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Assessment of Amount Rainfall Variability Using Kriging Filter Techniques over Iraq

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ABSTRACT

The amount of rainfall is considered one of the most important climate indicators that affects many sectors in Iraq, such as agriculture, industry, tourism, and infrastructure. The dataset that was used came from (NASA) data for (36) stations. Study areas have a large variance in amounts of rainfall relying on analyzing the annual rainfall for the year 2022. Central and southern areas have received less rainfall and re-analysis data was generated using a Geographic Information System (GIS) with two interpolation methods: kriging and Inverse Distance Weighting (IDW). The dense distribution of stations on the map of Iraq is due to the large study area, so the program needs to provide the largest number of stations to work with great accuracy. Thus, if the stations are few, the program is unable to work efficiently. The results revealed IDW indicator found western region of Iraq had less amount of observation rainfall, while other regions witnessed more than the amount of rainfall by (3.5 mm/day). The Kriging found a sensitive region in Iraq that appears in the western region, which shrinkage the area of minimum value in the Kriging indicator. The similar region found in Fao witnessed the same conditions. The maximum region had a closer gradient in couture line Western regions, while other regions witnessed more than the amount of rainfall by (0.15 mm/day). The kriging indicator was the efficient method for calculating the amount of rain in ambiguous areas where rainfall as its standard deviation was close to (0.0108012). While the IDW counterpart had a higher error rate this enhanced the reliance on it in the analysis and extracted the water distribution map more accurately. Knowing the amount of rain in each governorate enhances a better understanding of the environment helps in making better decisions to protect humans and the environment and improves the management of water resources and infrastructure projects.

Keywords: Amount of Rainfall, Kriging Filter, Climate indicators, GIS, Iraq.

Introduction

Rainfall is one of the most substantial matters for preserving all forms of whole life. Where represented as the backbone of meteorology research. Due to the high density of population and urbanization planning. Objective study the distribution and amount of rainfall in order to standardize the areas that actually require them. The study related to interpolation map of air pollution distribution for specific variable indicated extrapolated for data point this dependent variable mapping as sites form a surface over a geographical area in the same way grid point display [1]. Geostatistical interpolators outperformed analytics methods. The rainfall observations for spatially linear regression that used ordinary kriging yield more accurate predictions which stresses accounting to the collocated elevation. [2].Due to its spatial and temporal unpredictability, precipitation is one of the more challenging meteorological parameters to observe and measure. Rain gauges, radar, and satellites are the primary tools used to measure precipitation. Every technique has pros and cons of its own. Only a satellite is capable of collecting data on rainfall across both land and water [3]. The functionality to quickly compute watershed metrics that take into account the Euclidean or flow length distance to the stream or outlet, as well as the likelihood for overland movement, is provided by the Inverse Distance Weighted Percent Land Use for Streams (IDW-kriging) custom ArcGIS Indicators [4]. The data outputs were able to show that there were more periods of drought in Iraq [5].Precipitation data were obtained from NASA. Proper selection of gridded precipitation data is very important for a region where long-term precipitation observations are not available [6].According to the types of land geography, Iraq may be split into four regions: the Mesopotamian plain, Jazeera, and Western Plateau; the Plateau and Hills Regions; and the Mountain Region. The predominant types of climates are continental, subtropical, and semiarid. The Mediterranean climate prevails in the mountainous area, where rain often occurs from December to February or November to April [7].Since drought is not just a problem in desert areas, it may have an impact on all climatic systems worldwide. Drought risk has detrimental consequences for a number of economic and environmental sectors, such as agriculture, food supply, hydropower generation, the health sector, etc. [8].

Methodology and Data

Iraq is located in the northeast of the Arab world, to the southwest of the continent of Asia, extending from latitudes 6-29º - 27-37º to the north, and from longitudes 39'38º - 36'48º to the east. The circles of latitude occupy a length between north and south of about 925 km as shown in Fig 1. The length of the horizontal extension in terms of longitude between east and west is about 950 km. Which means the convergence of the maximum Eurasian horizontal extension. This location makes Iraq's climate transitional between the desert climate and the Mediterranean climate, which is a continental climate characterized by drought and high temperatures in the summer and low temperatures with little rain in the winter. The aims to use computerized statistical methods (IDW & Kriging) and obtain the best way to calculate the amount of rainfall using the (ARC GIS) program with NASA data. The treatment showed the spatial distribution of the regions with the amount of rainfall falling and showed the variation between the amounts of rain In comparison to the central and southern areas, the northern, mountainous part of Iraq has much more rainfall. Almost 90% of the yearly precipitation[9] The findings indicate that the upper trough over the eastern Mediterranean will facilitate the advection of warm, moist air from the tropics, resulting in baroclinic instability across Iraq and, in some cases, significant precipitation and torrential downpours [10].

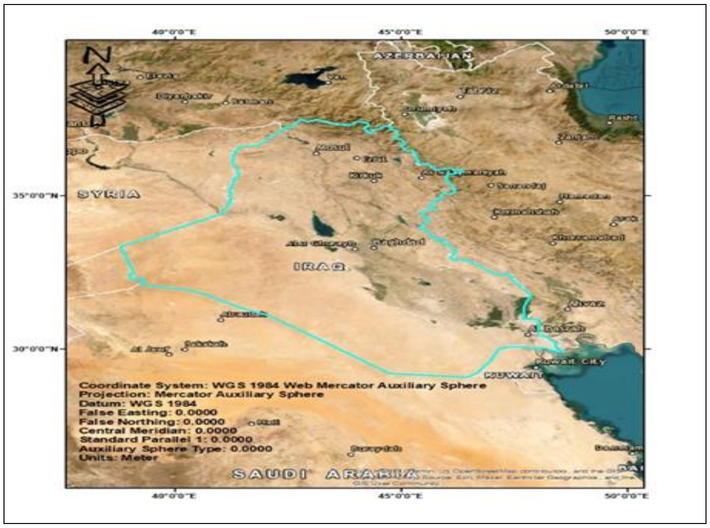

Figure 1. Geographical location of Iraq.

Data obtained from (NASA) the combined data for the stations was for the year 2022 for analyzing rainfall areas. They identified on the country's border map. This based on re-analyzing (6) stations Table 1. out of a total of (36) stations with known precipitation amounts by removing their data from the (arc GIS) program and performing statistical operations on them through the use of (IDW & Kriging) indicators, and making a comparison between them and the original analyzed data and the data that were obtained. From re-analysis and determining the best indicator by calculating the standard deviation.

Table 1. Location of stations

Stations		**Longitude °E**	**Latitude °N**
1	Fao	48.50	29.98
2	Baghdad	44.40	33.30
3	Duhook	43.00	36.87
4	Najaf	44.32	31.95
5	Ramadi	43.32	33.45
6	Tikrit	43.70	34.57

Inverse Distance Weighted (IDW)

The inverse distance weighted (IDW) is the methods one of the most commonly used interpolation methods; the IDW method assumes that the rate of correlation and similarity between neighboring points is proportional to their proximity. This assumption can be expressed as an inverse function of the distance between each point and its neighbors. This method is desirable when there is an appropriate distribution of local scale levels. All interpolation methods agree that local points have more correlation and similarity than distant points. When considering the accuracy of inverse distance interpolation methods, the most important factor is the power IDW Function is (Equ.1)[11].

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$$Z_{\circ} = \frac{\sum_{i-1}^{n} zi.d_1^{-n}}{\sum_{i-1}^{n} d_1^{-n}} \quad \text{------------------------------------ (1)}$$

Where:$Z_{\circ}$: The value that is currently expected to be linked with the variable zi. Zi: The value that the sample at point I represents is denoted by zi. di: The distance between the sample location and the estimate. N is the distance and weight coefficient. N: represents the total number of predictions produced for each validation event.

Kriging Filter

The Kriging assumes that the distance or direction between sample points indicates a spatial association. The output value for each site calculated using the Kriging tool by fitting a mathematical function to a set number of points, or to all points within a set radius Kriging Function is (Equ.2). Kriging is a multistep procedure that comprises data exploration, variogram modelling, surface creation, and (optionally) variance surface exploration. When there is a directional bias or spatially associated distance in the data, kriging is most suited. It frequently employed in geology and soil science. The kriging approach, on the other hand, bases the weights on both the general spatial arrangement of the measured points as well as the distance between the measured points and the predicted location. The spatial autocorrelation needs to be measure in order to use the spatial arrangement in the weights. Therefore, in conventional kriging, the weight, i, depends on a fitted model to the measured points, the distance to the predicted site, and the spatial correlations between the measured values nearby. The generic kriging formula is used in the parts that follow to make maps of the prediction surface and the accuracy of the forecasts[12].

$$Z* = \sum_{i=1}^{n} W\text{i } Z\text{ (xi)} \quad \text{------------------------------ (2)}$$

Where: Z∗ is estimated spatial variable, z (xi) is observed spatial variable wi is the weight of the variable statistic is the amount of observation. Within the fields of statistics and probability theory, the standard deviation is the most often used number in measuring statistical dispersion, since it provides insight into the width of the value ranges within a given collection of data. In order to make one of the two indicators reliable and its value closer to the basic observations, the results were subjected to the calculation of the standard deviation (σ) indicates how accurately the mean represents sample data(Equ.3)[13].

$$\sigma = \sqrt{\frac{\sum(x_i-\mu)^2}{N}} \quad \text{------------------------------- (3)}$$

Where: σ is standard deviation, x_i is Analyzed stations, μ is Re-analyze stations, N and is Number of stations

Results and Discussion

The rainfall distribution according to the type of climate that clearly effect on the kind and amount of it. Where the northern of Iraq had influence by Mediterranean climate that obviously received high amount of rainfall (>250 mm). Verification against the up-scaled observations shows that much of this bias is still present figure 2 on i.e., Sulaymanya, and Erbil (310.25, 237.25 mm) respectively. Whereas the central and southern of Iraq influence by semi-arid climate type that received less than (150 mm). That was clearly finding out in the central Baghdad and Najif (120.35 and 83.95mm) while south-west region Basra, Ramadi (69.35, 54.75mm). The nest distribution of Iraqi stations to achieved great accuracy need to provide the large number of stations to work as requirement to GIS program that built in. If there are a few stations, the program does not work due to the lack of input data accessible that necessary for available to reach the optimal outcome.

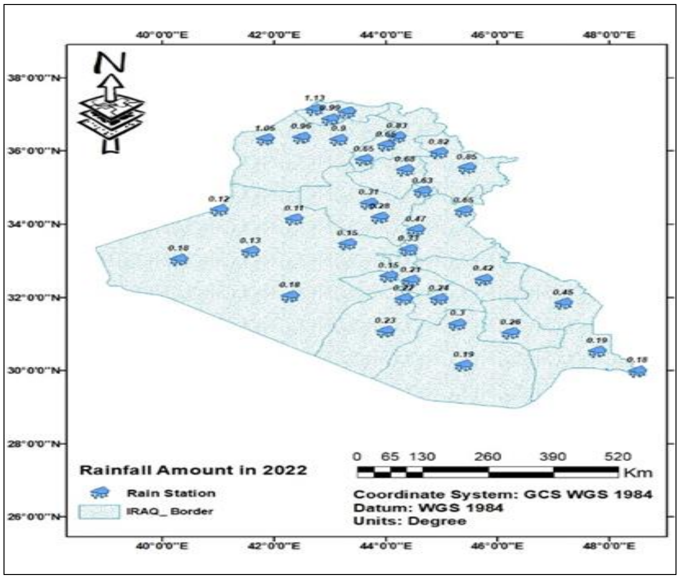

Figure 2. Distribution of annual rainfall observation for 2022 in Iraq

The data application performed using a GIS program meme, providing the algorithm for 30 stations' data that selected six stations from the total number of stations. These six-station chosen according to zooms that covered all of Iraq, taking into account the impact of climate change on Iraq to obtain output data to weigh each station. as shown in Figure 3. The indicator (IDW) depended on process of statistically computerized that presented value greater than observation rainfall by (0.35 mm/day) relatively for selective stations. In addition, the display as contour lines a new distribution that found out high value in northwest region the selection of stations distributed. Western of Iraq received less amount of rainfall in IDW method that disagree with observation data.

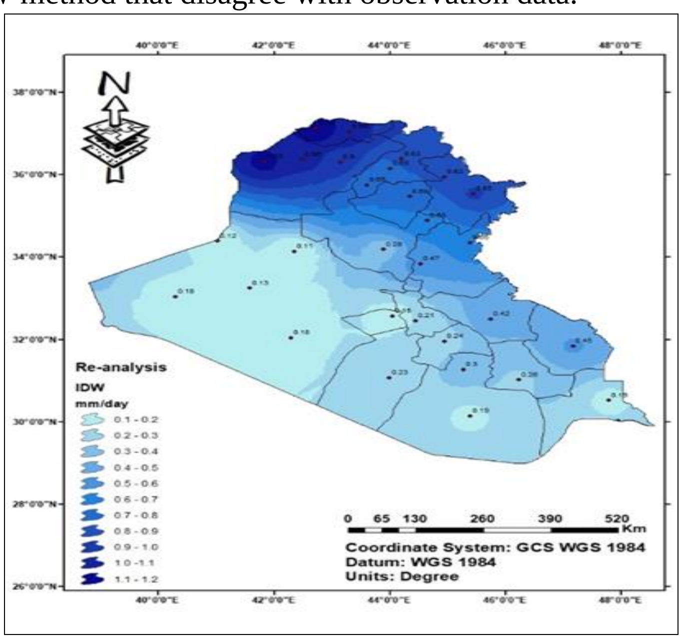

Figure 3. Annual rainfall distribution by using IDW indicator.

Kriging indicators has used artificial intelligent for distribution information of the element that used in this research. The surrounding point represent an important relationship for estimated objective point than grid points that used in IDW for this reason that shown the best results in Figure 4. The comparison IDW with kriging indictor procedures less value in average (0.15 mm/day). This lead to think that Kriging methods more efficient toward rainfall than both observation and IDW. The sensitive region in Iraq that appear in western part, which shrinkage area of minimum value in Kriging indictor. Similar case that found in Fao, while maximum region had more gradient in couture line. When deal with this indicator, lead to structure data that used previously entered as input and same way for processed using computerized techniques. The data here was very satisfied to the approved data, which verify outcome optimized for observational data.

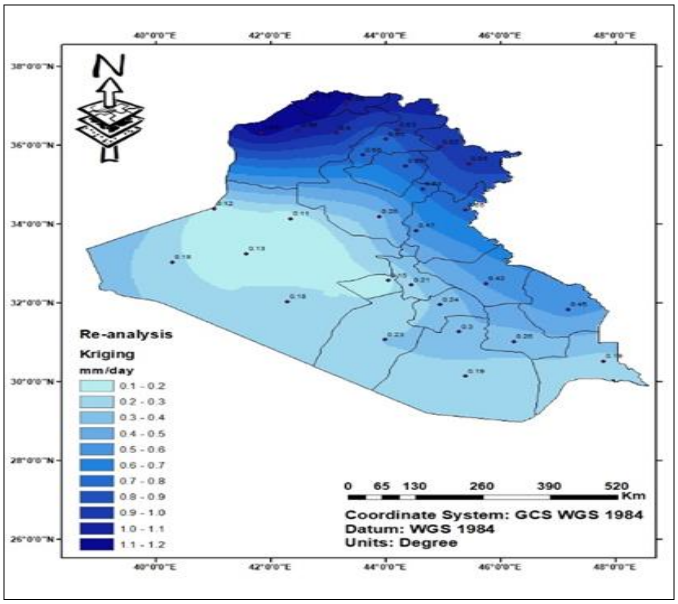

Figure 4. Kriging indicator.

Precipitation data obtained from NASA combined data for year 2022. The continuity time a series for whole year distributed over all governorates of Iraq. The ARC-GIS program used to re-analyze the combined data using two methods: inverse distance weighted (IDW) and statistical function to a set number of points, otherwise to all points within a set radius (Kriging). The results on rainfall amounts for each indicator appear as in Table 2, yield performed computerized statistical operations for all stations. Kriging indicators presented a significant analysis of the amount of rainfall and then re-analyzed it.

Table 2. Re-analyze of indicators.

Stations		Annual rainfall 2022 in mm/day (D)	Re-analyze-IDW in mm/day (E)	Re-analyze-kriging in mm/day (F)
1	Fao	0.18	0.22	0.19
2	Baghdad	0.33	0.37	0.33
3	Duhook	0.99	1.10	1.00
4	Najaf	0.22	0.24	0.21
5	Ramadi	0.15	0.21	0.15
6	Tikrit	0.31	0.40	0.33

The analytical method for distributing the stations indicated the locations of the stations without classifying the quantities on the rest of the lines of longitude and latitude, and that the northern regions are the highest in terms of rainfall amount, and the central and southern regions are the lowest. It was not possible to calculate the regression for rainfall in the neighboring regions and classify them, while the statistical methods for re-analysis (IDW and kriging) were sufficient to extract rain cantor and slope in a way that allowed each region to classified and to conduct a study and evaluate it. The IDW indicator showed that decline of the amount of rainfall in the northeastern regions was received larger amounts of rainfall. The comparison among three different regions: northern, central and western. Kriging indicator results sequential extraction from the area with the high rainfall extend to the area with the least amount of rainfall. By re-analyzed the data and extracting the standard deviation. That found out Kriging index presented a good giving result closer to observation, as in Table 3. Where SD Kriging was (0.0108012), whereas near to the SD value and that mean was closer to the greater the reliability results Table 3, SD value and that mean was closer to the greater the reliability results.

Table 3. $(D-E)^2$ and $(D-F)^2$ values.

	Stations	$(D-E)^2$	$(D-F)^2$
1	Fao	0.0016	0.0001
2	Baghdad	0.0016	0
3	Duhook	0.0121	0.0001
4	Najaf	0.0004	0.0001
5	Ramadi	0.0036	0
6	Tikrit	0.0081	0.0004
σ		0.0675771	0.0108012

The analytical method for distributing the stations indicated the locations of the stations without classifying the quantities on the rest of the lines of longitude and latitude. In addition, the northern regions are the highest in terms of rainfall amount, and the central and southern regions are the lowest. Moreover, it was not possible to calculate the regression for rainfall in the neighboring regions and classify them, while the statistical methods for re-analysis (IDW and kriging) were sufficient to extract rain cantor and slope in a way that allowed each region to classified and to conduct a study and evaluate it. The indicator (IDW) showed that the decline of the amount of rain in the northeastern regions was receiving larger amounts of rain compared to the northern and central regions and other random parts, while the indicator (kriging) made a sequential extraction. From the area with the most rainfall, extending to the area with the least amount of rainfall. Its purpose was to provide precipitation data in data-poor areas, to enhance knowledge of the amount of rain falling over the region, and to ascertain which two indicators were best at extracting data that could compared to satellite data.

Conclusions

The study of the terrain affects the amounts of rainfall, which method to find more accurate of rainfall in the northern regions well known by mountainous nature. The western regions got less rainfall beside that does not retain water because sandy nature of it. The central and southern regions are sedimentary regions so that retain water, but the amount of rainfall falling on them was small, and the program confused notice GIS has these effects. It was useful for studying and treating many areas by have knowledge about the pattern of rainfall, slope and contour. In addition, the amounts of rainfall on Iraq decrease from north to south. The results indicated that the central, southwestern, and southern regions until now suffering from drought and desertification. The IDW indictor found western region of Iraq had less amount of observation rainfall, while other regions witness more than amount of rainfall by (3.5 mm/day). The Kriging indicator found sensitive region in Iraq that appear in western region, which shrinkage area with minimum value in amount rainfall Similar case found in Fao too. The high gradient in couture line proportional with maximum rainfall region in the northern region. The comparison between observation with both of IDW and Kriging. The percentage error between observation and Kriging indictor had less error - witness more than amount of rainfall by (0.15 mm/day) - than observation and IDW, for this reason recommend Kinging indicator for estimate amount of rainfall in Iraq. Kriging index had high ability relaxing analysis data than IDW although had different technique especially for rainfall amounts.

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