Estimation of Carbon Dioxide Emissions Based on Near Roadway Monitoring Using Fast Response Instruments

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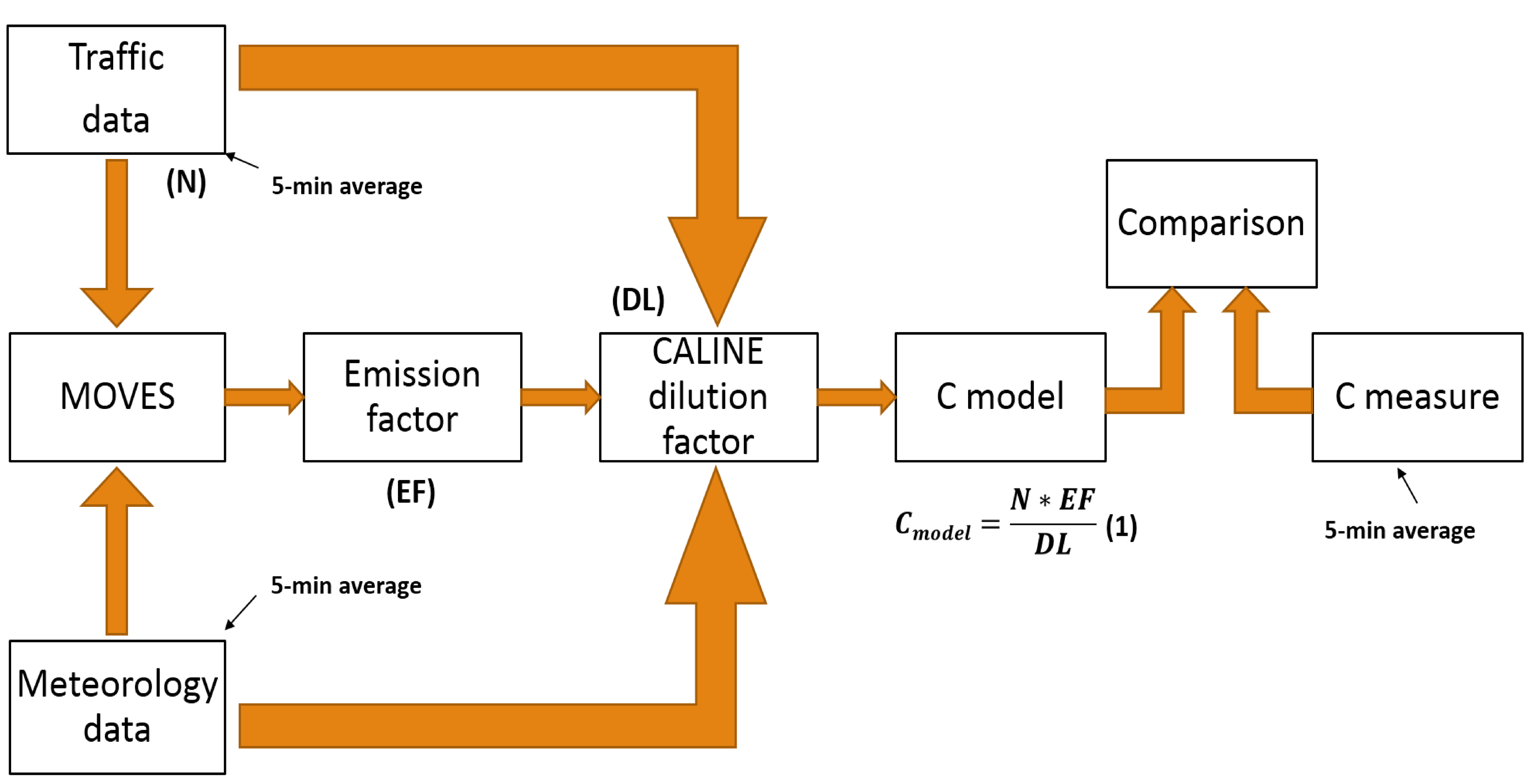
Presented at 2016 National Ambient Air Monitoring Conference, St. Louis, MO, August 8-11, 2016

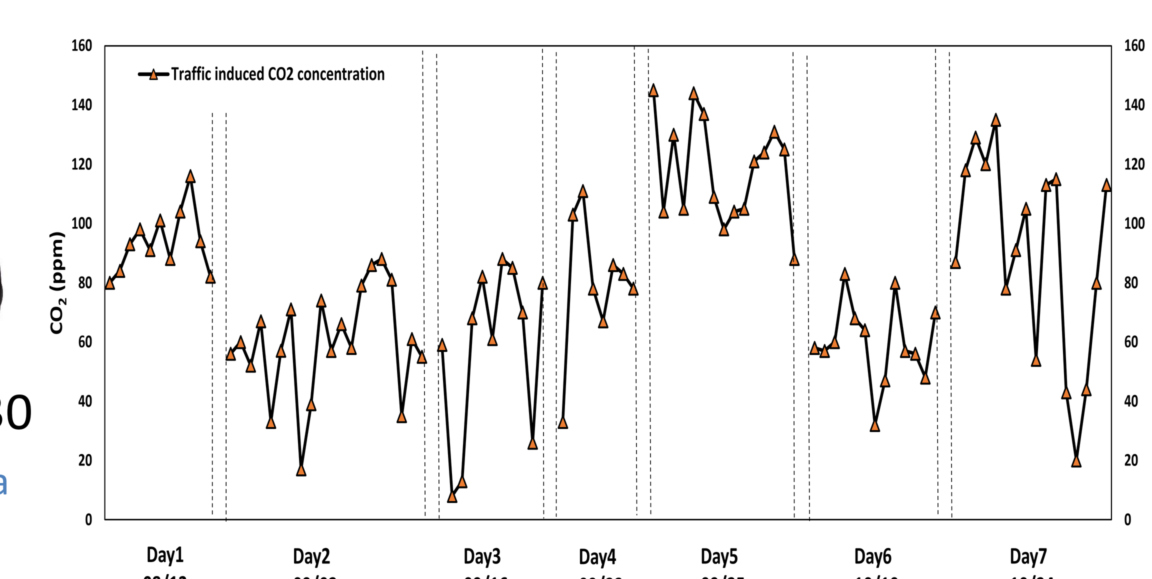
Introduction

A comparison between on-road measured carbon dioxide (CO_2) concentrations and modeled concentrations was presented as a function of vehicle mode of operation (congestion and free flow). Modeled CO_2 concentrations were calculated using (1) 5 min measurements of traffic and meteorology conditions near a roadway that is restricted to light-duty vehicles (LDVs), (2) Motor Vehicle Emission Simulator (MOVES) modeling and (3) inverse dispersion model calculations. The modeled concentrations were able to be compared to measured concentrations. Because changes in ambient air quality near roadways is very episodic due to rapid changes in traffic patterns and meteorological conditions. Near roadway monitoring programs designed to respond to changes in traffic conditions need to be measured in time periods as short as 5 minutes. The analysis is based on the assumption that air-quality models adequately describe the dilution process due to both traffic and atmospheric turbulence. The approach used to verify this assumption was to use MOVES to determine EFs for CO_2 and then estimate dilution using measured CO_2 concentrations.

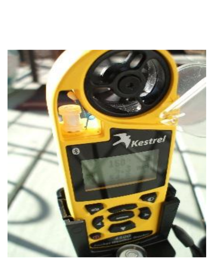
Model Procedure

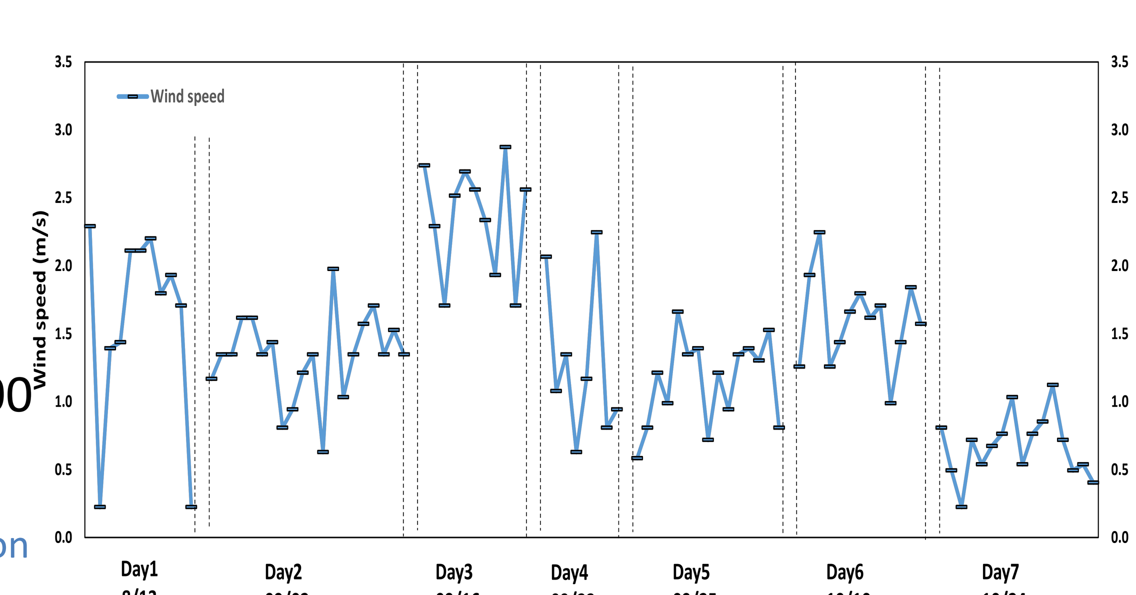


$$C_{model} = \frac{N * EF}{DL} \quad (1)$$

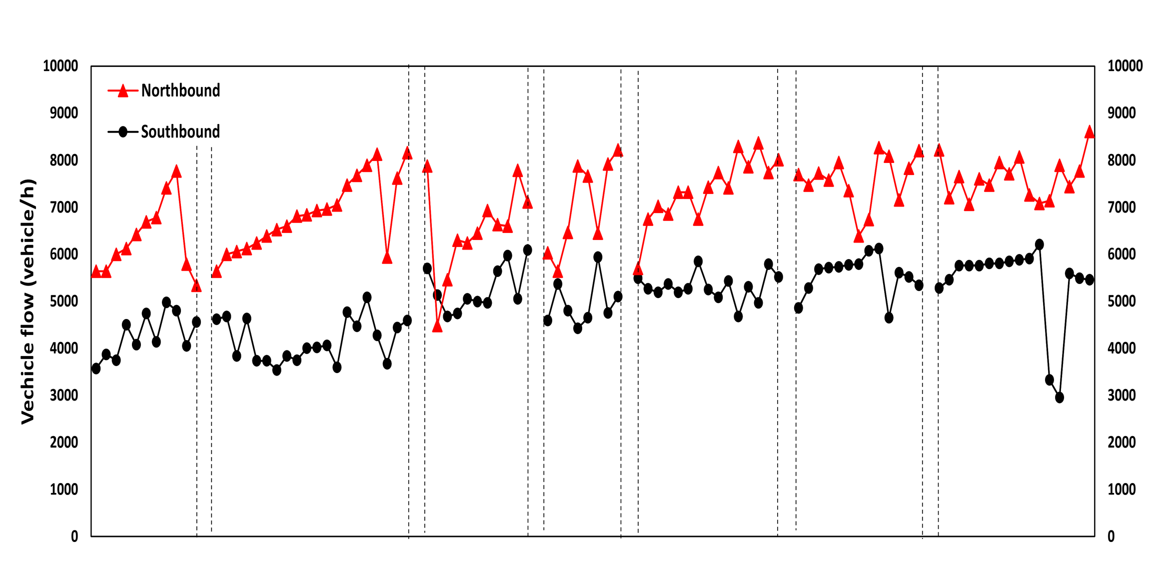


5-min average traffic data (N) for 7 sample days.





5-min average meteorology data for 7 sample days.



5-min average CO_2 concentration (background subtracted) for 7 sample days.

Results

Figure 1. Ensemble means of modeled CO_2 concentration with changing vehicle speed.

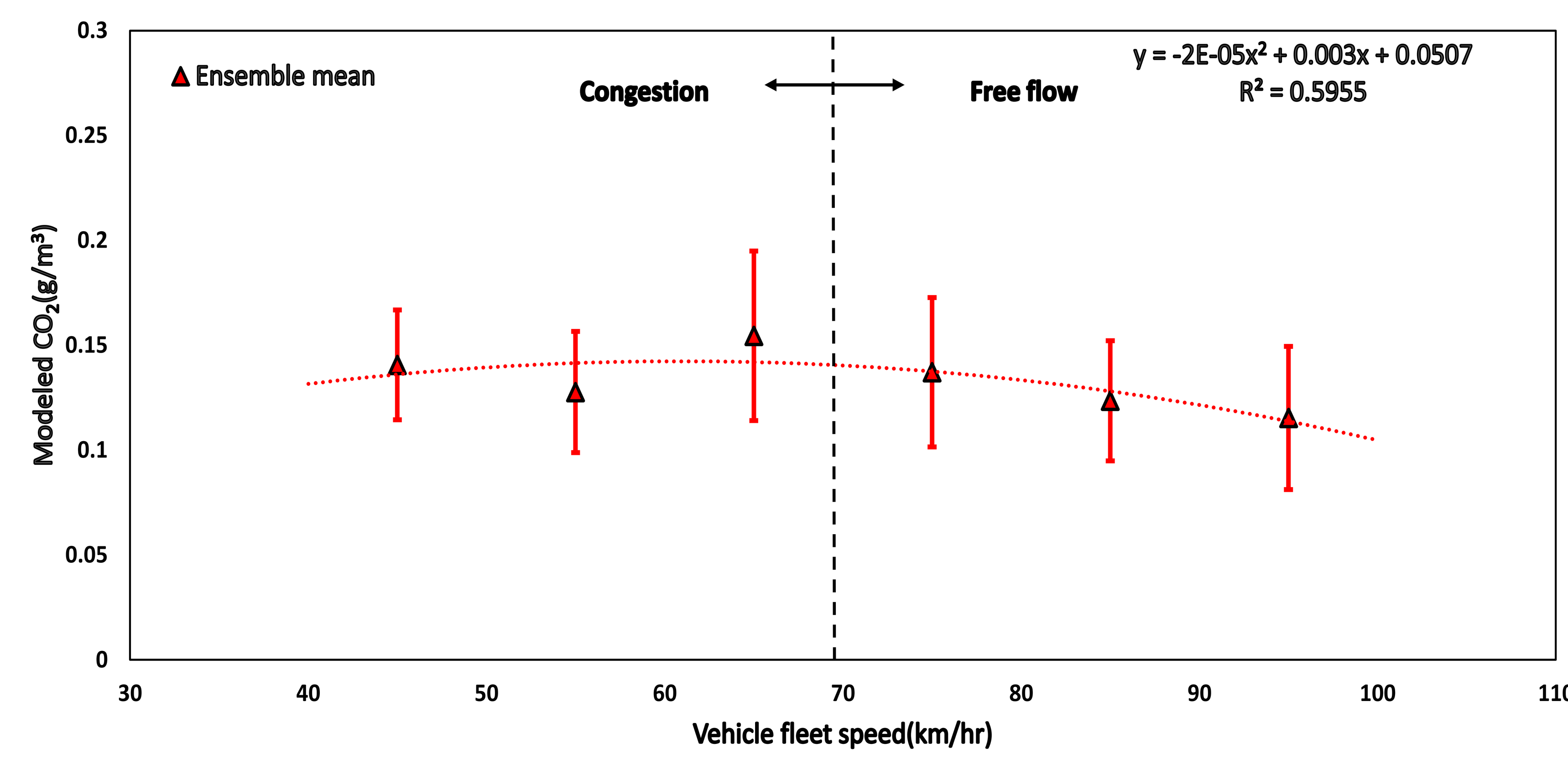


Figure 2. Compare measured CO_2 concentration with modeled CO_2 concentration in each speed interval.

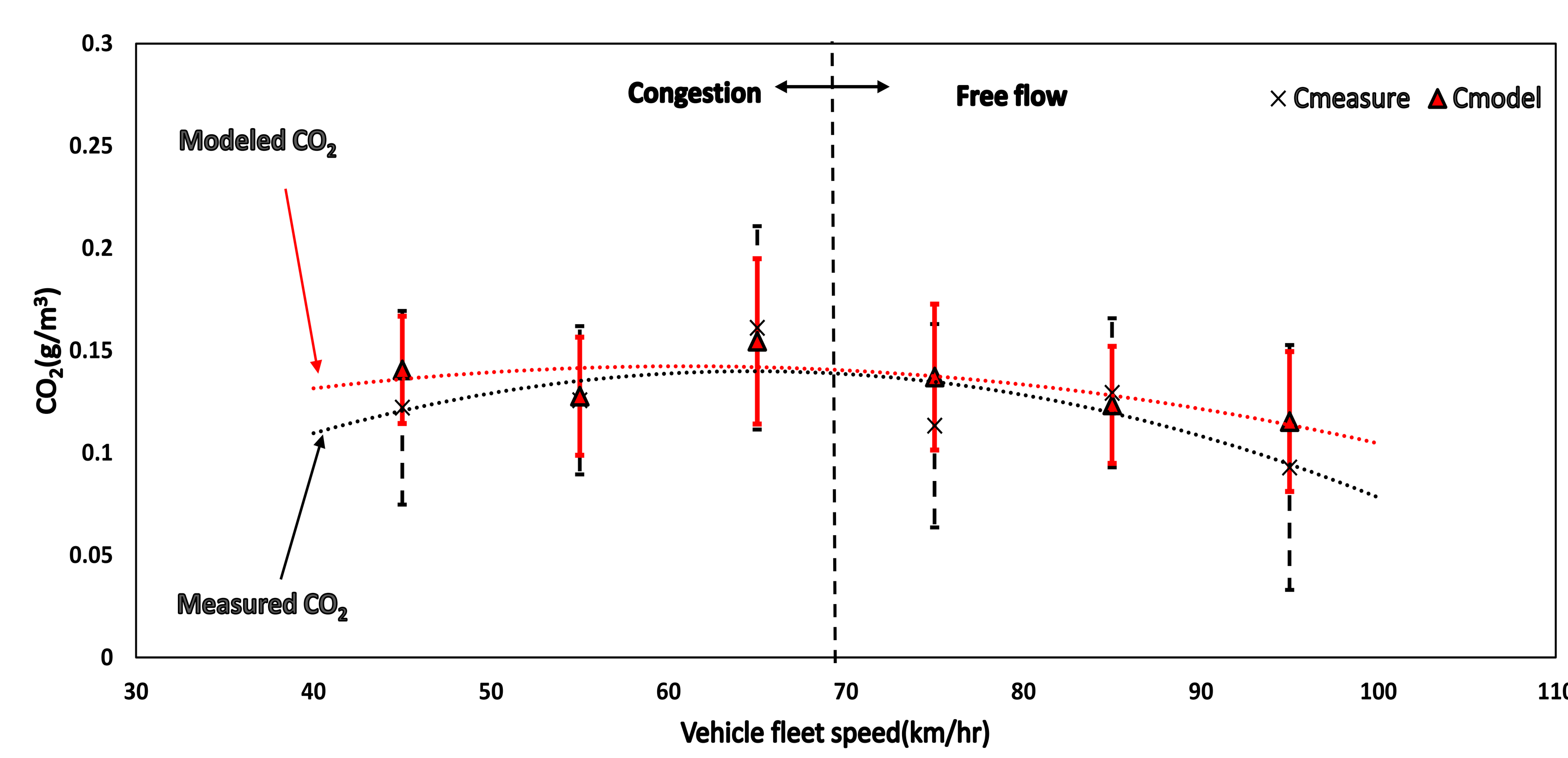


Table 1. Double-sided t-test for measured and modeled concentration in each vehicle speed interval. (α=5%)

Speed interval	40-50 (km/hr)	50-60 (km/hr)	60-70 (km/hr)	70-80 (km/hr)	80-90 (km/hr)	90-100 (km/hr)
Number of samples	14	12	20	18	25	10
P-value	0.22	0.89	0.65	0.09	0.53	0.45

Conclusions

- The variation in CO_2 concentrations with vehicle speed for 5-min measurements can be detected by near roadway monitoring.
- The good agreement on measured and modeled CO_2 concentrations indicates that simultaneous measurements of meteorological and traffic conditions can be used to determine CO_2 concentrations near roadways.

Future Work

- 1. CO_2 emission near roadway for highly congested traffic conditions.
- 2. CO_2 emission near roadway for traffic fleet with diesel trucks.

References

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2. Zhang, K. M.; Wexler, A. S.; Niemeier, D. A.; Zhu, Y.; Hinds, W.C.; Sioutas, C. Evolution of particle number distribution near roadways. Part III: Traffic analysis and on-road size resolved particulate emission factors. Atmos. Environ. 2005, 39 (22), 4155–4166.
3. Liu, Haobing, et al. "Vehicle emission and near-road air quality modeling in Shanghai, China, based on taxi GPS data and MOVES revised emission inventory." Transp. Res. Rec 2340 (2013): 38-48.