Multi-scale Modeling of Air Quality and Greenhouse Gases over Greater Boston, Part II: Sensitivity of Street-level Predictions to On-road Emissions from Traffic Activity Data

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Accurate prediction of hyperlocal air quality and greenhouse gases is essential for understanding urban pollution dynamics and distributions, particularly in Greater Boston where traffic emissions play a significant role. Regional-scale models have limited skills in predicting heterogeneous street-level concentrations controlled by complex interactions between local meteorology, traffic patterns and emissions, atmospheric chemistry, and urban morphology. In Part II of this study, street-scale $PM_{2.5}$ and CO_2 in typical months of summer and winter are simulated using the Model of Urban Network of Intersecting Canyons and Highways coupled with the SCRAM-SOAP-H^2O aerosol model (MUNICH-SSH), with urban meteorological variables and background chemical concentrations predicted by the Weather Research and Forecasting Model coupled with Chemistry and Greenhouse Gases (WRF-Chem-GHG), as described in Part I. On-road emissions are the primary source of pollutants within street canyons, and the accuracy of emission estimations is greatly influenced by variations in traffic activities. To assess the impact of uncertainties related to on-road emissions on street-level $PM_{2.5}$ and CO_2 predictions, different approaches for representing traffic activity are employed, including (1) the use of road inventory from the Massachusetts Department of Transportation, (2) the TransCAD transportation planning model, and (3) the integration of both datasets. The road inventory provides information on annual average daily traffic volume and speed limits for each street, while TransCAD utilizes socioeconomic data at the traffic analysis zone level and the capacity of each street to simulate traffic flows and speeds. Street-level traffic emissions are estimated with the Vehicular Emission Inventory model, which utilizes a bottom-up approach to estimate on-road emissions from traffic activities and corresponding emission factors. $PM_{2.5}$ predictions are evaluated with observations at the monitoring stations from the nationwide measurement networks and low-cost sensors in Greater Boston. The result analyses will focus on Greater Boston, including several cities (e.g., Boston, Chelsea, and Brookline) along major streets. The results show that road types dominate emissions simulated from the road inventory data. Higher $PM_{2.5}$ emissions and concentrations are estimated from the traffic activities simulated by TransCAD. Results from this study demonstrate potential improvements in street-scale air quality modeling by utilizing more reliable traffic activity data and integrating multiple datasets.

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