بسم الله الرحمن الرحيم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها

علي هذه الأفلام قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأفلام بعيدا عن الغبار

في درجة حرارة من ١٥-٢٥ مئوية ورطوبة نسبية من ٢٠-٤٠%

To be Kept away from Dust in Dry Cool place of 15-25- c and relative humidity 20-40%

بعض الوثائـــــق الاصليـــة تالفـــة

بالرسالة صفحات

لم ترد بالاصل

Cairo University
Faculty of Economics and Political Science
Department of Statistics

Spatial Modeling of Air Pollutants: The Case of Greater Cairo

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A Thesis submitted to the department of statistics, Faculty of Economics and Political Science in partial fulfillment the requirements for M.Sc. degree in statistics

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Abstract

Due to rapid population growth, ambitious development and industrialization facilities, pollution can be considered the expensive cost for development .The aim of this study is to introduce the main spatial techniques applied to modeling air pollution and applying it on Greater Cairo during 2007. Spatial modeling for three air pollutants (NO_2, SO_2, and PM_{10}) measured by the monitoring stations network have been conducted. Four methods for spatial interpolation have been used which are; Inverse Distance Weighting (IDW), Trend Surface Model, Splines, and Kriging. Data exploration and preparations required for applying kriging have been conducted including testing for normality, autocorrelation, and stationarity. Using Kolmogrov test no transformations were needed for NO_2 and PM_{10} while for SO_2 a square root transformation was needed to achieve normality .Using tests of similarity, the spatial stationarity has been assumed. These tests include Mann Witney, Wilcoxon, Kolmogrov-Semirnov, and Leven's test. Using root mean square (RMS), kriging and cokriging gave the best results for NO_2 and SO_2. However for PM_{10} linear trend surface model gave the best results. The main results of the study showed that PM_{10} values have exceeded the permissible limit in the stutied area. But NO_2, and SO_2 have only exceeded their permissible limits at specific areas only.

Keywords: Air Pollution, Spatial Interpolation, Kriging, Splines, Inverse Distance Weighting, Trend Surface Model, Cokriging

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Spatial Modeling of Air Pollutants: The Case of Greater Cairo

Summary of the thesis:

The aim of this study is introducing the main spatial techniques used for modeling air pollution and applying it on Greater Cairo during 2007. Spatial analysis for three air pollutants (NO_2, SO_2, and PM_{10}) measured by the monitoring stations network have been conducted.

This thesis can be decomposed into 5 chapters. Chapter 1 includes the introduction Chapter 2 represents the previous studies that have targeted similar concepts and aims. The *Spatial Analysis* concepts which are the methodology and statistical techniques are discussed in Chapter 3. Chapter 4 introduces the *case study* including the description of the *Greater Cairo Area* which is the area under study, the *data* used, and the results and findings after applying the spatial analysis techniques. Finally, chapter 5 includes the conclusions and recommendations.

From the literature review it is noticeable that most of the Egyptian studies have depended only on some descriptive methods and rarely some elementary inferential methods like the testing of hypothesis were used. The papers covering other countries have depended on more advanced techniques of spatial statistics, using data collected from network of monitoring stations. Application of more formal techniques for modeling air pollutants in Egypt is needed. This was the main motivation for developing this study

The applied methodology builds on spatial techniques. These techniques will be subsequently described. The reason for using these techniques should be noted. When data are geographically referenced, i.e., very rarely independently identically distributed (i.i.d), spatial dependence can exist and this dependence may be in all directions and the

relationships are highly complex. Distant data are less dependent than those that are near each other.

The data used in the analysis are the measurements of the air pollutants; NO_2, SO_2, and PM_{10} from air quality stations distributed through the Greater Cairo area. These stations are operated under the supervision of The Egyptian Environmental Affairs Agency (EEAA). The stations can be classified as industrial, urban, residential, traffic, remote and mixed. Each station measures one or more of the previously stated pollutants.

In spatial data the location of each monitoring station must be specified. The longitude and latitude are used as the coordinates for each monitoring station.

Arcgis is used for the analysis, where the *Geostatistical analyst* extension is utilized for applying the different interpolation techniques

The data analysis is divided into two main parts: data description and spatial interpolation.

From the data description, one can conclude that PM_{10} values exceed the permissible limit for all the available stations. Elkolaly and Fum Elkhalige exhibit the largest values of NO_2, and SO_2 which exceed the permissible limits. The fourth quarter can be considered the highly polluted period in year 2007. It witnesses the largest values of the three pollutants.

In the spatial interpolation part Four methods for spatial interpolation have been used which are; *Inverse Distance Weighting (IDW), Trend Surface Model, Splines*, and *Kriging*. The linear trend surface model was the first approach used to interpolate the values of the pollutants SO_2* (the transformed SO_2 to achieve normality), NO_2, and PM_{10}. Three maps were created for the Greater Cairo area for each pollutant. Linear trend surface model, was used with the three pollutants (SO_2*, NO_2, and PM_{10}) as it has the minimum RMS (Root Mean Square) compared to the quadratic and cubic models.

Using Inverse Distance Weighting, and setting p=2 , a map for the Greater Cairo area has been produced. Using the *optimal power*, other maps have been created using these powers. The optimal powers 1, 1.2714, and 2.5375 were used for NO_2, SO_2*, and PM_{10} respectively resulting in smaller root mean square (RMS) values. Although the values of the RMS using the optimal powers are smaller than that using the most commonly used power of 2, but the differences are very small.

Splines were also used as an interpolation method for the three pollutants. Thin plate spline gives the worst results while regularized spline and thin plate spline with tension give much better RMS values. Spline with tension can be considered the best interpolation methods for the three pollutants.

Comparing the RMS resulted from the different methods of interpolation used for each pollutant, Ordinary kriging can be considered the best method for interpolating NO_2 and SO_2*. While for PM_{10} the linear trend surface model is the best interpolating method.

One can notice that the difference between the RMS for ordinary kriging and Linear trend surface model for PM_{10} is very small, this may be due to the fact that Moran's I indicator and variogram graph shows no spatial autocorrelation while for NO_2 there is a significant spatial autocorrelation.

Cokriging gives good results, but the difference between it and ordinary kriging is not very large and this may be due to the fact that the three variables are not strongly correlated so there is no reason for using cokriging.

Since kriging gave the best result for interpolating the air pollutants used in the study, the details of applying it are introduced, including studying normality, spatial autocorrelation, and stationarity. Maps for the predicted values of each pollutant are presented using the kriging and cokriging methods as well as maps for the standard error values.

Based on the results and finding some conclusions and policy recommendations are presented as follows:

Conclusions:

In case of spatial autocorrelation kriging methods should be used for modeling spatial data as it can be considered the best interpolation method comparing to other interpolation methods (IDW, Splines, and Trend surface models). Besides, Kriging is the only method that gives the prediction standard error values.

Using Root Mean Square (RMS), cokriging gives better results than ordinary kriging although the difference between them is very small.

Greater Cairo area is suffering from a serious problem of Particulate Matters (PM_{10}) as its level exceeds the permissible limit stated by the Egyptian Law in the whole area under study. Down Town is suffering from high levels of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) concentrations.

Poor data areas, which are areas with insufficient number of sampling points (stations), have the largest values of prediction standard errors.

Recommendations:

Spatial analysis techniques must be used for analyzing air pollution and any environmental data sets. We cannot depend on descriptions only we need to get a general and reliable view for the whole area and that can be done through spatial analysis and take into consideration the autocorrelation effect. Kriging approach must be adopted as it gives good results and it is the only approach by which the reliability of the prediction can be assessed using the standard error values.

A great concern must be given for the monitoring stations. The quality of the stations themselves must be improved as the data sets contains huge amount of missing data due to technical problems. The distribution of the stations must be reconsidered in order to get more reliable results with smaller standard errors. There should be sufficient number of stations for each the pollutant in order to allow studying all these pollutants using spatial techniques.