MECHANICAL ENGINEERING
DISSERTATION DEFENSE

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Seyedmorteza Amini

Monday, March 19, 2018,
3PM in Bourns Hall A265

The Development and Application of Models for Dispersion of Roadway Emissions: The Effects of Roadway Configurations on Near Road Concentrations of Vehicle Emissions and Increasing the Spatial Resolution of Satellite-Derived PM2.5 Maps

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

Near road air quality is a public concern because exposure to elevated concentrations of vehicular pollution is associated with adverse health effects. Roadway design is suggested as a potential strategy to mitigate near-road exposure. The first part of my dissertation describes the development and application of roadway dispersion models to examine the effectiveness of roadway configurations as pollutant mitigation strategies. These configurations include depressed roadways and at-grade roadways with the presence of solid/vegetative barriers.

Roadside solid barriers increase dispersion of pollutants by lofting emissions and inducing a recirculation zone on their leeward edge. I adapt a model, developed using data from a wind tunnel, to describe ultrafine particle measurements made in a field study. This requires modifying the model to account for uncertainties in emissions and meteorological parameters of real-world studies. Results suggest that 1) a model developed under controlled conditions is useful in the complex environment of urban areas, 2) the surface can be taken neutral in modeling dispersion in urban areas., and 3) the primary impact of the barrier is equivalent to shifting the road upwind by a distance of $H(U/u_*)\cos\theta$.

I next analyze data from a wind tunnel that examined dispersion of emissions from depressed roadways using roadway dispersion models. I show that dispersion governed by the complex flow induced by depressed roads can be described using modified flat-terrain models. The modifications include 1) an initial vertical spread dependent on the geometry of the depressed roadway, and 2) increasing the friction velocity above its upwind value. Also, the vertical concentration profiles under neutral stability conditions are best explained with a vertical distribution function with an exponent of -1.3 rather than the -2 used in most currently used dispersion models.

Health risk assessment of PM2.5 on the community scale requires PM2.5 concentration estimations at the scale of tens of meters. The PM2.5 measurement from air quality stations and satellite-derived PM2.5 estimates cannot provide concentrations at this spatial resolution. In the last part of my dissertation, I describe a “downscaling” system that adapts roadway dispersion models to yield the concentration gradients that are not captured by satellite maps.