On-road vehicles are a major source of transportation CO2 greenhouse gas emissions in all the developed countries, and in many of the developing countries in the world. Similarly, several criteria air pollutants are associated with transportation, e.g., CO, NOx, and PM. The need to accurately quantify transportation-related emissions from vehicles is essential.

Transportation agencies and researchers in the past have estimated emissions using one average speed and volume on a long stretch of roadway. With MOVES, there is an opportunity for higher precision and accuracy. Integrating a microscopic traffic simulation model (such as VISSIM) with MOVES allows obtaining precise and accurate emissions estimates. The new EPA mobile source emissions model, MOVES2010a can estimate vehicle emissions on a second-by-second basis creating the opportunity to develop VIMIS 1.0 (VISSIM/MOVES Integration Software) to facilitate the integration process. This research presents a microscopic examination of five key transportation parameters (traffic volume, speed, truck percentage, road grade and temperature) on a 10-mile stretch of I-4 prototype; an urban limited access corridor in Orlando, Florida. The analysis was conducted using an advanced custom design technique; D-Optimality and I-Optimality criteria, to identify active factors and precisely estimate the regression coefficients and response variable.

The experiment identified the factors’ optimal settings and resulted in the development of Micro-STEM (Microscopic Stochastic Transportation Emissions Model). Significant emission rate reductions were observed from the experiment for speeds between 55 and 60 mph while maintaining up to 90% of the freeway’s capacity. However, vehicle activity characterization (i.e, speeds) showed a significant impact on the emission estimation approach.

Three different approaches were further examined to capture emissions on the modeled corridor. First, emissions were estimated for the entire section "by hand" using one average traffic volume and speed. Then, three advanced levels of detail were studied using VISSIM/MOVES to analyze sub-links: average speeds (AVG), second-by-second link driving schedules (LDS), and second-by-second operating mode distributions (OPMODE). This research analyzed how the various approaches affect predicted emissions of CO, NOx, PM and CO2. The results demonstrated that obtaining accurate and comprehensive operating mode distributions on a second-by-second basis improves emission estimates. Specifically, emission rates were highly sensitive to stop-and-go traffic and the associated driving cycles of acceleration, deceleration, and idling. Using the AVG or LDS approach may overestimate or underestimate emissions, respectively, compared to an operating mode distribution approach.

Additionally, model applications were examined to evaluate the environmental impacts and validate "Micro-STEM" model. Mitigation scenarios included the future implementation of managed lanes (ML) and general use lanes (GUL) on the I-4 corridor, a variable speed limits (VSL) scenario and a hypothetical restricted truck lane (RTL) scenario. Results of the mitigation scenarios showed an overall speed improvement on the corridor resulting in overall reduction in emissions and emission rates when compared to the base scenario (EX).

The proposed emission rate estimation process also can be extended to gridded emissions for ozone modeling, or to localized air quality dispersion modeling, where temporal and spatial resolution of emissions is essential to predict the concentration of pollutants near roadways.

Major: Civil PhD (Transportation)

Educational Career:
Bachelor's of B.S. Civil Engineering, BS, 1993, Cairo University
Master's of M.S. Civil Engineering, MS, 2003, University of Central Florida

Committee in Charge:
Dr. Ahmed Radwan, Chair, CECE