Scientific Bulletin of Politehnica University of Timişoara

Transactions on HYDROTECHNICS

Volume 66 (80), Issue 1, 2021

Estimation of the air temperature through statistical tools

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Abstract: Climate change is a global concern and in last period is observed an increase of temperatures significant. A method of estimating the climatic variable is presented in this paper, using the simple linear regression equation. Based on the meteorological stations, the average annual temperature is estimated function of altitude and longitudinal. This study proposes an empirical methodology for modelling and mapping the air temperature using geographical information systems (GIS) techniques. The study is focus on the relationship between annual mean temperature at climate stations of the catchment and elevation and location, as expressed by latitude and longitude. Finally, there are evaluated the regression coefficients and it been realized the final maps, using digital layers for each independent variable, and applying basic GIS tools.

Keywords: interpolation, IDW, Kriging, GIS

1. INTRODUCTION

Knowledge of the spatial distribution of climate data is an essential tool for managing natural resources and predicting climate data. Spatial interpolation is the process of using points with known values, in order to estimate the unknown values of other points. It estimates temperatures for places where there are no data records, using temperature readings obtained from nearby weather stations.

In some papers on climatological interpolation, such as Bigg's research (1991), which uses kriging interpolation, adding the influence of variables in the process, and Hutchinson's research (1995), it uses layout to improve splines interpolation. There are also studies that look for statistical relationships between geographical variables (orography, latitude, etc.) and climatological variables [2], [3], [7], [9], as well as studies that use information systems (GIS) to model these climatological variables [6], [4], [5].

Meteorological variables are required for applications in hydrology or water resources management are usually measured at meteorological stations and the data is valid only for the point at which they are measured. Based on spatial interpolation techniques, data from meteorological stations can be used to estimate meteorological variables in other locations.

In practice there are several interpolation methods, therefore the methods that best fit the data and purpose of the project must be chosen.

The advantages and disadvantages of each method depend very much on the characteristics of the data set: a method that fits well with a particular data set may be inappropriate for a different data set. Thus, criteria must be found to decide whether the chosen method is suitable for the point data set. It is also important to specify the interpolation objectives, as different purposes may require different criteria for evaluating the interpolation.

2. METHODOLOGY

The analysis of the measured value pairs gives the possibility to appreciate the curve drawn continuously between the points that form the value pairs and which gives the possibility to appreciate the allure of the curve (line, parabola, exponential equation, etc.).

To determine the parameters a, b, c of the equation:

$$y = a + bx_1 + cx_2 \quad (1)$$

Where: y is the estimated average annual temperature, and x_1 and x_2 are the altitude, respectively the latitude, leading to the solution of the following system of equations:

$$\begin{cases} \Sigma y = Na + b_1\Sigma x_1 + b_2\Sigma x_2 \\ \Sigma y x_1 = a\Sigma x_1 + b_1\Sigma x_1^2 + b_2\Sigma x_1 x_2 \\ \Sigma y x_2 = a\Sigma x_2 + b_1\Sigma x_1 x_2 + b_2\Sigma x_2^2 \end{cases} \quad (2)$$

A good linear correlation between two variables is considered if the following condition is met:

$$0.7 \leq |r| \leq 1 \quad (3)$$

$$r = \frac{n\cdot\sum_{i=1}^{m} x_i\cdot y_i - \sum_{i=1}^{m} x_i \cdot \sum_{i=1}^{m} y_i}{\sqrt{[n\sum_{i=1}^{m} x_i^2 - (\sum_{i=1}^{m} x_i)^2][n\sum_{i=1}^{m} y_i^2 - (\sum_{i=1}^{m} y_i)^2]}} \quad (4)$$

3. RESULTS

Based on the meteorological stations, we want to determine the regression equation with which we can estimate the average annual temperature depending on altitude and latitude.

A Geographic Information System is able to provide various tools for performing complex spatial analysis. Specifically, spatial analysis is defined as the process of manipulating spatial data, in order to extract

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new information and significance from the original data [14].

An example of spatial analysis is the process of spatial interpolation of data, which represents the process of using points with known values, in order to estimate the unknown values of other points.

To make a precipitation map for a specific area of interest based on data from weather stations in the area, they are not evenly distributed [15].

Spatial interpolation can estimate temperatures in places without data records, using temperature readings obtained from nearby weather stations.

This type of interpolated area is often called the statistical area. Elevation data, precipitation, snow accumulation, water masses and population density are other types of data that can be calculated using interpolation.

In a GIS, the spatial interpolation of these points can be applied to create a raster surface, with estimates made for all raster cells.

There are many methods of interpolation. In this study, IDW (Inverse Distance Weight) and Kriging interpolation methods were used.

In the IDW interpolation method, the sampling points are weighted during the interpolation, so that the influence of one point relative to other decreases with the distance from the unknown point.

The weighting is assigned to the points taken, using a coefficient that controls how the influence of the weighting will decrease as the distance from the new points increases.

The higher the weighting coefficient, the less effect the points will have if they are located further away from the unknown point during the interpolation process. As the coefficient increases, the value of the unknown point approaches the value of the nearest observation point. It is important to note that the IDW interpolation method also has some disadvantages: the quality of the interpolation result may decrease, if the distribution of points in the data sample is uneven.

Kriging interpolation starts from the assumption that the values of a spatial variable are auto correlated over short distances. In other words, around a certain point, the values in the close points will be similar to those in the central point, the differences increasing proportionally with the distance from it.

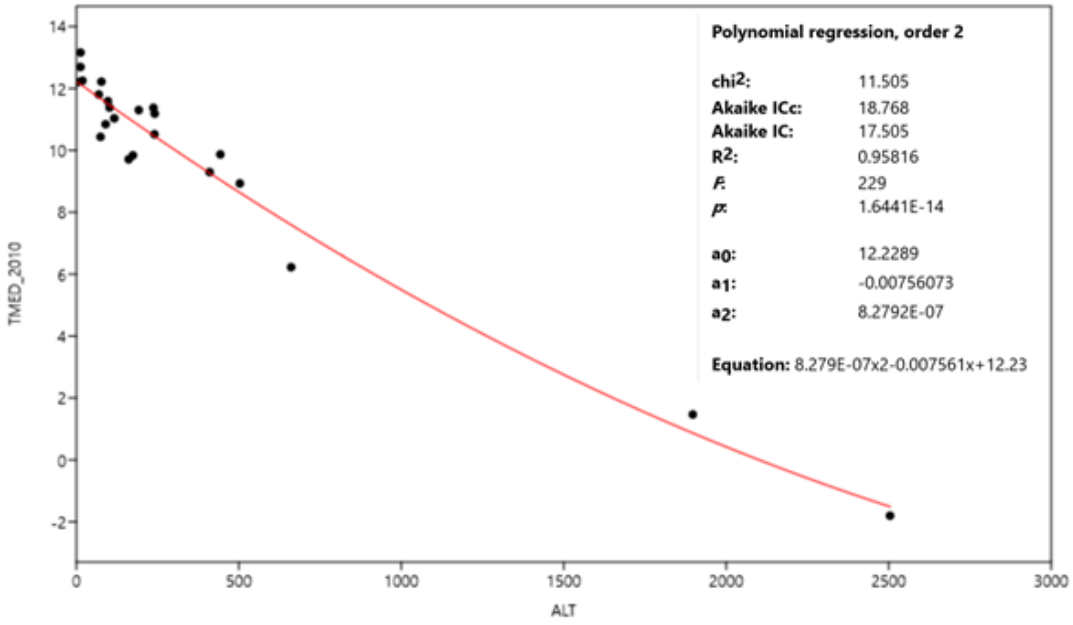

Figure 1. Correlation temperature – altitude in 2010 year

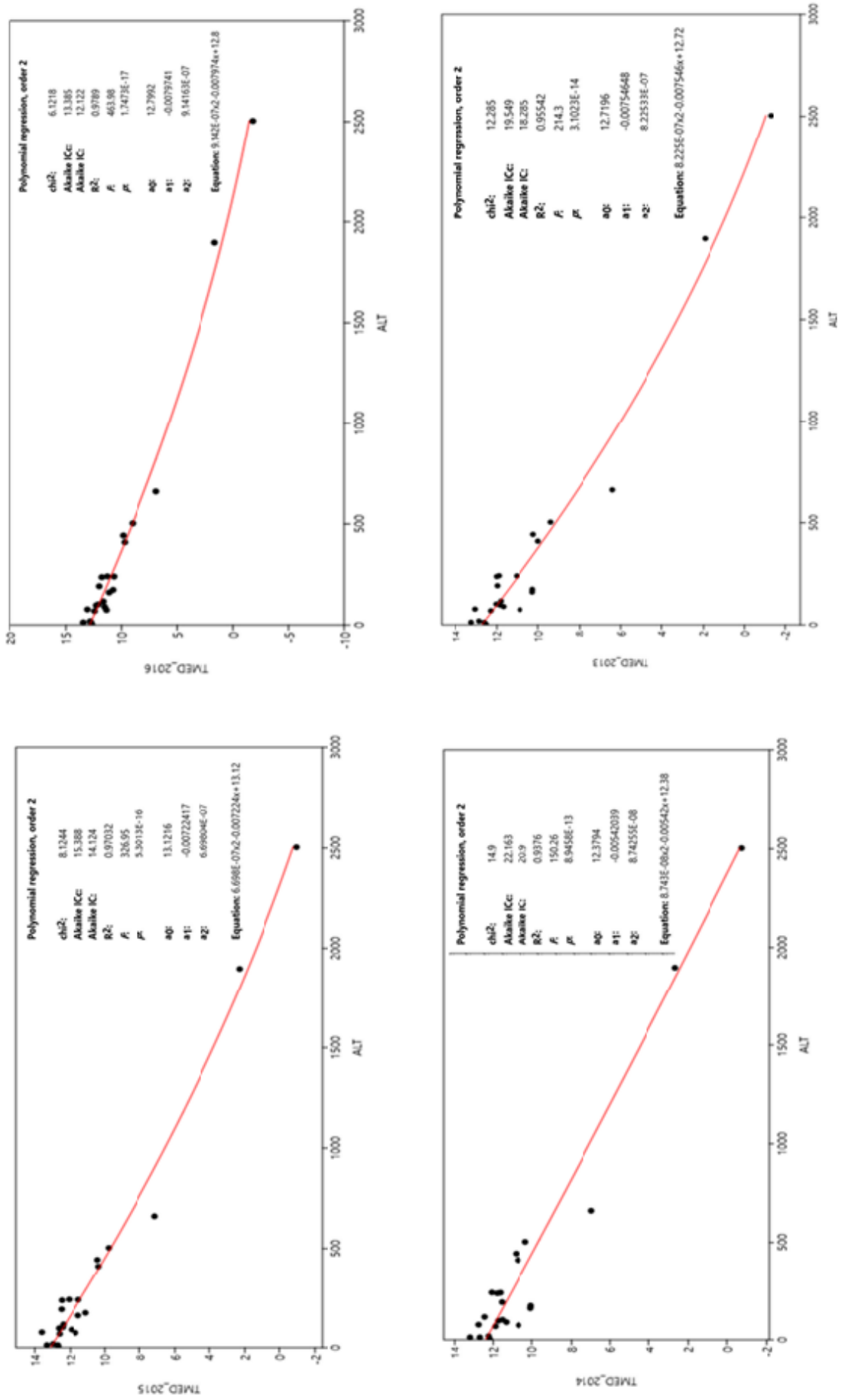

Figure 2. Correlation temperature - altitude during the period 2011 -2016

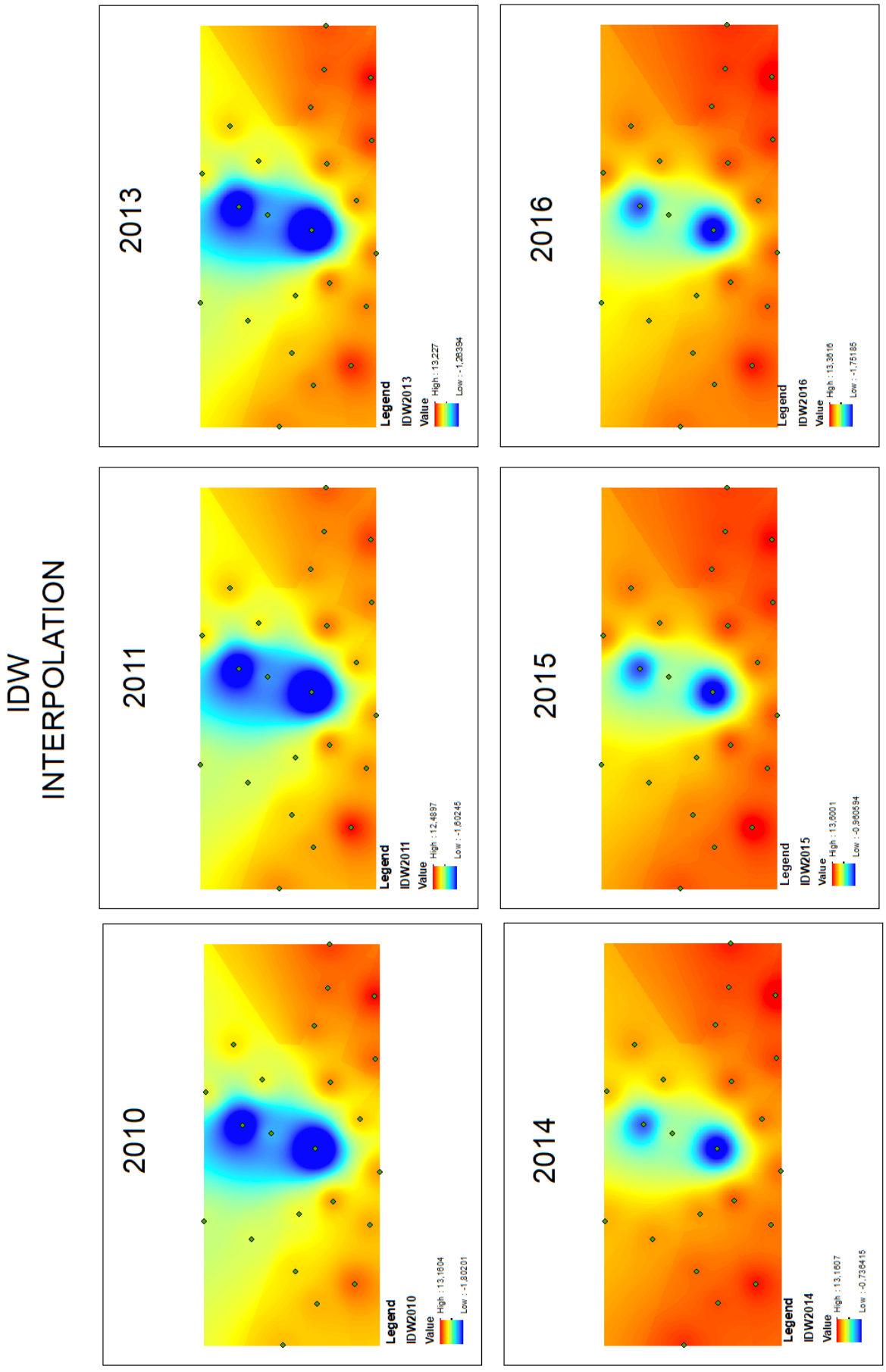

Figure 3. IDW Interpolation 2010 -2016

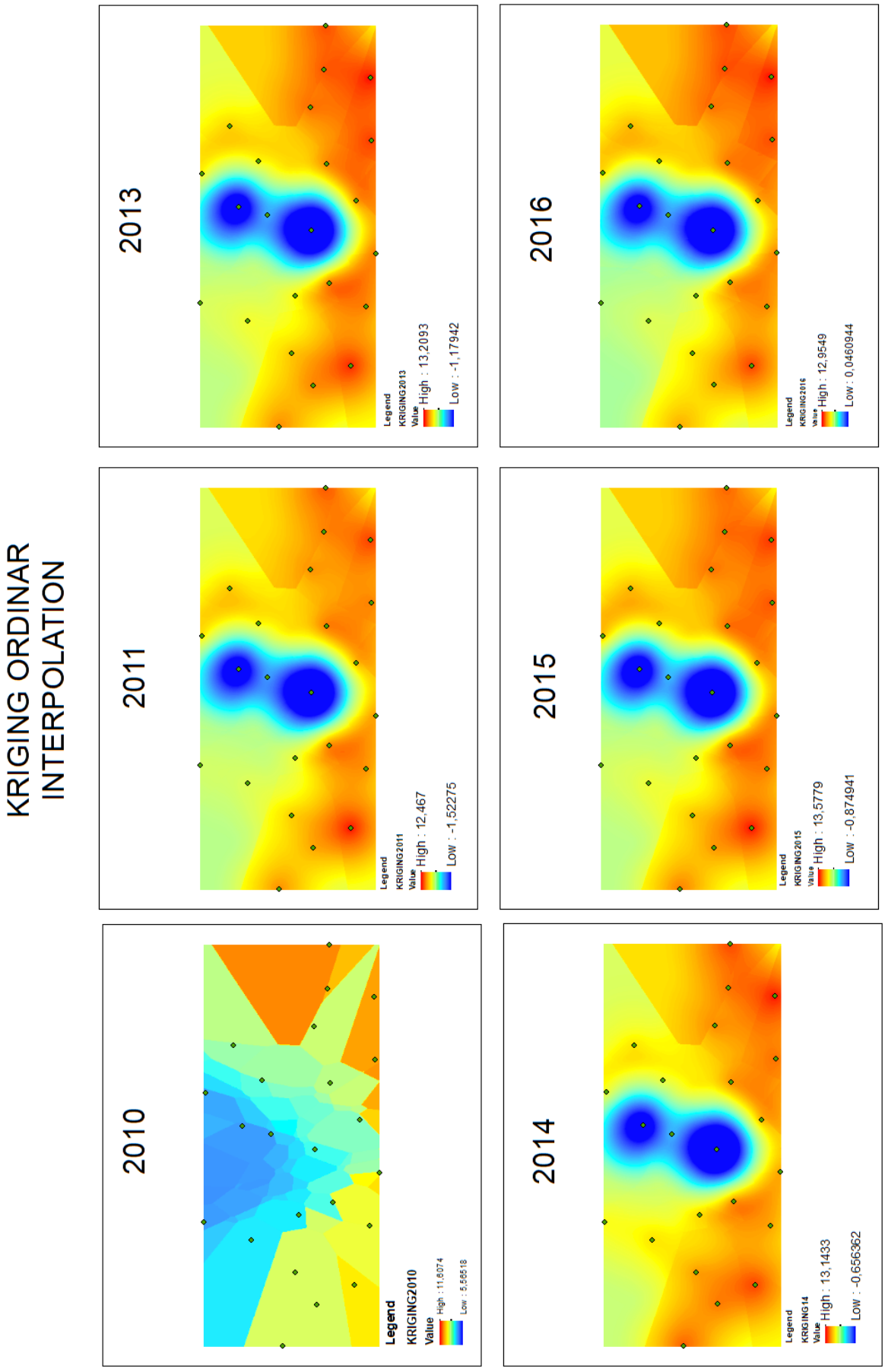

Figure 4. Kriging ordinary interpolation 2010 -2016

4. DISCUSSIONS. CONCLUSIONS

The regression equation will help us to estimate the average annual temperature at each point in space knowing its altitude and latitude. From the figures below, it is also observed that the temperature decreases with altitude (Figures 1 and 2).

This paper analyses an example of spatial interpolation of the average monthly temperature by different interpolation methods, such as: IDW: Inverse Distance Weighing (Figure 3) and Ordinary kriging (Figure 4).

Both the resulting spatial interpolation aspect and the cross-validation graphs indicate the multiple regression method as optimal.

In the case of IDW, the correlation line between the current residues and those recalculated in the absence of stations is much deviated from the ideal route, due to the inability of the method to correctly return the temperature values for two of the analyzed stations.

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