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# ROADSIDE HOT-SPOT ANALYSIS IN URBAN AREA

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**Abstract**: CALINE3-based models (CALINE4, CAL3QHC, and CAL3QHCR) are currently recommended by U. S. EPA for roadside hot-spot analysis. Recently, U. S. EPA proposes to remove CALINE3-based models for mobile source applications and replace it with AERMOD. We evaluate air dispersion models, AERMOD, CALINE4, and RLINE, to estimate concentrations of $PM_{2.5}$ for such analysis in downtown Los Angeles with high-rise buildings. The model performance indicates that AERMOD and RLINE provides an adequate description of roadside $PM_{2.5}$ concentrations, while CALINE3 generally overestimates the concentrations of $PM_{2.5}$.

***Key words:*** *Roadside Hot-Spot Analysis, AERMOD, Caline3, Urban Area*

## INTRODUCTION

Roadside hot-spot analysis assesses impacts of transportation emissions from mobile sources on local air quality of carbon monoxide (CO), lead (Pb), nitrogen dioxide ($NO_2$) and particulate matter (PM). Potential hot-spot analysis is one aspect of the State Implementation Plan (SIP) project-level conformity determinations, which is required by the Clean Air Act (ACC) in nonattainment or maintenance areas. It is also required for regional transportation plans (RTP), transportation improvement programs (TIP) and transportation project development/modification by transportation conformity rules and National Environmental Policy Act (NEPA) process.

The current version of U. S. EPA's Guideline on Air Quality Models, published as Appendix W to 40 CFR Part 51 (Appendix W) in 2005, addresses modelling mobile sources, with specific recommendations for each criteria pollutant. For CO, CAL3QHC (U. S. EPA, 1995) is recommended for screening and CALINE3 (Benson, 1984) for free flow situations. For Pb, CALINE3 and CAL3QHCR (Eckhoff and Braverman, 1995) are identified for highway emissions, while for $NO_2$, CAL3QHCR is listed as an option. No models for mobile emissions are explicitly identified for PM or $SO_2$, though CALINE3 is listed in Appendix A as appropriate for highway sources for averaging times of 1-24 hours. CALINE3 was developed in the late 1970's using P-G stability classes as the basis for the dispersion algorithms. CALINE3-based models used in quantitative hot-spot analyses have not undergone major updates since 1995 and have limitations in simulating air quality impacts of complex urban roadway networks. Zhang and Gao (2009) shows the increased turbulence due to vehicles and roads; Schulte and Venkatram (2013) shows that infinitely long roadside sound barriers increase vertical dispersion, induce vertical mixing and loft the emissions above the barrier , and Schulte et al. (2015) indicates the rapid vertical dispersion due to the presence of roadside buildings.

The recent proposed revisions to Appendix W include the proposal to remove CALINE3 for mobile source applications and replace it with AERMOD (Cimorelli et al., 2005), which incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and includes treatment of both surface and elevated sources, and both simple and complex terrain. In addition, the LINE and AREA source options in AERMOD implement a full numerical integration of emissions across the LINE and AREA sources. This proposed replacement is supported by two model performance comparison studies conducted by U. S. EPA (2015). One evaluates the CALTRANS 99 field study conducted along Highway 99 outside Sacramento, CA; the other evaluates the Idaho Falls, ID, field study conducted in an open field with a barrier between the line source and receptors. Both evaluations indicate that AERMOD performs better than CALINE4. However, both field studies do not represent either a suburban area with low building density or deep urban canyons with dense urban environments.

This paper compares AERMOD with CALINE3-based models (CALINE4) and RLINE (Snyder and Heist, 2013) using a field study conducted in downtown Los Angeles in 2008. The evaluation supports the proposed replacement when AERMOD is executed with onsite meteorological data.

**DESCRIPTION OF FIELD STUDY**

Figure 1 refers to a 400 m × 350 m area in downtown Los Angeles (LA) covering high-rise buildings and skyscrapers. The heights of the buildings vary from 5 to 187 m. The streets are three-lane one-way roadways. There are two street parking lanes on both sides. The street width is about 13 m. The field measurements were conducted during the weekdays from June 19, 2008 to August 1, 2008. Experiments were conducted for three days. Meteorological measurements lasted 12 hours for each day from morning (about 7:00 a.m.) to late afternoon (about 7:00 p.m.). DustTraks covered the morning (7:00 a.m. ~ 9:00 a.m. local time), evening (5:00 p.m. ~ 7:00 p.m. local time) commute and lighter mid-day (11:00 a.m. ~ 1:00 p.m. local time) traffic. DustTraks collected 1 Hz $PM_{2.5}$ for 6 hours. Traffic flows were recorded using digital cameras and manually counted afterwards (Pan et al., 2013). The averaged vehicle $PM_{2.5}$ emission rate among different fleet mixes was calculated based on EMFAC 2014 (CARB, 2014a). The fugitive $PM_{2.5}$ emission rate from paved roads was calculated based on CARB's miscellaneous process methodology 7.9 (CARB, 2014b). The resulting $PM_{2.5}$ emission rate is 0.16 g/km.

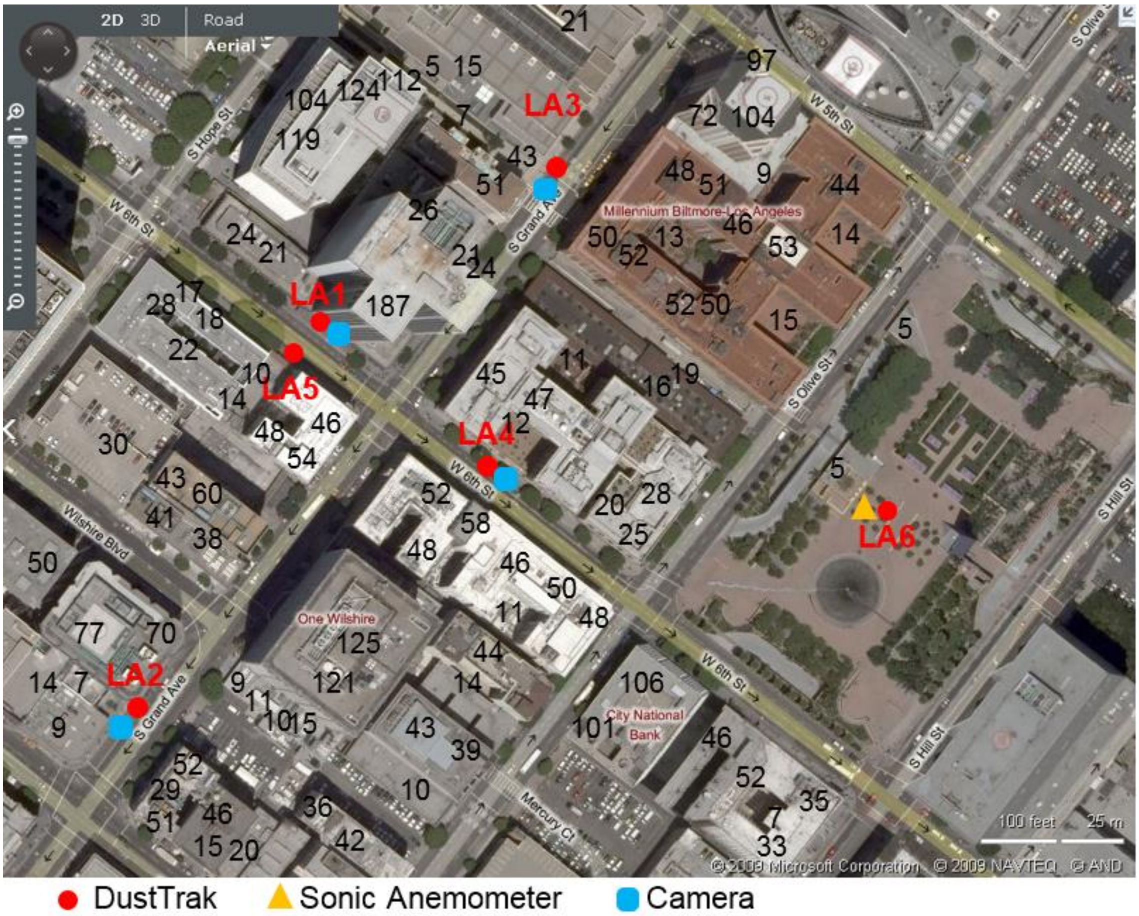


**Figure 1.** Site distribution in high-rise settlement-Los Angeles.
The numbers marked on buildings show height in meters (Pan et al., 2013)

## MODEL EVALUATION

Figure 2 shows the Quantile-Quantile (Q-Q) plot for the downtown LA field study. Q-Q plots are typically used to show model performance for ranked concentrations, which do not pair in time and location. It can be seen from Figure 2 that CALINE4 with onsite meteorological data generally overestimates the $PM_{2.5}$ concentrations for all concentrations ranges. This could be an indication that CALINE4 does not provide enough vertical mixing since CALINE4 does not require an input for standard deviation of vertical wind speed ($\sigma_w$). AERMOD with onsite meteorological data, especially the measured $\sigma_w$, appears to perform the best of all the dispersion models, being closest to the 1:1 line. AERMOD with nearby airport (LAX) meteorological data, however, has the worst performance over all concentration ranges. RLINE with onsite meteorological data has similar performance to AERMOD with onsite data, but it overestimates the highest concentration substantially. All dispersion models with onsite data tend to overestimate the high-end concentrations.

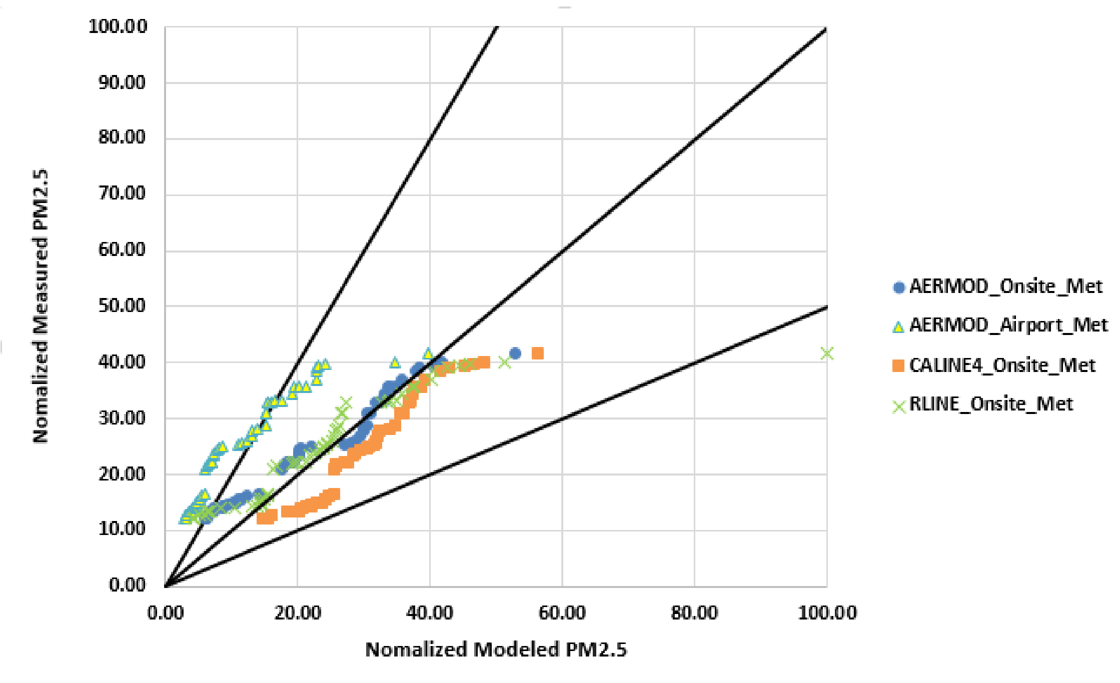


**Figure 2.** Q-Q Plot for Downtown LA Field Study

## SUMMARY

In response to the proposed replacement of CALINE3 with AERMOD in Appendix W, this paper compares air dispersion models' performance using a field study conducted in downtown LA, a typical high-rise unban environment. The results support the proposed replacement when onsite meteorological data is used as inputs to AERMOD.

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