# 0-6943: Evaluation of Air Quality Models with Near-Road Monitoring Data

## Background

Transportation agencies use air dispersion modeling (also known as air quality modeling) in evaluation of transportation projects to ensure their compliance with federal regulations including the National Environmental Policy Act and transportation conformity quantitative hot-spot analysis requirements. The literature indicates a wide range of variabilities involved in the modeling process for the particulate matter (PM) hot-spot analysis. The hot-spot analysis includes various modeling steps (traffic activity, emissions, and air dispersion) and is prone to different sources of variability including parameter uncertainty, parametric variability, algorithmic uncertainty, and model bias.

Sparse real-world data have limited the possibility of evaluating the variabilities involved in the hot-spot process. Availability of near-road monitoring data has provided a new source of data to address this gap. This study evaluated the PM hot-spot process with near-road monitoring data. Researchers evaluated the sensitivity of the model predictions to different input parameters such as data sources (traffic, emissions, meteorological, and background concentration data), model options (source type and land use), and model choice (AERMOD and CAL3QHCR). In addition to the sensitivity analysis, researchers also evaluated the potential association between $PM_{2.5}$ and key parameters.

## What the Researchers Did

Researchers used a case study approach that consisted of the following major steps:

- State-of-the-practice review—Researchers conducted an extensive literature review of near-road air quality, PM hot-spot process, and modeling components.
- Case study development—Researchers identified two near-road sites (Houston and Fort Worth) based on a set of criteria developed in coordination with the Texas Department of Transportation.
- Data exploration research (Track 1)—Using various data analysis and data exploration methods, researchers investigated the association between the near-road concentrations ($PM_{2.5}$, carbon monoxide [CO], and nitrogen dioxide [$NO_2$]) and the key factors including traffic, meteorology, and background concentrations.
- Modeling sensitivity analysis (Track 2)—Researchers formulated 10 scenarios to evaluate the variability for different data sources, model options, and model choices involved in the PM hot-spot process. Researchers evaluated the scenarios in the form of density histograms and qualitatively compared the scenarios to the near-road monitoring data to investigate the key components affecting the sensitivity of the modeling process.

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## What They Found

### *Track 1—Data Exploration*

The findings from the data exploration track are:

- The concentrations of CO, $PM_{2.5}$, and $NO_2$ for both sites were below the National Ambient Air Quality Standards limits.
- Among the meteorological parameters, wind direction and wind speed had an influence on CO and $NO_2$. For $PM_{2.5}$, the correlation with wind speed and wind direction was lower.
- The correlation between traffic parameters (annual average daily traffic [AADT], fleet-equivalent AADT, volume, and traffic speed) and near-road concentrations of $PM_{2.5}$ was low.
- Near-road $PM_{2.5}$ concentrations had a strong association ($R^2$ in the range of 0.83 to 0.91) with that of the background ambient monitoring stations.
- On average, the near-road increment (i.e., the difference between the near-road concentration and background concentration) was 2.4 $\mu g/m^3$ (or 12.8 percent). This increment could be attributed to the potential impact of traffic measured at the near-road monitors.

### *Track 2—Modeling Sensitivity Analysis*

The findings from the modeling track are:

- Different parameters affected the $PM_{2.5}$ concentration estimates from the modeling process, both at the individual modeling element level and cumulative across the entire modeling chain.
- The results highlight the importance of careful selection and processing of input parameters. As highlighted by the sensitivity analysis, quality assurance at every step of the modeling process is required to ensure valid concentration results.
- Researchers recommend reporting the distributions of the modeling results (density histograms of estimated concentrations) along with descriptive statistics such as design values. Showing modeling results in density histograms would provide a better understanding of the variabilities in the modeling results and help interpret the results in the proper context.

## What This Means

The data exploration indicated that the background concentration is the dominating factor in estimating the near-road $PM_{2.5}$ concentrations. Traffic volume and speed had a relatively weak association with the near-road concentrations for the two case study sites. Wind direction and speed had a correlation with the concentrations; however, the lack of hourly near-road concentration data at the time of this study prevented a detailed analysis of this potential correlation at an hourly resolution.

The results of the modeling variability analysis highlighted significant variations of the estimated near-road concentrations because of typical modeling options and data sources used in conducting a $PM_{2.5}$ hot-spot analysis. The range of variability was highest for the model options, followed by model choice and data source.

Researchers used seven methods to estimate the background concentration. Among the different methods developed, the normalized inverse square distance approach had the highest accuracy. However, based on the data analyzed, the background results showed low variability among the different methods (up to 1.1 $\mu g/m^3$).


## For More Information

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