# The spatial distribution patterns of temperature, precipitation, and humidity using geostatistical exploratory analysis (case study: Central Area of Iran)

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## Summary

Spatial Autocorrelation (SA) is the correlations of the observed data of an area in the form of spatial pattern. The criterion of SA phenomenon occurrence is when the distribution of one observed variable value follows a particular pattern systematically. The SA analysis is

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most useful and an important tool for investigating the spatial database, This analysis not only itself gives useful information about the relationship between the inner side, but the results for the most complex statistical analysis are given. The aim of this study is to investigate the pattern of the spatial distribution of temperature, rainfall and humidity model of spatial autocorrelation using Moran's central local and global statistics.

The main aim of this study is to investigate the spatial distribution patterns of temperature, precipitation, and humidity using geostatistical exploratory analysis in the central area of Iran. For this purpose, data from 72 synoptic stations of Iranian Meteorological Organization for the period from 1972 to 2012 were collected, reviewed, and analyzed. Methods used include ordinary, Sample and General Kriging with Circular, Gaussian, Spherical, and Exponential variograms, which is done in Arc GIS 10.2. Then, the errors criteria measures to assess their accuracy and precision have been used.

Kriging is a moderately quick interpolator that can be exact or smoothed depending on the measurement error model. Kriging uses statistical models that allow a variety of map outputs including predictions, standard errors, and probabilities. Kriging assigns weights according to a (moderately) data-driven weighting function, rather than an arbitrary function, but it is still an interpolation algorithm and will give very similar results to those of others methods in many cases. All Kriging techniques are based on the simple linear models as:

$$z^* = \sum_{i=1}^{n} \lambda_i z(x_i) \qquad (1)$$

Where $z^*$ is the estimator of the true value at any location, and $\lambda_i$ are the weights allocated to each observation such that

$$\sum_{i=1}^{n} \lambda_i = 1 \qquad (2)$$

The technique minimizes estimation variables by solving a set of Kriging equations, which include covariance between the point or volume to be estimated and the sample points and covariance between each pair of sample points .In this investigation, we have used the Simple, Ordinary, and Universal Kriging for interpolation of temperature, precipitation, and humidity. Various results are obtained with the use of different interpolation methods on similar data. With the wide and increasing applications of the spatial interpolation methods, there is also a growing concern about their accuracy and precision. Several error measurements have been proposed. Commonly used error measurements include: mean error (ME) or mean bias error (MBE), mean absolute error (MAE), mean squared error (MSE) and root mean squared error (RMSE). If ME and MSE are closer to zero, and RMSE is smaller, the better is the model. ASE and RSME should be the same or close. If ASE>RSME, then the method overestimates the primary variable. If ASE<RSME, then the method underestimates the primary variable. RMSSE should be close to 1. If RMSSE>1, the method underestimates the primary variable, and if RMSSE<1, it overestimates the primary variable.

The use of SA method for determining the degree of connectivity of the inter spatial objects was done through two approaches, they were: (1) Global Indicator Spatial Association (GISA) and (2) Local Indicator Spatial Association (LISA).The Moran's method worked in comparing particular variable value in each area with the value in all observed areas. GISA is the analysis of spatial associated pattern on a broader scale to see the data distribution, whether clustering was formed or not, dispersed, random in one space. GISA is defined in the equation (3).

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \cdot \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad (3)$$

Notation $n$ is the total observed case data, $w_{ij}$ is the spatial weight matrix element, $x_i$ is observed value I and $x_j$ is the value of neighbor observation j, and $\bar{x}$ is the average value x.GIS A value is interpreted by the use of Moran's I (I) ranging from – 1 to +1.Index I that had value of -1 represents data spread or averaged objects (uniform), I that had value of 0 represented random spread and independent. I that had value of +1 represented data/objects that were alike to form clustering. LISA is the analysis for SA quantification in the smaller area, which produces higher statistically significance (hotspots), lower statistically significance (cold spots), and outlier. LISA is defined in the equation (4).

$$I = z_i x \sum_{j=1}^{n} w_{ij} z_j \quad (4)$$

Where $z_i$ and $z_j$ are the amounts of I deviations. LISA was interpreted as follows, (1) if the variable in one observed location is the same with its neighborand has high value, it will be called as HH (high-high) or hotspots, (2) if the variable in one observed location is the same with its neighbor and has low value, it will be called as LL (low-low) or cold spots, (3) if the variable in one observed location has high value while its neighbor has low value, it will becalled as HL (high-low) or outlier, (4), if the variable in one observed location has low value while its neighbor has high value, it will be called as LH (low-high) or outlier.

Moran's global distribution pattern of the local and spatial analysis of precipitation in Iran suggests the fact that Iran has a very strong cluster pattern because the Moran index value was obtained near 1 (0.94). This indicates that local distribution of precipitation is non-uniform (spatial imbalance). Given the fact that Moran index only determines the cluster or random nature of precipitation distribution, hot and cold spots index was used to identify the locations of the clusters.

The results of this study showed that the pattern of trends in temperature, precipitation, and humidity are high clustered based on the global Moran index for moisture, which is higher than other elements of the cluster. Local Moran's results showed that the temperature, humidity, rainfall, and more central area follows a random pattern, however the pattern of temperature distribution is more scattered. Whereas the high value for the pattern of the rainfall and humidity levels are higher for high-elevated areas of Kerman and in part of the Zagros Mountains.

**Keywords:** Exploratory spatial data analysis (ESDA), Spatial autocorrelation (SA), Global indicator spatial association (GISA), Local indicator spatial association (LISA), Central area of Iran