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PRAĆENJE I OCJENA KLIME U 2018. GODINI
CLIMATE MONITORING AND ASSESSMENT FOR 2018



DRŽAVNI HIDROMETEOROLOŠKI ZAVOD
CROATIAN METEOROLOGICAL AND HYDROLOGICAL SERVICE

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PREDGOVOR

Prema izvješću Svjetske meteorološke organizacije (WMO), na temelju podataka globalnih središta za klimatske podatke, srednja godišnja temperatura u 2018. godini, koja se odnosi na prizemni sloj atmosfere i površinu mora, bila je četvrta po veličini od predindustrijskog razdoblja. Odstupanje od prosjeka za predindustrijsko razdoblje 1850. – 1900. godina bilo je $0.99 \pm 0.13^\circ\text{C}$. Za razliku od najtoplijih godina (2016. i 2017.) s pojavom El Niño događaja, 2018. godina počela je sa slabim La Niña događajem. Međuvladin panel o klimatskim promjenama (IPCC) u svom specijalnom izvješću o utjecaju globalnog zatopljenja od 1.5°C navodi da je globalna temperatura za razdoblje 2006. – 2015. godina bila 0.86°C iznad predindustrijskog prosjeka. Za usporedbu, srednja anomalija za razdoblje 2009. – 2018. godina bila je $0.93 \pm 0.07^\circ\text{C}$, dok je za razdoblje 2014. – 2018. zabilježena anomalija od $1.04 \pm 0.09^\circ\text{C}$. Oba zadnja razdoblja uključuju djelovanje El Niño događaja 2015.–2016. Iznadprosječne temperature prevladavale su i u 2018. godini. Prema podacima NOAA (National Oceanic and Atmospheric Administration), 2018. spada u 10 najtoplijih godina u Africi, Aziji, Europi, Oceaniji i Južnoj Americi.

U 2018. godini zabilježene su pozitivne anomalije oborine u odnosu na višegodišnji prosjek 1951. – 2010. godina. U nekim područjima sjeverne i istočne Afrike, Arapskom poluotoku, središnjoj i jugoistočnoj Aziji i Malajsom arhipelagu, jugozapadnoj Australiji, Novom Zelandu i istočnom dijelu Sjeverne Amerike one su iznad 90. percentila. Ispodprosječne oborine, dijelom ispod 10. percentuala, zabilježene su u središnjoj i istočnoj Australiji, sjevernoj i istočnoj obali Arapskog mora i sjeveroistoku Kaspijskog mora, kao i pojedim područjima Središnje i Sjeverne Amerike i južne Afrike. Područje leda na Arktiku bilježi minimum sredinom rujna, što je približno 28% manje od višegodišnjeg prosjeka prosjeka za razdoblje 1981. – 2010. i šesta je po redu najmanja vrijednost za rujan od početka motrenja. Antarktički ledeni pokrov je također bio ispod prosjeka za 2018. godinu. Za siječanj je površina leda bila druga najmanja, a za veljaču najmanja. Godišnji minimum se pojavio u veljači s površinom 2.28 milijuna četvornih kilometara, što je 33% manje od višegodišnjeg prosjeka te spada među najmanje površine leda od početka mjerjenja.

Godina 2018. bila je ekstremno topla i na cijelom području Republike Hrvatske. Istovremeno je prevladavalo kišno vrijeme na 7% i sušno na 3% područja, dok je preostalih 90% teritorija svrstano u kategoriju normalno. Ekstremne vremenske prilike na području Hrvatske obilježile su također 2018. godinu. Zagreb je 13. lipnja poslijepodne pogodilo grmljavinsko nevrijeme praćeno obilnom kišom i tučom. Poplavljeni su KBC Rebro, plućna bolnica Jordanovac, Ekonomski fakultet i neke škole. Zabilježeno je ukupno tridesetak intervencija is-pumpavanja vode iz prostora u istočnom dijelu grada i podsljemenskoj zoni. Na udare je puhalo vrlo jak i olujni vjetar koji je rušio i čupao stabla, a prema novinskim napisima zabilježena je i pojava pijavice. Olujno nevrijeme praćeno jakom grmljavinom i obilnom kišom pogodilo je Dubrovnik u noći s 1. na 2. listopada 2018., a prema podacima DHMZ-a u svega tri sata palo je 259.2 mm oborine, što je prouzročilo povodanju pri čemu su poplavljeni stambeni objekti kao i dio prometnica na dubrovačkom području.

dr. sc. Branka Ivančan-Picek

PREFACE

According to the report of the World Meteorological organization (WMO), based on data from global centres for climate data, 2018 finished as the fourth-warmest year globally since preindustrial time with anomaly of annual average global temperature of surface layer over land and surface temperature of ocean of $0.99 \pm 0.13^\circ\text{C}$ above the preindustrial average for the period 1850–1900. In contrast to the two warmest years (2016 and 2017), 2018 began with weak La Niña conditions. The IPCC special report on the impacts of global warming of 1.5°C reported that the average global temperature for the period 2006–2015 was 0.86°C above the pre-industrial baseline. For comparison, the average anomaly above the same baseline for the most recent decade 2009–2018 was $0.93 \pm 0.07^\circ\text{C}$, and the average for the past five years, 2014–2018, was $1.04 \pm 0.09^\circ\text{C}$ above this baseline. Both of these periods include the warming effect of the strong El Niño of 2015–2016. Above-average temperatures were wide spread in 2018. According to data from NOAA (National Oceanic and Atmospheric Administration), 2018 was ranked in the top 10 warmest years for Africa, Asia, Europe, Oceania and South America.

In 2018 large positive precipitation anomalies with respect to a 1951–2010 climatology, in some places above the 90th percentile, were observed in some regions in northern and eastern Africa, the Arabian Peninsula, central and south-east Asia and the Malay Archipelago, south-western Australia, New Zealand and eastern North America. Below-normal precipitation, partly below the 10th percentile, were found in central and east Australia, the northern and eastern coast of the Arabian Sea and north-east of the Caspian Sea, but also at some spots in Central and North America and southern Africa. The Arctic sea-ice extent reached its minimum in mid-September. The September monthly sea ice extent was 5.45 million square kilometres, approximately 28% below average and the sixth smallest September extent on record. Antarctic sea-ice extent was also well below average throughout 2018. The monthly extent in January was the second lowest, and in February the lowest. The annual minimum extent occurred in late February and the monthly average was 2.28 million square kilometres, 33% below average and ranked among the lowest in the record.

The year 2018 was extremely warm throughout the territory of Republic of Croatia. Wet weather was prevalent in 7% and dry weather in 3% of the territory of Croatia. The weather in the remaining 90% of Croatia's territory is classified as normal. An extreme weather is a characteristic of the year 2018. Zagreb was affected by a thunderstorm in the afternoon of 13 June 2018 accompanied by heavy rain and hail. Rebro and Jordanovac hospitals were flooded as well as the Faculty of Economics and Business and some school buildings. About thirty interventions of water pumping from buildings in eastern part of the city of Zagreb and Medvednica mountain zone have been done. Strong wind gusts occurred with a serious impact on environment including forest and waterspout has been observed. A severe storm brought heavy thunder and rainfall to Dubrovnik in the night between 1 and 2 October 2018. According to the data of the Croatian Meteorological and Hydrological Service, 259.2 mm of precipitation recorded in only three hours. This amount of rainfall led to flash flood, and a number of residential buildings and roads in the Dubrovnik area were flooded.

Branka Ivančan-Picek, PhD

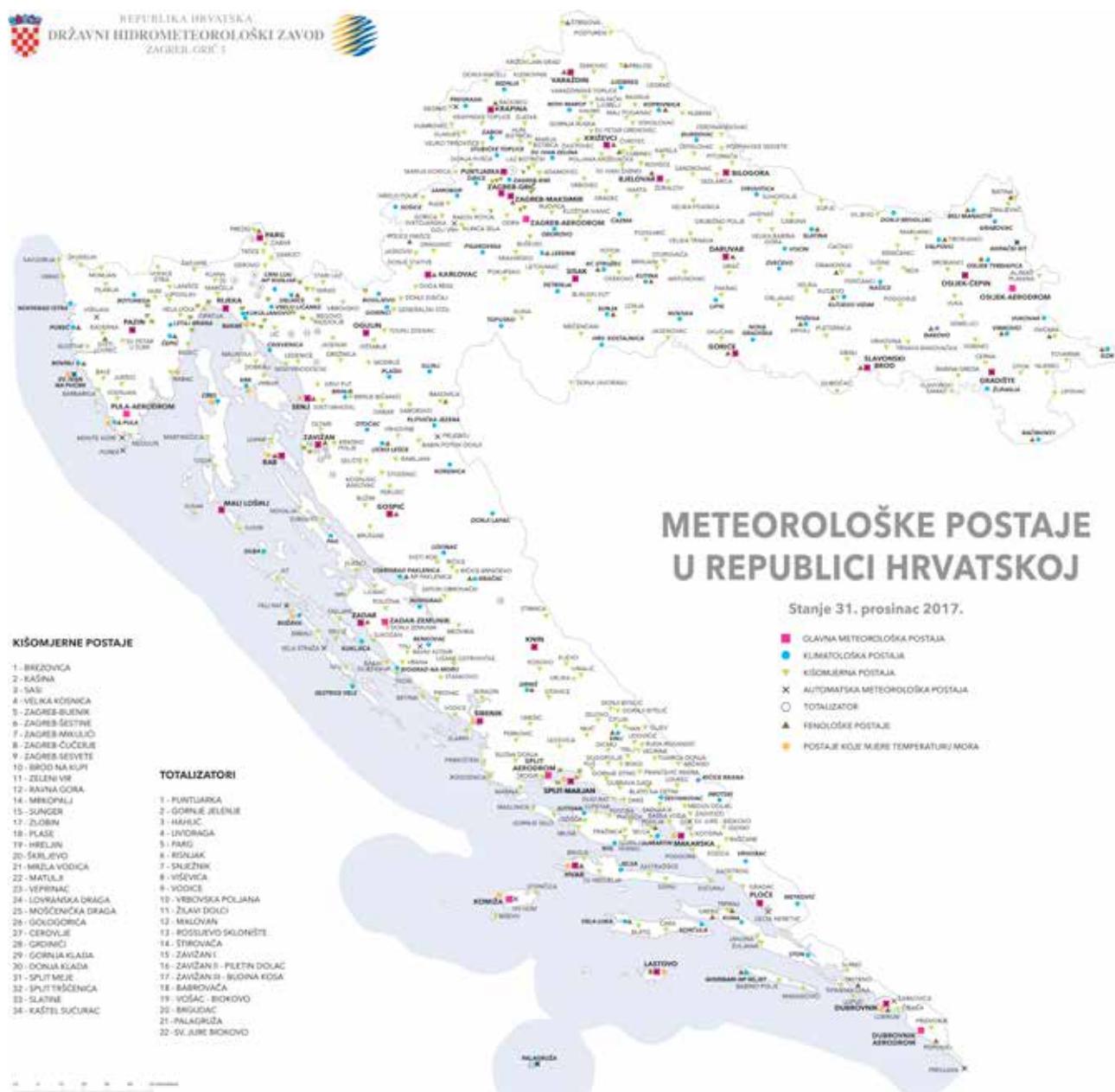
SADRŽAJ

TABLE OF CONTENTS

1.	Praćenje klime u Hrvatskoj	9
1.	Climate Monitoring in Croatia	9
2.	Kartografski prikaz mjesecnih, sezonskih i godišnjih anomalija temperature zraka i količine oborine za Hrvatsku za 2018. godinu	11
2.	Maps of monthly, seasonal and annual air temperature and precipitation anomalies in Croatia in the year 2018	11
3.	Ocjena anomalija temperature zraka i količine oborine za Hrvatsku za 2018. godinu.....	29
3.	Assessment of air temperature and precipitation amount anomalies in Croatia in the year 2018.....	29
3.1	Ocjena toplinskih i oborinskih prilika u Hrvatskoj za 2018. godinu	29
3.1	Assessment of climate anomalies in Croatia in 2018	29
3.2	Ekstremna klimatska razdoblja u 2018. godini	39
3.2	Extreme climate periods in 2018	39
3.3	Dodatna analiza klimatskih anomalija u 2018. godini	40
3.3	Additional analysis of climate anomalies in Croatia in 2018	40
3.3.1	Analiza anomalija godišnje temperature zraka i količine oborine	42
3.3.1	Analysis of annual air temperature and precipitation anomalies	42
3.3.2	Analiza dnevnih anomalija temperature zraka i količine oborine za meteorološke postaje Zagreb-Grič i Split-Marjan.....	42
3.3.2	Analysis of daily air temperature and precipitation amount anomalies for meteorological stations Zagreb-Grič and Split-Marjan	42
3.3.3	Hladni val u Hrvatskoj u veljači 2018. godine	44
3.3.3	Cold wave in Croatia in February 2018	44
3.3.4	Nevrijeme u Zagrebu, 13. lipnja 2018. godine	50
3.3.4	Severe weather in Zagreb, 13 June 2018	50
3.3.5	Nevrijeme u Dubrovniku, 2. listopada 2018. godine	55
3.3.5	Severe weather in Dubrovnik, 2 October 2018	55
4.	Ocjena klime za 2018. godinu na globalnoj ljestvici	59
4.	Climate assessment for the year 2018 on global scale	59
4.1	Temperatura zraka	59
4.1	Air temperature	59
4.2	Oborina	60
4.2	Precipitation	60
4.3	Morski led	62
4.3	Sea Ice	62
	Literatura	63
	References	63

1. PRAĆENJE KLIME U HRVATSKOJ

U okviru mreže meteoroloških postaja u Hrvatskoj djeluje sustav za praćenje klime temeljen na svakodnevnom prikupljanju klimatoloških podataka (termini 7, 14 i 21 sat) s 30 glavnih meteoroloških postaja (slika 1.1). Tako prikupljeni podaci, uz dan zakašnjenja, kompatibilni su s postojećim dugogodišnjim nizovima klimatoloških podataka koji su nastali na temelju istovrsnih klimatoloških motrenja.



Slika 1.1 Mreža meteoroloških postaja u Hrvatskoj

Figure 1.1 Meteorological Station Network in Croatia

1. CLIMATE MONITORING IN CROATIA

A climate monitoring system based on daily collection of climate data (observation times 7 am, 2 pm and 9 pm local time) from 30 main meteorological stations (Figure 1.1) is operational within the Meteorological Station Network of Croatia. With a one-day delay, the data thus collected is compared with the existing long-term climate data series generated by the same climate observations.

These are the components of the operational climate monitoring system in Croatia:

Operativni sustav praćenja klime u Hrvatskoj ima sljedeće komponente:

- Meteorološka motrenja (opražnja i mjerjenja) na 30 glavnih meteoroloških postaja;
- Dostava klimatoloških podataka pomoću HR-KLIMA izvješća svaki dan do 9 sati za klimatološke termine prethodnog dana;
- Kontrola podataka u DHMZ-u;
- Pohranjivanje podataka na računalnom sustavu DHMZ-a u obliku privremenih mjesecnih izvješća;
- Mjesecne analize klimatoloških podataka s izradom ocjene za svaki mjesec usporedbom klimatoloških podataka dotičnog mjeseca s višegodišnjim prosjekom za razdoblje 1961.–1990. godina;
- Ocjene klimatskih anomalija na razini godišnjih doba i godine kao cjeline;
- Redovito mjesecno, sezonsko i godišnje izvješćivanje javnosti, korisnika i stručnih krugova o ocjeni klime putem javnih glasila i stručnih biltena te internetske stranice DHMZ-a: http://klima.hr/ocjene_arhiva.php

Postupak ocjene klime obavlja se pomoću Conrad–Chapmanove metode (Penzar i Makjanić, 1980), koja na temelju odstupanja od višegodišnjeg prosjeka 1961.–1990. godina daje sljedeću klasifikaciju prikazanu u tablici 1.1.

Percentili predstavljaju procjenu vjerojatnosti (izraženu u postotcima) da odgovarajuća vrijednost anomalije u promatranoj razdoblju nije bila nadmašena. Na primjer, percentil 98 ukazuje da u 98% slučajeva prethodnih godina odgovarajuća vrijednost nije bila nadmašena to jest da se u stogodišnjem razdoblju mogu očekiti

- Meteorological observations at 30 main meteorological stations;
- Climate data delivery via HR-KLIMA reports by 9 a.m. every day for climate observation hours or terms from the previous day;
- Data quality control at the Meteorological and Hydrological Service of Croatia;
- Data archiving in the computer system of the Meteorological and Hydrological Service of Croatia in the form of temporary monthly reports;
- Monthly analysis of climate data with the evaluation of each month based on a comparison of climate data for the month in question with the multiannual average for the period 1961 – 1990;
- Climate anomalies assessment on seasonal or annual basis;
- Regular monthly, seasonal and annual reporting for the public, external users and the scientific community on climate evaluation using media and professional newsletters as well as the website of the Meteorological and Hydrological Service http://klima.hr/ocjene_arhiva.php.

The climate assessment procedure is based on the well-known Conrad-Chapman's method (Penzar and Makjanić, 1980). The following classification is obtained (Table 1.1) using anomalies from the multiannual average (1961 – 1990):

The percentiles are an estimated probability (expressed as a percentage) of the corresponding anomaly value in the period in question not being exceeded. For example, the 98th percentile indicates that the corresponding value was not exceeded in 98% cases in the previous years; that

Tablica 1.1 Klasifikacija klimatskih anomalija u razrede (kase) prema razdiobi percentila.

Table 1.1 Climate anomaly classification according to percentile ranks and classification ratings.

Za temperaturu	For temperature	Percentili	Percentiles
ekstremno hladno	extremely cold	< 2	
vrlo hladno	very cold	2–9	
hladno	cold	9–25	
normalno	normal	25–75	
toplo	warm	75–91	
vrlo toplo	very warm	91–98	
ekstremno toplo	extremely warm	> 98	

Za oborinu	For precipitation	Percentili	Percentiles
ekstremno sušno	extremely dry	< 2	
vrlo sušno	very dry	2–9	
sušno	dry	9–25	
normalno	normal	25–75	
kišno	wet	75–91	
vrlo kišno	very wet	91–98	
ekstremno kišno	extremely wet	> 98	

vati samo dvije godine, u prosjeku, u kojima će motrena vrijednost biti viša od razmatrane. Pomoću percentila P može se procijeniti povratni period T (izražen u godinama) iz relacije:

$$T = 100/P \quad \text{ako je } P < 50$$

$$T = 100/100-P \quad \text{ako je } P > 50$$

Na primjer za $P = 2\%$ slijedi $T = 50$ godina. Znači za percentil 2% vjerojatnost je da će se na primjer odgovarajuća temperatura zraka javiti 2 puta, u prosjeku, u 100 godina ili jedanput u 50 godina. Isti povratni period se dobije za $P = 98\%$.

Na temelju napravljene ocjene izrađuju se karte klimatskih anomalija (odstupanja od višegodišnjih prosjeka za razdoblje 1961.–1990. godina) te omeđuju područja odgovarajućih klasa (razreda) anomalija za područje Hrvatske. Te ocjene svrstavaju klimatske anomalije u klase u odnosu na navedene višegodišnje prosjekte. Taj pristup osigurava objektivnost ocjene klimatskih anomalija izbjegavajući tako subjektivnost pojedinca.

Na kartama anomalija uz svaku meteorološku postaju nazančena su dva broja. Gornji broj označava odstupanje meteorološkog elementa od višegodišnjeg prosjeka: za temperaturu zraka izraženo u Celzijevim stupnjevima ($^{\circ}\text{C}$) te za količinu oborine u postotcima (%) višegodišnjeg prosjeka. Donji broj uz postaju na kartama označava percentil prema kojem se postaja svrstava u odgovarajuću klasu. Nadalje, gornji broj omogućuje da unutar svake klase detaljnije uočimo odstupanje klimatskog elementa od višegodišnjeg prosjeka. Na primjer, unutar klase normalno, koja obuhvaća 50% percentila, mogu se pojaviti niže ili više vrijednosti temperature zraka ili količine oborine od višegodišnjeg prosjeka. Takve detaljnije analize mogu se napraviti za sve klase.

2. KARTOGRAFSKI PRIKAZ MJESEČNIH, SEZONSKIH I GODIŠNJIH ANOMALIJA TEMPERATURE ZRAKA I KOLIČINE OBORINE ZA HRVATSKU ZA 2018. GODINU

Slijedi prikaz anomalija srednjih mjesecnih, sezonskih i godišnjih vrijednosti temperature zraka definiranih kao odstupanje od višegodišnjeg prosjeka za referentno razdoblje 1961.–1990. godina. Vrijednosti anomalija temperature zraka označene su na postajama dok je bojom označena pripadnost klasi razdiobe čestina anomalija, izraženih u percentilima. Anomalije mjesecnih, sezonskih i godišnjih količina oborine za postaje izražene su u postotcima vsegodišnjeg prosjeka za navđeno referentno razdoblje dok je pripadnost klasi razdiobe čestina anomalija označena odgovarajućom bojom.

is to say, we can expect only two years, on average, with an observed value higher than what is considered the 98th percentile value in a 100-year period. According to percentile P, the return period (expressed in years) can be estimated from the expression:

$$T = 100/P \quad \text{if } P < 50$$

$$T = 100/100-P \quad \text{if } P > 50$$

For example, for the percentile $P = 2\%$, the return period is $T = 50$ years. For the percentile 2%, it means that the corresponding air temperature is likely to occur 2 times, on average, in the 100-year period or once in a 50-year period. The same return period is obtained for the percentile $P = 98\%$.

Climate anomaly maps (deviations from multiannual average 1961 – 1990) are drawn, and areas where the corresponding anomaly categories occur are demarcated for the entire Croatian territory based on the assessment obtained. These assessments classify climate anomalies into appropriate categories in relation to the mentioned multiannual averages. This approach ensures the objectivity of climate anomaly assessment.

Two numbers are specified in the climate anomaly maps for each meteorological station. The upper number describes the anomaly (deviation of the meteorological element from multiannual average), expressed in $^{\circ}\text{C}$ for temperature and in percentages (%) of the multiannual average for precipitation. The lower number specified in the maps for every station indicates the percentile. Every station falls under the appropriate category according to percentile ranks and classification ratings.

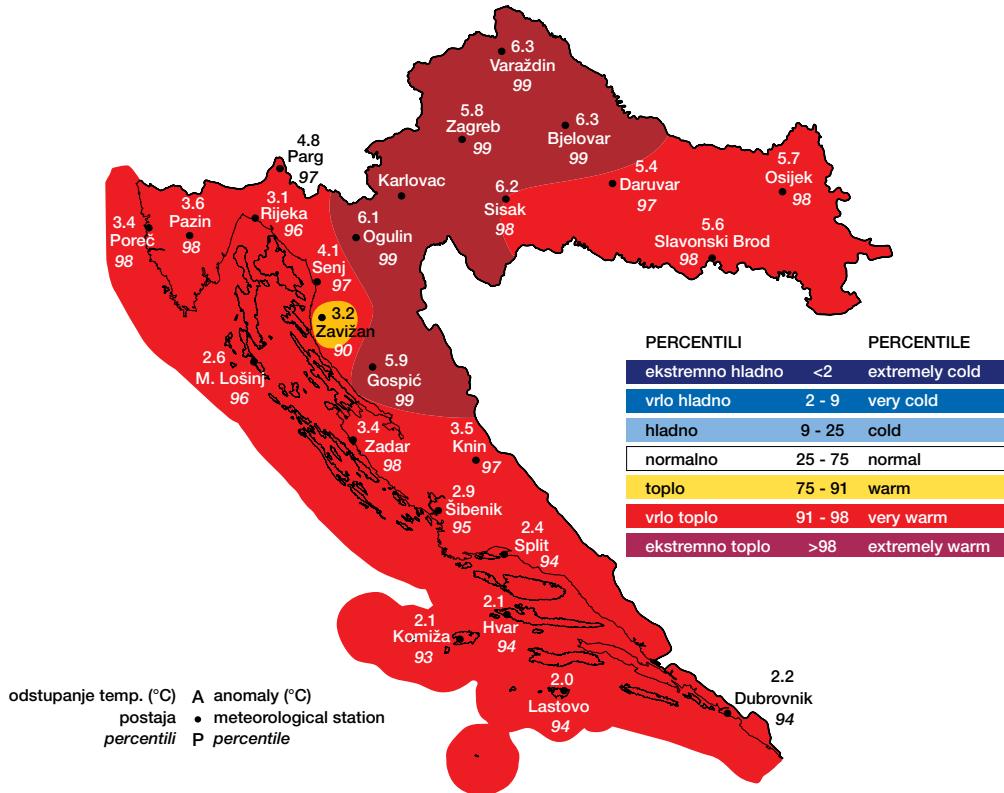
Furthermore, the upper number provides in detail the deviation of climate elements from the multiannual average in each category. For example, the value of air temperature or precipitation can be lower or higher than the multiannual average in the normal category, comprising 50% percentiles. Such detailed analyses can be made for all categories.

2. MAPS OF MONTHLY, SEASONAL AND ANNUAL ANOMALIES OF AIR TEMPERATURE AND PRECIPITATION AMOUNTS IN CROATIA IN 2018

In this section, anomalies of average monthly, seasonal and annual values of air temperature defined as a deviation from the multiannual average for the reference period 1961 – 1990 are shown as follows. The values of air temperature anomalies are indicated at the stations, and the colour describes the corresponding category of the frequency distribution of air temperature anomalies expressed in percentiles. Similarly, monthly, seasonal and annual precipitation amount anomalies for the stations are expressed in percentages of the multiannual average for the above mentioned reference period, and the colour describes the corresponding category of the frequency distribution of precipitation anomalies.

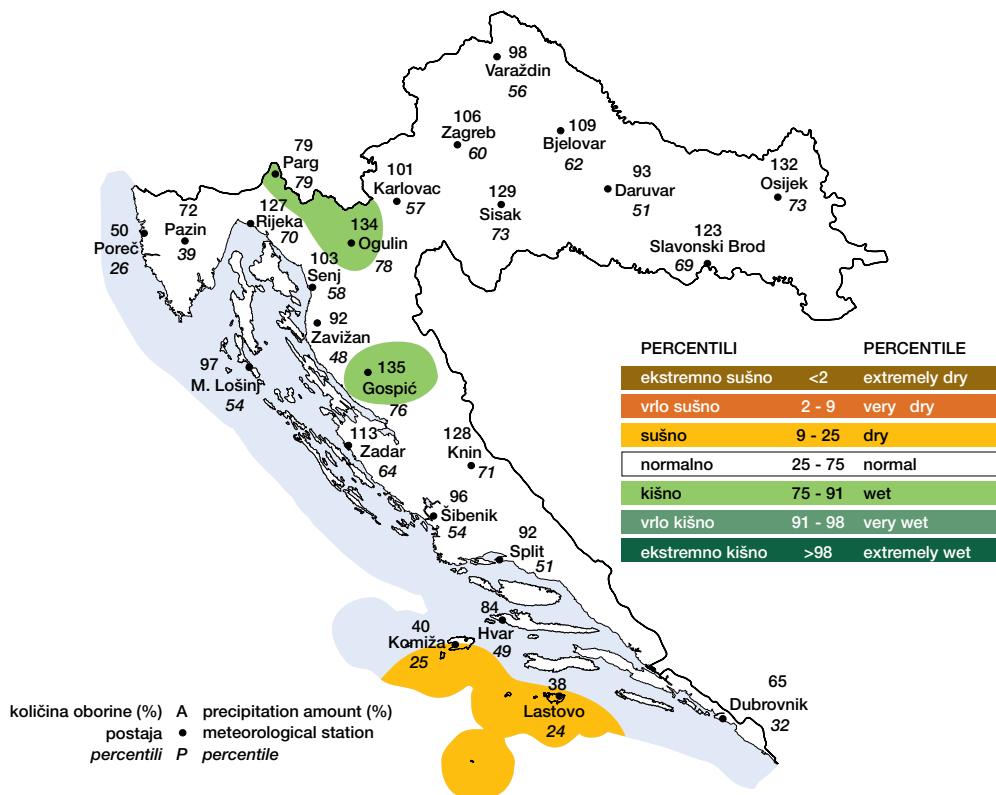
Odstupanje srednje mjesecne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za SIJEČANJ 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in JANUARY 2018



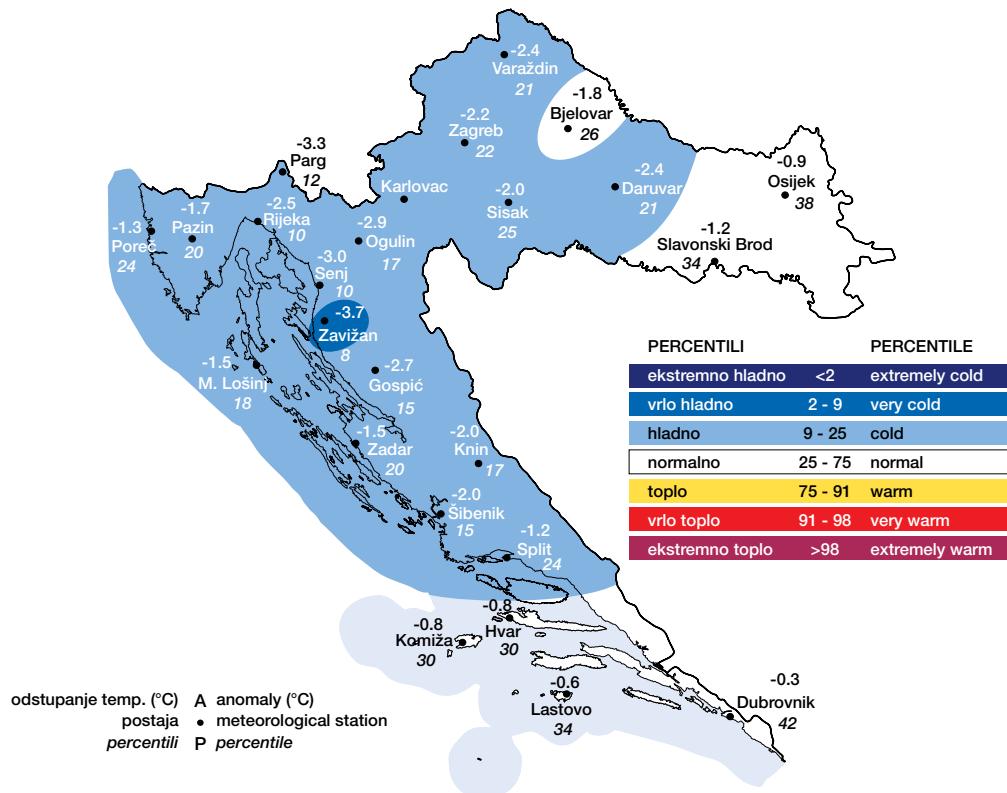
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za SIJEČANJ 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in JANUARY 2018



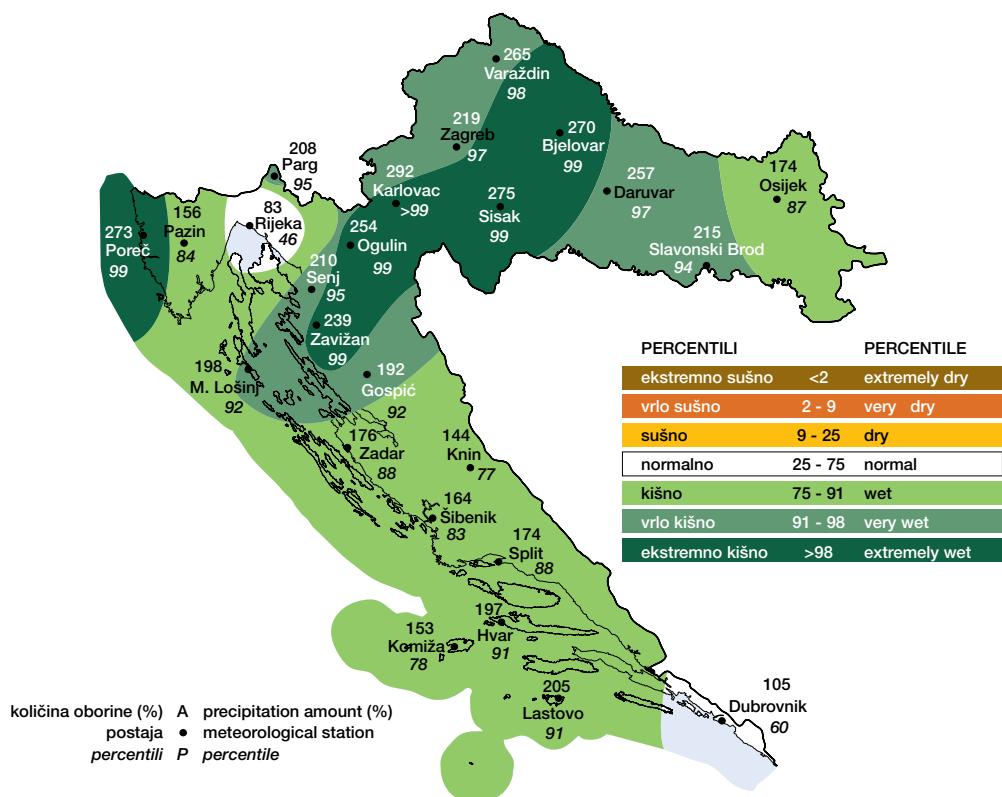
Odstupanje srednje mjesecne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za VELJAČU 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in FEBRUARY 2018



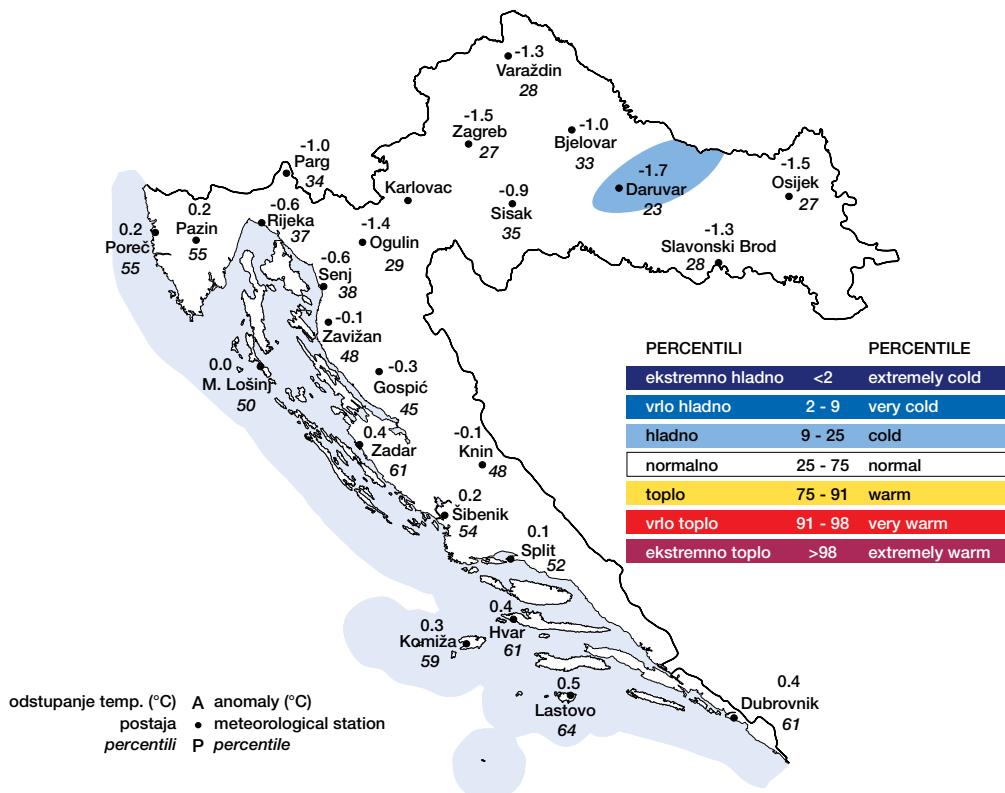
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za VELJAČU 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in FEBRUARY 2018



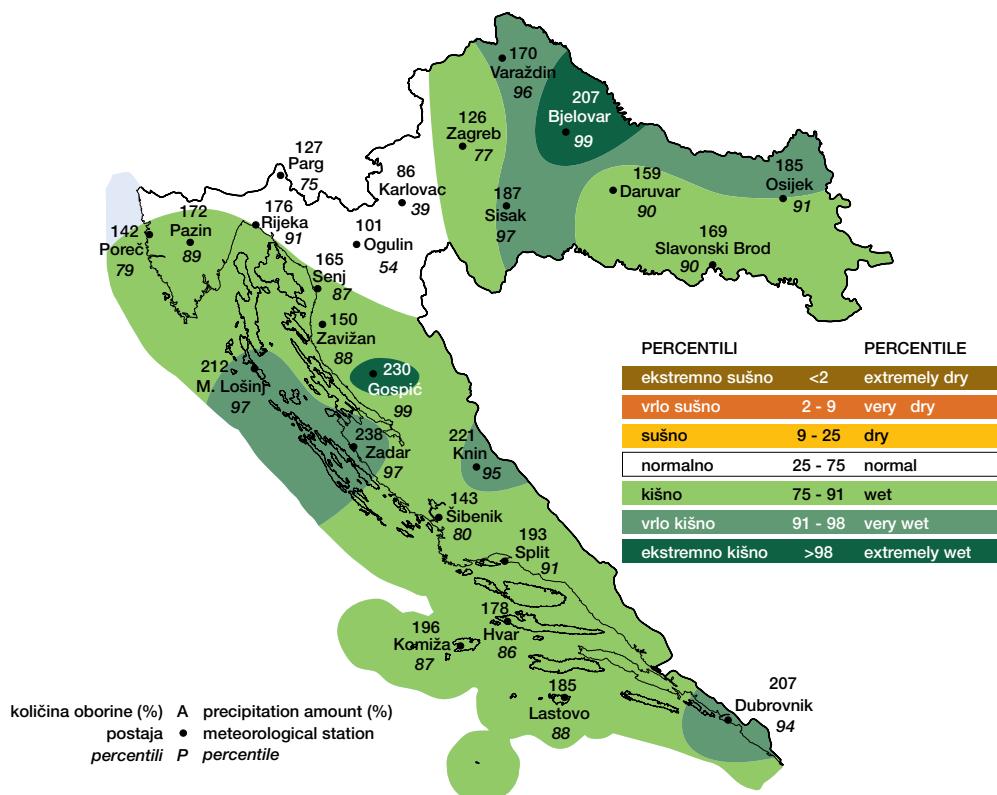
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za OŽUJAK 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in MARCH 2018



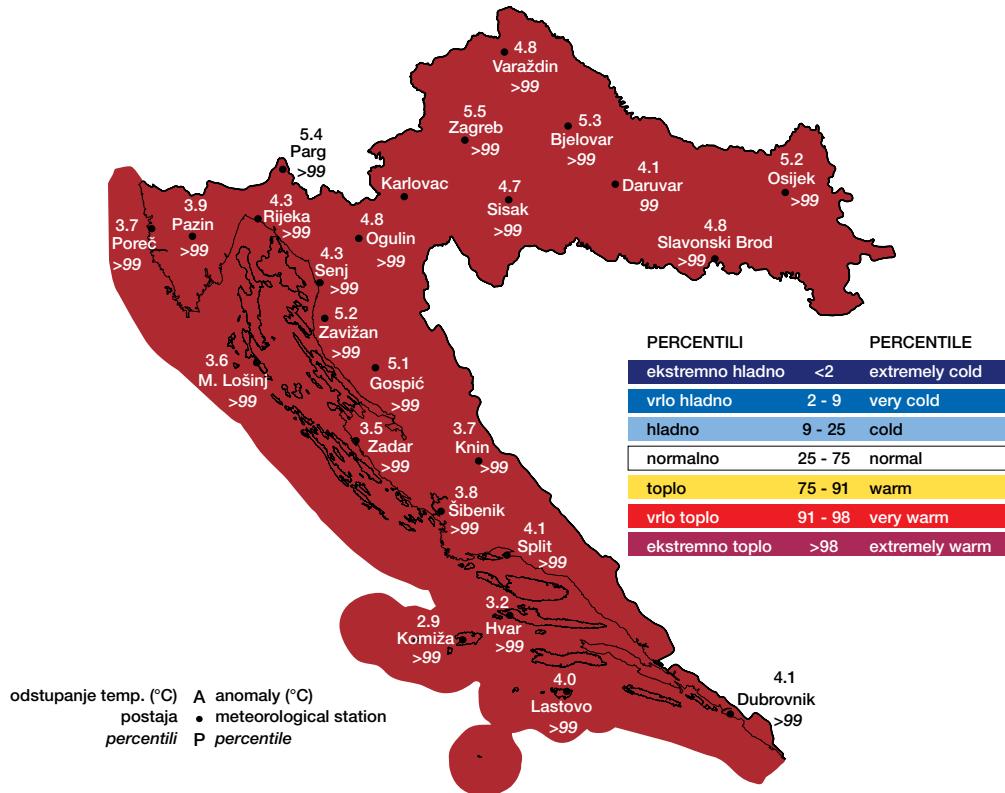
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za OŽUJAK 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in MARCH 2018



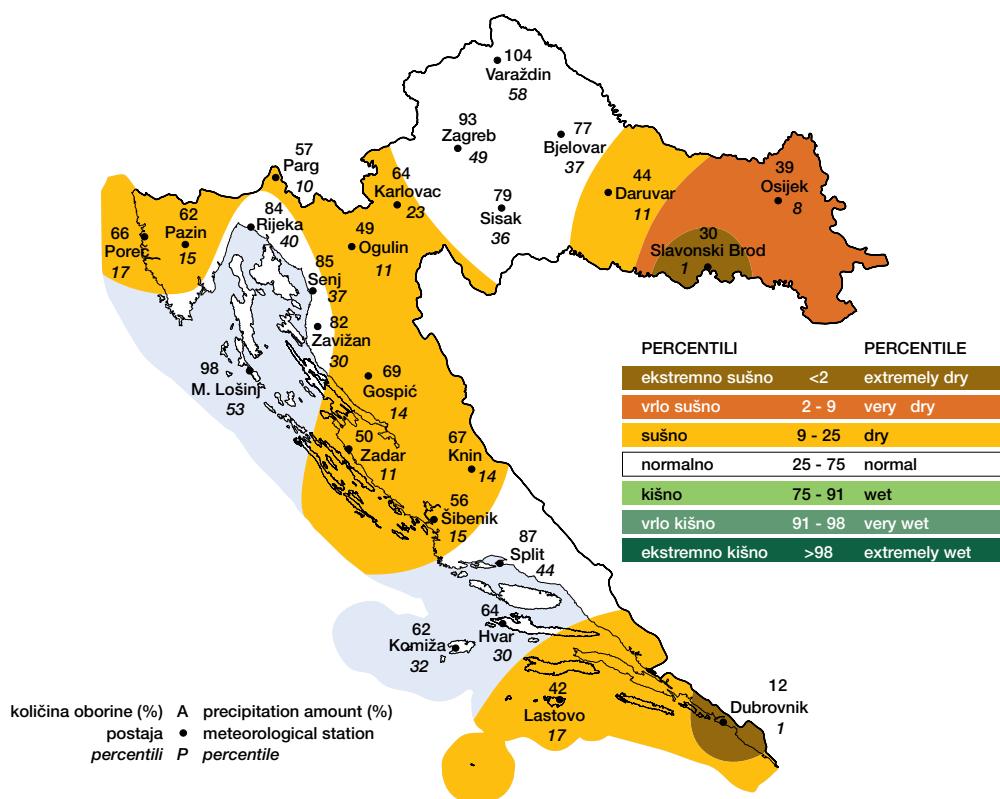
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za TRAVANJ 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in APRIL 2018



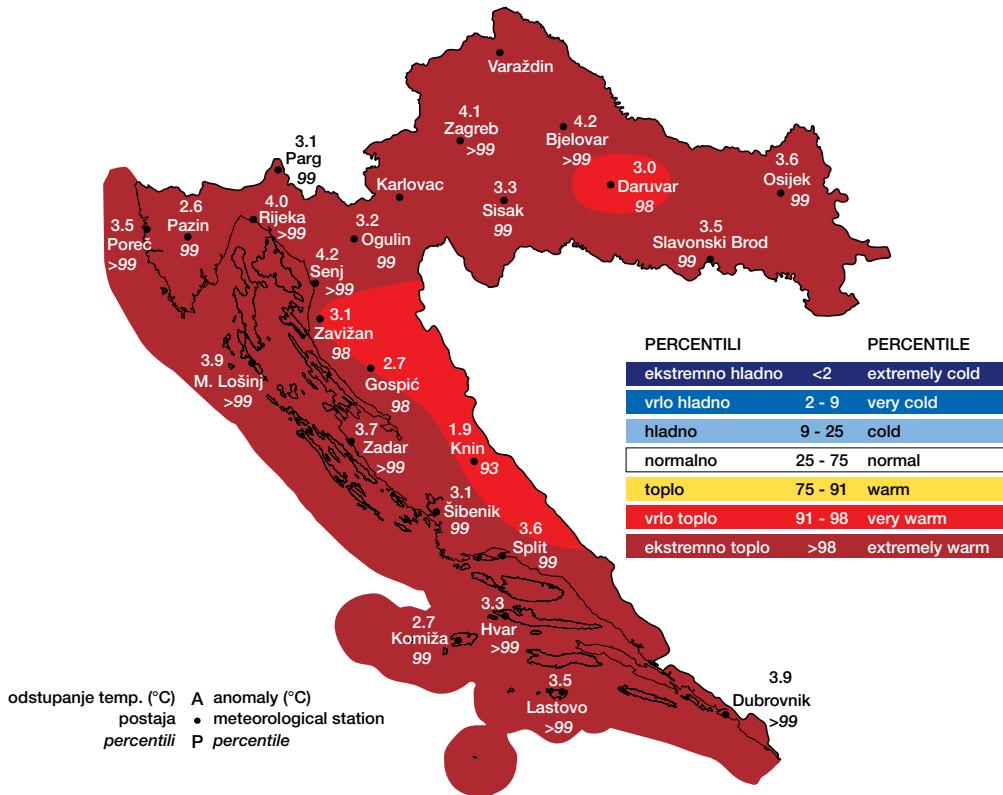
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za TRAVANJ 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in APRIL 2018



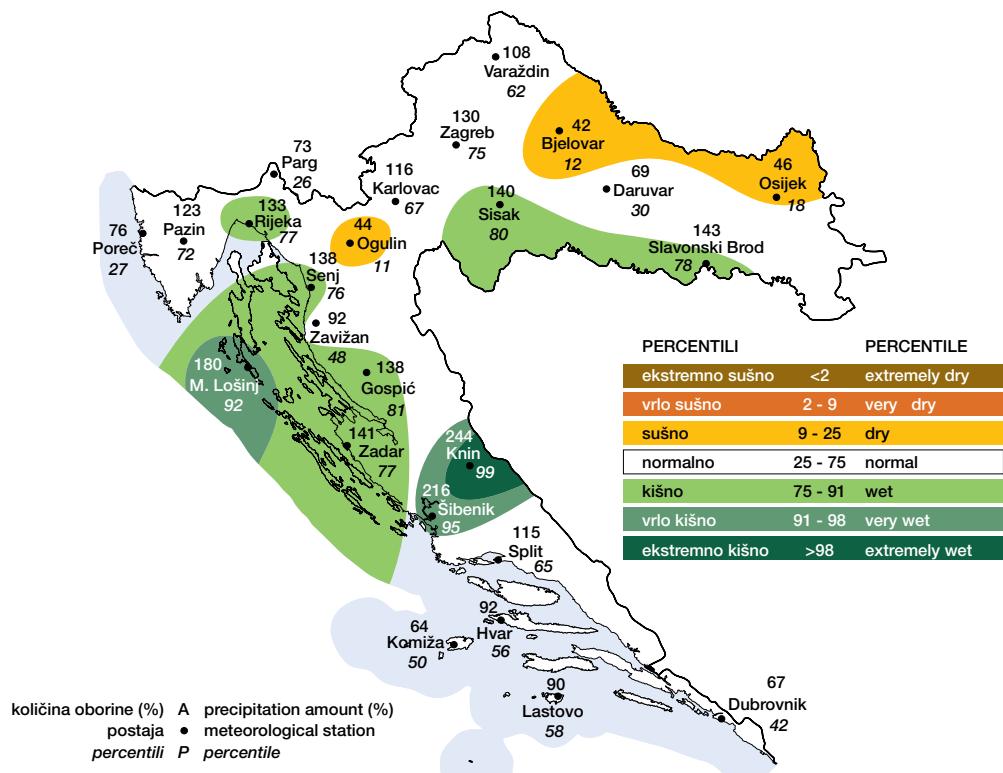
Odstupanje srednje mjesecne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za SVIBANJ 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in MAY 2018



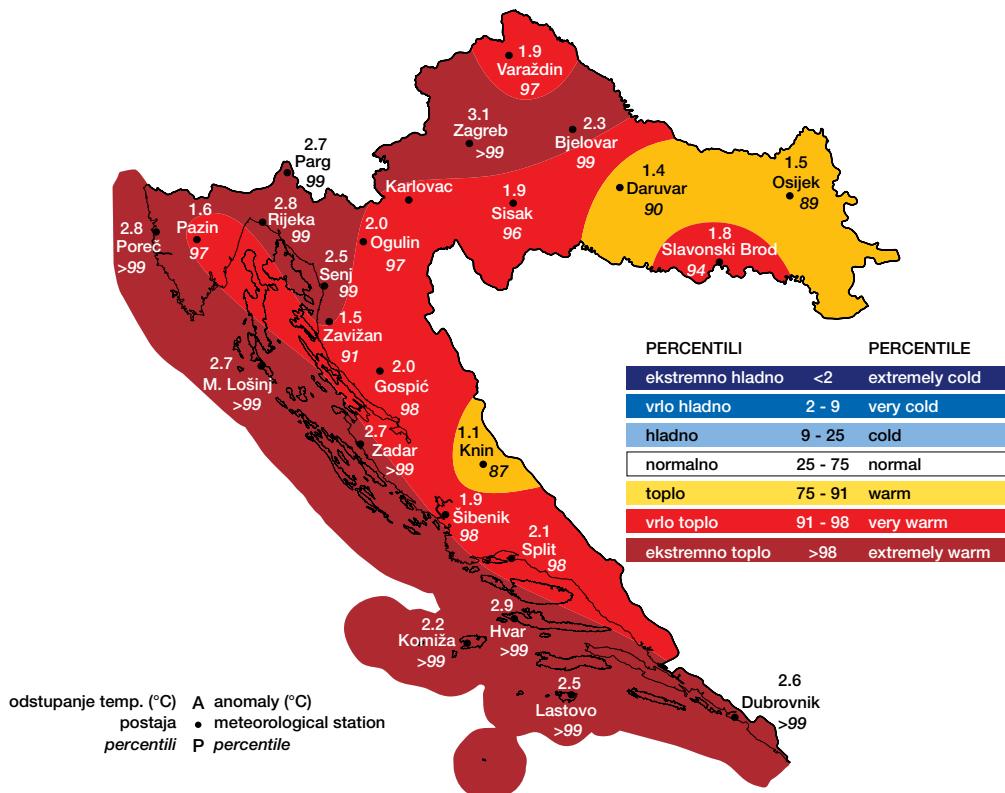
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za SVIBANJ 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in MAY 2018



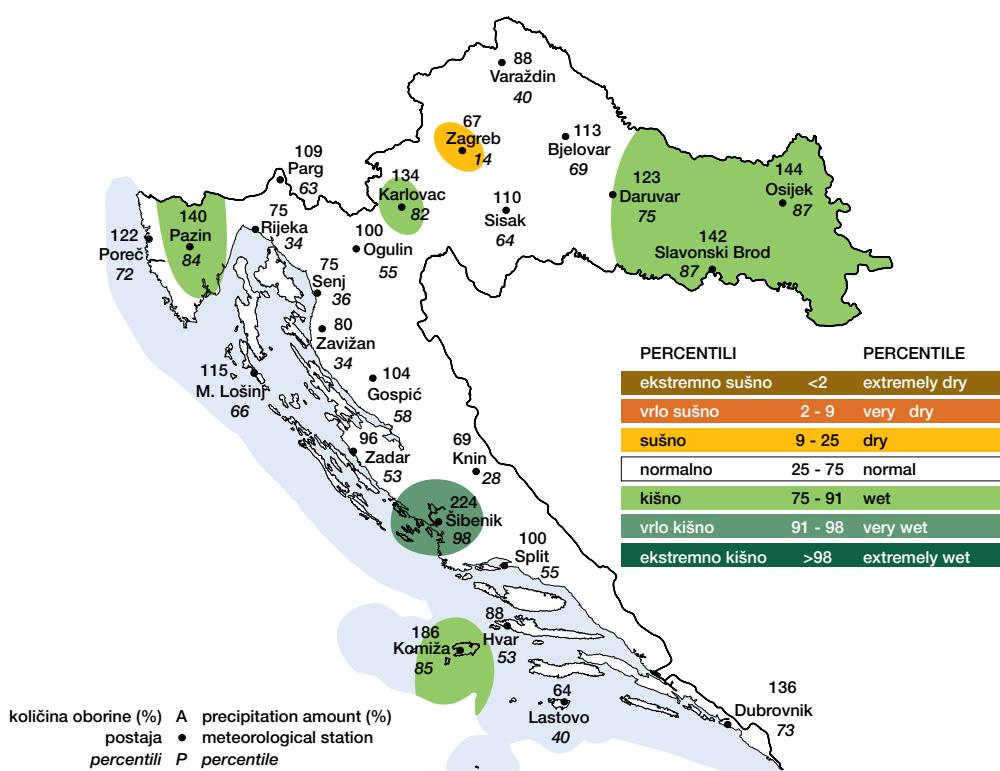
Odstupanje srednje mjesecne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za LIPANJ 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in JUNE 2018



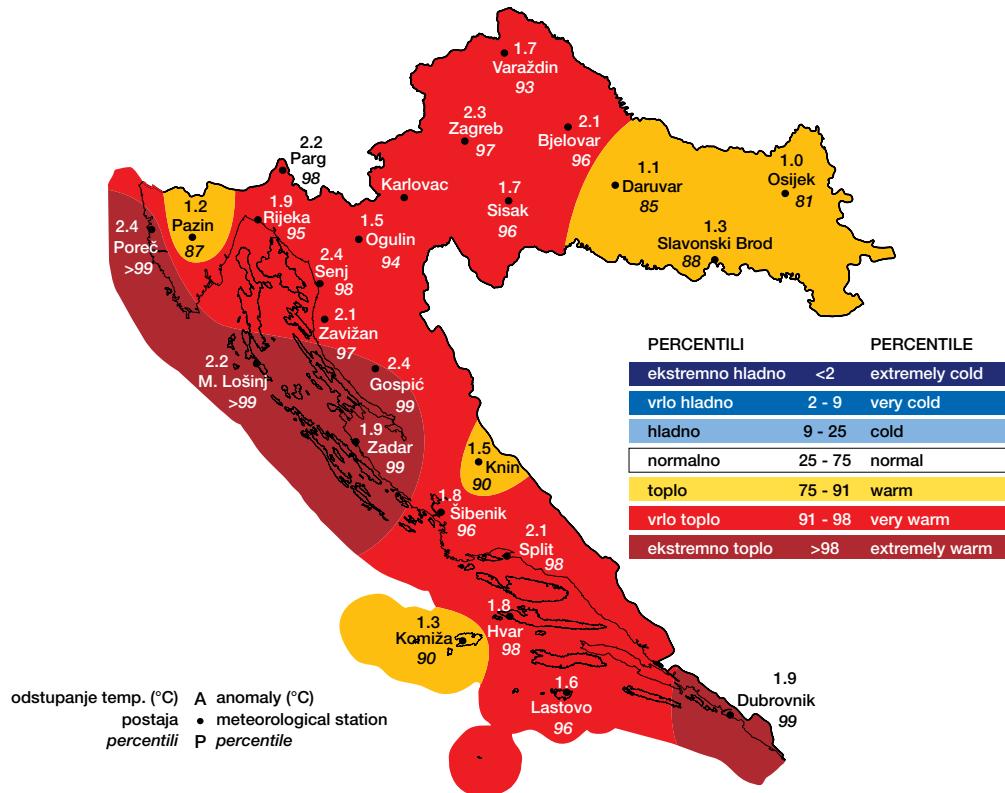
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za LIPANJ 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in JUNE 2018



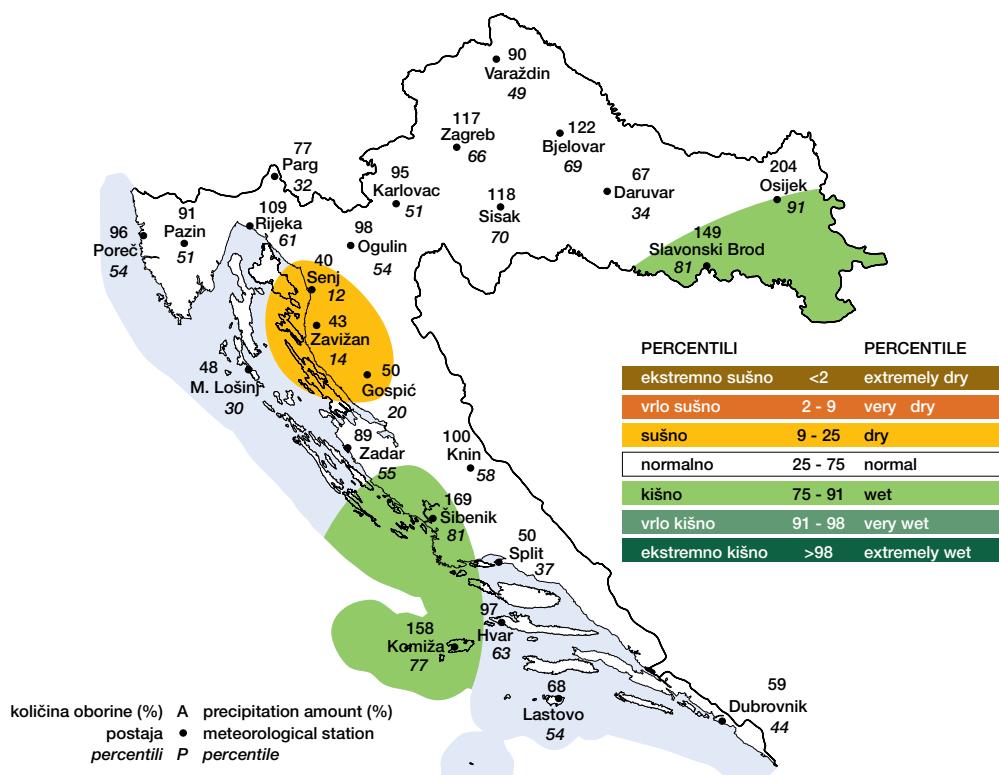
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za SRPANJ 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in JULY 2018



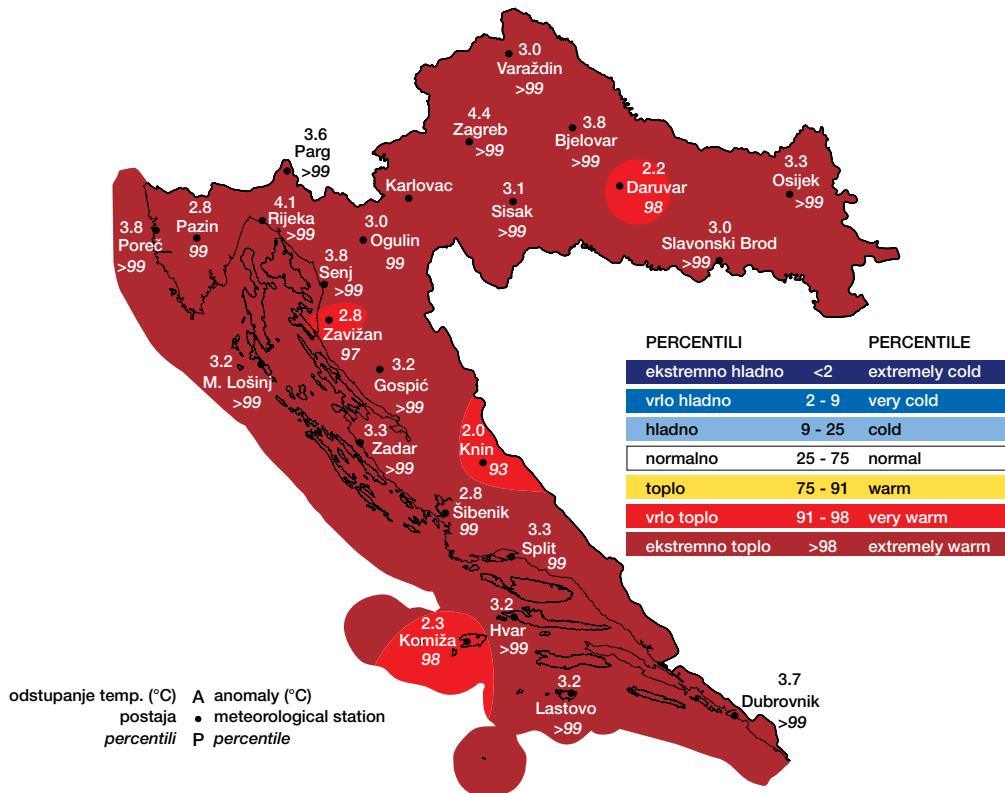
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za SRPANJ 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in JULY 2018



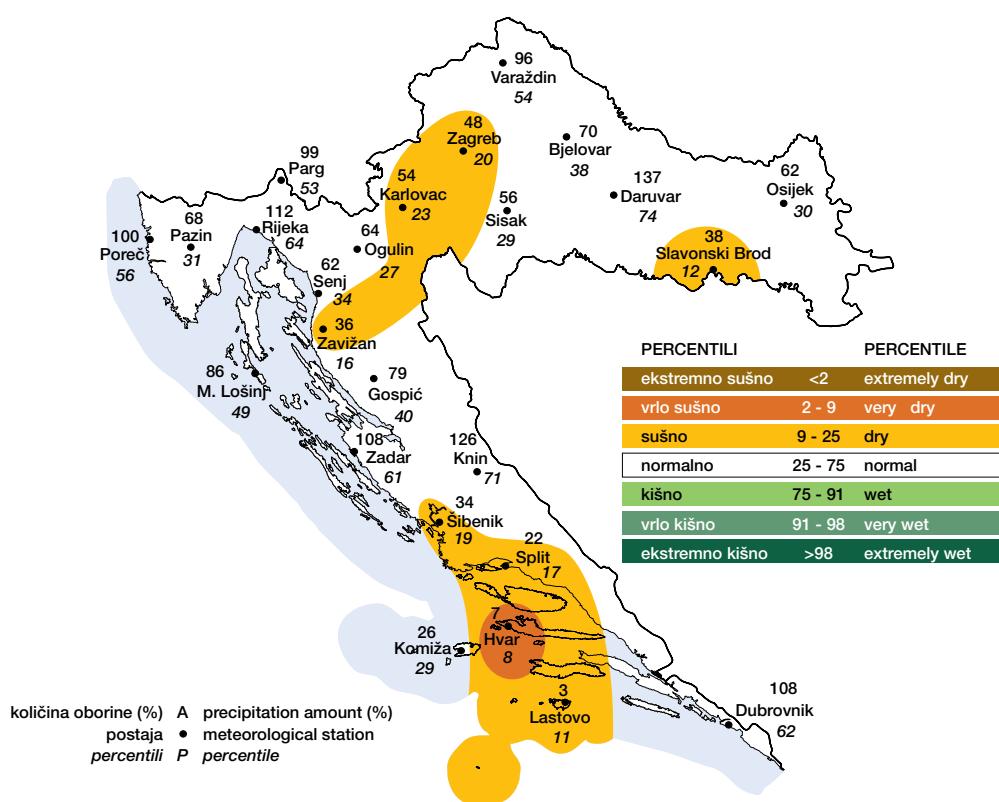
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za KOLOVOZ 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in AUGUST 2018



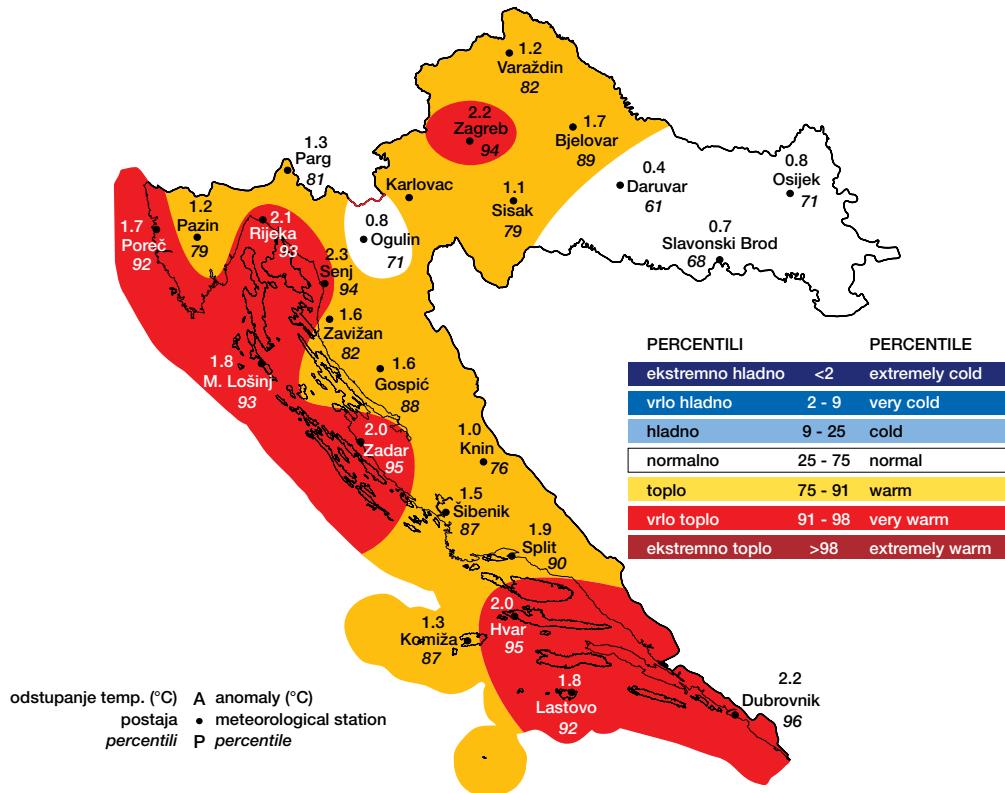
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za KOLOVOZ 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in AUGUST 2018



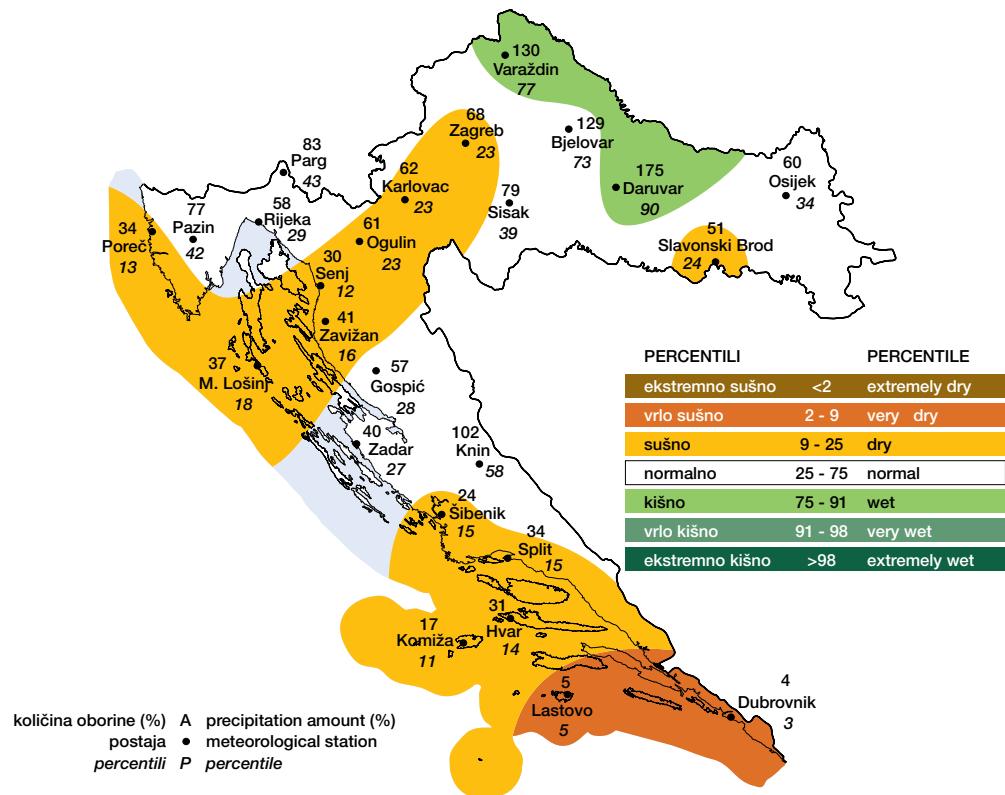
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za RUJAN 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in SEPTEMBER 2018



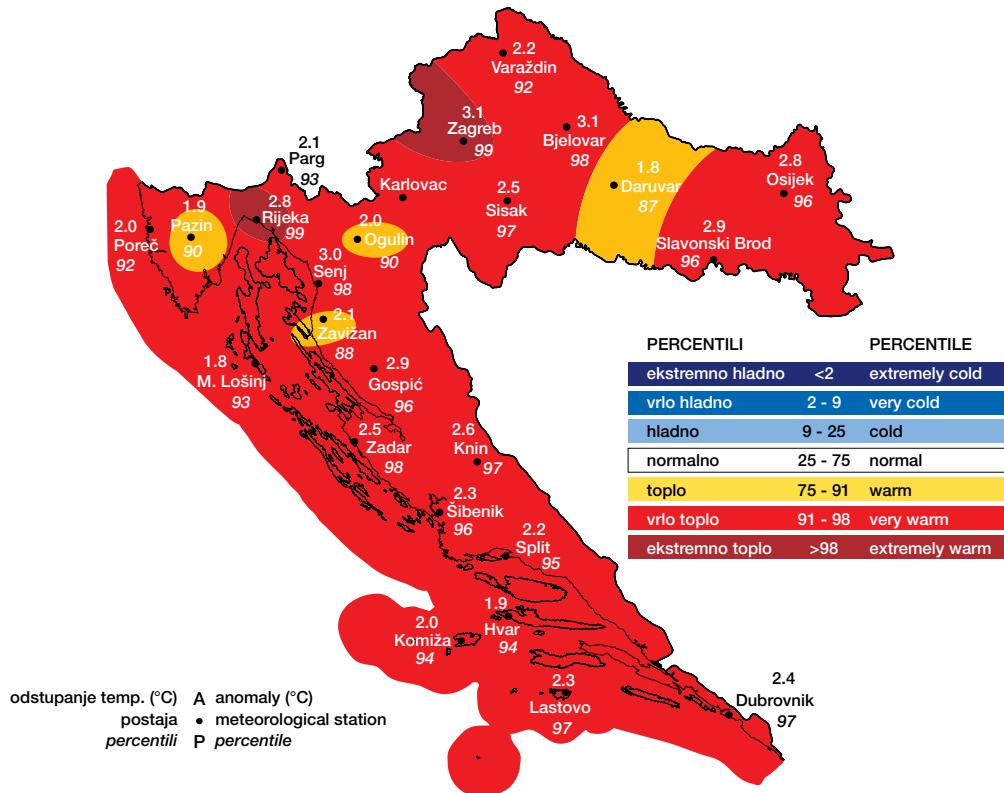
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za RUJAN 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in SEPTEMBER 2018



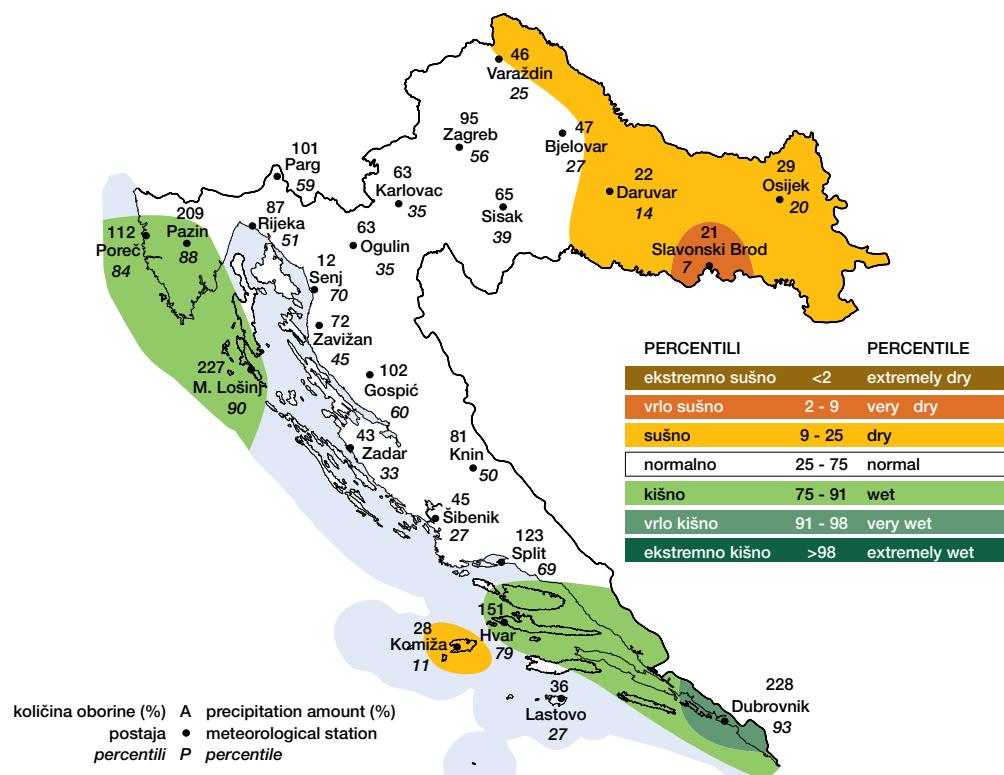
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za LISTOPAD 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in OCTOBER 2018



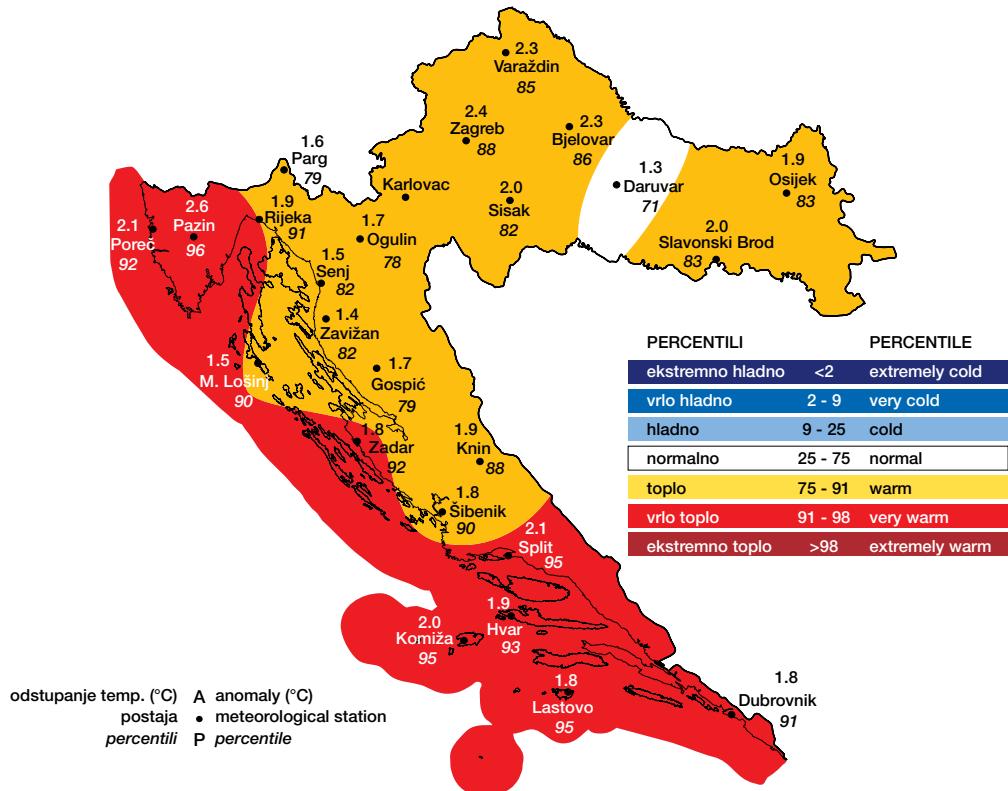
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za LISTOPAD 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in OCTOBER 2018



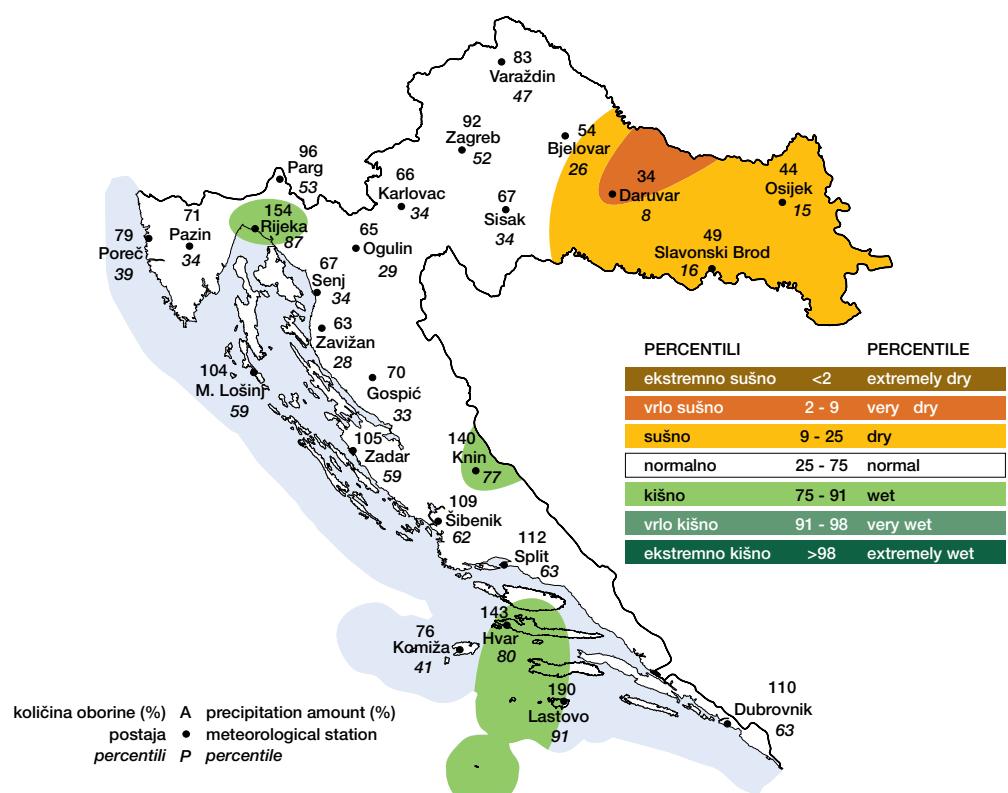
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za STUDENI 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in NOVEMBER 2018



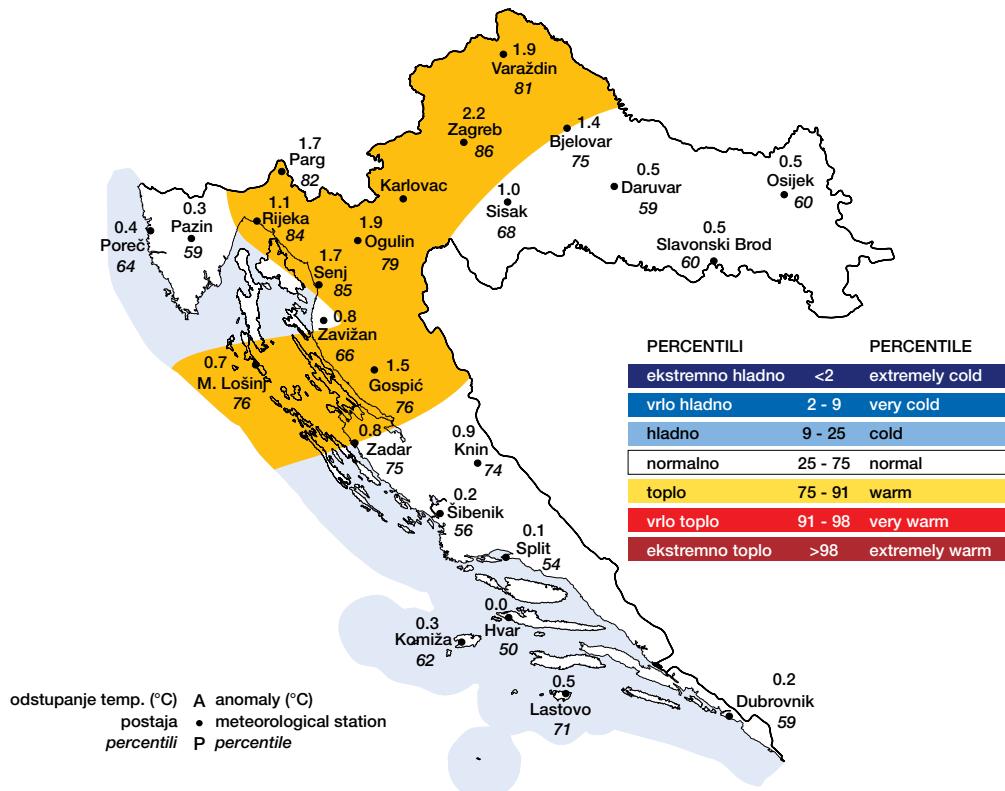
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za STUDENI 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in NOVEMBER 2018



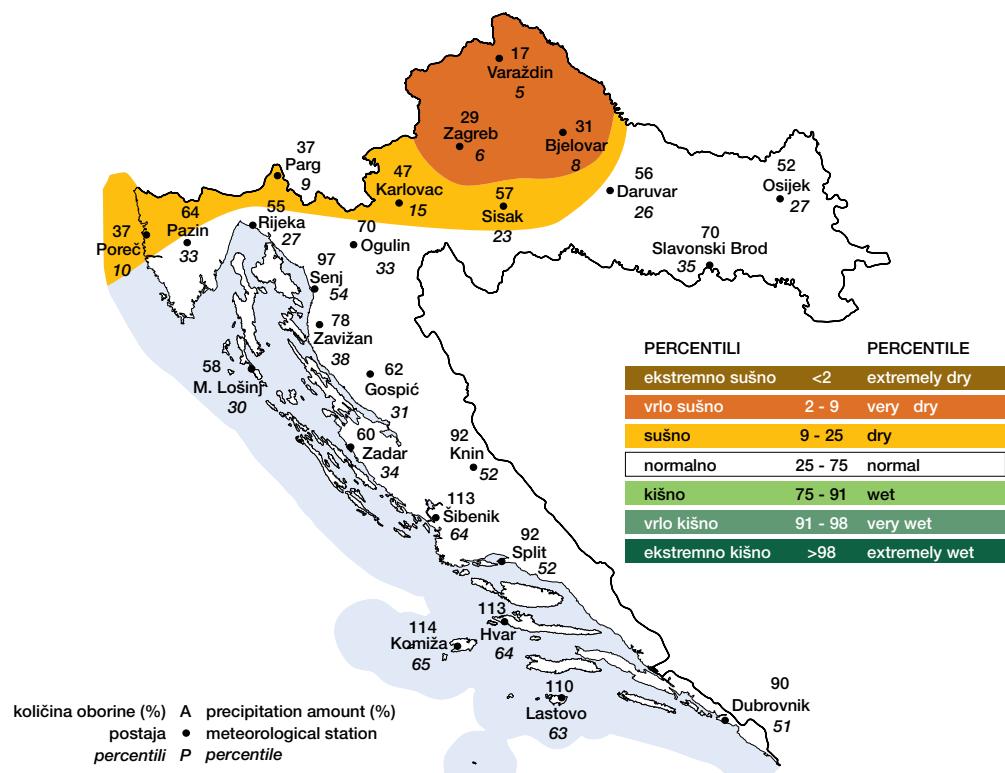
Odstupanje srednje mješevne temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za PROSINAC 2018. godine

Monthly air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in DECEMBER 2018



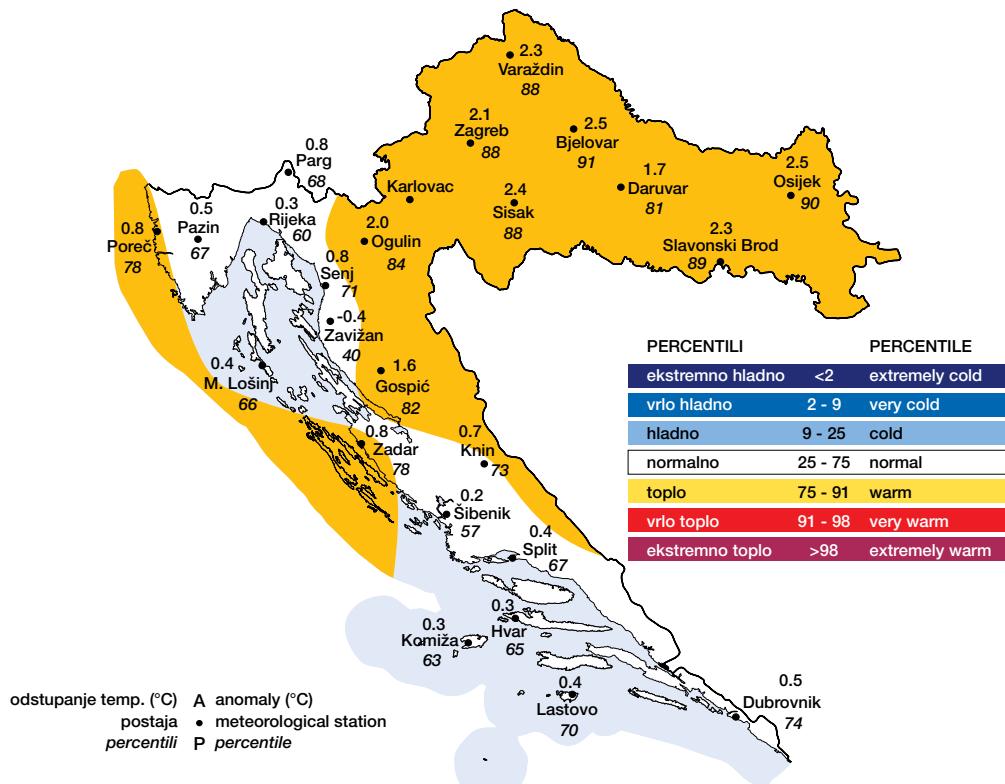
Mjesečne količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za PROSINAC 2018. godine

Monthly precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in DECEMBER 2018



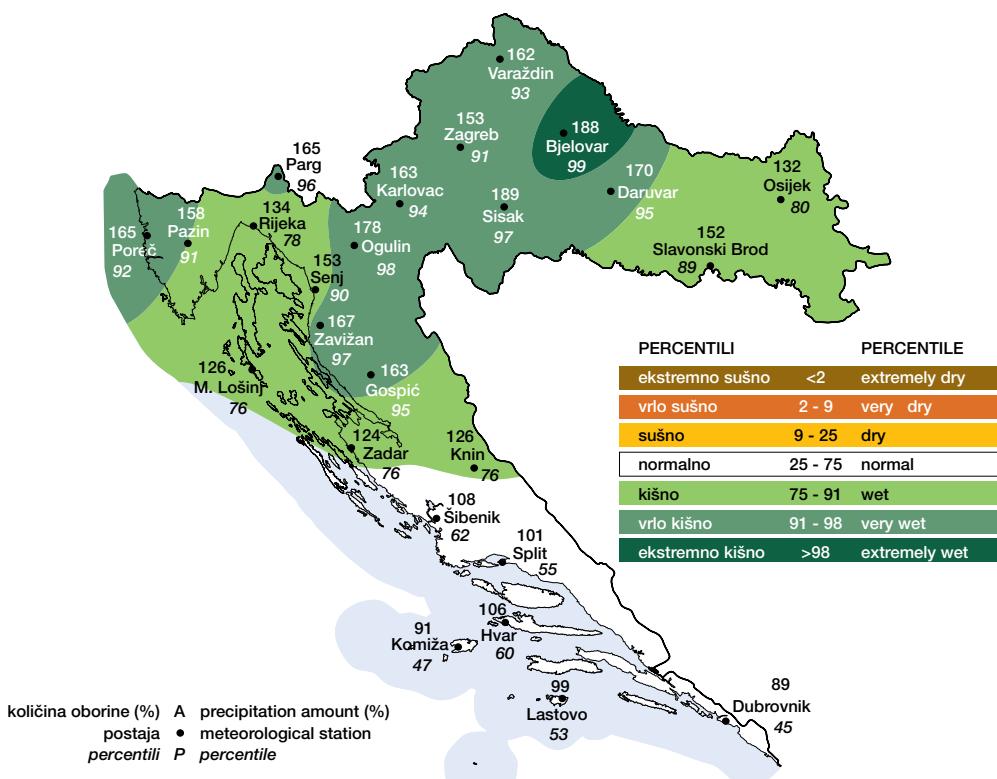
Odstupanje srednje sezonske temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za ZIMU 2017/2018. godine (prosinac 2017., siječanj i veljača 2018.)

Seasonal air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in the WINTER 2017/2018 (December 2017, January and February 2018)



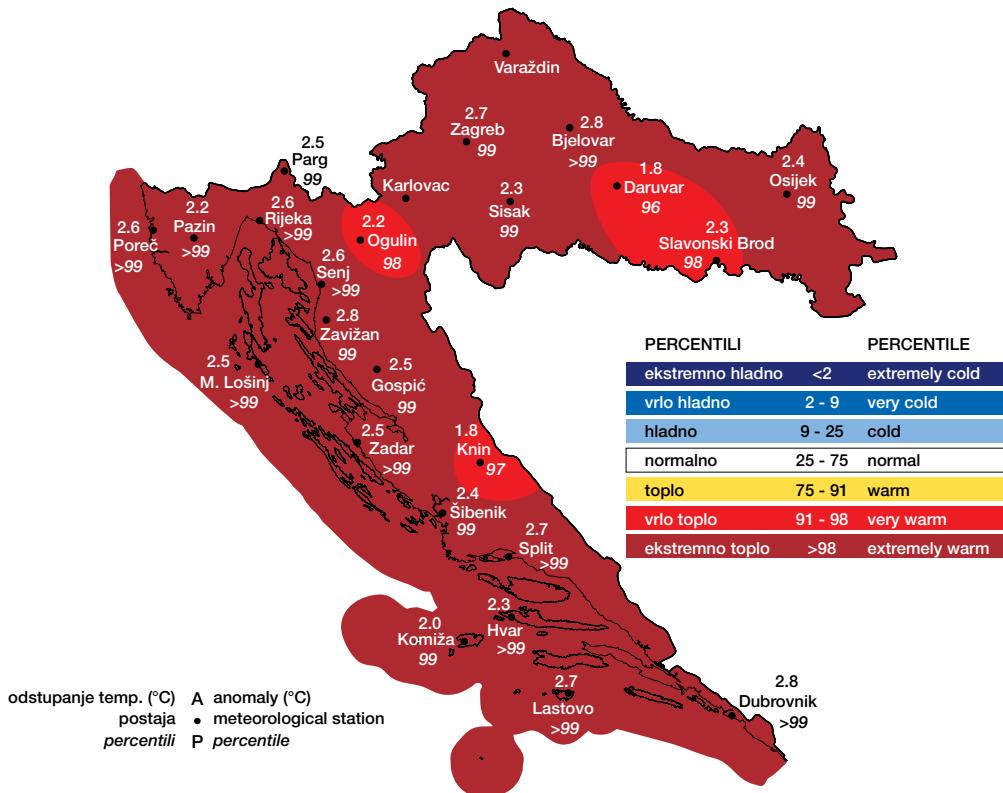
Sezonske količine oborine, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za ZIMU 2017/2018. godine (prosinac 2017., siječanj i veljača 2018.)

Seasonal precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in the WINTER 2017/2018 (December 2017, January and February 2018)



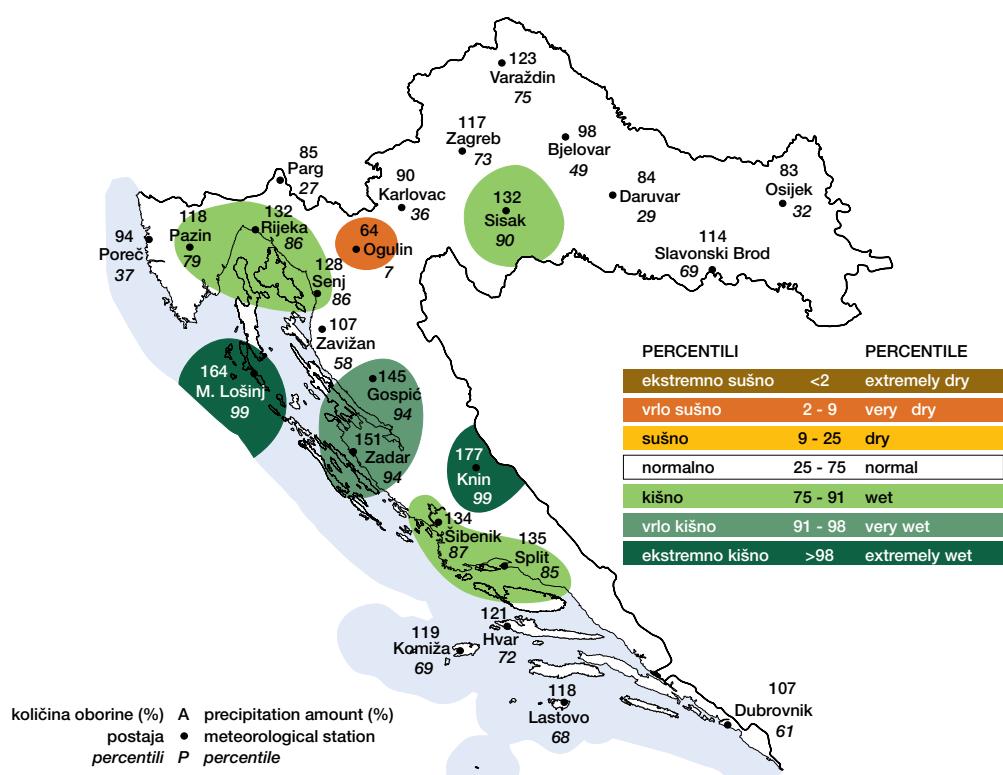
Odstupanje srednje sezonske temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za PROLJEĆE 2018. godine (ožujak–svibanj)

Seasonal air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in the SPRING 2018 (March–May)



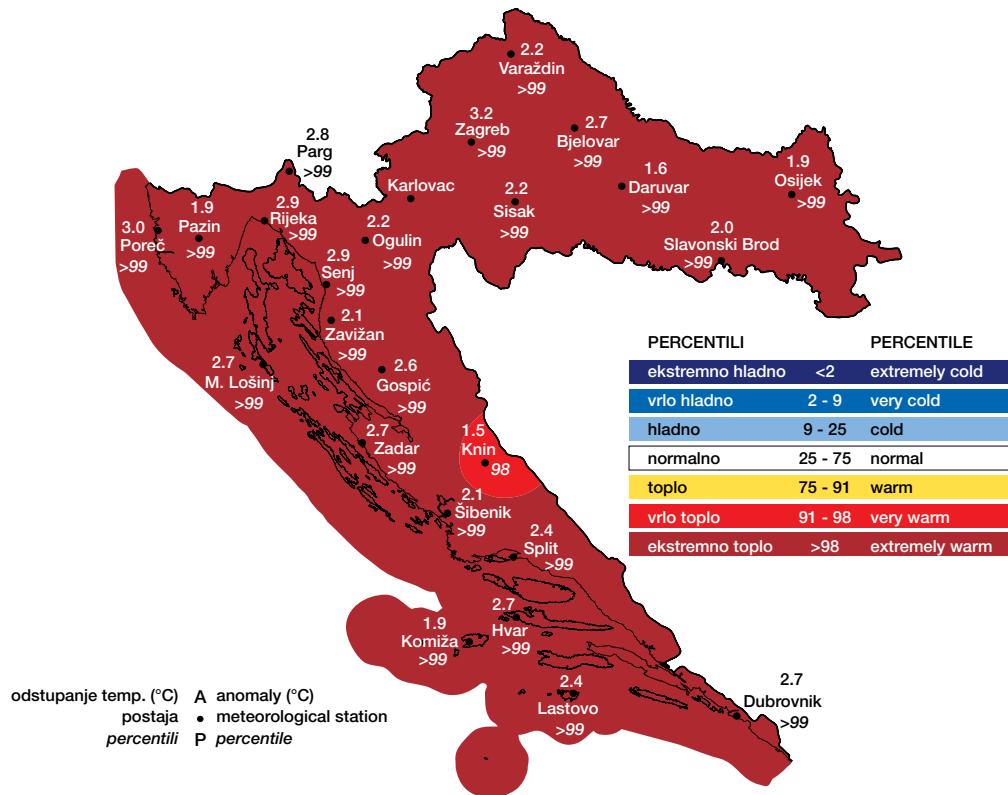
Sezonske količine oborine, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za PROLJEĆE 2018. godine (ožujak–svibanj)

Seasonal precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in the SPRING 2018 (March–May)



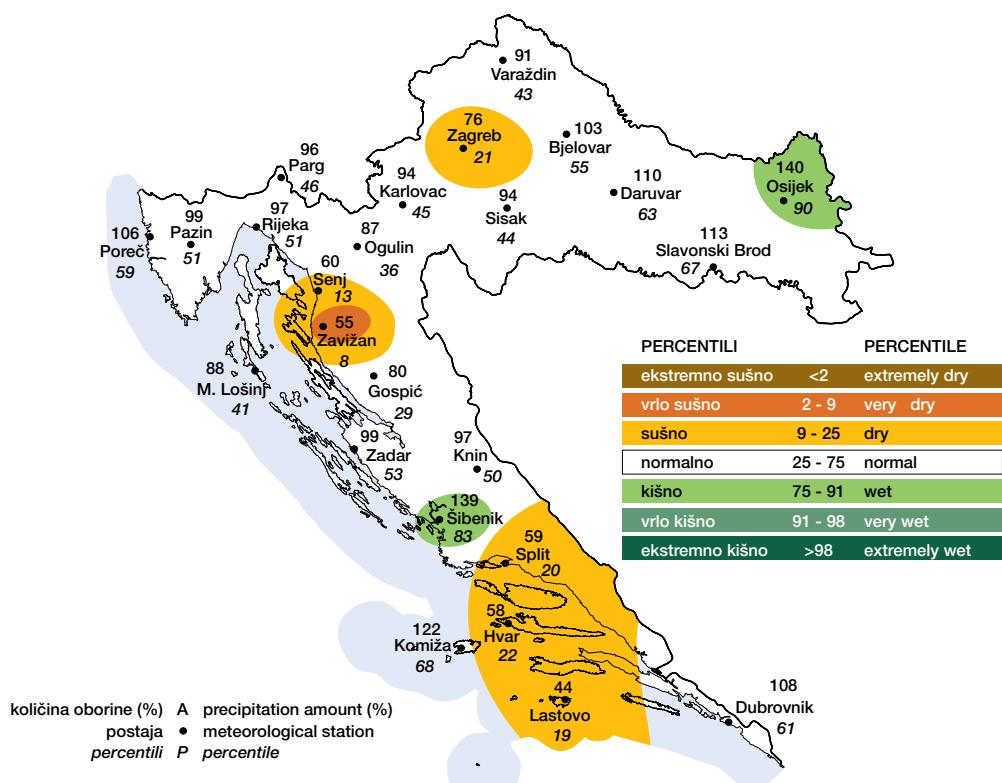
Odstupanje srednje sezonske temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za LJETO 2018. godine (lipanj–kolovoz)

Seasonal air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in the SUMMER 2018 (June–August)



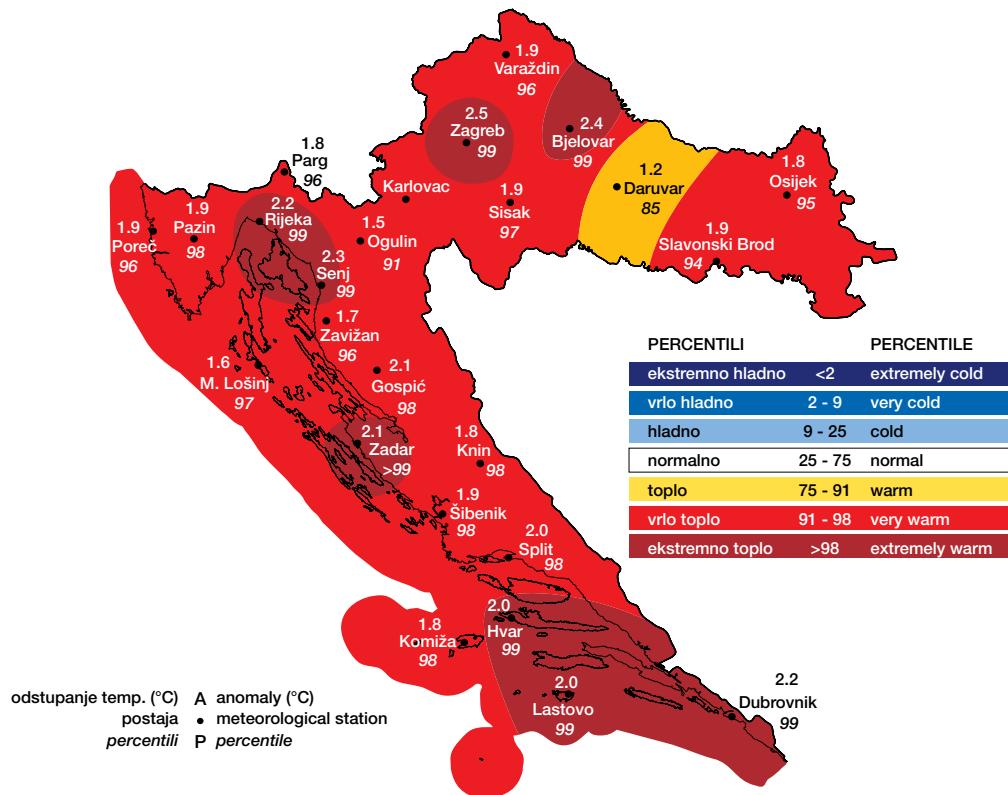
Sezonske količine oborine, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za LJETO 2018. godine (lipanj–kolovoz)

Seasonal precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in the SUMMER 2018 (June–August)



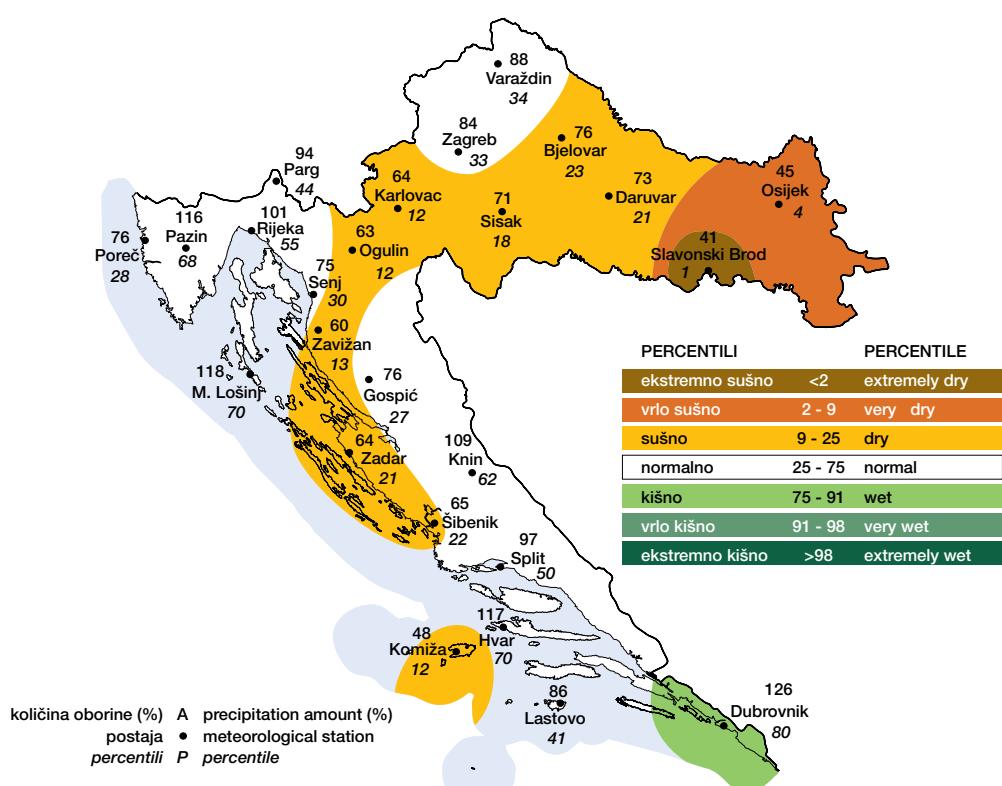
Odstupanje srednje sezonske temperature zraka ($^{\circ}\text{C}$) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za JESEN 2018. godine (rujan–studeni)

Seasonal air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in the AUTUMN 2018 (September–November)



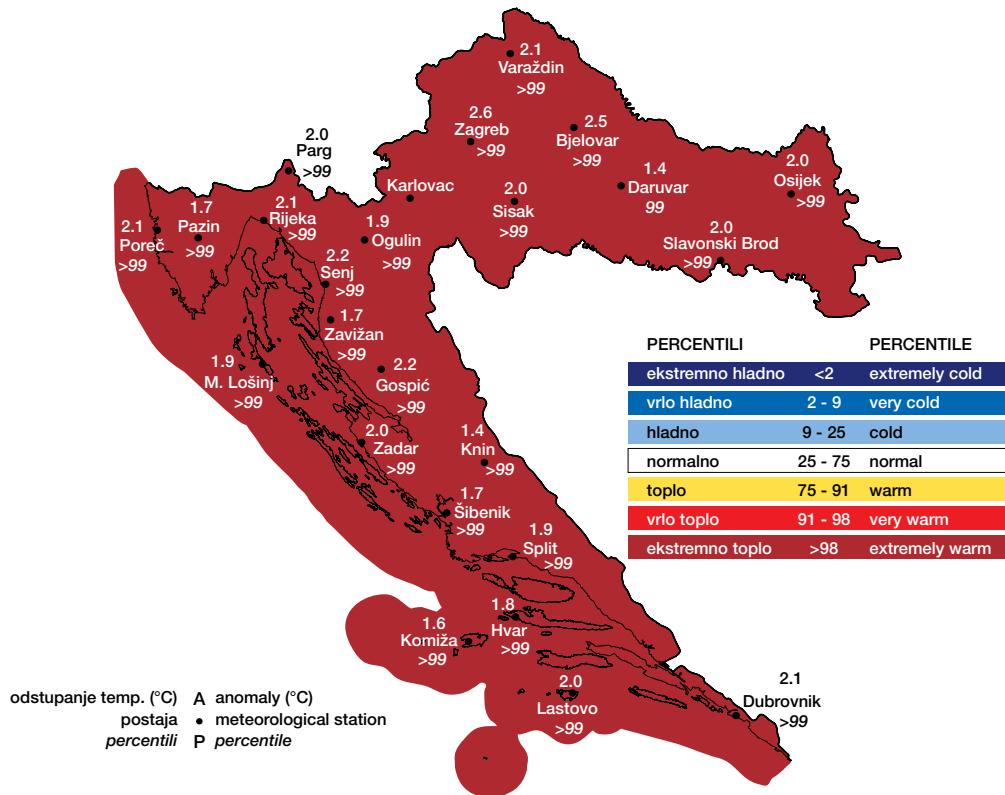
Sezonske količine oborina, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za JESEN 2018. godine (rujan–studeni)

Seasonal precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in the AUTUMN 2018 (September–November)



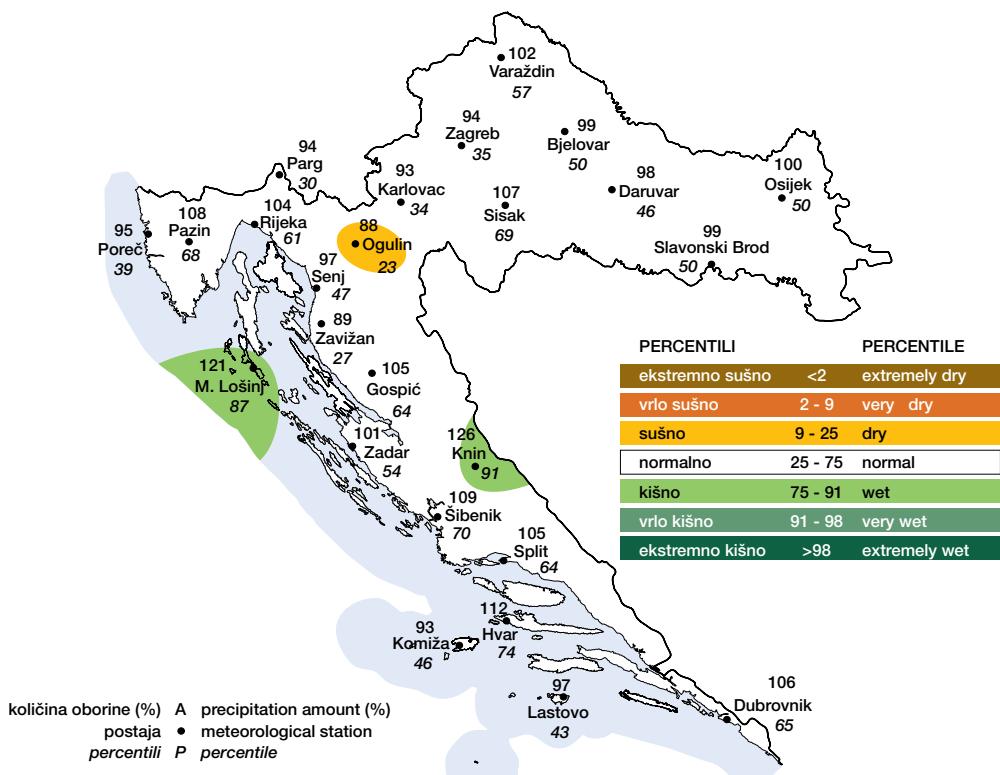
Odstupanje srednje godišnje temperature zraka (°C) od višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za 2018. GODINU

Annual air temperature anomalies in Croatia, relative to the multiannual average for the period 1961 – 1990, in the YEAR 2018



Godišnje količine oborine, u postotcima višegodišnjeg prosjeka za razdoblje 1961. – 1990. godina za Hrvatsku za 2018. GODINU

Annual precipitation amounts, in percentages of multiannual average for the period 1961 – 1990, in Croatia in the YEAR 2018



3. OCJENA ANOMALIJA TEMPERATURE ZRAKA I KOLIČINE OBORINE ZA HRVATSKU ZA 2018. GODINU

Analiza je napravljena na temelju kartografskog prikaza anomalija srednje mjesечne temperature zraka i mjesечne količine oborine definiranih u odnosu na višegodišnji prosjek 1961.–1990. godina kao i kartografskih prikaza odgovarajućih sezonskih i godišnjih anomalija za navedene parametre.

3.1 Ocjena toplinskih i oborinskih prilika u Hrvatskoj za 2018. godinu

Kvantitativna ocjena toplinskih i oborinskih prilika na području Hrvatske za 2018. godinu može se dopuniti sažetim opisom prikazanim u tablici 3.1. U tablici 3.1 analiziraju se mjesечna, sezonska i godišnja razdoblja u usporedbi s referentnim razdobljem 1961.–1990. godina. U prvom stupcu tablice su klase odstupanja tempe-

3. ASSESSMENT OF ANOMALIES OF AIR TEMPERATURE AND PRECIPITATION AMOUNTS IN CROATIA IN THE YEAR 2018

The analysis is based on maps showing the anomalies of average monthly air temperatures and monthly precipitation amounts defined as deviation from the multiannual average 1961 – 1990, as well as maps of the corresponding seasonal and annual anomalies for the above mentioned meteorological elements.

3.1 Assessment of climate anomalies in Croatia in 2018

The quantitative assessment of temperature and precipitation climate anomalies in Croatia in 2018 is supplemented with the brief description shown in Table 3.1. Monthly, seasonal and annual periods relative to the WMO reference period 1961 – 1990 are analyzed in Table 3.1.

Tablica 3.1 Klase odstupanja srednjih mjesечnih temperatura zraka od višegodišnjeg prosjeka (1961. – 1990.) i mjesечne količine oborine izražene u postotcima višegodišnjeg prosjeka (1961. – 1990.) za 2018. godinu, kao i ocjena toplinskih i oborinskih prilika za godišnja doba 2018. i za čitavu godinu

Table 3.1 Average monthly air temperature anomaly categories relative to the multiannual average 1961 – 1990 in 2018, and the assessment of anomalies of air temperature and precipitation amounts in all seasons of 2018, as well as entire 2018

Mjesec SIJEĆANJ 2018. Month JANUARY 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	3		
	vrlo toplo very warm	75		
	ekstremno toplo extremely warm	22		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	0		
	sušno dry	10		
	normalno normal	80	na podjednakom broju analiziranih postaja iznad odnosno ispod prosjeka at roughly equal number of analyzed stations above or below the average	
	kišno wet	10		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		

Mjesec VELJAČA 2018. Month FEBRUARY 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0	većinom ispod prosjeka mainly below average	
	vrlo hladno very cold	4		
	hladno cold	70		
	normalno normal	26		
	toplo warm	0		
	vrlo toplo very warm	0		
	ekstremno toplo extremely warm	0		
oborina precipitation	ekstremno sušno extremely dry	0	većinom ispod prosjeka mainly below average	
	vrlo sušno very dry	0		
	sušno dry	0		
	normalno normal	7		
	kišno wet	20		
	vrlo kišno very wet	20		
	ekstremno kišno extremely wet	53		
Mjesec OŽUJAK 2018. Month MARCH 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0	većinom ispod prosjeka mainly below average	
	vrlo hladno very cold	0		
	hladno cold	5		
	normalno normal	95		
	toplo warm	0		
	vrlo toplo very warm	0		
	ekstremno toplo extremely warm	0		
oborina precipitation	ekstremno sušno extremely dry	0	većinom iznad prosjeka mainly above average	
	vrlo sušno very dry	0		
	sušno dry	0		
	normalno normal	18		
	kišno wet	50		
	vrlo kišno very wet	25		
	ekstremno kišno extremely wet	7		

Mjesec TRAVANJ 2018. Month APRIL 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	0		
	vrlo toplo very warm	0		
	ekstremno toplo extremely warm	100		
oborina precipitation	ekstremno sušno extremely dry	8		
	vrlo sušno very dry	18		
	sušno dry	42		
	normalno normal	32	većinom ispod prosjeka mainly below average	
	kišno wet	0		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		
Mjesec SVIBANJ 2018. Month MAY 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	0		
	vrlo toplo very warm	20		
	ekstremno toplo extremely warm	80		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	0		
	sušno dry	15		
	normalno normal	45	na većem broju analiziranih postaja ispod prosjeka at greater number of analyzed stations below average	
	kišno wet	28		
	vrlo kišno very wet	8		
	ekstremno kišno extremely wet	4		

Mjesec LIPANJ 2018. Month JUNE 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	20		
	vrlo toplo very warm	35		
	ekstremno toplo extremely warm	45		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	0		
	sušno dry	3		
	normalno normal	66	većinom iznad prosjeka mainly above average	
	kišno wet	25		
	vrlo kišno very wet	6		
	ekstremno kišno extremely wet	0		

Mjesec SRPANJ 2018. Month JULY 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	30		
	vrlo toplo very warm	50		
	ekstremno toplo extremely warm	20		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	0		
	sušno dry	10		
	normalno normal	70	većinom ispod prosjeka mainly below average	
	kišno wet	20		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		

Mjesec KOLOVOZ 2018. Month AUGUST 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	0		
	vrlo toplo very warm	15		
	ekstremno toplo extremely warm	85		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	4		
	sušno dry	26		
	normalno normal	70	većinom iznad prosjeka mainly above average	
	kišno wet	0		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		

Mjesec RUJAN 2018. Month SEPTEMBER 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	20	većinom iznad prosjeka mainly above average	
	toplo warm	50		
	vrlo toplo very warm	30		
	ekstremno toplo extremely warm	0		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	10		
	sušno dry	40		
	normalno normal	40	većinom ispod prosjeka mainly below average	
	kišno wet	10		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		

Mjesec LISTOPAD 2018. Month OCTOBER 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	10		
	vrlo toplo very warm	85		
	ekstremno toplo extremely warm	5		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	4		
	sušno dry	25		
	normalno normal	53	većinom ispod prosjeka mainly below average	
	kišno wet	15		
	vrlo kišno very wet	3		
	ekstremno kišno extremely wet	0		

Mjesec STUDENI 2018. Month NOVEMBER 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	10		
	toplo warm	50		
	vrlo toplo very warm	40		
	ekstremno toplo extremely warm	0		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	5		
	sušno dry	20		
	normalno normal	65	većinom ispod prosjeka mainly below average	
	kišno wet	10		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		

Mjesec PROSINAC 2018. Month DECEMBER 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	60	većinom iznad prosjeka mainly above average	
	toplo warm	40		
	vrlo toplo very warm	0		
	ekstremno toplo extremely warm	0		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	20		
	sušno dry	20		
	normalno normal	60	većinom ispod prosjeka mainly below average	
	kišno wet	0		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		
Godišnje doba ZIMA 2017/2018. (XII 2017., I i II 2018.) Season WINTER 2017/2018 (XII 2017, I and II 2018)				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	35	većinom iznad prosjeka mainly above average	
	toplo warm	65		
	vrlo toplo very warm	0		
	ekstremno toplo extremely warm	0		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	0		
	sušno dry	0		
	normalno normal	25	na podjednakom broju analiziranih postaja iznad odnosno ispod prosjeka at roughly equal number of analyzed stations above or below the average	
	kišno wet	35		
	vrlo kišno very wet	33		
	ekstremno kišno extremely wet	7		

Godišnje doba PROLJEĆE 2018. (III—V) Season SPRING 2018 (III—V)				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	0		
	vrlo toplo very warm	17		
	ekstremno toplo extremely warm	83		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	3		
	sušno dry	0		
	normalno normal	60	na podjednakom broju analiziranih postaja iznad odnosno ispod prosjeka at roughly equal number of analyzed stations above or below the average	
	kišno wet	17		
	vrlo kišno very wet	8		
	ekstremno kišno extremely wet	12		
Godišnje doba LJETO 2018. (VI—VIII) Season SUMMER 2018 (VI—VIII)				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0		
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	0		
	vrlo toplo very warm	4		
	ekstremno toplo extremely warm	96		
oborina precipitation	ekstremno sušno extremely dry	0		
	vrlo sušno very dry	3		
	sušno dry	20		
	normalno normal	70	većinom ispod prosjeka mainly below average	
	kišno wet	7		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		

Godišnje doba JESEN 2018. (IX–XI) Season AUTUMN 2018 (IX–XI)				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0	na većem broju analiziranih postaja ispod prosjeka at greater number of analyzed stations below average	
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	10		
	vrlo toplo very warm	60		
	ekstremno toplo extremely warm	30		
oborina precipitation	ekstremno sušno extremely dry	3	na podjednakom broju analiziranih postaja iznad odnosno ispod prosjeka at roughly equal number of analyzed stations above or below the average	
	vrlo sušno very dry	15		
	sušno dry	33		
	normalno normal	44		
	kišno wet	5		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		
Razdoblje GODINA 2018. Period YEAR 2018				
	klasa category	% u odnosu na ukupnu površinu Hrvatske % of the total Croatian territory	odnos u klasi normalno s obzirom na prosjek normal category characteristics in relation to the average	
temperatura temperature	ekstremno hladno extremely cold	0	na podjednakom broju analiziranih postaja iznad odnosno ispod prosjeka at roughly equal number of analyzed stations above or below the average	
	vrlo hladno very cold	0		
	hladno cold	0		
	normalno normal	0		
	toplo warm	0		
	vrlo toplo very warm	0		
	ekstremno toplo extremely warm	100		
oborina precipitation	ekstremno sušno extremely dry	0	na podjednakom broju analiziranih postaja iznad odnosno ispod prosjeka at roughly equal number of analyzed stations above or below the average	
	vrlo sušno very dry	0		
	sušno dry	3		
	normalno normal	90		
	kišno wet	7		
	vrlo kišno very wet	0		
	ekstremno kišno extremely wet	0		

ture zraka od standardnog višegodišnjeg prosjeka kao i odgovarajuće klase količine oborine, u drugoj koloni je postotak u odnosu na ukupnu površinu Hrvatske za pojedinu klasu dok je u trećoj koloni raščlamba područja s vrijednostima temperature zraka i količine oborine iznad odnosno ispod odgovarajućeg višegodišnjeg prosjeka za klasu normalno.

The first column of Table 3.1 contains categories of the air temperature anomalies in reference to the WMO standard multiannual average (1961 – 1990) as well as corresponding precipitation amount categories. The second column contains the percentage of the total Croatian territory for each category, and the third column contains a division of the analyzed area with temperature and precipitation amount values above or below the corresponding multiannual average for the normal category.

Tablica 3.2. Popis ekstremnih klimatskih razdoblja na području Hrvatske u 2018. godini

Table 3.2 The list of extreme climate periods in Croatia in 2018

Mjesečna razdoblja Monthly periods		
ekstremno hladno <i>extremely cold</i>		niti jedno područje <i>no areas in this category</i>
	siječanj <i>January</i>	sjeverozapadna Hrvatska, dio središnje Hrvatske i Like <i>Northwestern Croatia, part of Central Croatia and Lika region</i>
	travanj <i>April</i>	cijela Hrvatska <i>entire Croatian territory</i>
	svibanj <i>May</i>	teritorij RH izuzevši šire područje Daruvara, Gospica i Knina <i>Croatian territory except the wider areas of the towns of Daruvar, Gospic and Knin</i>
ekstremno toplo <i>extremely warm</i>	lipanj <i>June</i>	dio središnje Hrvatske, dio sjevernog i srednjeg Jadrana te južni Jadran <i>part of Central Croatia, part of the Northern and Middle Adriatic as well as the Southern Adriatic</i>
	srpanj <i>July</i>	dio sjevernog i srednjeg Jadrana te šire područje Gospica i Dubrovnika <i>part of the Northern and Middle Adriatic and the wider areas of the towns of Gospic and Dubrovnik</i>
	kolovoz <i>August</i>	teritorij RH izuzevši šire područje Daruvara, Kina, Zavižan i dio južnog Jadrana <i>Croatian territory except the wider areas of Daruvar, Knin and Zavižan and part of the Southern Adriatic</i>
	listopad <i>October</i>	šire područje Zagreba i Rijeke <i>the wider areas of Zagreb and Rijeka</i>
ekstremno sušno <i>extremely dry</i>	travanj <i>April</i>	šire područje Dubrovnika i Slavonskog Broda <i>the wider areas of the towns of Dubrovnik and Slavonski Brod</i>
	veljača <i>February</i>	šire područje Poreča i dio središnje Hrvatske <i>the wider area of the town of Poreč and part of Central Croatia</i>
ekstremno kišno <i>extremely wet</i>	ožujak <i>March</i>	šire područje Bjelovara i Gospica <i>the wider areas of the towns of Bjelovar and Gospic</i>
	svibanj <i>May</i>	šire područje Knina <i>the wider area of the town of Knin</i>

Godišnja doba Seasons		
ekstremno hladno <i>extremely cold</i>		niti jedno područje <i>no areas in this category</i>
ekstremno toplo <i>extremely warm</i>	proljeće <i>Spring</i>	teritorij RH izuzevši dio istočne Hrvatske te šire područje Ogušina i Knina <i>Croatian territory except the part of Eastern Croatia and the wider areas of the towns of Ogulin and Knin</i>
	ljeto <i>Summer</i>	teritorij RH izuzevši šire područje Knina <i>Croatian territory except the wider area of the town of Knin</i>
ekstremno sušno <i>extremely dry</i>		niti jedno područje <i>no areas in this category</i>
ekstremno kišno <i>extremely wet</i>	zima 2017/2018. <i>Winter 2017/2018</i>	šire područje Bjelovara <i>the wider area of the town of Bjelovar</i>
	proljeće <i>Spring</i>	dio sjevernog Jadrana i šire područje Knina <i>part of the Northern Adriatic and the wider area of the town of Knin</i>

Godina 2018. Period YEAR 2018	
ekstremno hladno <i>extremely cold</i>	niti jedno područje <i>no areas in this category</i>
ekstremno toplo <i>extremely warm</i>	cijela Hrvatska <i>entire Croatian territory</i>
ekstremno sušno <i>extremely dry</i>	niti jedno područje <i>no areas in this category</i>
ekstremno kišno <i>extremely wet</i>	niti jedno područje <i>no areas in this category</i>

Prema podacima navedenim u tablici 3.1 godina 2018. je bila ekstremno topla na cijelom području Republike Hrvatske. Istovremeno je prevladavalo kišno vrijeme na 7% i sušno na 3% područja, dok je preostalih 90% teritorija svrstano u kategoriju normalno.

3.2 Ekstremna klimatska razdoblja u 2018. godini

Ekstremne klimatske prilike kao što su toplinski i hladni valovi te ekstremno sušna i vlažna razdoblja od osobite su važnosti jer znatno utječu na ljudе i gospodarstvo (tablica 3.2). Izdvajanje takvih razdoblja na različitim vremenskim ljestvicama (od mјesečne do godišnje)

According to the data shown in Table 3.1, 2018 was extremely warm throughout the Republic of Croatia. Wet weather was prevalent in 7%, and dry weather in 3% of Croatia's territory. The weather in the remaining 90% of Croatia's territory is classified as normal.

3.2 Extreme climate periods in 2018

Extreme climate conditions such as heat and cold waves and extremely dry and wet periods are of particular importance because they affect both people and economy (Table 3.2). Recognizing these periods on different time scales (month, season, year) is an excellent basis for further analysis of their impact on the economy (agriculture, touri-

izvrsna je dodatna podloga za analizu njihova utjecaja na gospodarstvo (poljodjelstvo, turizam, promet itd.), a katkad su nažalost i uzrok gubitka ljudskih života.

3.3 Dodatna analiza klimatskih anomalija u 2018. godini

Prikazana analiza klimatskih anomalija daje općenitu ocjenu klime u Hrvatskoj za 2018. godinu. Detaljniji uvid od prikazanog može dati analiza vremenskih pojava na vremenskoj ljestvici koja nije unaprijed definirana, nego koja ovisi o duljini trajanja klimatskog odnosno vremenskog događaja.

Na slici 3.1 su prikazane anomalije srednje dnevne temperature zraka za Zagreb-Grič u odnosu na referen-

sm, transport, etc.) and sometimes, unfortunately, the loss of human lives.

3.3. Additional analysis of climate anomalies in Croatia in 2018

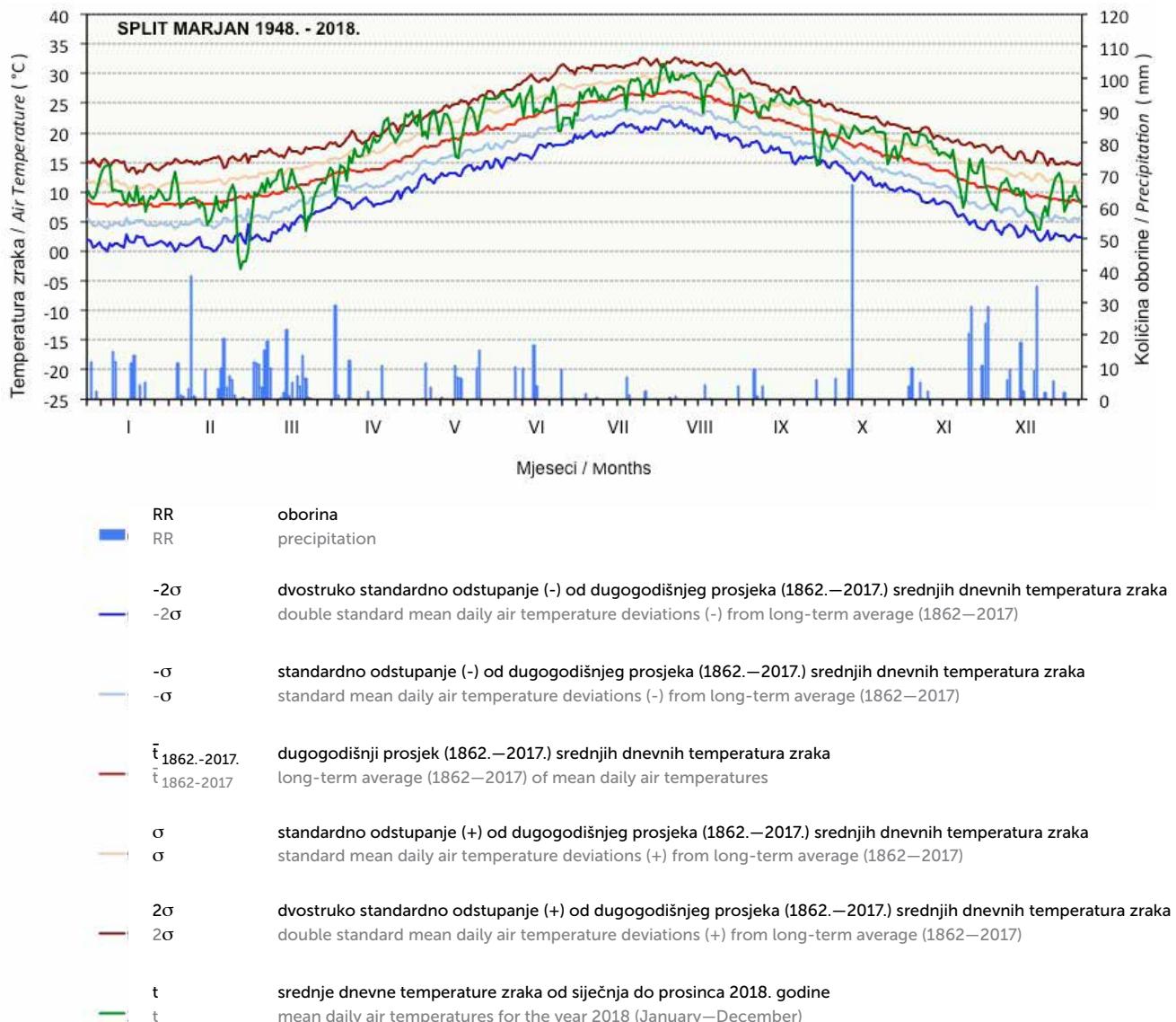
The presented analysis of climate anomalies provides a general assessment of climate anomalies in Croatia for the year 2018. An analysis of weather events on a scale that is not pre-defined, but dependent on the duration of climate or weather events, can provide a more detailed insight than the above analysis.

Figure 3.1 shows mean daily air temperature anomalies for Zagreb-Grič with respect to the 1961-1990 reference period. It is obvious that positive anomalies prevailed



Slika 3.1 Srednje dnevne temperature zraka za Zagreb-Grič za 2018. godinu u odnosu na dugogodišnji prosjek 1862. – 2017. godina i dnevne količine oborine za 2018. godinu

Figure 3.1 Mean daily air temperatures at Zagreb-Grič in 2018 relative to the long-term average 1862–2017, and daily precipitation amounts in the year 2018



Slika 3.2 Srednje dnevne temperature zraka za Split-Marjan za 2018. godinu u odnosu na dugogodišnji prosjek 1948. – 2017. godina i dnevne količine oborine za 2018. godinu

Figure 3.2 Mean daily air temperatures at Split-Marjan in 2018 relative to the long-term average 1948–2017, and daily precipitation amounts in the year 2018

tno klimatsko razdoblje 1961-1990. godina. Kao što je vidljivo sa slike prevladavale su pozitivne anomalije kada se gleda godina kao cjelina osobito u siječnju, travnju, svibnju, kolovozu i listopadu. Izraženiji hladni valovi bili su krajem veljače i ožujka te manje izraženi tijekom lipnja, rujna, studenog i prosinca.

Na slici 3.2 prikazane su anomalije srednje dnevne temperature zraka za Split-Marjan u odnosu na referentno klimatsko razdoblje 1961-1990. godina. Slično kao za Zagreb-Grič, prevladavale su pozitivne anomalije kada se gleda godina kao cjelina, osobito u siječnju, travnju, svibnju, kolovozu i listopadu. Izraženiji hladni valovi bili su krajem veljače i ožujka te manje izraženi tijekom lipnja, rujna, studenog i prosinca.

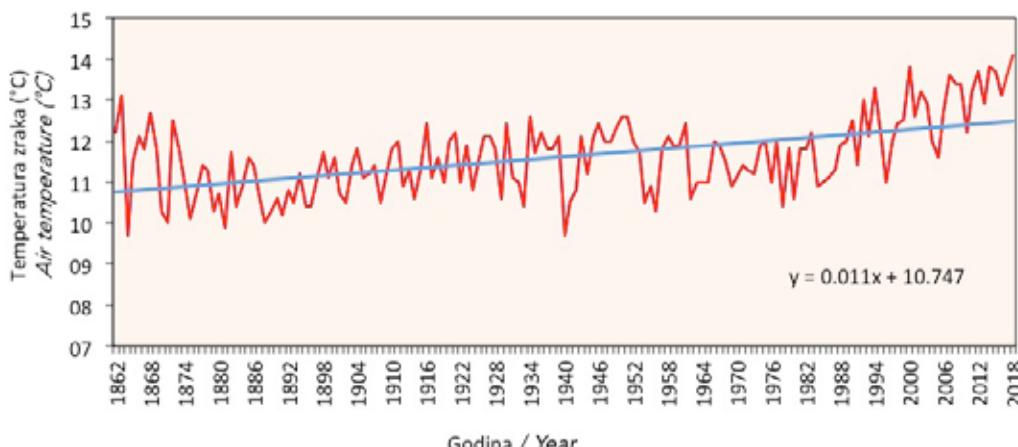
Stoljetni trend srednjih godišnjih temperatura zraka za Zagreb-Grič prikazan je na slici 3.3. Očigledan je i dalje pozitivan trend srednje godišnje temperature zraka $1.1^{\circ}\text{C}/100 \text{ god}$ uz odgovarajuće međugodišnje varijacije.

especially in January, April, May, August and October. The more pronounced cold waves occurred at the end of February and March and less pronounced during June, September, November and December.

Figure 3.2 shows mean daily air temperature anomalies for Split-Marjan with respect to the 1961-1990 reference period. Similarly to the previous case for Zagreb-Grič positive anomalies prevailed during the year 2018, especially in January, April, May, August and October. The more pronounced cold waves occurred at the end of February and March and less pronounced during June, September, November and December.

The secular average annual air temperature trend for Zagreb-Grič is shown in Figure 3.3. The positive trend in average annual air temperature of $1.1^{\circ}\text{C}/100 \text{ yrs}$ is apparent, with certain inter-annual variations.

In contrast to the positive average annual air temperature trend, a slight negative trend is noticed in annual



Slika 3.3 Srednje godišnje temperature zraka za Zagreb-Grič za razdoblje 1862. – 2018. godina

Figure 3.3 Mean annual air temperatures at Zagreb-Grič in the period 1862 – 2018

Za razliku od rastućeg trenda srednje godišnje temperature zraka uočava se slabo izražen negativan trend godišnjih količina oborine prikazan na slici 3.4. I u ovom slučaju prisutne su znatne međugodišnje varijacije.

3.3.1 Analiza anomalija godišnje temperature zraka i količine oborine

Srednja godišnja temperatura zraka za 2018. godinu na području Hrvatske bila je iznad višegodišnjeg prosjeka (1961. – 1990.). Anomalije srednje godišnje temperature zraka nalaze se u rasponu od 1.4°C (Daruvar i Knin) do 2.6°C (Zagreb-Grič).

Kategorizacija zasnovana na razdiobi percentila pokazuje da je 2018. godina još jedna u nizu ekstremno toplih godina. Cijela Hrvatska nalazi se u kategoriji **ekstremno toplo**.

Analiza godišnjih količina oborine koje su izražene u postotcima (%) višegodišnjeg prosjeka (1961. – 1990.) pokazuje da je u 2018. godini u Hrvatskoj na podjednako broju analiziranih postaja količina oborine bila viša odnosno niža od prosjeka dok je u Osijeku bila jednaka prosjeku. Usporedba s navedenim višegodišnjim prosjekom pokazuje da se količine oborine za 2018. godinu nalaze u rasponu od 88% (Ogulin) do 126% (Knin) spomenutog prosjeka. Šire područje Malog Lošinja i Knina nalazi se u kategoriji **kišno** dok se šire područje Ogulina nalazi u kategoriji **sušno**. Preostali dio Hrvatske nalazi se u kategoriji **normalno**.

Za postaju Zagreb-Grič srednja godišnja temperatura zraka za 2018. iznosi 14.1°C. zbog čega je 2018. najtoplja godina postaje Zagreb-Grič od početka meteoroloških motrenja, tj. od 1862. godine (slika 3.5).

3.3.2 Analiza dnevnih anomalija temperature zraka i količine oborine za meteorološke postaje Zagreb-Grič i Split-Marjan

U skladu sa standardnom operativnom praksom u Državnom hidrometeorološkom zavodu izrađuje se ocjena izuzetnosti srednjih dnevnih temperatura zraka za svaki mjesec u godini, a koja se također temelji na

precipitation amounts for Zagreb-Grič shown in Figure 3.4. Certain inter-annual variations of precipitation amounts exist in this case as well.

3.3.1 Analysis of average annual air temperature and precipitation anomalies

The average annual air temperature in Croatia in 2018 was above the multiannual average (1961 – 1990). Average annual air temperature anomalies were within the range from 1.4°C (Daruvar and Knin) to 2.6°C (Zagreb-Grič).

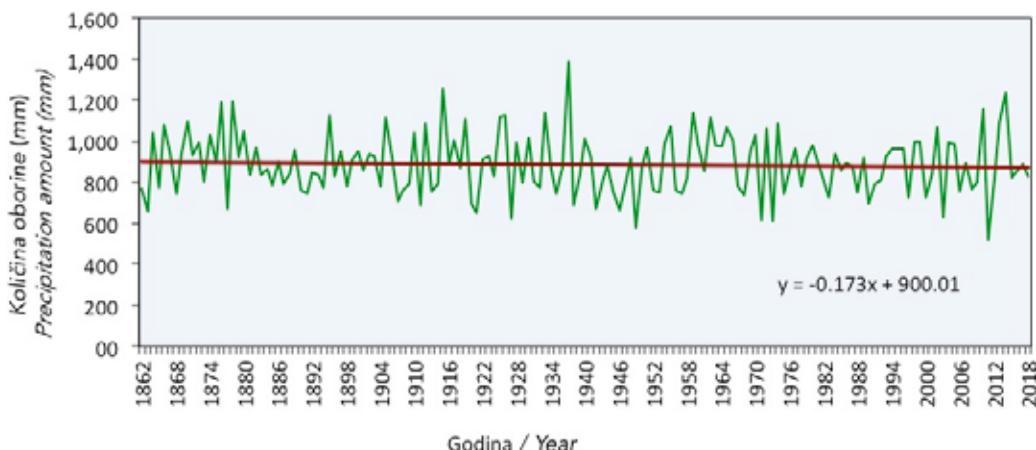
According to percentile ranks and classification ratings, thermal conditions in Croatia in 2018 dominantly fall into the **extremely warm** category (whole territory of the Republic of Croatia).

An analysis of annual precipitation amounts in 2018 expressed as percentages (%) of the 1961 – 1990 average indicates that precipitation amounts in Croatia at roughly equal number of analyzed stations were above or below the average, with the exception of the main meteorological station Osijek, where the precipitation amount was on par with the average. A comparison with the multiannual average reveals that the precipitation amounts in 2018 were within the range of 88%-126% of the above mentioned average. The wider areas of the towns of Mali Lošinj and Knin fall into the **wet** category while the wider area of the town of Ogulin falls into the **dry** category. The rest of Croatia is in the **normal** category.

A comparison of the average annual air temperature for the main meteorological station Zagreb-Grič in the period 1862-2018 indicates that the year 2018 is the warmest year on record (the average annual air temperature for Zagreb-Grič for the year 2018 is 14.1°C), as shown in Figure 3.5

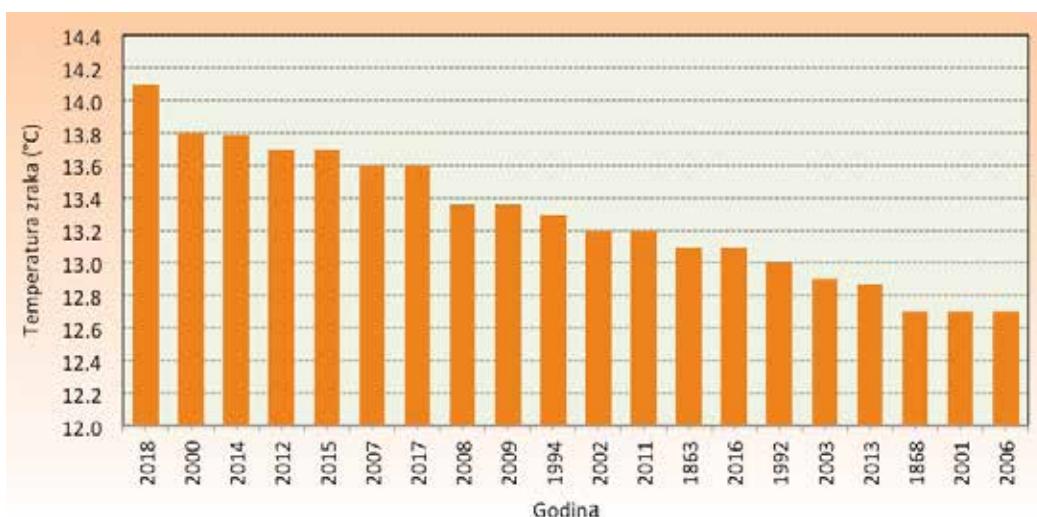
3.3.2 Analysis of daily air temperature and precipitation amount anomalies for meteorological stations Zagreb-Grič and Split-Marjan

Croatian Meteorological and Hydrological Service has a standard operational practice of doing an evaluation of extremeness of average daily air temperatures for every



Slika 3.4 Godišnje količine oborine za Zagreb-Grič za razdoblje 1862. – 2018. godina

Figure 3.4 Annual precipitation amounts at Zagreb–Grič in the period 1862 – 2018



Slika 3.5 Dvadeset najtopljih godina od početka meteoroloških motrenja (1862. – 2018.), Zagreb-Grič

Figure 3.5 The 20 warmest years on record (1862 – 2018) for Zagreb–Grič

Chapman-ovom kriteriju uz pretpostavku da se srednje dnevne temperature zraka za pojedini datum pokoravaju Gauss-ovoj razdiobi (Penzar i Makjanić, 1980.). Prema Chapman-ovom kriteriju izvanredno toplim smatra se dan u kojem pozitivna anomalija srednje dnevne temperature zraka premaši dvije standardne devijacije, dok se izuzetno hladnim smatra dan u kojem negativna anomalija premaši dvije standardne devijacije. Vjerojatnost pojave izvanredno toplih odnosno izvanredno hladnih dana je oko 2% to jest takvi događaji se pojavljuju u prosjeku dva puta u razdoblju od 100 godina. Na slici 3.1 i 3.2 prikazani su grafovi na kojima su vidljivi izvanredni dani tijekom 2018. godine za postaje Zagreb-Grič i Split-Marjan. Vizualnom ocjenom možemo zaključiti da su prevladavala razdoblja s pozitivnim anomalijama što je rezultiralo također pozitivnim godišnjim anomalijama prikazanim u poglavlju 2. Ipak, zabilježen je određen broj hladnih valova među kojima je najizraženiji onaj u po-

month of the year also based on the Chapman's criterion and on the assumption that the daily temperature averages for every date and location obey a Gaussian distribution (Penzar and Makjanić, 1980). Chapman's criterion defines an extremely warm day as a day with a positive average daily temperature anomaly exceeding two standard deviations, and an extremely cold day as a day with a negative anomaly exceeding two standard deviations. Extremely hot and extremely cold days have a probability of occurrence of around 2%. That is to say, such events on average occur twice in 100 years. Figures 3.1 and 3.2 also show extremely hot and cold days registered in 2018 at meteorological stations Zagreb-Grič and Split-Marjan. A visual assessment brings us to the conclusion that periods with positive anomalies prevailed, resulting in the positive annual anomalies (Chapter 2). However, there were some cold waves, the one in the last decade of February having been the most intensive. It caused considerable damage in the economy and will be addressed separately.

sljednjoj dekadi veljače koji je prouzročio znatne štete u gospodarstvu pa će biti posebno opisan.

Na slikama 3.1 i 3.2 također su prikazane dnevne količine oborine za meteorološke postaje Zagreb-Grič i Split-Marjan. Kao što je vidljivo iz poglavlja 2, zbroj dnevnih količina oborina za Zagreb-Grič za 2018. godinu bio je nešto manji od višegodišnjeg prosjeka uz znak da je u listopadu maksimalna dnevna količina oborine iznosila 44.8 mm. Manjak oborina zabilježen je tijekom lipnja, kolovoza i rujna, a znatniji manjak oborine bio je u prosincu. Ukupna godišnja količina oborine za Split-Marjan bila je malo iznad prosjeka (poglavlje 2) s kišnim razdobljem tijekom veljače i ožujka.

3.3.3 Hladni val u Hrvatskoj u veljači 2018. godine

Hladni val od 24. do 28. veljače 2018. godine zahvatio je veći dio Hrvatske. Uz to, veći dio kontinentalne Hrvatske našao se pod obilnim snijegom, kao i unutrašnjost Dalmacije. U Delnicama je izmjereno 180.2 cm snijega 28. veljače 2018., što je najveća visina snijega u Delnicama izmjerena u veljači otkako postoje mjerjenja. Desetak zaselaka na području Žumberka bilo je u potpunosti odsjećeno i zameteno snijegom. Mjestimice je palo i više od metra snijega, a u zapisima ga je bilo i 250 cm. Cestovni i željeznički promet je tekao otežano kroz Liku i Gorski kotar, a promet je povremeno bio i u prekidu, pogotovo za teretna vozila. Zbog snijega i olujnog vjetra nije bilo nastave u više škola u Lici i Gorskem kotaru. Slično je bilo i u dijelovima Hrvatskog Zagorja. U Lici i Gorskem kotaru angažirana je i Hrvatska vojska koja je ljudstvom i mehanizacijom pomagala čistiti prometnice i odvoziti snijeg, te dostaviti hrane i lijekova na zametenim područjima. U pomoć zametenom stanovništvu uključila se i Gorska služba spašavanja. Na Kvarneru i na području Rijeke puhalo je olujna bura koja je lomila grane, rušila stabla i prevrtala kontejnere, rušila građevinske skele i stabla, a prevrnula je i kamion. Vjetar je stvarao zapuhe snijega visoke nekoliko metara. Na Zavižanu je izmjerno 222 cm snijega, smetovi su bili i preko četiri metra. U Zagrebu su uslijed hladnoće vodovodne cijevi popuca-

Figures 3.1 and 3.2 also show daily precipitation amounts at meteorological stations Zagreb-Grič and Split-Marjan. As seen in the map describing the annual precipitation amounts in percentages of the multiannual average for the period 1961 – 1990, the sum of daily precipitation amounts at Zagreb-Grič in 2018 was slightly below the multiannual average (Chapter 2), but the maximum daily precipitation amount in October was 44.8 mm. A lack of precipitation was recorded in June, August and September and more pronounced during December. The total annual precipitation amount at Split-Marjan was slightly above the multiannual average with a wet period in February and March. (Chapter 2)

3.3.3 Cold wave in Croatia in February 2018

Most of Croatia was hit by a cold wave from 24 to 28 February 2018. Most of continental Croatia experienced heavy snowfall, as did the interior of Dalmatia. On 28 February, 108.2 cm of snow was measured in Delnice, the highest snow depth on record at the location in February. Ten small villages in Žumberak area were completely cut off and snowed in. More than a metre of snow fell in some places, with drifts reaching as high as 250 cm. Travel by road and rail through Lika and Gorski kotar, and especially cargo traffic, was difficult and occasionally disrupted. Several schools in Lika and Gorski kotar were closed due to snow and storm-strength wind. Parts of Hrvatsko Zagorje were in a similar situation. Croatian Army was called to Lika and Gorski kotar to provide the manpower and equipment to help clear roads, remove snow, and deliver food and medical supplies to the snowed-in areas. The Croatian Mountain Rescue Service also came to the aid of the snowed-in locals. Storm-strength bora wind in Kvarner and Rijeka area tore off boughs from trees, brought down entire trees and building scaffolds, and overturned trash containers and one truck. The snow drifts formed by the wind were several metres high. At Zavižan, 222 cm of snow was measured, with snowdrifts over 4 metres high. Water pipes in Zagreb burst



Slika 3.6 Snijeg u Gorskem kotaru i snježni nanosi u Delnicama 26. veljače 2018.

Figure 3.6 Snow in Gorski kotar and snow drifts in Delnice on 26 February 2018



Slika 3.7 Prevrtanje kamiona u Rijeci i snijeg na Visu, 26. veljače 2018. godine

Figure 3.7 Overturned truck in Rijeka and snow on the island Vis, 26 February 2018

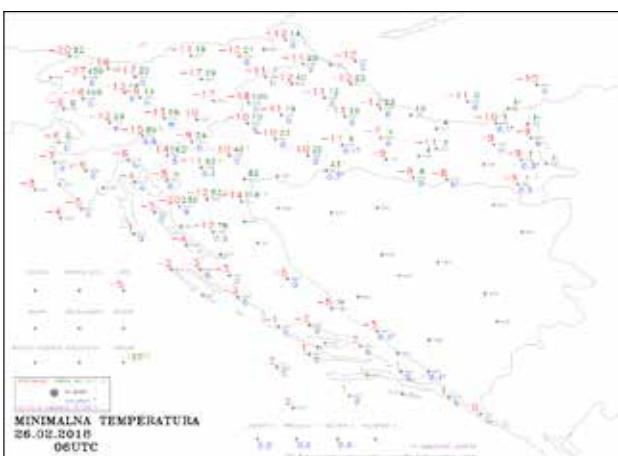
le, pa je bilo problema u vodoopskrbi, a uslijed skliskih površina na kolnicima i pločnicima, bilo je mnogo ozljeđenih građana. Diljem obale smrzavale su se barke u lukama, puhalo je bura, a more se ledilo na predmetima. Snijeg je pao u Šibeniku, Rijeci, Splitu, na Lastovu, Hvaru, Braču, Tribunj, u okolini Dubrovnika, čak i na Visu i Palagruži. More se zaledilo u okolini Pule. Ovakvi ekstremni vremenski uvjeti imali su sve karakteristike elementarne nepogode. Slika 3.8 prikazuje izmjerene minimalne temperature i količine oborine i visine snijega 26. veljače 2018. godine u 7 h po srednjeeuropskom vremenu, a slika 3.9 izmjerene brzine vjetra na postajama most Krk i GMP Rijeka u razdoblju od 24. do 28. veljače 2018. godine. Maksimalni zabilježeni udar vjetra na postaji Rijeka 25. veljače je iznosio 26.4 ms^{-1} , a na mostu Krk je zabilježen i maksimalan udar od 50.6 ms^{-1} .

Na svim analiziranim postajama srednja mjeseca temperatura zraka za veljaču 2018. bila je niža od više-



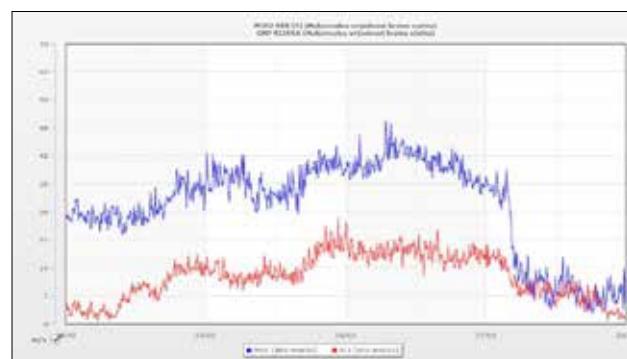
due to the cold, causing problems in water supply, and many citizens sustained injuries on the slippery roads and pavements. Boats froze in ports along the entire coast, bora wind blew, and seawater froze on objects. There was snow in Šibenik, Rijeka, Split, Lastovo, Hvar, Brač, Tribunj, the surroundings of Dubrovnik, and even in Vis and Palagruža. The sea froze in the surroundings of Pula. Such extreme weather had all of the characteristics of a natural disaster. Figure 3.8 shows the measured minimum temperatures, precipitation amounts and snow depths at 7:00 am CET on 26 February. Figure 3.9 shows the wind speeds measured at the stations Krk Bridge and main meteorological station Rijeka from 24 to 28 February 2018. The speed of the maximum wind gust measured at the station Rijeka on 25 February was 26.4 ms^{-1} , and the maximum wind gust measured at the Krk Bridge had the speed of 50.6 ms^{-1} .

The mean monthly air temperature in February 2018 was lower than the multiannual average (1961 – 1990) at all



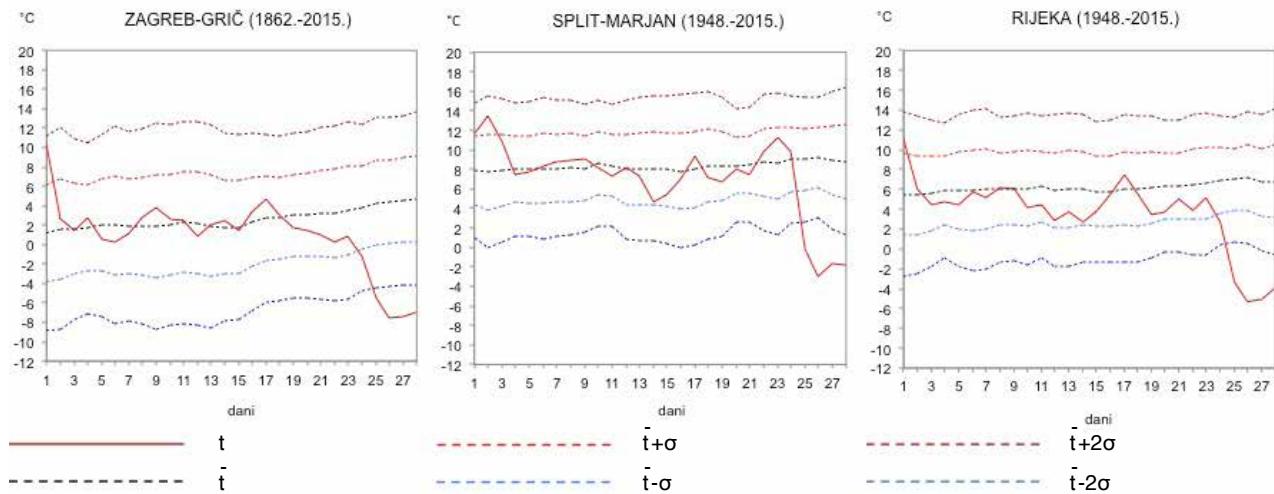
Slika 3.8 Minimalne temperature zraka, količine oborine i visine snijega 26. veljače 2018. na sinoptičkim postajama u Hrvatskoj i susjednim zemljama u 7 h po srednjoeuropskom vremenu

Figure 3.8 Minimum air temperatures, precipitation amounts and snow depths on 26 February 2018 at synoptic stations in Croatia and neighbouring countries at 7:00 am CET



Slika 3.9 Maksimalna brzina vjetra (ms^{-1}) na automatskoj postaji Krk-most i GMP Rijeka od 24. do 28. veljače 2018. godine

Figure 3.9 Maximum wind speed (ms^{-1}) at automatic weather stations Krk Bridge and main meteorological station Rijeka from 24 to 28 February 2018

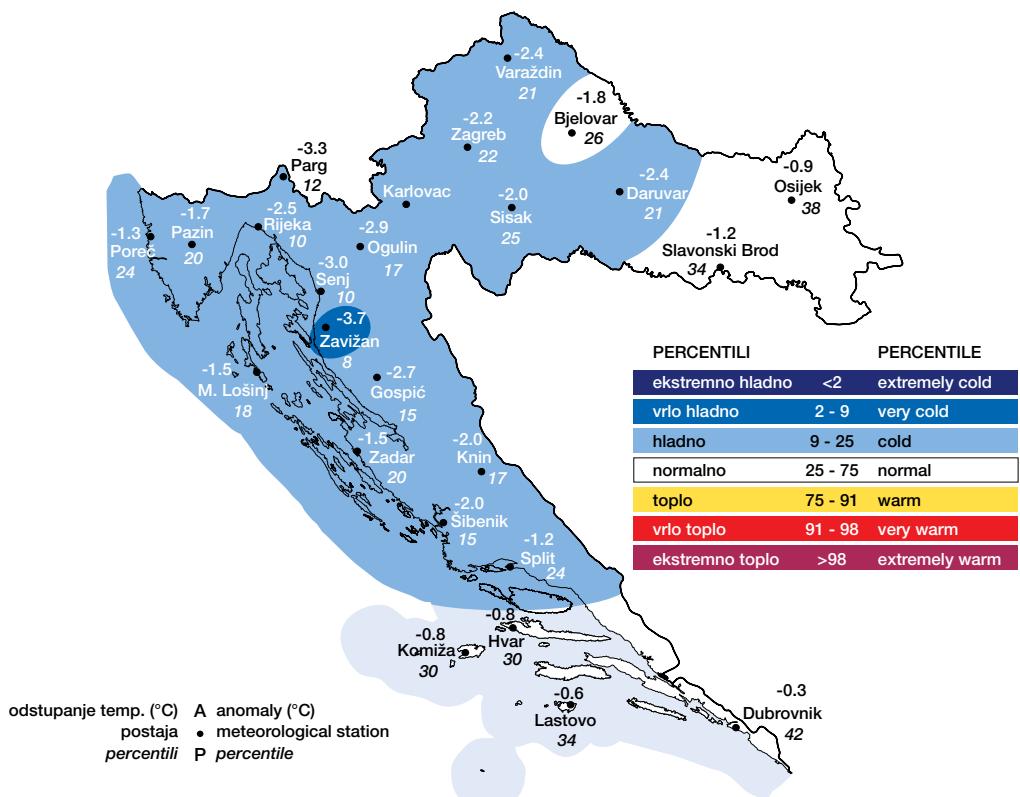


Slika 3.10 Srednja dnevna temperatura zraka za Zagreb-Grič, Split-Marjan i Rijeku za VELJAČU 2018. godine u usporedbi s dugogodišnjim srednjim vrijednostima (\bar{t}) i standardnim devijacijama (σ)

Figure 3.10 Mean daily air temperatures at Zagreb-Grič, Split-Marjan and Rijeka in February 2018 compared to long-term mean values (\bar{t}) and standard deviations (σ)

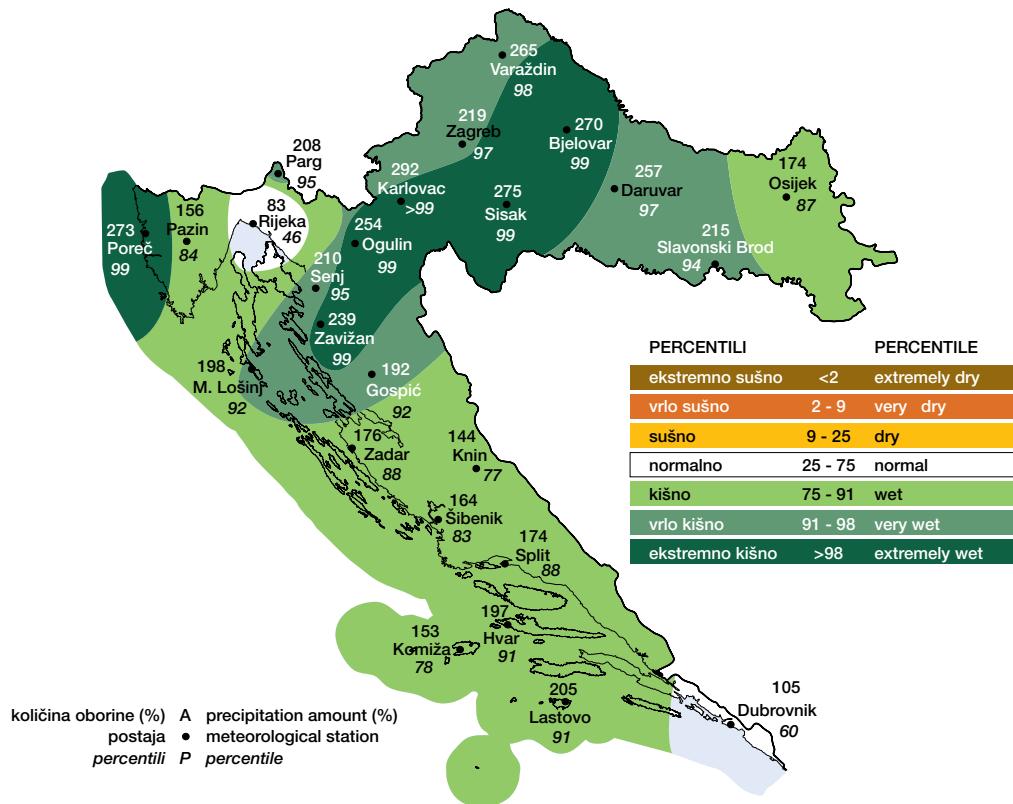
godišnjeg prosjeka (1961. – 1990.). Anomalije srednje mješevne temperature zraka bila su u rasponu od -3,7°C (Zavižan) do -0,3°C (Dubrovnik). Apsolutna minimalna temperatura zraka za veljaču 2018. bila je na svim analiziranim postajama niža od odgovarajućeg prosjeka (1961. – 1990.), a nalazila se u rasponu od -7,1°C (Zavižan)

analysed stations. Mean monthly air temperature anomalies ranged between -3.7°C (Zavižan) and -0.3°C (Dubrovnik). The absolute minimum air temperature in February 2018 was lower than the relevant average (1961 – 1990) at all analysed stations and ranged between -7.1°C (Zavižan) and -0.3°C (Ogulin). Two exceptionally cold days were re-



Slika 3.11 Odstupanje srednje mješevne temperature zraka (°C) za veljaču 2018. od prosječnih vrijednosti (1961. - 1990.)

Figure 3.11 Mean monthly air temperature anomalies (°C) in Croatia, relative to the multiannual average for the period 1961-1990 in February 2018



Slika 3.12 Mjesečne količine oborine izražene u % višegodišnjeg prosjeka (1961.-1990.) za veljaču 2018.

Figure 3.12 Monthly precipitation amounts given in percentages of multiannual average for the period 1961-1990 in Croatia, February 2018

žan) do $-0,3^{\circ}\text{C}$ (Ogulin). Na postaji Zagreb-Grič zabilježena su dva izvanredno hladna dana 26. i 27. veljače kada je izmjerena srednja dnevna temperatura zraka bila $-7,6^{\circ}\text{C}$ i $-7,4^{\circ}\text{C}$. U Rijeci i Splitu na postaji Split-Marjan su zabilježena tri izvanredno hladna dana 25., 26. i 27. veljače, pri čemu je najniža srednja dnevna temperatura u Rijeci iznosila $-5,3^{\circ}\text{C}$, a u Splitu $-3,0^{\circ}\text{C}$. U usporedbi s dugogodišnjim srednjim vrijednostima srednja dnevna temperatura bila je ispod dvije standardne devijacije za veljaču za vrijeme hladnog vala (slika 3.10).

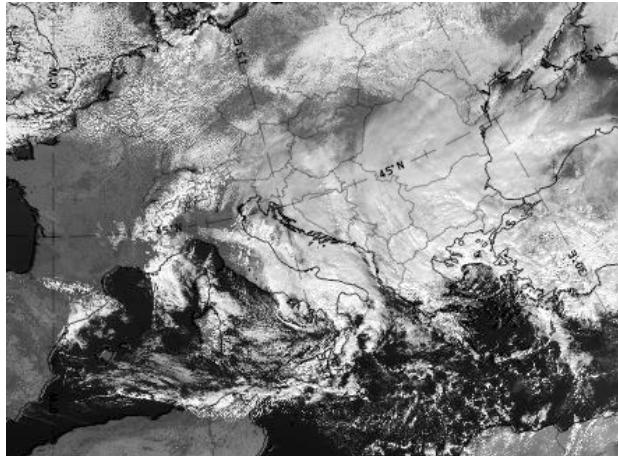
Usporedba s raspoloživim nizom analiziranih postaja pokazuje da je 28. veljače 2018. u Zadru zabilježena rekordna vrijednost apsolutne minimalne temperature zraka tj. mjesecni minimum za veljaču 2018. ($-6,4^{\circ}\text{C}$) jednak je apsolutnom minimumu postaje Zadar ($-6,4^{\circ}\text{C}$, 5. veljače 2012.). Prema raspodjeli percentila, toploinske prilike u Hrvatskoj za veljaču 2018. godine opisane su sljedećim kategorijama: **normalno** (šire područje Bjelovara, dio istočne Hrvatske i južni Jadran), **vrlo hladno** (Zavižan) i **hladno** (preostali dio Hrvatske) (slika 3.11). Anomalije srednje dnevne temperature zraka tj. odstupanja srednje dnevne temperature zraka od višegodišnjeg prosjeka (1961. – 1990.) za veljaču 2018. bile su negativne za sve promatrane gradove u Hrvatskoj.

Analiza količina oborine za veljaču 2018. (slika 3.12) koje su izražene u postotcima (%) višegodišnjeg prosjeka (1961. – 1990.) pokazuje da su količine oborine bile iznad višegodišnjeg prosjeka izuzevši postaju Rijeka. Oboriske prilike u Hrvatskoj za veljaču 2018. godine opisane

corded at the station Zagreb-Grič on 26 and 27 February 2018, when mean daily air temperatures of -7.6 and -7.4°C were measured. Three exceptionally cold days were recorded in Rijeka and at the station Split-Marjan on 25, 26 and 27 February, with the lowest daily air temperatures of -5.3°C in Rijeka and -3.0°C in Split. In comparison with the long-term mean values, the mean daily air temperature was below two standard deviations for February during the cold wave (Figure 3.10).

The comparison with the available data series of analysed stations reveals that monthly minimum for February 2018 in Zadar (-6.4°C , 28 February 2018) was on par with the absolute minimum on record (5 February 2012). According to percentile ranks, thermal conditions in Croatia in February 2018 fall into the **normal** (wider Bjelovar area, part of eastern Croatia and Southern Adriatic), **very cold** (Zavižan) and **cold** (the rest of Croatia) categories (Figure 3.11). Mean daily air temperature anomalies in February 2018 were negative in all considered cities in Croatia.

The analysis of precipitation amounts in February 2018 (Figure 3.12), expressed as percentages (%) of the multiannual average (1961 – 1990), shows that precipitation amounts were above the multiannual average, with the exception of station Rijeka. Precipitation conditions in Croatia in February 2018 fall into the **normal** (wider Rijeka and Dubrovnik area), **extremely wet** (wider Poreč area and part of Central Croatia), **very wet** (broader Pag area, part of Northern Adriatic, Lika and part of Northwestern and Eastern Croatia) and **wet** (the rest of Croatia) categories.



Slika 3.13 Meteosat-10 snimka visoke rezolucije u vidljivom dijelu spektra (eng. High Resolution Visible - HRV) 26. veljače 2018. u 12 UTC

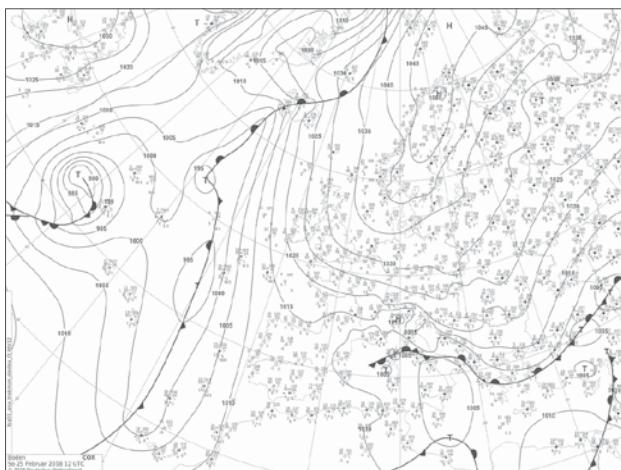
Figure 3.13. Meteosat-10 High Resolution Visible (HRV) imagery on 26 February 2018 at 12 UTC

su sljedećim kategorijama: **normalno** (šire područje Rijeke i Dubrovnika), **ekstremno kišno** (šire područje Po-reča i dio središnje Hrvatske), **vrlo kišno** (šire područje Parga, dio sjevernog Jadrana, Like te dio sjeverozapadne i istočne Hrvatske) i **kišno** (preostali dio Hrvatske).

Prema prizemnoj sinoptičkoj situaciji prema Hrvatskoj sa sjevera i sjeveroistoka Europe pružao se ogrank prostrane sibirske anticiklone, a 24. veljače na vrijeme u Hrvatskoj sve više je utjecala i ciklona s područja sjevera Afrike sa središtem u Tirenском moru. Zbog velikog gradijenta tlaka između dva spomenuta sustava duž obale je puhala olujna bura. Uz to na prednjoj strani ciklone pritjecala je velika količina vlažnog zraka sa Sredozemlja, dok je sa sjevera unutar anticiklone dolazio vrlo hladan zrak. Takva raspodjela zračnih masa uzrokovala je obilan snijeg u Gorskom kotaru i sjeverozapadnom dijelu Hrvatske, a snijeg je zabilježen i na obali i otocima. Slika 3.14 prikazuje sinoptičku situaciju 25. i 26. veljače 2018. u 12 UTC. Dalje je 27. veljače je utjecaj sibirske antici-

Figure 3.13 shows the distribution of cloud systems over Europe in the Meteosat-10 High Resolution Visible (HRV) imagery on 26 February 2018 at 12 UTC.

The surface synoptic situation shows that the ridge of a widespread Siberian anticyclone was extending toward Croatia from the north and north-east of Europe, and that the cyclone from the area of the Northern Africa whose centre was over the Tyrrhenian Sea increasingly affected the weather in Croatia on 24 February. Storm-strength bora blew along the coast due to the high pressure gradient between these two systems. In addition, a large amount of moist air was coming in from the Mediterranean at the front of the cyclone, while very cold air was coming in from the north inside the anticyclone. Such a distribution of air masses caused heavy snowfall in Northwestern Croatia, and snowfall was also recorded at the coast and the islands. Figure 3.14 shows the synoptic situations on 25 and 26 February 2018 at 12 UTC. After that, on 27 February, the Siberian anticyclone was the more dominant influence over



Slika 3.14 Prizemna sinoptička situacija 25. veljače u 12 UTC i 26. veljače 2018. u 12 UTC (izvor: Njemačka meteorološka služba-DWD)

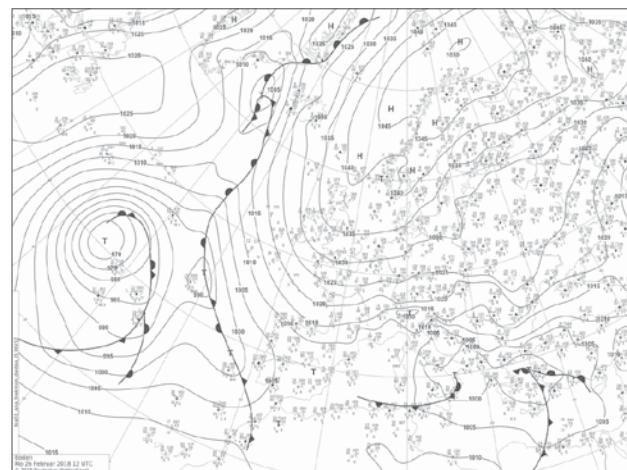
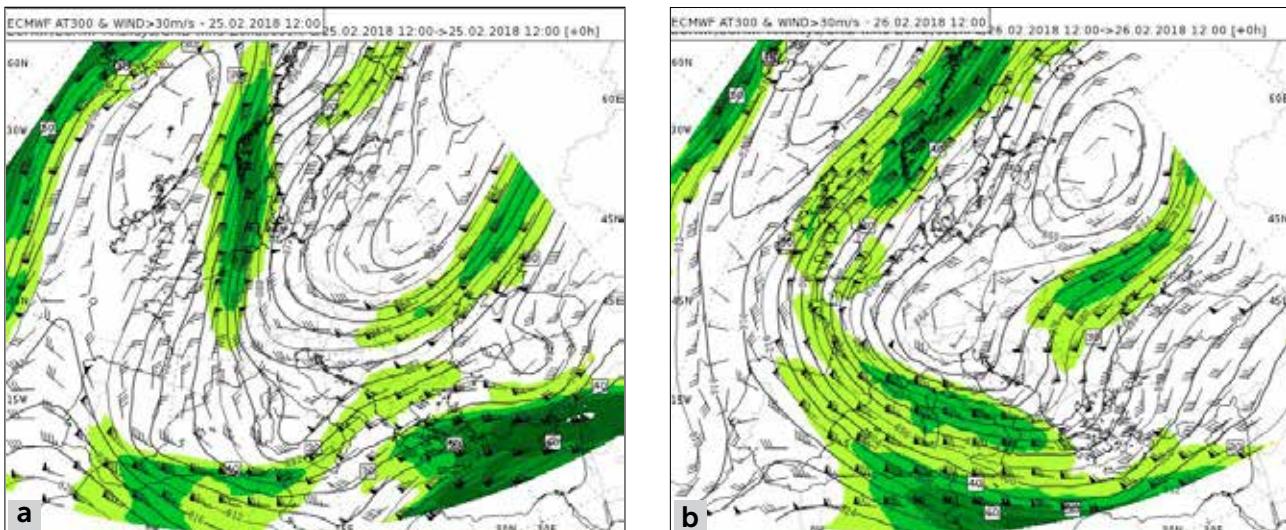
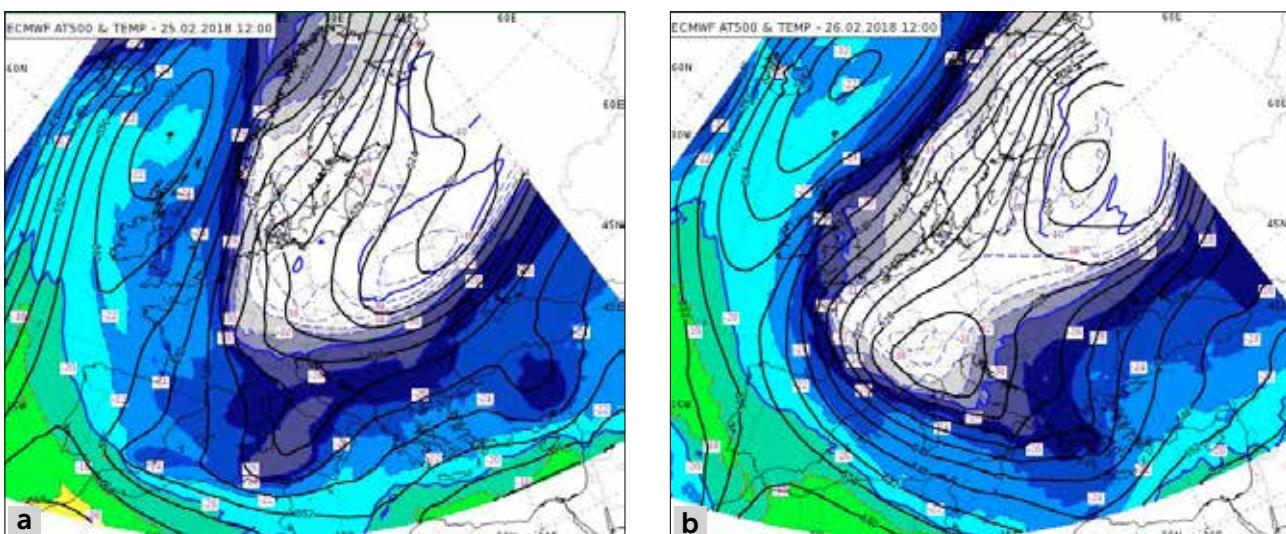


Figure 3.14 Surface synoptic situation on 25 February at 12 UTC and 26 February 2018 at 12 UTC (source: German Meteorological Service-DWD)



Slika 3.15 Razdioba geopotencijalnih visina (izohipse - pune crte u geopotencijalnim dekametrima), smjera i brzine vjetra (zastavice, brzine vjetra iznad 30 ms^{-1} (sjenčano-nijanse boje) na izobarnoj plohi 300 hPa na širem području Europe za dane 25. veljače (a) i 26. veljače 2018. (b) u 12 UTC (prema analizi Europskog centra za srednjoročnu prognozu vremena-ECMWF)

Figure 3.15 Distribution of geopotential heights (isohypes - full lines in geopotential decametres), wind speed and direction (flags) and wind speeds higher than 30 ms^{-1} (colour-shaded) on the isobaric surface of 300 hPa in the wider territory of Europe for the days of 25 February (a) and 26 February (b) 2018 at 12 UTC (according to ECMWF analysis)



Slika 3.16 Razdioba geopotencijalnih visina (izohipse - pune crte u geopotencijalnim dekametrima) i izotermi (nijanse boja) na izobarnoj plohi 500 hPa na širem području Europe za dane 25. (a) i 26. veljače (b) 2018. godine u 12 UTC (prema analizi ECMWF-a)

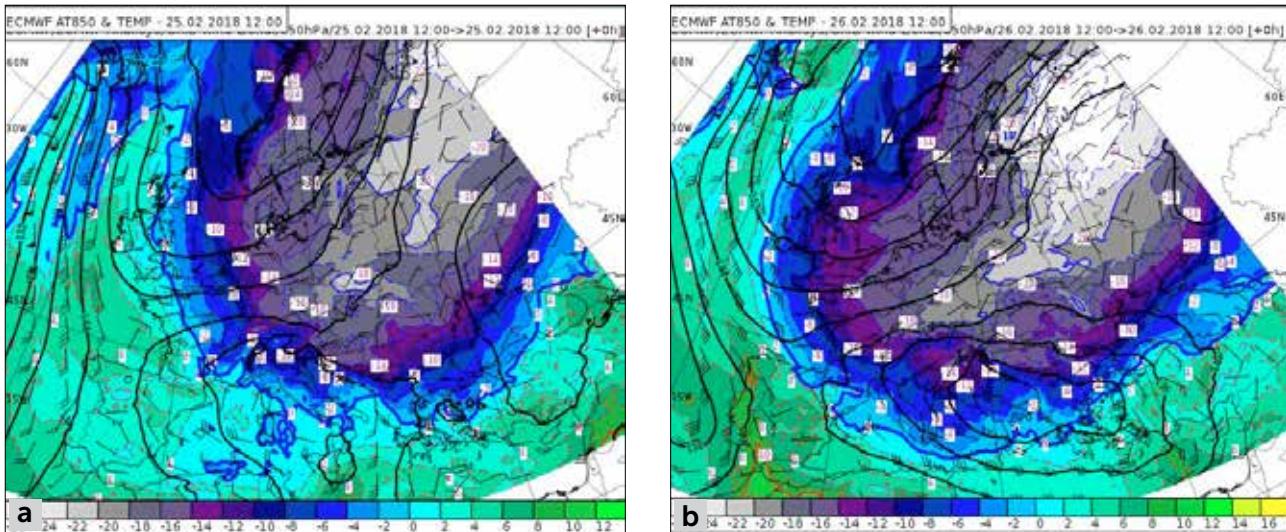
Figure 3.16 Distribution of geopotential heights (isohypes - full lines in geopotential decametres) and isotherms (colour-shaded) on the isobaric surface of 500 hPa in the wider territory of Europe for the days of 25 February (a) and 26 February (b) 2018 at 12 UTC (according to ECMWF analysis)

klone bio dominantniji nad područjem Hrvatske, te su se oborine smanjile, a vjetar oslabio, no sa sjevera se spustila polarna kontinentalna zračna masa s osjetno hladnjim zrakom.

Slika 3.15 prikazuje razdiobu geopotencijalne visine i brzine i smjera vjetra te područje mlazne struje (brzina vjetra veća od 30 ms^{-1}) na izobarnoj plohi 300 hPa dok je na slikama 3.16 i 3.17 prikazana razdioba visina temperature zraka na izobarnim plohama 500 hPa i 850 hPa za dane 25. i 26. veljače 2018. godine u 12 UTC.

the territory of Croatia, causing precipitation and wind to reduce. However, a polar continental air mass descended from the north, bringing perceptibly colder air.

Figure 3.15 shows the distribution of geopotential heights and wind speeds and direction, as well as the jet stream area (wind speed higher than 30 ms^{-1}) on the isobaric surface of 300 hPa, while Figures 3.16 and 3.17 show the distribution of geopotential heights and air temperatures on isobaric surfaces of 500 hPa and 850 hPa for the days of 25 and 26 February 2018 at 12 UTC.



Slika 3.17 Razdioba geopotencijalnih visina (izohipse - pune crte u geopotencijalnim dekametrima) i izotermi (nijanse boja), te vektoro vjetra na izobarnoj plohi 850 hPa na širem području Europe za dane 25. (a) i 26. veljače (b) 2018. godine u 12 UTC (prema analizi ECMWF-a)

Figure 3.17 Distribution of geopotential heights (isohypsies - full lines in geopotential decametres) and isotherms (colour shaded) as well as wind vectors on the isobaric surface of 850 hPa in the wider territory of Europe for the days of 25 February (a) and 26 February (b) 2018 at 12 UTC (according to ECMWF analysis)

Po visini je na 300 hPa nad područjem sjeverne Europe ciklona, koja sa sjevera Europe donosi hladan zrak prema središnjim dijelovima Europe, pri čemu je mlazna struja prelazi preko područja Hrvatske (slika 3.15). Na 500 hPa u sklopu duboke ciklone zadržava se hladni polarni zrak koji se zajedno s dolinom tijekom 24. veljače spuštao prema području središnjeg dijela Europe. Visinska ciklona s hladnim zrakom formirala se na Jadranu 26. veljače (slike 3.16b i 3.17b), i zadržavala nad područjem Hrvatske do 28. veljače nakon čega se postupno premještala prema istoku.

3.3.4 Nevrijeme u Zagrebu, 13. lipnja 2018. godine

Zagreb je 13. lipnja poslijepodne pogodilo grmljavinsko nevrijeme praćeno obilnom kišom i tučom. Poplavljeni su KBC Rebro, plućna bolnica Jordanovac, Ekonomski fakultet i škole (vidi sliku 3.18). Zabilježeno je ukupno tridesetak intervencija ispumpavanja vode iz prostora u istočnom dijelu grada i podsljemenskoj zoni. Na udare je puhaoo vrlo jak i olujni vjetar koji je lomio i čuo stabla, a prema novinskim napisima zabilježena je i pojava pijavice. Na postaji Zagreb-Maksimir izmjereno je 46.1 mm dnevne količine oborine, a na postaji Puntijarka 97.9 mm oborine (slika 3.19), što je i maksimalna dnevna količina oborine za lipanj za postaju Puntijarka otkad postoje mjerjenja, od 1981. godine. Dosadašnji maksimum iznosio je 66.1 mm, od 19. lipnja 1981. godine, a apsolutni maksimum je 133.7 mm od 4. srpnja 1989. godine. Temperatura zraka se naglo spustila za čak 7°C. Nevrijeme, mjestimice praćeno tučom, pogodilo je i druge dijelove kopnene Hrvatske, te Dalmaciju i Istru.

Satne količine oborine na postajama Zagreb-Maksimir i Puntijarka pokazuju da su najveće količine oborine pale poslije 12 h po srednjoeuropskom vremenu (slika 3.20). Prizemna sinoptička karta prikazana je na slici 3.21

An upper-level cyclone is located over the territory of Northern Europe at 300 hPa, bringing in cold air from the north of Europe to the central parts of Europe, with the jet stream crossing over Croatia's territory (Figure 3.15). Cold polar air remained at 500 hPa as a part of the deep cyclone and descended toward the central part of Europe together with the low on 24 February. The upper-level low with cold air formed in the Adriatic on 26 February (Figures 3.16b and 3.17b) and remained over the territory of Croatia by 28 February, after which it gradually moved toward the east.

3.3.4 Severe weather in Zagreb, 13 June 2018

In the afternoon of 13 June 2018, Zagreb was hit by a thunderstorm, with heavy rainfall and hail. University Hospital Centre Rebro, Clinical Centre for Pulmonary Diseases Jordanovac, the Faculty of Economics and Business, and several schools were flooded (see Figure 3.18). A total of about thirty interventions to pump water out of flooded buildings in the eastern part of the city and the district Podsljemenska zona (below Mount Sljeme) were reported. The storm was accompanied by gusts of very strong and storm-strength wind that felled and pulled out trees, and the media even reported about the occurrence of a waterspout. The daily precipitation amount recorded at the station Zagreb-Maksimir was 46.1 mm and the daily precipitation amount at the station Puntijarka was 97.9 mm (Figure 3.19), which is the maximum daily precipitation amount on record in June at the station Puntijarka since the beginning of measurements in 1981. The previous maximum of 66.1 mm was recorded on 19 June 1981, while the absolute maximum of 133.7 mm was recorded on 4 July 1989. Air temperature dropped suddenly by as much as 7°C. Storms, accompanied by localised hail, hit other parts of continental Croatia too, as well as Dalmatia and Istria.



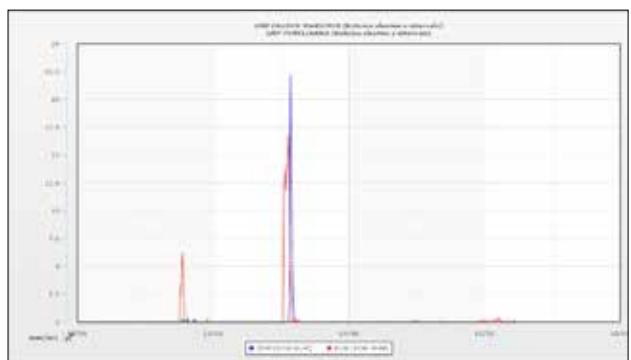
Slika 3.18 Poplava u Zagrebu 13. lipnja 2018. godine

Figure 3.18 Flood in Zagreb, 13 June 2018



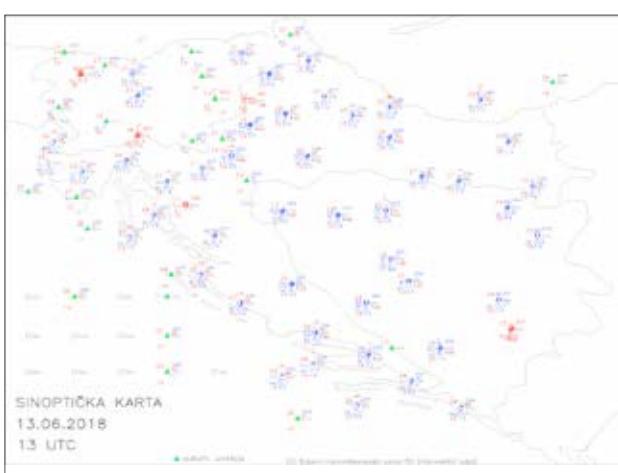
Slika 3.19 24-satne količine oborine nad područjem Hrvatske, izmjerene 14.lipnja 2018. u 7 h po srednjoeuropskom vremenu

Figure 3.14 24-hour precipitation amounts over the territory of Croatia, recorded on 14 June 2018 at 7:00 am CET



Slika 3.20 Satne količine oborine izmjerene na glavnim meteoroškim postajama Zagreb-Maksimir i Puntjarka , od 12. do 16. lipnja 2018. godine

Figure 3.20 Hourly precipitation amounts recorded at the main meteorological stations Zagreb-Maksimir and Puntjarka from 12 to 16 June 2018



Slika 3.21 Sinoptička karta, 13. lipnja 2018. godine u 14 h po srednjoeuropskom vremenu

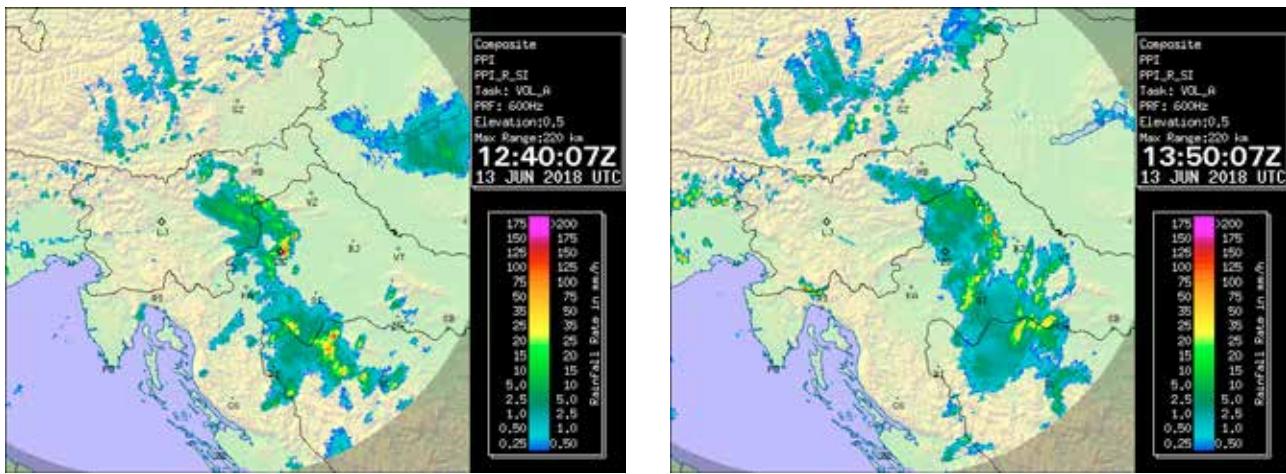
Figure 3.21 Synoptic map at 2:00 pm CET on 13 June 2018

za 13. lipanj 2018. godine u 15 h po srednjoeuropskom vremenu, te prikazuje područje koje je zahvatio mezoskalni konvektivni sustav (engl. Mesoscale Convecting System - MCS). Radarska slika centra Lisca (Slovenija)

Hourly precipitation amounts at the stations Zagreb-Maksimir and Puntjarka show that the highest precipitation amounts were recorded after 12:00 CET (Figure 3.20). The surface synoptic map at 3:00 pm CET on 13 June 2018 (Figure 3.21) shows the area affected by the Mesoscale Convecting System (MCS). The radar imagery from the centre Lisca (Slovenia) indicates that the maximum precipitation amounts (mm h^{-1}) were first recorded over Zagreb, and then eastwards, from Varaždin in the north to western Slavonija in the south, at about 2:00 pm CET (Figure 3.22).

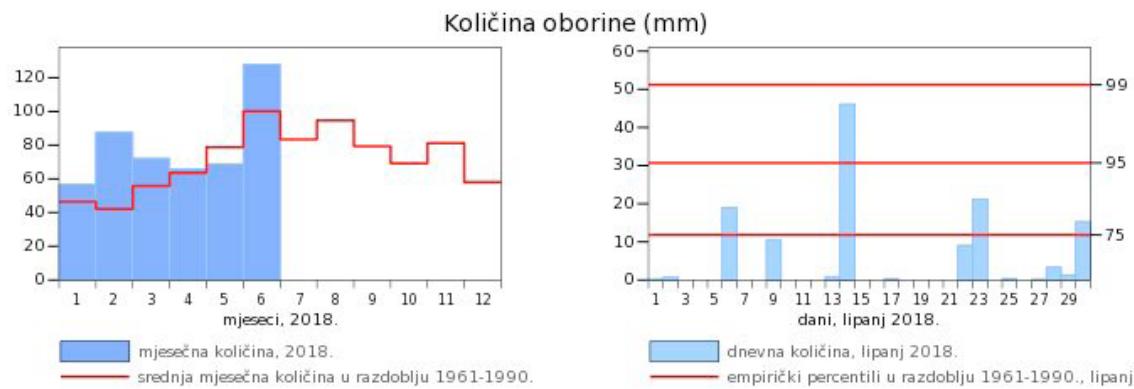
The comparison of monthly precipitation amounts for 2018 reveal that multiannual mean for June was exceeded (Figure 3.23) for meteorological station Zagreb-Maksimir. The highest daily precipitation amount was recorded on 14 June 2018, from rain of previous day in the afternoon period (Figure 3.23, on the right). The daily precipitation amount recorded on 14 June 2018 is at the same time absolute maximum for June 2018 for Zagreb-Maksimir.

The surface synoptic situation shows that the frontal system extending from the Bay of Biscay area toward the far north of Europe on 13 June 2018 was approaching Croatia. When it shifted over the Alps at midday, the surface cyclone centre closed over the western part of the Mediterranean, south of France. In addition, there were two



Slika 3.22 Radarska slika (radarski centar Lisca (Slovenija)), 13. lipnja 2018. u 1340 i 1450 h po srednjoeuropskom vremenu

Figure 3.22 Radar imagery (radar centre Lisca, Slovenia) at 01:40 and 2:50 pm CET on 13 June 2018



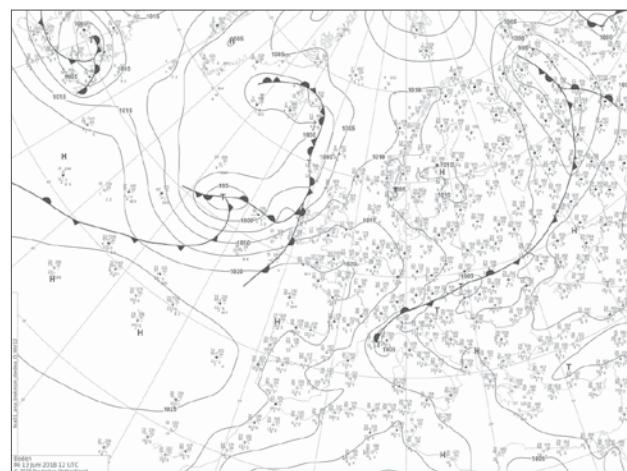
Slika 3.23 Usporedba mjesečne količine oborine u lipnju s višegodišnjim prosjekom (1961.-1990.) (lijevo), te dnevne količine oborine za lipanj u usporedbi s percentilima za razdoblje 1961.-1990. godine (desno) za postaju Zagreb-Maksimir

Figure 3.23 The comparison of the monthly precipitation amount for June with the multiannual mean for the period 1961-1990 (on the left) and the comparison of the daily precipitation amount in June with the percentiles for the period 1961-1990 (on the right) for the station Zagreb-Maksimir

ukazuje na najveće količine oborine (mm h^{-1}) najprije nad Zagrebom, a zatim istočnije, od Varaždina na sjeveru prema području zapadne Slavonije na jugu oko 14 h po srednjoeuropskom vremenu (slika 3.22).

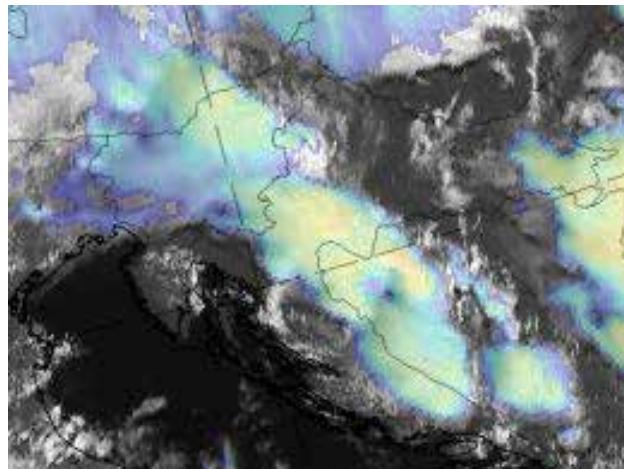
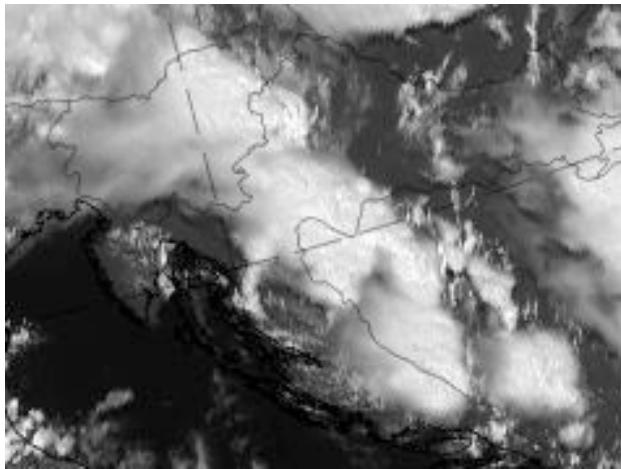
Usporedba mjesečnih količina oborine za 2018. godinu s višegodišnjim prosjekom (1961. – 1990.) pokazuje da je u lipnju premašen višegodišnji prosjek za postaju Zagreb-Maksimir (slika 3.23), a najveća dnevna količina oborine izmjerena je 14. lipnja 2018. (od kiše koja je padala 13. lipnja 2018. u popodnevnim satima). Dnevna količina oborine izmjerena 14. lipnja 2018. ujedno je i maksimalna dnevna količina oborine za lipanj 2018. za postaju Zagreb-Maksimir (slika 3.23 desno).

Prema prizemnoj sinoptičkoj situaciji frontalni sustav koji se pružao od područja Biskajskog zaljeva prema krajnjem sjeveru Europe 13. lipnja 2018. približavao se našim krajevima, a sredinom dana njegovim premeštanjem preko Alpa zatvorio se centar prizemne ciklone nad zapadnim dijelom Sredozemlja južno od Francuske. Osim spomenutog, bila su prisutna i dva plitka centra



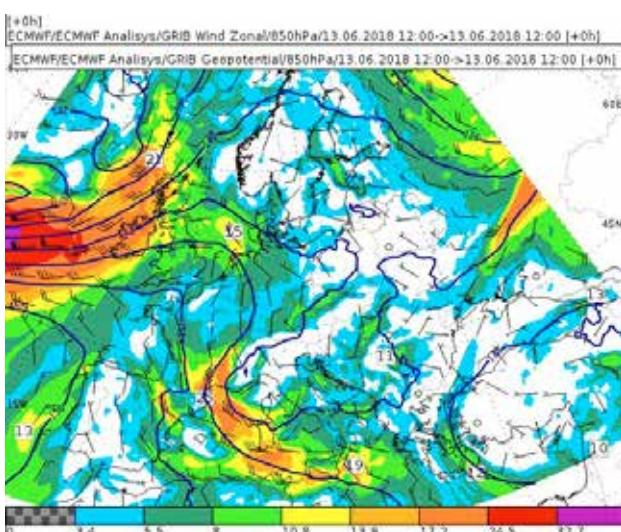
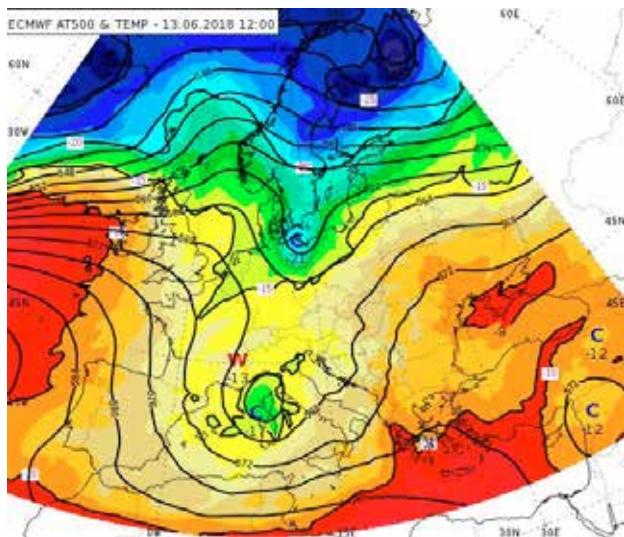
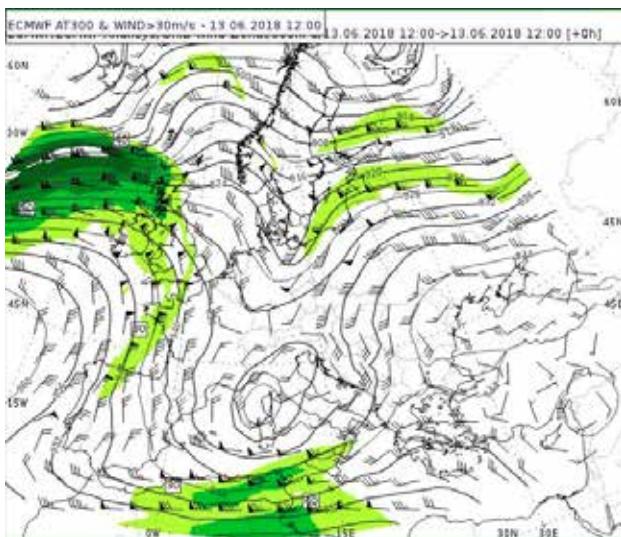
Slika 3.24 Prizemna sinoptička situacija 13. lipnja 2018. u 12 UTC (izvor: Njemačka meteorološka služba-DWD)

Figure 3.24 Surface synoptic situation on 13 June 2018 at 12 UTC (source: German Meteorological Service-DWD)



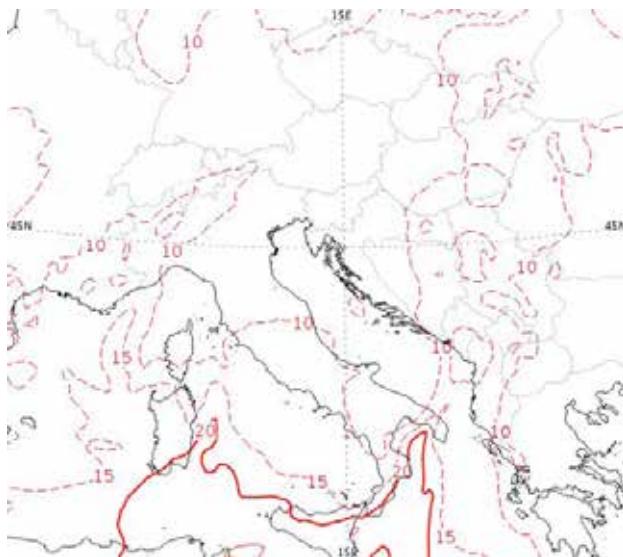
Slika 3.25 Meteosat-10 snimka visoke rezolucije u vidljivom dijelu spektra (eng. High Resolution Visible - HRV) (a), te "Sandwich" produkt kao kombinacija HRV satelitske snimke (eng. Color Enhanced - CE) i infracrvene IR 10.8 μm satelitske slike gdje boje označavaju vrijednosti temperature vrha grmljavinskih oblaka to jest neizravno njihovu visinu (b), 13. lipnja 2018. u 12 UTC

Figure 3.25 The High Resolution Visible (HRV) Meteosat-10 image (a) and the "Sandwich" product as a combination of the HRV satellite image (Colour Enhanced - CE) and infrared IR 10.8 μm satellite image, where the colours represent thundercloud top temperature values, or indirectly their height (b), 13 June 2018 at 12 UTC



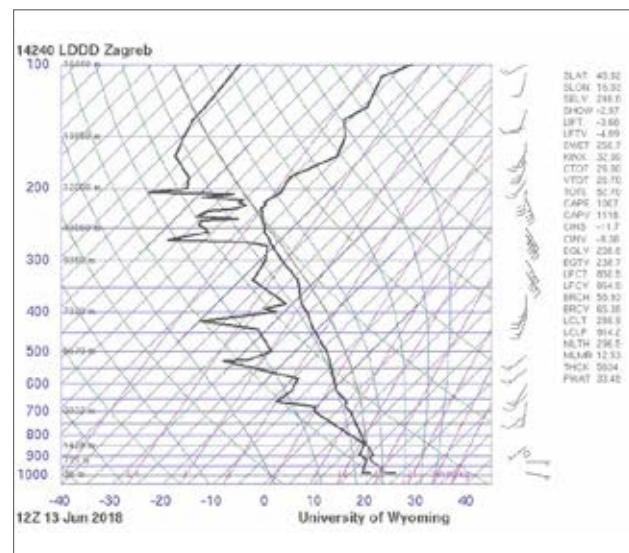
Slika 3.26 Razdioba geopotencijalne visine (izohipse - pune crte u geopotencijalnim dekametrima), brzine i smjera vjetra (zastavice) i brzine vjetra veće od 30 ms^{-1} na izobarnoj plohi 300 hPa (sjenčano u boji) (a), razdioba geopotencijalne visine (izohipse - pune crte u geopotencijalnim dekametrima) i temperature zraka (sjenčano u boji) na izobarnoj plohi 500 hPa (b), te razdioba geopotencijalne visine (izohipse - pune crte u geopotencijalnim dekametrima), brzine i smjera vjetra (zastavice), te temperature zraka (sjenčano u boji) na izobarnoj plohi 850 hPa (c), 13. lipnja 2018. u 12 UTC

Figure 3.26 Distribution of geopotential heights (isohypes - full lines in geopotential decimetres), wind speed and direction (flags) and wind speeds higher than 30 ms^{-1} on the isobaric surface of 300 hPa (colour-shaded) (a), distribution of geopotential heights (isohypes - full lines in geopotential decimetres) and air temperature (colour shaded) on the isobaric surface of 500 hPa (b), and distribution of geopotential heights (isohypes - full lines in geopotential decimetres), wind speed and direction (flags) and air temperatures (colour-shaded) on the isobaric surface of 850 hPa, 13 June 2018, 12 UTC



Slika 3.27 Smicanje vjetra visinom od 10 m visine u odnosu na vjetar na 500 hPa 13. lipnja 2018. u 12 UTC

Figure 3.27 Vertical wind shear at the altitude of 10 m in relation to wind at 500 hPa on 13 June 2018, 12 UTC



Slika 3.28 Radiosondažna mjerena profilna diagram s glavne meteorološke postaje Zagreb-Maksimir 13. lipnja 2018. u 12 UTC (izvor: University of Wyoming)

Figure 3.28 Radiosonde measurements from main meteorological station Zagreb-Maksimir on 13 June 2018 at 12 UTC (source: University of Wyoming)

sniženog tlaka, od kojih je jedan nad područjem središnje Hrvatske (slika 3.24). Visinski nam se približavala dolina sa zapada Europe s hladnom jezgrom (eng. cut-off low-COL) koja se 13. lipnja zadržavala nad područjem Genovskog zaljeva. Na slici 3.26 vidljiv je položaj visinske doline s hladnom jezgrom na topografijama izobarnih ploha 300 i 500 hPa u 12 UTC. Na prednjoj strani doline u jugozapadnoj struci pritjecao je zrak bogat vlagom, a os doline je navećer prelazila preko sjeverozapadnog dijela Hrvatske. U takvim sinoptičkim uvjetima atmosfera postaje hidrostaticki nestabilna i bogata vlagom što izrazito povoljno utječe na razvoj konvekcije.

Na tzv. "Sandwich" produktu koji je kombinacija satelitske HRV snimke i IR 10.8 µm snimke gdje boje označavaju vrijednosti temperature. Boje na slici označavaju intervale temperature niže od 240 K pri čemu je tamno plava toplija, a žuta, te crvena hladnija. Crvenom bojom su tako prikazani najhladniji, a tako vjerojatno i najviši, vrhovi oblaka MCS-a koji ukazuju na jaka uzlazna strujanja i razvoj grmljavinskih oblaka nad područjem sjeverozapadne Hrvatske (slika 3.25).

Nad kopnenim dijelom Hrvatske bilo je prisutno jako smicanje vjetra, kao i visoka vrijednost konvektivne raspoložive potencijalne energije (eng. convective available potential energy – CAPE) koja je prema mjerjenjima postaje Zagreb-Maksimir iznosila $1007 \text{ m}^2\text{s}^{-2}$ (slike 3.27 i 3.28) što je doprinijelo organizaciji konvektivnih ćelija. Prema radio-sondažnim mjerjenjima visina donje podnice oblaka je bila na oko 1000 m visine, a vidljivo je i smicanje vjetra visinom. Razvio se linijski mezoskalni konvektivni sustav (eng. squall line, MCS-Mesoscale convective system) od Varaždina na sjeveru prema području zapadne Slavonije na jugu (slika 3.22) koji je za posljedicu imao velike količine oborine, uključujući tuču, te prolazno jake i olujne udare vjetra na tom području.

shallow lower pressure centres, one of which was located over Central Croatia (Figure 3.24). An upper-level cut-off low (COL) was approaching Croatia from the west of Europe, staying over the Genoa Bay area on 13 June. Figure 3.26 shows the position of the upper-level cut-off low in the south-western flow, and the axis of the low crossed over Northwestern Croatia in the evening. In such synoptic conditions, the atmosphere becomes hydrostatically unstable and highly humid, which is very conducive to convection development.

In the so-called "Sandwich" product, the combination of the HRV satellite image and the IR 10.8 µm image, colours represent temperature values. The colours in the image represent temperature intervals under 240 K. Dark blue colour represents warmer, and yellow and red colder temperatures. The coldest - and thus probably the highest - MCS cloud tops, indicative of strong updraft and the development of thunderclouds over the area of Northwestern Croatia (Figure 3.25), are shown in red.

Strong wind shear and a high convective available potential energy (CAPE) value were recorded over continental Croatia. Station Zagreb-Maksimir measured $1007 \text{ m}^2\text{s}^{-2}$ (Figures 3.27 and 3.28), which contributed to the organisation of convective cells. Radiosonde measurements show that cloud lower boundary was at the approximate altitude of 1000 m, and they also reveal vertical wind shear. A squall line mesoscale convective system (MCS) developed in the area from Varaždin in the north to the area of western Slavonia in the south (Figure 3.22), which resulted in significant precipitation amounts, including hail, and temporary strong and storm-strength wind gusts in the area.

3.3.5 Nevrijeme u Dubrovniku, 2. listopada 2018.

Olujno nevrijeme praćeno jakom grmljavinom i obilnom kišom pogodilo je Dubrovnik u noći s 1. na 2. listopada 2018., a prema podacima DHMZ-a u svega tri sata pao je 259.2 mm oborine, što je prouzročilo povodanje pri čemu su poplavljeni stambeni objekti, kao i dio prometnica na dubrovačkom području (slika 3.29). To je i maksimalna zabilježena količina oborine u Dubrovniku od 1961. godine, od kada postoje mjerena. Dosadašnja maksimalna dnevna količina bila je 191,0 mm, izmjerena 2. rujna 2014. godine, a listopadski dnevni maksimum 154,8 mm, izmjerena 13. listopada 2002. godine. Količina oborine koja je pala s 1. na 2. listopada 2018. godine je viša nego sveukupna oborina koja je pala u prethodnih 6 mjeseci 2018. godine. Slika 3.30 prikazuje dnevne količine oborine zabilježene 2. listopada 2018. u 7 h po srednjoeuropskom vremenu. Vatrogasci su imali 30 intervencija ispumpavanja. Obilne oborine bilo je i u dubrovačkoj okolini, primjerice na postaji Dubrovnik-aerodrom je izmjereno 99,4 mm oborine (slika 3.30). Bilo je zatvorenih dijelova cesta, te su zabilježeni odroni.

Prema satnim količinama oborine na postaji Dubrovnik, najveće količine pale su poslije ponoći na automatskim kišomjerima na mjernim postajama Dubrovnik i Žarkovica (slika 3.31). Usporedba mjesecnih količina oborine za 2018. godinu pokazuje da je premašena količina oborine za listopad (slika 3.32) u odnosu na prosjek za razdoblje 1961. – 1990. godine za postaju Dubrovnik,

3.3.5 Severe weather in Dubrovnik, 2 October 2018

A severe storm brought heavy thunder and rainfall to Dubrovnik in the night between 1 and 2 October 2018. According to the data of the Croatian Meteorological and Hydrological Service (DHMZ), 259.2 mm of precipitation recorded in only three hours. This amount of rainfall led to flash flood, and a number of residential buildings and roads in the Dubrovnik area were flooded (Figure 3.29). This is the maximum precipitation amount on record in Dubrovnik since the beginning of measurements in 1961. The previous maximum daily amount was 191.0 mm, measured on 2 September 2014, and the previous daily maximum for October was 154.8 mm, measured on 13 October 2002. The precipitation amount recorded in the night between 1 and 2 October is higher than the total precipitation amount recorded in the previous six months of 2018. Figure 3.30 shows daily precipitation amounts recorded on 2 October 2018 at 7:00 am CET. The Fire Department was called to pump flood water out of 30 buildings. The surroundings of Dubrovnik experienced heavy rainfall too. For instance, 99.4 mm of precipitation was recorded at weather station Dubrovnik-Airport (Figure 3.30). There were road closures and landslides.

Hourly precipitation amounts from the station Dubrovnik show that the highest amounts were recorded after midnight at automatic rain gauges at meteorological stations Dubrovnik and Žarkovica (Figure 3.31). A comparison of monthly precipitation amounts for 2018 shows that the October precipitation amount (Figure 3.32) was exceeded



Slika 3.29 Poplava u Dubrovniku 2. listopada 2018. godine

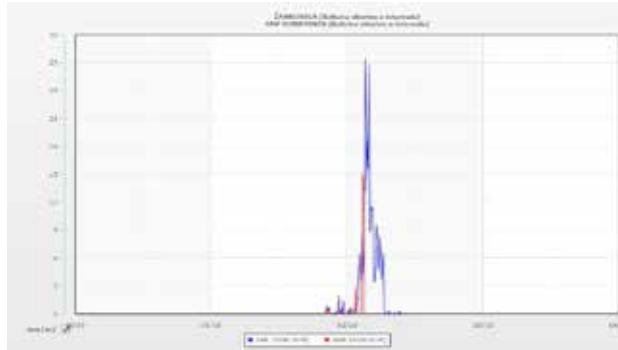
Figure 3.29 Flood in Dubrovnik, 2 October 2018





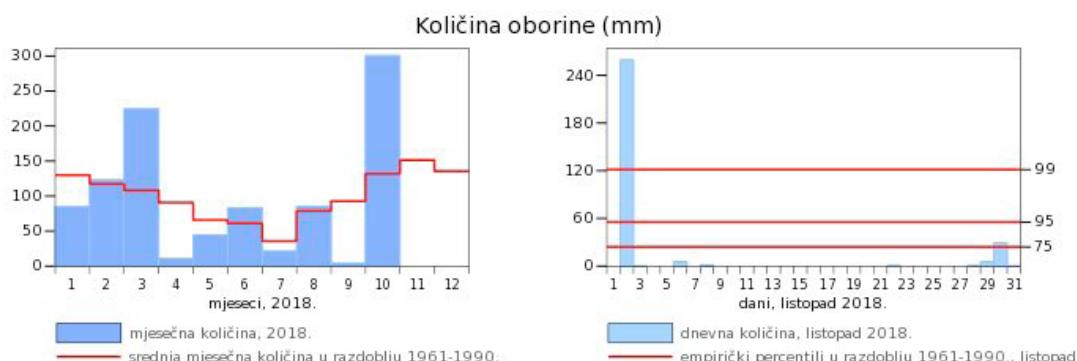
Slika 3.30 24-satne količine oborine nad područjem Hrvatske, izmjerene 2.listopada 2018. u 7 h po srednjoeuropskom vremenu

Figure 3.30 24-hour precipitation amounts over Croatia, recorded on 2 October 2018 at 7:00 am CET



Slika 3.31 Satne količine oborine izmjerene na automatskoj postaji Žarkovica i glavne meteorološke postaje Dubrovnik, od 30. rujna do 4. listopada 2018.

Figure 3.31 Hourly precipitation amounts recorded at automatic station Žarkovica and main meteorological station Dubrovnik, 30 September – 4 October 2018



Slika 3.32 Usporedba mjesečne količine oborine u listopadu sa srednjom mjesečnom količinom oborine u razdoblju 1961.-1990. godine (lijeko), te dnevne količine oborine za listopad u usporedbi s percentilima za razdoblje 1961.-1990. godine (desno) za postaju Dubrovnik

Figure 3.32 Comparison of the monthly precipitation amount in October with the mean monthly precipitation amount for the period 1961-1990 (on the left) and a comparison of the daily precipitation amount in October with the percentiles for the period 1961-1990 for the station Dubrovnik.

a pritom najveća dnevna količina oborine je izmjerena 2. listopada 2018. godine (slika 3.32 desno).

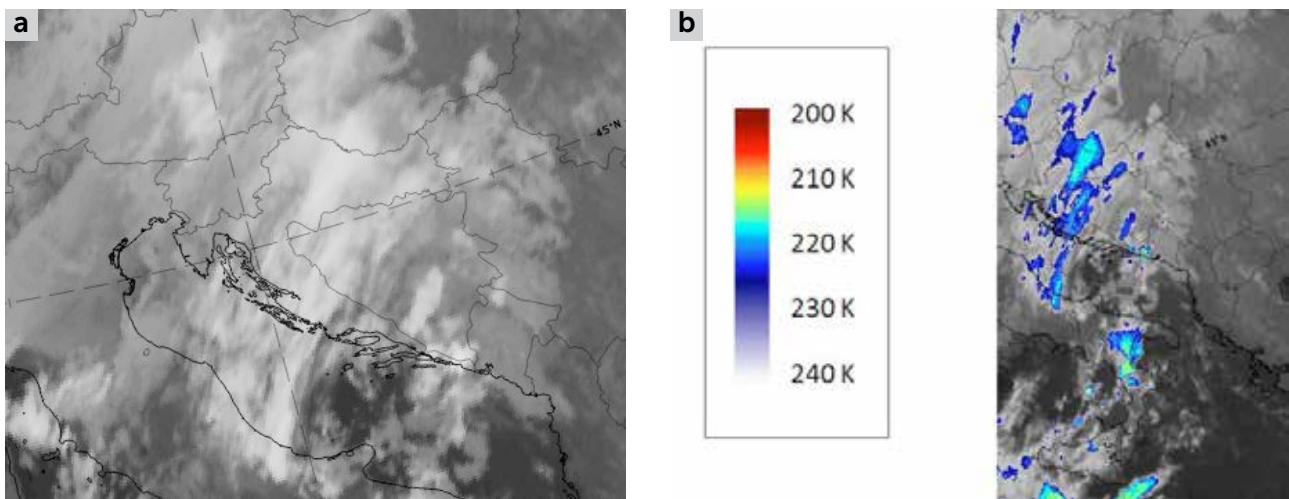
Na satelitskoj snimci u infracrvenom dijelu spektra IR 10.8 µm (slika 3.33a) vidljiva je raspodjela oblačnih sustava nad Europom. Dok je na satelitskoj snimci IR 10.8 µm gdje boje označavaju vrijednosti temperature plavom i zelenom bojom prikazano područje konvektivnih oblaka nad Dubrovnikom (slika 3.33b).

Analiza prizemne sinoptičke situacije (slika 3.34) pokazuje da je sa sjeverozapada jačao utjecaj anticyklone, no prizemno je Jadran bio pod utjecajem ciklone s centrom nad Genovskim zaljevom, pri čemu se плитki sekundarni centar sniženog tlaka, vidljiv na topografiji izobarene plohe 850 hPa, formirao nad područjem srednjeg Jadrana. Po visini se približavala dolina sa zapada, te je u jugozapadnoj struci pritjecao vlažan i topao zrak sa Sredozemlja, dok se unutar doline spuštao hladan zrak koji se odvojio u obliku hladne jezge (eng. cut-off low) koji

in relation to the 1961 – 1990 average at the station Dubrovnik and that the highest daily precipitation amount was recorded on 2 October 2018 (Figure 3.32, on the left).

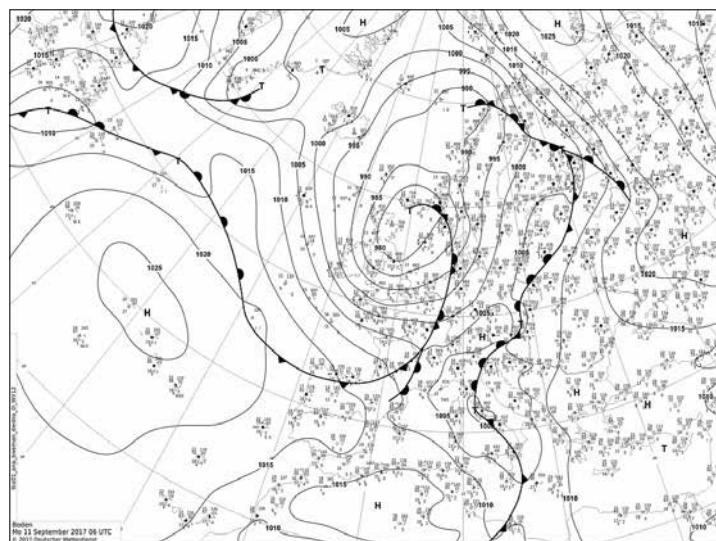
The satellite image in the infrared portion of the spectrum IR 10.8 µm (Figure 3.33a) shows the distribution of cloud systems over Europe. In the satellite imagery IR 10.8 µm, where the colours represent temperature values, the convective cloud area over Dubrovnik is shown in blue and green (Figure 3.33b).

An analysis of the surface synoptic situation (Figure 3.34) shows a growing anticyclonic influence from the northwest. However, on the surface, the Adriatic was under the influence of the cyclone whose centre was located over the Genoa Bay, with a shallow secondary low pressure centre, visible on the 850 hPa isobaric surface topography, having formed over the Central Adriatic. An upper-level trough was approaching from the west and moist and warm air was coming in from the Mediterranean in the south-west-



Slika 3.33 Meteosat-10 IR 10.8 μm crno-bijela satelitska snimka za šire područje Hrvatske (a), te IR 10.8 μm color satelitska snimka za šire područje Hrvatske gdje boje označavaju vrijednosti temperature odnosno neizravno visinu vrha grmljavinskih oblaka (eng. Color Enhanced - CE) (b), 2. listopada 2018. u 00 UTC

Figure 3.33 Figure 5. Meteosat-10 IR 10.8 μm black and white satellite image for the wider Croatian territory (a) and IR 10.8 μm colour satellite image for the wider Croatian territory, where colours represent temperature values and indirectly the thundercloud top height (Colour Enhanced - CE) (b), 2 October 2018, 00 UTC



Slika 3.34 Prizemna sinoptička situacija 2. listopada 2018. u 00 UTC (izvor: Njemačka meteorološka služba-DWD)

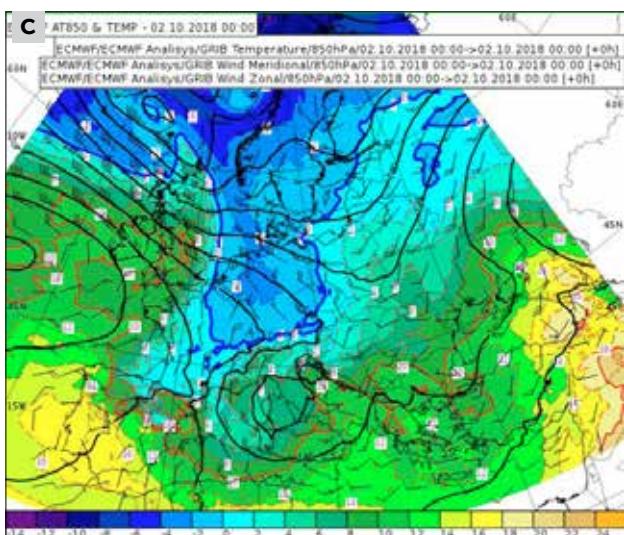
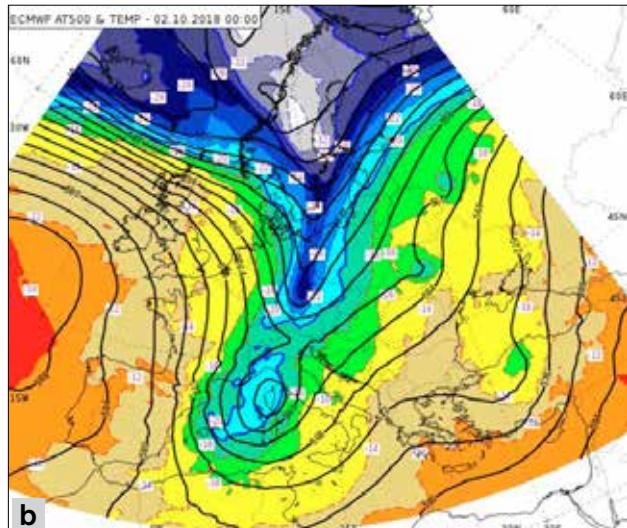
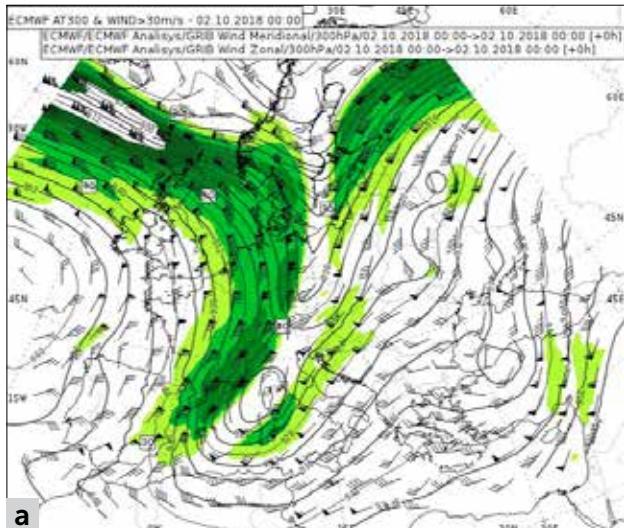
Figure 3.34 Surface synoptic situation on 2 October 2018 at 00 UTC (source: German Meteorological Service-DWD)

je vidljiv i na topografiji izobarne plohe 300 hPa. Mlazna struja pružala se preko sjevernog Jadrana prema sjevernoj Europi (slika 3.35a).

Na slici 3.35 vidljiv je položaj duboke visinske ciklone na izobarnim plohama 300 i 500 hPa. Na 850 hPa u 00 UTC vidljiv je i sekundarni centar visinske ciklone nad područjem sjevernog Jadrana. Takva sinoptička situacija imala je za posljedicu nestabilnu i vlagom bogatu atmosferu što su bili povoljni uvjeti za razvoj konvekcije. Osim toga, prizemno je nad dubrovačkim područjem na prednjoj strani plitke ciklone u južnom i jugoistočnom strujanju postojala i linija konvergencije (vidljivo na slici 3.36), kao i orografski utjecaj dizanja nestabilnog zraka

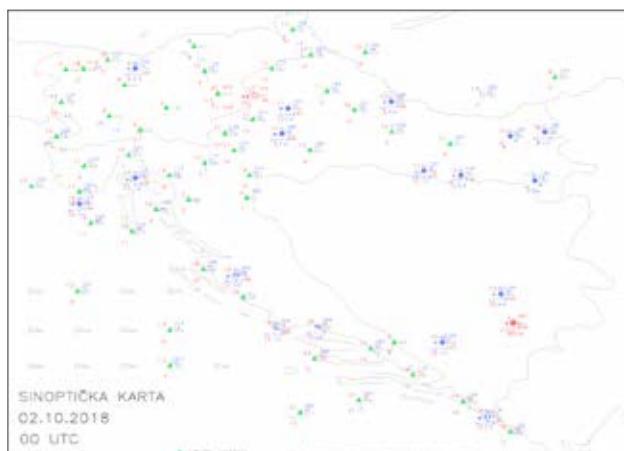
stern flow, whereas cold air separated in the form of a cut-off low was descending within the trough, as can be seen on the topography of the isobaric surface of 300 hPa. A jet stream stretched across the Northern Adriatic toward Northern Europe (Figure 3.35a).

Figure 3.35 shows the position of the deep cyclone on the isobaric surfaces of 300 and 500 hPa. A secondary cyclone centre is visible over the Northern Adriatic at 850 hPa at 00 UTC. Such a synoptic situation resulted in an unstable, high-humidity atmosphere conducive to convection development. In addition, there was a surface convergence line (shown on Figure 3.36) over the Dubrovnik area on the front side of the shallow cyclone in the southern



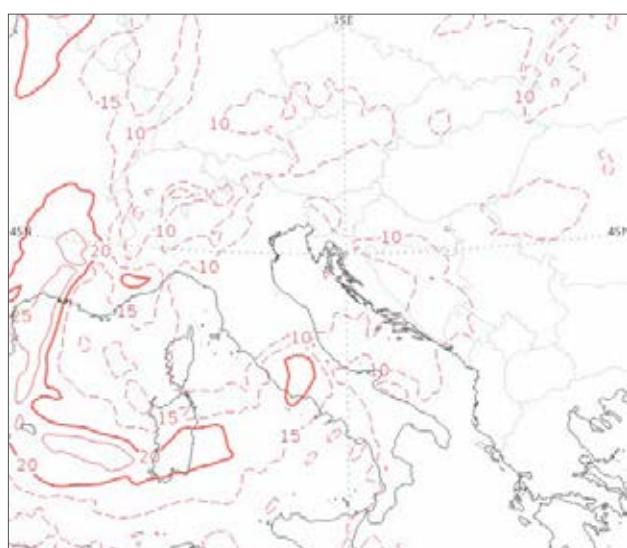
Slika 3.35 Razdioba geopotencijalne visine (izohipse - pune crte u geopotencijalnim dekametrima), brzine i smjera vjetra (zastavice) i brzine vjetra veće od 30 ms^{-1} na izobarnoj plohi 300 hPa (sjenčano u boji) (a), razdioba geopotencijalne visine (izohipse - pune crte u geopotencijalnim dekametrima) i temperature zraka (sjenčano u boji) na izobarnoj plohi 500 hPa (b), te razdioba geopotencijalne visine (izohipse - pune crte u geopotencijalnim dekametrima), brzine i smjera vjetra (zastavice) te temperature zraka (sjenčano u boji) na izobarnoj plohi 850 hPa (c), 2. listopada 2018. u 00 UTC

Figure 3.35 Distribution of geopotential heights (isohyps - full lines in geopotential decametres), wind speed and direction (flags) and wind speeds higher than 30 ms^{-1} on the isobaric surface of 300 hPa (colour-shaded) (a), distribution of geopotential heights (isohyps - full lines in geopotential decametres) and air temperatures (colour shaded) on the isobaric surface of 500 hPa (b), and distribution of geopotential heights (isohyps - full lines in geopotential decametres), wind speed and direction (flags) and air temperatures (colour-shaded) on the isobaric surface of 850 hPa, 2 October 2018, 00 UTC



Slika 3.36 Sinoptička karta, od 2. listopada 2018. godine u 00 UTC.

Figure 3.36 Synoptic map on 2 October 2018, 00 UTC



Slika 3.37 Smicanje vjetra visinom (usporedba vjetra na 10 m visini u odnosu na 700 hPa) 2. listopada 2018. godine u 00 UTC

Figure 3.37 Vertical wind shear (comparison of wind at the altitude of 10 m in relation to 700 hPa) on 2 October 2018, 00 UTC.

pri čemu su i konvektivni procesi bili dodatno pojačani. Osim navedenog bilo je prisutno i smicanje vjetra visinom što dodatno pogoduje razvoju organizirane konvekcije (slika 3.37).

Uz nestabilnu atmosferu, vlažan zrak i liniju konvergencije te dodatni orografski utjecaj podizanja zraka bila su zadovoljena sva tri uvjeta potrebna za razvoj konvekcije. Kao posljedica toga bile su bujične poplave s velikim štetama.

4. OCJENA KLIME ZA 2018. GODINU NA GLOBALNOJ LJESTVICI

4.1 Temperatura zraka

Procjenjuje se da je srednja globalna temperatura za 2018. godinu bila $0.99 \pm 0.13^\circ\text{C}$ iznad višegodišnjeg prosjeka za predindustrijsko razdoblje (1850. – 1900). Procjena se zasniva na pet neovisnih nizova podataka srednje globalne temperature čiji su rezultati predstavljeni na slici 4.1. Globalna temperatura odnosi se na prizemni sloj atmosfere i površinu mora. Godina 2018. je četvrta najtoplja godina od početka mjerjenja, a u razdoblju 2015. – 2018. četiri od pet godina su bile najtoplje od početka mjerjenja. Istovremeno je 2018. najhladnija od četiri najtoplje godine iz te skupine. Za razliku od najtoplijih godina (2016. i 2017.) s pojavom El Niño dođađa 2018. godina počela je sa slabim La Niña događajem. Međuvladin panel o klimatskim promjenama (IPCC) u svom specijalnom izvješću o utjecaju globalnog zatopljenja 1.5°C navodi da je globalna temperatura za razdoblje 2006. – 2015. godina bila 0.86°C iznad predindustrijskog prosjeka. Za usporedbu srednja anomalija iznad istog prosjeka za razdoblje 2009. – 2018. godina bila je $0.93 \pm 0.07^\circ\text{C}$, te prosjek za razdoblje 2014.–2018., bio

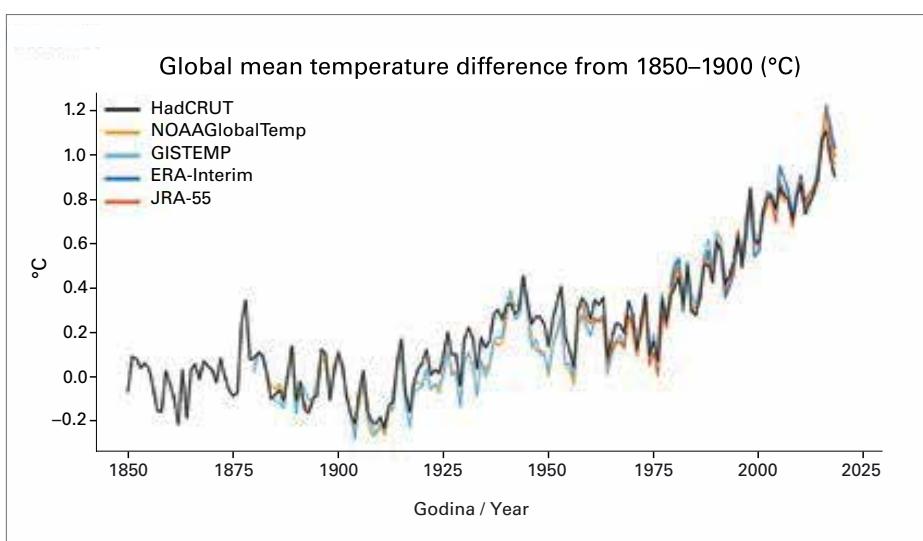
and south-eastern flow, along with the orographic influence of the unstable air lift, boosting the convective processes even more. In addition to all of the above, vertical wind shear was also present, contributing further to the development of an organised convection (Figure 3.37).

Considering the unstable atmosphere, moist air, convergence line, and additional orographic influence of the air lift, all three conditions for the development of a convection were met. This resulted in flash floods that caused substantial damage

4. CLIMATE ASSESSMENT FOR THE YEAR 2018 ON GLOBAL SCALE

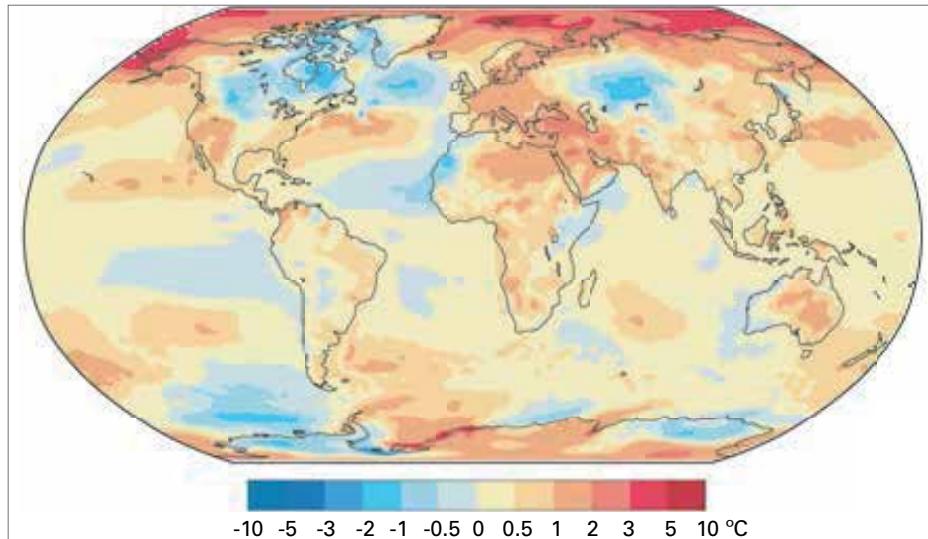
4.1 Air temperature

The global mean temperature for 2018 is estimated to be $0.99 \pm 0.13^\circ\text{C}$ above the preindustrial baseline (1850–1900). The estimate comprises five independently maintained global temperature datasets and the range represents their spread (Figure 4.1). Global temperature refers to planetary boundary layer and sea surface. The year 2018 was the fourth warmest on record and the past four years – 2015 to 2018 – were the top four warmest years in the global temperature record. The year 2018 was the coolest of the four. In contrast to the two warmest years (2016 and 2017), 2018 began with weak La Niña conditions, typically associated with a lower global temperature. The IPCC special report on the impacts of global warming of 1.5°C (Global Warming of 1.5°C) reported that the average global temperature for the period 2006–2015 was 0.86°C above the pre-industrial baseline. For comparison, the average anomaly above the same baseline for the most recent decade 2009–2018 was $0.93 \pm 0.07^\circ\text{C}$, and the average for the past five years, 2014–2018, was $1.04 \pm 0.09^\circ\text{C}$ above



Slika 4.1 Anomalije srednje globalne temperature zraka u odnosu na višegodišnji prosjek za razdoblje 1850. – 1900. godina za pet neovisnih nizova podataka globalne temperature (izvor: UK Met Office Hadley Centre, iz WMO, 2019)

Figure 4.1 Global mean temperature anomalies with respect to the 1850–1900 baseline for the five global temperature datasets (Source: UK Met Office Hadley Centre, from WMO 2019)



Slika 4.2 Anomalije površinske temperature za 2018. godinu u odnosu na razdoblje 1981. –2010. godina (izvor: ECMWF ERAInterim data, Copernicus Climate Change Service, iz WMO, 2019)

Figure 4.2 Surface-air temperature anomaly for 2018 with respect to the 1981 – 2010 average. (Source: ECMWF ERAInterim data, Copernicus Climate Change Service, from WMO, 2019)

je $1.04 \pm 0.09^{\circ}\text{C}$. Oba zadnja razdoblja uključuju dejovanje El Niño događaja 2015. – 2016. (WMO, 2019).

Iznadprosječne temperature prevladavale su u 2018. godini (slika 4.2). Prema podacima NOAA (National Oceanic and Atmospheric Administration), 2018. spada među 10 najtoplijih godina u Africi, Aziji, Europi, Oceaniji i Južnoj Americi. Samo Sjeverna Amerika nije bila u skupini 10 najtoplijih godina. U Sjevernoj Americi od postojećih 109 godina mjerena, 2018. je bila 18 najtoplijia godina. Istočje se nekoliko naglašeno toplih područja. Na Aktiku su prevladavala područja toplija 2°C i ponegdje 3°C . Iako su arktičke anomalije manje od onih 2016. godine bile su izuzetno velike u odnosu na višegodišnji prosjek. Na nekim područjima Europe, dijelu sjeverne Afrike, Srednjeg istoka i južnoj Aziji bilo je također izuzetno toplo gdje su u nekim državama zabilježeni rekordi od početka mjerjenja (Češka, Francuska, Njemačka, Mađarska, Srbija, Švicarska) ili među pet najtoplijih (Belgija, Estonija, Izrael, Latvija, Pakistan, Moldova, Slovenija, Ukrajina). Za Europu kao cjelinu 2018. godina bila je među tri najtoplje godine kao i jugozapadni dio Sjedinjenih Američkih Država te istočni dio Australije (za zemlju kao cjelinu bila je treća najtoplijia godina) dok je za Novi Zeland 2018. bila druga najtoplijia godina u postojećem nizu mjerena. Nasuprot tome, područja ispodprosječnih temperatura su razmjerno ograničena. Dio Sjeverne Amerike, Grenlanda, središnje Azije, zapadnog dijela sjeverne Afrike, dijelovima istočne Afrike, obalnim područjima zapadne Australije te zapadnim dijelovima tropske Južne Amerike bili su hladniji od prosjeka iako ne znatno (WMO, 2019).

4.2 Oborina

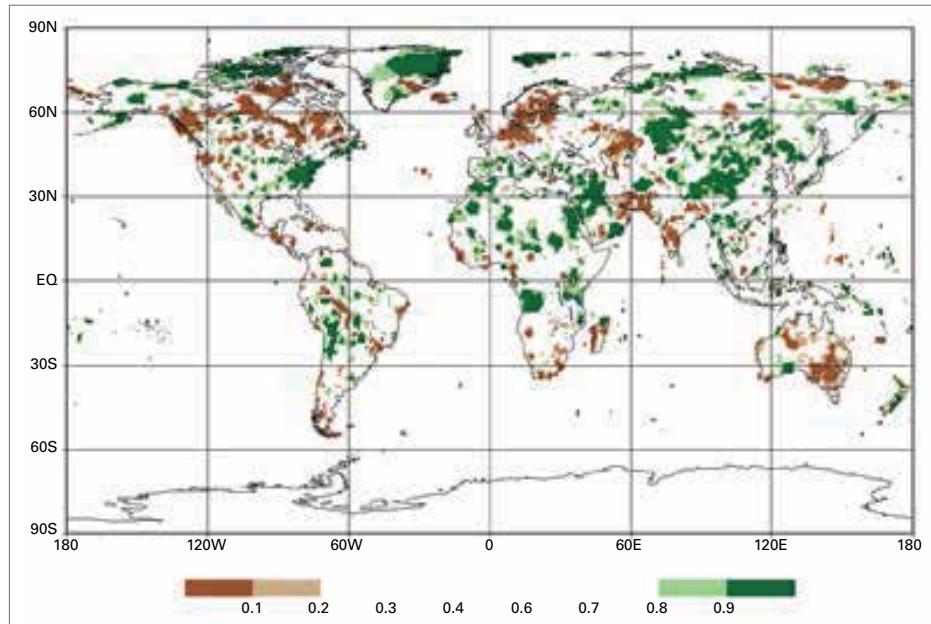
Iako je početkom 2018. postojao slabo izražen La Niña događaj, kasnije transformiran u neutralne uvjete, uobičajeni utjecaj na oborine je izostao. Na primjer, u Kaliforniji se dogodilo nekoliko poplava što je u suprot-

this baseline. Both of these periods include the warming effect of the strong El Niño of 2015–2016 (WMO, 2019).

Above-average temperatures were wide spread in 2018 (Figure 4.2). According to continental numbers from NOAA, 2018 was ranked in the top 10 warmest years for Africa, Asia, Europe, Oceania and South America. Only for North America did 2018 not rank among the top 10 warmest years, coming eighteenth in the 109-year record. There were a number of areas of notable warmth. Over the Arctic, annual average temperature anomalies exceeded 2°C widely and 3°C in places. Although Arctic temperatures were generally lower than in the record year of 2016, they were still exceptionally high relative to the long-term average. An area extending across Europe, parts of North Africa, the Middle East and southern Asia was also exceptionally warm, with a number of countries experiencing their warmest year on record (Czechia, France, Germany, Hungary, Serbia, Switzerland) or one in the top five (Belgium, Estonia, Israel, Latvia, Pakistan, the Republic of Moldova, Slovenia, Ukraine). For Europe as a whole, 2018 was one of the three warmest years on record. Other areas of notable warmth included the south-western United States, eastern parts of Australia (for the country overall it was the third warmest year) and New Zealand, where it was the joint second warmest year on record. In contrast, areas of below-average temperatures over land were more limited. Parts of North America and Greenland, central Asia, western parts of North Africa, parts of East Africa, coastal areas of western Australia and western parts of tropical South America were cooler than average, but not unusually so (WMO, 2019).

4.2 Precipitation

Although weak La Niña conditions were present at the beginning of 2018, later changing to neutral, the usual effects on precipitation were absent. For example, several floods occurred in California, where the opposite is expe-



Slika 4.3 Godišnje količine oborine u 2018. godini izražene kao percentili za referentno razdoblje 1951. – 2010. godina. Naznačena su najsušnija područja s 20% najmanjih oborina (smeđe) i najvlažnija područja s 20% najviših oborina (zeleno). Područja do 10% najmanjih količina označena su tamnosmeđe odnosno 10% najviših količina tamnozeleno. (Source: Global Precipitation Climatology Centre, DWD, iz WMO, 2019)

Figure 4.3 Annual total precipitation in 2018 expressed as a percentile of the 1951–2010 reference period for areas that would have been in the driest 20% (brown) and wettest 20% (green) of years during the reference period, with darker shades of brown and green indicating the driest and wettest 10%, respectively (Source: Global Precipitation Climatology Centre, DWD, from WMO, 2019)

nosti s očekivanjem za La Niña događaje. Za razliku od drugih važnih klimatskih varijabli ne postoji pojedinačni indikator kojim se mogu sažeti globalne promjene oborine. Primjerice, promjena intenziteta i čestine oborine kao posljedica predviđenih klimatskih promjena nije obuhvaćena mjesecnim ili godišnjim prosjecima oborine. Razvijeni su dodatni indeksi koji daju dodatne informacije. Jedan takav indeks je "slijed uzastopnih vlažnih dana" ("consecutive wet days"- CWD), koji daje najdulji niz CWD-a u danom razdoblju. Drugi indeks je "RX5" koji označava najviše 5-dnevne količine oborina. Najdulja CWD razdoblja javljaju se za vrijeme indijskog monsuna i u intertropskoj zoni konvergencije (Inter-Tropical Convergence Zone – ITCZ) u Južnoj Americi i Malajskom arhipelagu. Područja jakih dnevnih oborina (dnevne oborine > 20 mm) su vezane za ITCZ kao i s afričkim i indijskim monsunima kao i tropskim olujama te navjetrenim stranama obalnih planina. Postoje također područja s najvećim RX5. Registrirane su lokalno 5-dnevne količine oborine više od 300 mm u Afganistanu, povezane s bujičnim poplavama i ljudskim žrtvama.

U 2018. godini zabilježene su pozitivne anomalije oborine u odnosu na višegodišnji prosjek 1951. – 2010. godina, u nekim mjestima iznad 90. percentila i nekim područjima istočne Afrike, Arapskom poluotoku, središnjoj i jugoistočnoj Aziji i Malajskom arhipelagu, jugozapadnoj Australiji, Novom Zelandu i istočnom dijelu Sjeverne Amerike (Slika 4.3). Iznadprosječne oborine zabilježene su u Japanu, jugozapadnoj i jugoistočnoj Europi, pojedinim područjima Južne Amerike te prethodno spomenutog Afganistana. Iznadprosječne oborine zabilježene su također oko Arktičkog oceana.

ected during La Niña events. Unlike other important climate variables, there is no single indicator that can usefully summarize global precipitation changes. Indeed, some of the predicted changes in precipitation in response to climate change affect the frequency and intensity of rainfall that are not well captured by simple monthly or annual averages. A number of indices have been developed that provide this additional information. One such measure is "consecutive wet days" (CWDs), which gives the longest spell of such CWDs in a given period. Another is "RX5", which captures the highest 5-day rainfall total. The longest periods of CWD occur in the Indian monsoon and in the Inter-Tropical Convergence Zone (ITCZ) across South America and the Malay Archipelago. Regions with heavy precipitation days (> 20 mm daily precipitation) are related to the ITCZ as well as the African and Indian monsoons, but also to tropical storm activities and on the windward slope of mid-latitude coastal mountains. These are, on average, also the regions with the highest RX5. More than 300 mm was recorded locally over 5 days in Afghanistan, reflecting a series of events in May with intense rainfall causing flash floods and associated fatalities.

In 2018 large positive precipitation anomalies with respect to a 1951 – 2010 climatology, in some places above the 90th percentile, were observed in some regions in northern and eastern Africa, the Arabian Peninsula, central and south-east Asia and the Malay Archipelago, south-western Australia, New Zealand and eastern North America (Figure 4.3). Above-average precipitation amounts were also observed in Japan, south-west and south-east Europe, some spots in South America and the previously noted event in

Ispodprosječne oborine, dijelom ispod 10. percentila, zabilježene su u središnjoj i istočnoj Australiji, sjevernoj i istočnoj obali Arapskog mora i sjeveroistoku Kaspijskog mora, kao i pojedim područjima Središnje i Sjeverne Amerike i južne Afrike. Deficit oborine također je zabilježen u središnjoj i sjevernoj Europi i Argentini. Neka od ovih područja imali su ispodprosječne oborine i 2017. godine kao što su dijelovi južne Afrike, istočne Australije ili sjevernog dijela Sjeverne Amerike (WMO, 2019).

4.3 Morski led

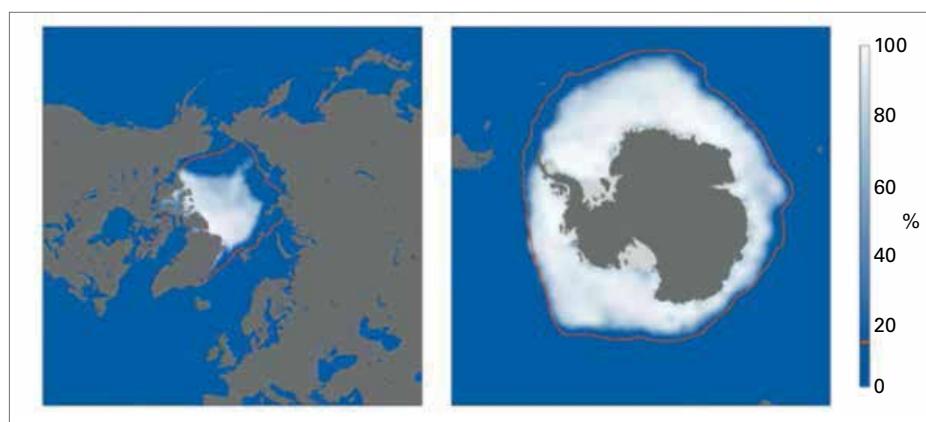
Arktički ledeni pokrov u 2018. godini bio je znatno ispod prosjeka na rekordno niskoj razini za prva dva mjeseca u godini. Godišnji maksimum pojavio se u ožujku s površinom 14.48 milijuna četvornih kilometara, približno 7% manje od višegodišnjeg prosjeka 1981. – 2010. godina. Površina leda bila je treća najmanja u razdoblju satelitskih motrenja (1979. – 2018.) prema NSIDC (United States National Snow and Ice Data Center) i C3S (Copernicus Climate Change Service). Jedino su u ožujku 2016. i 2017. godine bile manje vrijednosti. Područje leda postiže minimum sredinom rujna. Veličina tog područja je bila 5.45 milijuna četvornih kilometara, približno 28% is-

Afghanistan. Above-average precipitation was also observed around the Arctic Ocean.

Below-normal precipitation, partly below the 10th percentile, were found in central and east Australia, the northern and eastern coast of the Arabian Sea and northeast of the Caspian Sea, but also at some spots in Central and North America and southern Africa. Rainfall deficits were also reported from central and northern Europe and Argentina. Some of these regions also experienced below normal precipitation amounts in 2017, such as parts of southern Africa, eastern Australia or northern North America (WMO, 2019).

4.3 Sea Ice

Arctic sea-ice extent was well below average throughout 2018 and was at record low levels for the first two months of the year. The annual maximum occurred in mid-March and the March monthly extent was 14.48 million square kilometres, approximately 7% below the 1981–2010 average. This ranked as the third lowest March extent in the 1979–2018 satellite record, according to data from NSIDC (United States National Snow and Ice Data Center) and the Copernicus Climate Change Service (C3S). Only March 2016 and 2017 were lower. Following the below-average



Slika 4.4 Koncentracija morskog leda (u %) za rujan 2018. godine iz C3S analize (plavo i bijelo sjenčanje). Roza linija pokazuje pro-sječne klimatološke granice leda za razdoblje 1981. – 2010. godina (izvor: ECMWF Copernicus Climate Change Service (ERA-Interim) data, iz WMO, 2019)

Figure 4.4 Average sea-ice concentration (in %) for September 2018 from the C3S analysis (blue and white shading). The pink line shows the climatological ice edge for the period 1981–2010 (Source: ECMWF Copernicus Climate Change Service (ERA-Interim) data, from WMO, 2019)

pod prosjeka i šesta po redu najmanja vrijednost za rujan od početka motrenja (Slika 4.4, lijevo; WMO, 2019).

Antartički ledeni pokrov je također bio ispod prosjeka za 2018. godinu. Za sječanj je površina leda bila druga najmanja, a za veljaču najmanja. Godišnji minimum se pojavio u veljači s površinom 2.28 milijuna četvornih kilometara, 33% ispod višegodišnjeg prosjeka te kao najmanja površina prema C3S i druga najmanja po ocjeni NSIDC.

Antarktički led postiže maksimum krajem rujna i početkom listopada čiji je iznos bio 17.82 milijuna če-

maximum extant, sea-ice extent ranked second lowest on record to the end of May and continued to rank among the 10 lowest until the end of August. Similar to 2017, a strong, persistent low-pressure system over the Arctic helped to inhibit ice loss and keep temperatures below average, especially during late summer. The Arctic sea-ice extent reached its minimum in mid-September. The September monthly sea ice extent was 5.45 million square kilometres, approximately 28% below average and the sixth smallest September extent on record (Figure 4.4, left, WMO, 2019).

Antarctic sea-ice extent was also well below average throughout 2018. The monthly extent in January was

tvornih kilometara, 4% ispod prosjeka. Prema C3S procjeni to je druga najmanja vrijednost od početka mјetreњa, a po NSIDC procjeni peta najmanja vrijednost (Slika 4.4, desno; WMO, 2019).

Literatura

WMO, 2019: *WMO statement on the state of the global climate in 2018.*

the second lowest, and in February the lowest. The annual minimum extent occurred in late February and the monthly average was 2.28 million square kilometres, 33% below average and ranked record low in the C3S dataset and second lowest in the NSIDC data.

The Antarctic sea-ice extent reached its annual maximum in late September and early October. The September monthly average extent was 17.82 million square kilometres, 4% below average and the second smallest on record according to the C3S dataset, and fifth smallest according to the NSIDC data (Figure 4.4, right, WMO, 2019).

Literatura

WMO, 2019: *WMO statement on the state of the global climate in 2018.*