Air & Waste Management Association
2015 Annual Meeting

Analysis of High Time-Resolution Measurement of Gaseous and Particulate Pollution Near the Port of New York and New Jersey

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R2PIER

Region 2 Port-area Investigation of Emissions Reduction (R2PIER)

"Determine the extent to which certain key actions in the [Port's Clean Air] Strategy ultimately lead directly to emissions reductions. The outcome will be a quantification of the emissions benefit over time from the select Strategy actions"

Focus of this study is:

- To observe via in situ air monitoring whether emissions improvements in the Port area translate to detectable local-scale air quality improvements
- To characterize local air quality in an environment with multiple major transit source types (port, highway, airport)
- To develop research strategies to decouple confounding source signals

R2PIER

Clean Air Strategy details:

Ships

- Emissions Control Area effective August 2012 (mandatory 1% S fuel, down from around 2.5%)
- Low sulfur fuel switching incentive (down to 0.2% S, but program replaced with clean vessel incentive in Jan 2013)
- Clean vessel incentive: ships that have cleaner engines and use lower sulfur fuel qualify for an incentive (began Jan 2013)

Trucks

- Truck replacement program: about 170 old drayage trucks were replaced with newer vehicles since June 2012
- Also note: thousands of existing trucks were wiped out in Sandy (Oct 2012; ~2500 trucks lost, unknown what fraction served the port)

Cargo handling equipment

- Fleet modernization program: replacing 125 older pieces of cargo handling equipment with new, cleaner equipment (as of Dec 2012, 37 were complete)

Tug boats

- Ultra low sulfur diesel (15 ppm S, down from 500 ppm) mandated in late 2012

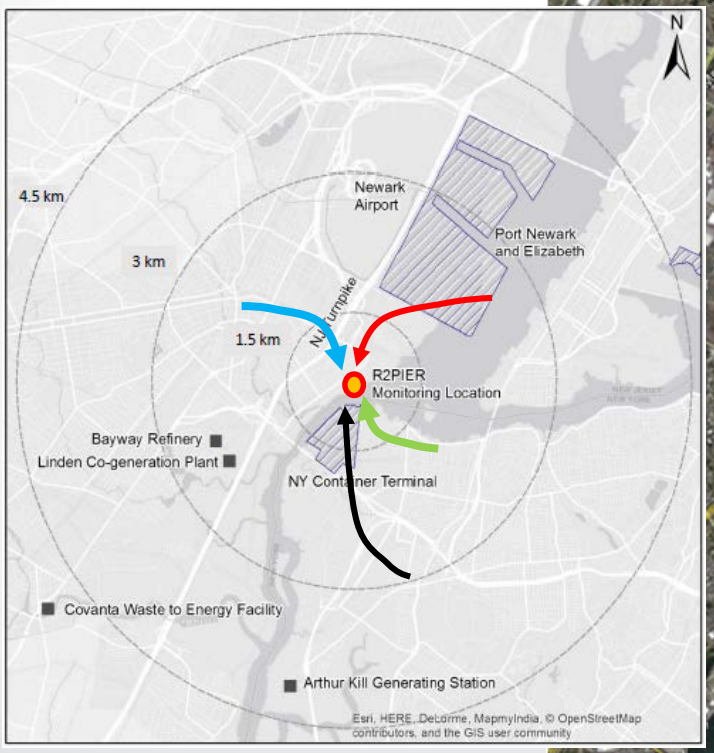
Locomotives

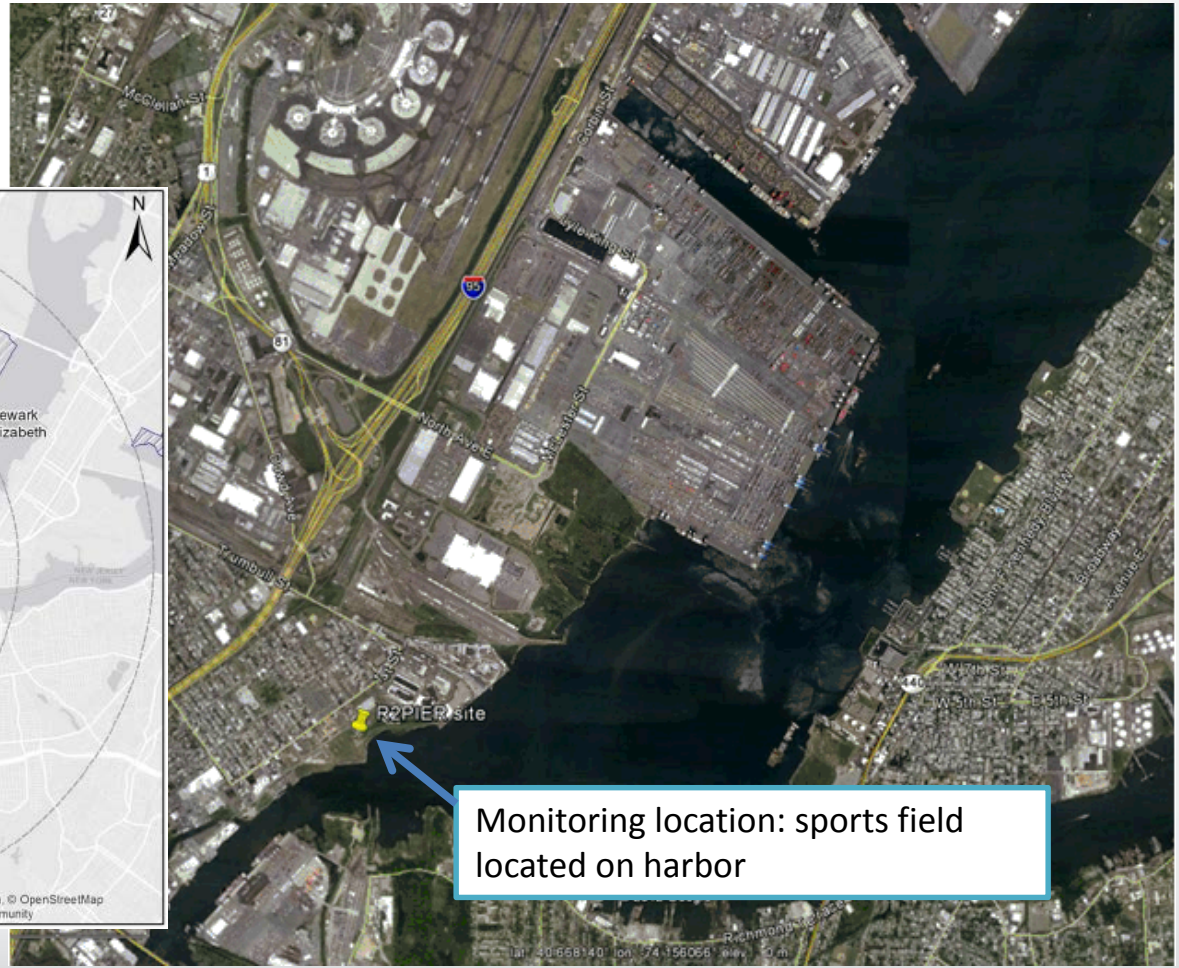
- 2 switcher locomotives replaced with cleaner engines, another one pending

R2PIER Study Design

Multi-year study, multipollutant data collected at 1 minute time resolution

Data to be combined with new inverse modeling approaches in order to estimate source areas contributing to concentrations over time





R2PIER measurements

Sampling timeframe: June, 2012 to present, planned conclusion in September 2015.

Measurements:

Gas-phase:	Carbon monoxide (CO)
	Oxides of nitrogen (NO, NO_2)
	Sulfur dioxide (SO_2)
Particle-phase:	Black carbon (BC)
	$PM_{2.5}$
Additional:	Wind speed and direction
	Temperature, relative humidity

All measurements conducted at 1 minute time resolution. Gases and BC using standard ambient-level monitoring instrumentation, real-time $PM_{2.5}$ measured using Thermo SHARP aiming for high time resolution (nephelometry + beta attenuation detection)

R2PIER measurements

Measurements: additions in summer 2014

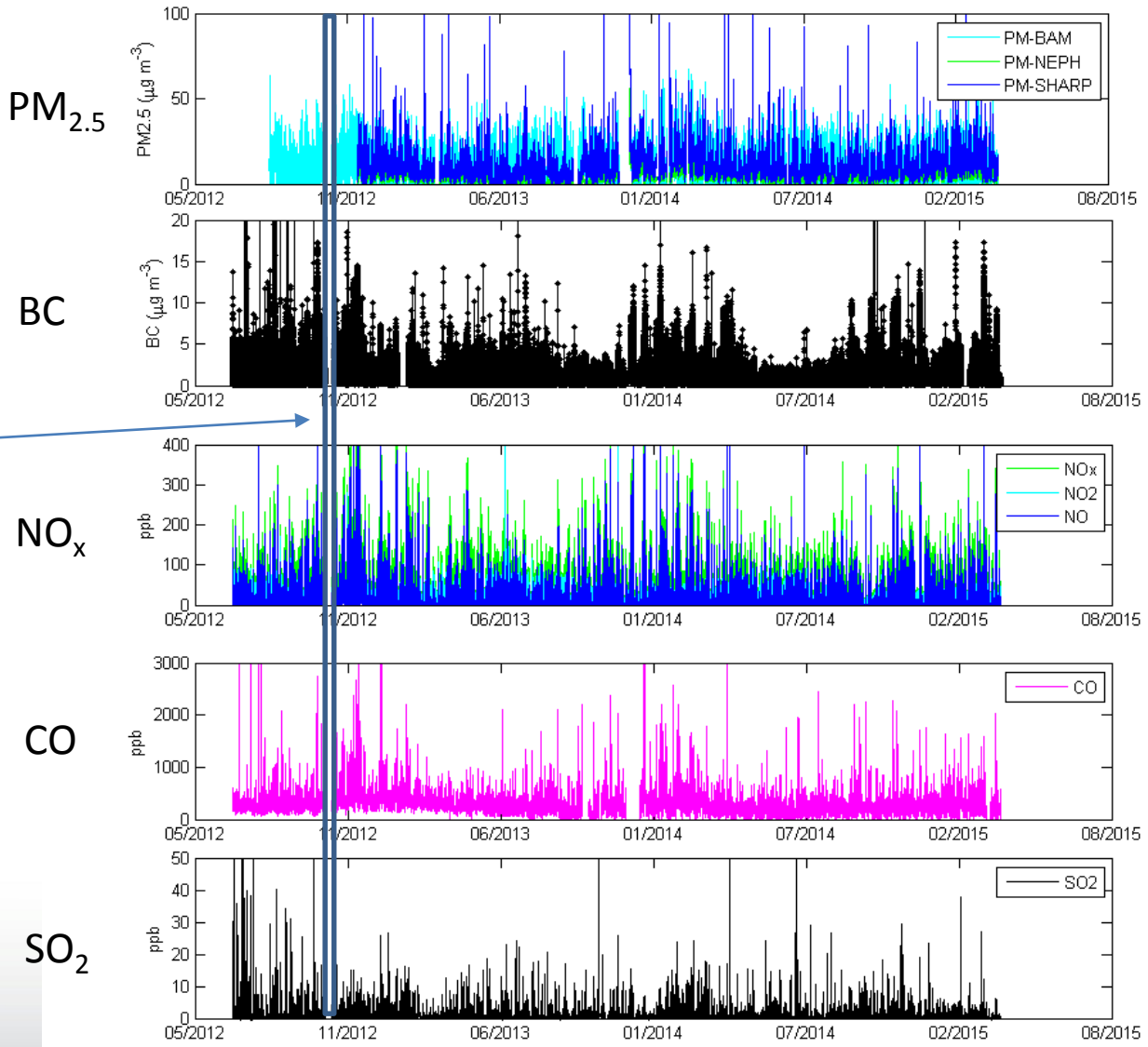
Gas-phase: Carbon dioxide (CO_2) – trial addition to explore emission factor estimation

Particle-phase: Metals (hourly) via Xact 625

Preliminary data

>1.1 million 1-minute recorded observations per pollutant

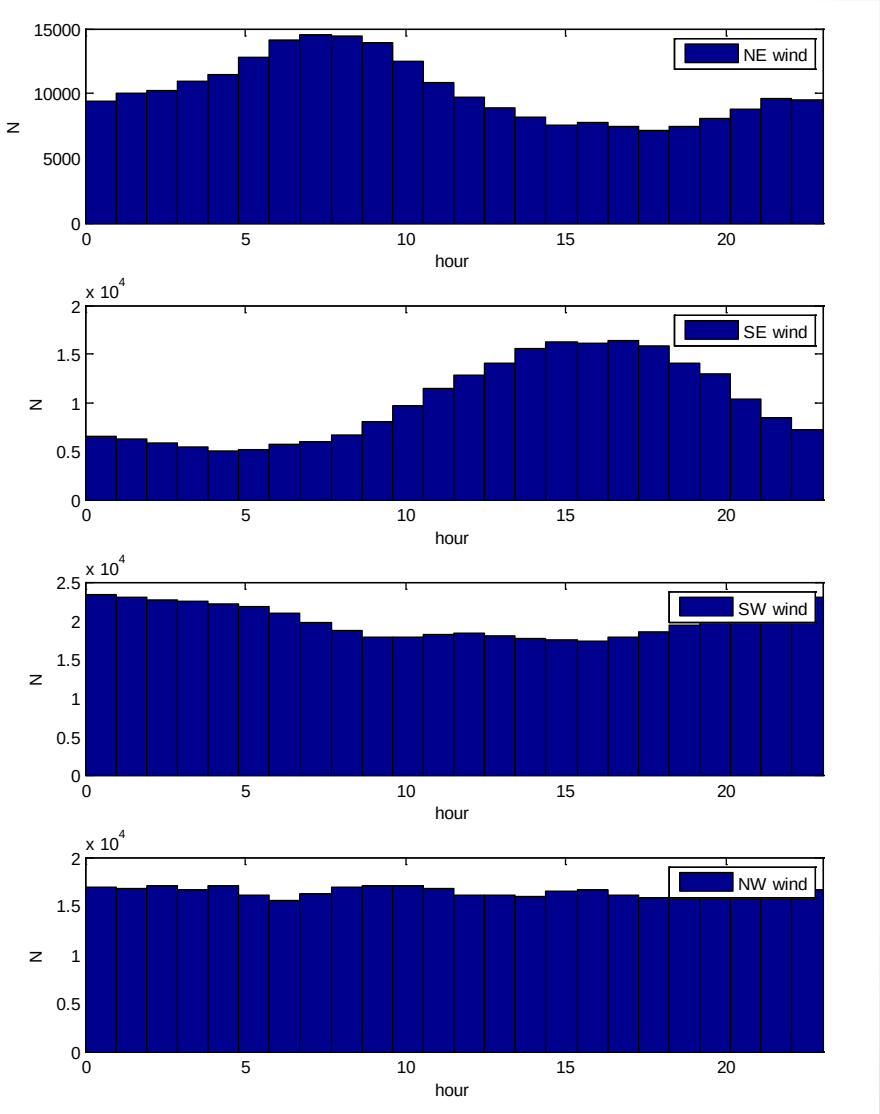
Notable several week interruption in Oct-Nov 2012 due to Hurricane Sandy.



Data analysis

Subdividing data by hour of day, by wind direction, range of ~5000 – 22,000 observations per 90 degree wind angle and hour of day.

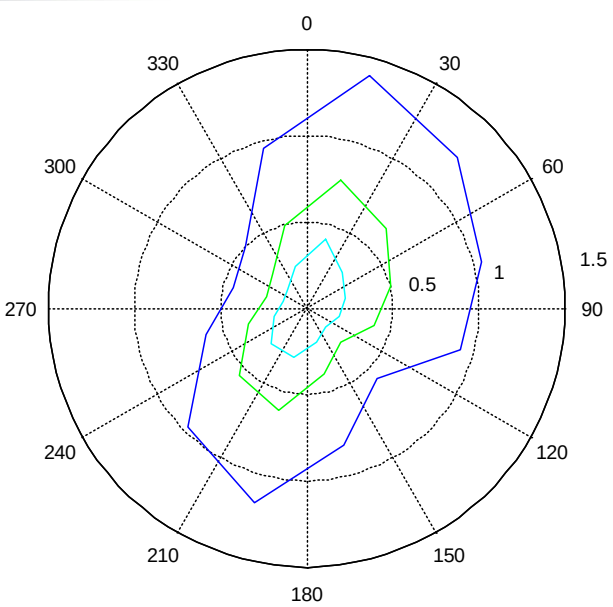
Diurnal trend evident in shift of NE / SE wind sectors.



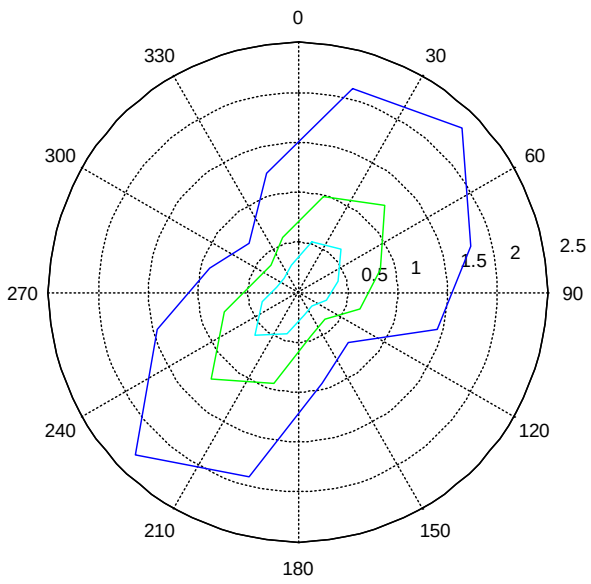
Data analysis

Simple look at concentration percentiles as function of wind direction

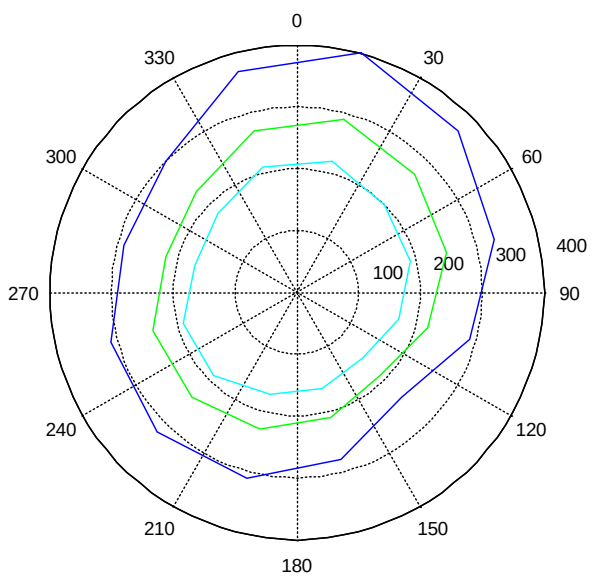
Black carbon (µg/m^3)



SO_2 (ppb)



CO (ppb)

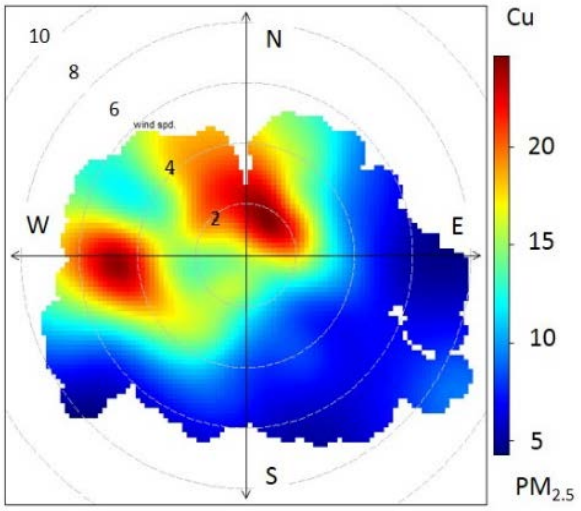


Data analysis

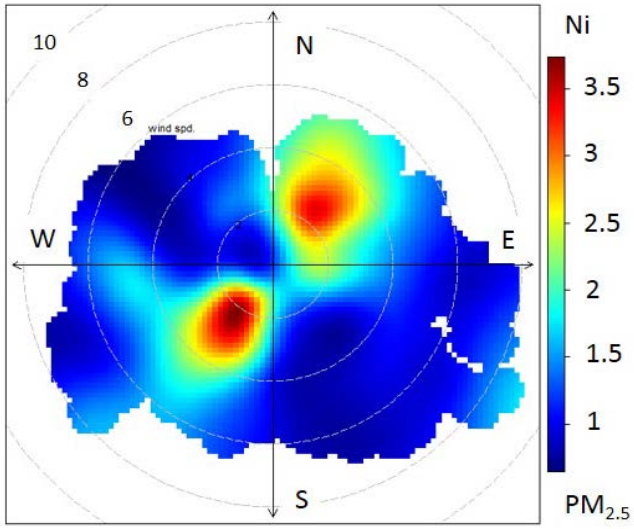
Simple look at concentration percentiles as function of wind direction

- Hourly metals measured during June 2014 – March, 2015; plotted as function of wind direction and speed.

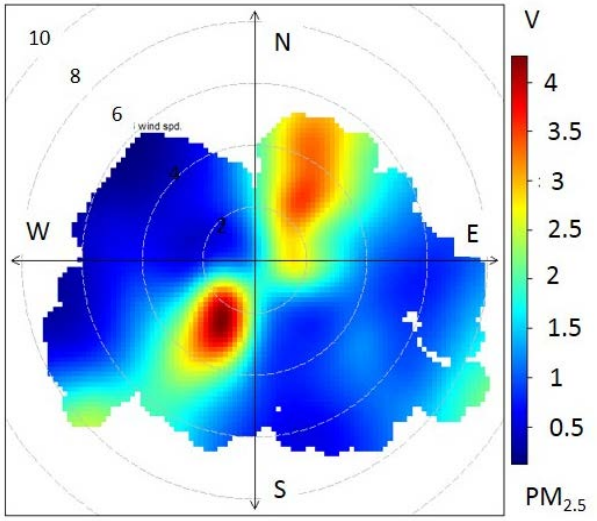
Copper



Nickel



Vanadium



Metals

- Time series shows substantial variability; different patterns apparent across sources
- Ni & V strongly track one another, S appears to be from a different source, disparate sources of Cu, Fe.

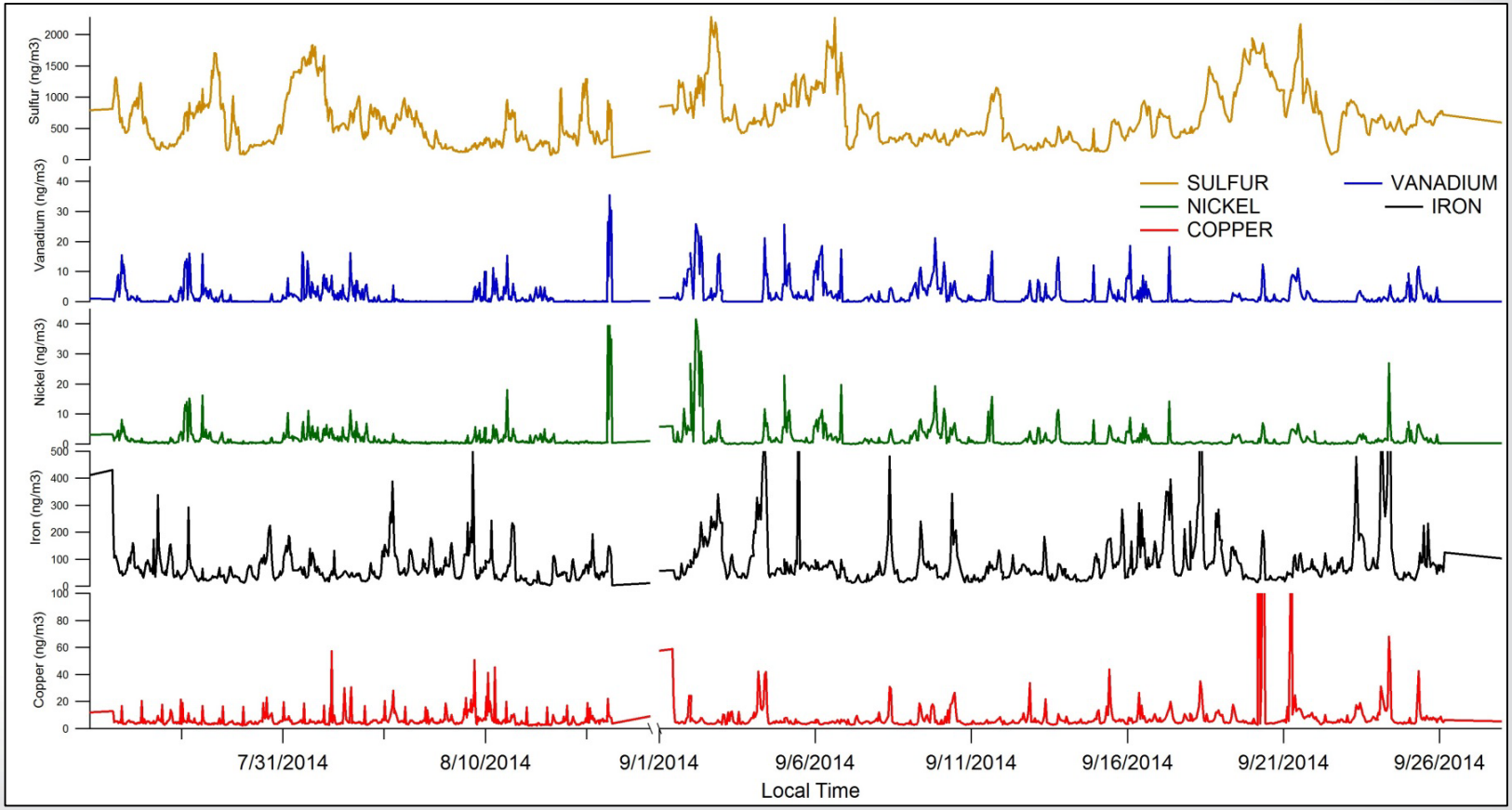
Sulfur (S)

Vanadium (V)

Nickel (Ni)

Iron (Fe)

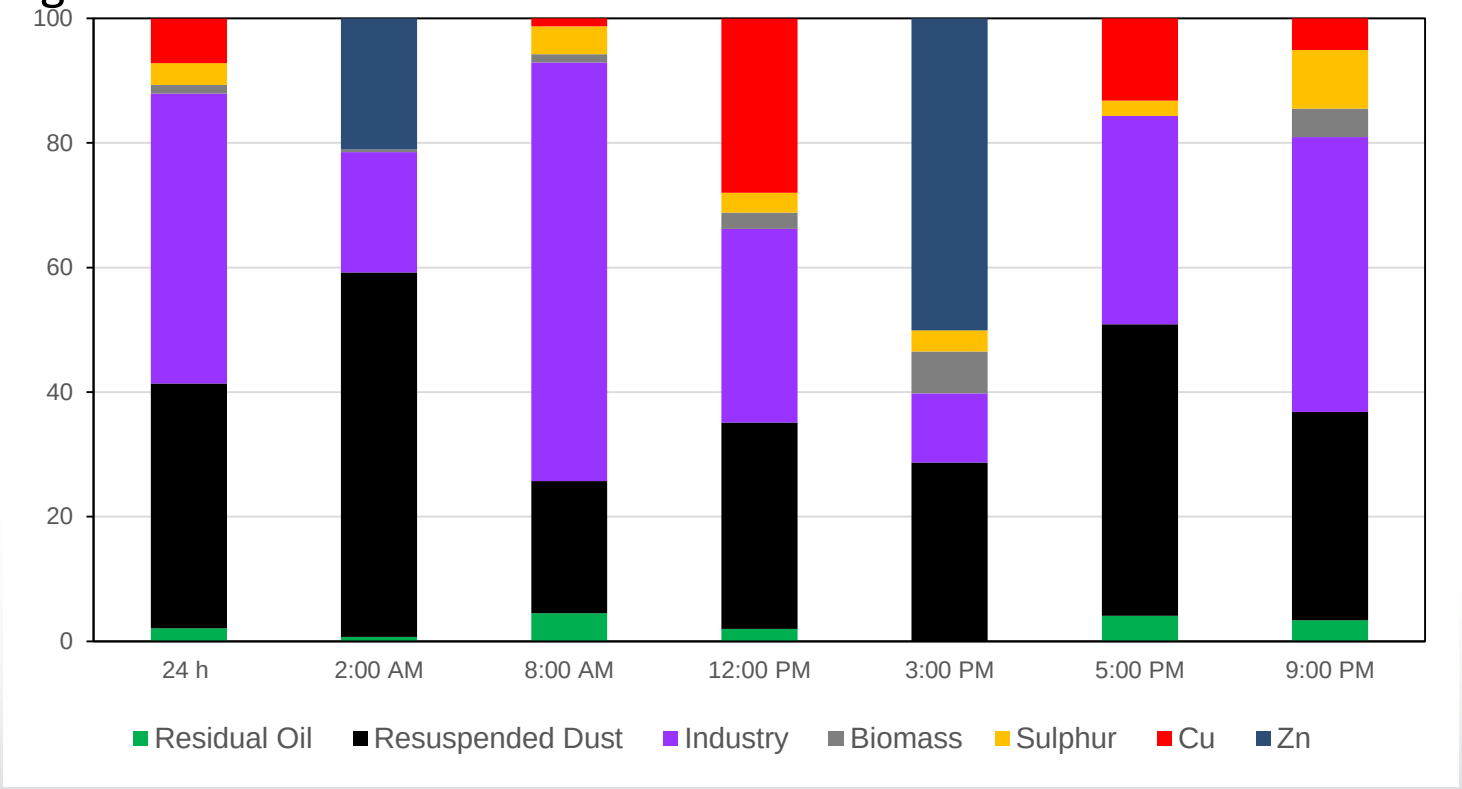
Copper (Cu)



Using Hourly Data in PMF

Planned analysis of the metals data will include EPA's Positive Matrix Factorization (PMF); employed to infer sources of specific elements.

In example output below, Fe attributed mostly to dust and industry, but associated with source emissions containing Cu and Zn, too (but only at particular times of the day) using a six-factor solution.

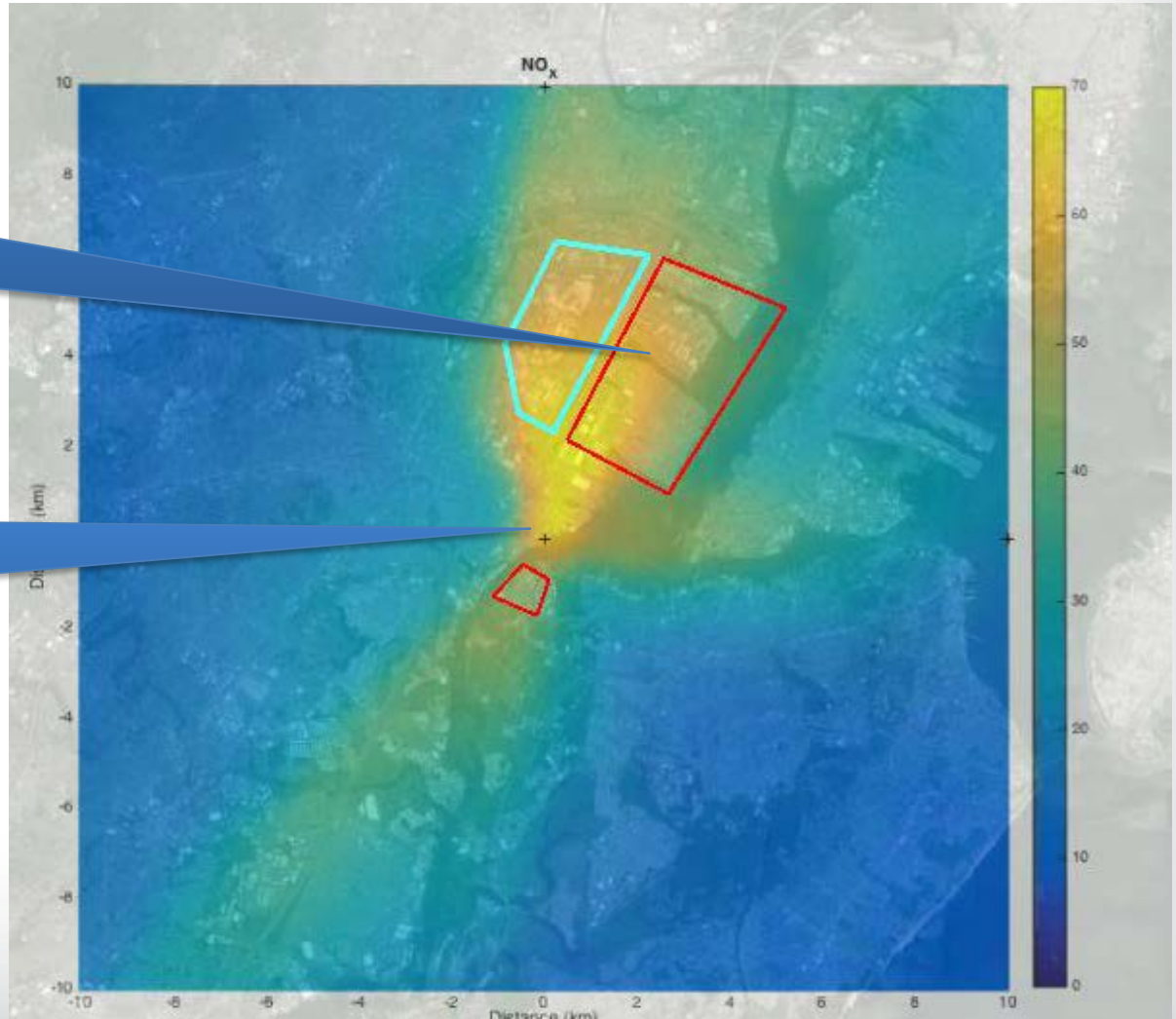


Inverse modeling

Non-parametric trajectory analysis

For air that passes over here

NTA Estimates the average NOX at the receptor here



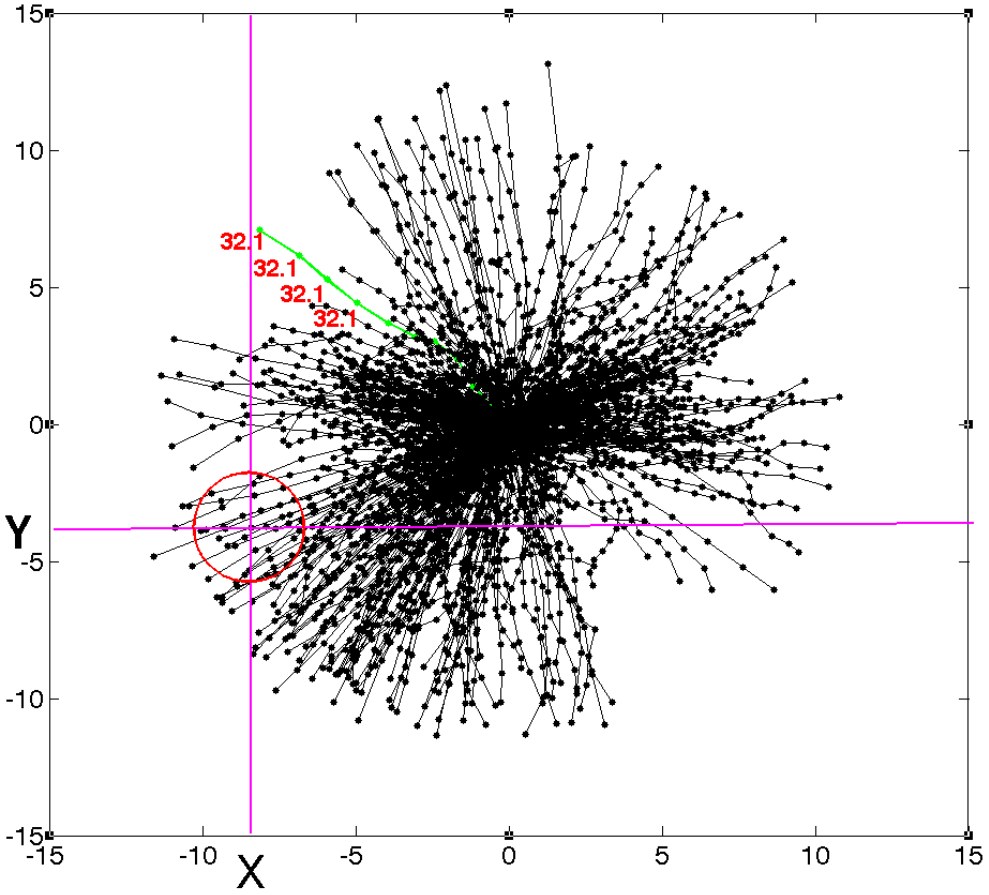
Utilizing 1-minute pollutant readings and wind data to estimate source contributions.

Inverse modeling

Non-parametric trajectory analysis

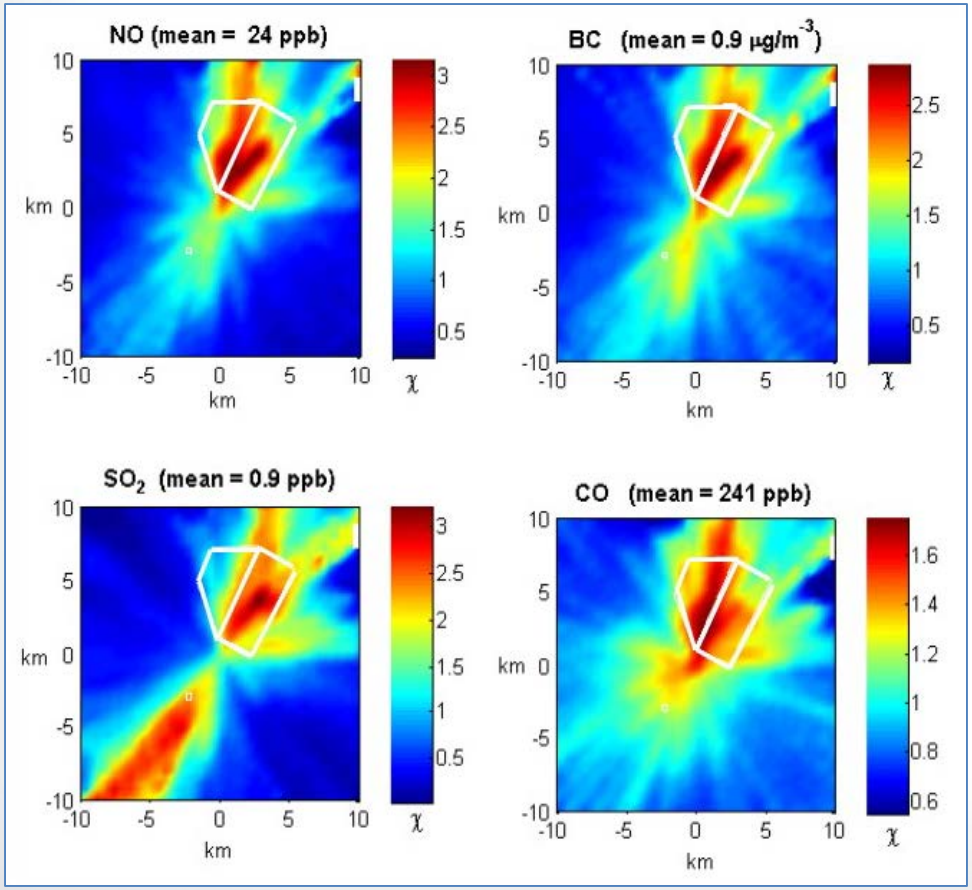
NTA calculates back-trajectories and allocates measured concentrations along the pathway to the monitoring locations.

Value at any given location is a weighted sum of observation values, where pathways passing closer to the location (X,Y) have a higher weight in the summation.



Case study – Hurricane Sandy

Non-parametric trajectory analysis

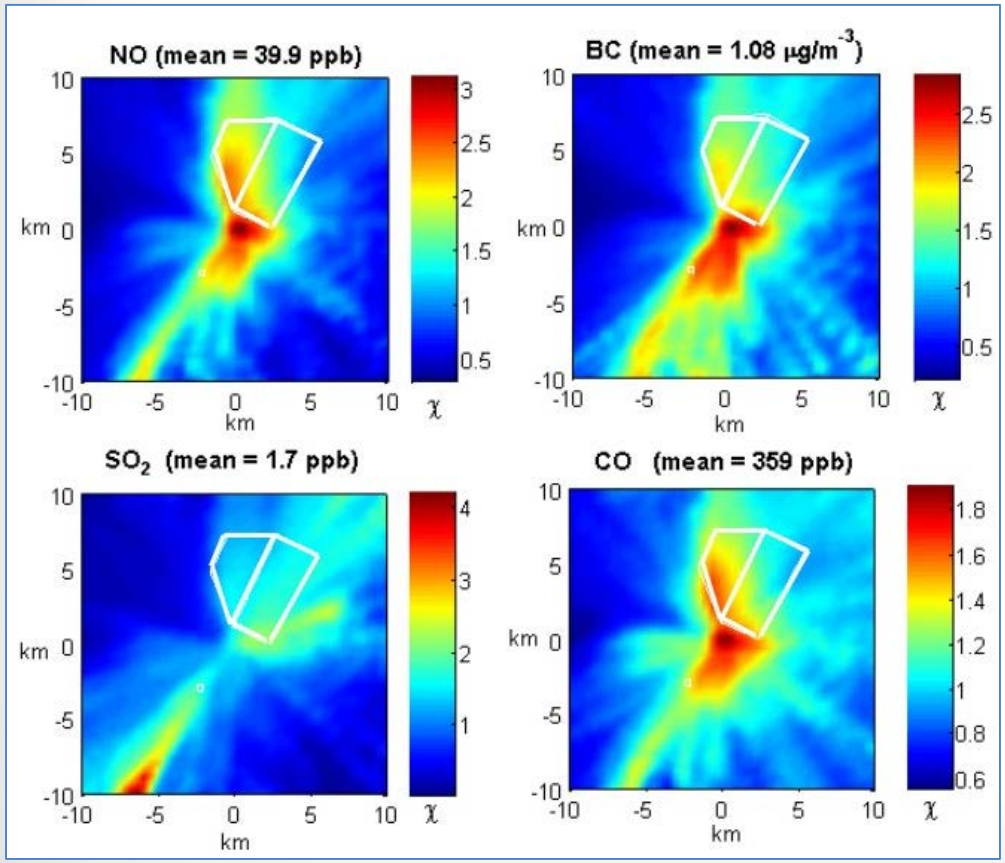


Before the storm:
Normalized concentrations ($X = C_{x,y}/C$) in areas surrounding the measurement site for September-October, 2012.

The measurement site is located at the center of the map, with a white rectangle showing the general vicinity of the port and a trapezoid showing the general vicinity of a major international airport west of the port.

Case study – Hurricane Sandy

Non-parametric trajectory analysis



Immediately after the storm: Normalized concentrations ($X = C_{x,y}/C$) in areas surrounding the measurement site for mid-November-December, 2012.

Summary

- Sampling to conclude in September 2015

- Ongoing focus of analysis is observing contributions from multiple sources surrounding the monitoring site, and quantifying how they change over the sampling timeframe.

- Inverse modeling and time series approaches, combined with high time resolution monitoring, expand the amount of information that can be obtained from a single monitoring site.

Acknowledgements

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