A spatial analysis of Fine Particulate Matter and Aerosol Optical Thickness in China

Introduction

Fine particulate matter (pm2.5) is a major air quality concern. It is defined as particulate matter with diameter of 2.5 um or less. Airborne particulates can be inhaled by the human lungs, where they are absorbed into blood and consequently are responsible for harmful health effects. “Aerosol Optical Thickness” is the degree to which aerosols prevent the transmission of light by absorption or scattering of light. AOT could also be used to estimate the air condition.

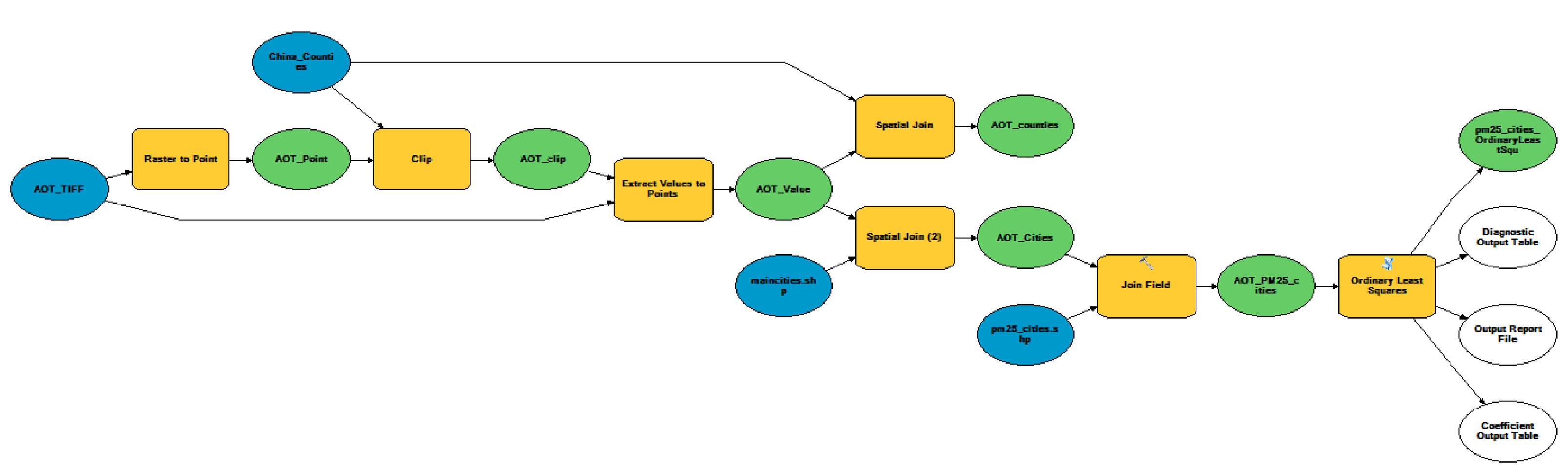
Studies showed there is a linear correlation between PM2.5 and AOT in separately considering with several cases, like anthropogenic aerosol, dust aerosol. In this study, the relationship between PM2.5 and AOT will be tested based on dataset of China. Since PM2.5 concentrations depend on meteorological conditions, the correlation of PM2.5 with meteorological data and AOT with meteoroidal data would be tested, too.

It is known that China is suffering serious air pollution. Chinese government has made the decision to enforce stricter regulations., like development of other energy, . The aim of this study is to improve the air condition monitoring methods and provide efficient advice for Chinese government to make policies of managing air pollution.

Method

ArcGIS

This chart shows the methods used in ArcGIS, which resulted in AOT and PM2.5 distribution in China on county level, city level and a regression result of AOT by PM2.5.



Geoda

Spatial error regression

Data Source	PM2.5.shp	AOT.shp
Dependent Variable	PM2.5	AOT
Independent Variable	Temperature Humidity Wind Speed	Temperature Humidity Wind Speed

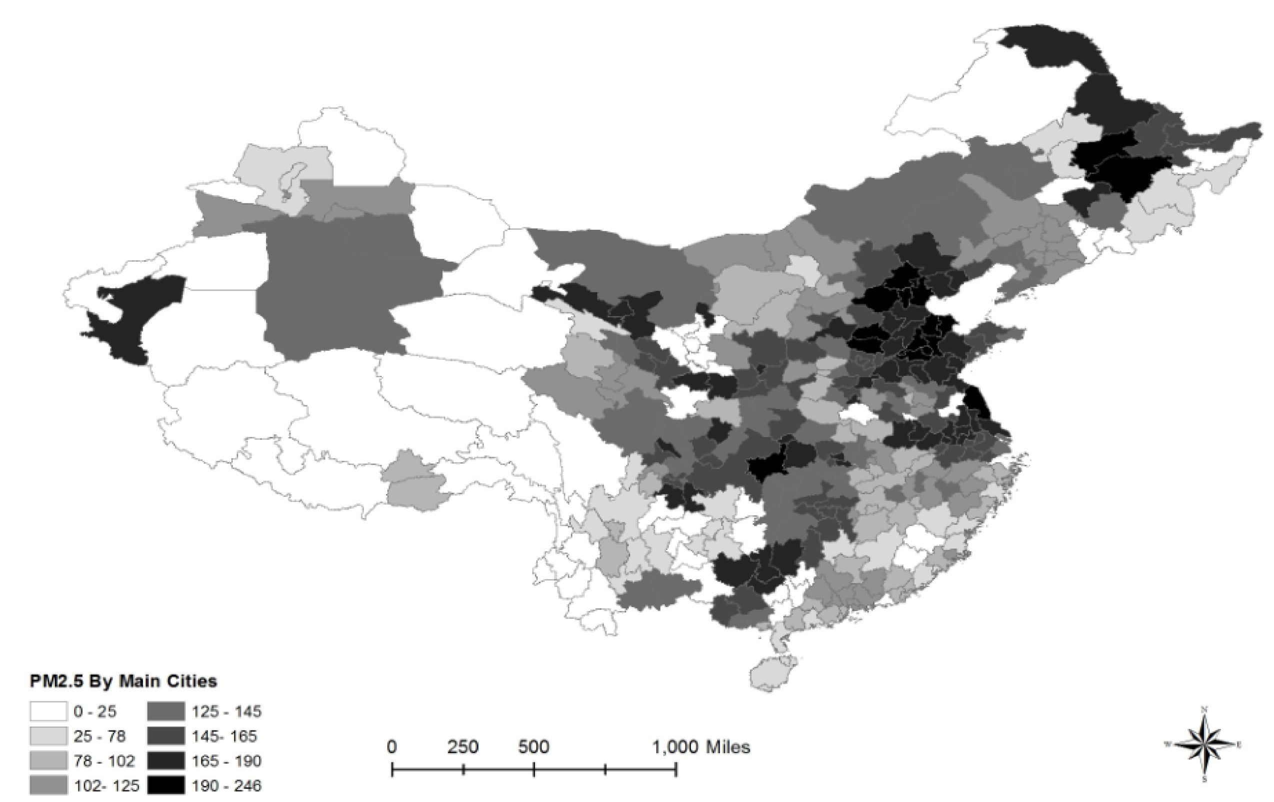
These two regression are both used spatial error model. Because there is spatial dependence among independent variables.

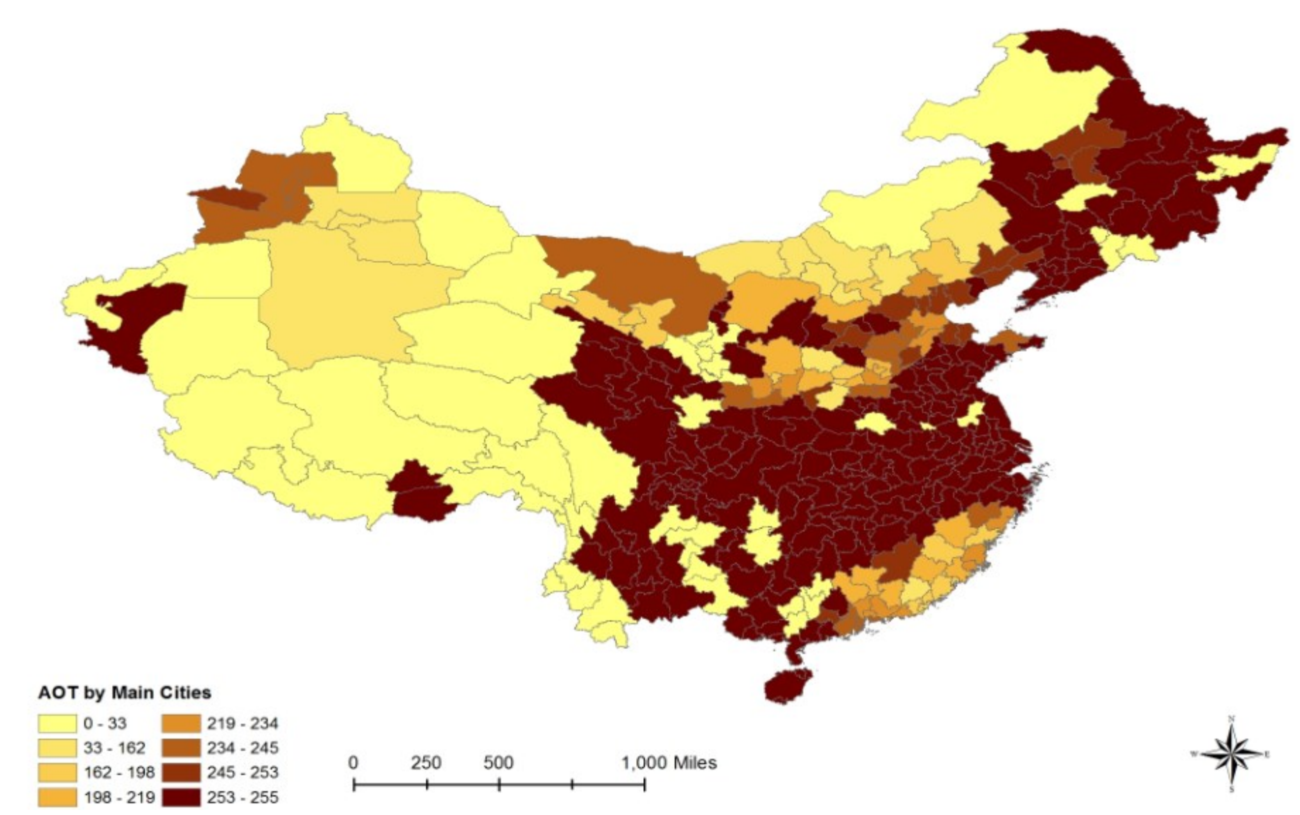
Cluster map

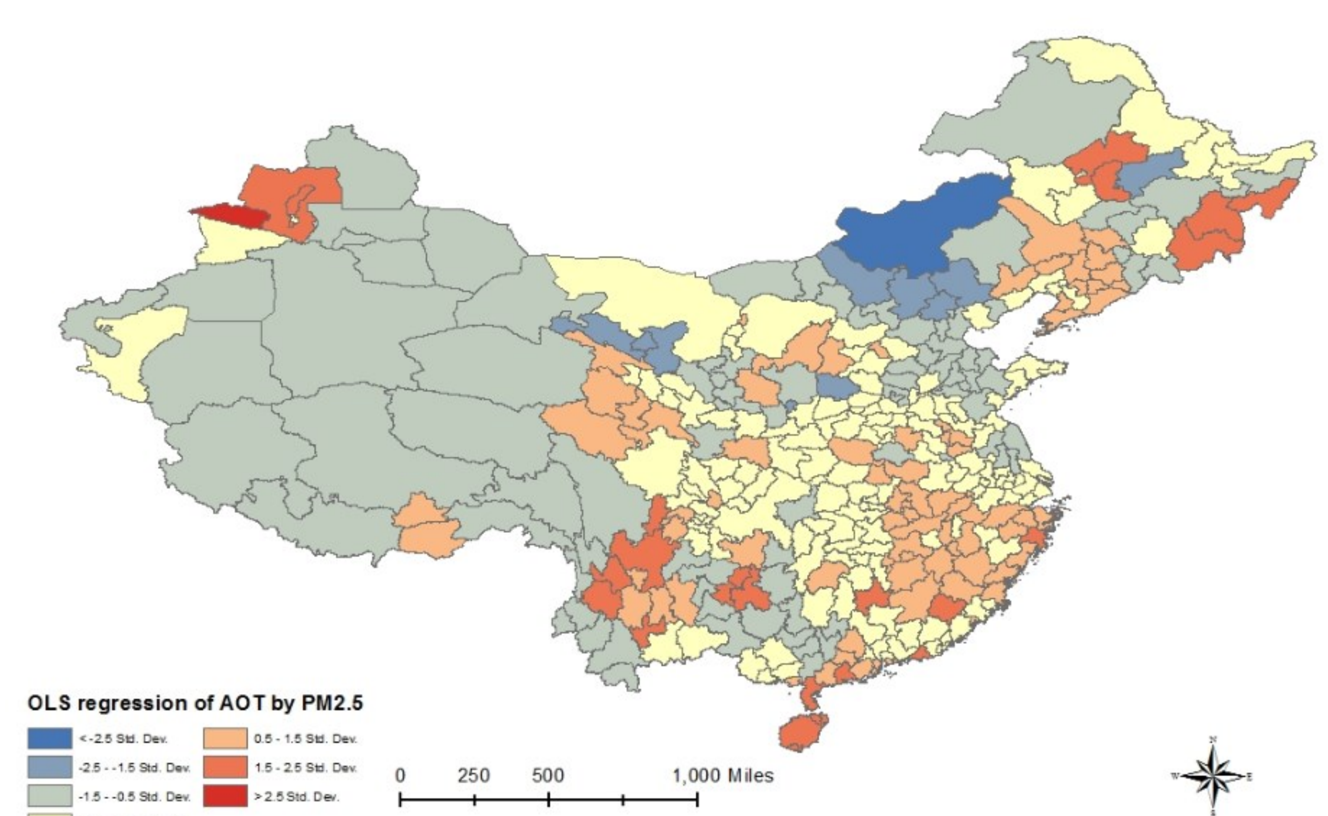
Cluster maps of PM2.5, AOT and a OLS regression of AOT by PM2.5 are created by Univariate Local Moran’I. The results would show the high air pollution clustered areas and low air pollution clustered areas estimated by PM2.5 and AOT. The cluster map of OLS (ordinary least squares) regression of AOT by PM2.5 would compare the different results estimated by PM2.5 and AOT..

Result

Spatial Distribution of PM2.5, AOT and Regression Residuals of AOT







Results of spatial analysis

Moran’s I

Data set	PM2.5 (counties)	AOT (counties)	Regression of AOT by PM2.5 (counties)
Moran’s I	0.524213	0.585508	0.587581

All these three spatial distribution of high values and low values in datasets is spatially clustered (based on the statistically significant p-value).

Regression

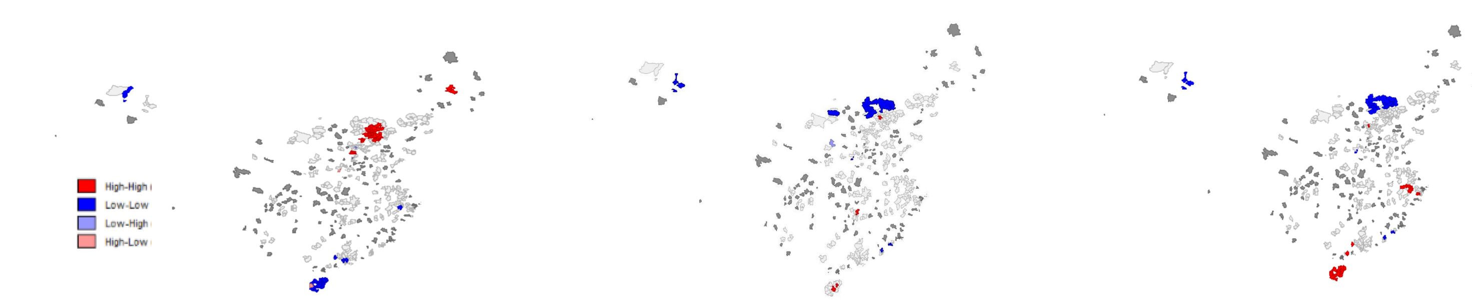
Variable	Coefficient	Std.Error	z-value	Probability
CONSTANT	173.239	7.64974	22.6464	0.00000
Temp_N	-1.70686	0.17363	-9.83045	0.00000
Humidity_N	-0.0729417	0.0753173	-0.968459	0.33282
wind2	0.531506	0.434641	1.22286	0.22138
LAMBDA	0.787904	0.0198951	39.603	0.00000

Among the indicators of PM25 regression, only the value of Temperature is negatively related to PM2.5. While other factors have insignificant effects.

Variable	Coefficient	Std.Error	z-value	Probability
CONSTANT	229.339	6.30983	36.3463	0.00000
Avg_wind2	0.299434	0.492161	0.608405	0.54292
Avg_Humidi	0.0895829	0.0771908	1.16054	0.24583
Avg_Temp_N	0.266775	0.195968	1.36132	0.17341
LAMBDA	0.655863	0.0286358	22.9036	0.00000

Among the indicators of AOT regression, there is no significant factors .

Cluster map

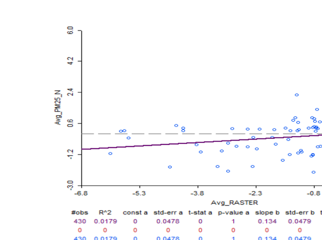


	PM2.5	AOT	Regression of AOT by PM2.5
Hebei province and Beijing	High-high	Low-low	Low-low
Hainan Island	Low-low	High-high	High-high

Relationship between PM2.5 and AOT

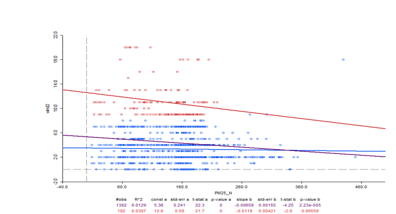
Summary of OLS Results - Model Variables

Variable	Coefficient [a]	StdError	t-Statistic	Probability [b]	Robust_SE	Robust_t	Robust_Pr [b]
Intercept	82.370582	6.758203	12.188238	0.000000*	9.423891	8.740613	0.000000*
AVG_AVG_PM	1.109413	0.053229	20.842365	0.000000*	0.066500	16.683021	0.000000*



PM2.5 is positively related to AOT but positive effect is not very strong.

Relationship between PM2.5 and Wind speed

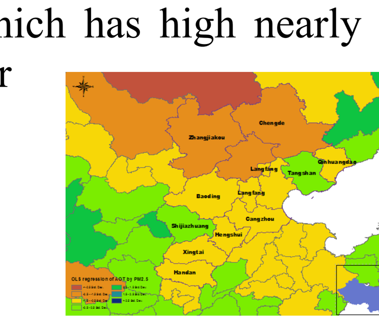


Based on the result of regression of PM2.5, the wind speed has insignificant effects. But when the analysis focus on high wind speed (nearly or over 10), the negative effect on PM2.5 is significant. The result indicates that when the wind speed is high enough, it has a significantly negative effect on PM2.5.

Discussion and Further study

Comparing the air condition of Hebei Province and Hainan Island, both PM2.5 and AOT value estimate a lower air pollution in Hainan. While in Hebei Province, the PM2.5 value showed a low air condition, in contrast, the AOT value showed a better air condition. Based on the cluster map of Regression of AOT, the low correlation between AOT and PM2.5 clustered in Hebei Province and the high correlation clustered in Hainan explained the different estimations of air condition.

Unfavorable atmospheric diffusion conditions often cause different levels of air pollution in different atmospheric layer. Shijiazhuang is a city of Hebei, which has high nearly formation contaminant concentration, but its atmospheric mixed layer pollutant load is not high (LiMeng, 2015). The similar results also showed in this study. Hebei province and Beijing area showed a low-low cluster of the OLS results, which means in Hebei and Beijing area, the values of AOT and PM2.5 are significantly negative related. This study supports the previous work. Further study could focus on more detailed measurements of air pollution.



Citation

PM2.5 data source: Center for Geographic Analysis (CGA) Data verse, Harvard

AOT data source: NASA Earth Observations

China county map: Open Geospatial Consortium

China city map: Esri Support Center

Picture source: http://projectpengyou.org/wp-content/uploads/2013/04/beijing-smog-469x300.jpg

Li M, Tang G, Huang J, et al. Characteristics of winter atmospheric mixing layer height in Beijing-Tianjin-Hebei region and their relationship with the atmospheric pollution[J]. Environ. Sci, 2015, 36(6): 1935-1943.

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Geographic Coordinate System:

WGS 84

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