The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

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Monday, December 10, 2018, 3pm in Winston Chung Hall 205/206

The Development and Application of Semi-empirical Dispersion Models: Impact of Roadside Structures, Identifying Emission Sources, and Producing Concentration Maps at different Temporal and Spatial Scales

Doctor of Philosophy, Graduate Program in Mechanical Engineering
University of California, Riverside, December 2018
Dr. Akula Venkatram, Chairperson

Dispersion models play an essential role in understanding the impact of pollutant emissions on air quality. Once their results have been evaluated with observations, they are used by regulatory agencies and planning bodies to permit new sources and develop policies to mitigate the impact of emissions on air quality In my research, I developed and applied a class of dispersion models referred to as semi-empirical models whose formulation depends on representing some of the governing processes with parameters whose values are obtained by fitting model estimates to corresponding observations. I apply these models to understand the processes governing air pollution at two different scales: at tens of meters from highways, and tens of kilometres within a region characterized by high particulate pollution.

In recent years, roadway design is suggested as a potential strategy to mitigate the impact vehicular emissions on near-road air quality. In my research, I developed a dispersion model to estimate the impact of a solid noise barrier upwind of a highway on concentrations downwind of the road. The results showed that an upwind barrier reduces the downwind concentration by enhancing turbulence and shifting the emissions upwind through the action of the recirculating zone formed behind the upwind barrier. I also propose a tentative model to estimate on-road concentrations within the recirculation zone..
The applicability of the downwind barrier dispersion models to real-world measurements was also explored in my research. First, a field study was conducted to measure ultra-fine particles (UFP) concentration and micrometeorology data near a barrier a freeway in Riverside, California. Two models for downwind barriers were evaluated with data collected and emission factors were estimated for the fleet. The primary effect of a downwind barrier was equivalent to shifting the line sources on the road upwind by a distance of about .

Next, UFP concentrations were measured downwind of a solid barrier and a solid barrier with vegetation simultaneously to estimate the incremental effect of tall vegetation on the mitigation caused by a solid barrier. The vegetation above the solid barrier reduced turbulence levels of the air passing through it, thus reducing the entrainment of pollutants into the wake of the solid barrier. This added to the concentration reduction induced by the solid barrier most of the time; however, this was not the case for all of the observed data.

I then apply dispersion models at regional scales by interpreting PM2.5 concentrations measured by a network of 40 low cost monitors located in the Imperial Valley of southern California. This valley is bordered by deserts on the east and the west, the Salton Sea on the North, and Mexico to the South. Particulate matter can be transport into the valley from across these borders, and be generated from within the valley itself because of agricultural activity. These borders are represented by line sources and the valley by an area source. I estimate the emissions from these sources by fitting model estimates to daily and annually averaged measurements made at 40 monitors. Once these emissions are determined, I use them as inputs in the dispersion model to construct PM2.5 maps at a much finer resolution than that provided by the monitors.

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