Exposure to traffic-related air pollutants in health studies is often obtained from air quality models at a relatively coarse spatial resolution that is unable to capture concentration hotspots near roadways thus has the potential to underestimate the risk. The goal of this work is to improve the characterization of exposure and health risk to traffic-related air pollutants. The hypothesis is that dispersion models can reduce the error for large-scale exposure and risk assessment because of the capability for fine-resolution modeling. This overall hypothesis was verified by the following 3 studies.

The first study describes the development of a modeling framework that combined space-time kriging and Gaussian dispersion to inform exposure estimates for traffic-related air pollutants with a high spatial resolution. This framework reduces CPU-time by 88-fold by reducing the required meteorological data, while retaining the accuracy of exposure estimates. With this work, air quality models can be used to achieve fine-resolution modeling.

The second study compared a series of six different hourly-based exposure metrics including ambient background concentration from space-time ordinary kriging (STOK), ambient on-road concentration from research line source dispersion model (R-LINE), a hybrid concentration combining STOK and R-LINE, and their associated indoor concentrations from an indoor infiltration mass balance model. Using a hybrid-based indoor concentration as the standard, outdoor STOK metrics yielded large error at both population (67% to 93%) and individual level (average bias between -10% to 95%). The results of the study will help future epidemiology studies to select appropriate exposure metric(s) and reduce potential bias in exposure characterization, or even address exposure misclassification.

The third study refines the hybrid approach further to model concentrations at a Census block level (~105,000 Census blocks) using a chemical transport air quality model, Community Multiscale Air Quality (CMAQ) model at a 36 km × 36 km grid resolution. The resultant concentration fields were than used to estimate on-road PM$_{2.5}$-related mortality. The results show that the hybrid modeling approach estimated 24% more on-road PM$_{2.5}$-related mortality than CMAQ. This highlight the importance to characterize near-road primary PM$_{2.5}$ at fine spatial scales, and suggest the potential for previous studies to have underpredicted the on-road PM$_{2.5}$ related mortality estimates.