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GIS-based spatial wind mapping using satellite data in Iraq

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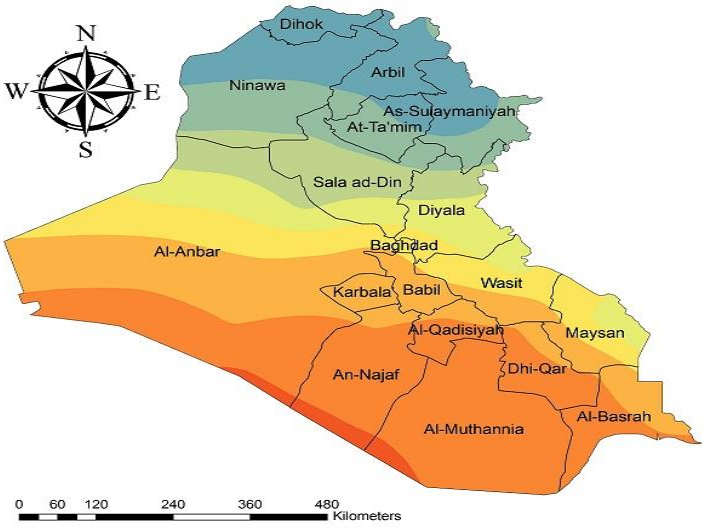
Abstract

Energy demands are increasing and the availability of fossil fuels is decreasing. Therefore scientists focus more on renewable energy. The study of wind characteristic must be conducted and also spatial wind mapping are important before developing systems for wind energy. Spatially wind mapping provide informative image for wind data. We aim to spatially mapping of wind data in Iraq at different heights. GIS-based mapping of wind provide us a geographical distribution which make it useful for decision making and also wind energy planning development. The mapping of wind speed was achieved to determine the potential areas in Iraq at different heights. Interpolation is achieved by the Kriging method. The coordinate system is based on the World Geodetic System (WGS).

Keywords: GIS, Wind Speed, Satellite Data, Mapping, Kriging Method.

Introduction

The study of wind characteristics and mapping must be known before developing wind energy systems. The wind characteristics is important to locate good sites for construction of wind systems in Iraq (Figure 1). GIS mapping of wind data is useful for making decision and also planning in development in wind energy. Wind speeds at heights of 10 and 50 m for each selected sites are used to produce maps. Wind turbines, are not other generators, they produce energy directly when wind is available. The wind cannot stored and used later. The output is fluctuating from wind turbine. Therefore the variability should be taken into account. Also taking into consideration that we can't transport the wind and we must convert it. Renewable energy sources is explained in details in [1, 12, and 13]. There are many methods deterministic and also geo-statistical used to interpolate meteorological parameters. The reader should refer to [2, 5, 7, and 8]. In this paper we use Kriging method to obtain maps in raster format. The condition for geo-statistical method is that the data should exhibit a Gaussian distribution.



Figure(1): Map of Iraq.

Materials and Methods

It is a necessary condition to the application of geostatistics, that there is a spatial relation between observations data. The experimental variogram represent degree of dissimilarity between data value, and therefore autocorrelation can be found at various distances[4, 10, and 14]. Equation (1) represent the value variogram for a distance separation of *h*, and is equal to half the average squared difference between the value at *z* (x_i) and the value at *z* ($x_i + h$):

$$\hat{\gamma}(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [z(x_i) - z(x_i + h)]^2 \qquad (1)$$

Where *N* (*h*) represent the number of data pairs in a given class of distance and direction. From analysis we can use a model for fitting the values[6, 9, 15, and 17].

Fitting a variogram model: The variogram is expressed as a mathematical function prior using the kriging method. It is typically achieved finding a function well fitted to the variogram. In this study we use spherical. Below the spherical function adopted (equation 2), which is expressed as:

$$\gamma(h) = \begin{cases} c_0 & \text{when } h = \varepsilon \text{ (a very small lag)} \\ c_0 + c\left(\frac{3h}{2a} - \frac{1}{2}\left(\frac{h}{a}\right)^3\right) & \text{when } 0 < h \le a \\ c_0 + c & \text{when } h > a \end{cases} \qquad (2)$$

Where c_0 is the nugget variance, $c+c_0$ is sill, *h* is the lag and *a* is the range. The spherical model is the most commonly used model for experimental data [3, 11, and 16]. Figure (2) represent a classic variogram.

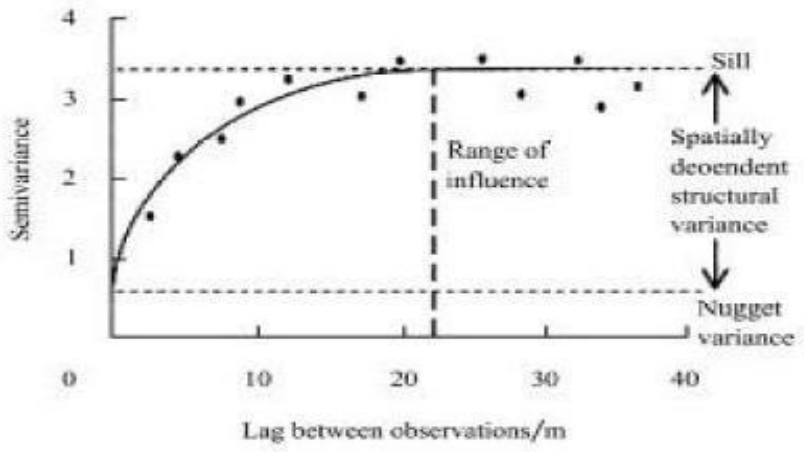


Figure (2): The variogram.

Results and Discussion

Kriging method take into account the spatial correlation, and it is better than inverse distance method. Kriging is used frequently because of its many more advantages. Maps were constructed using the Geographic Information System (GIS) software and the Geostatistical analyst extension. The Kriging method for surface interpolation method was used. The produced wind maps are shown in figures (3) to (7) using simple kriging and Spherical Model. Samples of these maps for months: January, February, July, August, and October at 10 m height.

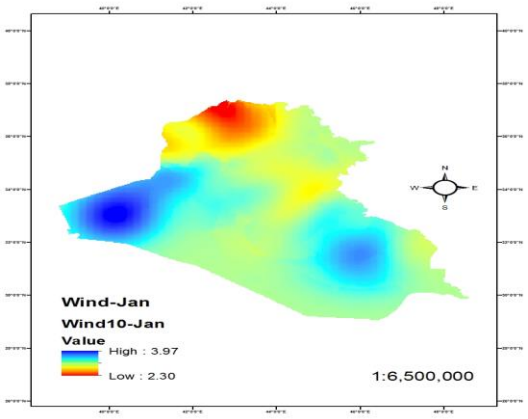


Fig (3): Wind Map January 10m.

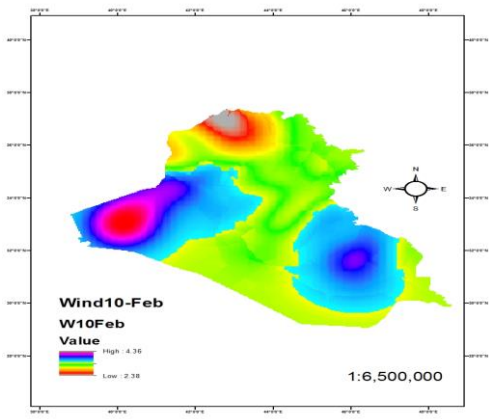


Fig (4): Wind Map February 10m.

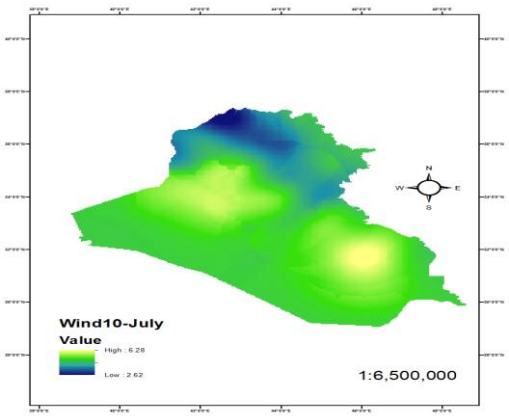


Fig (5): Wind Map July 10m.

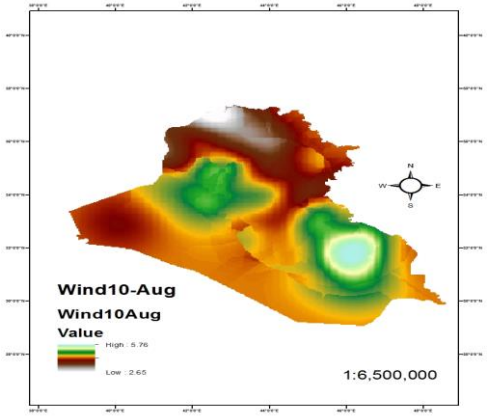


Fig (6): Wind Map August 10m.

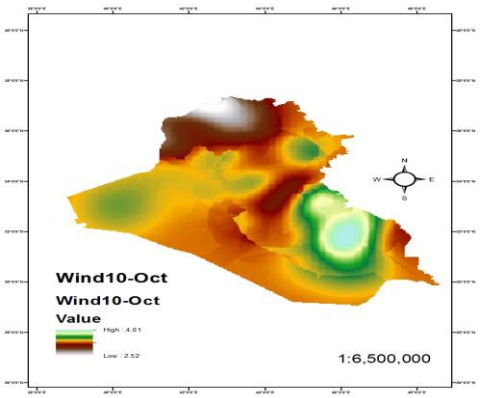


Fig (7): Wind Map October 10m.

The produced wind maps are shown in figures (8) to (12) using simple kriging and Spherical Model. Samples of these maps for months: January, February, July, August, and October at 50 m height. Geostatistics is more sophisticated method among interpolation techniques. Geographical information systems with geostatistics is frequently used for spatial mapping of regionalized variables, i.e. variables that are distributed continuously. GIS analysis make it possible to deal with large data.

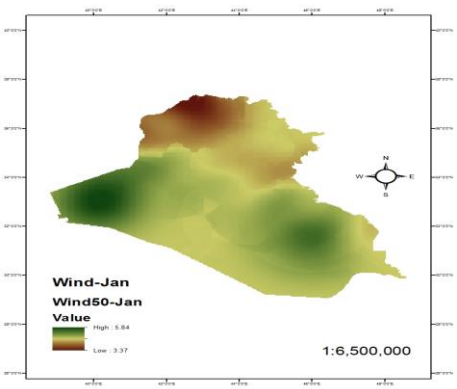


Fig (8): Wind Map January 50m.

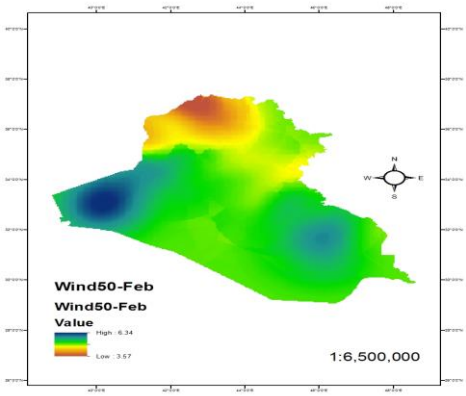


Fig (9): Wind Map February 50m.

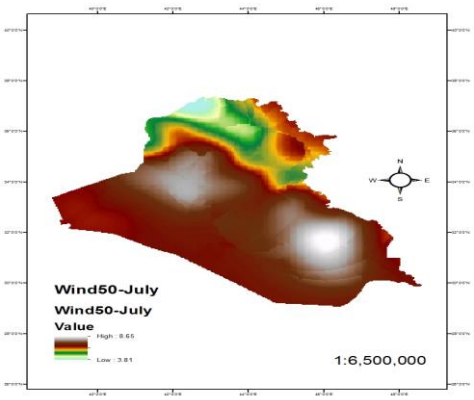


Fig (10): Wind Map July 50m.

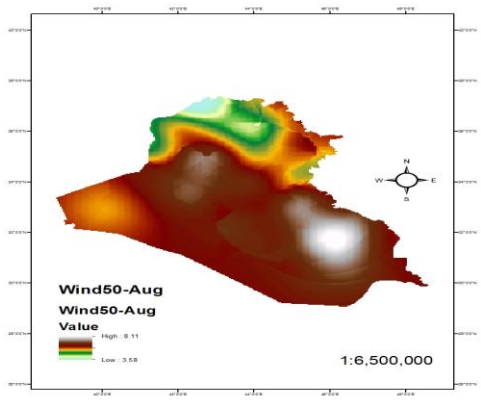


Fig (11): Wind Map August 50m.

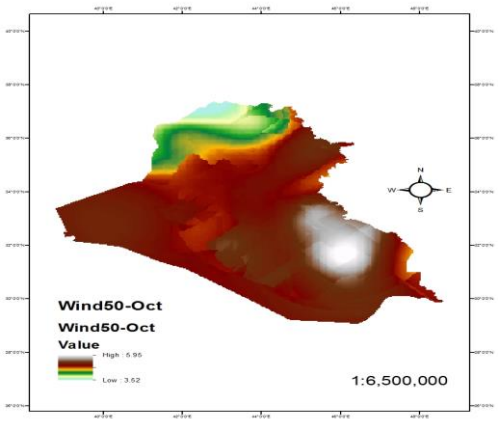


Fig (12): Wind Map October 50m.

Conclusion

GIS can be considered as an excellent tool that help us in decision making. Machines for wind harvesting is very costly. Therefore we should study the characteristics of the wind for each site to reduce costs. There is demand for energy and also the of fossil fuels availability are decreasing, and accordingly we must focus renewable energy.

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