Transportation & Air Quality Research Group

Understanding Real-Driving Emissions of Light-Duty Vehicles Using A Portable Emission Measurements System

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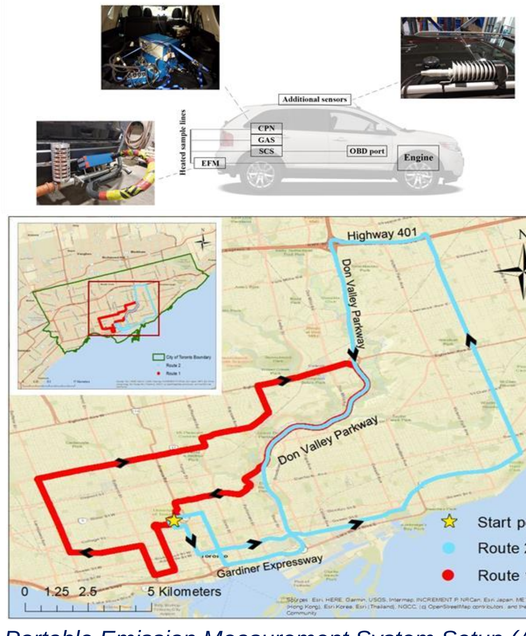
Introduction

- *Vehicular emission models are powerful tools to estimate emissions and fuel consumption from mobile sources.*
- *Challenges exist in current vehicular emission models since they cannot adequately represent real-driving conditions in the local context.*
- *It is worth exploring the emission profiles of multiple pollutants, including CO, CO_2, NO_x, and particulate matters, and their association with engine parameters and vehicle kinematics.*
- *This study employs a state-of-the-art portable emission measurements system (PEMS) to measure real-driving emissions in Toronto.*
- *The association between real-driving emissions and their impact factors is thoroughly discussed.*

Methods

Experiment Design

- *PEMS is set up with five modules: exhaust flow meter, sampling control system, gas analyzer, particle counter and on-board diagnostics.*
- *Repeated measurements are conducted on two designed routes located in Toronto.*
- *The red route has more urban driving while the blue one has more highway driving.*
- *Both routes take about 1.5 hours to finish and are repeated for at least 15 times.*



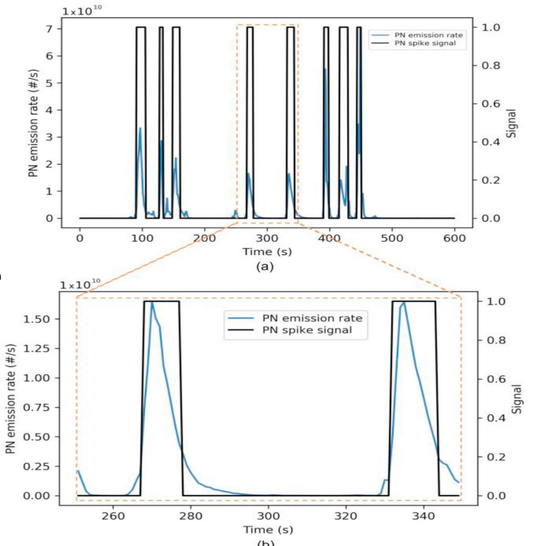
Portable Emission Measurement System Setup (Above)
On-Road Emission Test Routes (Below)

Data Analysis and Modelling

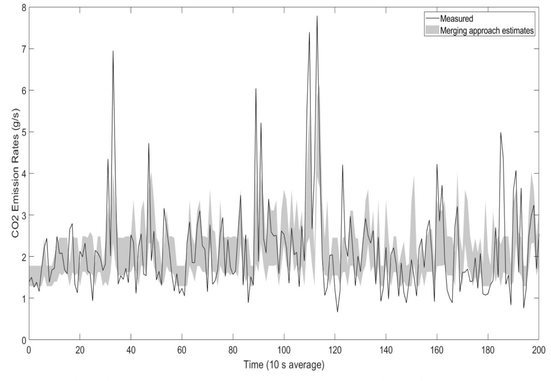
- *The correlation between various engine and vehicle kinematic parameters and emissions is investigated spatially and temporally.*
- *Specifically, as an emerging concern due to the wide introduction of gasoline direct injection vehicles, ultra-fine particle (UFP) emissions are associated with engine operation, traffic conditions and road characteristics, with emphasis on UFP emission spikes.*
- *A novel binning emission model is developed, which utilizes the existing regulatory emission modelling structure with great improvement in model accuracy, flexibility, and interpretability.*

Major Outcomes

- *CO, CO_2, NO_x, and particulate matter emissions are strongly positively related to engine speed, torque, and load.*
- *Engine lean-burn produces significantly lower CO, CO_2 , and particulate matter emissions, while there is less NO_x during rich burn.*
- *CO, NO_x, and particulate matter emissions are higher at a low ambient temperature.*
- *In each test trip, 25% of the duration is attributed to spike events, but they contribute 75% of total particulate matter emissions.*
- *High particulate matter emission spikes are often observed after an increase of engine torque from zero, as well as during engine braking.*
- *Eliminating temporal dependency in real-world emission data can improve the performance of emission models.*
- *Our approach can effectively reproduce measurements when contrasted with real-driving emissions.*
- *The standing regulatory emission model has a robust modelling approach, but their emission database cannot adequately capture the variability in real driving.*



Capture UFP emission spikes using spike detection algorithm



Modelled vs. measured CO_2 emission in a test trip

Challenges & Opportunities

- *Practical eco-driving recommendations can potentially reduce particle emissions in urban environments, including the avoidance of unnecessary idling, sharp acceleration and heavy braking.*
- *Traffic smoothing measures can also reduce particle emissions.*
- *Future development of emission control strategies and technologies should focus on understanding and minimizing particle emission spikes.*
- *The novel binning model provides a unique opportunity to substantially improve the standing regulatory modelling tool, as well as current vehicular emission inventory.*
- *Future work can significantly benefit from collecting additional real-driving emission data with various vehicle models and further validating our model.*