LUR Mapping of $PM_{2.5}$ Under Different Wind Seasons in Beijing

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Introduction

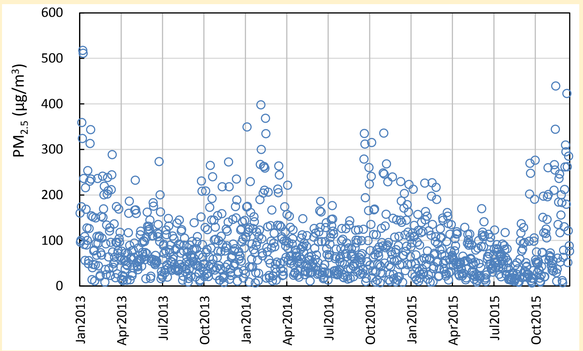
Accompanying the rapid urbanization and increase in the number of traffic vehicles, many Chinese cities have experienced elevated level of $PM_{2.5}$. The yearly average $PM_{2.5}$ concentration in Beijing is around 70-90 μg/m^3 in recent years. Red alerts of haze and health advisories for protective measures have frequently issued in winter.

Beijing has two major aerosol sources, PM produced locally (e.g., from traffic) and those originated from neighboring highly-industrialized provinces (such as Hebei). The prevailing wind speed and direction vary substantially between summer and winter, resulting in large variation in $PM_{2.5}$ as well. However, the impacts of wind on spatial distribution, contribution from the two sources, and seasonal variation of $PM_{2.5}$ in Beijing has not been fully explored. In this report, a Land-Use Regression model, using predictor variables at different spatial scales, was applied to investigate these impacts under different wind season. We also compared our LUR results with NASA MODIS AOD products.

Pangu plaza and Olympic stadium (Bird's Nest) in 2014, Beijing

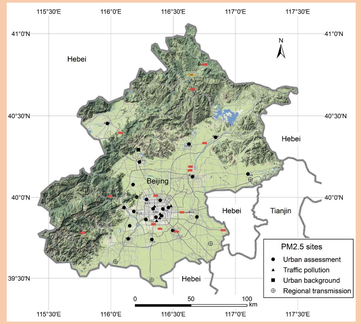
Data collection

- Hourly $PM_{2.5}$ data from 35 sites, 2013-2015 from Beijing DEP
- Meteorological data from China Meteorologica Data Service Center
- Landsat5 TM remote sensing image for recent land use classification
- Ranked and detailed road networks
- ASTER GDEM data
- AOD data (MAIAC data) from NASA, 2013-2015

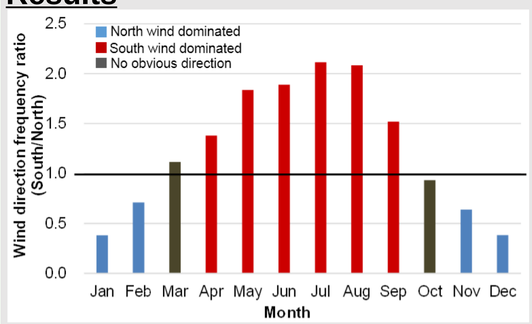


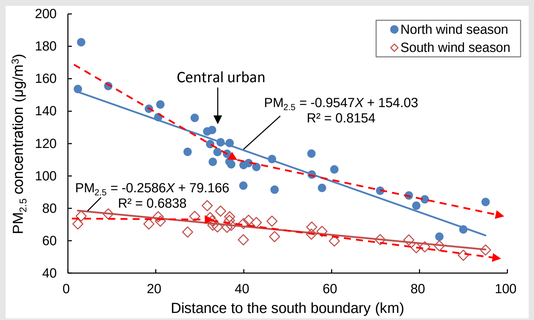
Methods

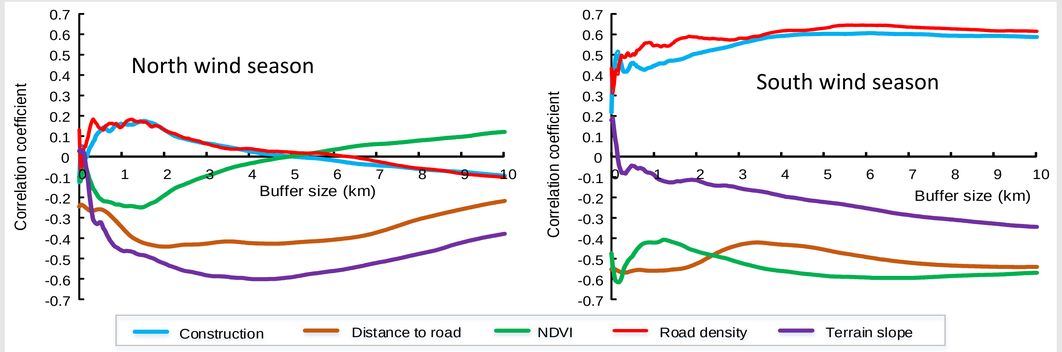
The whole period was divided into 2 periods, south-wind dominated season and north-wind dominated season, based on monthly wind direction frequency. For each season, we (1) fit the regional spatial trend of $PM_{2.5}$, (2) prepared land use variables and a series of continuously increasing buffers with 30m step size, (3) regressed the residual (the local variation) of the first step with land use variables at different buffers and find the optimal buffer for each variable, (4) built the land use model with stepwise linear regression method, and predict spatial distribution of $PM_{2.5}$, and (5) validated the model and evaluate the spatial and temporal variations of $PM_{2.5}$ and each part of contribution through the seasonal maps and regression functions.



Results

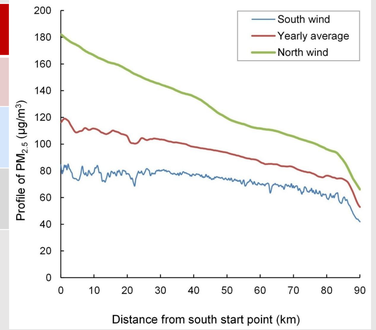


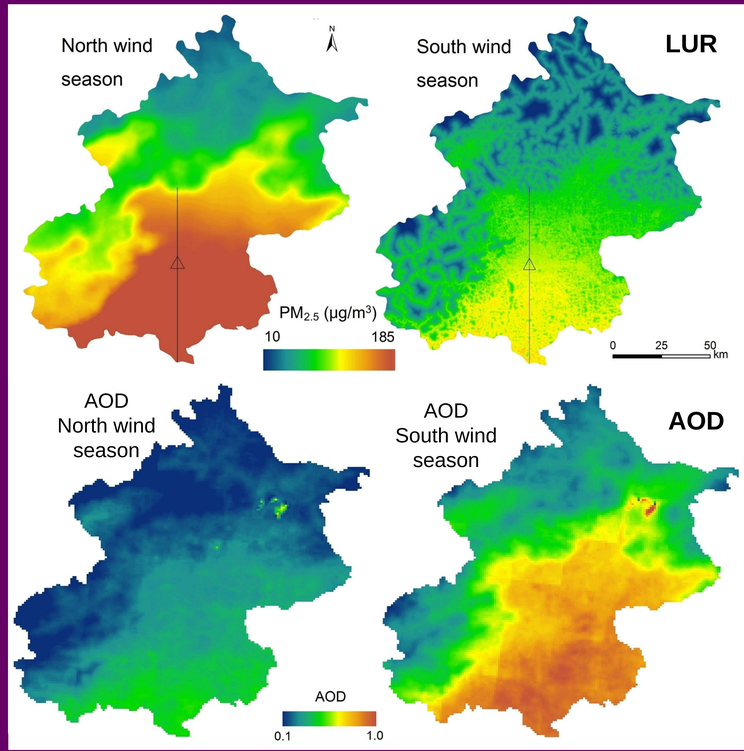




Season	LUR function	Adj. R^2	CV R^2
North wind	$Ln(P) = 5.3252 - 0.0235Slope - 0.0081DTS$	0.89	0.84
South wind	$Ln(P) = 4.5539 - 0.1413Distance - 0.2292NDVI - 0.0089Slope - 0.0037DTS$	0.83	0.78
Average	$Ln(P) = 4.8350 - 0.2415Distance - 0.0057DTS$	0.88	0.85

Terrain slope (*Slope*), Distance to the nearest road (*Distance*), Normalized difference vegetation index (*NDVI*), Distance to south ($DTS=Y-Y_0$) and Y_0 is the Y coordinate value at south end of Beijing.





Conclusions

- LUR model was able to produce detailed $PM_{2.5}$ mapping in Beijing;
- North wind season showed obvious regional patterns, but south wind season appeared to be locally characterized and largely influenced by traffic roads;
- Highly polluted events were associated with southwest and north east wind during November to February;
- MODIS AOD products from NASA showed similar spatial pattern with LUR results and was highly correlated with LUR map (r=0.88);
- There is a good potential to mutually examine the map quality of $PM_{2.5}$ and others (e.g. NO_2, O_3) derived from LUR and remote sensing.

References

1. Beckerman B. S., et al. A hybrid approach to estimating national scale spatiotemporal variability of $PM_{2.5}$ in the contiguous United States. Environmental Science & Technology, 2013, 47(13): 7233-7241.
2. Li, R.K., et al. Diurnal, seasonal, and spatial variation of $PM_{2.5}$ in Beijing. Science Bulletin, 2015, 60(3), 387-395.

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