The spatial analysis and optimization of rain gauging station network in Kurdistan Province using the Kriging Error Variance

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Extended Abstract

Introduction

The prediction of the occurrence of floods and the reduction of damages caused by it is strongly influenced by the modeling of physical phenomena and the spatial-temporal distribution of precipitation. The purpose of the research was to optimize the rainfall gauging network in Kurdistan province using Kriging estimation variance and taking into account the topography of the area. In this study, to optimize the rain gauging network in Kurdistan province, rainfall data of the rain gauging, synoptic, and climatology stations were used. In order to reduce the costs, stations close to each other that are located in the same height range and also have the same error variance, were removed from the existing network. In order to reduce the maintenance cost of the stations, after clustering of the area, 8 stations whose removal had little impact on the accuracy of the data, were identified in the province. Then. In order to strengthen the network, the optimization of new stations was put on the agenda and 28 points were set as the proposed stations.

Materials and methods

After reviewing the existing stations' data, 145 stations were selected for the analysis and optimization of the existing network. After selecting the normal data and spatializing them, due to the large extent of the area and the variability of the average annual precipitation, Kurdistan province is divided into smaller regions with less variations in the average rainfall. The regional division or clustering of stations is carried out using the functions available in the ArcGIS 10.2.2 software and based on the main catchment basins. In the next step, the spatial distribution of rainfall and the variance of the errors in all clusters are calculated separately. Given the importance of highlands in receiving rainfall and supplying water, the distribution of rain gauges on elevation layers has been studied. At this stage, redundant stations were eliminated, and stations which are located in close proximity of each other, and are located in the same elevation range and also have the same error variance, can be eliminated too. At the final stage, adding new stations and strengthening the network took place. At this stage, the priority is to build the station for areas where the variance of the errors is high. After adding each station, the error variance of the whole system is calculated again. Adding a new station to the network will continue as long as the network error reaches its minimum.

Discussion

1-Normality test of data

After spatializing the rainfall data, their normal distribution was investigated using the Kolmogorov – Smirnov

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test. The results show that the distribution of data at 95% level does not have a significant difference with a normal distribution.

2- Division of the region and clustering of stations

In this study, using the region's digital elevation map, and based on the analyses made in the software ArcGIS 10.2.2, clustering of stations and division of the region was carried out. The entire area of interest is divided into 8 clusters.

3- Calculating the Kriging error of the existing network

The amounts of the rainfall data error can be obtained by calculating the Kriging error of the existing network. As mentioned in the previous sections, the calculation of the error in the Kriging method is a function of semi-variogram (spatial structure) of the variable and this feature increases the estimation accuracy of the variable error.

4- Distribution of the stations on elevation layers and determination of the redundant stations

By studying the distribution of the stations on altitudes, stations which had no impact on the accuracy of data extraction were removed. The candidate stations for removal were located in a same range of elevation, and showed similar error values. In order to be sure of the decision taken, by eliminating each station, the overall error of the network in each cluster is calculated, and an increase in the error values represents the wrong station is being removed.

5- Adding the proposed stations and calculating the variance of the new network error

Adding new stations to the network is done based on the Kriging variance. The priority of the station construction is for areas that display a high error. In the Kriging error variance method, adding a new station to the network is done based on $E\acute{o}^2$ (error variance), in a way that points with equal error variance or greater than the value of data variance is considered as the first priority for the construction of the station. The points whose error variances are between the variance of data and ½ of the variance of data, is the second priority and finally, the third priority belongs to the points whose variances are between ½ and ¼ of the variance. In this research, based on Kriging variance, 28 stations have been proposed to strengthen the rain gauging network in Kurdistan Province.

Conclusion

Given that precipitation is considered as the main entrance to the planning of sustainable water resources development, in this study, the optimization of rain gauging station network in Kurdistan province was investigated using the Kriging error variance. In previous studies, generally, entropy has been considered as the main model for network modification, therefore, due to the limitations of these methods in not using the semi-variogram features, in this research, the geo-statistic method based on kriging error variance was used due to its high accuracy. The amount accuracy increase in this method depends to a large extent on the semi-variogram features (spatial structure) of the precipitation, which can be used to calculate the error variance rate for the new station before the construction and inventory of the station. In order to strengthen the network, the optimization of new stations was put on the agenda and 28 points were set as the location of the proposed stations. For practical comparison of the results, the error variance values were calculated before and after the addition of the proposed stations, the average error variance of the annual precipitation in the province decreased by 11%, with the largest decrease belonging to the central part of the province with 24.03%.

Keywords: Optimization, geo-statistics, Error variance, Rain gauging network, Kurdistan Province

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