

Assessment of Near-Source Air Pollution at a Fine Spatial Scale Utilizing a Mobile Monitoring Approach

A&WMA 2015 Conference – Raleigh, NC

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Background

- Ports play a critical role in the United States and global economies.¹
- The Panama Canal is undergoing an expansion which will double its capacity and allow for larger vessels to pass through.²
- While this is expected to provide a positive economic impact, the environmental impact is uncertain.
- Port facilities service traffic from ocean going vessels (OGV), on-terminal equipment, heavy trucks, and rail.
- Research on roadways and railways has shown they contribute to elevated levels of harmful pollutants nearby.³⁻⁶

Project Overview

- Early effort in investigating the effect of ports on the local-scale air quality (within a few hundred meters from the terminals).
 - Mobile monitoring campaign conducted around the Port of Charleston
 - Measurement data supplemented with modeling results from AERMOD and RLINE
- Use data to isolate the port contribution from other source contributions (e.g. roadways) and control for confounding variables (e.g. meteorological conditions)

Study Overview



Wando Welch Terminal

Source:

<http://www.scspace.com/>



GMAP Vehicle

- Mobile monitoring campaign
 - February and March, 2014
 - Port of Charleston area in South Carolina
 - Measurement conducted using EPA's Geospatial Monitoring of Air Pollution (GMAP) vehicle
- GMAP vehicle
 - all-electric
 - measures real-time (1 Hz) concentrations of BC, NO₂, UFP, PM_{2.5}, PM₁₀, CO, and CO₂
 - on-board GPS records geospatial coordinates
 - 3 to 4 hour range
 - Repeated laps at various times of day and week near different port terminals
- Meteorological conditions recorded with nearby stationary sampling

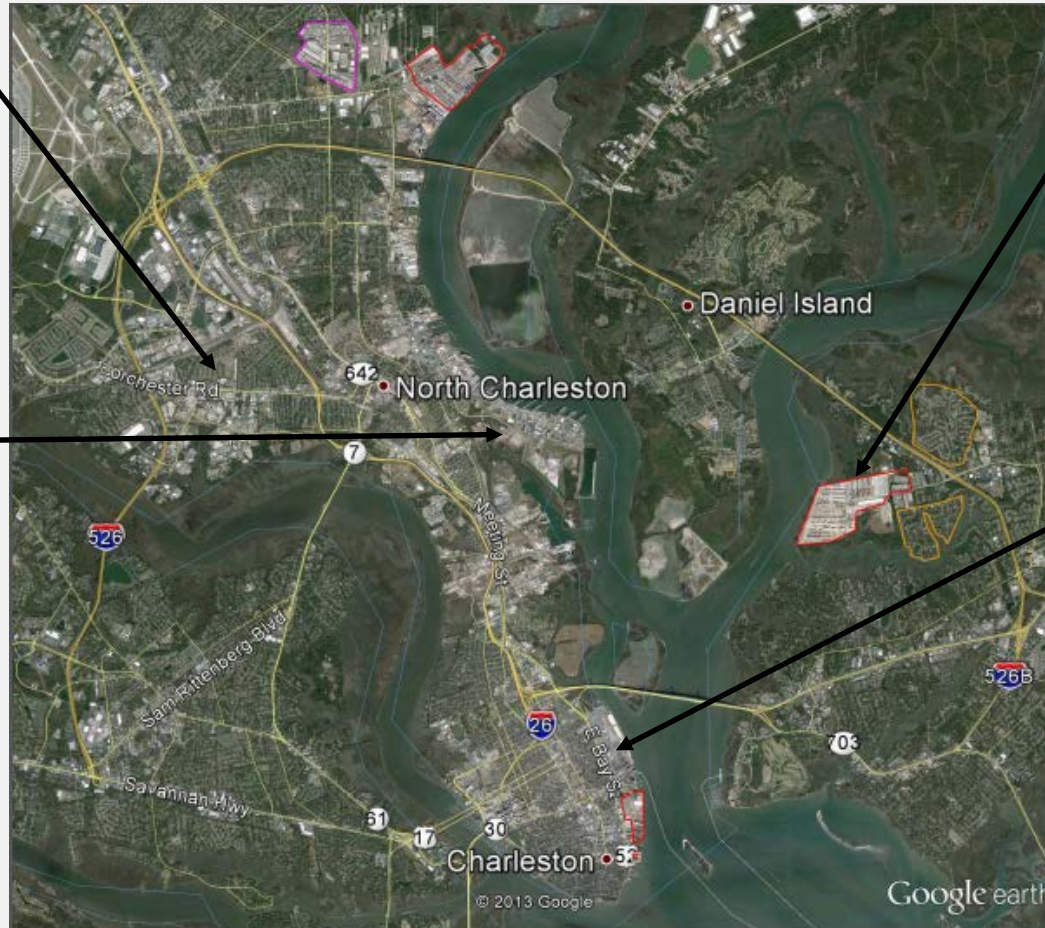
Port of Charleston

Bennett Rail
Yard

Wando
Welch
Terminal

Veteran's
Terminal

Columbus
Street
Terminal



Driving Routes

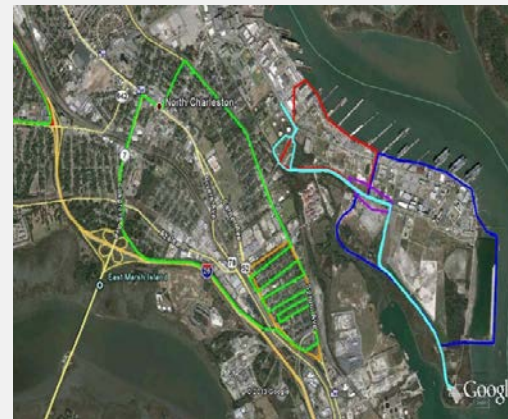
- Sampling at each occurred over 3-4 hour periods on multiple days
- Measurement start times were selected to cover a wide range of port operational times
 - Normal port operational hours are 7 AM to 7 PM
- Driving routes shown in green.
- Port terminals outlined in red.



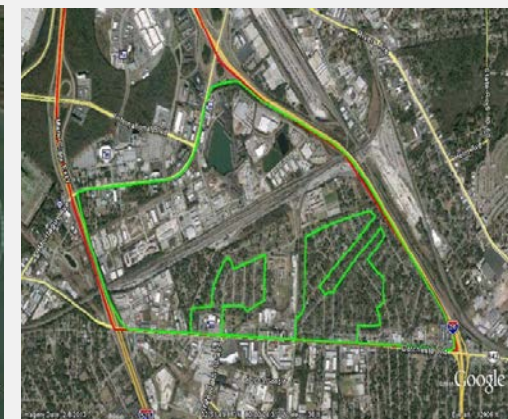
Wando Welch Terminal
(10 sampling days)



Columbus Street Terminal
(6 sampling days)



Veteran's Terminal (4
sampling days)



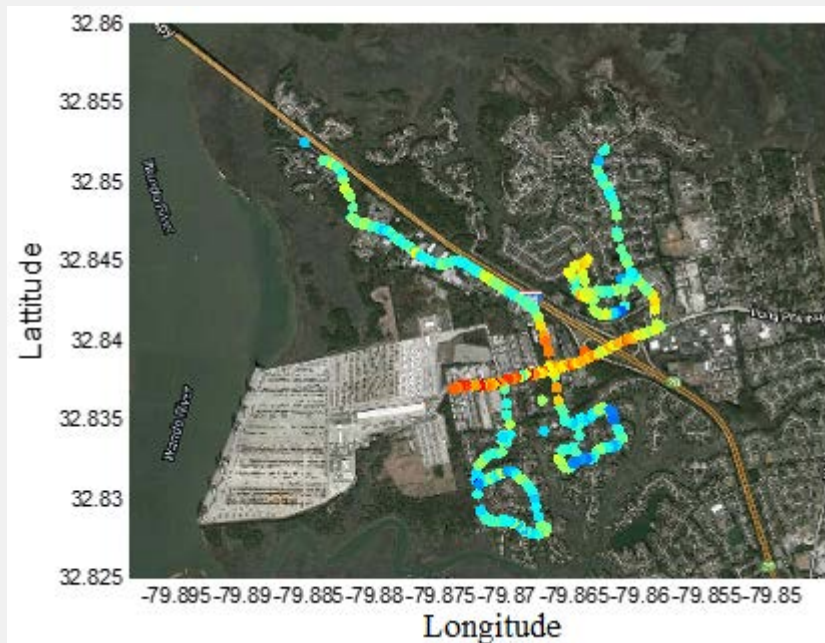
Bennett Rail Yard (4
sampling days)

GMAP Vehicle Instrumentation

Measurement	Sampling Rate	Instrument	Stationary/ Mobile
NO ₂	1s	Visible (450 nm) absorption Cavity Attenuated Phase Shift Spectroscopy (CAPS, Aerodyne Research, Inc., Billerica, MA, USA)	Mobile
Carbon monoxide (CO)	1 s	Quantum cascade laser (QCL, Aerodyne Research, Inc., Billerica, MA, USA)	Mobile
Carbon dioxide (CO ₂)	1 s	Li-COR 820 non-dispersive infrared (NDIR), (LI-COR, Lincoln, Nebraska USA)	Mobile
Particle number concentration (size range 5.6-560 nm, 32 channels)	1 s	Engine Exhaust Particle Sizer (EEPS, Model 3090, TSI, Inc., Shoreview, MN, USA)	Mobile
Particle number concentration (size range 0.5-20 µm, 52 channels)	1 s	Aerodynamic Particle Sizer (APS, Model 3321, TSI, Inc., Shoreview, MN, USA)	Mobile
Black carbon	1-5 s	Single-channel Aethalometer (Magee Scientific, AE-42, Berkeley, CA, USA)	Mobile
Longitude and latitude	1 s	Global positioning system (Crescent R100, Hemisphere GPS, Scottsdale, AZ, USA)	Mobile
3D wind speed and direction	1 s	Ultrasonic anemometer (RM Young, Model, Traverse City, MI, USA)	Stationary
SO ₂	1 s	Ecotech 9850 (Ecotech, Knoxfield Victoria, 3180, Australia)	Stationary

Spatially Averaged Concentration

- Each point represents average of all black carbon concentrations ($\mu\text{m}/\text{m}^3$) measured within 20 m radius.
- High concentrations observed along major roadways (significant non-port impact)
- Analysis will focus on measurements within neighborhood zones (outlined in black)



Wando Welch Terminal



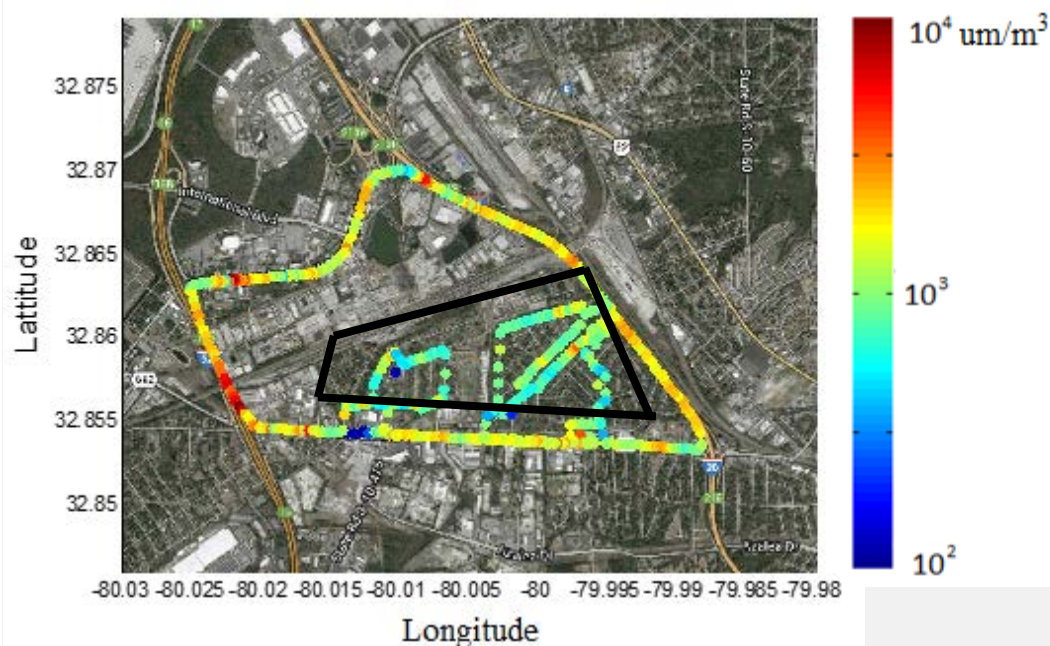
Columbus Street Terminal

Spatially Averaged Concentration

- Spatially averaged Black Carbon concentrations ($\mu\text{m}/\text{m}^3$) at Veteran's Terminal and Bennett Rail Yard



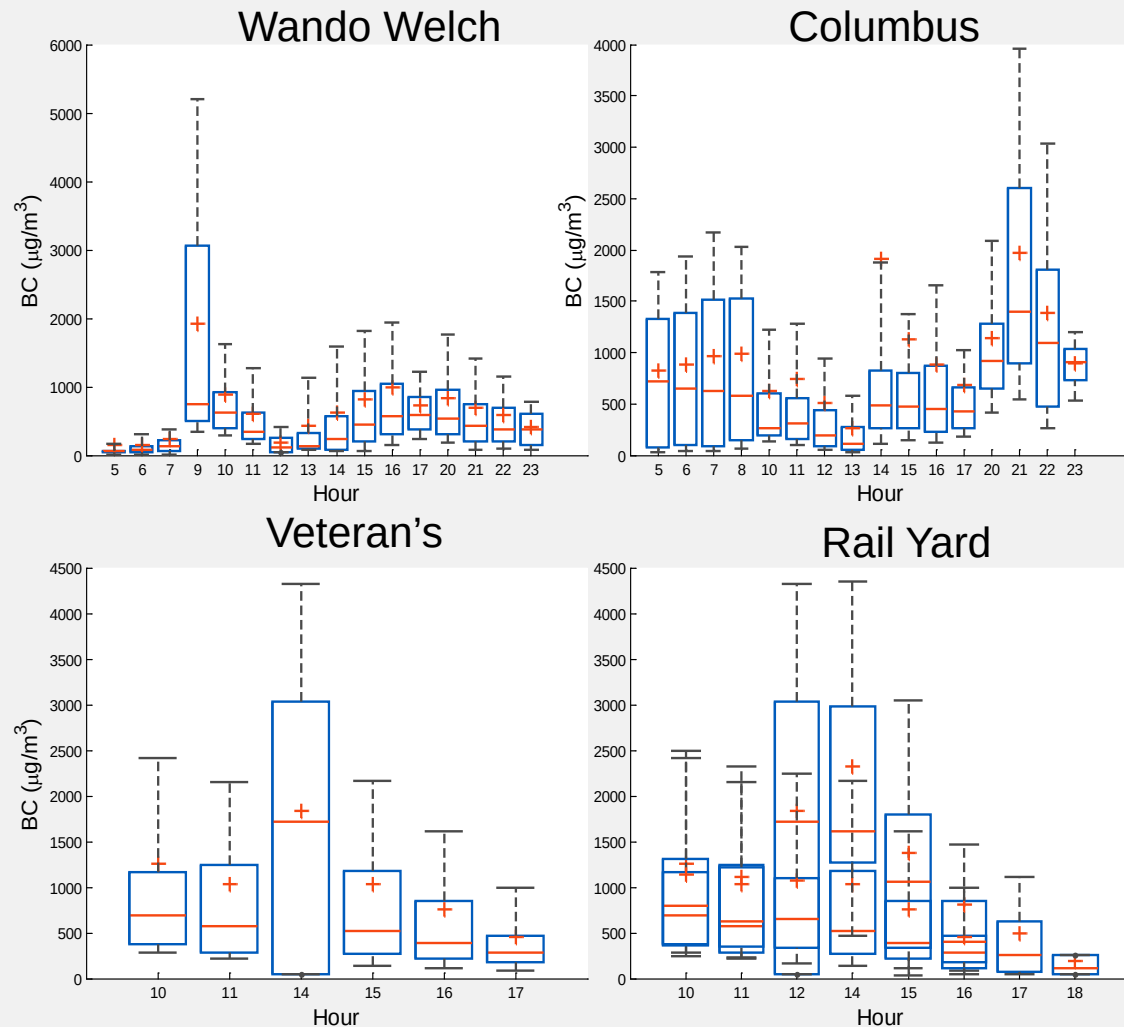
Veteran's Terminal



Bennett Rail Yard

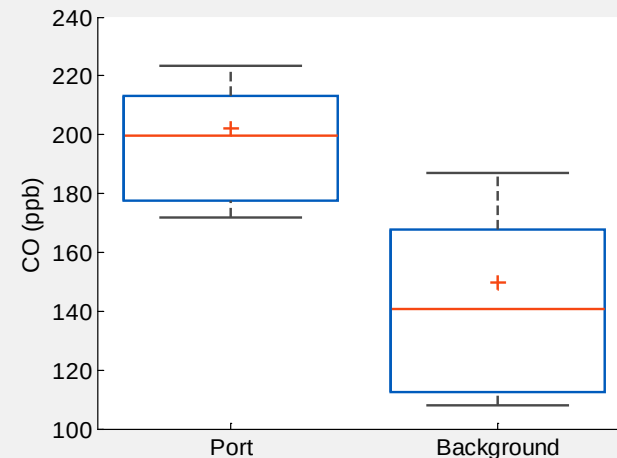
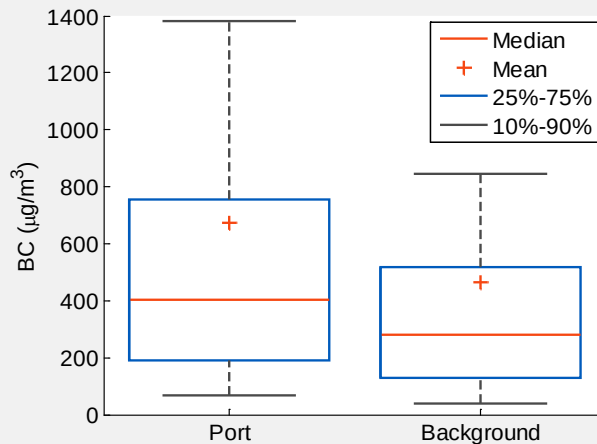
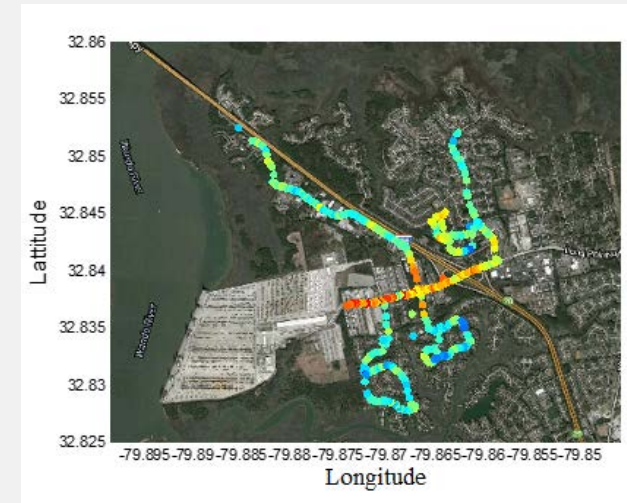
Time of Day

- Distributions of concentration show high variability in measurement
- Higher concentrations observed in the morning and afternoon (likely traffic related spikes)
- Generally higher concentrations observed during port operational hours (7 AM to 7 PM)
- Significant non-port effect observed – high concentrations outside of port hours
- Limited hours of measurement at Veteran's Terminal and Rail Yard



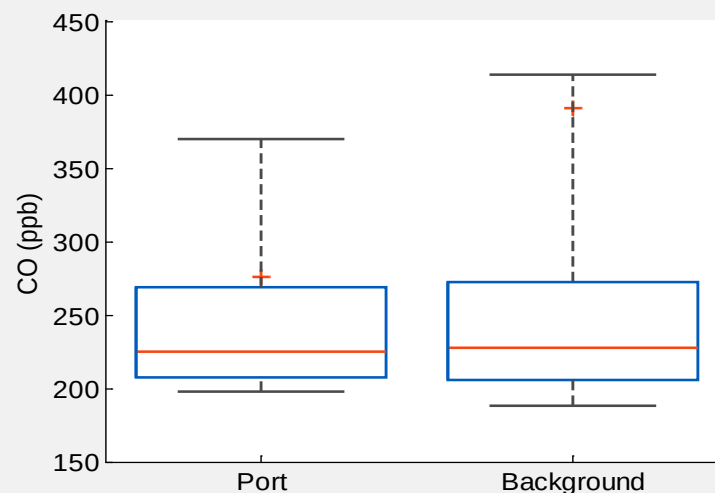
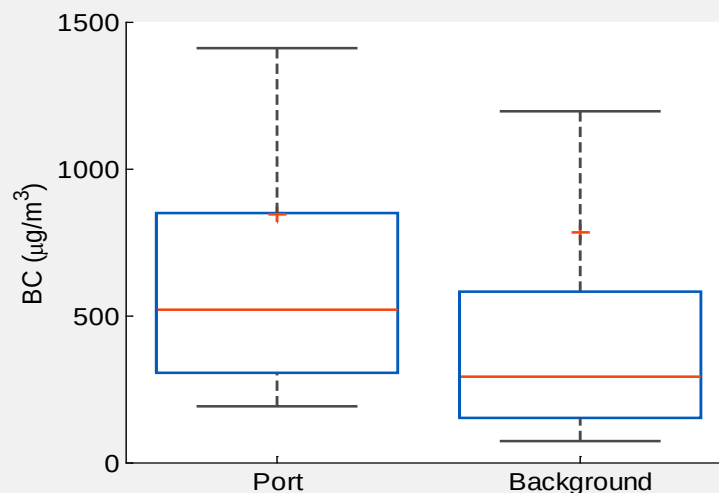
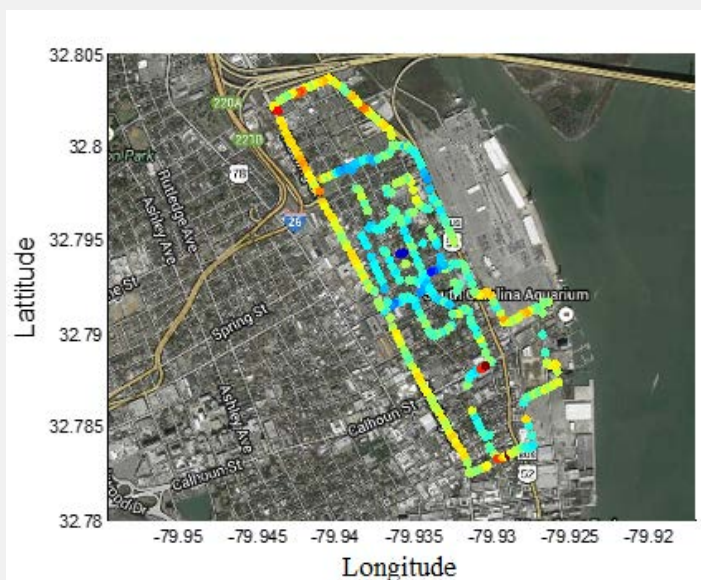
Wando Welch Terminal

- Local background concentration is taken by selecting periods where wind is from a direction away from the port (from the South at Wando for lower neighborhoods)
- This is compared to periods where wind is blowing from over the port
- Comparison was confined to periods during normal port operating hours (7 am to 7 pm) during similar atmospheric conditions to make a more fair comparison
- A significant effect from the port is observed in all measured pollutants (only BC and CO shown)



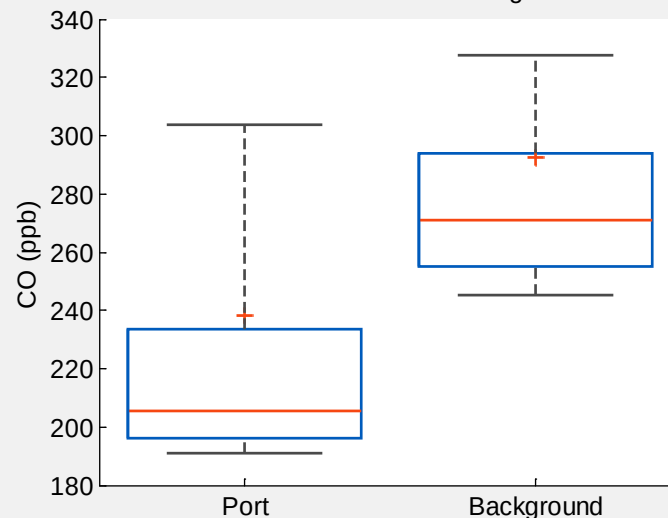
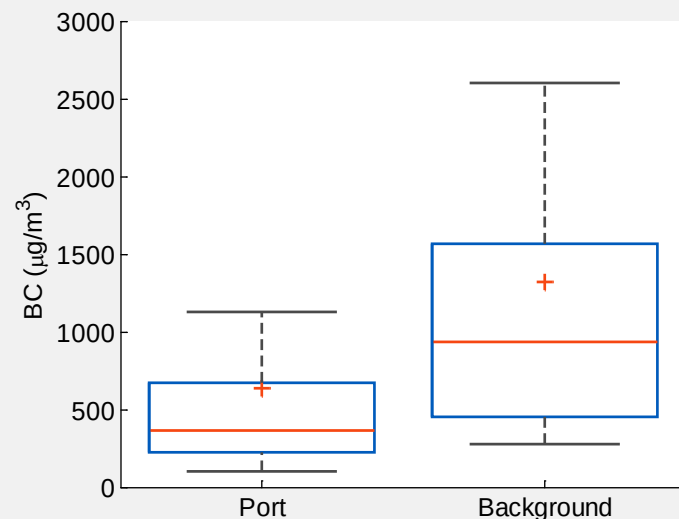
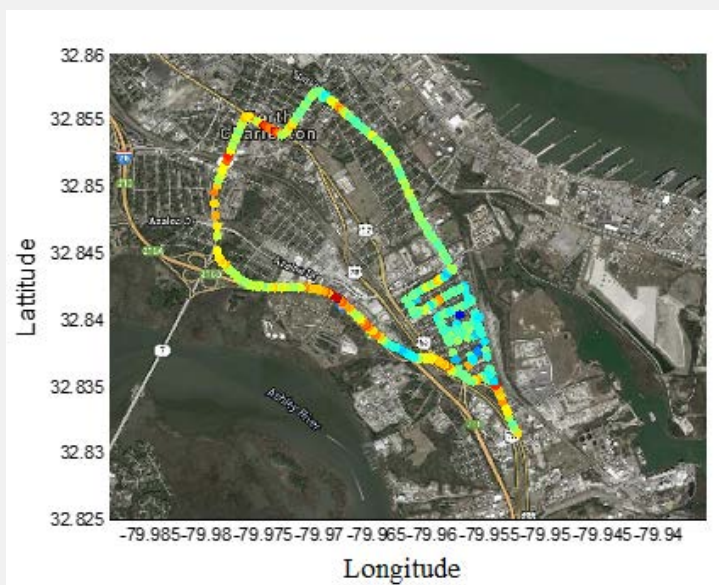
Columbus Street Terminal

- Only small (if any) port influence is observed at the Columbus Street terminal
- Many confounding sources in the vicinity make it difficult to isolate port effect



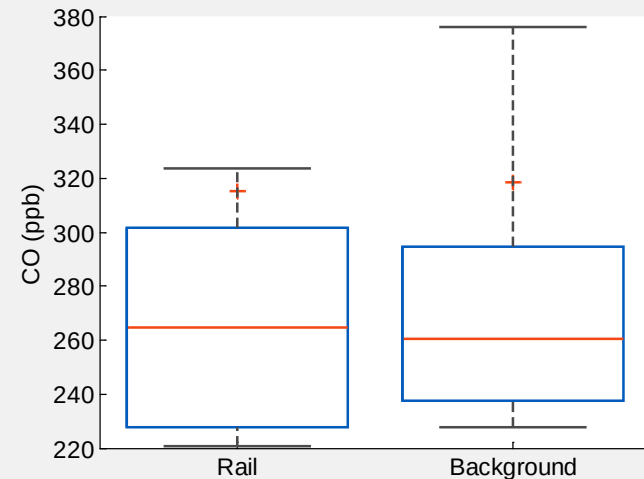
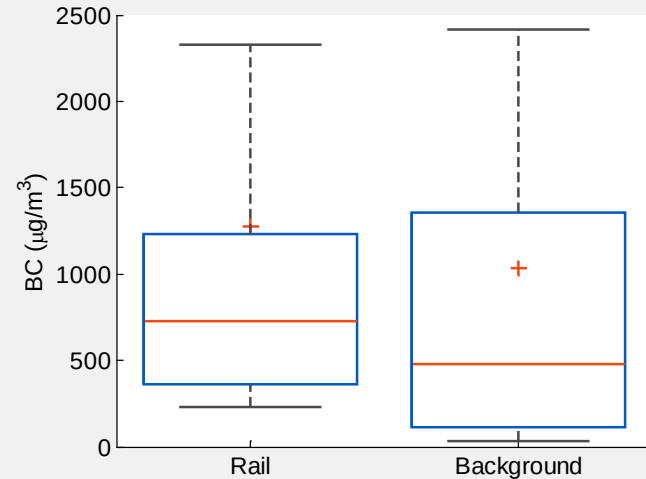
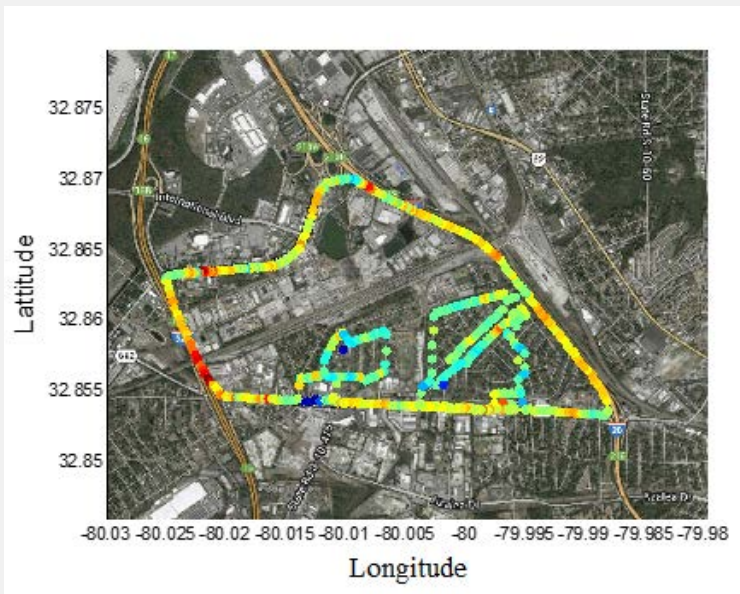
Veteran's Terminal

- “Background” is observed to be higher near Veteran’s Terminal
- Port is further away from neighborhood reducing its impact
- Major highway immediately on the far end of the neighborhood causing much higher concentration when wind is blowing from that direction

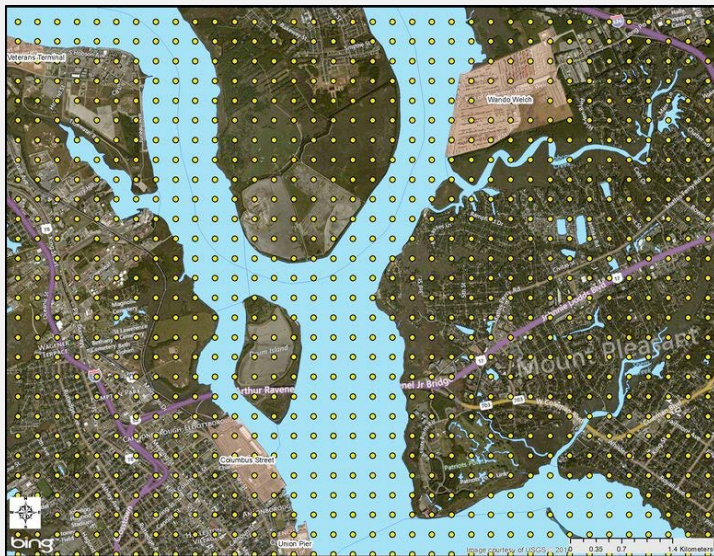


Bennett Rail Yard

- Little difference observed between rail and background
- Very strong influence from major roadways in all directions



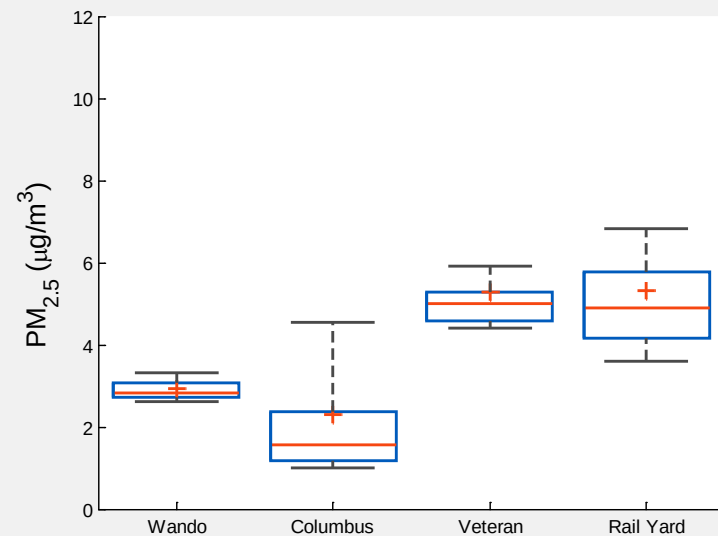
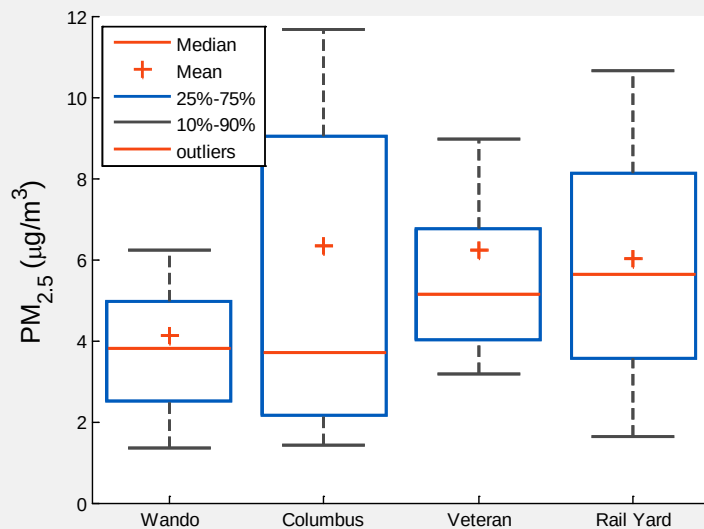
Modeling Analysis



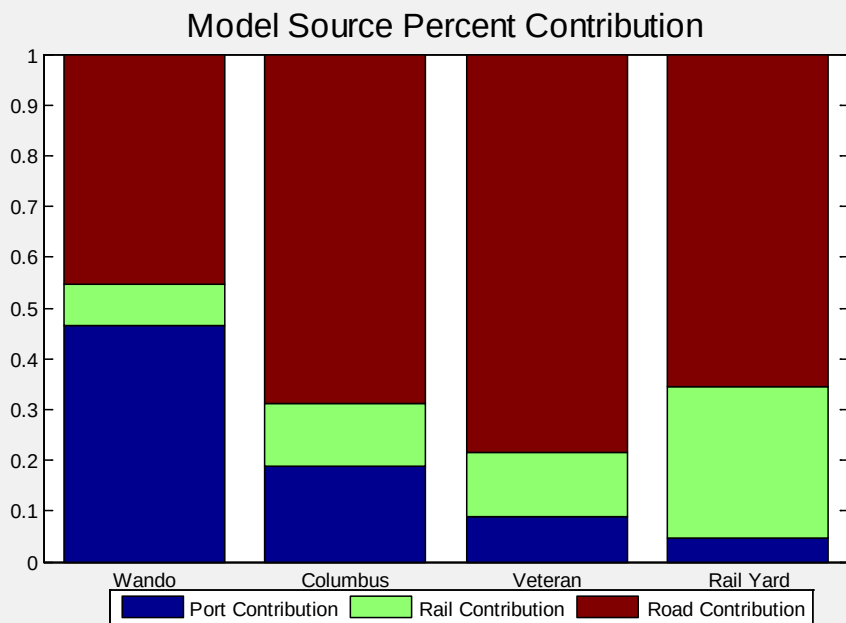
- Model port-related emissions of PM_{2.5} using AERMOD and RLINE
 - AERMOD models port on-terminal sources such as heavy equipment and docked vessels as area source using emissions inventory data
 - RLINE models roadway and railways as line sources using AADT counts
- Receptor grids Uniformly spaced at 270m resolution (8,100 receptors)

Modeling Analysis

- Differences in sampling times/days, met conditions and distance from source to sampling locations makes it difficult to accurately compare each site to each other
- However, comparison between measurement and model in the neighborhood regions along the four measurement routes for $PM_{2.5}$ shows good qualitative agreement at Wando, Veteran's and the Rail Yard
- Model results for Columbus Street terminal are much lower than measurement, suggesting the model may be missing some major emission source near this location



Modeling Analysis



- Isolating percent contribution from the three source types shows that roadway sources dominate port and rail source everywhere except Wando Welch terminal
- Measurement route near Veteran's terminal is further away than other terminal routes, explaining minor port impact
- Port contribution only relates to on-terminal activity. Part of road and rail contribution would also be attributable to port activity

Summary and Future Work

- Mobile monitoring campaign conducted around the Port of Charleston, South Carolina, using GMAP vehicle.
- Very large amount of data collected – over 55 hours of real-time sampling of multiple pollutants and meteorological conditions.
- Ports are shown to have a potentially significant impact on local air quality (Wando Welch) which quickly diminishes away from the port (Veteran's). This effect can be difficult to isolate as the impact of roadways is generally much higher.
- This work represents an early effort in mapping near-port air quality. More port-related mobile monitoring campaigns may be conducted to facilitate a more comprehensive analysis.
- This data will be used to develop and refine a community tool, C-PORT, for near-source air quality assessment.

ACKNOWLEDGMENTS

This project was supported in part by an appointment to the Research Participation Program at the Office of Research and Development, U.S. Environmental Protection Agency, administered by the Oak Ridge Institute for Science and Education through an interagency agreement between the U.S. Department of Energy and EPA.

The US Environmental Protection Agency through its Office of Research and Development funded and conducted the research described here through Contract EP-C-09-027 with ARCADIS, Geraghty & Miller. Mention of trade names or commercial products does not constitute endorsement or recommendations for use. Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

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