Title

A Community-Scale Modeling System to Assess Port-Related Air Quality Impacts

ISBN

978-3-319-24476-1

Authors

Isakov, V
Barzyk, T
Arunachalam, S
et al.

Publication Date

2016-02-11

Peer reviewed

Chapter 63
A Community-Scale Modeling System to Assess Port-Related Air Quality Impacts

Vlad Isakov, Timothy Barzyk, Saravanan Arunachalam, Michelle Snyder and Akula Venkatram

Abstract Near-port air pollution has been identified by numerous organizations as a potential public health concern. Based upon multiple near-road and near-source monitoring studies, both busy roadways and large emission sources at the ports may impact local air quality within several hundred meters of the ports. As the volume of trucking and freight movement increases, near-road air quality along transportation routes could be affected well outside port boundaries. Health effects have been associated with near-road exposures and proximity to large emission sources, so characterizing emission sources is important for understanding potential health effects. To address this need, we have developed a new community-scale tool called C-PORT to model emissions related to all port-related activities—including, but not limited to ships, trucks, cranes, etc.—and predict concentrations at fine spatial scales in the near-source environment. C-PORT represents one of the first efforts to develop a reduce-form modeling system that is optimized for community-scale applications. The modeling system includes dispersion algorithms for area, point, and line sources related to port activities, and emissions from the port terminals. The use of the reduced-form approach in C-PORT enables us to examine what-if scenarios of changes in emission volume, such as due to changes in traffic counts, fleet mix, speed, or in port emissions due to equipment or vehicles in near real-time,

V. Isakov (✉)
Atmospheric Modeling and Analysis Division, National Exposure Research Laboratory, U.S. Environmental Protection Agency, RTP, Durham, NC, USA
e-mail: Isakov.Vlad@epa.gov

T. Barzyk
Human Exposure and Atmospheric Sciences Division, National Exposure Research Laboratory, Office of Research and Development, U.S. EPA, Research Triangle Park, Durham, NC, USA

S. Arunachalam · M. Snyder
Institute for the Environment, University of North Carolina, Chapel Hill, NC, USA

A. Venkatram
Department of Mechanical Engineering, University of California, Riverside, CA, USA

D.G. Steyn and N. Chaumerliac (eds.), *Air Pollution Modeling and its Application XXIV*, Springer Proceedings in Complexity,
DOI 10.1007/978-3-319-24478-5_63

using a web-based easy-to-use interface. The C-PORT model can be used to examine different scenarios of air quality impacts in order to identify potentially at-risk populations located near emission sources, and the effects that port expansion may have on them. We present an illustrative example of the near-port modeling assessment focusing on the Port of Charleston in South Carolina, USA, to complement a field-study that was conducted during spring 2014 to take air quality measurements in residential neighborhoods in the port vicinity.

63.1 Introduction

Many Ports are important drivers for some regional economies. As regional ports and infrastructure agencies prepare for additional freight, nearby communities voice concerns about increased emissions and air pollution exposure. As has been established in near-road and near-source monitoring studies, busy roadways and large emission sources may impact local air quality within several hundred meters of the source. A significant portion of this traffic is related to the freight transportation system that moves containers with heavy-duty diesel trucks. These trucks, in addition to the large commercial marine vessels that transport these goods in and out of ports are a significant source of pollution in the immediate vicinity of the port. As the volume of trucking and freight movement increases, near-road air quality along transportation routes could be affected well outside port boundaries (Hagler et al. 2013). Health effects have been associated with near-road exposures and proximity to large emission sources, so characterizing emission sources is important for understanding potential health effects. However, there is a lack of tools that can be applied to study near-source pollution in an easy manner, and explore the benefits of improvements to air quality and exposures—either due to voluntary or mandatory programs. Screening-level or reduced-form air quality modeling is a useful tool for examining what-if scenarios of changes in emission volume, such as those due to changes in traffic counts, fleet mix, or speed, or changes in port emissions due to equipment or vehicles. Examining various scenarios of air quality impacts in this way can identify potentially at-risk populations located near emission sources, and the effects that port expansion may have on them. To address this need for a systems approach, we have developed a new community-scale tool called C-PORT to model emissions related to all port-related activities (including, but not limited to ships, trucks, cranes, etc.), and predict concentrations at fine spatial scales in the near-source environment.

63.2 Community-Scale Modeling Tool C-Port

C-PORT represents one of the first efforts to develop a reduce-form modeling system that is optimized for community-scale applications. The modeling system includes dispersion algorithms for area, point, and line sources related to port activities, and emissions from the port terminals. C-PORT incorporates modeling algorithms developed through research and development of the R-LINE model on pollutant transport and dispersion from roadways (Snyder et al. 2013). The use of the reduced-form approach in C-PORT enables us to examine what-if scenarios of changes in emission volume, such as due to changes in traffic counts, fleet mix, speed, or in port emissions due to equipment or vehicles in near real-time, using a web-based easy-to-use interface (Barzyk et al. 2015). The C-PORT model can be used to examine different scenarios of air quality impacts in order to identify potentially at-risk populations located near emission sources, and the effects that port expansion may have on them. Key model features include the ability to select and change model inputs (roadway sources, area sources, ships at the terminal and ships in transit), perform the analysis, and visualize the results. An example of C-PORT, a computer screen snapshot, is shown in Fig. 63.1. The figure illustrates how the model results (e.g. near-road pollutant gradients) are visualized for a selected scenario.

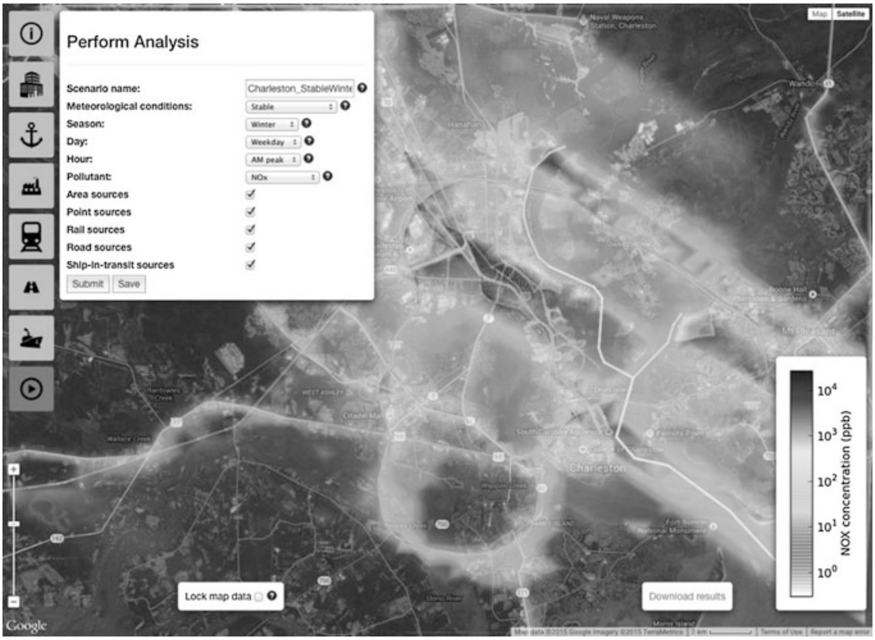

Fig. 63.1 Computer screen snapshot of the C-PORT model

63.3 Illustrative Example of C-PORT Application in Charleston, SC

We applied the C-PORT model as a part of the near-port modeling assessment in Charleston, South Carolina, USA. Figure 63.2 show a map of the study area. We have also conducted a field-study during spring 2014 to take air quality measurements in residential neighborhoods in the port vicinity. High-resolution monitoring using EPA's Geospatial Monitoring of Air Pollution (GMAP) vehicle was performed along driving routes near several port terminals and rail yard facilities, recording geospatial coordinates and measurements of pollutants including black carbon (BC), size-resolved particle count ranging from ultrafine to coarse, carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen dioxide (NO_2). Additionally, a portable meteorological station was used to characterize local meteorology. Port activity data was provided by the Port Authority of Charleston and includes counts of ships and trucks, and port service operations such as cranes and forklifts during the sampling time periods. These data are analysed in order to characterize the impact of the port activity on local scale air quality. Preliminary analysis shows the

Fig. 63.2 Map of the study area showing locations of port terminals in Charleston, SC

highest concentrations are found along major roadways. Modeling provides relative contributions of traffic emissions, emissions from port terminals, and emissions from ships to the total concentrations at model receptors. Further analysis will be performed to use the model-based estimates of relative contributions of various port-related source categories in order to isolate the effect of port-related activity on local communities. The C-PORT modeling application will help to identify potentially at-risk populations located near emission sources at the port terminals, and the effects that change in port-related activities may have on them.

Disclaimer Although this work has been reviewed and approved for publication by the U.S. Environmental Protection Agency, it does not necessarily reflect the views and policies of the agency.

Questions and Answers

Questioner: Stefano Alessandrini
Question: Does your model treat the buoyant plumes as independent? An interaction could eventually enhance the rise compared to what can happen treating them separate.

Answer: We agree with your comment on the need to carefully consider the interaction of plumes in the model to adequately represent the complex processes affecting the plume behavior. However, the C-PORT model is based on a steady-state Gaussian dispersion model formulations and therefore doesn't consider plume interactions. Increasing complexity of model formulations to account for plume interactions might not be feasible for a web-based, real-time reduced-form models such as C-PORT.

Questioner: Jukka-Pekka Jalkanen
Question: How do you estimate the axillary engine usage of ships at berth? This is an area of large uncertainty in port emissions modeling.

Answer: We agree with your comment on the need to accurately characterize ship emissions. We provide default emissions for all ship emissions at 17 ports in southeastern US, and we recognize that the uncertainty in these default ship emissions could be high. However, for a reduced-form model such as C-PORT, an ability to provide quick calculations and bound the uncertainty in ship emissions. The user can change these emissions and run C-PORT to calculate a difference in resulting concentrations for low and upper bounds of emission estimates in order to understand the impact of uncertainty in emission inputs on modeled concentrations.

References

Barzyk TM et al (2015) A near-road modeling system for community-scale assessments of mobile-source air toxics: the community line source (C-Line) modeling system. Environ Model Softw 66:46–56. doi:10.1016/j.envsoft.2014.12.004

Hagler G et al (2013) Panama Canal expansion illustrates need for multimodal near-source air quality assessment. Environ Sci Technol 47:10102–10103. doi:10.1021/es403145x

Snyder MG et al (2013) RLINE: a line source dispersion model for near-surface releases. Atmos Environ 77:748–756. doi:10.1016/j.atmosenv.2013.05.074