Uncertainty in the Spatial Interpolation of Urban Rain Gauges Data

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Abstract

Rainfall data is useful in many fields such as urban management, agriculture, and so on. Spatial interpolation is widely used to interpolation continue rainfall data from discrete rainfall gauges. The uncertainty in spatial interpolation is change in different region. Paper focus on urban small area of Beijing city, Xicheng District and analyses uncertainty of spatial interpolation from four aspects: rainfall gauge number, density, position, spatial interpolation methods. RMSE and cross-validation is adopted to evaluate the accuracy of interpolation and the lowest RMSE is taken as optimal. The results suggest that more gauges can get a good performance with low error compared to little stations; and dense gauges network gets high accuracy than sparse station. Ordinary kriging is simple than other method and has a good estimation (except co-kriging) in small area spatial interpolation. Co-kriging has a high accuracy in interpolation but complex in computation and must be considering in the other variables.

Keywords: uncertainty, rainfall gauge data, spatial interpolation, RMSE.

1. Introduction

The rainfall is considered a useful variable in many fields other than agriculture, such as ecology, forestry, health and diseases, and other civil engineering (Chapman and Thornes, 2003). Often, continuous rainfall data is necessary to model continuous phenomena. Thus, rainfall data interpolation is important. A number of methods have been proposed for the interpolation of rainfall data. Spatial interpolation of rainfall data is of great importance for hydrological modelling (Ly and Charles et al., 2011).

Rainfall estimation by rain gauge-radar combination is a professional method in meteorology(Haberlandt, 2007; Garcia-Pintado and Barbera et al., 2009). This method can get a more precise value, but the limitation is the lack of meteorological knowledge. In addition, spatial interpolation of precipitation data is of great importance for hydrological modelling (Ly and Charles et al., 2011). Geostatistical methods are widely applied and increasingly preferred in spatial interpolation from point measurement to continuous surfaces. It allows one to capitalize on the spatial correlation between neighboring observations to predict attribute values at unsampled locations.

Uncertainty is a hot research issue in rainfall interpolation. The accuracy and subjectivity (degree of subjective influence in the data) are the main research interests. Four spatial interpolation methods, including Thiessen polygon, inverse distance weighted (IDW), ordinary kriging (OK), and ordinary cokriging (OCK), were widely adopted for spatial interpolation (RichardE and Valerie et al., 2006; WenXia and Xiaoling et al., 2010; Luo and Xu et al., 2011; Xian and Youpeng et al., 2011; Ma and

Zuo, 2012). In these studies, gauge number, interpolation method, the spatial-temporal scale of data is most often mentioned. But those are focus on large spatial scale, lake, river basin. In urban regional environment, the influent elements are changed. In urban area, such as Beijing Xicheng district, the influence of terrain elevation and urbanization feature (mountains and lakes) is weak. In discrete gauges monitor mode, the position, number, density of stations and interpolation methods are the main elements for uncertainty research.

The objectives of this study were focused on uncertainty of spatial interpolation of rainfall data of local regional area in Beijing Xicheng district. In this paper, about four spatial interpolation methods are introduced to estimate rainfall data; and low root-mean-squared error (RMSE) is used to indicate the accuracy of interpolation data. Comparison and cross validation are brought in to evaluate the influence of gauge number, density, interpolation methods for spatial interpolation of rainfall data.

2. Methodology

Thiessen polygon, inverse distance weighted (IDW), ordinary kriging (OK), and ordinary co-kriging (OCK) are used for spatial interpolation considering other factors such as gauge numbers, gauge density, gauge position. For number test, we used different number of closed station and evaluated accuracy; with density test, we chosen some gauges at dense, middle, sparser area and tested its' value; for position, we adopted some gauges with different distance for test.

Low root mean squared error (RMSE) shows reliable estimates for the areas where the rainfall intensity is not known. The cross-validation is performed with different set of parameters and rainfall gauges each time and the set with the lowest RMSE is taken as optimal.

3. Experiment and Result

As a central district of Beijing of China, Xicheng District is home to the headquarters of the Communist Party of China, offices of State agencies and more than 80 governmental ministries and agencies. The area of Xicheng District is about 50 km^2 and has a little climatic diversity. By 2012, about 34 rain gauges station were deployed in Xicheng district. In here, we used 34 stations data.

For the main procedures we used the package Geostatistical Analyst package of software Arcgis 10.1. (ESRI, 2012), which were carried out trend analyzes, adjusting of semivariogram and cross-validation. We used inverse distance weighted (IDW), ordinary kriging (OK), and ordinary co-kriging (OCK) for experiment and get preliminary result.

As mentioned in IDW principle, weights are proportional to the inverse of the distance raised to the power value *p*. Therefore, An optimal power value can be determined by minimizing the root mean square error (RMSE). In here, we used

ArcGIS function to evaluate the optimal power value(for example p = 1.085).As shown in below figure, RMSE of IDW is 30.22655, but it is 32.61151 in ordinary kriging.

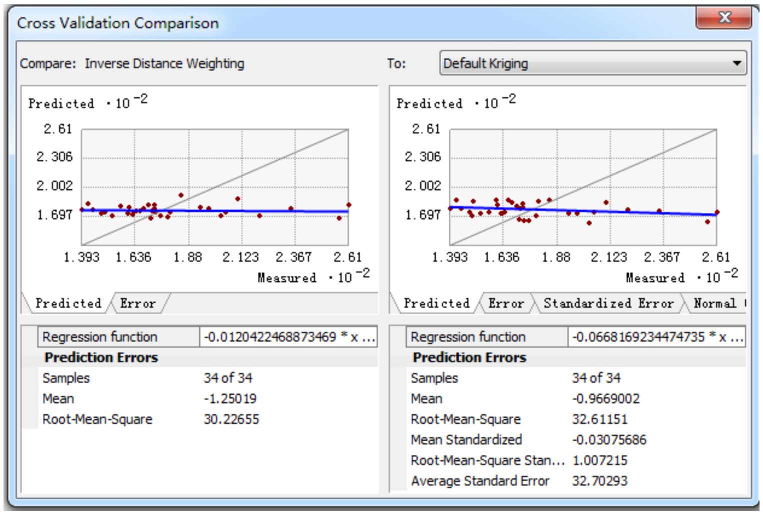

Figure1: Cross Validation Comparison dialog shows the comparing between IDW and ordinary Kriging.

4. Conclusion

For the spatial interpolation of rainfall gauges data in Beijing Xicheng District tended to tell the truth that influence of terrain and environment is weak. Source data and method used in spatial interpolation are the main factor of uncertainty.

Different gauges number brings different uncertainty in spatial interpolation. More gauges can get a good performance with low error compared to little stations. The different interpolation scales (such as distance between stations) give the different results. Dense gauges network with small distance can get accurate estimation than long distance. Different spatial interpolation methods have big difference in results. These results suggest that ordinary kriging is simple than other method and has a good estimation (except co-kriging) in small area spatial interpolation. But co-kriging is complex than other and should be considering in the other variables.

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