

**Spatiotemporal Variations of Aerosol Optical Depth and the
Spatial Heterogeneity Relationship of Potential Factors Based on the
Multi-Scale Geographically Weighted Regression Model in Chinese
National-Level Urban Agglomerations**

Supplementary Material

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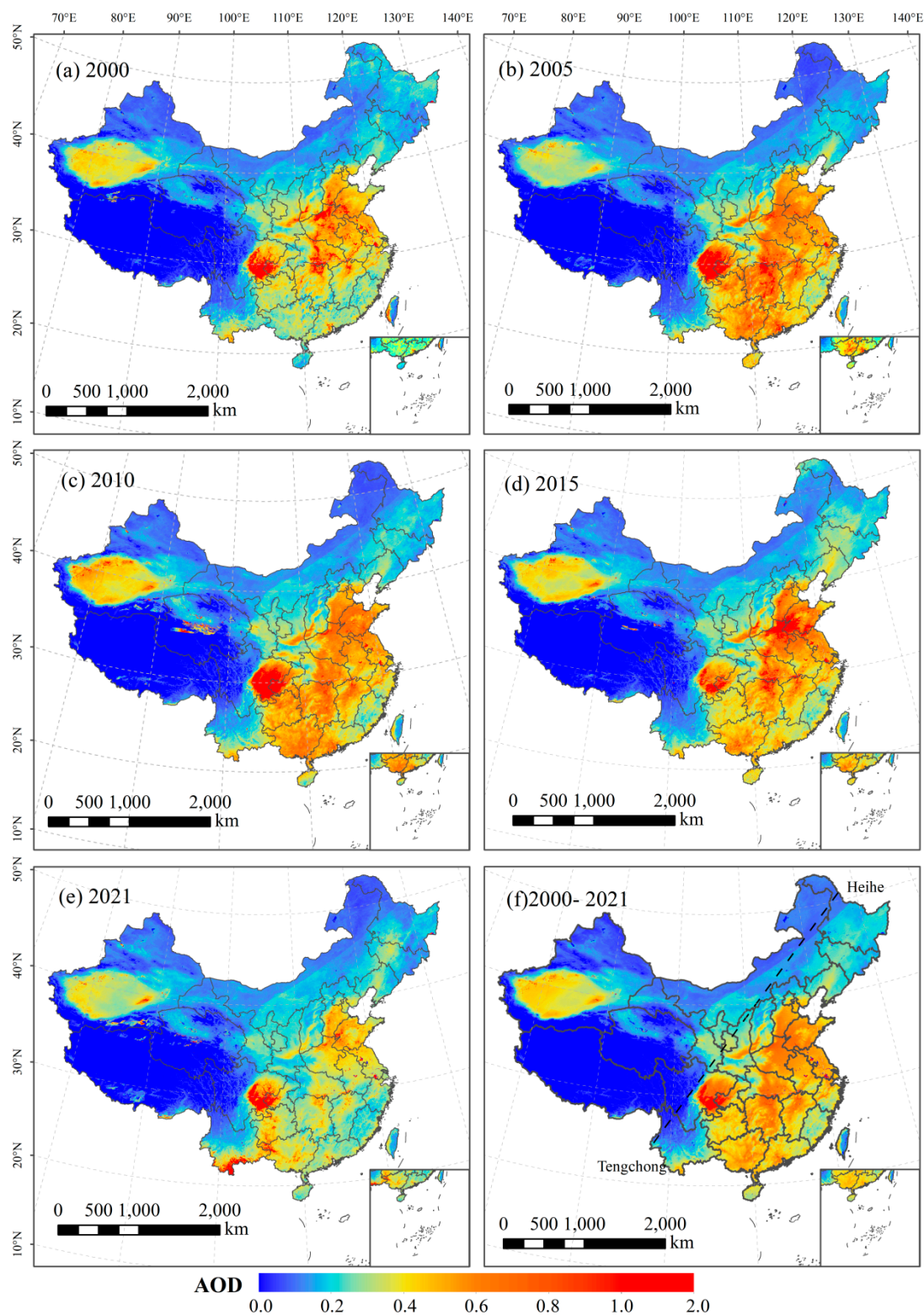
Text

Text S1: Possible uncertainties of AOD data

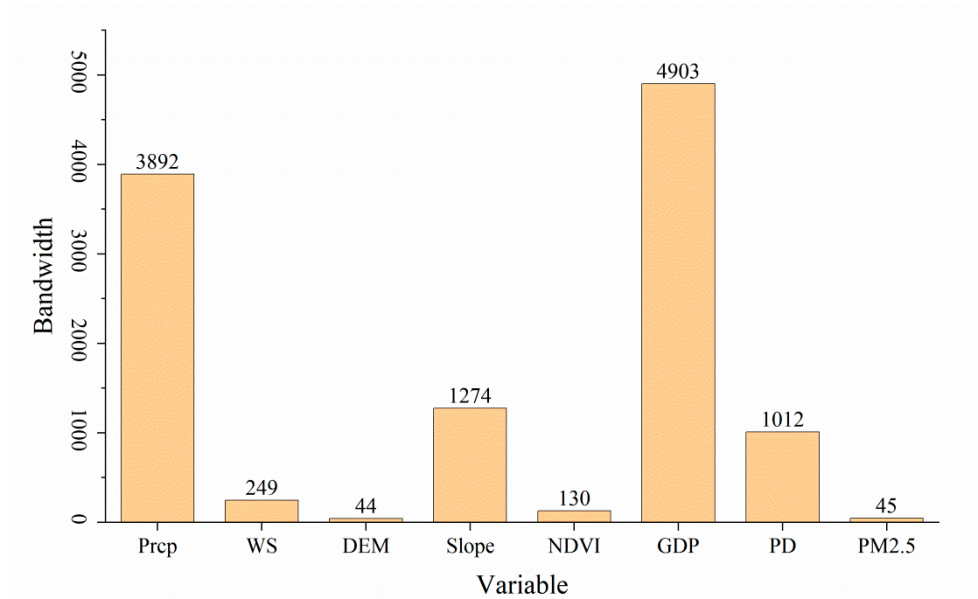
In this study, the spatially continuous MCD19A2 data was used to analyze the spatial distribution and changing trend of AOD in China and urban agglomerations. To ensure the accuracy of the results, we further discuss the potential effect on the uncertainty of AOD according to the Bessel formula.

In the Google Earth Engin (GEE) database, all daily AOD product data were masked by the quality control band (AOD_QA), while pixels containing clouds and surfaces with snow and ice were excluded. Then, these daily AODs were aggregated into monthly composite data using the weighted average method to reduce the impact of data anomalies. Using these monthly AOD data, we further estimated the AOD values for each city cluster. Firstly, the vacancy values of all urban agglomerations were eliminated, and the peripheral pixel average of 5*5 was used to replace the vacancy values. Then, average the pixel values for each study area. It is worth noting that the missing value of each city cluster is less than 95%. These time and space averaging steps generally reduce the uncertainty of AOD quantification across urban agglomerations, according to the Bessel formula $(\sum(\delta - \bar{\delta})^2 / \sqrt{n-1})$, n represents the number of samples and δ denotes the AOD estimation error at the per-pixel scale [1-4]). Therefore, when the sample size n is large enough, the uncertainty of AOD will be reduced.

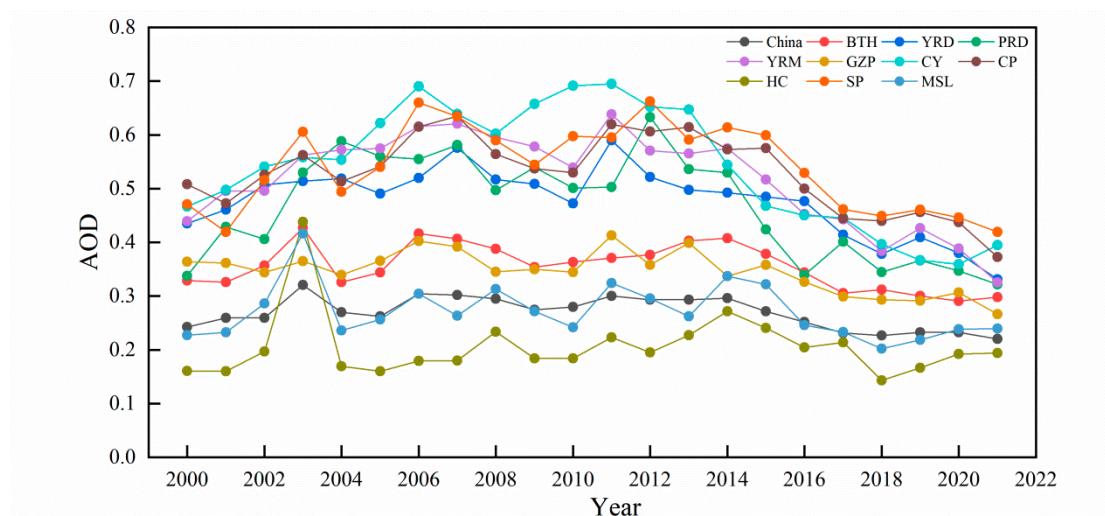
Figures



Supplementary Figure S1. Spatial distribution of AOD by year: (a) 2000, (b) 2005, (c) 2010, (d) 2015, (e) 2021, (f) 2000-2021.



Supplementary Figure S2. Spatial bandwidth of all variables in MGWR model. Prcp: precipitation, WS: wind speed, DEM: digital elevation model, Slope: slope, NDVI: normalized differential vegetation index, GDP: gross domestic product, PD: population density, PM2.5: particulate matter with an aerodynamic diameter less than 2.5 μm .



Supplementary Figure S3. Annual trends in the AOD in the urban agglomerations from 2000 to 2021. BTH: Beijing-Tianjin-Hebei, YRD: Yangtze River Delta, PRD: Pearl River Delta, YRM: Middle Yangtze River, GZP: Guanzhong Plain, CY: Chengdu-Chongqing, CP: Central Plains, HC: Ha-Chang, SP: Shandong Peninsula, MSL: Mid-Southern Liaoning.

Tables

Supplementary Table S1. The detailed information for 10 urban agglomerations.

urban agglomeration	Location (Climate conditions)	Area (10 ⁴ km ²)	GDP (billion)	Population (million)
North China				
Beijing-Tianjin-Hebei (BTH)	(Warm temperate continental monsoon-type climate)	22.6	9637.8	112.7
Lower Yangtze River Plain, East China				
Yangtze River Delta (YRD)	(subtropical monsoon climate)	21.3	23841.3	166
South China				
Pearl River Delta (PRD)	(Tropical monsoon climate)	5.6	12632.5	86
Central China, the middle reaches of the Yangtze River				
Middle Yangtze Rive (YRM)	(subtropical monsoon climate)	31.7	10598.9	130
Upper Yangtze River area, Sichuan Basin				
Chengdu-Chongqing (CY)	(subtropical monsoon climate)	18.5	6959.9	95
Central and Eastern China				
Central Plains (CP)	(Temperate monsoon climate & subtropical monsoon climate)	28.6	8878.4	160
East China				
Shandong Peninsula (SP)	(Temperate monsoon climate)	15.7	8309.6	98.5
Northwest China				
Guanzhong Plain (GZP)	(Warm temperate continental monsoon climate)	10.7	2550.7	39.4
North-central Tohoku Plain				
Ha-Chang (HC)	(Temperate monsoon climate)	26.4	2257.6	39.5
South-central Liaoning				
Mid-Southern Liaoning (MSL)	(Temperate monsoon climate)	8.3	2308.8	31.1

Data source: China Statistical Yearbook 2021.

Supplementary Table S2. Multicollinearity test for AOD influence variables: variance inflation factor (VIF)

PM2.5	NDVI	LST	PD	GDP	DEM	Slope	WS	Prcp	Tmp	RH
2.478	2.677	30.141	3.133	3.848	2.589	1.271	1.674	4.327	43.944	9.622

PM2.5: particulate matter with an aerodynamic diameter less than 2.5 μm , NDVI: normalized differential vegetation index, LST: land surface temperature, PD: population density, GDP: gross domestic product, DEM: digital elevation model, Slope: slope, WS: wind speed, Prcp: precipitation, Tmp: temperature, RH: relative humidity.

References

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