



Montenegro and climate modeling

03-04. june Zagreb



Climate of Montenegro

- The geographical position of Montenegro determines its climate as the dominant Mediterranean
- The southern part is characterized by pure Mediterranean climate (with long, hot and dry summers and relatively mild and rainy winters)
- The central part and one part of the North have the characteristics of mountain climate with evident influence of the Mediterranean Sea (which is reflected through the precipitation regime and higher mean temperatures in the coldest months)
- The far northern part of the country has a continental climate (with characteristic large daily and annual temperature fluctuations and low annual rainfall)

Analysis of previous weather conditions and the current state

Monitoring and evaluation of climate indicate that the climate of Montenegro changed under the influence of global climate change and variability

The clearest indicators are:

- a significant increase in air temperature,
- increase in sea surface temperature and mean sea level,
- changes in extreme weather and climate events.

On the basis of belonging to a certain type of climate, and to display the current situation, we chose four representative municipalities in Montenegro (Zabljak, Pljevlja, Podgorica and Bar)

We used data from the Institute for Hydrometeorology and Seismology

The following table shows the mean annual air temperature for four selected municipalities

Table 1. Mean annual air temperature for 4 municipalities' representatives of climate types

	Climatological normal	Decade						
Regions	'61-'90	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10	Δ
Municipality of Zabljak	4.6	5.1	4.7	4.5	4.7	5.4	6.0	+1.4
Municipality of Pljevlja	8.1	8.6	8.1	7.9	8.2	8.8	9.1	+1.0
Municipality of Podgorica	15.3	15.5	15.4	15.0	15.4	15.8	16.3	+1.0
Municipality of Bar	15.5	15.7	15.7	15.3	15.6	15.9	16.8	+1.3

(Δ- deviation of the Decade (2001-2010) annual temperature of climatological normal)

Annual precipitation amounts (mm), per decades are shown in the following table

Table 2. Decadal annual precipitation (mm)

	Climatological normal	Decade						
Regions	'61-'90	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10	Δ
Municipality of Zabljak	1455.6	-	1514.2	1564.4	1287.5	1370.1	1610.6	+155.2
Municipality of Pijevlja	796.5	735.7	865.4	865.4	740.4	733	839.86	+43.4
Municipality of Podgorica	1657.9	1632.1	1695.2	1695.2	1521.7	1593.7	1781.6	+123.7
Municipality of Bar	1390.9	1414.1	1480.5	1480.5	1218.9	1241.9	1463.9	+73

(Δ - Deviation of the Decade (2001-2010) annual precipitation of climatological normal)

Climate analysis was performed by climate decades, to obtain a summary of the observed extreme events in Montenegro in the past 15 years and their projections parallel to the EBU-POM regional model.

What we can immediately notice is that the trends observed and projected climate change well matched.

The maximum and minimum temperature values as well as the maximum amounts of precipitation per decades for the reference period are presented in Tables 3,4 and 5.

Table 3. Decadal Records largest maximum air temperature in the period 1951-2010

	Decade					
Regions	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10
Municipality of Zabljak		30.4	28.2	30.6	31.3	32.4
Municipality of Pijevlja	38.0	35.0	33.2	36.2	38.2	38.1
Municipality of Podgorica	41.2	40.6	39.2	41.4	41.6	44.8
Municipality of Bar	35.4	35.9	36.8	37.7	37.0	36.6

Table 4. Decadal records the smallest minimum air temperature in the period 1951-2010

	Decade					
Regions	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10
Municipality of Zabljak		-26.4	-22.7	-26.4	-25.7	-24.6
Municipality of Pljevlja	-29.4	-29.0	-27.0	-29.2	-26.7	-23.5
Municipality of Podgorica	-9.7	-9.2	-8.5	-9.6	-8.4	-6.7
Municipality of Bar	-7.0	-7.2	-4.9	-4.4	-5.3	-4.3

Table 5. Decadal records largest maximum daily rainfall during the period 1951-2010

	Decade					
Regions	'51-'60	'61-'70	'71-'80	'81-'90	'91-'00	'01-'10
Municipality of Zabljak		207.4	146.5	122.6	144.2	141.3
Municipality of Pljevlja	55.5	79.4	90.2	123.5	77.9	81.1
Municipality of Podgorica	128.4	128.2	133.7	226.8	108.4	145.9
Municipality of Bar	180.8	135.4	157.1	224.0	124.2	200.7

Regional EBU-POM model

EBU - POM is totally linked atmospheric - oceanic regional climate model , under which developed software for connecting atmospheric and oceanic component models.

- The atmospheric component of the model is the EBU (ETA BELGRADE UNIVERSITY),
- The oceanic component of the model is a POM (PRINCETON OCEAN MODEL) model.

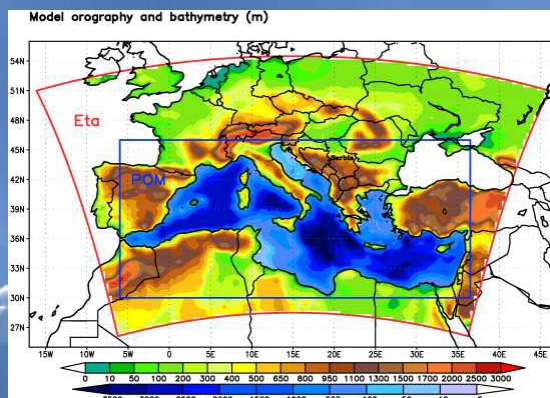


Figure 1. Geographic location, model domain. Red frame is marked by atmospheric domain components and dark blue ocean domain component model.

Some results of regional model

The results of the regional climate model EBU - POM from the experiments of future climate change on the territory of Montenegro, are focused on the results of scenario A1B for the periods 2001-2030 and 2071-2100 and the A2 scenario for the period 2071-2100.

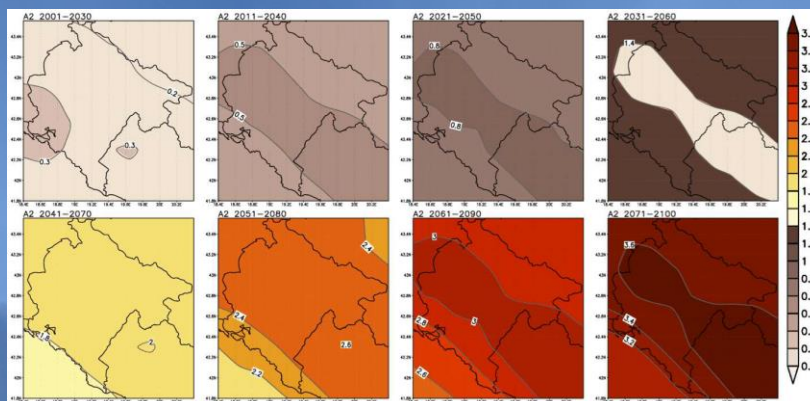
The research focuses on changes in two main terrestrial meteorological parameters, temperature at 2 meters and accumulated precipitation.

Changes in these parameters are shown in relation to the mean value of the base period 1961-1990.

Table 6. The projected value of the temperature change under climate scenario

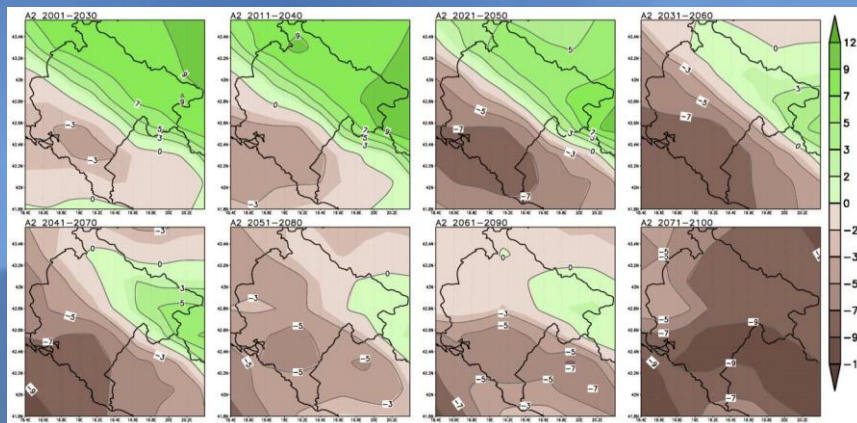
The climatescenario	Season	Temperatures °C	
		The southern part of MNE	The northern part of MNE
A1B scenario2001-2030	DJF- December , January, February	0.5 °C	0.9 °C
	MAM- March, April , May	0.8 °C	1.1 °C
	JJA-June, July , August	1.0 °C	1.3 °C
	SON- September , October, November	0.7 °C	0.7 °C
A1B scenario2071-2100	DJF- December , January, February	1.6 °C	2.6 °C
	MAM- March, April , May	1.6 °C	2.6 °C
	JJA-June, July , August	2.4 °C	3.4 °C
	SON- September , October, November	1.6 °C	2.4 °C
A2 scenario2071-2100	DJF- December , January, February	2.6 °C	3.4 °C
	MAM- March, April , May	2.8 °C	3.6 °C
	JJA-June, July , August	3.4 °C	4.8 °C
	SON- September , October, November	2.6 °C	3.0 °C

Figure 2: Change in mean annual temperature (°C) compared to the period 1961-1990, thirty-rated sliding the period from 2001 to 2100 according to the A2 scenario



Compared to precipitation model results show negative and positive changes in precipitation, depending on the part of Montenegro and the season. Negative changes, according to the A2 scenario, range up to -50 % in the southern part of Montenegro during the JJA season.

Figure 3. Change in mean annual rainfall accumulation (%) compared to the period 1961-1990 , thirty-rated sliding the period from 2001. to 2100. under scenario A2



Conclusions

1. According to the results regional model EBU-POM, compared to scenario A2, the territory of Montenegro can expect constant growth temperature during successive thirty-year period in the twenty-first century.
2. Under this scenario, the rate of increase in temperature will be higher in the second half of the twenty-first century to the final annual mean temperature anomalies for the last thirty years, on average, amounted to + 3.5 °C above the climatological normal period 1961-1990.
3. Change in precipitation regime is complex and the scenario considered in the first half of this century, the territory of Montenegro is divided into the northern areas of the south with a positive and a negative anomaly. In mid-century, the area negative anomalies will slowly spread to the northern parts of both two second last thirty-year period we have a situation that approximately 90% of the territory has a negative anomaly of rainfall.
4. Finally trump for a thirty year period we have a situation that on the whole territory we have a deficit in relation to the reference period 1961-1990, with a maximum of 10% of annual accumulation.

