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Daily Estimation of High Resolution PM2.5 Concentrations over BTH area by Fusing MODIS AOD and Ground Observations

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The satellite-borne Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth (AOD) is often used to predict ground-level fine particulate matter (PM2.5) concentrations. The associated estimation accuracy is always reduced by AOD missing values and by insufficiently accounting for the spatio-temporal PM2.5 variations. This study aims to estimate PM2.5 concentrations at a high resolution with enhanced accuracy by fusing MODIS AOD and ground observations in the polluted and populated Beijing–Tianjin–Hebei (BTH) area of China in 2014 and 2015. A Bayesian-based statistical downscaler was employed to model the spatio-temporally varied AOD-PM2.5 relationships. We resampled a 3 km MODIS AOD product to a 4 km resolution in a Lambert conic conformal projection, to assist comparison and fusion with CMAQ predictions. A two-step method was used to fill the missing AOD values to obtain a full AOD dataset with complete spatial coverage. The downscaler has a relatively good performance in the fitting procedure (R2 = 0.75) and in the cross validation procedure (with two evaluation methods, R2 = 0.58 by random method and R2 = 0.47 by city-specific method). The number of missing AOD values was serious and related to elevated PM2.5 concentrations. The gap-filled AOD values corresponded well with our understanding of PM2.5 pollution conditions in BTH. The prediction accuracy of PM2.5 concentrations were improved in terms of their annual and seasonal mean. As a result of its fine spatio-temporal resolution and complete spatial coverage, the daily PM2.5 estimation dataset could provide extensive and insightful benefits to related studies in the BTH area. This may include understanding the formation processes of regional PM2.5 pollution episodes, evaluating daily human exposure, and establishing pollution controlling measures.