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Estimating high-resolution PM2.5 concentrations over Beijing-Tianjin-Hebei region of China using space-time regression model and satellite remote sensing

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The use of satellite-retrieved aerosol optical depth (AOD) data and statistical modeling is a promising approach to estimate exposure to PM2.5, especially inferring fine-scale PM2.5 concentrations over densely populated urban areas. However, few studies have conducted high spatial resolution assessments of ground-level PM2.5 for China due to the lack of high-resolution AOD products. In this study, taking advantage of the fused 3 km-resolution AOD data, we developed a geographically and temporally weighted regression (GTWR) model to estimate daily PM2.5 concentrations for the Beijing-Tianjin-Hebei (BTH) region of China from January 1, 2013 to December 31, 2015, using surface PM2.5 measurements and ancillary information. The GTWR model accounts for spatial-temporal variations in PM2.5–AOD relationships simultaneously, and the overall model performs well (R2 of 0.84 in cross-validation (CV)). These results are notably better than those from daily geographically weighted regression model (CV R2 of 0.66). The fused 3-km AOD dataset, blending the newly released 3 km-resolution Moderate Resolution Imaging Spectroradiometer (MODIS) Dark Target AOD data with the 10 km-resolution MODIS Deep Blue AOD data, improved data availability of MODIS original 3-km AOD product and presented more spatial variations compared with MODIS 10-km AOD product, thereby enhancing model performance compared with MODIS operational 3-km AOD product.

As a result, the daily fine-scale PM2.5 maps over the BTH region were generated, which are useful to present the detailed particle gradients for the densely populated urban area. Our predicted results demonstrate that the multi-year mean of satellite-based PM2.5 concentration for the study region was 72.43 μg/m3 with a decreasing trend from 76.75 μg/m3 in 2013 to 66.03 μg/m3 in 2015. Temporally, a total of 445 days among all the predicted 1000 days with daily mean PM2.5 concentrations greater than 75 μg/m3 (the maximum daily mean value of Chinese Ambient Air Quality Standard Grade II), indicates that about 45% days were heavily polluted; Spatially, the city-average PM2.5 concentrations ranged from 44.73 μg/m3 for Zhangjiakou city in the northern area to 103.87 μg/m3 for Handan city in the southern area, and 9 out of 13 cities with more than 75 μg/m3 of city mean values, which shows most areas within the study region were severely polluted. Therefore, air pollution in the BTH region still should be given more cause for alarm based on the short-term pollution events and long-term PM2.5 trend despite of its decreasing trend from 2013 to 2015.