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A satellite-based geographically and temporally weighted regression model for ground-level $PM_{2.5}$ estimation over Beijing-Tianjin-Hebei region in China

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Statement of the Problem: Using satellite-retrieved aerosol optical depth (AOD) and statistical model is a potential approach to estimate exposure to $PM_{2.5}$ for regional studies. However, studies of assessment of ground-level $PM_{2.5}$ for China at a high spatial resolution have been limited due to the lack of high resolution AOD product. The purpose of this study is to estimate daily high-resolution distribution of ground-level $PM_{2.5}$ using satellite remote sensing.

Methodology & Theoretical Orientation: The newly released MODIS AOD data at 3 km resolution were processed as the main predictor. A geographically and temporally weighted regression (GTWR) model was developed to estimate daily $PM_{2.5}$ concentrations over Beijing-Tianjin-Hebei region from January 1, 2013 to December 31, 2015. The surface $PM_{2.5}$ measurements were the dependent variable and combined AOD data, land use and meteorological data were used as the independent variables. The GTWR model is able to simultaneously accounts for spatial non-stationarity and temporal variability of the relationship between $PM_{2.5}$ and AOD, which can enhance the $PM_{2.5}$ estimation accuracy.

Findings & Conclusion: The overall model R2 value generated by GTWR model was 0.84 in model validating process, which was significantly better than those from geographically weighted regression (R2 of 0.51) and temporally weighted regression (R2 of 0.58) models. The annual mean of satellite-derived $PM_{2.5}$ for China was 70.80 μg/m^3 over the study period, 100% higher than the national ambient $PM_{2.5}$ standard of 35 μg/m^3. The ground $PM_{2.5}$ predictions shows significant seasonality and winter was the most polluted season. There was virtually no ascending or descending trend for ground $PM_{2.5}$ concentrations (-0.0002 day-1) from Jan 1, 2013 to Dec 31, 2015. In addition, predicted $PM_{2.5}$ maps at high-resolution grid are useful to present the detailed particle gradients and investigate $PM_{2.5}$ hotspots. The findings from the study demonstrated the promising potential of GTWR model for air pollution mapping.

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