Measuring the Impact of Charleston Port Activities on Local Air Quality

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Introduction

Ports are a critical feature of the nation's economy:

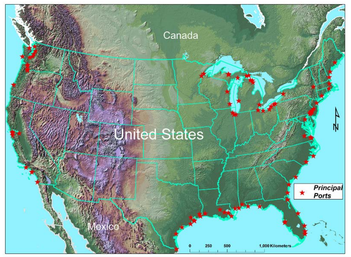
- port commerce supports 13 million jobs and contributes $3.15 trillion to the economy;
- value of goods shipped through seaports represents 11% of the GDP;
- US has 360 commercial ports, including 150 deep-draft seaports (see figure below);
- ports may be considered multi-modal transportation facilities (includes truck and rail yard).

Multiple air pollutant species can be emitted from these multi-modal facilities:

- carbon monoxide (CO),
- oxides of nitrogen (NO, NO_2, NO_x),
- particulate matter with an aerodynamic diameter < 10µm are referred to as PM10;
- particulate matter < 2.5 µm in diameter are referred to as $PM_{2.5}$;
- black carbon (BC); etc.

Near-sources, such as ports, may impact local air quality several hundred meters away;

- Health effects have been associated with these near-road exposures.



Principal Ports of U.S.

Panama Canal Expansion

Panama Canal Expansion Driving Expansion Across US:

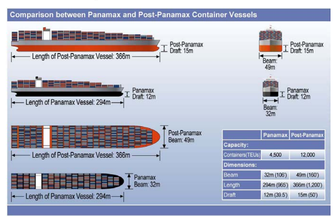
- expansion scheduled for completion in 2016;
- Post-Panamax vessels can haul 2.5 times as many containers as Panamax vessels (see figure below)

Port of Charleston South Carolina:

- expanding operations in anticipation of freight volume growth;
- fourth largest U.S. container port -- twenty-foot equivalent units (TEUs);

Charleston Study Science Questions:

- What is the spatial extent of local air pollution elevated over the background, downwind of a major port facility in Region 4 (i.e., Charleston, SC)?
- What is the spatial and temporal variability of near-port air pollution, under different meteorological conditions and source emission characteristics?



Panamax versus Post-Panamax Vessels

U.S. Environmental Protection Agency
Office of Research and Development

Environmental Concerns and Drivers

Near-road/Near-source research issues include:

1. Concern regarding local-scale air pollution and communities (including environmental justice issues);
2. Impact of rail yards on local air quality and PM nonattainment;
3. Need for additional analysis on local-scale air pollution impacts due to port activity expansion;
4. Need for data-driven (as opposed to solely modeled estimates) documentation of port-area emission changes;
5. Need for simplified community-scale tools able to provide rapid scenario assessments for mitigation strategies, modal shifts, etc.; and
6. Need to determine the impact of existing emission reduction strategies and assess the need for additional emission reduction strategies.

Science Questions

1. What is the spatial and temporal nature of air pollution emissions and near-source concentrations associated with rail yards or ports, and related truck traffic?
2. What is the spatial extent of local air pollution elevated over the background, downwind of a major port facility (e.g., Charleston, SC)?
3. What is the spatial and temporal variability of near-port air pollution, under different meteorological conditions and source emission characteristics?
4. How can the signal from one source of interest be isolated in a complex environment of clustered confounding sources?
5. How can increases (e.g., increased freight-handling activity related to Panama Canal expansion) or decreases (e.g., port voluntary programs, rail yard engine improvements) in source emissions from a port or rail yard be detected using a combined air pollution measurement and modeling strategy?
6. What mitigation strategies can provide meaningful improvement in near-source air pollution for ports, rail yards, or related intermodal transportation?
7. How can transferable research tools for EPA Regions be developed to use in assessing progress towards emission improvements and addressing environmental justice concerns for specific sources of interest?

Research Strategies

Assessment Strategy	Pros	Cons
Stationary, fixed site measurements	Predominately Federal Equivalent Method/Federal Reference Method (FEM/FRM) analyzers	High cost; infrastructure; operation
Mobile monitoring – GMAP – Geospatial Measurements of Air Pollution	Electric vehicle; High-resolution—spatial and temporal	Short term sampling; moderate cost; "data snapshot"
GIS analyses	Data visualization, spatial resolution	Data quantity/quality may need improvement
Monitor/model hybrids	Screening tools for evaluating air pollution impacts	Spatial/temporal resolution may be limited due to data inputs
Low-cost sensors	Lower cost; potential for higher spatial and temporal resolution	Emerging technology; sensor quality; data quality issues

Port of Charleston Study Strategy

Facilities of interest:

- Wando Welch Terminal; Columbus St. Terminal/Union Pier; Veterans Terminal;
- Bennett Rail Yard

Measurement Campaign:

- electric vehicle (GMAP) outfitted with real-time air monitoring instruments;
- vehicle has an on-board battery and inverter supporting driving and powering the air monitoring instruments;
- daily sampling duration, limited by power availability, is usually limited to approximately 2-3 hours of driving mode sampling;
- sampling days were repeated and routes were driven multiple times during the sampling period.

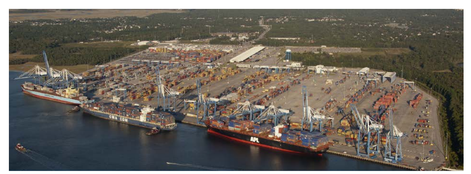
Sampling Regime Considerations:

- port activity hours – 7 am to 7 pm when ships are being loaded/unloaded;
- electric vehicle range – 3-4 hours depending on route to be driven, laps, and road speed;
- non-port activity hours – Coordinated with Port Authority of Charleston;
- weekdays (Monday – Saturday) – Sampling events were planned for Tuesday-Saturday, with Monday used as a preparation or sampling makeup day in case of weather-related cancellation or technical issues;
- avoidance of sample start times coinciding with typical commute hours;
- sample start times – Week 1: 4 am sampling start each day; Week 2: 1:30 pm sampling start; Week 3: 9 am sampling start;
- meteorology – local meteorological data collected using a portable meteorology station at a stationary location in the vicinity of route driven.

Parameters Measured, Sampling Rate, and Instruments.

Measurement	Sampling Rate	Instrument	Stationary/ Mobile
NO_2	1 s	Visible (450 nm) absorption (CAPS, Aerodyne Research, Inc, Billerica, MA, U.S.)	Mobile
Carbon monoxide (CO)	1 s	Quantum cascade laser (QCL, Aerodyne Research, Inc., Billerica, MA, U.S.)	Mobile
Carbon dioxide (CO_2)	1 s	Li-COR 820 NDIR, (LI-COR, Lincoln, Nebraska U.S.)	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, U.S.)	Mobile
Particle number concentration (size range 0.5-20 µm, 52 channels)	1 s	Aerodynamic Particle Sizer (APS, Model 3321, TSI, Inc., Shoreview, MN, U.S.)	Mobile
Black carbon	1-5 s	Single-channel Aethalometer (Magee Scientific, AE-42, Berkeley, CA, U.S.)	Mobile
Longitude and latitude	1 s	Global positioning system (Crescent R100, Hemisphere GPS, Scottsdale, AZ, U.S.)	Mobile
3D wind speed and direction	1 s	Ultrasonic anemometer (RM Young, Model 81000, Traverse City, MI, U.S.)	Stationary
SO_2	1s	Ecotech 9850 (Ecotech, Knoxfield, Victoria, 3180, Australia)	Stationary

Port of Charleston Area
Source: http://www.scspa.com/



Wando Welch Terminal.
Source: http://www.scspa.com/

Summary

The study yielded a rich data set (200,000+ seconds of quality assured data) that is undergoing analysis and is being used to develop a screening modeling tool (C-PORT) for near-source air quality assessments. Future work may include expansion of the C-PORT model to be used for other multi-modal transportation facilities.