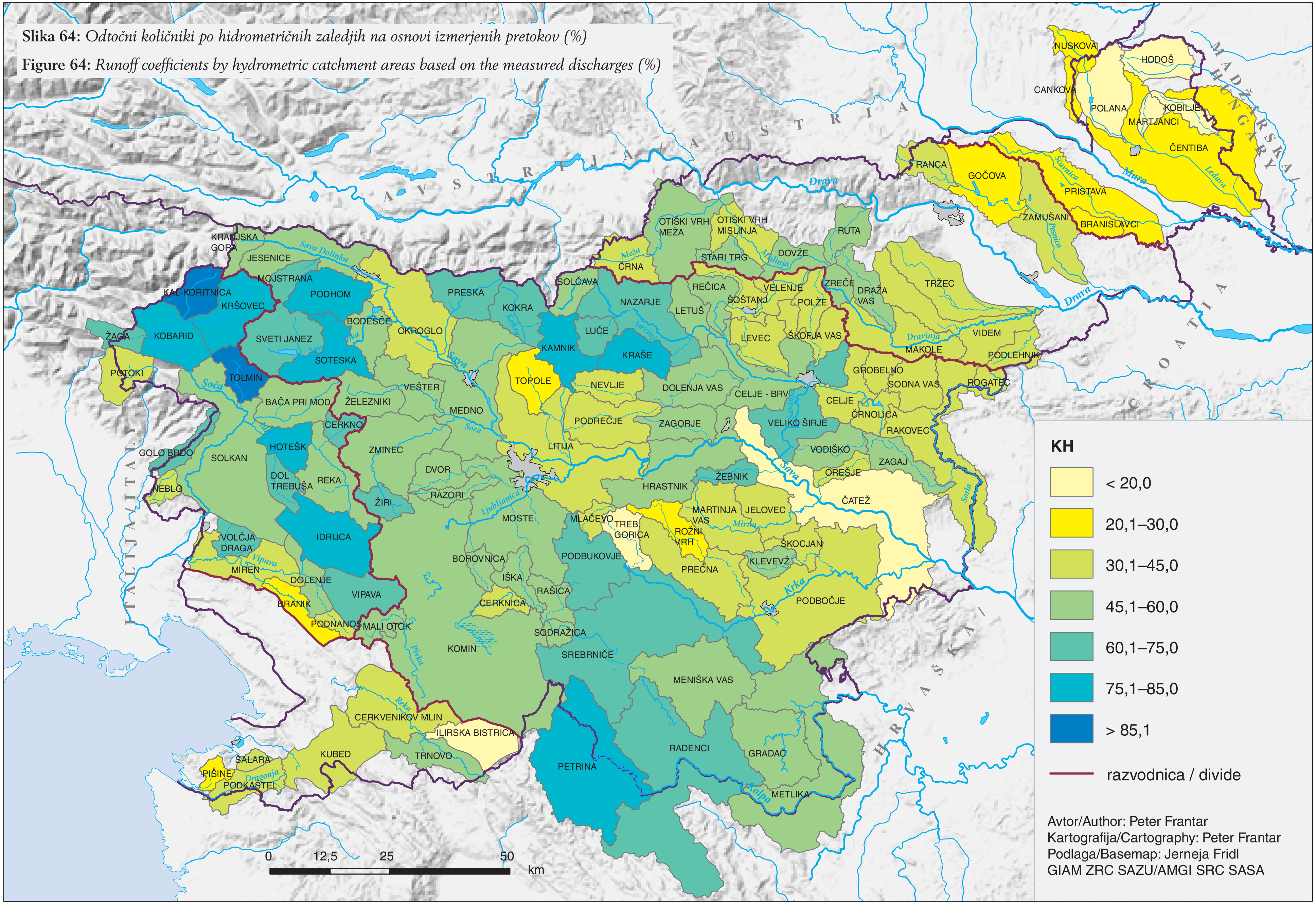
In the area of Slovenske gorice, the coefficients are between 30% (in the Ščavnica river basin) and 35% (in the Pesnica river basin). A similar share of runoff is also exhibited by the Slovenian Coast (Obala) (the river basin of the Branica, Drnica and Dragonja). Somewhat less than 40% of the precipitation also runs off from the area of Haloze.

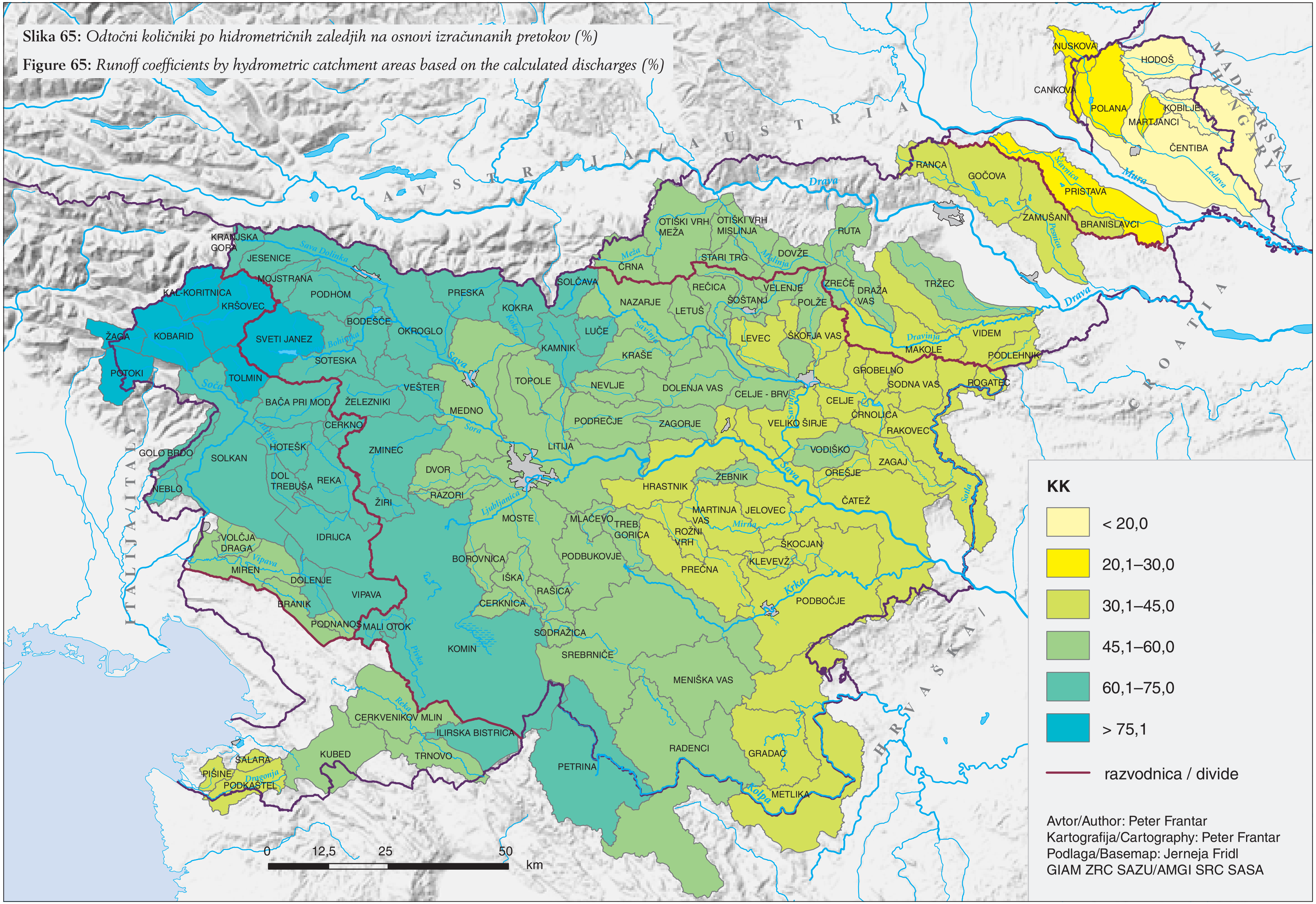
A runoff coefficient of between 40% and 45% is exhibited by the area with rivers of Polskava, Dravinja, Sotla, Hudinja and Voglajna, lower Savinja, lower Posavje region, Mirna, Radulja and the lower Krka up to the lower Pokolpje with Lahinja.

Between 45% and 60% of the precipitation flows into the Podonavje (the Danube river basin) from the highest parts of Pohorje and

Slika 64: *Odtočni količniki po hidrometričnih zaledjih na osnovi izmerjenih pretokov (%)*

Figure 64: *Runoff coefficients by hydrometric catchment areas based on the measured discharges (%)*





Slika 65: *Odtočni količniki po hidrometričnih zaledjih na osnovi izračunanih pretokov (%)*

Figure 65: *Runoff coefficients by hydrometric catchment areas based on the calculated discharges (%)*

Obala (porečja Branice, Drnice in Dragonje). Slabih 40 % padavin odteče še z območja Haloz.

Odtočni količnik med 40 in 45 ima območje od Polskave, Dravinje, Sotle, Hudinje in Voglajne, spodnje Savinje, spodnjega Posavja, Mirne, Radulje in spodnje Krke vse do spodnjega Pokolpja z Lahinjo.

Med 45 in 60 % padavin odteče v Podonavju iz najvišjih predelov Pohorja in Kobanskega, porečja Meže, Pake in srednje Savinje. Poleg teh območij je tu še pas porečij s povirji na Menini planini, osrednji del Ljubljanske kotline, Ljubljansko barje, Krimsko hribovje in zgornji deli Krke ter srednji deli Kolpe. V jadranskem povodju je tu Vipavska dolina z zaledji Vipave (razen povirja): Lijaka, Branice in Močilnika, ki se najverjetneje preko Krasa povezuje z zaledji Reke in Rižane.

Odtočni količnik med 60 in 70 imajo hidrometrična zaledja v zahodni Sloveniji. Območje sega na jugu vse od prvih gorskih pregrad med Snežnikom in Kočevskim rogom preko Javornikov, Nanosa, Trnovskega gozda in Banjšic vse do Goriških brd. Seveda pa za temi pregradami obsega tudi porečje kraške Ljubljanice, Cerkljansko, Idrijsko in Škofjeloško hribovje ter vzhodni del naših Julijskih Alp, zahodne Karavanke ter Kamniško-Savinjske Alpe.

Velike odtočne količnike, nad 70, ima manjše območje naših zahodnih Julijskih Alp: porečje Nadiže, Učje, Soče nad Kobaridom, Tolminke in Save Bohinjke z Mostnico.

Kobansko, the river basin of the Meža, Paka and central Savinja. In addition to these areas, there is also the belt of river basins with their headwaters on the Menina planina, the central part of the Ljubljana Basin, the Ljubljana Marshes, the Krim highlands, the upper parts of the Krka and the central parts of the Kolpa. In the Adriatic catchment area, this is the Vipava Valley with the hydrometrical catchment areas of the Vipava (except for the Vipava spring watershed): Lijak, Branica and Močilnik, which is most probably linked to the catchment areas of the Reka and Rižana rivers over the Karst.

A runoff coefficient of between 60% and 70% is exhibited by the hydrometric catchment areas in western Slovenia. In the south, the area reaches up to the first mountain barriers between Snežnik and Kočevski rog, over Javorniki, Nanos, Trnovski gozd and Banjšice and up to Goriška brda. Behind these barriers, it encompasses the karstic Ljubljanica river basin, the Cerkljansko, Idrijsko and Škofjeloško hribovje hills, the eastern part of the Julian Alps in Slovenia, the western Karavanke Mountains and the Kamniško-Savinjske Alps.

High runoff coefficients in excess of 70% are exhibited by a smaller area in our western Julian Alps: the river basin of the Nadiža, Učja, the Soča above Kobarid, the Tolminka and the Sava Bohinjka with Mostnica.

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Slika 66: *Zelenci poleti*

Figure 66: *Zelenci in the summer*


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Slika 67: *Slap Boka* / **Figure 67:** *The Boka waterfall*