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Average and Extreme Precipitation Heights in Bačka (1951-1990)

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Abstract *Pluviometric regime of the Bačka, as well as the remaining part of Vojvodina partly has the characteristics of middle European, Danubian type, which has the feature of uneven dispersion of precipitation by months. In the study of pluviometric features of the surveyed area, we use the data from eight meteorological stations. This paper renders more detailed analysis of precipitation regime, average monthly and annual precipitation heights and extreme dayly and monthly heights as well as for the separate climatic regions of North and South Bačka. All the parameters were discussed for the period between 1951 and 1990. On the basis of analyses, certain deviations in the occurrence of primary and secondary maxima and minima of precipitation in comparison to the results of previous researches have been established.*

Key words *Bačka, pluviometric regime, precipitation heights*

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Geographical Location, Borders and Size

The examined area of Bačka is situated in the central part of mild climatic zone between 45º16' and 46º22' North Latitude and 18º36' and 20º37' East Longitude. In other words, Bačka stretches in meridian direction in a length of 1º6' or about 122 km. Bačka occupies western and middle part of Vojvodina. On the north it stretches to the state border of Hungary, on the east the border is the Tisza River; the south border is the Danube, whereas on the west it stretches to the state border of Croatia. Its total area is 8.956 km², which makes 41,6% of the total area of Vojvodina.

Method

The formation of climate in a certain place or region happens under the mutual influence of sun radiation, global atmosphere circulation and conditions of the surface. Since climate is the result of longstanding influence of above mentioned factors it has a characteristic of certain stability (Milosavljević and ass., 1973).

In the research of pluviometric characteristics of Bačka, data from eight meteorological stations include the period between 1951 and 1990. The exception is meteorological station in Bačka Topola which began its work in 1961, and thus for the first ten-year period, values were calculated by the method of interpolation between neighboring meteorological stations. It is important to emphasize that the data from two pluviometric stations were also used in the analysis of average precipitation heights: Apatin and Bogojevo.

The data were taken from the following meteorological stations:

Palić – 46º06' North Latitude and 19º46' East Longitude; altitude 102 m. Meteorological station Palić is situated in the north coastal part of Lake Palić, which means next to the important hydrogeographic object that can have a modifying effect on quantity of precipitation. Moreover, this station is situated in a border region of Bačka wattle plateau and Subotica sandy terrain, which can, with its geological and pedological characteristics, modify relevant climatic elements, especially precipitations;

Senta – 45º56' North Latitude and 20º05' East Longitude; altitude 80 m. Meteorological station Senta is situated on the right bank of Tisza, which means next to the important hydrogeographic object that can have a modifying effect on precipitation and other climatic elements. At the same time, station is located on a wattle terrace in a border region between Bačka and Banat;

Bačka Topola – 45º49' North Latitude and 19º39' East Longitude; altitude 100 m. Meteorological station Bačka Topola is situated in the middle part of the area examined on Bačka plateau;

Sombor – 45º45' North Latitude and 19º06' East Longitude; altitude 89 m. This meteorological station is located in west-northwest part of Bačka and it belongs to typical depression environment (contact of the wattle terrace and Danube alluvial plain, with the Danube and Great Bačka Canal nearby);

Bečej – 45º37' North Latitude and 20º04' East Longitude; altitude 75 m. Meteorological station Bečej is situated on the right bank of Tisza river, which means next to the important hydrogeographic object that can have a modifying effect on certain climatic elements. At the same time, station is located on a wattle terrace in a border region between Bačka and Banat;

Vrbas – 45º34' North Latitude and 19º39' East Longitude; altitude 87 m. This meteorological station is situated in central part of Bačka, on a wattle terrace, where Great Bačka Canal is nearby;

Bački Petrovac – 45º22' North Latitude and 19º34' East Longitude; altitude 85

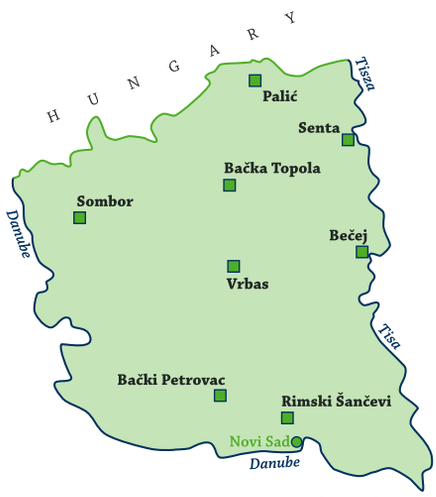

Figure 1. *Locations of meteorological stations in Bačka*

m. Meteorological station Bački Petrovac is situated in the south part of an area examined, which has a typical depression relief - wattle terrace, where Little Bačka Canal is nearby, where Fruška gora is also not far;

Rimski Šančevi – 45°20' North Latitude and 19°51' East Longitude; altitude 84 m. Meteorological station Rimski Šančevi lies in the south part of Bačka, in a typical depression environment – wattle terrace. It is placed near the Danube and not far from Novi Sad and Fruška gore, which has some influence on the precipitations of this part of Bačka.

When Bačka was divided into climatic regions, few difficulties arose. There is no single meteorological station on the whole area of western Bačka (west from imagined line Sombor – Bački Petrovac). Exceptions are few pluviometric stations whose data show us that this part of Bačka has the highest rate of precipitation (Apatin – 658 mm, Bogojevo – 620 mm, Plavna – 650 mm, Bačka Palanka – 646 mm).

Certain climatic data from meteorological stations in neighboring Croatia – Ilok and Osijek (the only ones in the vicinity of the area examined) and meteorological station Šid in Srem were also taken into account. Meteorological station Ilok is situated on the right bank of the Danube, just opposite Bačka Palanka, with an altitude of 133 m. Station Osijek is situated about 30km west from the border of the area examined, on the Drava river, with an altitude of 89m. Station Šid is situated on the south piedmont area of Fruška gora, with an altitude of 105m. By air-line, it is about 20km far from border parts of Bačka to the south, with no significant obstacles in a relief (altitude from 115 to 140m).

Analysis of climatic elements and their comparison with meteorological stations in South Bačka (Bački Petrovac and Rimski Šančevi) lead to the conclusion that noticeable difference is apparent only when precipitation heights are concerned (Ilok – 680mm, Osijek – 690mm, Šid – 670mm, Bački Petrovac – 616mm and Rimski Šančevi – 596mm), while other differences between climatic values are negligible.

While analysing climatic elements, especially precipitations, of meteorological stations all over Bačka, author noticed certain differences in values. These differences are the result of their parallel position, i.e. of North Longitude of their location and position in relation to geomorphologic objects and two rivers that set the boundaries of Bačka from west, south and east – Danube and Tisza. Consequently, Bačka is divided into two precipitation (climatic) regions.

Climatic region of Bačka wattle plateau (meteorological stations Palić, Bačka Topola, Sombor and Vrbas) includes northern and central parts of Bačka. It must be mentioned that this region is not strictly connected with Bačka wattle plateau, but it got its name because the plateau covers the greatest part of the territory of the region. Western border is represented by a line that goes to the south from the state border with Hungary, between the Danube and road Gakovo-Sombor, to an area between Kupusina and Stapar, from where it bends towards east to Vrbas, thus making the south border that nearly follows the terrace of Great Bačka Canal. From Vrbas, the border of this region bends towards north, taking the eastern position, crossing Krivaja and Čik, as well as roads Mileševo-Bečej, Utrine-Ada and Boagaraš-Senta, in order to reach Tiza at Adorjan, and then follow Tisza to the state border with Hungary, which, at the same time, sets the boundaries of this place from the north.

Plate 1. *Approaching rain storm over Palić lake; photo: L.Lazić*

Climatic region between Danube and Tisza on wattle terrace, alluvial terrace and alluvial plateau with western precipitation variety (meteorological stations Senta, Bečej, Bački Petrovac and Rimski Šančevi) includes west, south, eats and central parts of Bačka. Western precipitation variety covers the area west from imagined line Sombor – Bački Petrovac.

Here, it should also be mentioned that there are two more divisions of Bačka, concerning climatic conditions.

Academician PhD. Branislav Bukurov in his work "Physical and geographical problems of Bačka" (1975) gave examples of four climatic types of Bačka. **Danube-basin with western and southern varieties** - includes broader zone of Danube Basin from the state border with Hungary until the mouth of Tisza in the Danube.

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This zone has two parts: meridian and parallel. On the spot where these two parts meet, the Danube-basin zone widens in a slight curve and extends to somewhat broader area. The basic characteristics of this type are slightly fresher July temperatures and slightly milder average January temperatures. Also, the highest precipitation height is recorded here, especially in its western part. The next type, **Tisza-basin type**– includes narrow belt around Tisza. That is mainly alluvial and the lowest terrain in Bačka. It is characterized with high average July temperatures and low average January temperatures. Tisza-basin type has less sediment than Danube-basin type. The next is **North Bačka type** – includes the northern half of Bačka, between Danube-basin and Tisza-basin zone, all over to Great Bačka Canal. It is characterized with the highest average July and the lowest average January air temperatures, as well as with the lowest precipitation height compared to other climatic types. At the end, there is **South Bačka type** – it mainly includes south Bačka wattle terrace and with its climatic characteristics it represents the connection between wet Danube-basin and Tisza-basin zones and dry North Bačka zone. Author concludes that Danube-basin type has characteristics closer to maritime climate, whereas north and northeast parts of Bačka to continental climate, while other parts of Bačka represent a slight transition between these two, not very different climates. (Bukurov, 1975)

Katić and associates in his work "Climate of SAP Vojvodina" (1979) divided Bačka into three agro-climatic regions. **West Bačka** – includes Danube Basin from Bezdan to Futog. Its border on the west and south is the Danube River, and on the north the border is the state border with Hungary. From the east, if the state border with Hungary is the starting point, the border goes down the line of road Gakovo-Sombor. From Sombor it goes southeast towards Bački Brestovac, from where it goes south between Odžaci and Lalić in order to follow the railway line Ratkovo-Gajdobra-Gložan-Futog. **North Bačka** – occupies the northern part of Bačka. On the north it is marked with the state border with Hungary. From the west side, the border is represented by road Gakovo-Sombor that leads to Great Bačka Canal, which, at the same time, represents the south border of this region all the way to Vrbas. From Vrbas, the border bends in a slight curve towards Bačko Petrovo Selo, from where the eastern border is represented by Tisza. **South Bačka** – occupies south parts of Bačka. On the west it borders on West Bačka region, and on the north on North Bačka region. Eastern border is represented by Tisza, from its mouth in the Danube to Bačko Petrovo Selo, whereas south border is represented by the Danube from Futog to the mouth of the Tisza River. (Katić and ass., 1979)

When analyzing these two divisions of Bačka, compared to average air temperatures and precipitation heights, it can be concluded that Bukurov's division is more precise. The reason lies in the fact that in his division the *Tisza-basin climatic type* was singled out (meteorological stations Senta and Bečej). Namely, according to the division of Katić and his associates, meteorological station Senta belongs to agro-climatic region North Bačka although average air temperatures and precipitation heights greatly differ from those found there. Thus, meteorological station Senta has the highest average annual air temperature (10,95°C) in whole Bačka, whereas those in North Bačka are the lowest (Palić – 10,58°C, Sombor – 10,60°C...). Moreover, higher annual precipitation heights were recorded in meteorological station Senta (572mm) than in those in North Bačka (Palić – 537mm, Vrbas - 557mm...). When we speak about meteorological station Bečej we can conclude that values of climatic elements insignificantly differ from those in *South Bačka climatic type*, to which this station belongs according to Katić. Furthermore, meteorological station Sombor, according to Bukurov's division does not belong to *Danube-basin climatic type*, whereas Katić and his associates put it into *agroclimatic region West Bačka* (equivalent to Danube-basin type). Meteorological station Sombor has lower average air temperatures (average annual air temperature is 10,60°C) and lower precipitation heights (average annual precipitation height is 580mm) than those in West Bačka, which means that it is correct to put it in the climatic region of North Bačka.

Apart from the opinion that climatic division of Branislav Bukurov is the most precise one, the author decided to include division with only two climatic regions in his work. The reason lies in the fact that on the territory of Bačka, marked with the Danube River and an imagined line Sombor-Bački Petrovac, there is no single meteorological station. Moreover, Tisza-basin type is not singled out because it is less significant than Danube-basin which was not individually included in this division, only as a western precipitation variety as part of the climatic region between Danube and Tisza on wattle terrace, alluvial terrace and alluvial plateau.

Moreover, in order to make it compatible with climatic regions of Banat (north, middle and south) and Srem (north and south), the climatic region of Bačka wattle plateau will be referred to as **Climatic region of North Bačka**, and climatic region between Danube and Tisza on wattle terrace, alluvial terrace and alluvial plateau with western precipitation variety will be referred to as **Climatic region of South Bačka**.

Precipitation Regime

Distribution of annual height of precipitation by months is called pluviometric regime or precipitation regime. It does matter whether in each month of the year the precipitation height will be the same, as it could theoretically be concluded on the basis of the annual height. What is important is the actual precipitation height, for

Table 1. *Mean monthly and annual quantity of precipitation (mm) in Bačka between 1951-1990.*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	annual
Palić	34,4	32,1	31,8	42,2	54,9	73,4	56,9	50,1	36,8	29,4	48,7	46,4	537,0
B.Topola	40,2	34,0	36,0	46,7	60,0	78,3	59,1	52,8	37,9	32,2	49,1	48,4	574,7
Sombor	36,4	35,3	34,2	49,6	59,8	76,9	61,8	51,9	37,4	38,6	51,6	46,7	580,3
Vrbas	35,2	33,6	34,3	44,5	58,4	74,8	57,9	53,7	35,9	35,5	47,8	45,4	557,0
Senta	39,5	38,8	35,8	43,2	66,0	78,9	48,5	52,9	37,9	33,1	49,0	49,2	572,8
Bečej	39,4	37,8	36,6	49,0	59,7	73,2	62,2	56,0	38,0	35,4	48,4	50,7	586,4
B.Petrovac	40,0	41,9	39,6	49,7	61,3	85,2	55,0	58,6	39,2	38,7	53,5	53,4	616,2
R.Šančevi	34,9	37,2	38,5	48,7	60,6	84,3	61,7	55,9	35,6	39,0	49,1	50,2	595,7
Apatin	48,6	42,8	46,2	53,4	61,8	88,6	65,6	57,9	42,9	38,3	58,1	53,8	658,0
Bogojevo	44,0	42,1	42,5	51,1	57,5	81,7	58,9	57,3	42,8	39,3	53,4	49,3	620,0
North Bačka	36,5	33,7	34,1	45,8	58,3	75,9	58,9	52,1	37,0	33,9	49,3	46,7	562,2
South Bačka	41,1	40,1	39,9	49,2	61,1	82,0	58,6	56,4	39,4	37,3	51,9	51,1	608,2
Bačka	**39,3**	**37,6**	**37,5**	**47,8**	**60,0**	**79,5**	**58,8**	**54,7**	**38,4**	**35,9**	**50,9**	**49,3**	**589,8**

Source: *Meteorological yearbooks 1951-1990.*

Table 2. *Mean monthly and annual quantity of precipitation (mm) observed in decades for Bačka between1951-1990.*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	annual
1951/60.													
North Bačka	32,3	42,0	29,7	45,5	62,4	76,5	59,4	47,3	36,8	39,0	53,1	53,1	577,1
South Bačka	41,4	53,9	40,7	54,6	68,3	77,5	59,5	53,9	43,6	44,2	59,8	59,3	656,6
Bačka	**36,9**	**47,9**	**35,2**	**50,0**	**65,3**	**77,0**	**59,5**	**50,6**	**40,2**	**41,6**	**56,4**	**56,2**	**616,8**
1961/70.													
North Bačka	42,7	38,5	33,4	48,3	50,2	66,3	68,6	47,4	39,5	20,4	52,3	60,6	567,9
South Bačka	48,5	47,3	42,2	51,2	57,7	74,3	70,6	49,0	41,6	22,1	55,8	71,9	632,2
Bačka	**46,1**	**43,8**	**38,7**	**50,0**	**54,7**	**71,1**	**69,8**	**48,4**	**40,8**	**21,4**	**54,4**	**67,4**	**606,4**
1971/80.													
North Bačka	29,7	28,1	29,7	46,3	61,5	81,5	66,7	63,3	33,9	47,9	48,0	35,8	572,4
South Bačka	32,5	32,3	31,0	46,8	60,8	89,8	63,1	70,7	36,3	50,7	50,2	35,7	599,8
Bačka	**31,4**	**30,6**	**30,5**	**46,6**	**61,0**	**86,5**	**64,5**	**67,7**	**35,3**	**49,5**	**49,4**	**35,7**	**588,8**
1981/90.													
North Bačka	39,0	29,6	42,8	43,0	59,7	79,5	41,7	48,6	37,0	29,5	44,5	38,3	533,1
South Bačka	41,3	33,3	47,9	48,3	60,7	85,5	40,9	50,0	38,3	34,3	44,6	39,0	564,2
Bačka	**40,4**	**31,8**	**45,8**	**46,2**	**60,3**	**83,1**	**41,2**	**49,5**	**37,8**	**32,4**	**44,5**	**38,8**	**551,7**

Source: *Meteorological yearbooks 1951-1990.*

which expressive spatial and temporal uncertainty is characteristic (Katić and al., 1979)

Vojvodina is well known in literature by the Danubian type of rain regime, characterized by the highest rate in June (primary maximum), abundance in October (secondary maximum), and the lowest rate in winter, more precisely in January and February (Pavle Vujević, 1924). About the same characteristics of annual precipitation are shown by other authors in different periods (Anderko, 1901, and Milosavljević, 1948) only in other periods (Katić and ass., 1979).

As a contrast to this, Vojvodina, i.e. values for Bačka, in this case (1951-1990) indicate striking deviations. Secondary maximum has been moved from October to November, primary minimum does not occur in January or February but in October, the month of former secondary maximum and secondary minimum occurs in March. Only the occurrence of primary maximum suits the results of former researches (table 1).

During the year, two maxima and two minima of precipitation are explicitly shown (table 1).. The first, higher maximum occurs in June (79,5 mm) and May (60,0 mm), the second in November (50,9 mm) and December (49,3 mm). Primary minimum occurs in October (35,9 mm), and secondary in March (37,5 mm) and February (37,6 mm).

In observing maximum and minimum of precipitation in meteorological stations, smaller deviations are recorded. Thus, e.g. in meteorological station Sombor the occurrence of the minimal amount of sediment is in March, in meteorological station in Vrbas it is in February and in meteorological station Rimski Šančevi in January.

At the same time, when these values are observed in climatic regions, the deviation occurs in the climatic region of North Bačka, where primary minimum occurs in February (33,7mm), and secondary minimum in October (33,9mm) (table 1).

Mean Monthly and Mean Annual Precipitation Heights

On the basis of observations between 1951 and 1990, the annual precipitation value on the territory of Bačka is 589,8 mm on average. The highest mean annual precipitation quantity has been recorded at meteorological station Bački Petrovac (616,2 mm). If we also take into consideration the values from pluviometric stations, the highest precipitation quantity is then recorded at pluviometric station Apatin (658,0 mm). The lowest mean annual precipitation quantity has been recorded at the station in Palić (537,0 mm), what indicates a great difference of 121,0 mm between the two (table 1).

The same relation has been noticed when observing Bačka by its region. Namely, mean annual quantity of precipitation in South Bačka (608,2 mm) is higher than in climatic region of North Bačka (562,2 mm).

It has already been citied that the wettest month is June, but it is interesting to compare mean monthly amounts of sediment for this month in different meteorological stations, i.e. pluviometric stations. In June, the highest rate of precipitation occurs in Apatin (88,6 mm) and Bački Petrovac (85,2 mm), the least in Bečej (73,2 mm) and Palić (73,4 mm). At the same time, the highest difference in quantity of precipitation is also recorded in this month, when pluviometric station in Apatin gets about 15,2 mm more precipitation than the one in Palić (table 1).

Annual variation of precipitation, which represents the difference between the sum of precipitation of the wettest and the driest month, is 43,6 mm (June – 79,5 mm; October – 35,9 mm), whereas the relative variation is 7,4 %. The smallest annual variation is recorded at meteorological station in Bečej (6,4 %), and the highest at the station in Rimski Šančevi (8,3%). The data indicate the even annual dispersion of precipitation height on the territory of Bačka.

Moreover, it is necessary to point to a very important observation when the regime of the precipitation height during the period observed is concerned. Namely, a significant decrease in precipitation quantity from the beginning to the end of the period observed was noticed. Thus, for example, in the first decade of the period observed (1951/60) the precipitation sum for whole Bačka was 616,8 mm, and it successively decreased in decades to follow – 606,4 mm (1961/70), 588,8 mm (1971/80) and 551,7 mm (1981/90). Consequently, precipitation height in decade 1981/90 is for 10,6 % less than in decade 1951/60. When climatic regions are concerned, pattern of decrease in precipitation height is much more noticeable in South Bačka (14,1 %) than in North Bačka (7,6 %). Moreover, when North Bačka is in question, it can be noticed that the decrease in precipitation height does not have a constant flow, since in decade 1971/80 there were more precipitations than in the previous one (1961/70). (table 2)

When observing precipitation heights by seasons, it is clearly seen that the largest amount of precipitation in Bačka is to be expected in summer (193,0 mm), then in spring (145,4 mm), then comes winter (126,2 mm), and the smallest amount of precipitation is in autumn (125,3 mm). It is noticeable that winter has fewer precipitations than autumn in following meteorological stations: Palić, Sombor, Vrbas and Rimski Šančevi. Moreover, winter shows fewer values than autumn in the climatic region of North Bačka (table 3).

Table 3. *Mean precipitation heights (mm) observed in seasons and vegetative period in Bačka between 1951-1990.*

	Winter	Spring	Summer	Autumn	VP
Palić	112,9	128,8	180,4	114,9	314,2
B.Topola	122,6	142,7	190,2	119,2	334,8
Sombor	118,4	143,6	190,7	127,6	337,5
Vrbas	114,1	137,2	186,4	119,3	325,2
Senta	127,6	144,9	180,3	119,9	327,4
Bečej	127,9	145,3	191,4	121,8	338,1
B.Petrovac	135,3	150,6	198,8	131,4	349,0
R.Šančevi	122,4	147,8	201,9	123,6	346,7
Apatin	145,2	161,4	212,1	139,3	370,2
Bogojevo	135,4	151,1	197,9	135,5	349,4
North Bačka	117,0	138,1	186,9	120,2	327,9
South Bačka	132,3	150,2	197,1	128,6	346,8
Bačka	**126,2**	**145,4**	**193,0**	**125,3**	**339,2**

Source: *Meteorological yearbooks 1951-1990.*

As Bačka is mainly agricultural area, it is of great importance to survey the height of precipitation in vegetative period (from the beginning of April to the end of September). Mean precipitation height in that period in Bačka was 339,2 mm, the least value at meteorological station in na Palić 314,2 mm, the highest value in Apatin, 370,2 mm. South Bačka has larger precipitation height in vegetative period (346,8 mm), whereas North Bačka has only 327,9 mm (table 3). The importance of quantity of precipitation in this period is the most clearly seen in the fact that any lack of water influences productivity of plant, i.e. demands irrigation. According to Longwin (1972), precipitation of over 8mm during 12 hours is important for cultivated plants, whereas precipitation of over 30mm during 24 hours is unfavorable or even harmful.

According to above mentioned, it can be said that the area of Bačka is arid. The least sediment can be found in northeast part, which actually represents the territory of Subotica sandy terrain. The most precipitations are to be found in west and southwest parts of Bačka. This can be explained by the fact that this region is more exposed to wet air masses that come from west. Furthermore, the area of west and southwest Bačka, compared to some other parts, has more areas covered in water and forests, which are an important source of humidity. It was also noticed that south parts of Bačka have more sediment than north ones, which can be explained by the nearness of Fruška gora above which greater amounts of sediment are to be found – in the same period, in meteorological station Iriški venac the mean annual precipitation height was 786,3 mm (Tomić et al., 1998).

Method of Cumulation

To show annual flow of precipitation we use so called method of cumulation. This method allows us to show precipitation height in σ from an annual sum. Cumulative precipitation heights in each month represent the sum of precipitations from 1 January to the end of the month observed, and single precipitation heights show participation of the sum of the month observed in an annul precipitation sum (Dukić, 1981).

According to information in table 4. it can be seen that the largest amount of precipitation in Bačka is at the end of spring and beginning of autumn (May, June, July), almost 35 % from an annual sum. This completely suits the most frequent appearance of cyclones on Vc line (Sava and Danube valley), whose number during months of May and June represents almost 1/3 (31,5 %) of the total number of cyclones that appear during a year. In the first half of a year there is more precipitation than in the second. However, in the first half precipitation height increases until the end of the period, whereas in the second half it first goes down and at the end of the period it goes up.

Pluviometric Coefficient of Precipitation According to Ango

Pluviometric coefficient represents the relationship between the actual precipitation height in ‰ (from an annual sum) and even distribution of precipitation according to Ango's classification. Even distribution of precipitation is calculated in a following way: months with 31 days have 85‰ precipitation of an annual sum which has 1.000‰, whereas months with 30 days have 82‰, and February has 77‰. Ango's coefficient is calculated when the value of a single precipitation height (‰) for a given month is divided by even distribution value of the same month (‰).

Months that have pluviometric coefficient bigger than 1 are wet months and those whose coefficient is less than 1 are dry months. Values of pluviometric coefficient are shown in table 5.

According to values from table 5. it can be concluded that on the territory of Bačka there are 8 wet and 4 dry months. The driest months are October, March and January, while the wettest are June, May and July.

Extreme Precipitation Heights

In order to more fully observe movements of precipitation heights and their influence on the environment it is necessary to show extreme precipitation heights: daily absolute maxima, absolute monthly maxima and absolute monthly minim of precipitation.

Absolute daily maximum represents the highest daily precipitation rate in one month and in a longer series of consecutive years. If values from *table 6.* are compared to those from *table 1*, it can be seen that absolute daily maxima of certain months are larger than mean precipitation heights in those months. It is also noticed that those values are biggest in a period at the end of spring and the beginning of summer. This completely suits the most frequent appear-

Table 5. *Values of pluviometric coefficient according to Ango for Bačka between 1951-1990.*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
North B.	0,76	0,78	0,71	0,99	1,22	1,65	1,23	1,09	0,80	0,71	1,07	0,97
South B.	0,80	0,86	0,77	0,99	1,18	1,64	1,13	1,09	0,79	0,72	1,04	0,99
Bačka	0,78	0,83	0,75	0,99	1,20	1,64	1,17	1,09	0,79	0,72	1,05	0,98

Table 4. *Single (σ) and cumulative (σ) monthly precipitation heights (‰) for Bačka between 1951-1990.*

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
North Bačka	σ	64,9	59,9	60,7	81,5	103,7	135,0	104,8	92,7	65,8	60,3	87,7	82,6
	σ	64,9	124,9	185,5	267,0	370,7	505,7	610,5	703,1	768,9	829,2	916,9	1000,0
South Bačka	σ	67,6	65,9	65,6	80,9	100,5	134,8	96,3	92,7	64,8	61,3	85,3	84,0
	σ	67,6	133,5	199,1	280,0	380,5	515,3	611,6	704,4	769,2	830,5	915,8	1000,0
Bačka	σ	66,6	63,8	63,6	81,0	101,7	134,8	99,7	92,7	65,1	60,9	86,3	83,6
	σ	66,6	130,4	194,0	275,0	376,7	511,5	611,2	704,0	769,1	829,9	916,2	1000,0

Table 6. *Daily absolute maxima of precipitation (mm) for Bačka between 1951-1990.*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	max
Palić	29,1	28,5	22,7	42,4	55,2	**85,7**	64,5	45,8	32,1	28,1	54,2	35,2	85,7
B.Topola	28,2	50,0	66,0	36,8	37,5	**76,4**	61,6	46,7	36,8	27,8	30,4	30,0	76,4
Sombor	26,8	40,8	21,2	42,1	64,5	**83,3**	63,1	61,0	37,8	33,4	37,6	27,9	83,3
Vrbas	23,0	35,4	26,1	43,0	72,3	65,0	**101,3**	51,1	41,5	32,4	37,4	36,2	101,3
Senta	33,8	38,0	37,7	35,0	62,5	**78,4**	62,5	58,5	48,3	30,7	43,2	29,6	78,4
Bečej	27,6	36,2	23,6	32,5	54,2	42,3	**110,8**	67,2	56,5	36,1	40,1	33,6	110,8
B.Petrovac	29,0	61,0	35,0	32,1	37,5	**79,0**	71,0	51,3	52,6	32,2	28,9	41,4	79,0
R.Šančevi	29,2	36,3	32,6	35,2	**91,8**	60,0	91,6	42,9	33,4	30,1	28,4	30,2	91,8
North Bačka	29,1	50,0	66,0	43,0	72,3	85,7	101,3	61,0	41,5	33,4	54,2	36,2	101,3
South Bačka	33,8	61,0	37,7	35,2	91,8	79,0	110,8	67,2	56,5	36,1	43,2	41,4	110,8
Bačka	**33,8**	**61,0**	**66,0**	**43,0**	**91,8**	**85,7**	**110,8**	**67,2**	**56,5**	**36,1**	**54,2**	**41,4**	**110,8**

Source: *Meteorological yearbooks 1951-1990.*

ance of cyclones on Vc line (Sava and Danube valley).

Absolute daily maximum in Bačka represents 110,8 mm and it was recorded on 24. July 1966. in Bečej. Second largest absolute daily maximum was recorded in Vrbas on 5. July 1967, 101,3 mm. All other meteorological stations have this value less than 100 mm. Thus, Rimski Šančevi have a value of 91,8 mm (22. May 1987), Palić 85,7 mm (7. June 1981), Sombor 83,3 mm (30. June 1974), Bački Petrovaac 79,0 mm (6. June 1981), Senta 78,4 mm (30. October 1974) and Bačka Topola 76,4 mm (30. June 1974) (table 5).

When values of absolute daily maxima in climatic regions are compared it can be see that in four months (March, April, June and November) highest amounts appear in North Bačka, while maximum amounts of absolute daily maxima for South Bačka appear in other eight months (table 6).

Absolute monthly maximum represents the highest precipitation rate in one month and in a longer series of consecutive years. The month of June with its 225 mm has the highest absolute precipitation sum in Bačka and that value was recorded in 1973. in Sombor. Two more values of absolute monthly maximum over 200mm were recorded: in Bečej in July 1966. (222 mm) and Bački Petrovac in August 1975. (205 mm). Values of this parameter also have their maxima at the end of spring and during summer. (table 7).

When values of absolute monthly maxima in climatic regions are compared it can be see that in only three months (April, June and October) highest amounts appear in North Bačka, while maximum amounts of absolute monthly maxima for South Bačka appear in other nine months (*table7*).

The wettest year in Bačka was 1955. when in Bački Petrovac 936 mm were recorded, in Sombor 912 mm, in Rimski Šančevi 888 mm, in Bečej 854 mm, in Senta 842 mm of sediment etc. Meteorological stations in North Bačka recorded lower values of annual maximum precipitations. Thus, the highest value recorded in Vrbas in 1955. was 801 mm, and in Palić 736 mm (table 7).

Table 7. *Absolute monthly and annual maxima of precipitation (mm) for Bačka between 1951-1990.*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	max
Palić	85	98	63	96	119	170	137	135	100	116	156	143	736
B.Topola	106	132	80	106	142	174	141	143	112	101	111	152	761
Sombor	104	86	73	**127**	159	**225**	176	158	116	**146**	125	121	912
Vrbas	115	105	78	84	145	170	173	124	117	96	154	114	801
Senta	97	119	**117**	87	148	165	140	130	97	115	**164**	142	842
Bečej	**120**	104	78	95	150	138	**222**	168	**140**	107	131	137	854
B.Petrovac	104	**139**	115	93	138	193	144	**205**	**140**	113	157	**182**	**936**
R.Šančevi	95	113	**117**	90	**176**	205	169	148	89	113	156	150	888
North Bačka	115	132	80	127	159	225	176	158	117	146	156	152	912
South Bačka	120	139	117	95	176	205	222	205	140	115	164	182	936
Bačka	**120**	**139**	**117**	**127**	**176**	**225**	**222**	**205**	**140**	**146**	**164**	**182**	**936**

Source: *Meteorological yearbooks 1951-1990*

Table 8. *Absolute monthly and annual minima of precipitation (mm) for Bačka between 1951-1990*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	min
Palić	4	3	2	11	3	10	3	7	1	0	3	0	345
B.Topola	5	4	2	16	18	22	14	2	1	0	2	0	419
Sombor	3	2	4	14	10	17	6	2	1	0	6	0	401
Vrbas	3	3	3	10	15	24	7	1	1	0	5	1	**336**
Senta	2	3	3	14	13	23	8	6	1	0	3	0	382
Bečej	2	1	0	10	13	13	9	6	1	0	3	0	**361**
B.Petrovac	5	3	6	13	17	20	4	8	1	0	9	1	378
R.Šančevi	2	2	3	15	15	30	2	8	2	0	7	3	364
North Bačka	3	2	2	10	3	10	3	1	1	0	2	0	336
South Bačka	2	1	0	10	13	13	2	6	1	0	3	0	361
Bačka	**2**	**1**	**0**	**10**	**3**	**10**	**2**	**1**	**1**	**0**	**2**	**0**	**336**

Source: *Meteorological yearbooks 1951-1990*

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Table 9. *Absolute monthly uncertainty of precipitation (mm) and coefficient of uncertainty according to Hellman for Bačka between 1951-1990.*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	annual
Uncertainty	118	138	117	117	173	215	220	204	139	146	162	182	600
Coefficient	60,0	139,0	-	12,7	58,7	22,5	111,0	205,0	140,0	-	82,0	-	2,8

Absolute monthly minimum represents the lowest precipitation rate in one month and in a longer series of consecutive years. The month of October has the lowest sum of monthly precipitation in Bačka. During October, all meteorological stations, at least once in a period observed, recorded lack of precipitation. The lowest values appear, as by a rule, during autumn and winter, whereas they are to a certain extent higher during spring and summer. The driest years in Bačka were 1961. (Vrbas – 336 mm, Palić – 345 mm and Bački Petrovac – 378 mm), 1971. (Rimski Šančevi – 364 mm and Sombor – 401 mm), 1983. (Senta – 382 mm and Bačka Topola – 419 mm) and 1990. (Bečej – 361 mm) (table 8).

It is interesting that in a wetter climatic region (south) only insignificantly lower absolute annual minima were recorded than in North Bačka.

Absolute monthly uncertainty of precipitation represents a difference between maximum and minimum sum of precipitation in one month in a longer series of consecutive years. March and April (117 mm) and January (118 mm) have the lowest uncertainty level, whereas July (220 mm), June (215 mm) and August (204 mm) have the highest level of uncertainty. Moreover, a great uncertainty of absolute annual precipitation heights is also noticeable and it represents even 600 mm. (table 9)

Values of uncertainty coefficients according to Hellman also indicate there is a great uncertainty between maximum and minimum monthly precipitation heights (maximum monthly precipitation height is divided by minimum height). (table 9)

Conclusion

While analysing climatic elements, especially values of precipitation heights in different meteorological stations all over Bačka, author noticed certain differences in values. These differences are the result of their parallel position, i.e. of North Longitude of their location and position in relation to geomorphologic objects and two rivers that set the boundaries of Bačka from west, south and east – Danube and Tisza. Consequently, Bačka is divided into two climatic regions: Climatic region of Bačka wattle plateau (meteorological stations Palić, Bačka Topola, Sombor and Vrbas) includes northern and central parts of Bačka and Climatic region between Danube and Tisza on wattle terrace, alluvial terrace and alluvial plateau with western precipitation variety (meteorological stations Senta, Bečej, Bački Petrovac and Rimski Šančevi) includes west, south, eats and central parts of Bačka. Western precipitation variety covers the area west from imagined line Sombor – Bački Petrovac.

According to Pavle Vujević (1924), Vojvodina is well known in literature by the Danubian type of rain regime, characterized by the highest rate in June (primary maximum), abundance in October (secondary maximum), and the lowest rate in winter, more precisely in January and February. About the same characteristics of annual precipitation are shown by other authors in different periods (Anderko, 1901, and Milosavljević, 1948) only in other periods (Katić and ass., 1979).

As a contrast to this, Vojvodina, i.e. values for Bačka, in this case (1951-1990) indicate striking deviations. Secondary maximum has been moved from October to November, primary minimum does not occur in January or February but in October, the month of former secondary maximum and secondary minimum occurs in March. Only the occurrence of primary maximum suits the results of former researches.

On the basis of observations between 1951 and 1990, the annual precipitation value on the territory of Bačka is 589,8 mm on average. The highest mean annual precipitation quantity has been recorded at meteorological station Bački Petrovac (616,2 mm). If we also take into consideration the values from pluviometric stations, the highest precipitation quantity is then recorded at pluviometric station Apatin (658,0 mm). The lowest mean annual precipitation quantity has been recorded at the station in Palić (537,0 mm), what indicates a great difference of 121,0 mm between the two.

When observing Bačka by its climatic regions it is noticeable that climatic region of South Bačka (608,2 mm) has higher precipitation height than i climatic region of North Bačka (562,2 mm).

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