Geostatistical Interpolation for Spatial Data

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Abstract: Continuous surfaces of rainfall climate variable are becoming increasingly used as input to spatially explicit atmospheric ,hydrologic ,ecologic and environmental models. Several methodologies exist for spatial interpolation of climate and weather parameters, among them is the ordinary kriging method .A large sampling effort is required to produce an accurate geostatistical map, and the extraction and analysis of each sample is often expensive, The effectiveness of a particular sampling scheme is dependent upon the spatial variability of the quantity being measured .In this paper ,we used the ordinary kriging method to estimate the rainfall distribution in Iraq. A total of 24 real points are used for evaluation. The results presents samples of maps for months January, October, March for years 2004, 2013 within the period of data.
Key Words: Rainfall, Spatial, Geostatistical, Region, Kriging Techniques.

Introduction:

Rainfall is an important climatological parameter and knowledge of its temporal and spatial patterns is useful for researchers working in many disciplines, In this study , spatial interpolation techniques were implemented in a Geographic Information System (GIS) to study the spatial variability of monthly rainfall in Iraq. Ten years (2003-2013) of climate data (average monthly rainfall)from 24 weather stations distributed throughout Iraq were used in the analyses. Literature suggests that there is no single preferred method of interpolation and the selection of interpolation method is usually based on the available data, desired level of accuracy, and available resources. In this paper we used ordinary kriging techniques in the geostatistical analyst that aims to estimate values at unknown points by using known measurements and the continues surface data can be interpolated from the isolated point data such as weather station. The kriging interpolation technology was named by Matheron in honor of Danie Krige, who first formulated and implemented this form of interpolation in 1951 [1].Kriging is basically an estimator used to find the best linear unbiased estimate of a second-order stationary random field with an unknown constant mean [2].It is an optimal and unbiased linear technique for estimation. Compared with the traditional interpolation methods, it provides the 'best' possible estimates of unknown values from sample data [3].

Kriging interpolation method, used here, is one of the most popular and useful methods to predict unknown values from data observed at known locations, especially in geo-statistical. This method produces visually appealing map from irregularly space data and uses variogram to express trends suggested in the data [4].

Materials:

Iraq lies within the moderate northern region, system similar to that of Mediterranean where rainfall occurs almost in winter, autumn, spring and disappears in summer. The region is often divided into three rainfall zones according to the annual rainfall factor; Northern region, Middle region and Southern region [5]. Rainfall in Iraq varies from 50 mm per year in the SW to 1200 mm per year in the NE. The western desert of Iraq mostly receives <100 mm per year. The Mesopotamian flood plain and Jezira area receive 100-300 mm of precipitation per year. Rainfall in the foothills is 300-700 mm per year; the mountainous region of N and NE Iraq receives >700 mm of rain. Over half of Iraq lies within the arid and semi-arid zones (with<150 mm/year rainfall) [6] . The evaporation is very high in the country. The quantity of vaporation varies from one place to the other. Cyclones moving across Iraq are coming from the west; their source is the Atlantic Ocean. They are usually moving east toward the Mediterranean Sea and then in the direction of Cyprus, Lebanon and Jordan finally toward Iraq, or the Arabian Gulf or the Caspian Sea. The numbers of cyclones vary with seasons, months and places over which they are passing. Usually they are increasing in the winter, decreasing in the autumn and finally disappear completely in the summer. Also the number of cyclones moving over the south is greater than that moving across both zone of mountains and foothills. For instance, the annual number of cyclones in the

south is about 75 while in the north is reaches 40. However, the north and northeast of Iraq usually receive higher amount of rain than the south. This is because the precipitations in the north are orthographic as much as it is cyclonic [7].

Method:

While it is a simple task to create a surface map using the default options that the Geostatistical Analyst provides, it is important to follow a structured process such as the one shown Figure (1).Represent and explore the Rainfall data to make better decisions when creating a surface. When exploring Rainfall data obvious errors in the input sample data that may drastically affect the output prediction surface, examine how the data is distributed, look for global trends, and so forth. Geostatistical Analyst provides many data exploration tools list in three ways:

• Examine the distribution of your data.
• Identify the trends in your data, if any.
• Understand the spatial autocorrelation and directional influences.

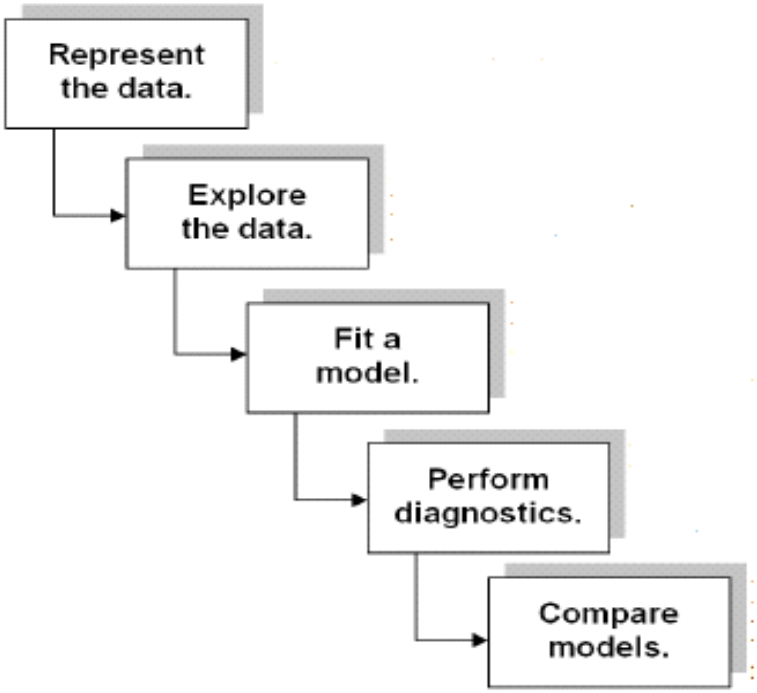

Figure 1: Surface Fitting Methodology

Discussion:

The variogram plays a central role in the analysis of geostatistical data. A valid variogram model is selected and the parameters of that model are estimated before kriging (spatial prediction) is performed. These inference procedures are generally based upon examination of the empirical variogram , which consists of average squared differences of data taken at sites lagged the same distance apart in the same direction. The ability of the analyst to estimate variogram parameters efficiently is affected significantly by the sampling design , i.e. the spatial configuration of sites where measurements are taken.

The variogram is a critical input to geostatistical studies (1) it is a tool to investigate and quantify the spatial variability of the phenomenon under study (2) most geostatistical estimation or simulation algorithms require an analytical variogram model,which they will reproduce with statistical fluctuations, In the construction of numerical models, the variogram reflects some of our understanding of the geometry and continuity of the variable, and can have a very important impact on predictions from such numerical models.

To describe the sample variogram for use in geo-statistical techniques such as kriging it is necessary to fit a mathematical model to the estimates of semi variance. The model fitted is defined by its type and the model coefficients which may include the nugget variance c_0 , structured variance c, still c_0+c , range a and gradient m Figure (2). Calculating the variogram is now readily accessible and it has become a welcome tool within the remote sensing community for kriging techniques [9].

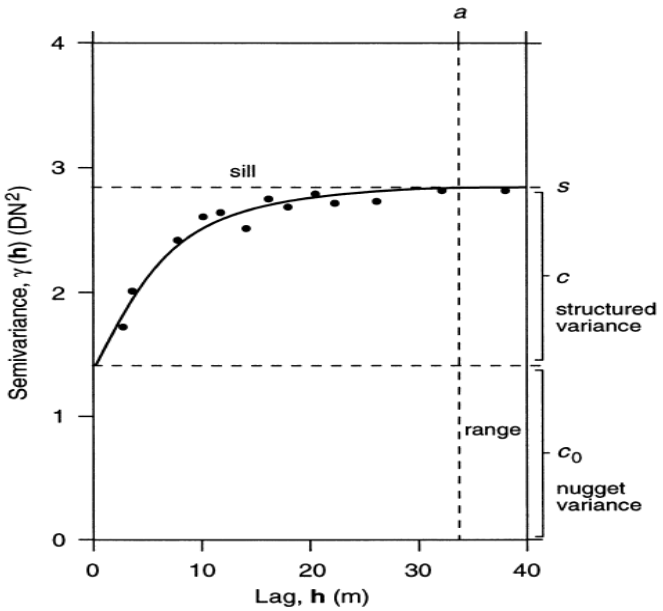

Figure 2: A generalized Variogram with Descriptors

Representing and Exploring Distribution of Spatial Data

Histogram:

The interpolation methods that are used to generate a surface give the best results if the data is normally distributed (a bell-shaped curve). If Rainfall data is skewed (lopsided), it might choose to transform the data to make it normal. Thus, it is important to understand the distribution of Rainfall data before creating a surface.

Normal QQ Plot

The quantile-quantile (QQ) plot is used to compare the distribution of the data to a standard normal distribution, providing another measure of the normality of the data. The closer the points are to the straight (45 degree) line in the graph, the closer the sample data follows a normal distribution.

Identify Gobal Trends in Spatial Data:

If a trend exists Rainfall Data, it is a nonrandom (deterministic) component of a surface that can be represented by a mathematical formula.

Fitting Model

Using the semivariogram/covariance cloud, it determine the overall spatial autocorrelation of the weather station. By examined semivariogram values, which showed the difference squared of the rainfall measurements taken at pairs of sampling locations separated by different distances. The goal of semivariogram/covariance modeling is to determine the best fit for a model that will pass through the points in the semivariogram. The semivariogram is a graphic representation used to provide a picture of the spatial correlation in the dataset.

Perform Diagnostics

ArcGIS Geostatistical Analyst provides validation and cross-validation tools that allow to evaluate the model and predictions. The tools quantify the accuracy of the model; it can either accept the model and its parameters or you can change the model and refine the parameters to create a better surface[8].

Compare Models

The Geostatistical Analyst can compare the predictions displayed in two or more mapped surfaces. This allows to make an informed decision as to which model provides more accurate predictions of unmeasured weather station based on cross-validation statistics.

Result:

Some optimal maps result from ordinary kriging technique for monthly rainfall data in Iraq shown in Figures (3,4,5)an annual of 2013 in Figure (6) .

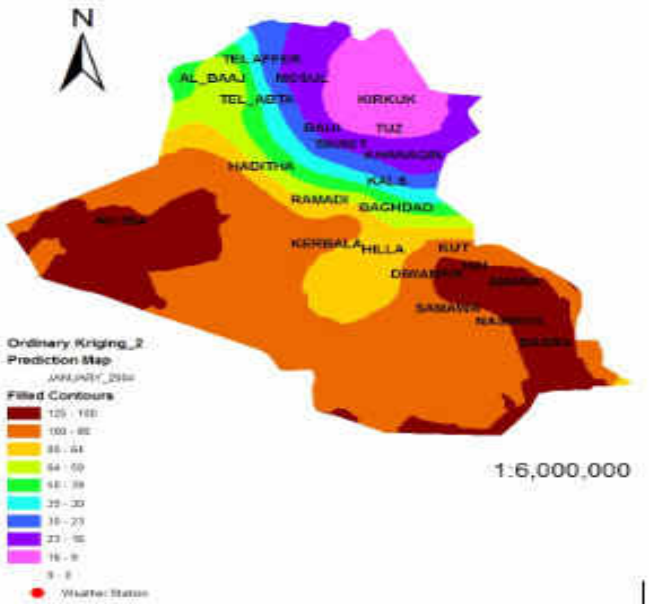

Figure 3: Rainfall Surface for January 2004

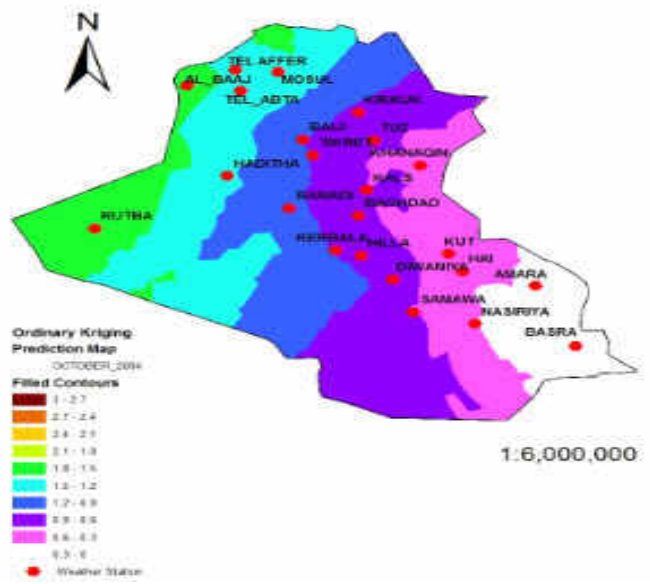

Figure 4: Rainfall Surface for October 2004

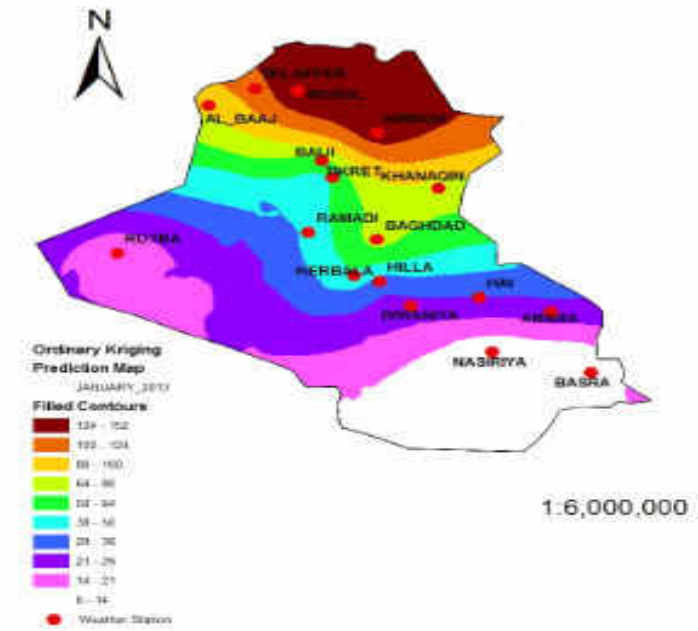

Figure 5: Rainfall Surface for January 2013

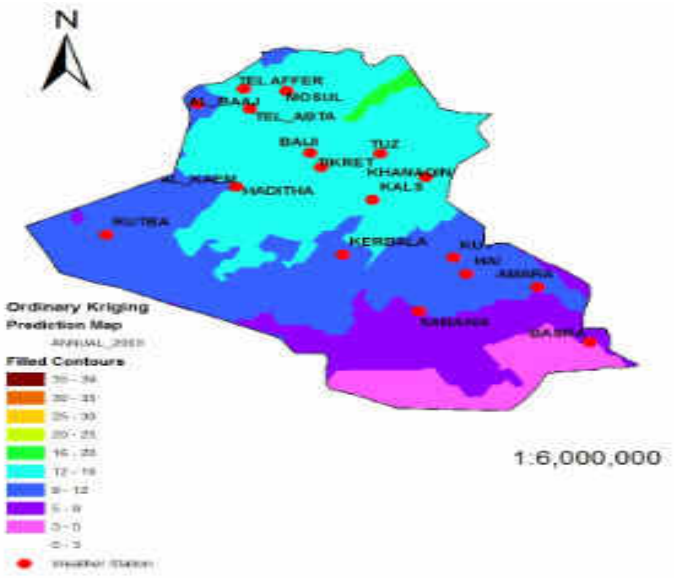

Figure 6: Rainfall Surface for Annual-2013

Conclusion:

Because of small number of weather stations in Iraq and not all working for that we used kriging techniques in geostatistical analyst to produce the predicted values of rain per iraq. Maps were produced for the last ten years because the continuous surfaces important for agriculture , water resource management and environmental models. Ordinary kriging method gave encouraging results when applied to the data rains in Iraq and achieved high precision of the results predicted.

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