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Inverse modeling to estimate local source contributions in a complex environment with nearby port, airport, highway, and industrial sources

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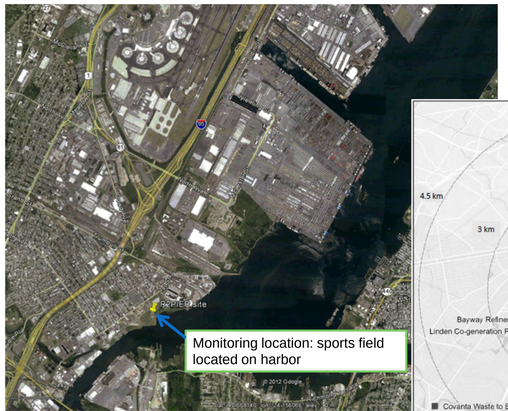
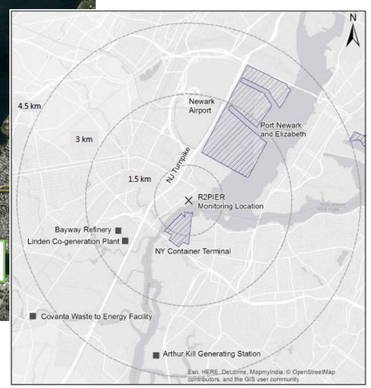
Introduction

- Source apportionment is challenging in urban environments with clustered source emissions that have similar chemical signatures.
- The Port of New York and New Jersey is one of the largest ports, in terms of container traffic, in the United States and also has a significant surrounding population. Nearby the port is located other major sources, including a major highway, airport, and industrial facilities.
- Voluntary and regulatory-based emission reductions were predicted to reduce emissions in the vicinity of the port, including a shift towards lower sulfur content in shipping fuel.
- An emerging measurement and modeling strategy was conducted in Elizabeth, New Jersey to observe gaseous and particulate pollution near the Port of New York and New Jersey, over 2012-2015. This combined measurement and modeling strategy was attempted to resolve multiple source areas geographically, and reveal significant shifts in source signals over time.

Field Study





Sampling timeframe:
June, 2012 – September, 2015 (~3 years)

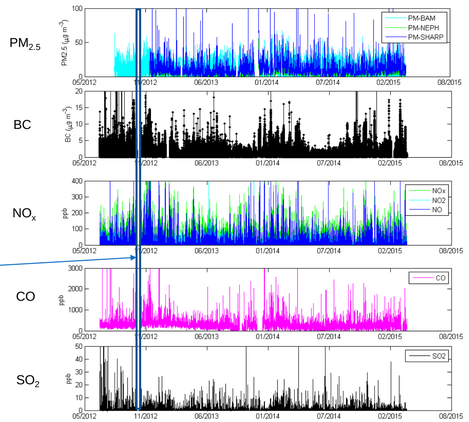
Measurements:

Gas-phase:	Carbon monoxide (CO) – 1 minute
	Oxides of nitrogen (NO, NO_2) – 1 minute
	Sulfur dioxide (SO_2) – 1 minute
Particle-phase:	Black carbon (BC) - ~1 minute
	Metals – hourly (2014-2015)
	$PM_{2.5}$ – 1 minute
Additional:	Wind speed and direction – 1 minute
	Temperature, relative humidity - 1 minute

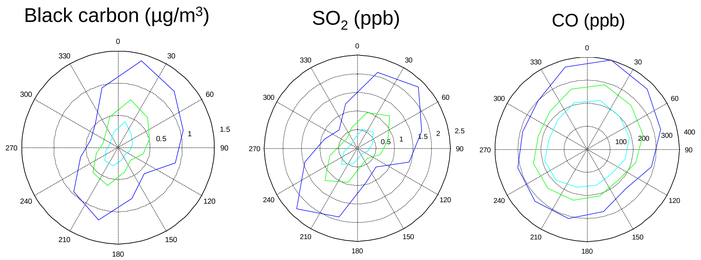
Field study data review

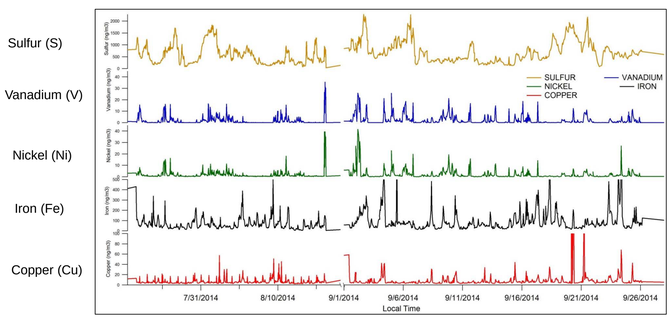
>1.1 million 1-minute recorded observations per pollutant, over the three year data collection period

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



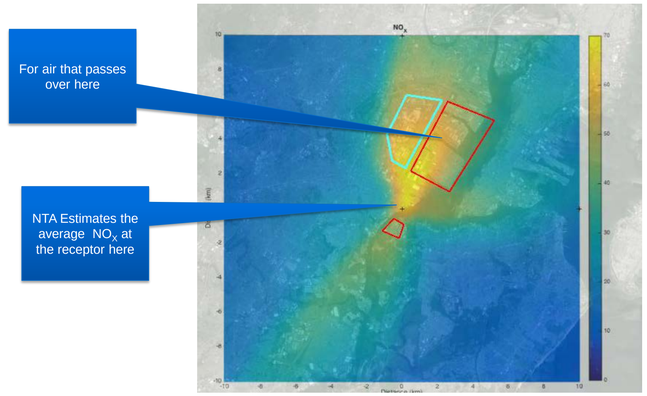
Wind directional trends: One-minute pollutant data are sorted by wind direction, with 25th, 50th, and 75th percentiles plotted for each 15 degrees of wind direction. BC and SO_2 show higher concentrations from the NE and SW, whereas CO is more uniform with wind direction.



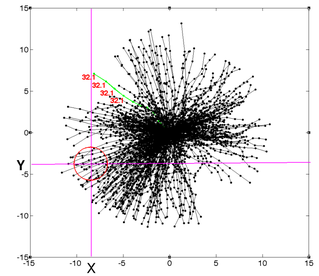


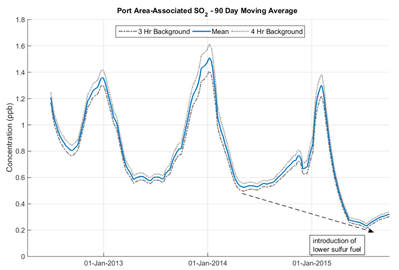
- PM elemental composition shows substantial variability; different patterns apparent related to source influences.
- Ni & V strongly track one another, S appears to be from a different source, disparate sources of Cu, Fe.

Inverse modeling: Non-parametric trajectory analysis



NTA calculates back-trajectories and allocates measured concentrations along the pathway to the monitoring locations. The figure to the right shows an example of trajectories originating at a monitoring location. The resulting value at any given location is a weighted sum of observation values, where pathways passing closer to a specific location (X,Y) have a higher weight in the summation. (Henry et al., 2007)





Background was estimated through a time series approach, looking at the smoothed 3-hour or 4-hour baseline of the high time resolution data. NTA was run with the background-adjusted data and SO_2 associated with the port area was isolated.

The preliminary analysis indicates that the shift from 1% to 0.1% sulfur shipping fuel in January 2015 resulted in a lower observed summertime SO_2 associated with the port.

Next Steps

Data analysis of the full data set is ongoing, with planned analyses to include comparing the time series-derived background against nearby regulatory monitoring stations, conducting NTA analysis focusing on multiple source areas surrounding the monitoring site, and source apportionment analysis of the metals data.

Acknowledgements

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Reference: **Henry, R. C.** 2007. Locating and Quantifying the Impact of Local Sources of Air Pollution. *Atmospheric Environment* **42**, 358-363. DOI: 0.1016/j.atmosenv.2007.09.039