

UKV – Carstic Coastal Water Management Endangered by Climate Changes

Project is oriented on research of:

unwanted consequences of climate changes in coastal carstic water aquifer - salinity and temperature rise, water quality decreasing including undertaking some measures for adaptation on them in sectors of water resources, tourism, agriculture and health. Extraordinary seasonal water consumption especially during summer months when a necessity for the water is the highest.

Duration: May 2020 – Oct 2022

Partners: - Faculty of Geotechnical Engineering, University of Zagreb, Varaždin

- Faculty of Civil Engineering, University of Rijeka, Rijeka
- Croatian Meteorological and Hydrological Service, Zagreb
- Croatian Geological Institute, Zagreb





Analysis of the current climate and climate projections in the pilot area of the Bokanjac-Poličnik basin near Zadar

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Croatian Meteorological and Hydrological Service

ZAMG, Wien, 5th October 2022



Content

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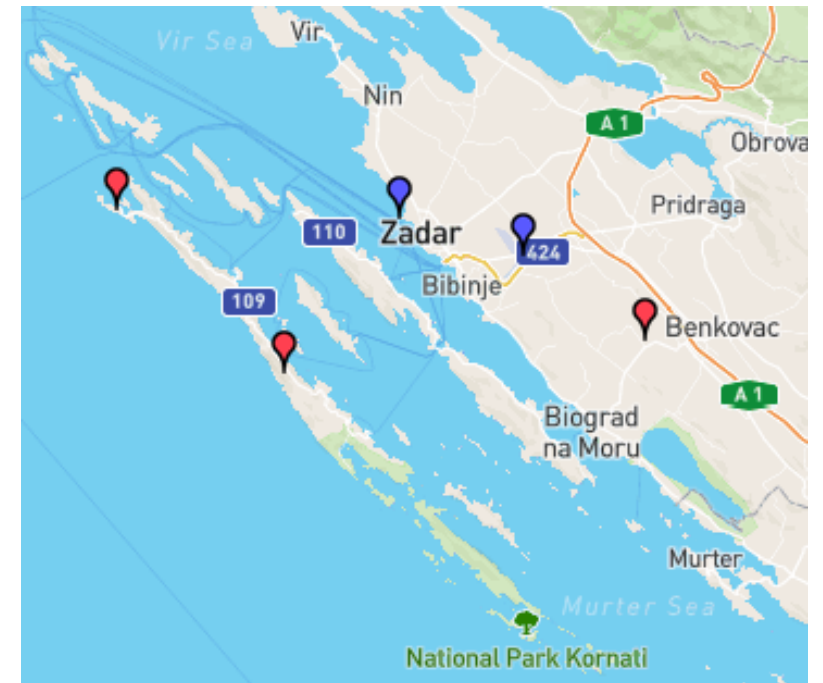
2. Climate modeling

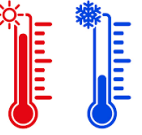
- 2.1. Regional climate model simulations
- 2.2. Simulations of historical climate and statistical bias correction
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DATA

DHMZ meteorological station **Zadar** ($h = 5 \text{ m}$, $\phi = 44^{\circ}08'$, $\lambda = 15^{\circ}13'$)

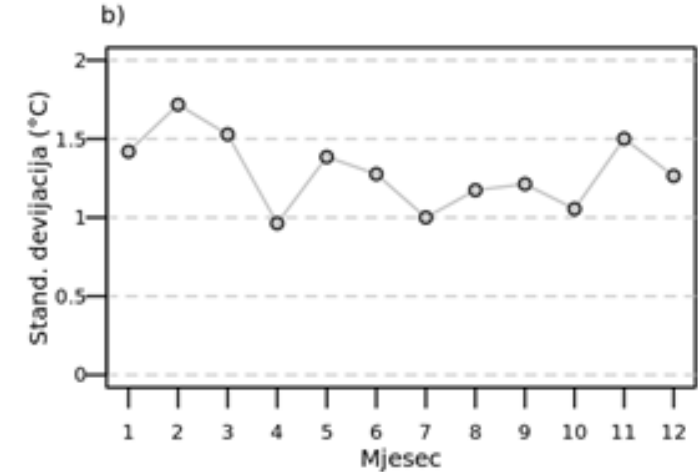
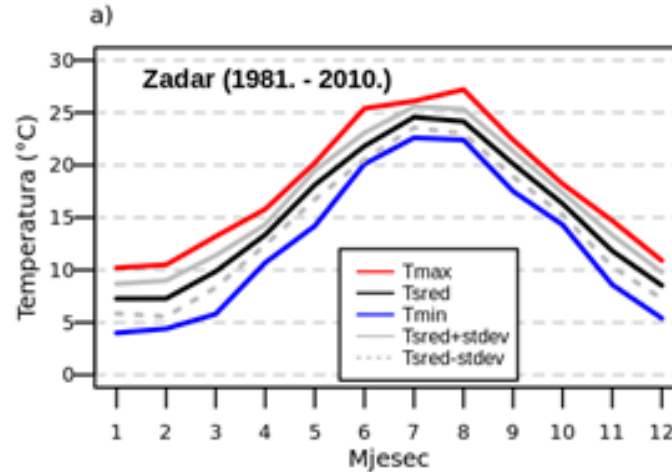
- Monthly mean temperature and precipitation, 1981 – 2010
- Trends for the period 1951 - 2019
- Climate (Köppen)
- annual trends and interannual variability
- Standardized precipitation index (SPI)
- Standardized precipitation evapotranspiration index (SPEI)





1.1. General climatic characteristics

- moderately warm rainy climate (*Csa*)
 - the coldest month $-3^{\circ}\text{C} < T_{\text{sred}} < 18^{\circ}\text{C}$
 - the driest month in warm period $< 40 \text{ mm}$ (3x less than the rainiest)
 - hot summer $T_{\text{sred}} > 22^{\circ}\text{C}$



	DJF	MAM	JJA	SON	YEAR
Sred	7.7	13.8	23.5	16.1	15.3
Stdev	1.0	0.9	0.9	0.8	0.6
Maks	10.2	15.8	26.2	17.7	16.3
Min	5.6	11.6	22.1	14.5	14.2

- Annual temperature
 - max in **VIII** (24.6°C), min in **II III** (7.3°C)
 - Spring is colder than autumn
 - variability is equal throughout the year

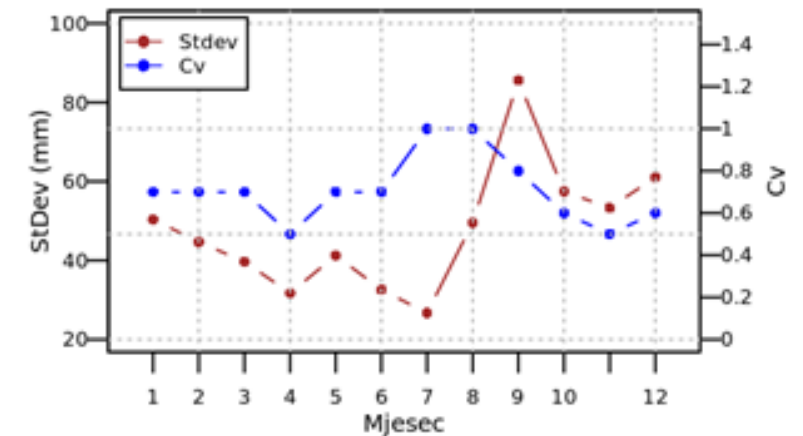
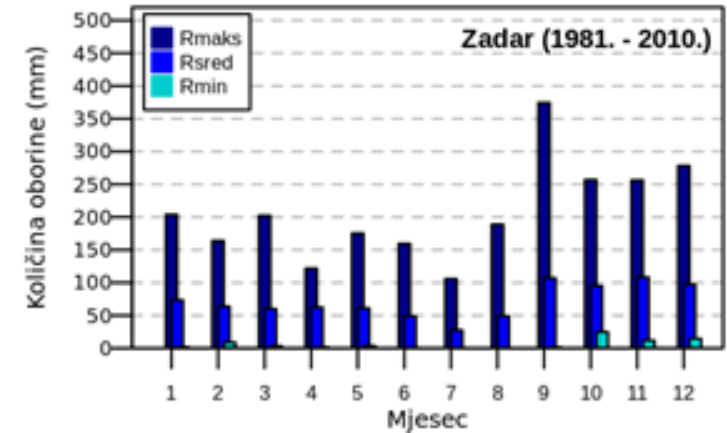
T_{annual} : $+0.6^{\circ}\text{C}$ according to the 1961 – 1990





- Annual precipitation – maritime type
 - 64% in the cold part of the year
 - max in **XI** (108.3 mm), min in **VII** (27.5 mm)
 - Variability between 30% and 50%, annually more stable 19%

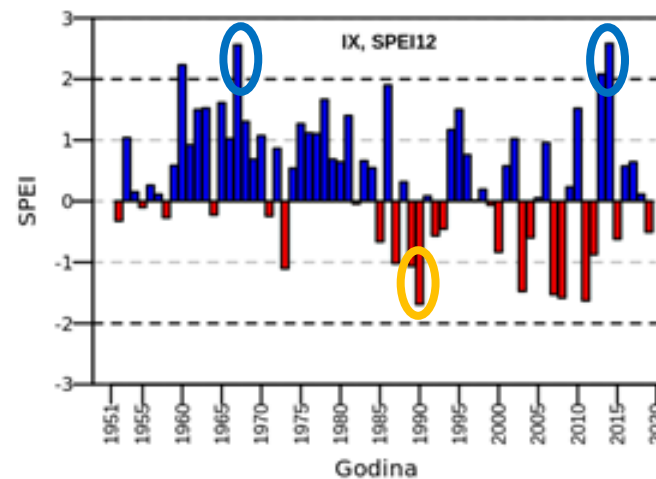
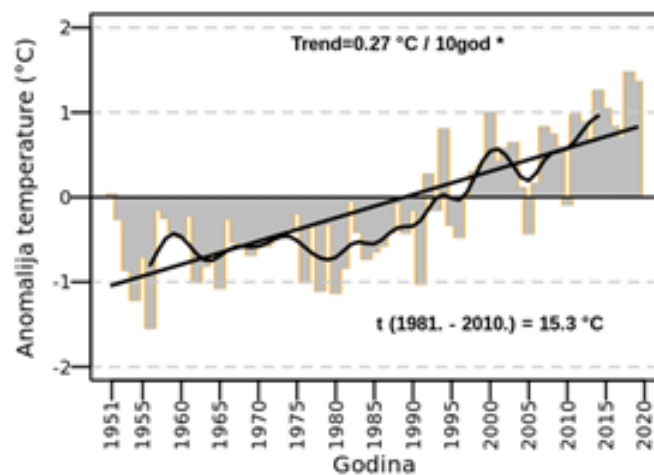
	DJF	MAM	JJA	SON	YEAR
Sred	233.5	183.8	125.3	310.3	854.0
Stdev	99.0	52.9	64.6	117.6	160.3
cv	0.40	0.30	0.50	0.40	0.19
maks	455.0	290.7	305.2	549.7	1195.5
min	50.9	42.2	38.9	66.1	587.8



R_{annual} : - 88 mm according to 1961 – 1990

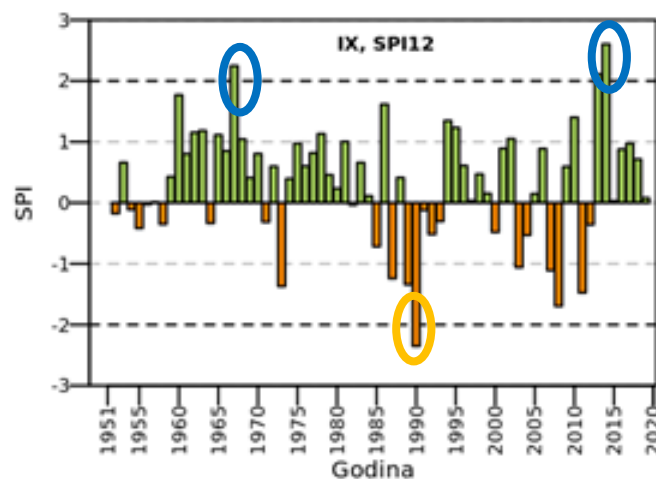
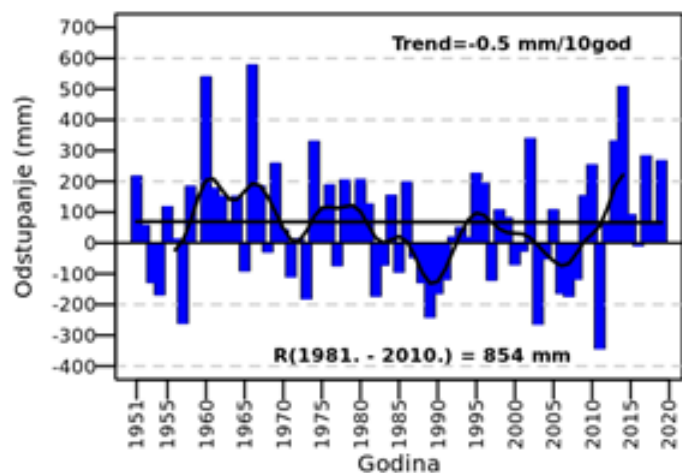


1.2. Climate anomalies and trends, 1951 – 2019

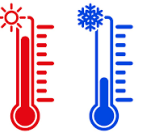


Left: Time series for mean annual temperature and precipitation anomalies, linear trend and 5-year moving average

Right: SPEI-12 and SPI-12 for September (hydrological year)

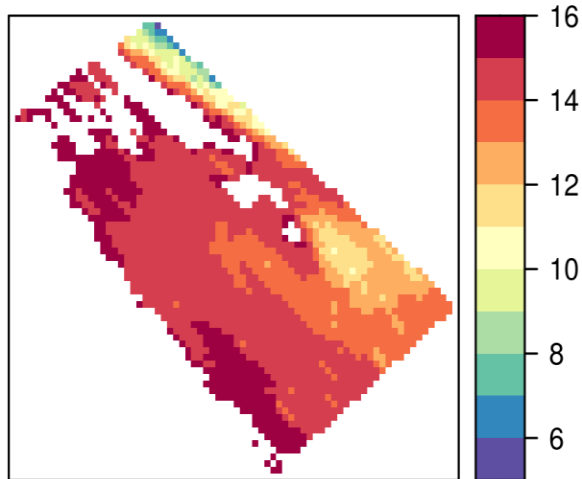


Trend/10 y	DJF	MAM	JJA	SON	YEAR
t (°C)	0.22	0.27	0.34	0.22	0.27
R (mm)	-7.2	-7.2	-8.1	2.4	-0.5
R (%)	-3.1	-5.8	-3.5	0.8	-0.1

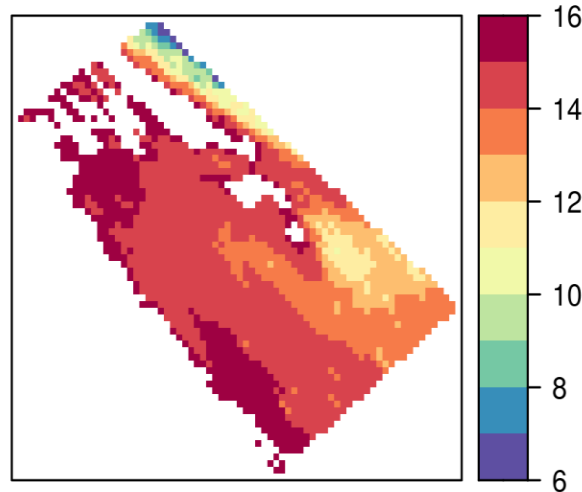


1.3 Grid analysis - temperature

a Srednja godišnja temperatura zraka [°C]
Razdoblje 1981.-2010.
Kalendarska godina



b Srednja godišnja temperatura zraka [°C]
Razdoblje 1981.-2010.
Hidrološka godina



Area: Bokanjac-Poličnik basin = 1935 km²
DEM 1000m
27 m < n.v. < 674 m (Orljak) - 1264 m (southern
Velebit)

42% n.v. < 100 m
27% 100 – 200 m
31% > 200 m

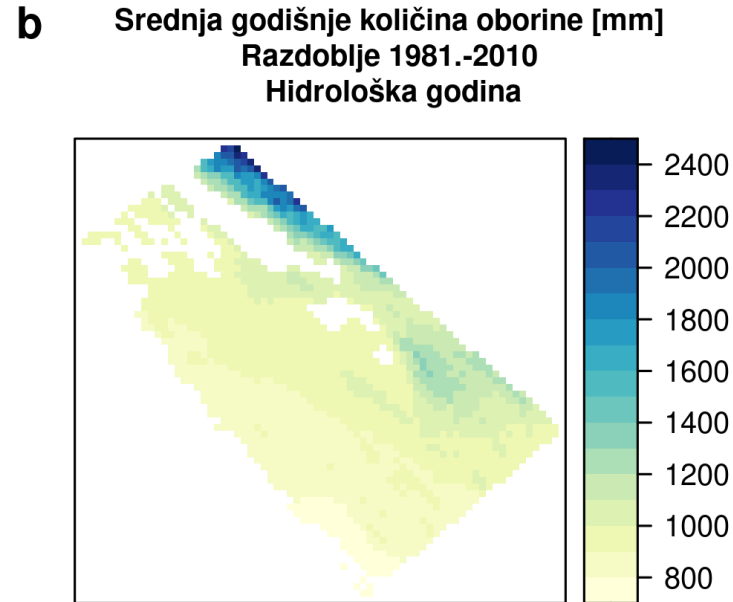
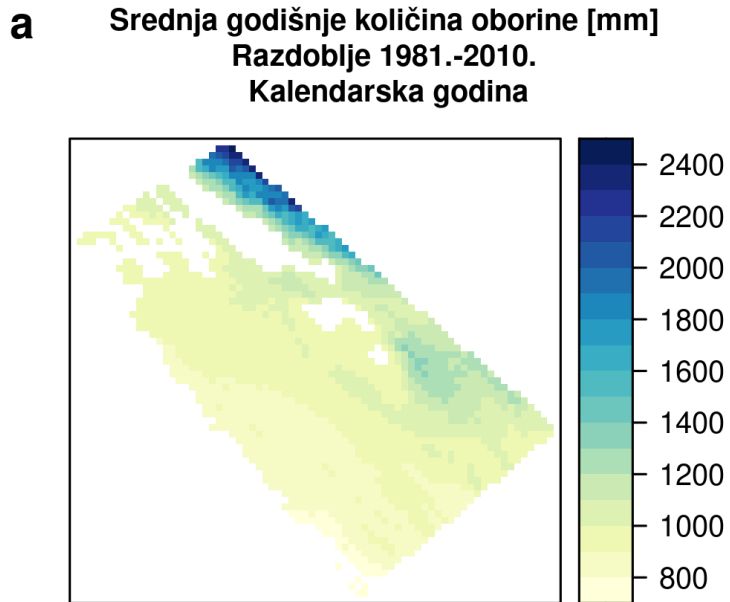
	Air temperature (°C)		
	gr.min	gr.sred	gr.maks
01	-2.9	5.4	7.3
02	-2.4	5.7	7.4
03	0.7	8.6	10.3
04	4.5	12.2	13.9
05	9.7	17.2	18.9
06	12.9	21.0	22.5
07	15.6	23.9	25.3
08	15.3	23.5	24.8
09	10.7	18.9	20.3
10	6.9	14.8	16.4
11	2.0	9.9	11.6
12	-1.8	6.6	8.5
God	6.0	14.0	15.5

⇒ Data from one station are not representative for the whole area

The use of grids in the assessment of climatic features - for the area without measurements!



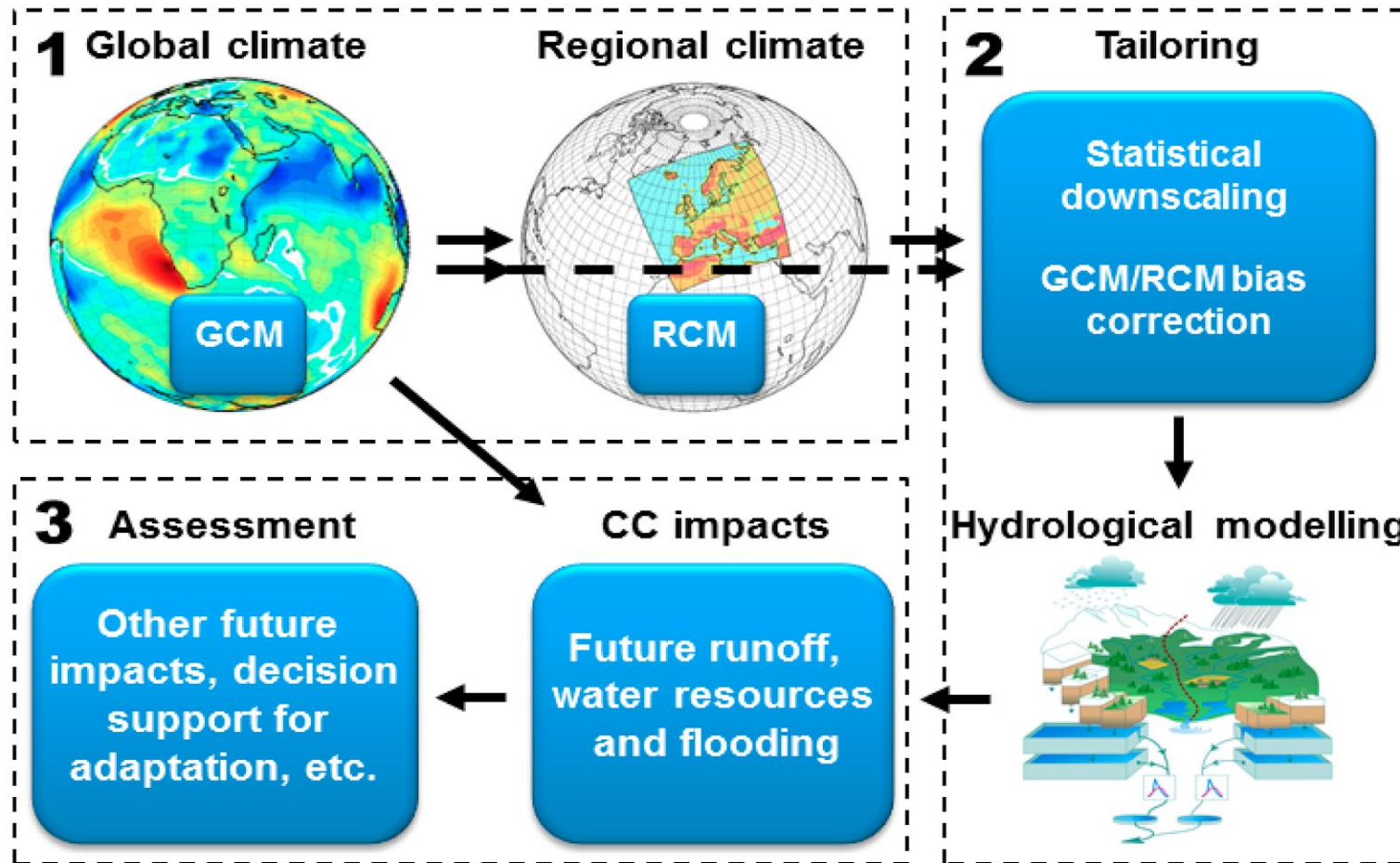
1.3. Grid analysis – precipitation



Južno priobalje: 776 mm
Orljak: 1300 mm
Southern Velebit: > 2000 mm

	Precipitation (mm)		
	gr.min	gr.sred	gr.maks
01	69.4	90.5	233.0
02	60.1	79.2	202.9
03	62.8	78.0	184.9
04	61.6	80.1	194.8
05	47.9	71.3	162.1
06	51.4	63.8	125.3
07	25.0	34.1	74.9
08	40.1	54.3	106.7
09	72.0	102.8	212.0
10	80.8	110.1	241.9
11	101.6	133.7	317.0
12	90.6	120.4	321.9
Year	776.2	1017.8	2464.3

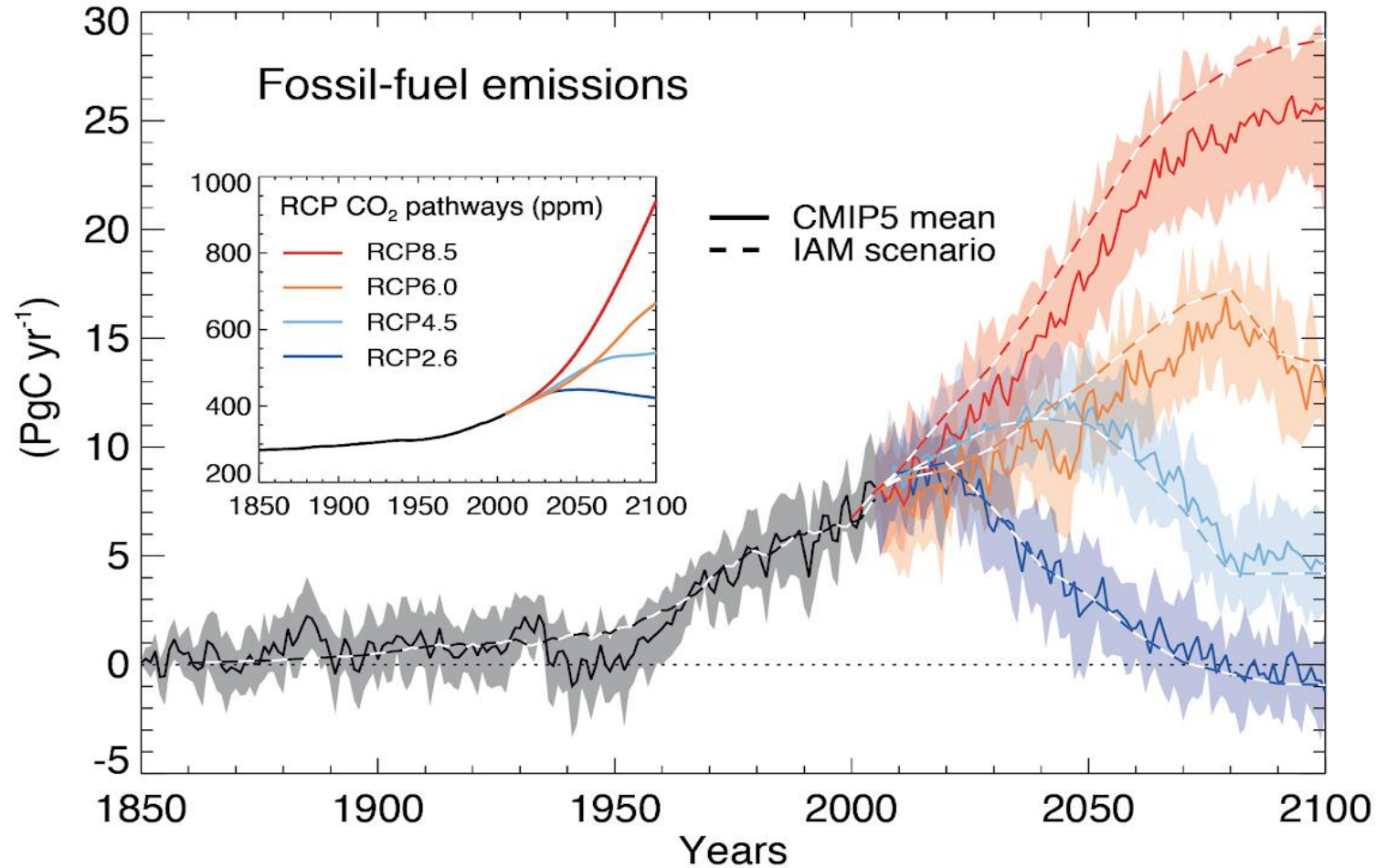
2.1 Regional climate model simulations



Source: Olsson et al. (2016) Hydrological Climate Change Impact Assessment at Small and Large Scales: Key Messages from Recent Progress in Sweden. *Climate*, 4(3), 39; doi:10.3390/cli4030039

2.1 Regional climate model simulations

IPCC SCENARIOS



2.2 SIMULATIONS OF HISTORICAL CLIMATE AND STATISTICAL BIAS CORRECTION

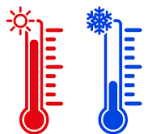
1971 -2005 historical climate

2006 - 2070 projections under RCP2.6

2006 - 2070 projections under RCP4.5

2006 - 2070 projections under RCP8.5

Referent climate in this study: 1981 -2010



2.2 HISTORICAL CLIMATE AND STATISTICAL BIAS CORRECTION

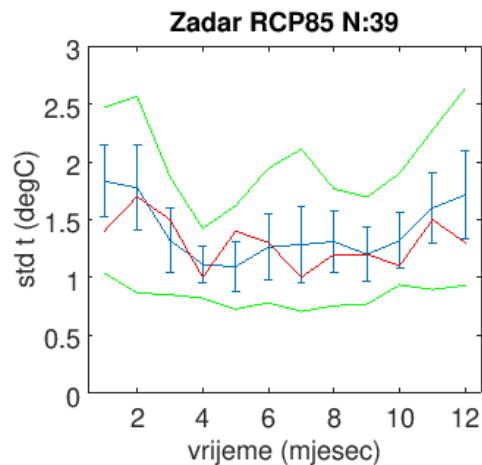
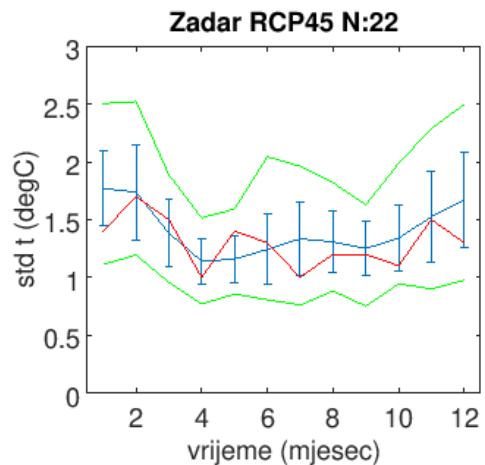
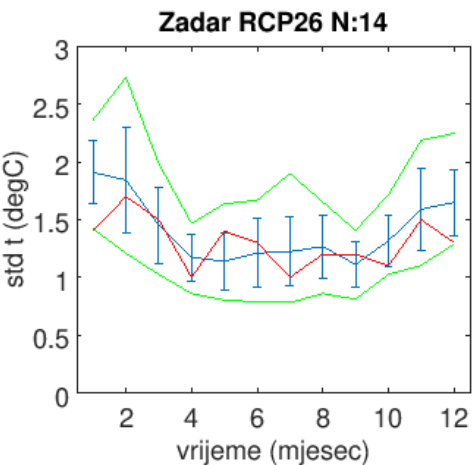
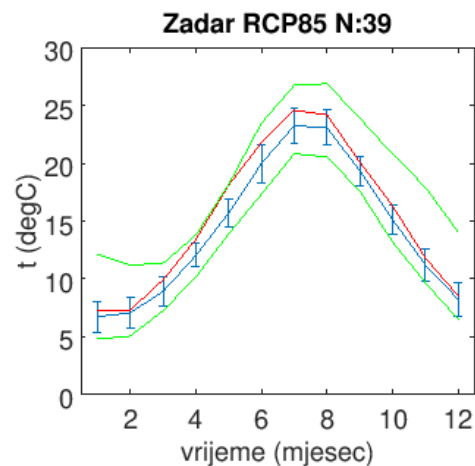
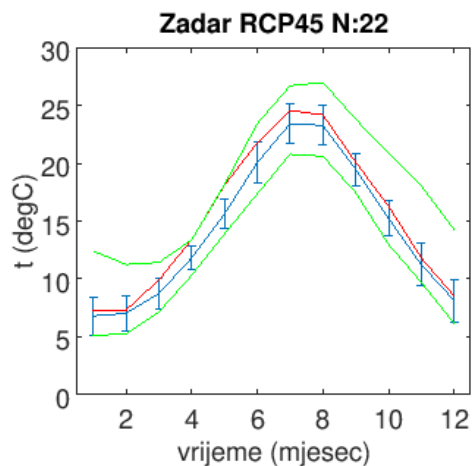
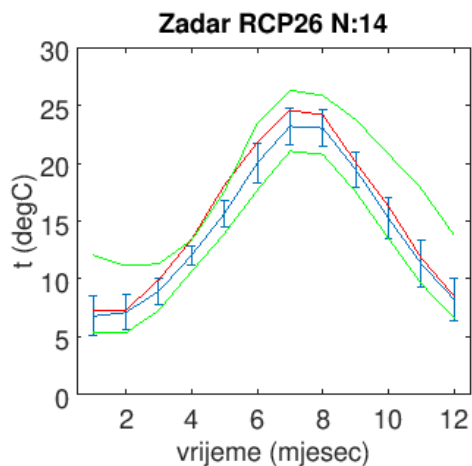
Monthly mean air temperature ($^{\circ}\text{C}$) (first row) and monthly standard deviation ($^{\circ}\text{C}$) second row.

First column: models for RCP2.6 scenario;
Second column: models for RCP4.5 scenario;
Third column: models for RCP8.5 scenario.
Blue: mean & standard deviations within RCM ensemble;
Green: span within RCM ensemble;
Red: measurements.

Time period: 1981 – 2010

Source: DHMZ measurements & *original* simulations of regional climate models.

Location: Zadar





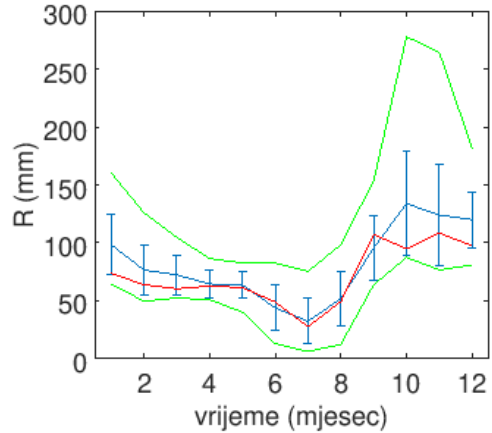
2.2 HISTORICAL CLIMATE AND STATISTICAL BIAS CORRECTION

Mean monthly precipitation (mm; first row) and **monthly coefficient of variation** (without dimension, second row).

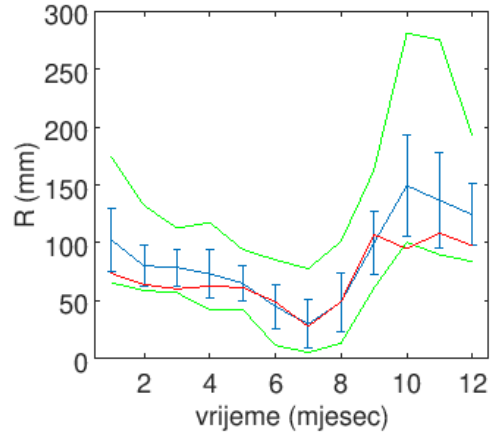
First column: models for **RCP2.6**;
second column: models for **RCP4.5**;
third column: models for **RCP8.5**.
Blue: mean and standard deviation within RCM ensemble;
green: span within RCM ensemble;
red: measurements.

Time: 1981 – 2010. Source: measurements from DHMZ and raw simulations of regional climate models.
Location: Zadar

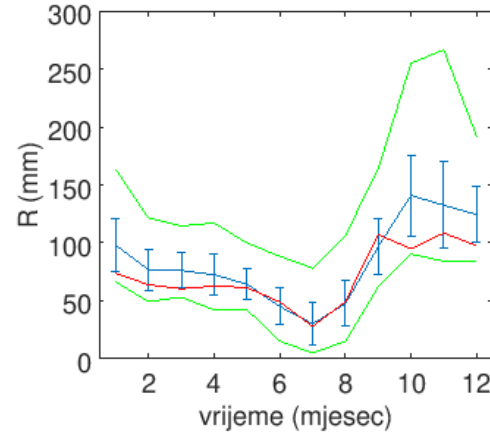
Zadar RCP26 N:14



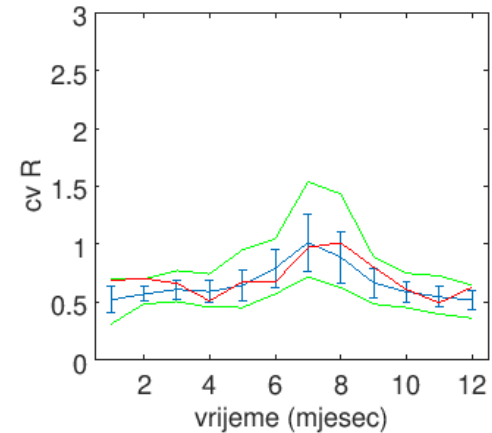
Zadar RCP45 N:22



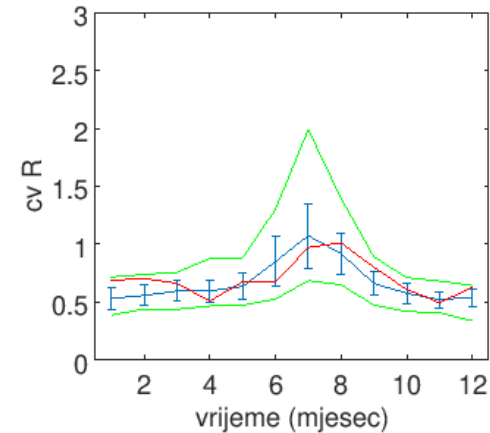
Zadar RCP85 N:39



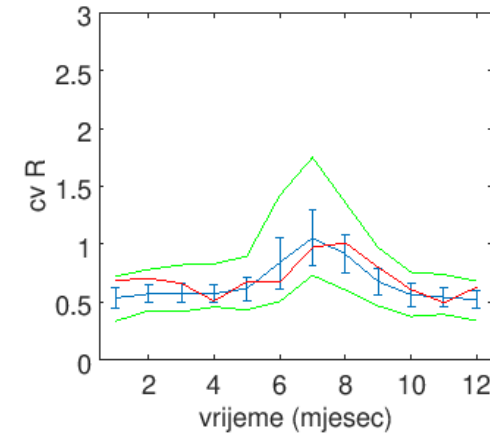
Zadar RCP26 N:14

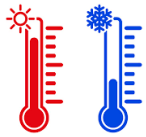


Zadar RCP45 N:22

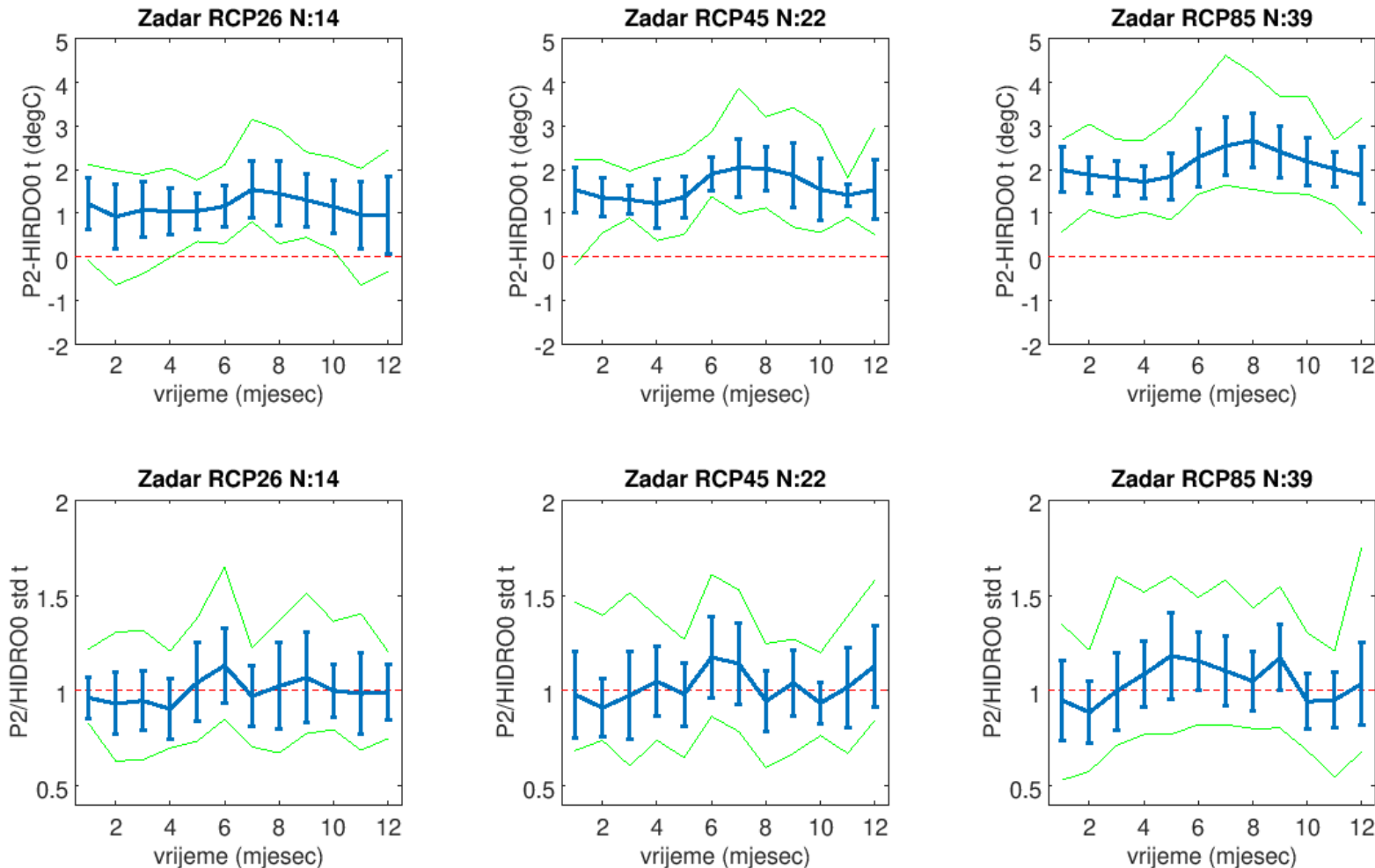


Zadar RCP85 N:39



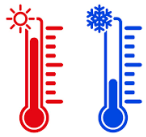


2.3 FUTURE CLIMATE SIMULATIONS & IMPACT OF STATISTICAL PROCESSING ON THE CLIMATE CHANGE SIGNAL

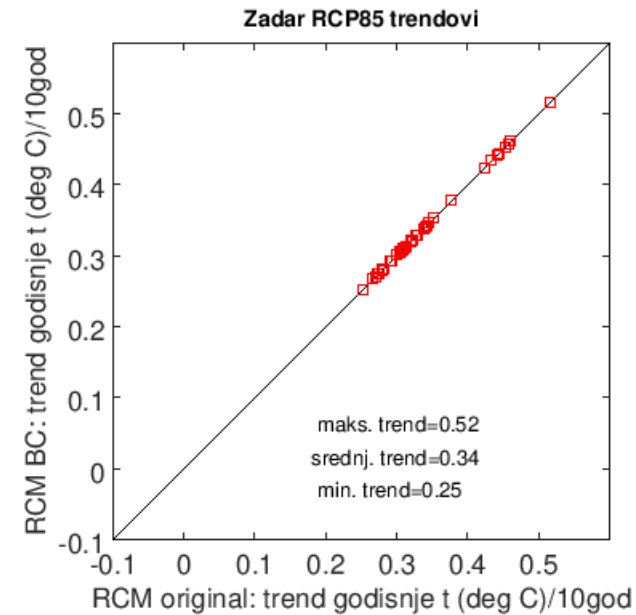
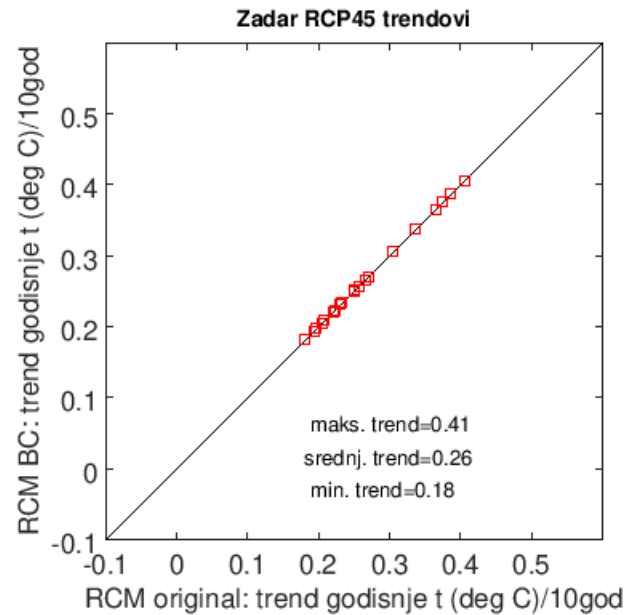
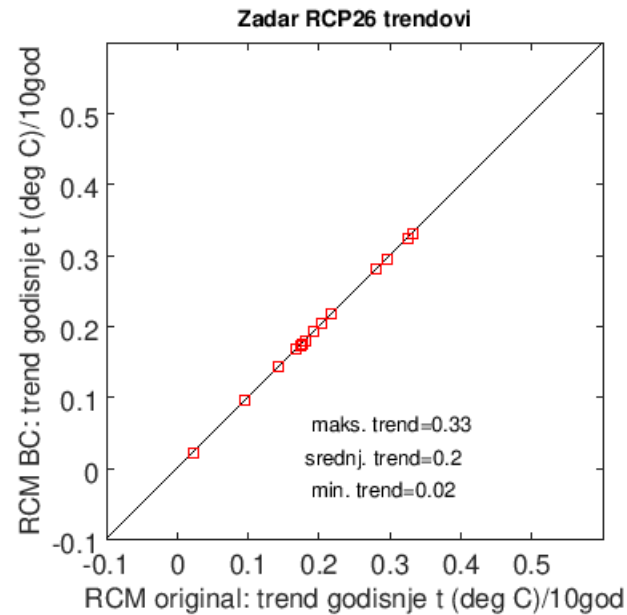


Difference of monthly mean temperature between future period 2041 – 2070 and referent climate 1981 – 2010 (first row) and the **ratio of monthly standard deviations** between future and 2041 – 2070 and current climate 1981 – 2010 (second row).

First column: RCP2.6;
Second column: RCP4.5;
Third column: RCP8.5.
Location: Zadar



2.3 FUTURE CLIMATE SIMULATIONS & IMPACT OF STATISTICAL PROCESSING ON THE CLIMATE CHANGE SIGNAL



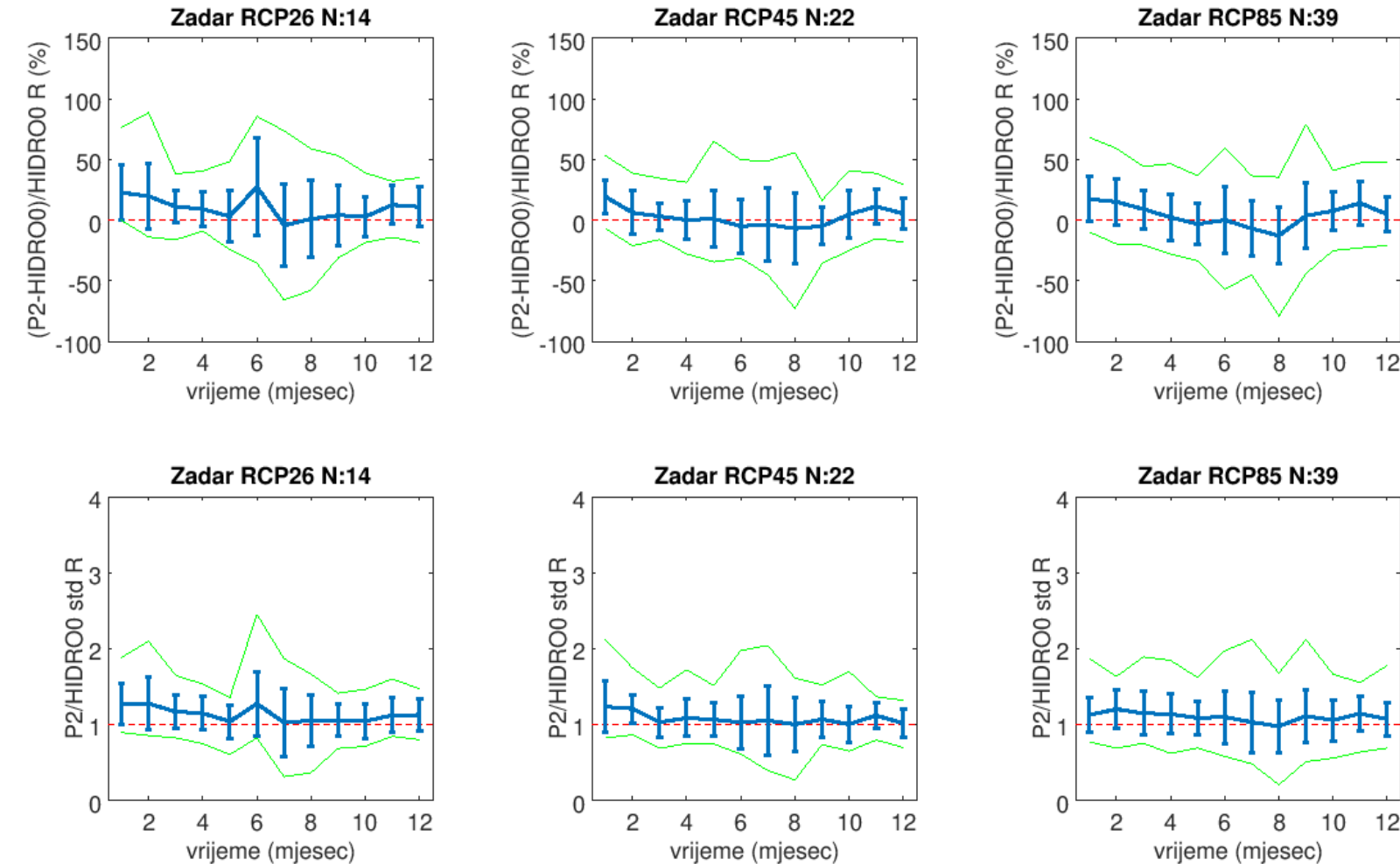
Warming on an annual scale for period 2041 -2070 according 1981 - 2010:

RCP2.6: 1.1°C
RCP4.5: 1.6°C
RCP8.5: 2.1°C

Comparison of **linear trends** in the original simulations (x-axis) and statistically processed simulations (y-axis) for 1971 – 2070. Analyzed quantity: **trend of annual temperature (°C/10 year)**. Scenarios: **RCP2.6 (left)**, **RCP4.5 (middle)** i **RCP8.5 (right)**. Location: Zadar



2.3 FUTURE CLIMATE SIMULATIONS & IMPACT OF STATISTICAL PROCESSING ON THE CLIMATE CHANGE SIGNAL



Relative difference of monthly precipitation between future 2041 – 2070 and referent climate 1981 – 2010 (first row) & **ratio of monthly coefficient of variation** between future 2041 – 2070 and referent climate 1981 – 2010 (second row).

First column: RCP2.6;

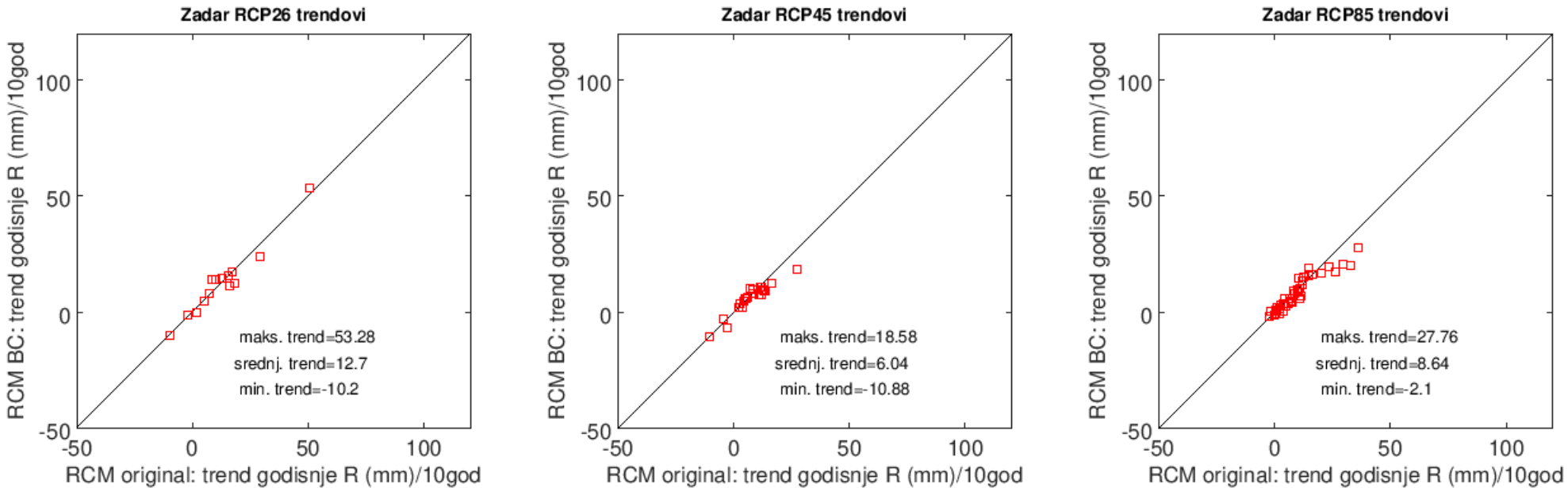
Second column: RCP4.5;

Third column: RCP8.5.

Location: Zadar.



2.3 FUTURE CLIMATE SIMULATIONS & IMPACT OF STATISTICAL PROCESSING ON THE CLIMATE CHANGE SIGNAL



Increase of precipitation on annual scale for period 2041 - 2070 according 1981 - 2010:

RCP2.6: 87.8 mm

RCP4.5: 30.8 mm

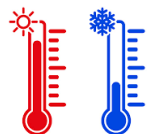
RCP8.5: 50.3 mm

Comparison of **linear trends** in the original simulations (x-axis) and statistically processed simulations (y-axis) for 1971 – 2070. Analyzed quantity: **trend of annual precipitation (mm/10 year)**.

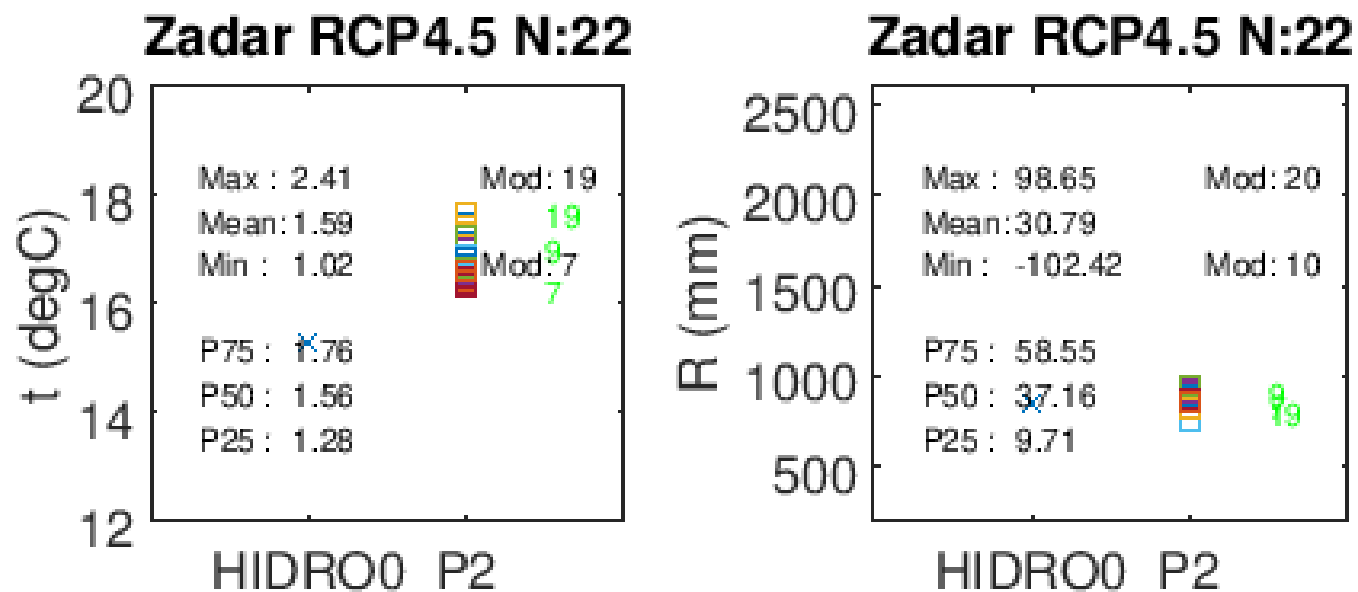
Scenarios: **RCP2.6 (left)**, **RCP4.5 (middle)** i **RCP8.5 (right)**.

Location: Zadar

2.4 DEFINING A SUBSET OF REGIONAL CLIMATE SIMULATIONS FOR THE NEEDS OF HYDROLOGICAL ANALYSES



Simulated **mean annual temperature (left column)** i **mean annual precipitation (right column)** for two periods: 1981 – 2010 (HIDRO0) & 2041 – 2070 (P2).



Statistical information on Figs:

- maximum signal between two periods (in which model),
- Mean signal between two periods,
- minimum signal between two periods (in which model),
- 25., 50. i 75.-ti percentil of all analysed signals in the one scenario.

Green: selected subset of models

Location: Zadar

Selected models are RCM7, RCM9 i RCP19:
 RCM7: ICHEC-EC-EARTH_rcp45_r1i1p1_KNMI-RACMO22E_v1,
 RCM9: IPSL-IPSL-CM5A-MR_rcp45_r1i1p1_SMHI-RCA4_v1,
 RCM19: MOHC-HadGEM2-ES_rcp45_r1i1p1_DHMZ-RegCM42_v1.



Thanks for your attention!



More about the project:

<https://www.ukv-projekt.eu/>

