Mobile Source Dispersion Modeling

Overview of Issue

There are several potential improvements to consider for future versions of AERMOD, including increasing the options for modeling mobile source line sources (i.e., highway and intersection projects), as well as accounting for different types of roadway design. The recent revisions to the *Guideline* included the replacement of CALINE3 with AERMOD as the preferred dispersion model for refined applications for roadway projects[1]. These regulatory applications include mobile source modeling for transportation conformity hot-spot analyses for particulate matter ($PM_{2.5}$ and PM_{10}) and carbon monoxide (CO).

Currently, AERMOD is used to model air quality from roadways using an elongated area source or a set of volume sources, though it does not contain a "true" non-buoyant line source. The area source approach may be relatively easy to implement, but the area source algorithms do not consider plume meander under low wind conditions, which can be particularly important for surface releases. The volume source approach included in the current version of AERMOD does consider plume meander under low wind conditions, but can be more complex to implement due to the number of sources required and the limitations that can exist for receptor placement for volume sources. EPA's PM Quantitative Hot-spot guidance discusses the use of area and volume sources to model air quality from roadways. [2]

R-LINE is a Research LINE source model, developed by EPA's Office of Research and Development (ORD). R-LINE uses state-of-the-art Gaussian dispersion algorithms, similar to AERMOD, and contains a "true" line source algorithm based on Romberg integration of point sources (Snyder et al., 2013a), it is tailored to roadway applications, and it considers plume meander under low wind conditions. R-LINE and its algorithms may offer an additional pathway for future modeling of mobile sources.

In addition, AERMOD does not contain algorithms to account for dispersion around solid noise barriers near roadways and roadways within a depression. However, R-LINE has beta implementation of solid barrier and depressed roadway algorithms for modeling complex roadway configurations. These algorithms are still under development by ORD, but there is an opportunity to include them once they have been appropriately evaluated and peer-reviewed (e.g., journal publication).

Current Implementation in AERMOD

AERMOD is currently capable of modeling a roadway source as either an area or volume source. The current implementation of the "LINE" source type represents a source as an elongated area source, which does not include considerations for low wind conditions (i.e., meandering). Volume sources, which can also be used to model line sources, however, have a treatment of meander which accounts

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[1] While AERMOD has been identified as the preferred model for refined mobile source modeling, the EPA has retained the CAL3QHC model as the preferred screening approach for CO screening demonstrations of highway projects. However, AERMOD can still be used for such screening demonstrations when paired with screening meteorology generated from MAKEMET. See the Technical Support Document provided as part of the Appendix W FRM package (U. S. EPA, 2016).

[2] Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas, EPA Office of Transportation and Air Quality, EPA-420-B-15-084, November 2015.

for the contribution of emissions in the downwind dispersion plume. The volume source method is computationally accurate and contains low wind meandering treatment, but is computationally intensive due to the number of sources needed to meet the AERMOD volume source criteria. The current area and volume approaches do not include noise barriers next to roadways and roadways depressed below the surrounding terrain.

Summary of Current Literature or Research

R-LINE Dispersion Model

Snyder et al., 2013a

This work outlines the R-LINE model formulations as well as the integration scheme and model assumptions. The Romburg integration scheme is explained as approximating a line using an exact point source dispersion solution and the systematic addition of point sources until convergence at the receptor is reached. Special attention is paid to cases where the receptor is located very near the line source. In this case, a minimum number of iterations is required to ensure that the spacing between the points used to approximate the line source is smaller than the distance from receptor to the line.

A model performance evaluation is conducted where the R-LINE model is compared to the concentrations from the Idaho Falls line source tracer experiment (Finn et al., 2010), the CALTRANS Highway 99 real-world tracer study (Benson, 1992), and the 2006 near road study in Raleigh, North Carolina (Baldauf et al., 2008). The R-LINE model showed good performance in a variety of atmospheric conditions, including stable, neutral and convective conditions; in a variety of wind conditions, including low winds, high winds, and winds parallel to the road; and in a variety of configurations including upwind, downwind, and close to the source.

Venkatram et al., 2013

This work outlines the new formulation of the horizontal and vertical surface dispersion curves used in R-LINE. These new formulations are based on data from the 1958 Prairie Grass Project, 2008 Idaho Falls line source tracer experiment (Finn et al., 2010), and EPA's neutral boundary layer meteorological wind tunnel. This article describes performance of the current AERMOD dispersion curves versus the new R-LINE dispersion curves for the Idaho Falls line source experiment.

Heist et al., 2013

This work evaluated the performance of the R-LINE, AERMOD-AREA, AERMOD-VOLUME, CALINE, and ADMS models in two applications. The first application of the models was in the Idaho Falls tracer experiment (Finn et al., 2010), which used a grid of receptors placed predominately downwind of a simulated line source that emitted a tracer gas. The second application was in the CALTRANS Highway 99 study (Benson, 1992), in which a tracer gas was systematically released from vehicles traveling down a highway. Measurements were taken along the median of the divided highway and along a transect from 50 to 200 meters. The conclusion of this work is that CALINE (version 3 and 4) produced more scatter than the other models in the model to measurement comparisons. In addition, the R-LINE, AERMOD-AREA, AERMOD-VOLUME and ADMS, all performed well with similar results. Overall, R-LINE showed slightly better model performance than AERMOD-AREA and AERMOD-VOLUME.

Barrier Algorithms

There have been multiple barrier algorithms proposed for inclusion to dispersion models, such as those presented by Schulte et al. (2014) and Venkatram et al. (2016). EPA's ORD is still working with R-LINE to

develop and evaluate algorithms to simulate the effects of solid barriers near roadways. This work is on-going and will utilize measurements take in EPA's wind tunnel (Heist et al., 2009), during the Idaho Falls experiment (Finn et al., 2010), the Raleigh near road study in 2006 (Baldauf et al., 2008), and the Phoenix, Arizona field study (Baldauf et al., 2016). However, these studies are limited in their range of meteorological conditions, duration, and variety of noise barrier characteristics (e.g. distance from roadway, height, and multiple barriers) studied.

Depressed Roadway Algorithm

There has been less work conducted on the development of depressed roadway algorithms in comparison to barrier algorithms. EPA's ORD is working to develop and evaluate a depressed roadway algorithm as part of R-LINE, utilizing wind tunnel studies (Heist et al., 2009) and the 2008-2009 field study in Las Vegas (Kimbrough et al., 2013; Baldauf et al., 2013).

Considerations for Updates in Model System

The EPA is currently working with the Federal Highway Administration (FHWA) on a joint initiative through a formal Interagency Agreement (IA) to advance several aspects of air quality dispersion modeling for mobile sources. In particular, the IA is the primary funding mechanism for a project to incorporate the R-LINE algorithms into AERMOD. The IA also provides funding to EPA's ORD to supplement existing efforts to conduct wind tunnel studies to further refine and develop solid barrier algorithms.

The primary focus of the IA is the creation of a new "RLINE" source type into the AERMOD modeling system. This work will implement the current R-LINE algorithms to simulate dispersion from line sources, such as roadways. The RLINE source type will contain the newly formulated surface dispersion parameterizations and will have features tailored to roadways. Incorporation of R-LINE will include model functionality extensions to utilize AERMOD's emissions processing for temporally variable emissions. The option to have RLINE sources classified as urban, like other AERMOD source types, with adjustments to meteorology and surface roughness will be added as an ALPHA option. The R-LINE algorithms will be implemented as two different source types. The first, the RLINE source type, will be added as a beta option and have inputs that match the current LINE source type to allow users to easily switch between LINE and RLINE calculations. The second, the RLINEXT source type, will be added as a beta option and have additional inputs, similar to the R-LINE model. In addition, the RLINEXT source type will offer the solid barrier and depressed roadway configurations as ALPHA options.. The EPA plans to have an internal draft of the R-LINE integration by mid-2018, with a potential beta release in the public version of AERMOD in mid-2019.

R-LINE and its algorithms are still being researched and developed, especially the roadway configurations for barriers and depressed roadways. EPA's ORD, partly in coordination with the FHWA IA, continues to take wind tunnel measurements to refine and improve these algorithms, but a database of relevant field studies highlighting these source configurations is needed. Once these algorithms have been thoroughly tested they could be incorporated into the RLINE source type. Their initial incorporation will be in an alpha form to allow testing and evaluation before they would be publicly released as a beta option(s) in AERMOD. The alpha (or beta) options would be available with the new RLINE source in AERMOD, so will potentially be available for public release in mid-2019.

Any future release of AERMOD alpha and/or beta options would be available for testing and comment by the user community, and potential future incorporation into AERMOD for regulatory purposes.

References

Baldauf, R., Thoma, E., Hays, M., Shores, R., Kinsey, J., Gullett, B., Kimbrough, S., Isakov, V., Long, T., Snow, R. and Khlystov, A. (2008). Traffic and meteorological impacts on near-road air quality: Summary of methods and trends from the Raleigh near-road study. Journal of the Air & Waste Management Association, 58(7), pp.865-878.

Baldauf, R.W., Isakov, V., Deshmukh, P., Venkatram, A., Yang, B. and Zhang, K.M. (2016). Influence of solid noise barriers on near-road and on-road air quality. Atmospheric Environment, 129, pp.265-276.

Baldauf, R.W., Heist, D., Isakov, V., Perry, S., Hagler, G.S., Kimbrough, S., Shores, R., Black, K. and Brixey, L. (2013). Air quality variability near a highway in a complex urban environment. Atmospheric environment, 64, pp.169-178.

Benson, P.E. (1992). A review of the development and application of the CALINE3 and 4 models. Atmospheric Environment. Part B. Urban Atmosphere, 26(3), pp.379-390.

Finn, D., Clawson, K.L., Carter, R.G., Rich, J.D., Eckman, R.M., Perry, S.G., Isakov, V. and Heist, D.K. (2010). Tracer studies to characterize the effects of roadside noise barriers on near-road pollutant dispersion under varying atmospheric stability conditions. Atmospheric Environment, 44(2), pp.204-214.

Heist, D.K., Perry, S.G. and Brixey, L.A. (2009). A wind tunnel study of the effect of roadway configurations on the dispersion of traffic-related pollution. Atmospheric Environment, 43(32), pp.5101-5111.

Heist, D., Isakov, V., Perry, S., Snyder, M., Venkatram, A., Hood, C., Stocker, J., Carruthers, D., Arunachalam, S. and Owen, R.C. (2013). Estimating near-road pollutant dispersion: A model inter-comparison. Transportation Research Part D: Transport and Environment, 25, pp.93-105.

Kimbrough, S., Baldauf, R.W., Hagler, G.S., Shores, R.C., Mitchell, W., Whitaker, D.A., Croghan, C.W. and Vallero, D.A. (2013). Long-term continuous measurement of near-road air pollution in Las Vegas: seasonal variability in traffic emissions impact on local air quality. Air Quality, Atmosphere & Health, 6(1), pp.295-305.

Schulte, N., Snyder, M., Isakov, V., Heist, D. and Venkatram, A. (2014). Effects of solid barriers on dispersion of roadway emissions. Atmospheric environment, 97, pp.286-295.

Snyder, M.G., Venkatram, A., Heist, D.K., Perry, S.G., Petersen, W.B. and Isakov, V. (2013a). RLINE: A line source dispersion model for near-surface releases. *Atmospheric environment*, *77*, pp.748-756.

Snyder, M.G. and Heist, D.K. (2013b). User's Guide for R-LINE Model Version 1.2: A Research LINE source model for near-surface releases. Atmospheric Modeling and Analysis Division.

U. S. EPA (2016). Technical Support Document (TSD) for Replacement of CALINE3 with AERMOD for Transportation Related Air Quality Analyses, EPA- 454/ B-16-006

U.S. EPA (2015). Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM2.5 and PM10 Nonattainment and Maintenance Areas, EPA-420-B-15-084

Venkatram, A., Snyder, M.G., Heist, D.K., Perry, S.G., Petersen, W.B. and Isakov, V. (2013). Re-formulation of plume spread for near-surface dispersion. Atmospheric environment, 77, pp.846-855.

Venkatram, A., Isakov, V., Deshmukh, P. and Baldauf, R., 2016. Modeling the impact of solid noise barriers on near road air quality. Atmospheric Environment, 141, pp.462-469.