Environmental Research, Technology Demonstration and Conference Project

ECF Project:	ECF 2018-26
Project Title:	On the rapid plume mixing in vehicle wakes and its implication to practical models of pollutant dispersion after line sources
Principal Investigator:	Dr Liu Chun Ho, Department of Mechanical Engineering, The University of Hong Kong
Total Approved Grant:	$500,000
Duration:	14/7/2019 to 13/1/2022
Project Status/Remarks:	Completed
Project Scope:	This project used both laboratory experiments and mathematical modeling to examine the effect of vehicle wakes on tailpipe dispersion together with the (direct) impact on the roadside, pedestrian-level air quality, in order to address the scientific question "How much is the deviation from the assumption of infinitely small, continuous line source in case the wake effect of (different) vehicles is included in tailpipe pollutant dispersion modeling?" The results shed some light on the roadside, pedestrian-level air quality in urban areas in response to vehicular tailpipe emission. The findings had been used to review and improve the reliability of the current vehicular plume dispersion models. The core objectives are to – (a) elucidate the rapid plume mixing in the wakes of vehicles; (b) quantify the uncertainty of the prevailing tailpipe emission modeling practice; and (c) review the roadside, pedestrian-level air quality using Environmental Protection Department's vehicle emission estimation model together with the relevant traffic mix and flow data for specific locations.
Summary of the Findings/Outcomes:	The wake after an on-road vehicle substantially influences the tailpipe pollutant dispersion which, however, is neglected in the conventional vehicular dispersion models. The dynamics is complicated by flow instability and coherence. Remote sensing is the most practicable measures for large-scale emission control. Its reliability, however, is largely dictated by how well the complicated vehicular flows and instrumentation constraint are tackled in particular the broad range of scales and short sampling duration. In this project, a complementary solution consisting of laboratory experiments and mathematical modelling was performed to examine the flow and vehicular dispersion. In particular, large-eddy simulation (LES) was employed to calculate the spatio-temporal dynamical processes in details. Apart from statistical analyses, fast Fourier transform (FFT) and proper orthogonal decomposition (POD) based on the LES results were used to look into the transient transport which was hardly realized by laboratory or field measurements. In the perspective of remote sensing deployment, tailpipe dispersion was governed by the recirculating wake in which the pollutant concentrations were highly fluctuating and positively showed. High-frequency signal was unavoidable filtered out. Plume chasing for a longer sampling duration was more accurate but is logistically impractical in busy traffic. Hence, on-road remote sensing data should be interpreted carefully.