Report:

Climate and climate change data on national level Republic of Serbia

Institute for Development of Water Resources

"Jaroslav Černi"

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DRINK ADRIA

Adriatic IPA
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Report about existing climate and climate change data on national level

Republic of Serbia

This draft is prepared by DRINKADRIA project team at the Institute for water resources development "Jaroslav Cerni", Belgrade Serbia as a contribution to DRINKADRIA project implementation activities relevant for WP4

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Table of Content

1. INTRODUCTION

In this report, the selected general data for Republic of Serbia are presented. Since there is no pilot location in republic of Serbia, all data and information presented in this report apply to the whole territory. Climatic characteristics are exhibited based on data included in the official National Water Management Master Plan and include overall synthesis on precipitation and temperature as the most important climatological parameters of relevance for water management. Moreover, the short, general characteristics and specificities of surface and ground waters are presented.

Although different methodologies are applied in the climate change assessments and studies, from paleoclimate analysis, satellite observations the most frequent approaches are application of different methodologies, e.g., trend analyses, on the observed data and regional climatological models .

All global and regional climate models (RCMs) predict an increase in temperature and a decrease in precipitation in Serbia, with expected range from 2°C to 6°C/100 years, largely depending on the selected scenario and to a much lesser extent on the analyst (IPCC 2007; SINTA 2008; SEECOF 2010; CC-Waters 2011).

Annual precipitation predictions range from current levels (trend=0) to -25%/100 years. However, only a few of these models offer spatial (within Serbia) and temporal (yearlong) distributions. Each prediction is sensitive to assumption uncertainties and calculation imperfections. The quality of a prediction grows with increasing validation by recorded long-term trends.

Although the climatic models are widely used, the comprehensive analyses of the trend in the historical data sets are of the great significance. Given that, analyses of Climate parameters presented in this report are based on available data for observed Temperature and Precipitation, on the annual, seasonal and monthly level. Moreover,, some remarks are given for daily data.

All trend charts presented in this report are generated by application of the Surfer software, based on data recorded at analyzed temperature/precipitation or hydrological stations, removing the stochastic component by regional averaging.

2. EXISTING CLIMATE FEATURES IN SERBIA

2.1 Characteristic of present Climate

Serbia is landlocked country with diverse topography. The climate of Serbia is under the influences of the landmass of Eurasia and Atlantic Ocean and Mediterranean Sea. With mean January temperatures around 0 °C, and mean July temperatures around 22 °C In the northern part of the country, the climate is more continental, with cold winters, and hot, humid summers. In the south, summers and autumns are drier, and winters are relatively cold, with heavy inland snowfall in the mountains. Differences in elevation, proximity to the Adriatic Sea and large river basins, as well as exposure to the winds results in climate variations. Southern Serbia is subject to Mediterranean influences. However, the Dinaric Alps and other mountain ranges contribute to the cooling of most of the warm air masses. Winters are quite harsh in the Pešter plateau, because of the mountains, which encircle it. One of the climatic features of Serbia is Košava, a cold and very squally southeastern wind which starts in the Carpathian Mountains and follows the Danube northwest through the Iron Gate where it gains a jet effect and continues to Belgrade and can spread as far south as Niš. Generally speaking, mean annual air temperatures are more uniform than mean temperatures in singular months. Annual mean air temperatures in the North part of the Republic vary between 10 and 11.8 ^{o}C, in lower areas in the Central and South parts between 10 and 12 ^{o}C. Lower temperatures occur in hilly and mountainous regions. Mean annual temperatures linearly decline with increase of terrain elevation. Mean annual temperatures for the Republic are approximately as follows: on elevation of 300 m 11,4 ^{0}C; on 1000 m 7.3 ^{0}C and on 1700 m 3.3 ^{0}C. Therefore, vertical mean temperature gradient is approximately –0.6 ^{0}C / 100 m.

Precipitation is one of the most important climatological components. Average depth of precipitation on the territory of Republic of Serbia is 734 mm/year. Precipitation regime is very heterogeneous with respect to time and space due to the atmospheric processes and topographic characteristics. The Southwest parts of Kosovo belong to the Maritime precipitation regime (precipitation that occurs during cold half of a year (October-March) presents more than 50% of total annual rainfall). Other parts of the Republic have Continental regime (more that 50% of total annual rainfall occurs in warmer half of a year). Central and Eastern part of Kosovo and Metohija belong to the transition zone that is characterized with influence of both mentioned regimes.

Total annual precipitation in the River Beli Drim watershed and particularly in its right tributaries (Pećka Bistrica, Erenik and others) is 1500 mm/year. Something smaller but also substantial precipitations occur in the watersheds of upper Ibar River, Plavska River and Lepenica River (more than 900 mm/year). In the central part of the Republic, total annual precipitation depths vary from 1000 mm/year (in mountainous regions) to 600 mm/year. There is a tendency toward decreasing of precipitation depths from the West to the East in the plain areas.

Table 1: average monthly and annual precipitation (mm)at the selected localities in Serbia.

Station	**Month**												**Year**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Sombor	35,4	33,5	33,0	48,7	60,0	76,3	60,9	48,8	35,8	40,6	53,4	44,7	571
Kikinda	33,5	34,7	32,3	44,8	53,0	74,1	52,9	50,2	36,4	35,1	48,0	46,3	541
Zrenjanin	35,2	36,3	36,1	45,7	62,4	83,9	58,8	47,7	36,0	35,1	47,8	47,3	571
Novi Sad	43,6	43,4	43,8	52,0	62,5	85,9	67,5	54,0	38,4	41,6	54,4	56,6	643
S. Mitrovica	40,8	39,7	40,3	49,6	60,9	84,5	65,1	52,0	39,5	44,0	54,0	53,1	623
Beograd	48,3	44,1	48,9	55,3	73,6	95,8	66,2	50,0	47,6	44,9	57,8	57,5	690
Šabac	47,7	43,9	46,1	54,8	65,4	84,6	65,4	55,7	47,6	47,6	60,3	60,0	678
Valjevo	50,1	45,5	52,1	62,7	86,7	98,8	75,9	69,4	54,5	54,0	62,7	57,8	770
S. Palanka	44,9	38,5	44,7	49,7	66,9	88,4	59,1	47,3	42,6	45,3	54,4	49,0	631
Rudnik	71,3	72,1	72,2	80,2	105,2	121,3	90,9	74,8	66,2	61,7	74,6	75,8	966
Negotin	51,8	47,7	46,8	55,7	82,3	91,0	68,3	56,4	50,5	45,8	56,1	60,2	713
Kragujevac	42,6	38,5	43,9	50,6	74,2	82,5	67,8	48,8	42,5	39,4	48,8	49,1	629
Požega	50,3	45,5	47,3	54,9	82,6	83,8	79,1	57,9	56,9	55,2	63,5	52,7	729
Zlatibor	62,0	58,6	58,0	72,7	100,8	103,0	90,0	76,3	77,5	73,1	84,7	67,9	924

Sjenica	45,5	40,4	37,8	47,7	73,6	80,2	65,3	61,6	55,0	60,8	74,0	53,0	695
Dimitrovgr.	39,2	39,2	43,7	52,4	79,2	85,8	55,5	43,5	39,1	43,3	58,9	48,8	629
Niš	38,6	38,3	39,8	51,6	64,5	63,4	43,3	41,8	41,0	40,0	57,8	51,6	571
Vranje	40,0	41,5	42,6	50,3	65,5	70,1	49,2	38,2	45,8	52,2	66,1	52,8	614
Priština	35,8	38,3	38,6	51,4	69,7	62,0	48,3	44,7	43,2	50,0	65,0	53,2	600
Prizren	67,8	54,5	57,9	58,2	69,1	65,2	54,5	44,4	56,5	60,5	84,1	72,3	744

The majority of surface water in Serbia originates out of its territory, approximately 92% (162, 5 billion m^3 / year) entering the country from the upstream countries. Domicile surface water resources are approximately 16 billion m^3 /year, e.g., 8%. In the table bellow, average, maximum and low flows are presented for selected localities for the largest rivers.

Table 2: Flows at the largest rivers in Serbia

River	Station	Q (m^3/s)		
		Q_{av}	$Q_{min\ 95\%}$	$Q_{max\ 1\%}$
Dunav	Bezdan	2267	952	7017
	Pančevo	5264	1976	15311
Tisa	Senta	794	134	3914
Sava	Sr. Mit.	1535	272	6379
Morava	LJ. Most	234	35	2396
Drina	Radalj	362	69	4940

Groundwater is significant source for drinking water supply in Serbia, more precisely; over 70% of population and industry use it. More than half of groundwater is from alluvial aquifers, with **80-90%** being infiltrated river water.

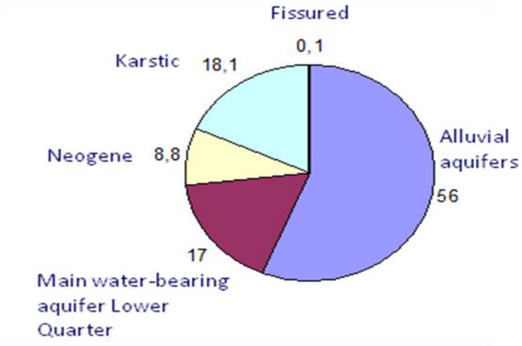


Figure 1: aquifers types in Republic of Serbia

2.2 Observed Climate changes in Serbia

The period selected for observed data analysis in this report is from 1949 to 2006. This period is convenient because it is relatively long (58 years), data are available from numerous monitoring stations, and they exhibit a close similarity to estimated long term temperature and precipitation trends (JČI 2011; HMSS 2011).

Temperature

To assess past temperature trend, 26 temperature stations were selected (JČI 2011). They are presented in the table 3

Table 3: Monthly and yearly temperature trends for period 1949 – 2006 (°C/100yrs)

	Temper. station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Okt**	**Nov**	**Dec**	**Annual**
1	TS Sombor	2.9	1.4	2.6	-0.2	2.3	1.6	1.7	2.0	-0.6	0.9	-1.3	-1.8	**1.0**
2	TS S.Mitrovica	1.7	1.3	2.4	-0.4	2.2	0.5	0.3	1.2	-1.0	1.6	-1.3	-1.8	**0.6**
3	TS Senta	3.2	2.6	3.2	0.9	3.0	2.3	2.3	2.1	-0.2	1.9	-0.9	-1.6	**1.6**
4	TS Beograd	2.5	2.5	4.0	0.6	2.8	1.7	1.8	1.9	-0.9	1.4	-0.7	-1.5	**1.3**

5	TS Zlatibor	2.9	1.6	2.8	0.0	2.2	1.5	1.6	0.6	-2.1	1.8	-1.4	-2.3	**0.8**
6	TS Kruševac	1.8	1.5	3.4	0.0	1.7	1.0	1.0	0.7	-1.6	0.9	-2.0	-2.9	**0.5**
7	TS Niš	1.2	0.8	3.0	-0.3	1.1	0.4	1.0	0.5	-2.0	1.0	-2.2	-2.7	**0.1**
8	TS Požega	1.8	1.6	4.1	1.6	3.3	2.7	2.3	1.4	-0.5	1.5	-2.4	-2.9	**1.2**
9	TS Pirot	2.1	1.6	4.3	1.3	2.6	2.2	2.2	1.8	0.1	2.0	-1.6	-1.4	**1.4**
10	TS Vranje	0.5	0.1	2.5	-0.6	0.9	0.7	0.6	-0.1	-2.3	0.3	-2.6	-3.1	**-0.3**
11	TS Zaječar	2.9	2.1	4.5	0.1	1.9	2.0	1.8	1.2	-1.1	0.8	-2.1	-1.9	**1.0**
12	TS Knjaževac	1.9	0.6	3.1	-0.8	1.2	0.8	0.4	-0.3	-2.4	0.0	-3.1	-2.4	**-0.1**
13	TS V. Gradište	1.3	1.0	2.2	-0.7	1.1	0.5	0.6	0.5	-2.1	0.0	-1.8	-2.9	**0.0**
14	TS Aleksandrovac	1.1	1.4	2.6	-1.9	-0.7	-1.0	-0.6	0.0	-2.1	1.0	-2.2	-3.4	**-0.5**
15	TS Leskovac	0.6	-0.4	2.2	-1.1	0.4	0.2	0.0	-0.9	-3.4	-0.8	-3.6	-3.2	**-0.8**
16	TS Prokuplje	0.4	0.2	2.3	-1.8	-0.3	-0.8	-0.2	-0.6	-2.5	0.4	-2.9	-3.2	**-0.7**
17	TS Ćuprija	1.2	0.4	2.2	-1.1	0.7	-0.2	0.1	-0.1	-2.4	0.0	-2.4	-3.1	**-0.4**
18	TS Čačak	2.1	1.0	2.8	0.2	2.1	1.2	1.5	1.1	-1.0	1.1	-2.6	-1.9	**0.6**
19	TS Novi Pazar	4.4	4.2	5.8	2.1	3.6	3.4	3.6	2.5	1.3	3.4	-0.6	-0.3	**2.8**
20	TS Sjenica	2.9	1.4	2.8	-0.2	1.3	1.4	2.1	0.9	-1.1	2.0	-2.1	-1.0	**0.9**
21	TS Ivanjica	3.4	2.8	4.6	1.4	3.0	2.4	2.3	1.1	-0.5	2.2	-1.5	-0.8	**1.7**
22	TS Jagodina	1.1	1.6	3.8	-0.4	2.4	1.3	1.6	1.3	-0.9	1.2	-1.8	-2.7	**0.7**
23	TS Čumić	2.3	2.0	3.0	-1.0	1.0	0.0	0.4	1.1	-0.8	2.3	-1.2	-1.9	**0.6**
24	TS Valjevo	2.1	1.2	2.9	0.2	2.6	1.4	1.7	2.0	-0.5	1.6	-1.8	-2.1	**0.9**
25	TS Dragaš	0.6	-0.4	2.5	-0.9	-0.5	-0.9	-1.6	-1.9	-4.3	0.7	-1.9	-3.3	**-1.0**
26	TS Bujanovac	1.8	0.6	3.4	0.1	1.8	1.4	1.0	0.0	-0.6	2.4	-1.3	-1.9	**0.7**
	Average	**1.9**	**1.3**	**3.2**	**-0.1**	**1.7**	**1.1**	**1.1**	**0.8**	**-1.4**	**1.2**	**-1.9**	**-2.2**	**0.6**

It is observed based on analyses that the annual average temperature trend in Serbia was found to be about 0.6°C/100 years. The spatial distribution is shown in Figure 2 .

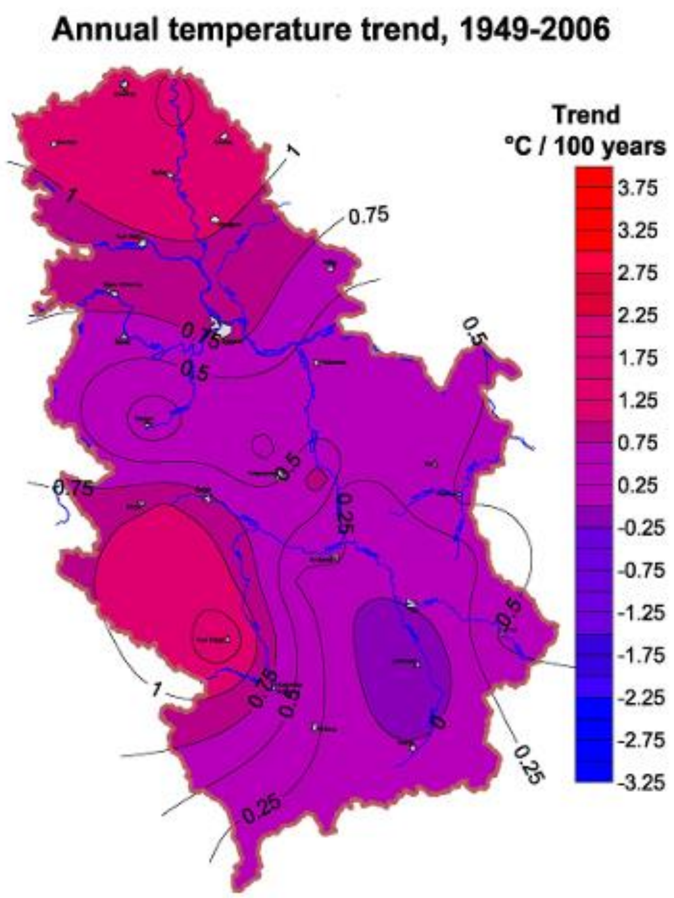


Figure 2: Temperature trends in annual data series in Republic of Serbia (Dimkic et al, 2011)

The greatest increase was noted in mountainous regions and in the north of the country, and the smallest increase in the southeast of the country.

The greatest increase has been recorded in the **spring** (some 1.5°C/100yrs), followed by the **summer** (1.0°C/100yrs) and **winter** (0.5°C/100yrs), while the **autumn** exhibited a negative trend of about -0.7°C/100yrs .

If the seasons were assessed by calendar instead of groups of three months, the claim about the greatest T increase over the summer months would become quite questionable in Serbia.

Short remarks regarding Temperature daily data: While all stations reported a significant temperature increase (trend) for daily maxima, the daily minima exhibited from no distinct trend to a negative trend in the southeastern part of the country (consistent with annual trends); in the remainder of the country it was positive but much lower than that of the daily maxima. Nearly all stations recorded a downward stochastic trend, indicating relative consistency of the described temperature trends.

Precipitation

To assess past precipitation trend, 34 precipitation stations were selected (JČI 2011). They are presented in the table 4.

Table 4 Monthly and yearly precipitation trends for period 1949 – 2006 (%/100yrs)

	Precip. station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec	Annual
1	PS Bezdan	-4.3	-60.1	2.0	-21.1	-48.2	-6.9	15.7	43.8	97.5	49.8	-32.9	-43.7	**-1.7**
2	PS Šid	62.3	-7.8	23.8	35.2	6.5	42.9	50.8	16.7	99.2	110.3	12.2	-47.8	**33.2**
3	PS Horgoš	-2.6	-8.8	30.3	35.2	-63.6	-7.7	63.8	25.1	116.6	39.6	-76.4	-31.1	**7.2**
4	PS Jaša Tomić	-35.3	-76.9	-1.3	68.3	-9.3	21.7	25.5	50.4	121.0	36.7	-76.5	-37.0	**9.4**
5	PS Prijepolje	-7.6	34.2	9.6	90.7	6.3	-26.1	4.7	86.8	97.6	23.5	22.9	42.2	**30.4**
6	PS Kuršumlija	-11.7	-35.0	-38.0	44.1	-18.5	-42.5	60.4	22.7	68.4	-92.0	-42.8	-1.9	**-7.4**
7	PS Leskovac	-9.5	-3.8	-37.0	65.7	-9.4	-4.5	40.0	31.9	90.7	13.9	-38.5	13.9	**11.9**
8	PS Beoce	-49.7	16.4	45.8	85.4	-5.0	-5.4	77.6	75.6	113.5	12.0	-20.3	20.8	**30.9**
9	PS Pirot	12.6	-47.0	4.1	37.3	-19.4	-6.4	-26.8	110.9	34.4	-4.4	-90.3	-6.8	**-2.4**
10	PS Vranje	-49.8	-32.4	-51.1	12.0	-27.6	15.1	-27.7	66.1	-4.1	-32.1	-117.4	-52.2	**-25.9**
11	PS Knjaževac	-5.4	-25.0	-11.1	63.1	-23.2	-8.2	-55.8	45.3	79.7	22.9	-80.6	-52.4	**-6.2**
12	PS Svrljig	24.0	-13.9	2.1	47.4	-58.0	2.4	17.8	115.2	46.7	-19.4	-51.6	-30.8	**3.6**
13	PS Voluja	-22.9	-70.1	9.2	58.2	-54.8	-76.7	-76.6	21.8	7.0	13.1	-93.0	-45.5	**-31.0**
14	PS Aleksandrovac	-54.2	-33.4	-68.0	26.7	-96.0	-12.3	14.4	36.9	28.9	-78.7	-51.1	-6.2	**-24.2**
15	PS Vučje	22.2	64.1	-4.1	-9.0	-87.7	-28.2	34.1	26.3	55.4	8.7	-46.2	3.9	**-2.1**

16	PS Trećak	-28.8	-78.1	-43.1	23.4	-90.9	-39.1	-15.9	-30.3	-13.7	-107.6	-47.6	-37.3	**-43.0**
17	PS Ćuprija	-1.1	10.3	16.8	69.0	-64.1	10.3	-6.4	39.9	64.4	25.3	-39.3	-4.2	**7.4**
18	PS Kosjerić	-5.2	27.6	-23.9	15.9	-54.9	-4.1	-9.0	3.2	54.6	7.1	-15.4	-6.8	**-2.9**
19	PS Novi Pazar	-40.6	6.2	5.5	68.7	-43.7	-29.1	57.5	50.3	102.1	-11.3	-7.7	9.8	**13.7**
20	PS Brodarevo	-26.2	17.8	-34.8	66.2	-30.5	-1.2	-17.2	21.7	122.5	-45.9	11.9	0.4	**7.2**
21	PS Ivanjica	-75.3	-5.6	-57.9	13.7	-60.8	-31.1	5.3	28.4	92.1	-13.1	38.0	-3.5	**-5.9**
22	PS Vranovina	-30.1	4.1	-36.7	66.7	-20.8	-1.2	59.3	81.8	102.9	0.0	-10.5	36.9	**22.5**
23	PS Rekovac	-20.2	-19.1	4.4	33.1	-71.7	9.5	1.3	69.5	93.7	-4.4	-56.2	-28.5	**-0.7**
24	PS D. Šatornja	-55.2	-38.2	-49.3	20.7	-68.0	55.1	32.8	49.5	71.9	28.4	17.4	7.9	**8.8**
25	PS Osečina	-11.8	-14.3	3.1	39.5	-27.9	79.1	50.4	55.9	86.2	59.7	11.0	-8.1	**29.3**
26	PS Dragaš	46.2	46.4	59.2	37.7	-46.2	-55.6	-16.6	39.7	4.8	-11.2	-32.6	54.5	**7.4**
27	PS Bujanovac	-55.9	-16.2	-38.6	45.7	-65.7	22.4	2.7	7.3	13.1	-24.2	-110.2	7.4	**-18.8**
28	PS Jajinci	-8.4	-17.2	-16.6	41.9	-75.8	-14.7	-6.4	63.0	73.4	64.0	-38.0	-10.3	**1.5**
29	PS Senta	-24.9	-61.2	2.9	34.4	-43.7	-5.5	35.3	10.0	131.0	37.2	-59.2	-30.0	**1.0**
30	PS S. Mitrovica	-26.0	-84.4	-9.9	1.3	-52.9	-8.4	2.3	70.5	74.6	87.2	-38.2	-112.5	**-8.1**
31	PS K. Reka-Brus	13.0	-18.3	-52.8	40.5	-42.7	-19.4	-5.2	42.1	100.3	-49.5	-63.9	-23.1	**-7.7**
32	PS Martinci	-15.0	-59.1	3.3	9.9	-45.4	-6.7	10.9	77.5	91.2	86.7	-11.5	-70.9	**4.1**
33	PS Krupac	-27.1	-93.3	-61.9	-20.6	-55.5	-38.1	-61.0	-18.3	26.1	-74.2	-132.2	-40.8	**-50.3**
34	PS Bogojevo	-17.9	-44.3	-6.6	-33.1	-16.4	-2.4	53.2	27.7	65.4	57.8	-39.8	-75.9	**-2.2**
	Average	**-16.0**	**-21.7**	**-12.4**	**35.7**	**-43.7**	**-6.6**	**11.5**	**43.1**	**70.9**	**6.3**	**-41.4**	**-17.9**	**-0.3**

The annual average precipitation trend in Serbia was found to be slightly negative. The spatial distribution is shown on Figure 3 (JČI 2011, period 1949-2006; Smailagić 2009, period 1950-2004).

The change in magnitude of precipitation is of great interest among the scientific community since it is important input in water management policies and infrastructure development. Diverse methodologies are applied in the assessment and modeling (trend analysis, climate models). With respect to spatial scale, projections of the future precipitation magnitude refer to local, regional, continental and global scale. According to the available literature precipitation amount, magnitude, and temporal distribution are changing. Observed and detected changes and associated influence on hydrological cycle affect water management and human society in many ways.

It is noteworthy to mention that understanding of data sets, methodology applied, and associated constrains are prerequisite for the reasonable findings.

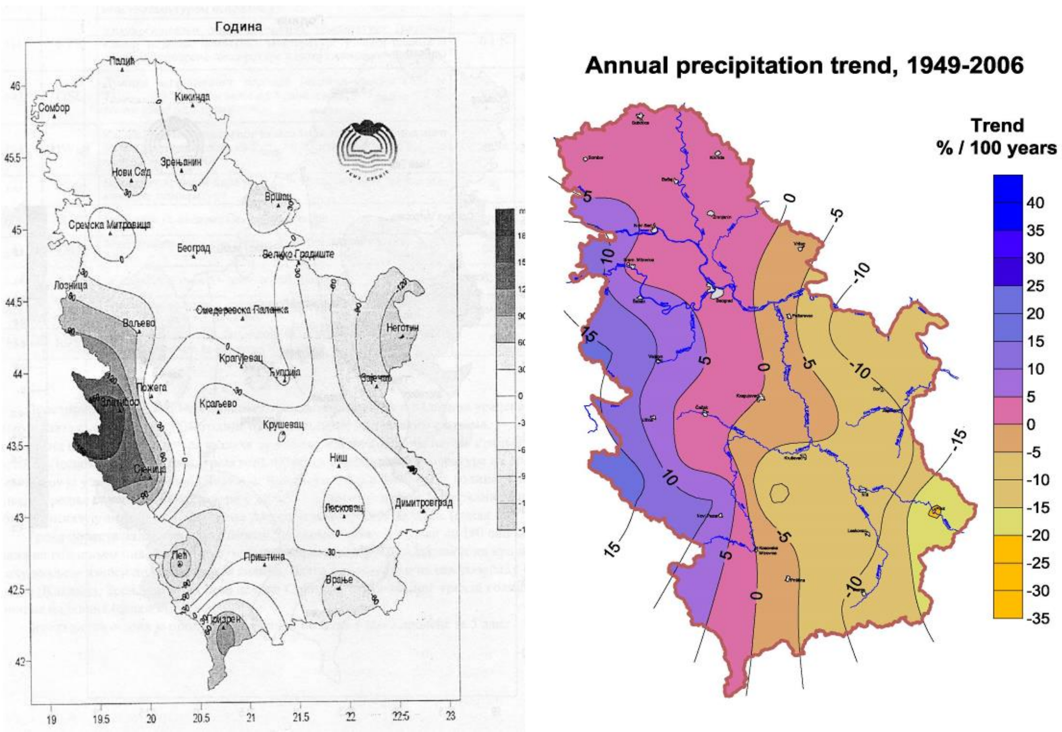
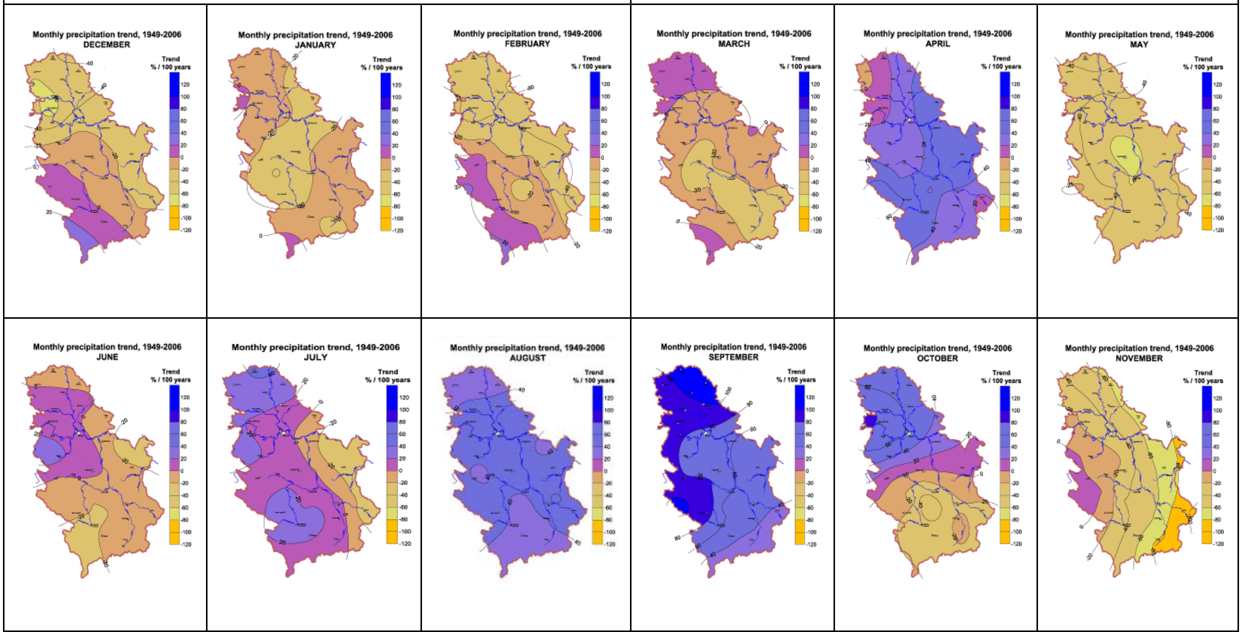


Figure 3 Observed precipitation data annual trends evaluation in Serbia by Smailagic (left Figure, in mm/55 yrs) and Dimkic (right Figure, in %/100 yrs) Source: Smailagic (2009) and Dimkic et.al. (2012).

Despite that results depicted in Figure 3 origin from different methodologies applied for trend assessment in individual studies they exhibit similarities with respect to trends in observed precipitation data across the Serbia. Furthermore, the findings from majority of GCM and RCM demonstrate decrease in average precipitation in Serbia, with more significant trend in eastern part of the country. According to results of trend evaluation in average precipitation data by Dimkic et.al.(2012) the lowest negative trend is from -5% to 0% /100 yrs in Central Serbia with gradual trend decrease in average precipitation in Eastern Serbia. These trend projections agree very well with observed data. The summary results for monthly data are exhibited in figure 4.

WINTER | SPRING



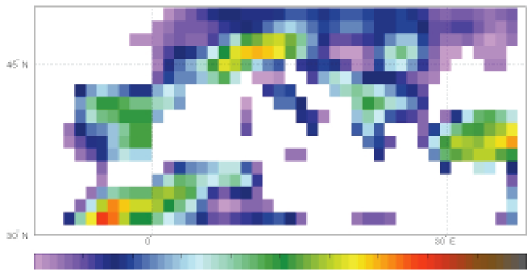
SUMMER | AUTUMN

Figure 4. Spatial precipitation trend distribution by month(%/100yrs).

Short remarks regarding precipitation daily data: To a large extent in line with the annual distribution of the precipitation trend, daily maxima exhibited an upward trend in the western and northern parts of the country (albeit with an upward stochastic trend, suggesting increasing unpredictability), while there was a downward trend of daily maxima in the southeastern part of the country, in parallel with a declining stochastic component.

3. CLIMATE CHANGE SCENARIOS

Since the first GCM the improvement of resolution is significant by the development of Regional Climate Models (RCM). Different RCM models are developed in Serbia (SINTA 2008; SEECOF 2010; CC-Waters 2011, etc)



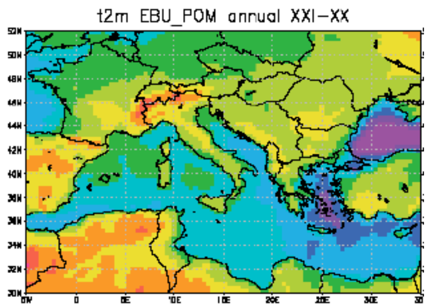
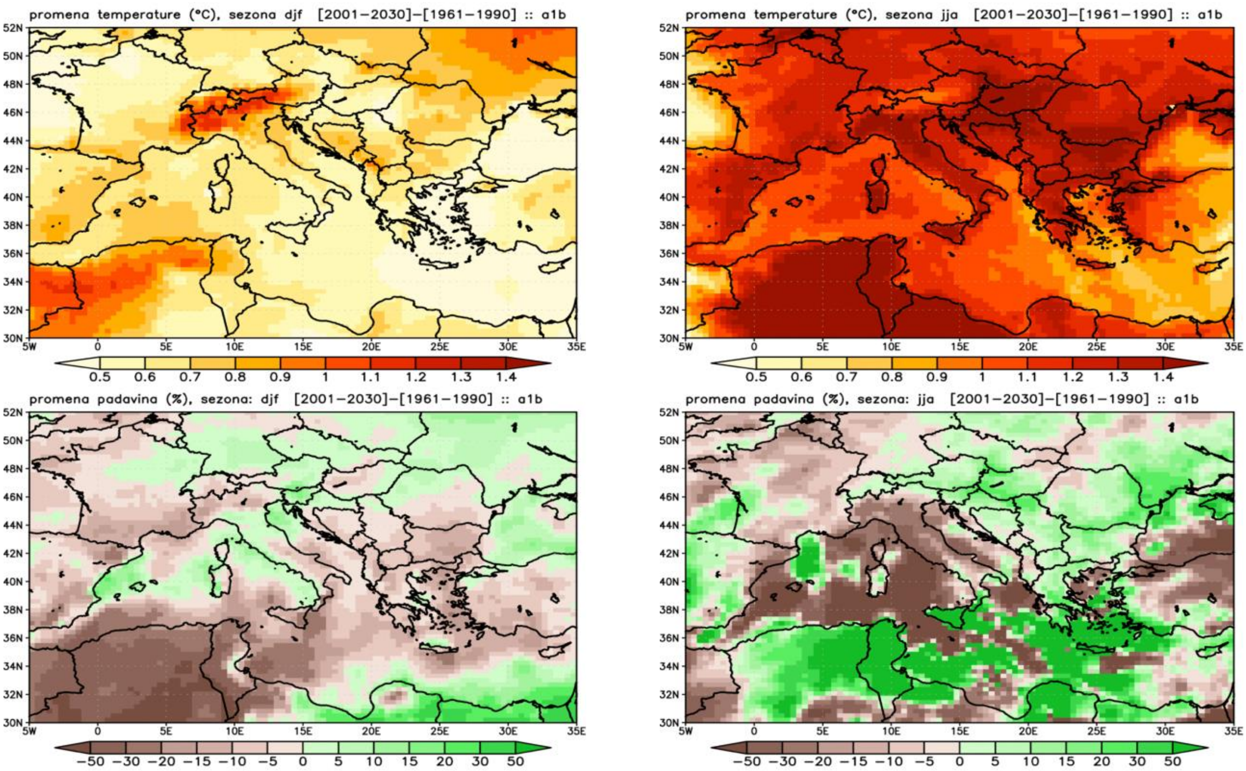


Figure 5a: Echam4 model; world scale 1,125° - 2° Fig. 5b : Ebu-Pom model; med scale 0,2° - 0,25°

The most significant improvement is accomplished in last years within the Climate change centre of Hydrometeorological Service of Serbia in cooperation with the faculty of Physics at the University of Belgrade. Figures bellow present climate change predictions developed by this centre, based on scenario A1B i A2 (Djurdjevic, 2012).



Since for the near future, the difference between two scenarios are unsignificant, results based on scenario A1B are presented .

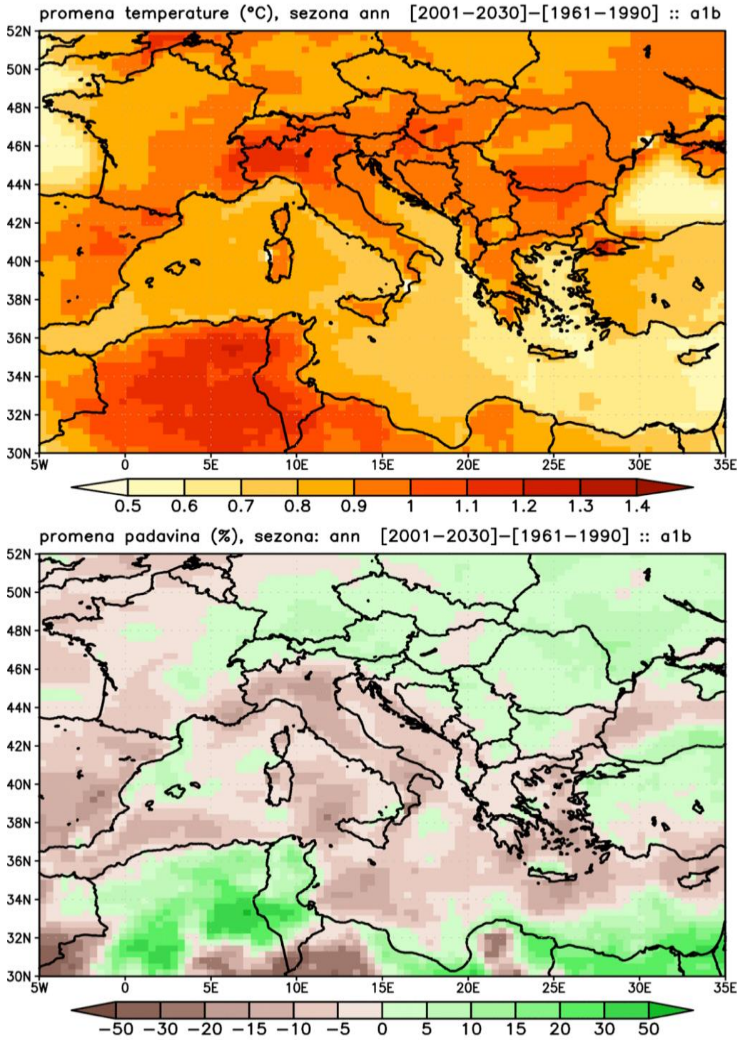


Figure 8: change in precipitation and temperature based on scenario A1B

Based on the figures, the average temperature change an the annual basis is around +1°C, e.g., while change in precipitation are between - 5% to ±5%.

For the long term predictions, the results based on both scenarios (A1B and A2) are presented in this report. Based on data exhibited in Figure 9 (a and b).

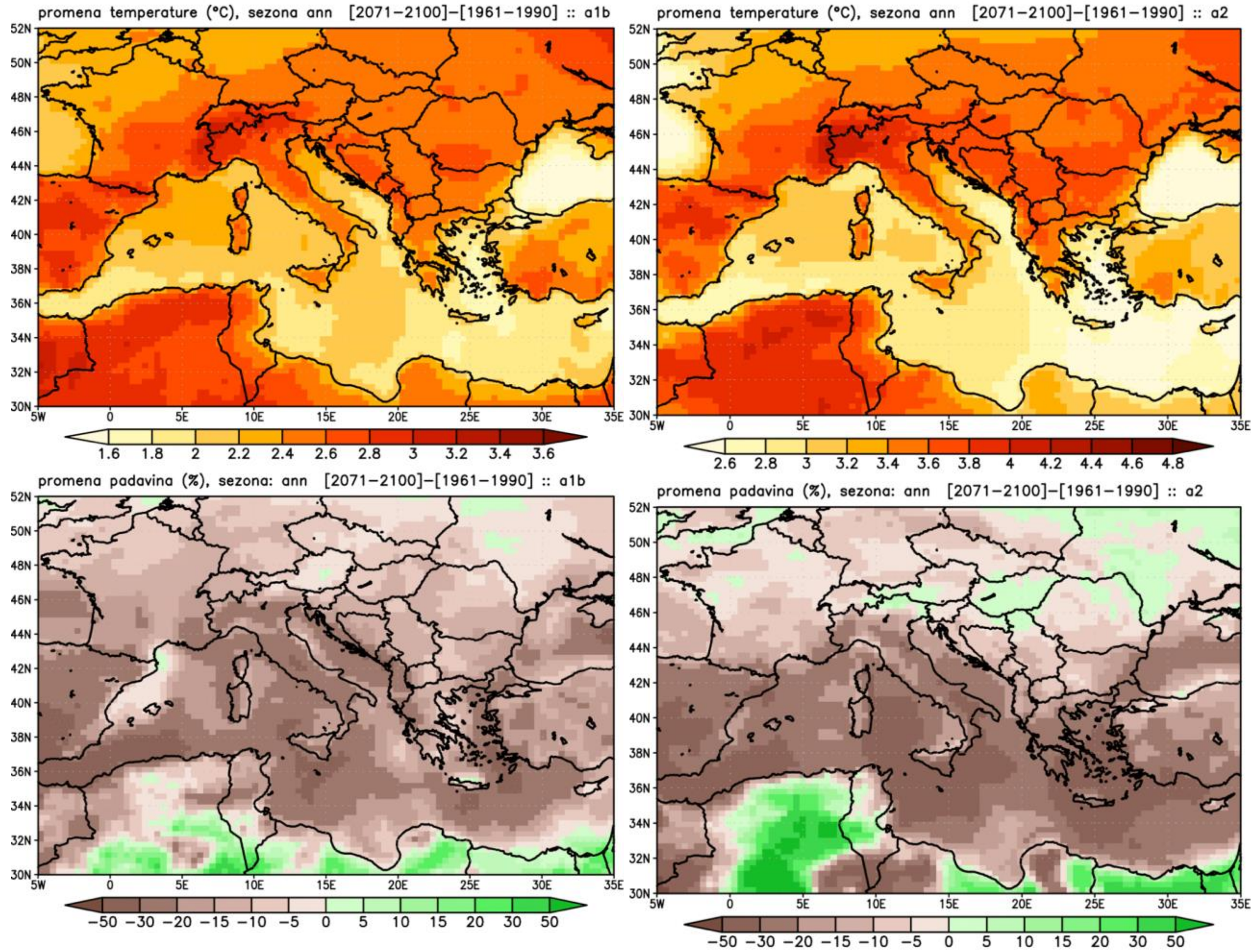


Figure 9 : Changes in precipitation and temperature based on scenarios A2 and A1B

According to this two scenarios, by the end of 21 century change in the annual average precipitation values are expected to be approximately -15%, while for the temperatures there are difference in the predicted changes in average temperatures +2.5°C and +3.7°C, for A1B and A2 , respectively.

4. UNCERTAINITIES

When we think about prediction of future changes in climate and especially water sector, we must consider the probability and reliability of such events. Two reasons exist why is especially important to underline uncertainties in any forecast or projection. First, because ordinary people often accept any projection as one claim, and they are often confused seeing quite (sometimes totally) opposite results in several different projections. Second, because uncertainties is not the same for different issues. There are many sources of uncertainty, e.g., length of time series used for assessment, spatial resolution, selected scenarios, data quality, etc.

Two approaches for the degree of certainty are proposed by the IPCC (IPCC 2013, Summary for Policymakers):

• Qualitative Confidence according to type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement.

• Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment).

When it comes to variables and phenomena that impact water resources management, the Strategy on adaptation to climate change for the Danube River Basin (DRB), (ICPDR, 2013), Figure 10, weighty uncertainties for the CC impacts in the DRB are attributed to floods, sedimentation and contamination, etc. The medium certainty is assigned to the great number of variables/ events, e.g., droughts, runoff, water availability, low flow, etc. High and very high certainties are assigned to the average precipitation and temperature projections, respectfully. Figure 8 depicts graphically level of certainty associated with different impacts on Danube River Basin. Our opinion is that this figure is very illustrative and representative for Serbia: the most certainty forecast is related to temperature increasing, after that to snow regime, than to precipitation, runoff and drought forecasts, and the most uncertainty field (regarding the main issues and from the water point of view) are floods. That's because generally decrease of precipitation on annual level is expecting in Serbia, but also likely increase of extreme rainfall, particularly on hours scale.

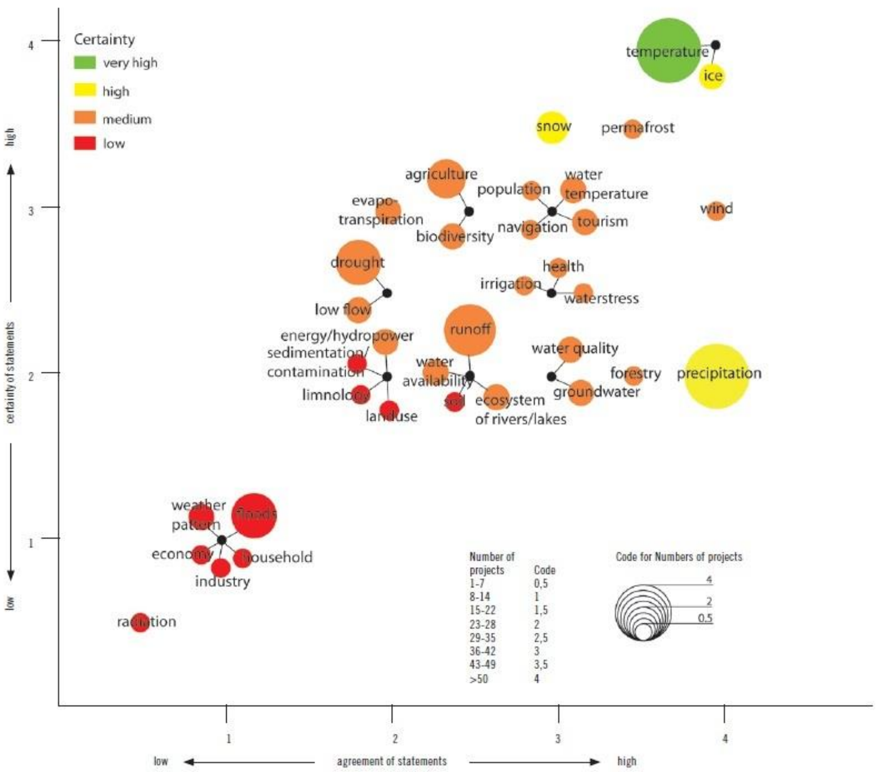


Figure 10: Certainty for the impacts in the Danube River Basin due to projected climate changes (ICPDR, 2013)

Even exist, the lowest uncertainties exist for observed changes. Measured data with relevant long period of observation increase certainty not just regarding observed changes, but also with respect to future prediction results and conclusions.

Uncertainty is inherent in any prediction and as the distance in the future increases, so does the degree of uncertainty (i.e. the range of possible developments expands while the probability of occurrence of each one of them decreases).

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