Evaluation and modeling of data from low-cost air quality sensors for accurate PM2.5 estimation

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PM2.5 is a critical air quality parameter associated with many air pollution-mediated adverse health effects. In the United States, the Environmental Protection Agency (EPA) provides precise measurements of PM2.5 but a sparse distribution of EPA monitoring sites limits the availability of such data at high spatial resolution. Recent development in low-cost sensors such as PurpleAir (PA) sensors, which can be deployed at high density, show promise to overcome this challenge. However, data generated by these sensors are noisier and tend to overestimate PM2.5 relative to EPA measurements Although models can be used to improve the accuracy of PM2.5 estimates from PA sensor measurements, the validity of these models for sensors in different locations is not fully understood. In this work, we used the PA sensor network and EPA data from Cook County in the Chicago area to evaluate the robustness of correction models and their applicability for sensors in other locations. Our objectives were, (a) to investigate the impact of distance of PA sensor from EPA on model accuracy, and (b) to determine if data from multiple low-cost sensors can be used to generate more precise estimates of PM2.5. Our results demonstrated a dependence of model prediction accuracy on distance, with the accuracy reduced significantly for distances > 30 km from the PA sensor site. Moreover, a higher prediction accuracy was observed with models built using multiple PA sensors ($R2 = 0.50 \sim 0.70$, RMSE = 2.5 ~ 3.0) than models built with single PA sensor ($R2 = 0.30 \sim 0.60$, RMSE = 1.9 ~ 3.5), although the improvements were minimal when data from more than 3 sensors were used. Our results indicate that the accuracy of PM2.5 estimation from low-cost sensor data can be improved by considering the distance and incorporating multiple sensors in the model.

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