Geosciences

Науки о Земле

Interpolation and Extrapolation of Precipitation Quantities in Serbia

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Abstract. The aim of this paper is to indicate the problems with filling the missing data in precipitation database using interpolation and extrapolation methods. Investigated periods were from 1981 to 2010 for Northern (Autonomous Province of Vojvodina) and Proper Serbia and from 1971 to 2000 for Southern Serbia (Autonomous Province of Kosovo and Metohia). Database included time series from 78 meteorological stations that had less than 20% of missing data. Interpolation was performed if station had missing data for five consecutive months or less. If station had missing data for six consecutive months or more, extrapolation was performed. For every station with mising data correlation with at least three surrounding stations was performed. The lowest acceptable value of correlation coefficient for precipitation was set at 0,300.

Keywords: precipitation quantities; interpolation; extrapolation; correlation coefficient; Serbia.

Introduction

Serbia is a country on Balkan peninsula in southeastern Europe with a surface area of 88.361 km^2. It has two provinces: Vojvodina in the north and Kosovo and Metohia in the south (Picture 1). In the middle is so-called Proper Serbia. Official measurements of meteorological parameters in Serbia started in the last decade of XIX century, but avalaible data are for the period 1949-2011 and they are provided by the Republic Hydrometeorological Service of Serbia (1). The global standard normal period for the research of climate change is at least 30 years long (2), (3).

The frequency of extreme climate events, among them certainly the occurrence of fluctuations in air temperature, activated climatologists and meteorologists, globally, on focusing their research on the detection and definition of the causes and consequences of climate change. In the last twenty years, several leading international research institutions devoted their attention to the analysis of climate change (3), (4), (5), (6), (7). They based their investigation on the results of meteorological elements and phenomena observation conducted in the last 100 to 150 years, trying to predict the possible scenarios of climate change in the twenty-first century on global and regional level (8).

LOCATIONS OF METEOROLOGICAL STATIONS, DATABASE AND METHODS

The data used in this paper was provided by the Republic Hydrometeorological Service of Serbia for 78 meteorological stations: 11 from Vojvodina, 9 from Kosovo and Metohia and 58 from Proper Serbia (Picture 2). In this paper, two investigation periods were used. Period 1981-2010 was used for the stations located on the territory of Vojvodina and Proper Serbia, but at the stations located on the territory of Kosovo and Metohia it could not be done. This is because after the bombing of Serbia in 1999. stations in Kosovo and Metohija stopped working or continued to work under the rule of local Albanians who stopped sending data in the Republic Hydrometeorological Service of Serbia. Because of this, the research period for stations located on the territory of Kosovo and Metohia was moved 10 years earlier (1971-2000).

Precipitation quantities were obtained on a monthly level for a period of 30 years so every station had 360 parameters. Stations taken into consideration were those that had less than 20% of missing data (Table 1).

Picture 1. Geographical locations of investigated meteorological stations in Serbia (made by S.Savić)

Picture 2. Proper Serbia with its provinces Vojvodina and Kosovo and Metohia (9) www.newworldencyclopedia.org/entry/serbia

Two methods were used for the filling of missing data. First method is interpolation which was conducted if a station had missing data for five consecutive months or less. Second method was extrapolation and it was performed if a station had missing data for six consecutive months or more. (9) For the first method, used method was arithmetic mean, while for the second method in first step was performed Person product moment correlation coefficient and then arithmetic mean.

Table 1: Missing data of investigated meteorological stations

Meteorlogical station	Years with missing data	Meteorlogical station	Years with missing data	Meteorlogical station	Years with missing data
Smederevo	1980-2011	Petrovac	1972-1978, 1985-1990	Bački Petrovac	1985-1987, 1990, 1999
Loznica	1985-1989	Bela Palanka	1962-1990	Blaževo	1961-1989
Zlatibor	1985-1989	Sokobanja	1985-1990	Bosiljgrad	1985-1989, 1993, 1996-2004
Požega	1985-1989	Žagubica	1960, 1985-1989	Vladimirci	1957-1958, 1985-1990, 2008-2010
Kraljevo	1985-1989	Blace	1960-1989	Debeli Lug	1949-1951, 1960, 1963, 1975-1980, 1985-1990, 1993-2009
Kuršumlija	1985-1991	Bujanovac	1985-1990	Kaona	1949-1957, 1964-1990

Ćuprija	1985-1990	Preševo	1964-1990	Kučevo	1949-1989, 1993-2009
Bečej	1990	Brus	1961-1990	Ljubovija	1985-1989, 1991
Šabac	1985-1989, 2008-2010	Ivanjica	1985-1990	Pačarađa	1976-1991
Bač	1956-1987-1990	Babušnica	1970, 1985-1989	Kukavica	1985-1990
Bela Crkva	1986-1987, 1990	Novi Pazar	1985-1990	Užice	1985-1990
Bagrdan	1969-1991	Jošanička banja	1965-1990	S.Mitrovica	-
Jagodina	1985-1989	Jastrebac	1949-1961, 1964-1990	Čumić	1964-1989
Aleksinac	1964-1990	Trgovište	1969-1989,1993	K.Kamenica	1958-1992
Leskovac	1970, 1985-1989	Bukulja	1972-1990, 1999-2007	K.Mitrovica	1985-1991
Vrnjačka Banja	1985-1989	Rudnik	1956-1962, 1985-1990	Podujevo	1964-1991
Knjaževac	1985-1989, 2004-2005	Goč	1964-1990, 1993-1996	Prizren	1985-1991
Rekovac	1985-1990	Crni Vrh	1966-1989	Suva reka	1962, 1964-1991
Prokuplje	1985-1989	Dragaš	1960-1961, 1970-1971, 1982-1983, 1985-1991	Priština	1985-1991
Bajina Bašta	1958,1964-1990	Vlasina	1985-1989, 1995, 1998-2002, 2004-2007	Pirot	1962, 1985-1989
Vlasotince	1963, 1958-1989	Kopaonik	1949, 1960-1971, 1973-1989	Peć	1985-1991
Krupanj	1964-1989	Aleksandrovac	1985-1989, 1996	Uroševac	1985-1991

Source: (1), (made by D. Milošević)

Results and discussion

In practice, extrapolation is subject to a greater uncertainty and a higher risk of producing suspicious results (12) (13) compared to the interpolation. This problem was encountered in the analysis performed in this paper (Table 2).

Table 2: Values of correlation before and after extrapolation on investigated stations

Name of the station	Name of correlated stations	Correlation values before extrapolation	Correlation values after extrapolation	Difference between correlation values
Jastrebac	Brus	0.517	0.513	-0.004
	Blace	0.584	0.558	-0.026
	Prokuplje	0.584	0.549	-0.035
Trgovište	Preševo	0.525	0.513	-0.012
	Vranje	0.663	0.641	-0.022

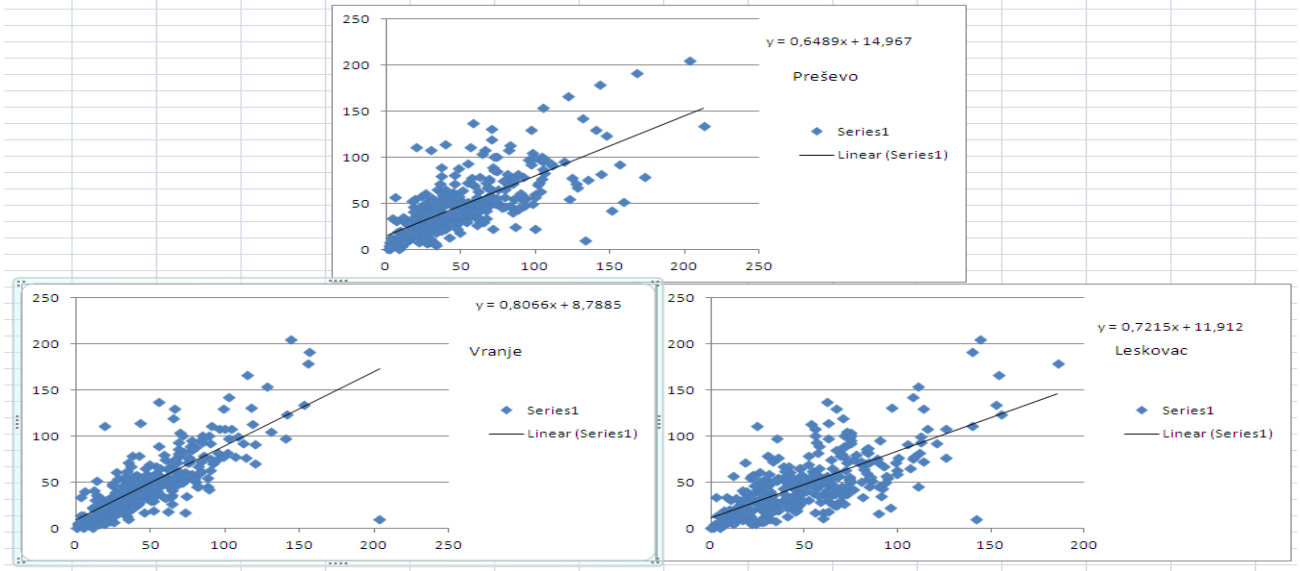
	Kukavica	0.546	0.533	-0.013
Kukavica	Vlasotince	0.467	0.382	-0.085
	Leskovac	0.592	0.481	-1.101
	Vranje	0.530	0.446	-0.084
Užice	Sjenica	0.510	0.496	-0.016
	Blaževo	0.513	0.508	-0.005
	Jošanička banja	0.408	0.413	-0.005
Kosovska Kamenica	Preševo	0.579	0.444	-1.033
	Vranje	0.639	0.537	-1.002
	Leskovac	0.519	0.479	-0.040
Kosovska Mitrovica	Kosovska Kamenica	0.447	0.505	-0.058
	Kuršumlija	0.491	0.452	-0.039
	Novi Pazar	0.523	0.498	-0.025
Podujevo	Kosovska Mitrovica	0.589	0.607	+0.018
	Kosovska Kamenica	0.467	0.523	+0.056
	Kuršumlija	0.610	0.595	-0.015
Prizren	Suva Reka	0.621	0.632	+0.011
	Uroševac	0.526	0.541	+0.015
	Peć	0.502	0.521	+0.019
Suva Reka	Uroševac	0.510	0.542	+0.032
	Priština	0.569	0.577	+0.008
	Peć	0.398	0.384	-0.014
Priština	Kosovska Mitrovica	0.648	0.683	+0.037
	Podujevo	0.657	0.638	-0.019
	Kosovska Kamenica	0.612	0.598	-0.014
Peć	Kosovska Mitrovica	0.410	0.373	-0.037
	Priština	0.420	0.436	+0.016
	Uroševac	0.310	0.328	+0.018
Uroševac	Priština	0.585	0.567	-0.018
	Kosovska Kamenica	0.537	0.477	-0.060
	Preševo	0.503	0.494	-0.009

(made by I. Leščešen)

As table 2 shows, extrapolation is made in 12 meteorological stations. In 8 stations we can see reducing the value of correlation after extrapolation. The highest reducing had station Kosovska Kamenica (0.692) and the lowest station Užice (0.008). The highest increase of correlation had Prizren (0.015).

Example 1. Performing extrapolation to get missing data for meteorological station Kosovska Kamenica. Selected stations for correlation analysis were: Preševo (value of correlation coefficient before extrapolation was 0,575), Vranje (value of correlation coefficient before extrapolation was 0,639) and Leskovac (value of correlation coefficient before extrapolation was 0,519).

Picture 3. Extrapolation of missing data at meteorological station Kosovska Kamenica

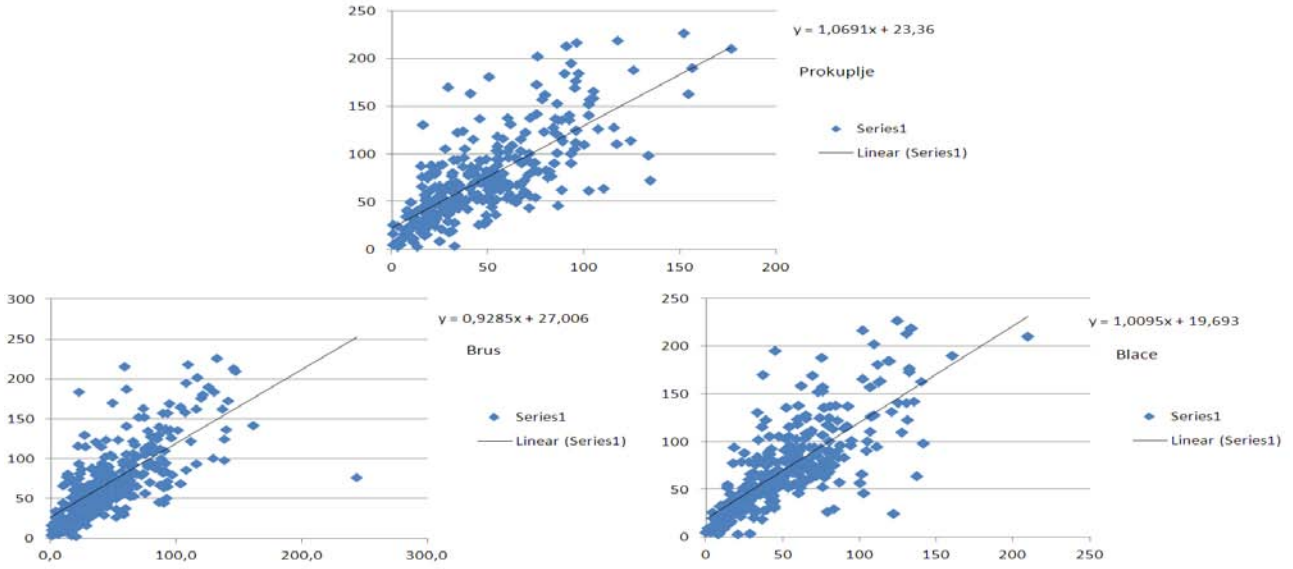


(made by R. Stojsavljević)

After extrapolation value of correlation coefficient decreased for 0,049 on average. Correlations between Kosovska Kamenica and Preševo changed to 0,444, between Kosovska Kamenica and Vranje to 0,537 and between Kosovska Kamenica and Leskovac to 0,479.

Example 2. Performing extrapolation to get missing data for meteorological station Jastrebac. Selected stations for correlation analysis were: Brus (value of correlation coefficient before extrapolation was 0,517), Blace (value of correlation coefficient before extrapolation was 0,584) and Prokuplje (value of correlation coefficient before extrapolation was 0,584).

Picture 4. Extrapolation of missing data at meteorological station Jastrebac

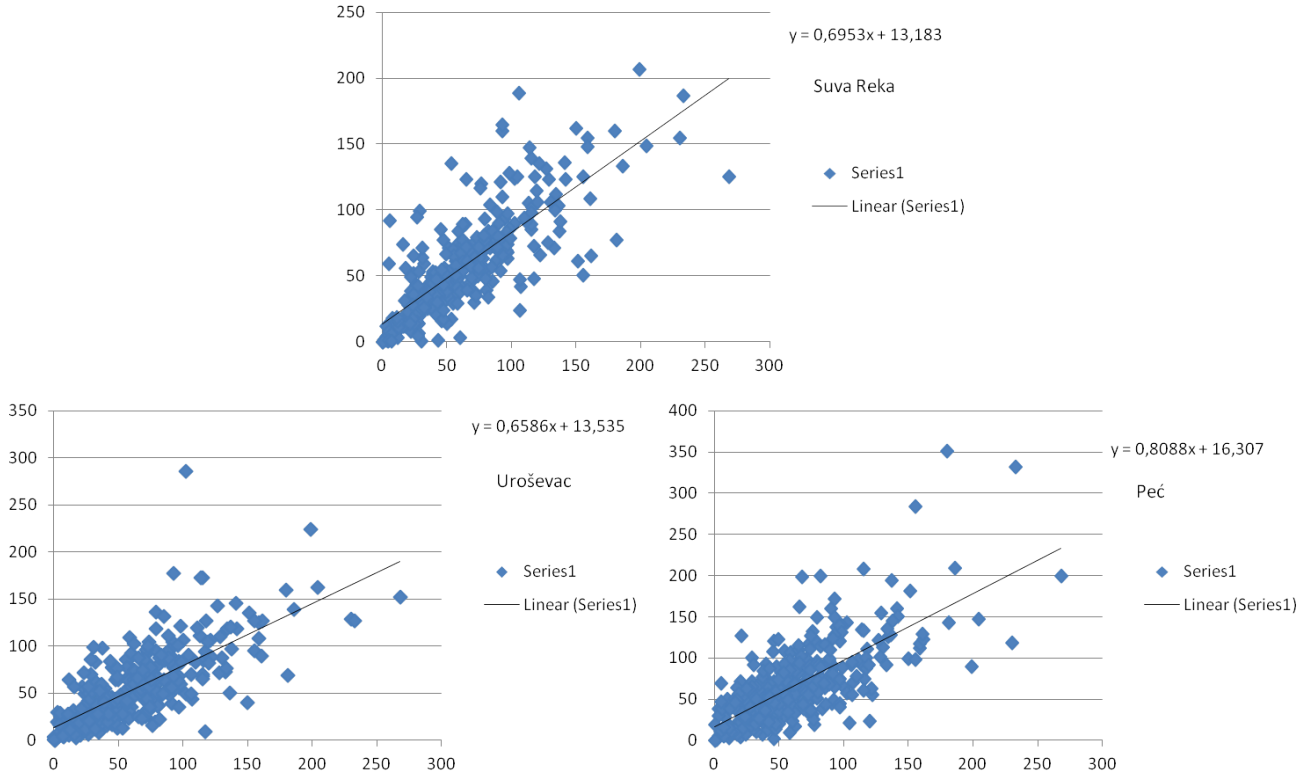


(made by S. Stojanov)

After extrapolation value of correlation coefficient decreased for 0,022 on average. Correlations between Jastrebac and Brus changed to 0,513, between Jastrebac and Blace 0,558 and between Kosovska Kamenica and Prokuplje 0,549.

Example 3. Performing extrapolation to get missing data for meteorological station Prizren. Selected stations for correlation analysis were: Suva Reka (value of correlation coefficient before extrapolation was 0,621), Uroševac (value of correlation coefficient before extrapolation was 0,526) and Peć (value of correlation coefficient before extrapolation was 0,502).

Picture 5. Extrapolation of missing data at meteorological station Prizren



(made by V. Majstorović)

After extrapolation value of correlation coefficient changed, but in this case level of correlation has increased for 0,015 on average. Correlations between Prizren and Suva Reka changed to 0,632, between Prizren and Uroševac 0,541 and between Prizren and Peć 0,521.

Extrapolation was used for filling missing data in the time series and it was expected that this method would give a higher values of correlation coefficient between the corelated stations as a result. In this paper it was shown that using this method for the purpose of filling missing data in the database of precipitation quantities has its drawbacks (correlation coefficient decreased after extrapolation) and that other methods shoud be considered for use.

Conclusion

Many problems were encountered with completing the database of precipitation quantities in Serbia: a number of stations could not be included in the research because their missing data exceeded 20% of all data, investigation period for the stations located at Kosovo and Metohia was moved to earlier period and problems with extrapolation. In many cases the values of correlation coefficient decreased after the usage of extrapolation method. This showed that using extrapolation method for filling missing data in precipitation quantities database has its drawbacks. Values of correlation coefficient did not increase or decrease significantly and this is one of the good outcomes. In any case, other methods should be used for the purpose of missing data filling in the future and a comparative analysis of their results and the results obtained in this paper should be conducted.

Acknowledgment

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Интерполяция и экстраполяция условий выпадения осадков в Сербии

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Аннотация. Цель данной работы заключается в указании проблем с заполнением недостающих данных в базу данных с помощью осадков интерполяции и экстраполяции методов. Исследованные периоды были с 1981 по 2010 год для Северного (автономного края Воеводина) и правильная Сербии и с 1971 по 2000 для Южной Сербии (Автономный край Косово и Метохия). База данных включены временные ряды с 78 метеорологических станций, которые были меньше, чем 20% отсутствующих данных. Интерполяция выполняется, если станция была недостающих данных в течение пяти месяцев подряд или меньше. Если станция была недостающие данные в течение шести месяцев подряд или более, экстраполяция была выполнена. Для каждой станции с mising корреляции данных, по крайней мере, три окружающих станций было выполнено. Самое низкое допустимое значение коэффициента корреляции осадков была установлена на уровне 0,300.

Ключевые слова: количества осадков; интерполяция; экстраполяция; коэффициент корреляции; Сербия.