Scientific Bulletin of Politehnica University Timisoara

Transactions on HYDROTEHNICS

Volume 68(82), Issue 1, 2023

THE ANALYSIS OF THE SPATIAL CORRELATION BETWEEN RAINFALL AND ALTITUDE

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Abstract: This paper analyses the correlation between the altitude and rainfall from a catchment area. The study area is the Banat hydrographical area, situated in the western part and southwestern part of Romania and it covers a surface of 18.320 km^2. To use IDW to interpolate spatial rainfall, long-term rainfall data (1981-2022) were necessary for analysis in the process.

Keywords: rainfall, regression, altitude, DEM

1. INTRODUCTION

In the last decades, the variability of seasonal precipitation has shown significant increases, a fact that is directly reflected in the increasing trends of flows in the respective season [2], [3].

Romania has a temperate-continental climate, and precipitation increases in value from the plains to the mountains and decreases, horizontally, from west to east [6].

The main factors that lead to important changes are the variations in precipitation in a certain area.

2. METHODOLOGY

The study area is the Banat hydrographical area (figure 1), situated in the western part and southwestern part of Romania, limited to the north of the Mureș River, to the south of the Danube River. This hydrographical area covers a surface of 18.320 km^2 and includes several river hydrographical basins namely: Aranca, Bega Veche, Bega, Timiș, Bârzava, Moravița, Caraș, Nera, Cerna, etc. From a climatic perspective, Banat hydrographical area falls in the transition temperate continental climate with Mediterranean influences, the result of overlapping Atlantic air circulation with invasions of Mediterranean air. This climate generates a moderate character of the thermal regime, with periods of heating in winter, and the annual average of precipitations amount ranging from 600 mm/year.

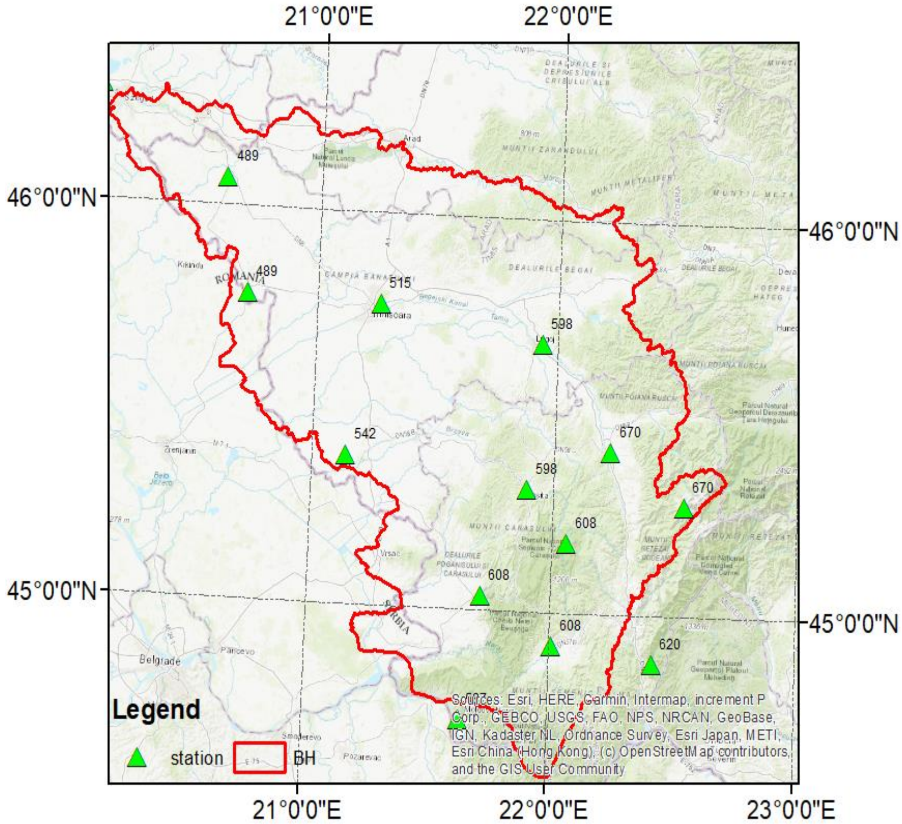

Figure1. Location map of the study area

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Kriging interpolation is used to estimate the spatial distribution of precipitation according to altitude based on the X and Y coordinates.

The equation used for multiple linear regression is:

$$y = a + \sum_1^n b_i * x_i \pm \varepsilon \qquad (1)$$

Where: ŷ - dependent variable; xi - the independent variables; n - the number of independent variables; a - the free term; bi - partial regression coefficients; ε - the standard error of estimation of the dependent variable

The condition for minimizing the residual variance implies the equalization of the partial derivatives of the above expression concerning the free term and each partial regression coefficient [5]:

$$\sum_1^n y_i = N * a + b_1 \sum_1^n x_{1i} + b_2 \sum_1^n x_{2i} + \cdots + b_n \sum_1^n x_{ni}$$

$$b_1 : \sum_1^N (y_i - a - b_1 \sum_1^n b_i x_{1i}) * \sum_1^N x_{1i} \qquad (3)$$

The standard error for the partial regression coefficients is determined by the relationship [7]:

$$S_{b_1} = b_1 \sqrt{\frac{(1 - R^2)}{(R^2 - R^2_{y-x_2})(N-3)}} \qquad (4)$$

Where: S_b standard error for coef. b; R^2 coefficient of multiple determination; N the number of samples; R^2_{y-x2} the coefficient of determination between y and x.

The intensity of the relationship between the set of independent variables and the dependent variable is calculated in the form of the multiple correlation coefficient [1]:

$$R = \sqrt{\frac{a \cdot \sum_{j=1}^N y_j + b_1 \cdot \sum_{j=1}^N x_{1j} \cdot y_j + \ldots + b_n \cdot \sum_{j=1}^N x_{nj} \cdot y_j - \frac{(\sum_{j=1}^N y_j)^2}{N}}{\sum_{j=1}^N y_j^2 - \frac{(\sum_{j=1}^N y_j)^2}{N}}} \qquad (5)$$

The IDW was developed by the U.S. National Weather Service in 1972 and is classified as a deterministic method.

The IDW method is also for multivariate interpolation and is based on the assumption that the attribute value of an unsampled point is the weighted average of known values within the neighborhood [8].

3. RESULTS AND DISCUSSIONS

The annual average rainfall of 12 locations for the period of 41 years from 1981 to 2022 in the Banat hydrographical area was analyzed. Table 1 represents the annual mean rainfall distribution in mm.

Table 1. Average Annual Rainfall in mm for 1981-2022

Station	Altitude	Rain
Tarcu	2192	675
Semenic	1447	610
Oravita	308	607
Caransebes	280	670
Bozovici	250	608
Resita	208	598
Baile H	168	620
Lugoj	124	598
MoldovaV	109	587
Timisoara	90	515
Sanicolau M	87	489
Banloc	84	542
Jimbolia	82	489
Grand Total	**5429**	**7608**

The spatial distribution of annual mean rainfall is shown in Figure 2 and indicates that annual mean rainfall is greater than 600 mm west part of the catchment area, and the north parts are receiving more smaller amount than other regions.

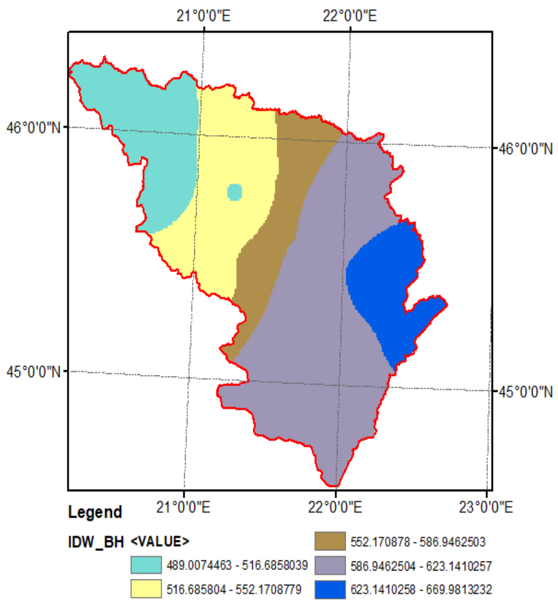

Figure 2. IDW map of Banat area

For the purpose of using IDW to interpolate spatial rainfall, long-term observed rainfall data were necessary for analysis in the process.

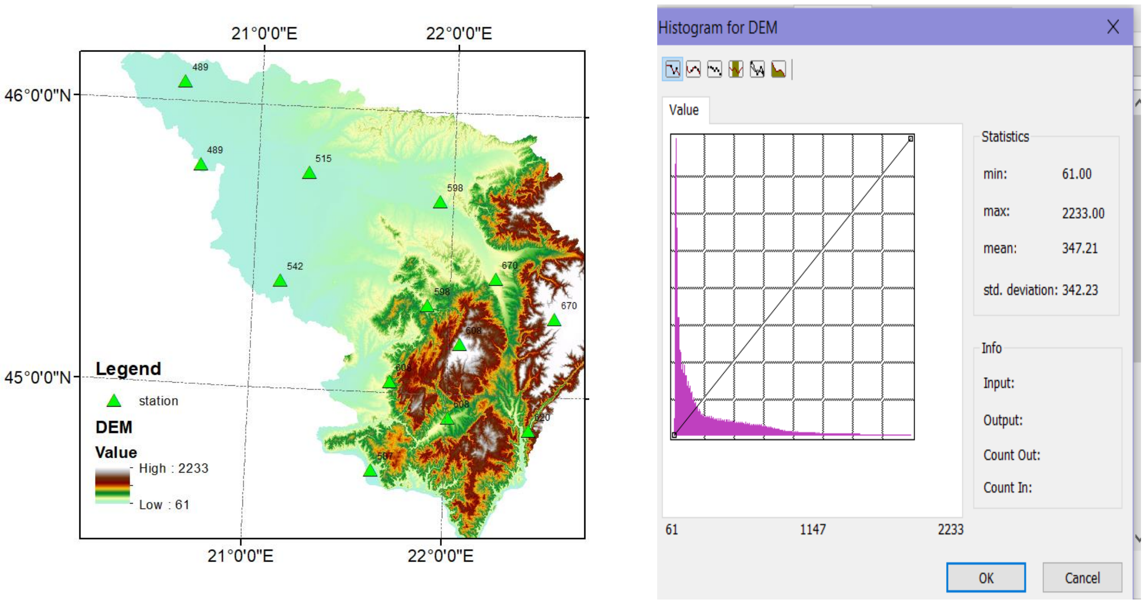

Figure 3. DEM of the study area   and histogram

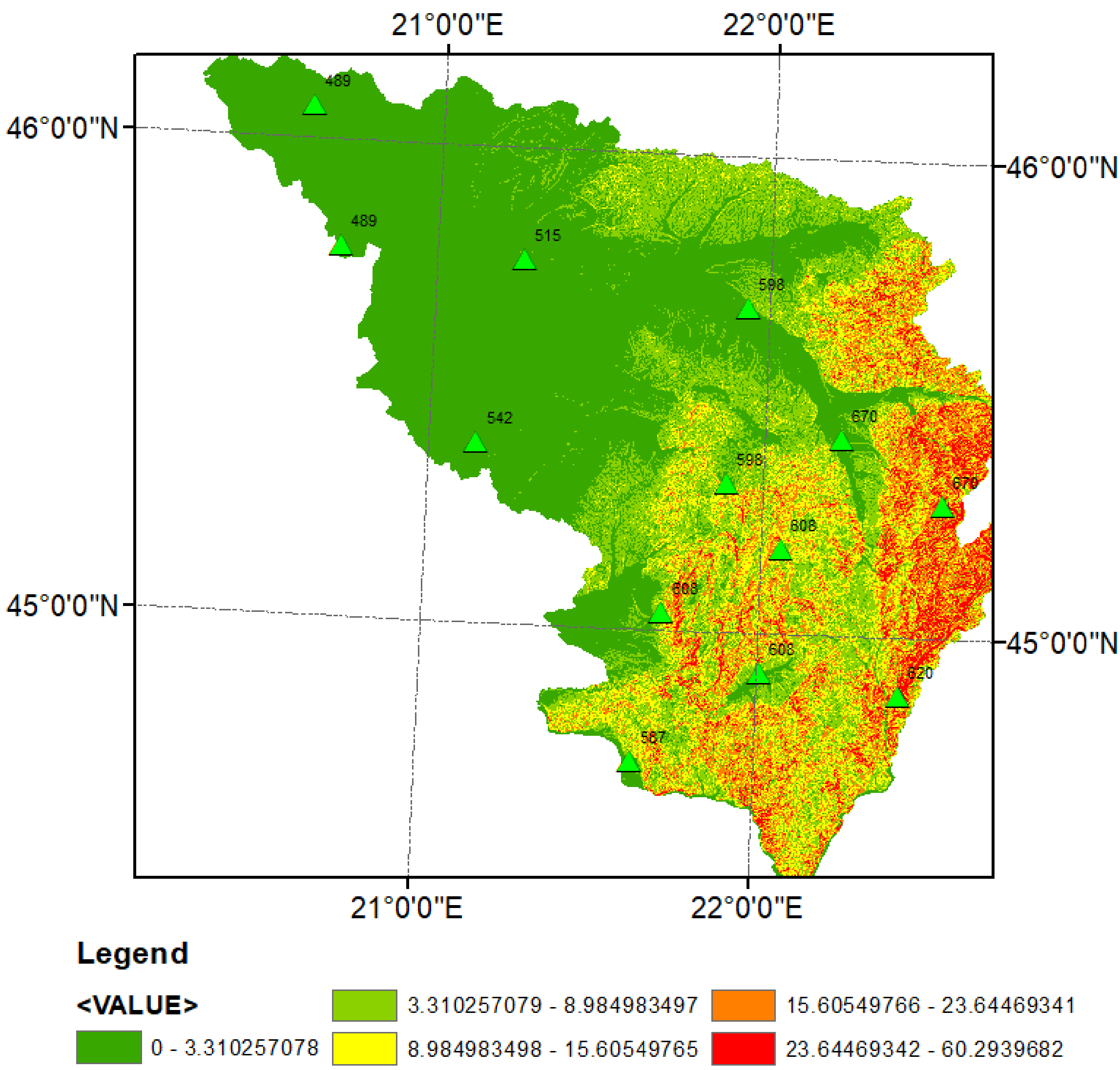

Figure 4. The slope map of Banat hydrographical area

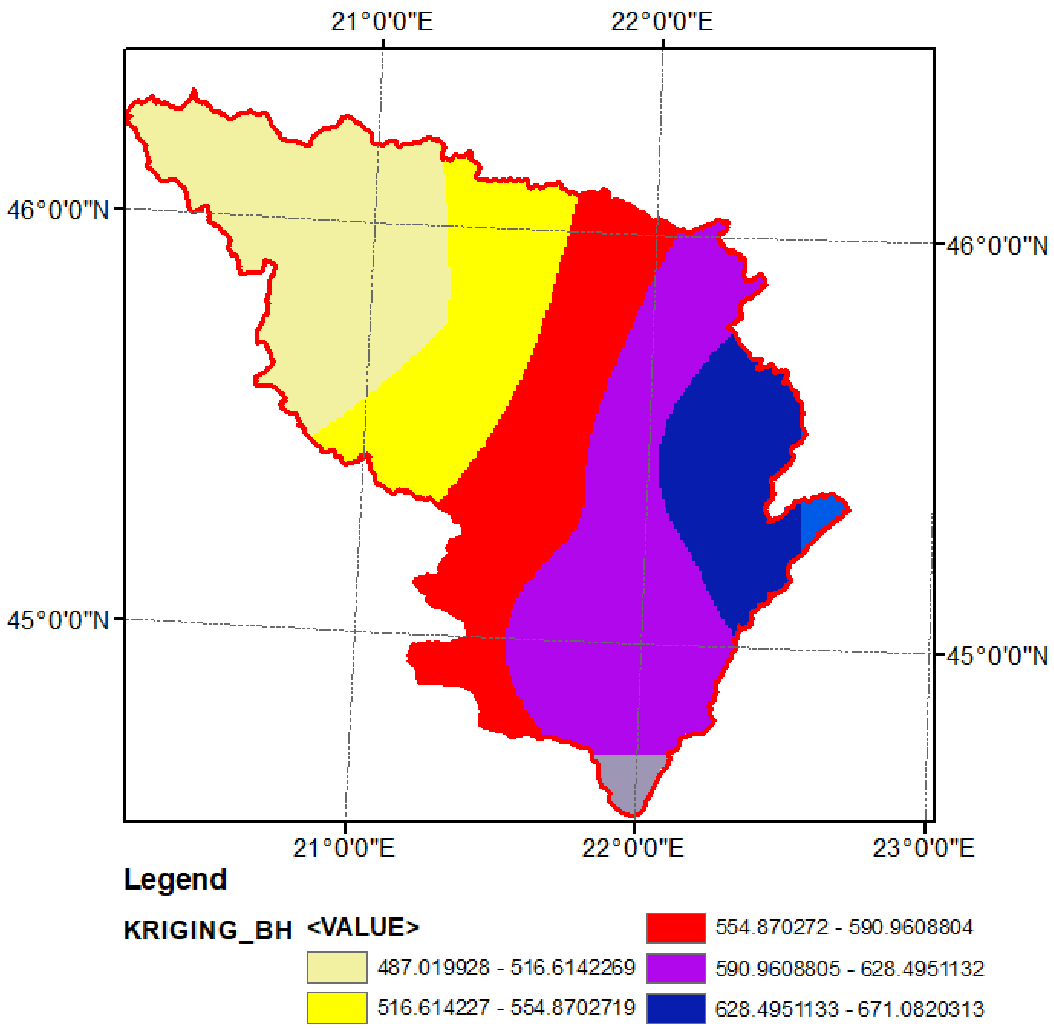

Figure 5. The Kriging map.

Kriging is a method of spatial interpolation that originated in the field of mining geology and is named after South African mining engineer Danie Krige. Kriging is one of several methods that use a limited set of sampled data points to estimate the value of a variable over a continuous spatial field.

The Figure 6 shows the yearly average Annual Rainfall of 3 rain stations in mm from 1981-2022. The lowest average rainfall was 184.75 mm recorded in the year 2000 at Timisoara and the highest average rainfall was 896.48 mm recorded in the year 2005 at Bozovici station.

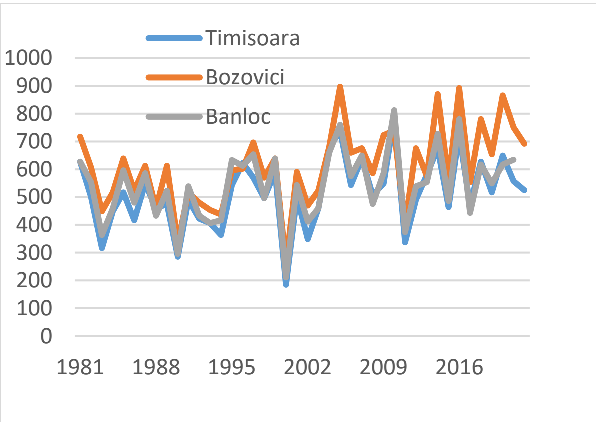

Figure 6. Average Annual Rainfall 1981-2022

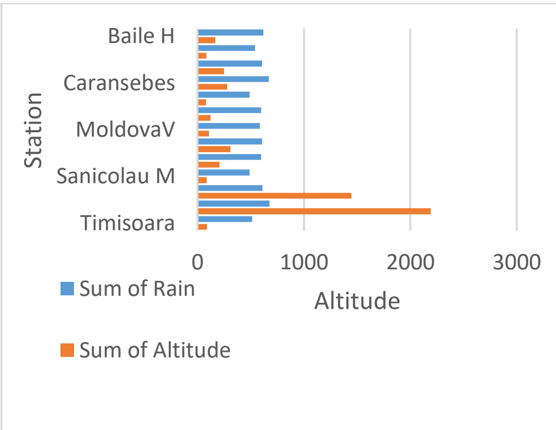

Figure 7. Altitude – rain for 1981-2022

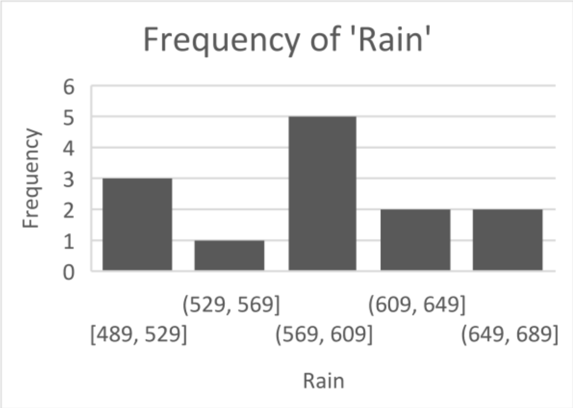

Figure 8. Frequency – rain for 1981-2022

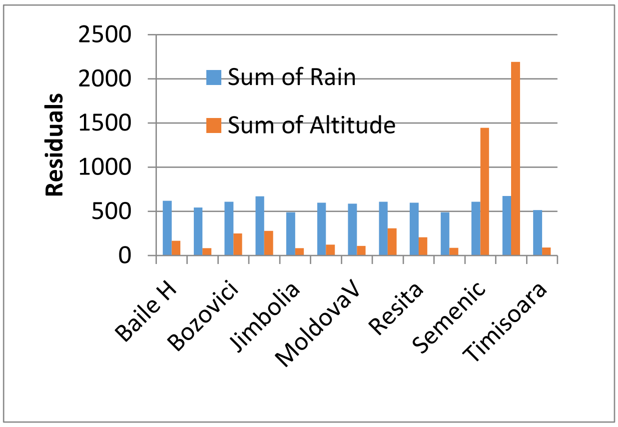

Figure 9. Residuals plot

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	184093.0563	184093.0563	1.314487	0.278276802
Residual	10	1400493.194	140049.3194		
Total	11	1584586.25			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1055.65	1161.07	-0.91	0.38	-3642.67	1531.37	-3642.67	1531.37
675	2.29	2.00	1.15	0.28	-2.16	6.75	-2.16	6.75

RESIDUAL OUTPUT

Observation	*Predicted 2192*	*Residuals*	*Standard Residuals*
1.00	343.73	1103.27	3.09
2.00	336.85	-28.85	-0.08
3.00	481.38	-201.38	-0.56
4.00	339.15	-89.15	-0.25
5.00	316.20	-108.20	-0.30
6.00	366.67	-198.67	-0.56
7.00	316.20	-192.20	-0.54
8.00	290.97	-181.97	-0.51
9.00	125.80	-35.80	-0.10
10.00	66.15	20.85	0.06
11.00	187.74	-103.74	-0.29
12.00	66.15	15.85	0.04

The study area exhibits different rainfall distribution patterns which are influenced by various spatio-temporal factors in which temperature, altitude, and urbanization.

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