Ongoing research in EPA/ORD aligned with LISTOS, the re-design of the Photochemical Assessment Monitoring System and TROPOMI launch

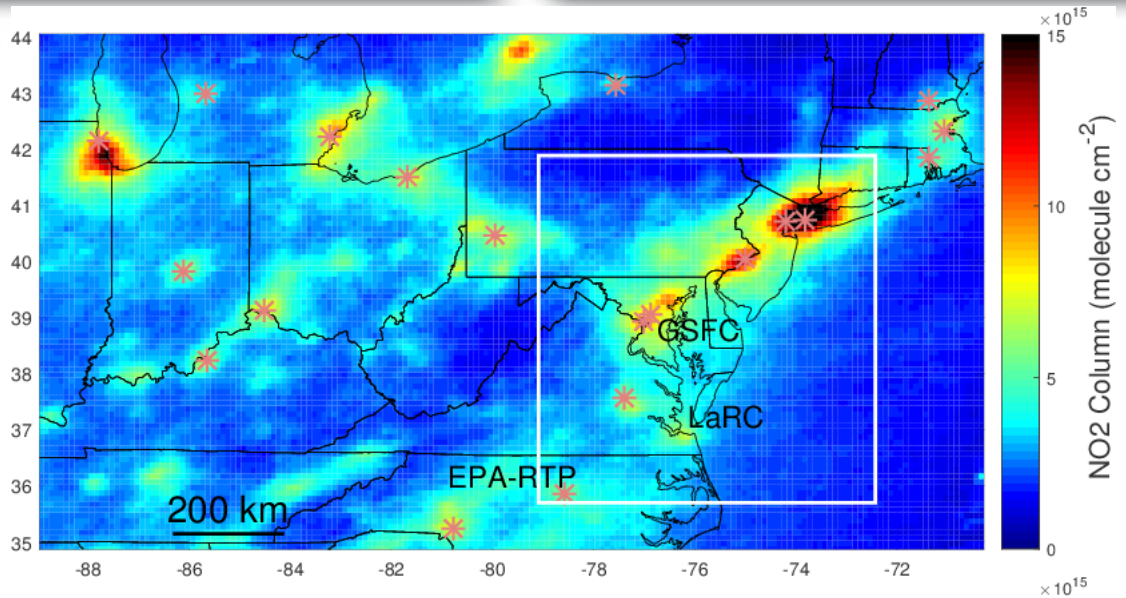
U.S. EPA Team
Office of Research and Development
National Exposure Research Laboratory
Presented by Luke Valin

April 10, 2018

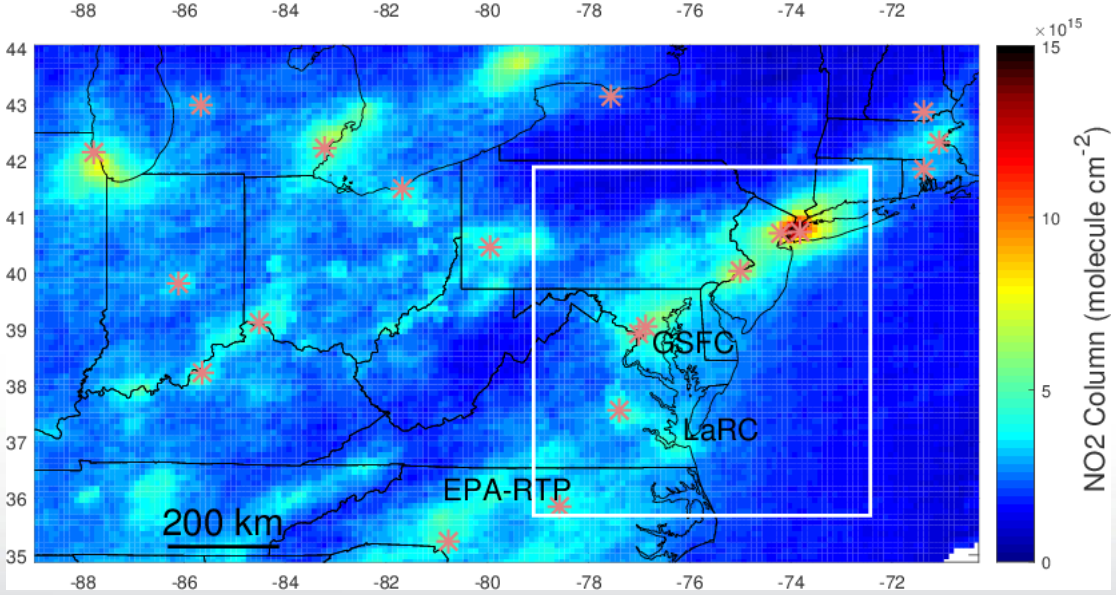
Decreases in NOx, Decreases in Ozone
But issues of poor Ozone AQ remain

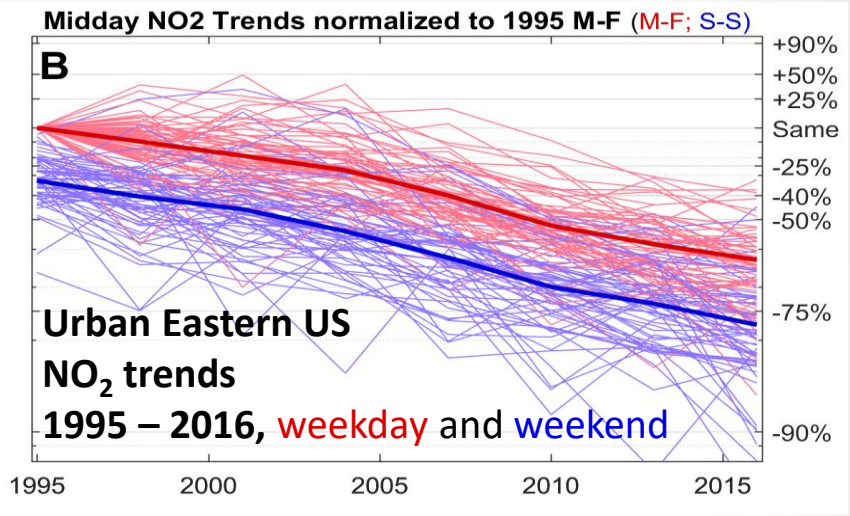
OMI BEHR NO2 Column

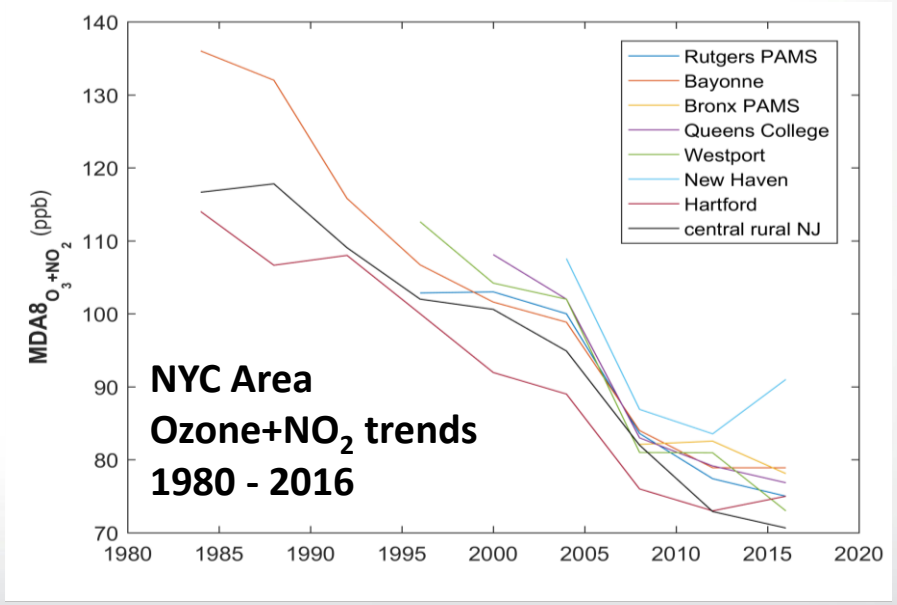
May – July, 2005-2006



May – July, 2015-2016







Photochemical Assessment Monitoring System (PAMS)

Photochemical Assessment Monitoring System (PAMS)

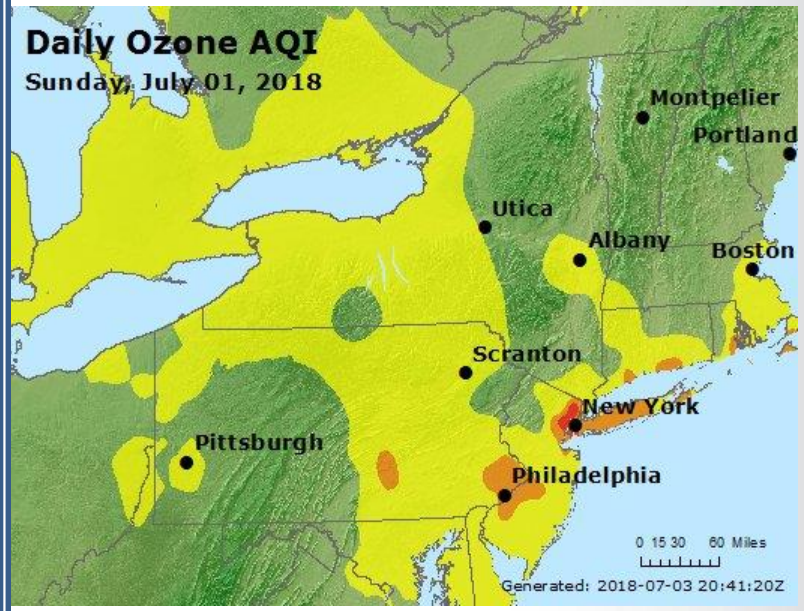
SLAMS + PAMS Networks

Emissions

Chemistry + Mixing

Photo courtesy of Xinrong Ren on board the UMD Cessna, July 1 2018

Transport and Exposure



PAMS network aims to building an understanding of the factors affecting surface layer ozone and provide measurements and metrics that are useful for assessing air quality models

Protect the health of sensitive groups by ensuring compliance of O_3 National Ambient Air Quality Standard

PAMS element #1: Required Measurements

Required PAMS Ozone Season measurements

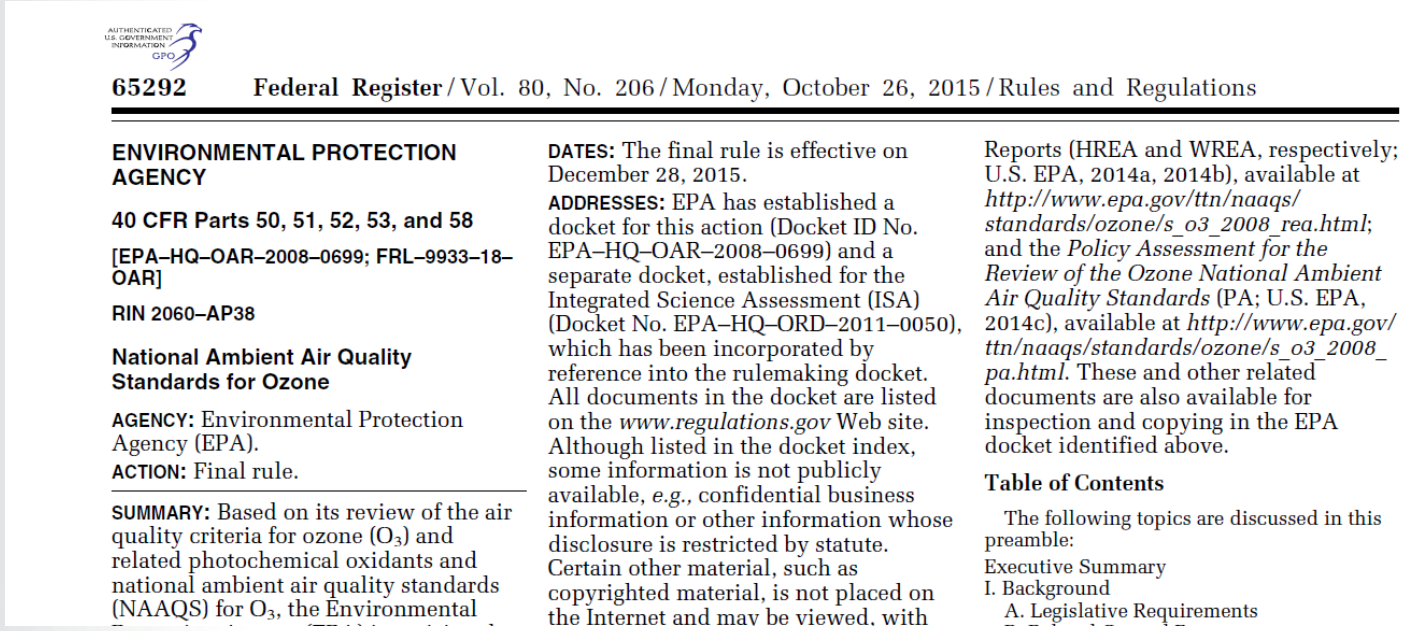
- Hourly speciated VOCs
- "True" NO2
- 8-hour average aldehyde cartridges (or continuous formaldehyde - Please see Andrew Whitehill for more details)
- Hourly boundary layer or mixed layer height measurement (Please see Jim Szykman for more details)
- Meteorology measurements

If co-located with NCORE site

- High-precision NO_y
- ppb precision CO
- Speciated PM2.5
- Hourly PM2.5 mass
- Year-round O_3

PAMS required measurements are not the focus of this presentation but provide a valuable starting point for the measurements discussed here

PAMS element #2: Enhanced Monitoring Plan



65292 **Federal Register** / Vol. 80, No. 206 / Monday, October 26, 2015 / Rules and Regulations

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 50, 51, 52, 53, and 58

[EPA–HQ–OAR–2008–0699; FRL–9933–18–OAR]

RIN 2060–AP38

National Ambient Air Quality Standards for Ozone

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: Based on its review of the air quality criteria for ozone (O_3) and related photochemical oxidants and national ambient air quality standards (NAAQS) for O_3, the Environmental

DATES: The final rule is effective on December 28, 2015.

ADDRESSES: EPA has established a docket for this action (Docket ID No. EPA–HQ–OAR–2008–0699) and a separate docket, established for the Integrated Science Assessment (ISA) (Docket No. EPA–HQ–ORD–2011–0050), which has been incorporated by reference into the rulemaking docket. All documents in the docket are listed on the *www.regulations.gov* Web site. Although listed in the docket index, some information is not publicly available, *e.g.*, confidential business information or other information whose disclosure is restricted by statute. Certain other material, such as copyrighted material, is not placed on the Internet and may be viewed, with

Reports (HREA and WREA, respectively; U.S. EPA, 2014a, 2014b), available at *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_2008_rea.html*; and the *Policy Assessment for the Review of the Ozone National Ambient Air Quality Standards* (PA; U.S. EPA, 2014c), available at *http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_2008_pa.html*. These and other related documents are also available for inspection and copying in the EPA docket identified above.

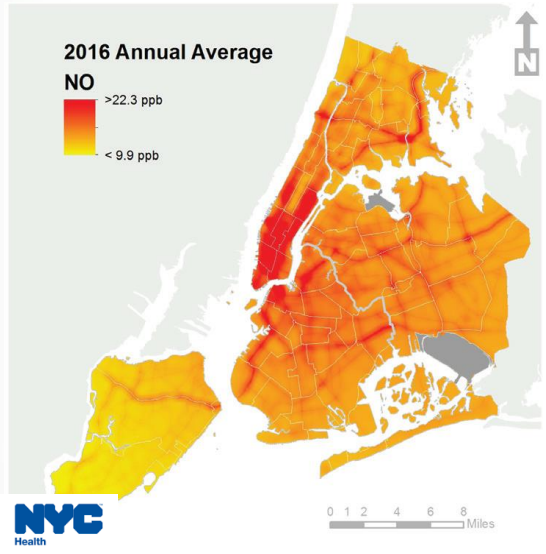
Table of Contents

The following topics are discussed in this preamble:

"The second part of the network design **required states with O3 non-attainment areas [and all states in the OTR] to develop and implement Enhanced Monitoring Plans (EMPs)** which were intended to allow monitoring agencies the needed flexibility to implement additional monitoring capabilities to suit the needs of their area."

EMP: An opportunity to bridge scales

Distributed sensor networks

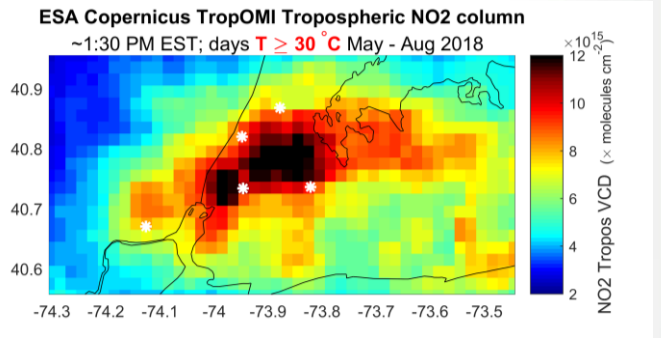


Characterizing emissions near the source

Reference Monitoring Sites

Rigorous and detailed measurements

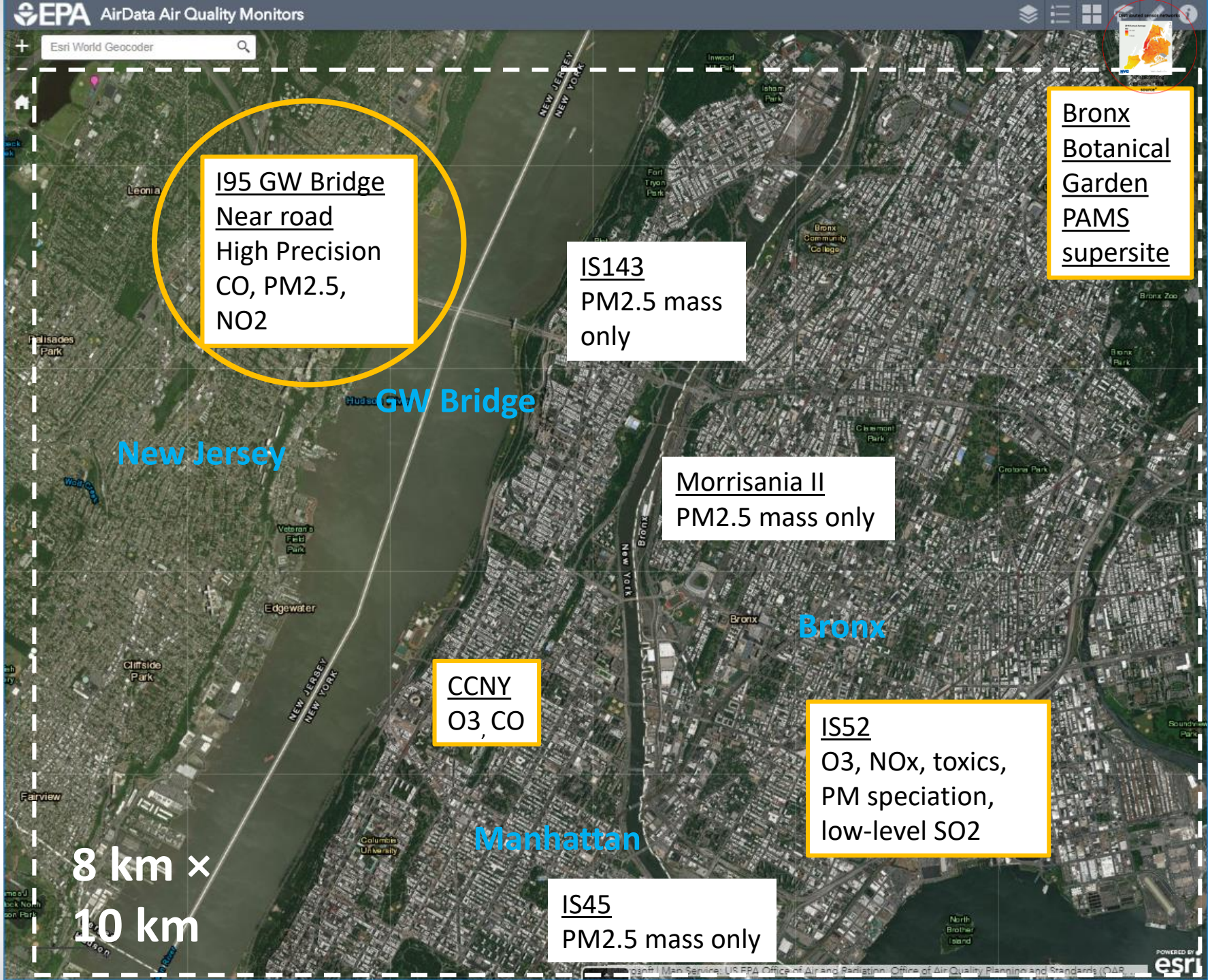
Satellite-based monitoring



Hourly maps of pollutant transport

7 BEACON nodes in Bronx, Harlem and Fort Lee

- Deployed side-by-side with FRM/FEM instrumentation
- Vaisala GMP343 CO2 (±0.5 ppm) Alphasense AQ sensor package (four gases), optical PM sensor
- CO2 is the key measurement because it is a relatively high quality measurement of an emitted species aiding interpretation of AQ sensor data.
- Applications of these units are multiplying: ~60 units in Bay Area, with collaborator health, hyper-local emissions studies ongoing or published



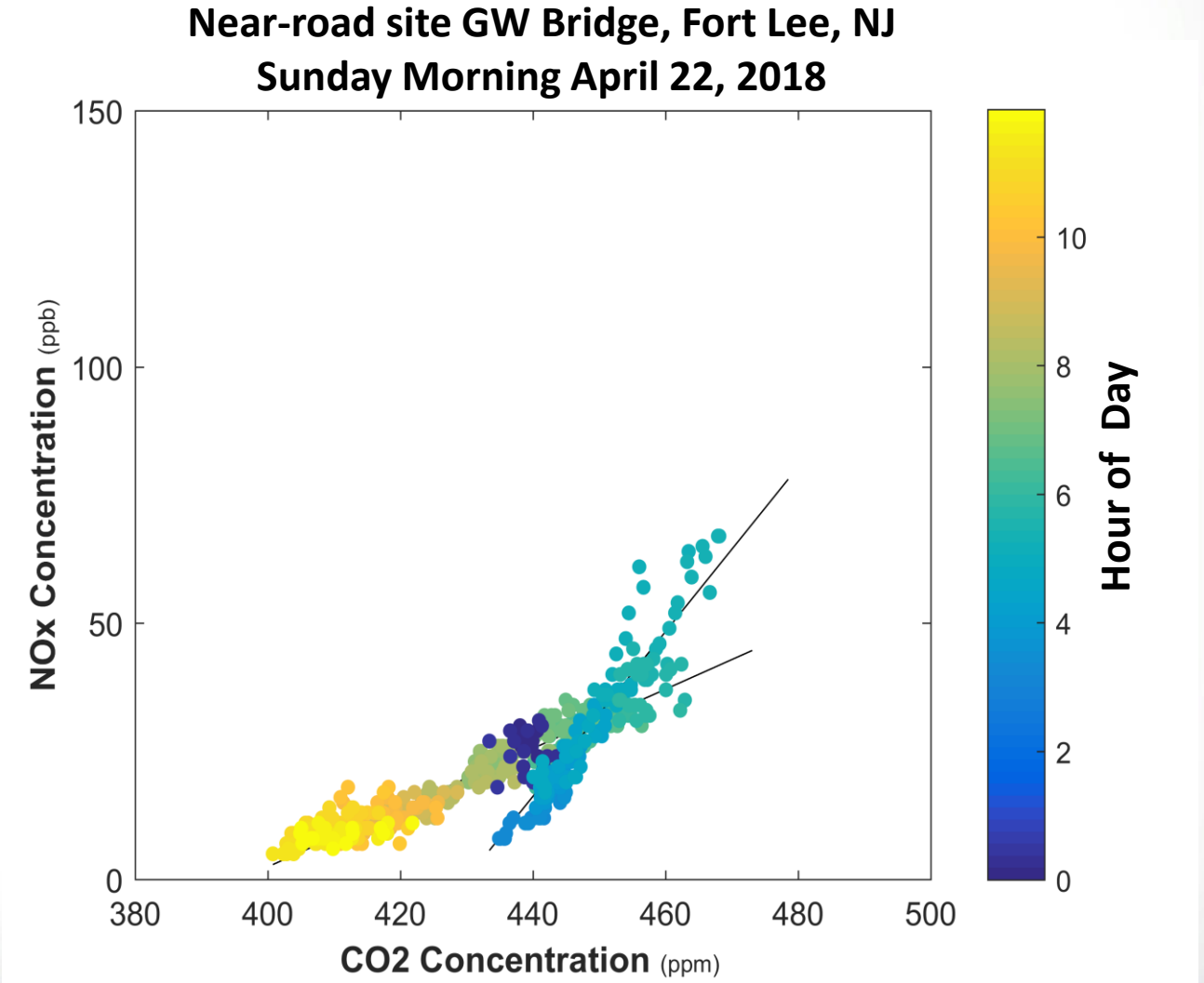
Lamont-Doherty Earth Observatory
Columbia University | Earth Institute

NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

Integration of CO2 sensors at AQ sites helps characterize NOx emission factors

What is the rate of NOx emission per unit of fuel burned in real world conditions?

UC Berkeley and Columbia in discussions to propose broader distribution in NYC area – see Roisin Commane for more details



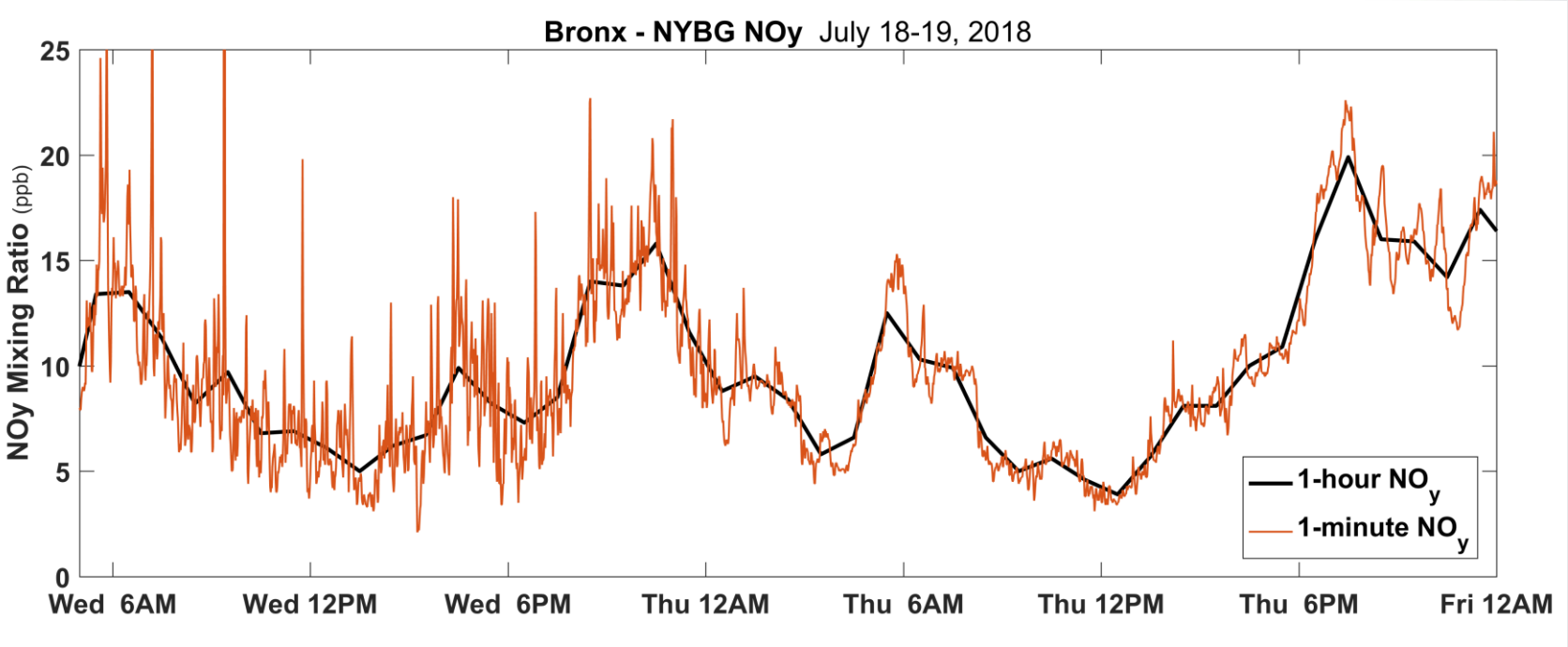
Lamont-Doherty Earth Observatory
Columbia University | Earth Institute

NEW YORK STATE OF OPPORTUNITY. Department of Environmental Conservation

Bridging to finer scales: 1-minute nitrogen oxide data

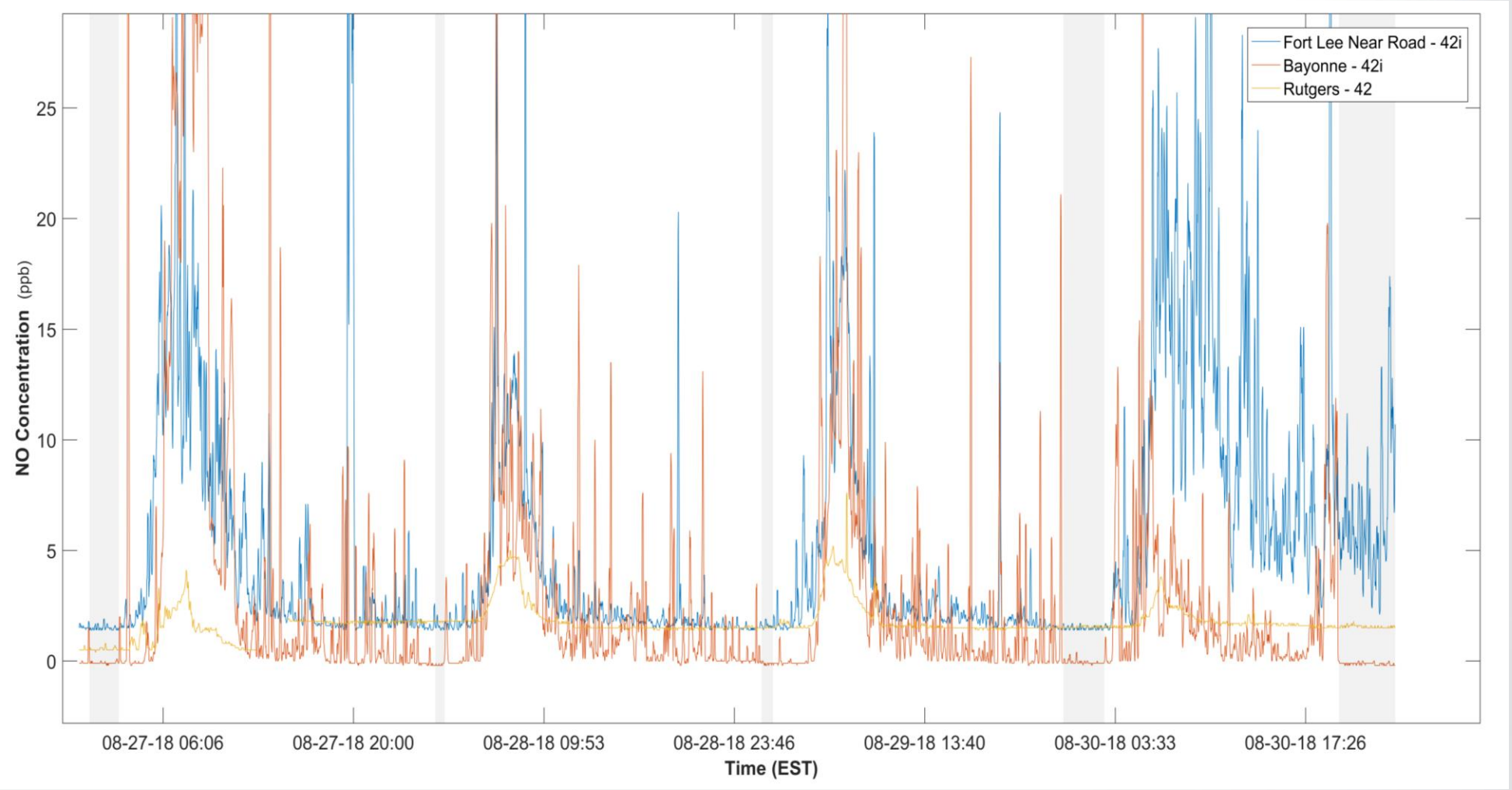
EPA requires 1-hour reporting of most data products for compliance reasons (black line)

1-minute data provides more detailed picture of improving our understanding of sources pollutants and dispersion



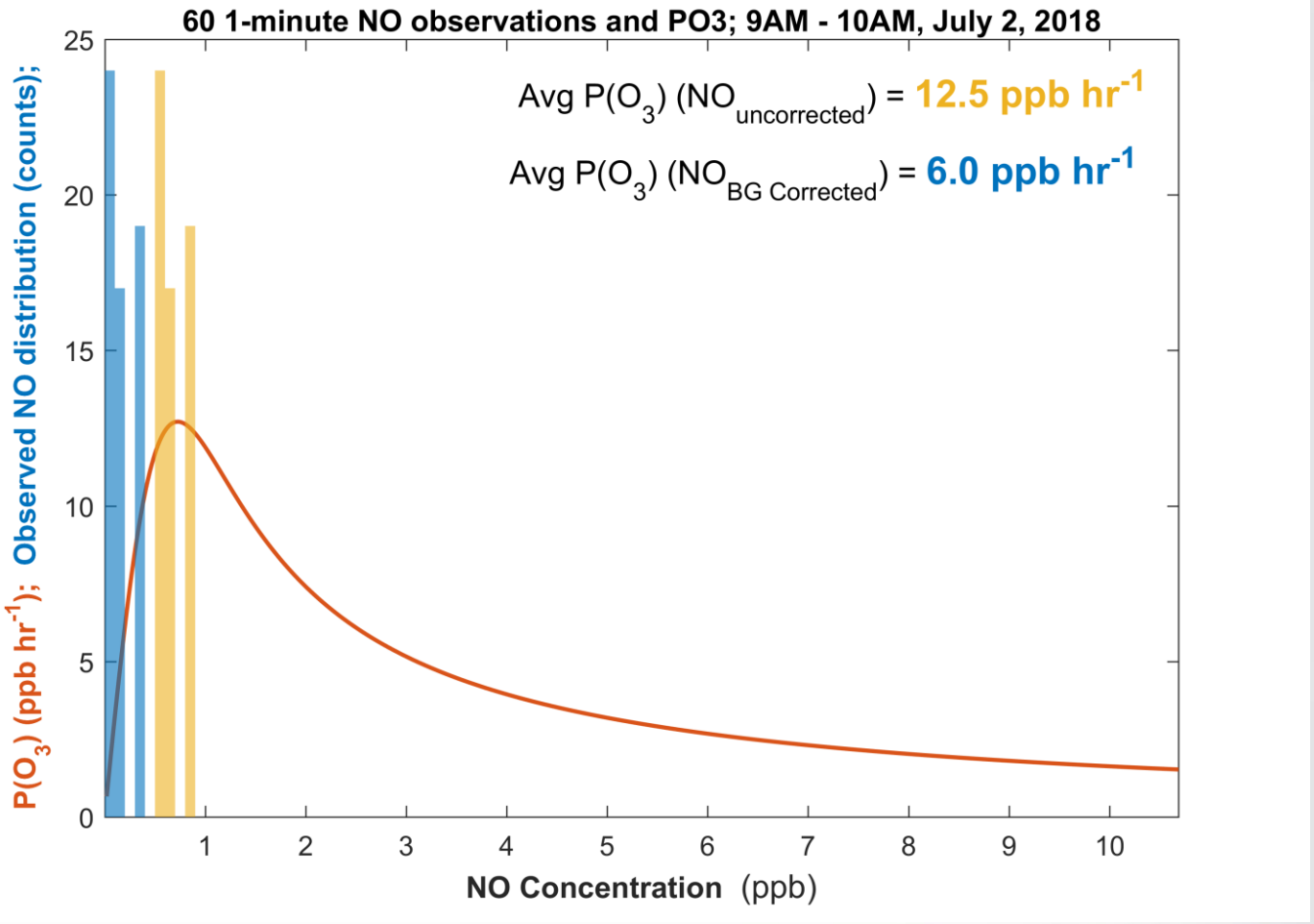
Application of 1-minute data: NO baseline correction

At nighttime, if ozone concentrations are non-zero, the concentration of NO should reach zero



Application 1 (continued): Baseline NO correction and Ozone production

- Select time periods when nighttime NO concentrations are steady.
- Adjust daytime and nighttime NO measurements by the determined offset
- **Two-fold difference of P(O3) inferred for a ~0.5 ppb correction of NO baseline**

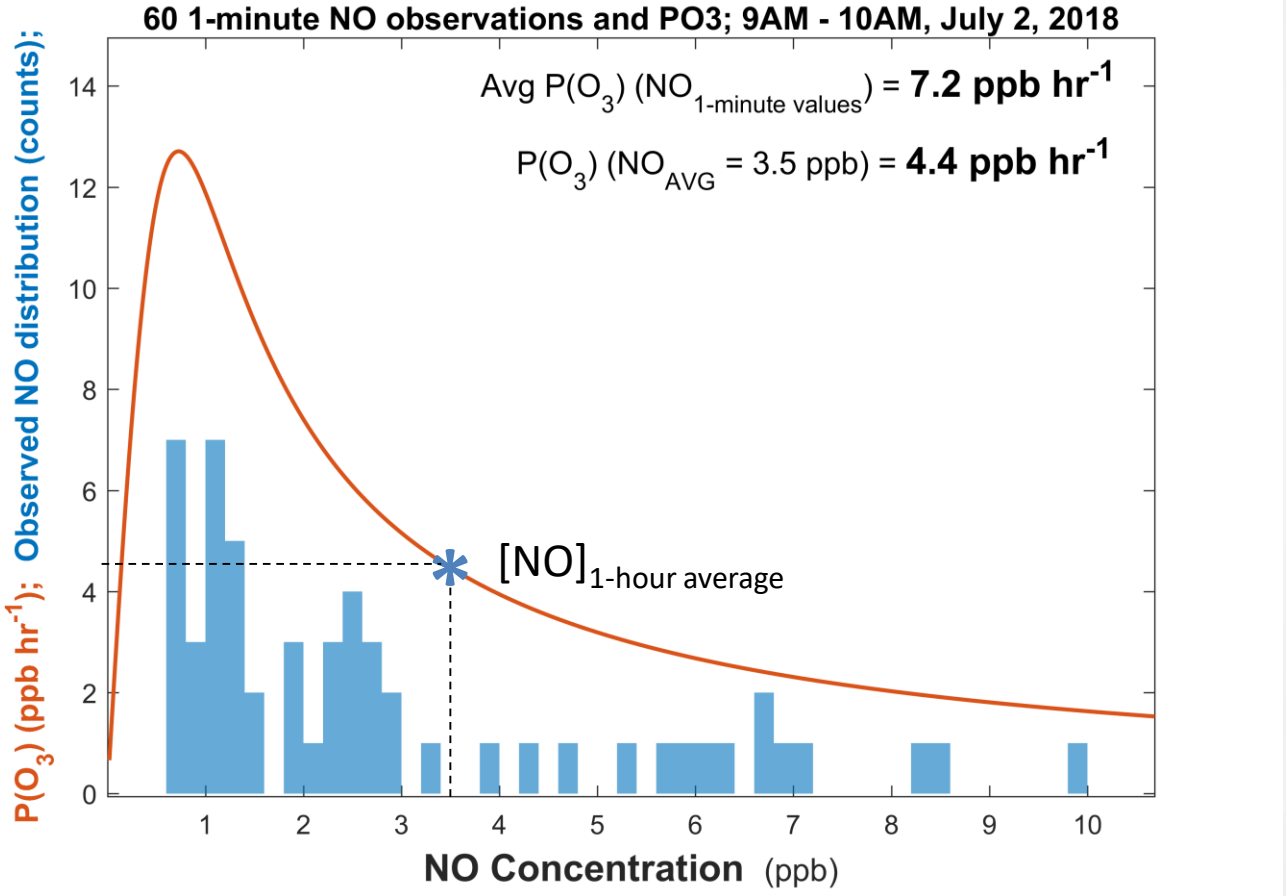


Application #2: Understanding O_3 production near NO sources

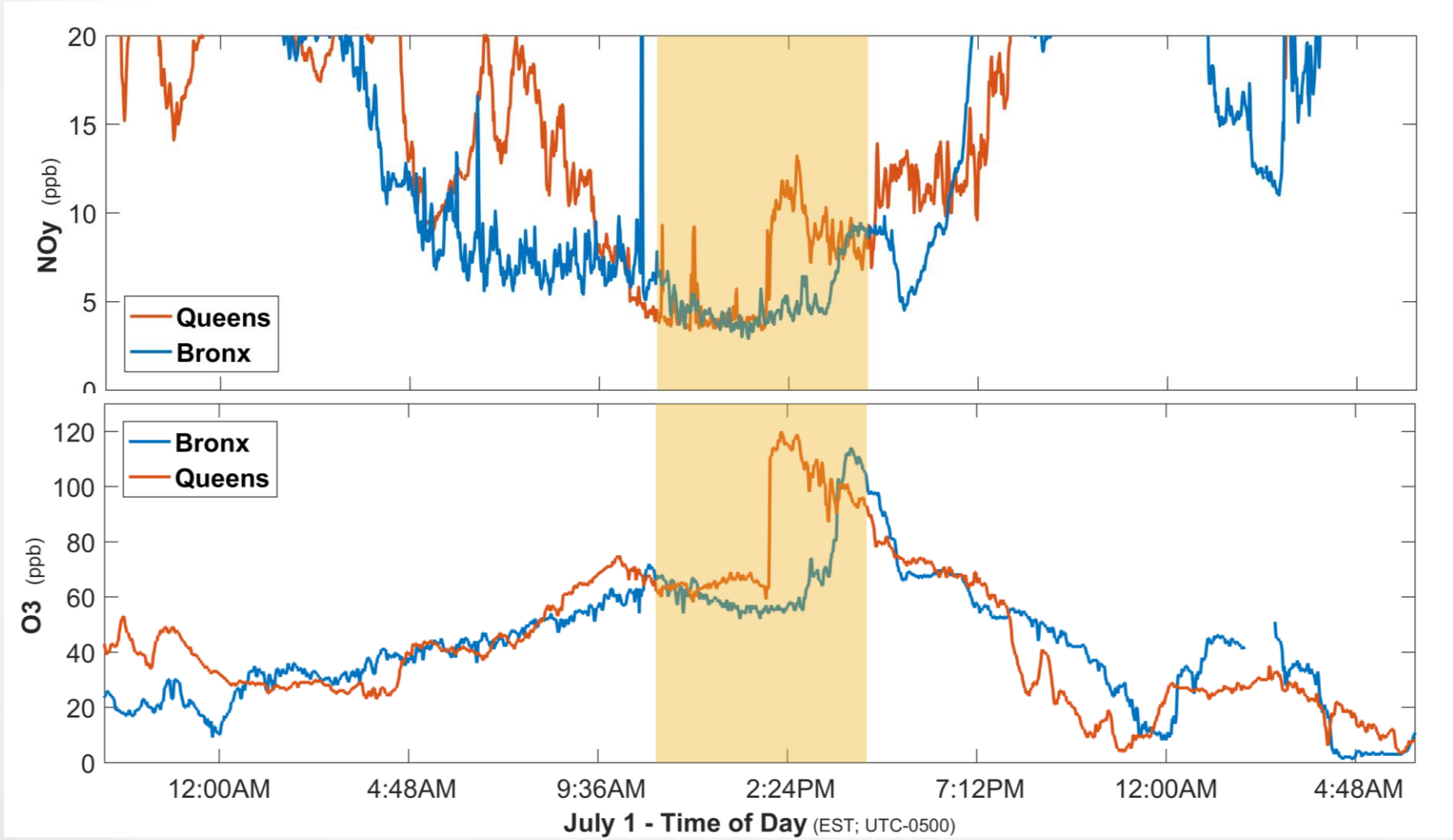
Issue 2:

The average of ozone production in places where NO varies rapidly does not equal the ozone production for average NO

- Almost a two-fold difference of inferred P(O3) when accounting for minute-to-minute NO variations



Application #3:
Characterize airmass dynamics



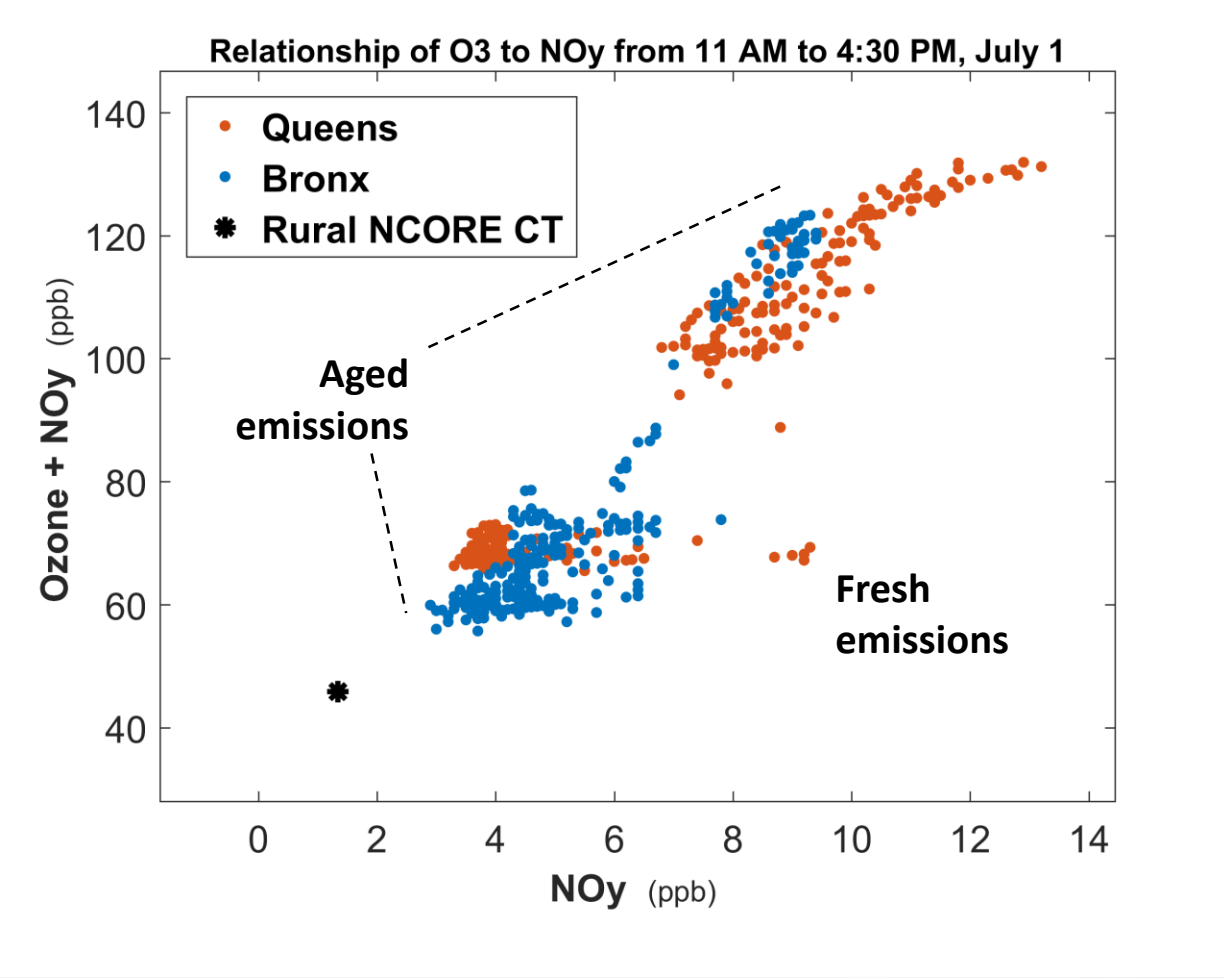
Seabreeze passes and ozone concentrations increase by 60 ppb in minutes

Application #3:
Airmass dynamics and O_3 Production

- In the aged airmass there are approximately 5 – 9 ppb of ozone molecules for every NO_y molecule.

- The relationship extrapolates to the rural NCORE site in NW Connecticut.

- The relationship can be directly compared to modeld Ozone/NO_y ratios

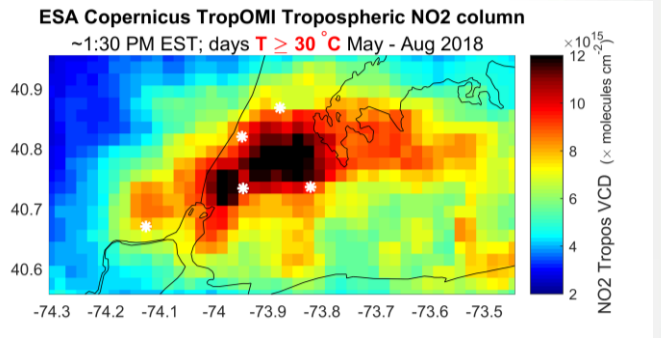


Understanding what's going on overhead

Reference Monitoring Sites

Rigorous and detailed measurements

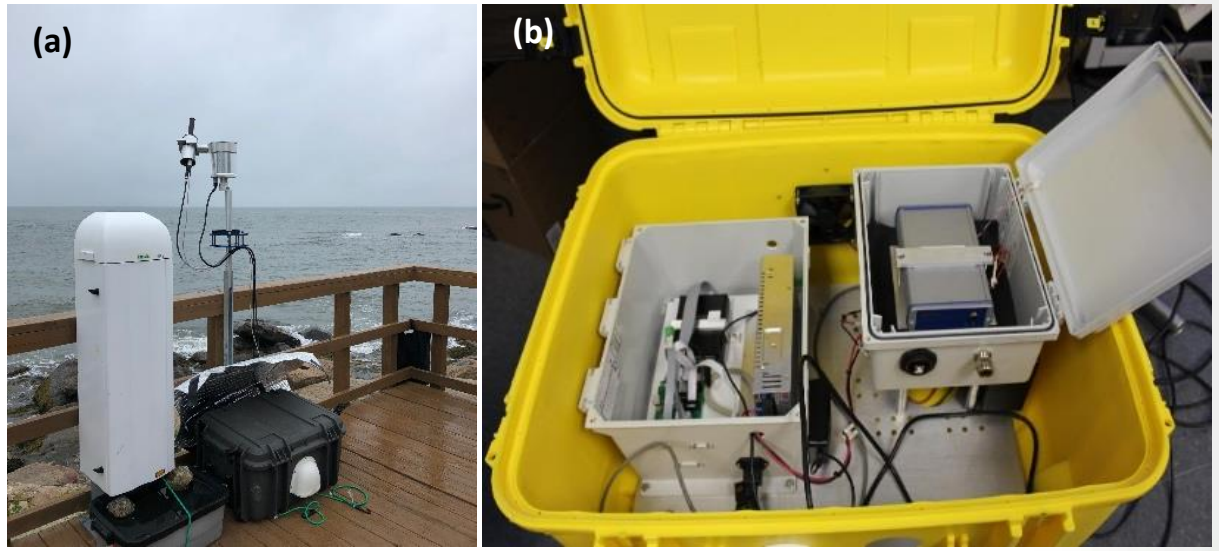
Satellite-based monitoring



Hourly maps of pollutant transport

Pandora Ground-Based Spectrometer

- System developed at NASA Goddard by Herman, Cede, and Abuhassan with a focus on satellite validation.
- Ground-based direct sun/moon & sky scanning remote sensing for air quality and atmospheric composition (1S - ~270 – 530 nm, 0.6 nm; 2S – 400 – 900 nm, 1 nm) provides slant column measurements.
- NRT Standard Operational Products at high frequency (~ 2 mins): Total Column Ozone (+/-15 DU, ~5%); Total Column NO2 (+/-0.05 DU, ~10%)
- Research products: HCHO column, SO2 column & near surface NO2,
- Successfully deployed for multiple field campaigns (e.g. DISCOVER-AQ, KORUS-AQ, LMOS and OWLETS) as well as long-term monitoring.

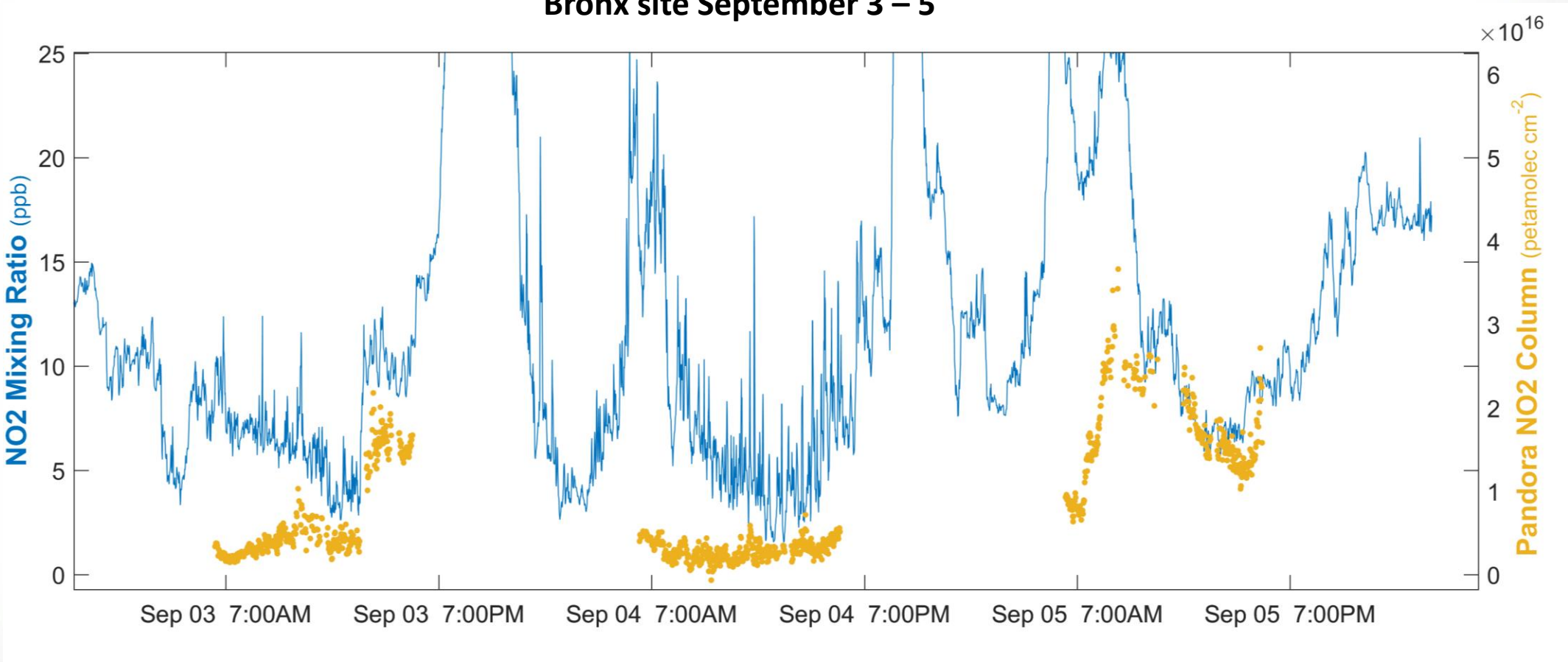


Pandora Pictures: (a) enhanced sun tracker; Pan55 deployment at FWS Outer Island in LIS (b) redesigned integrated layout

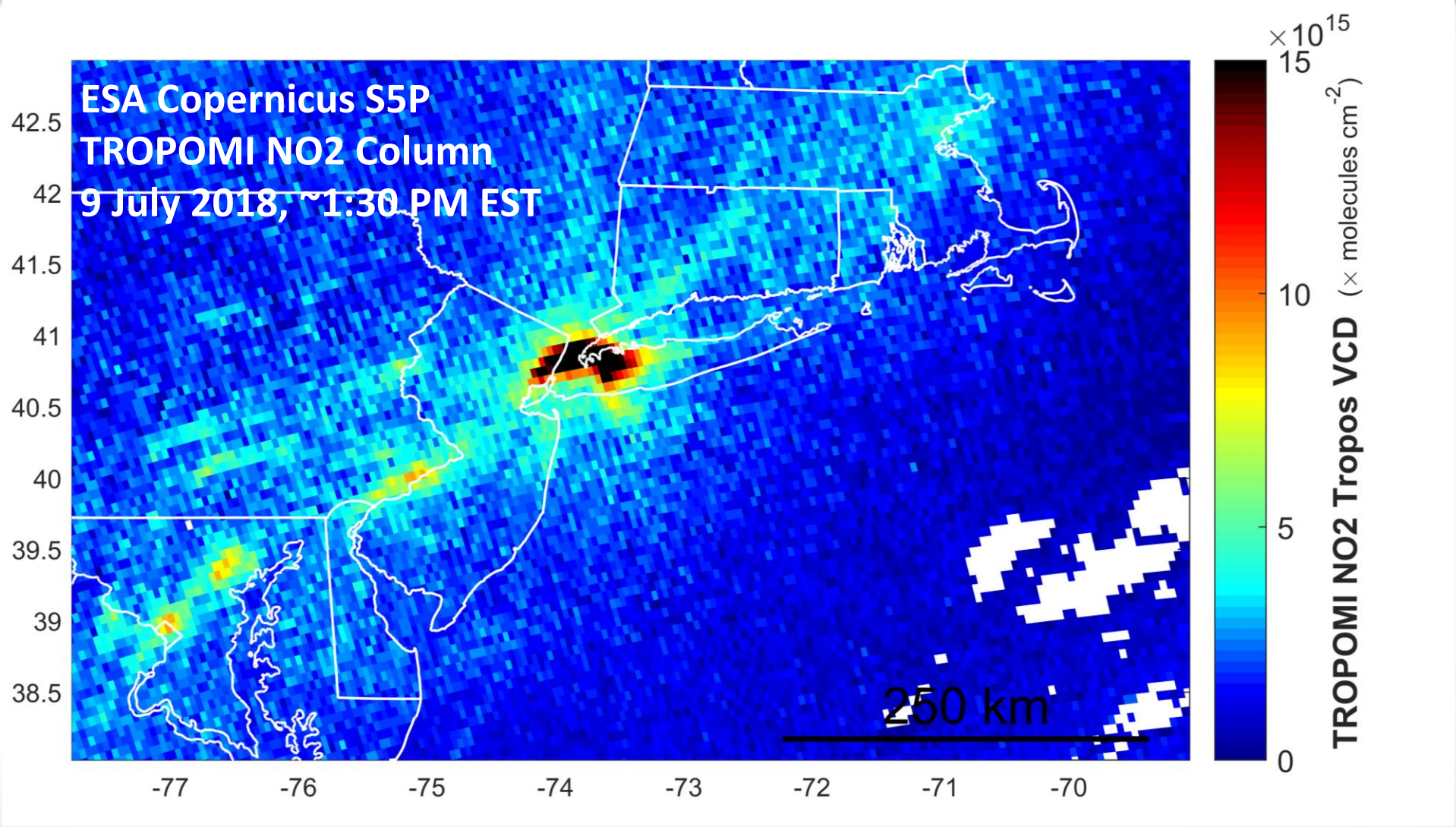
Phase I Pandora Long-Term Deployments in tandem with LISTOS

Pandora NO2 Columns: Precise and detailed measurements when it is sunny

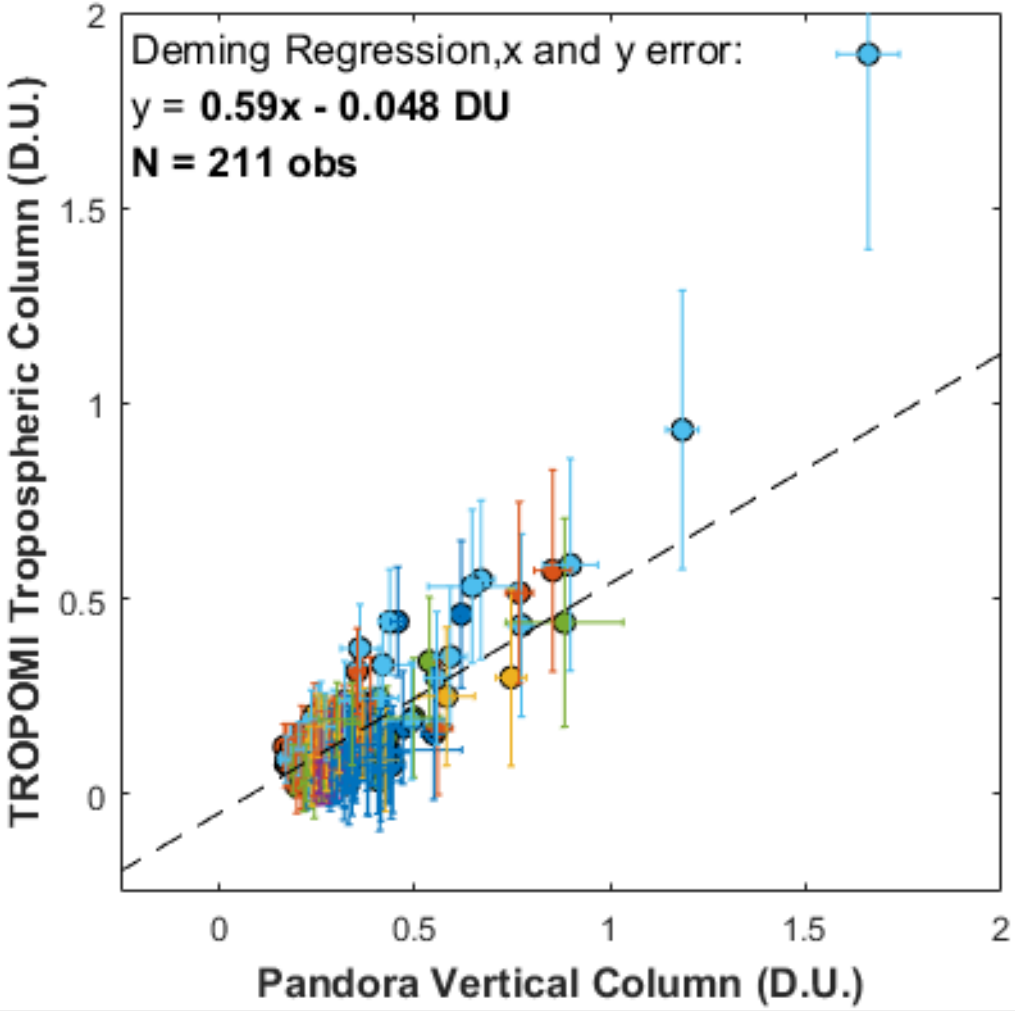
Bronx site September 3 – 5



Satellite-based measurements of NO2 column are enhancing our understanding of pollutant sources and transport

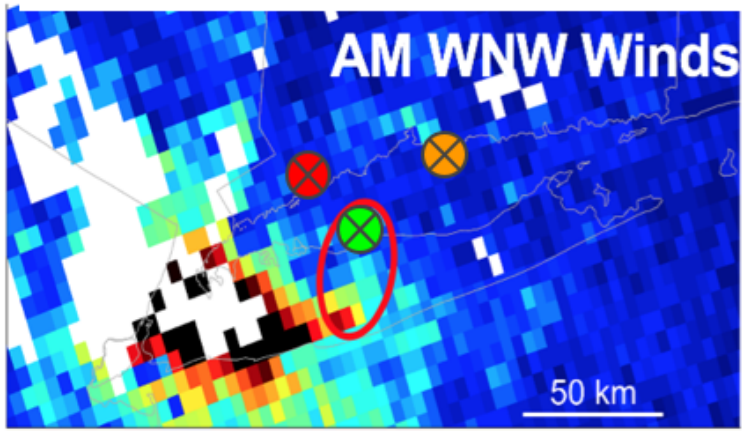


TROPOMI vs Pandora NO2
June – Sept 15, 2018

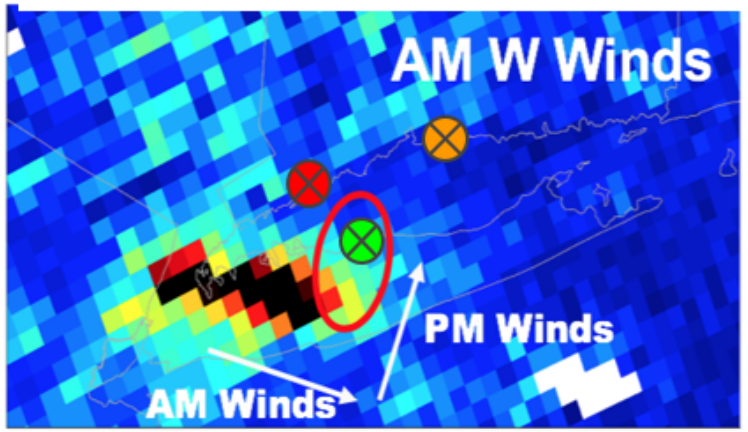


Extent of NYC NO2 plume shifts northward over 3-day heatwave, confirming conceptual model of pollutant transport in region

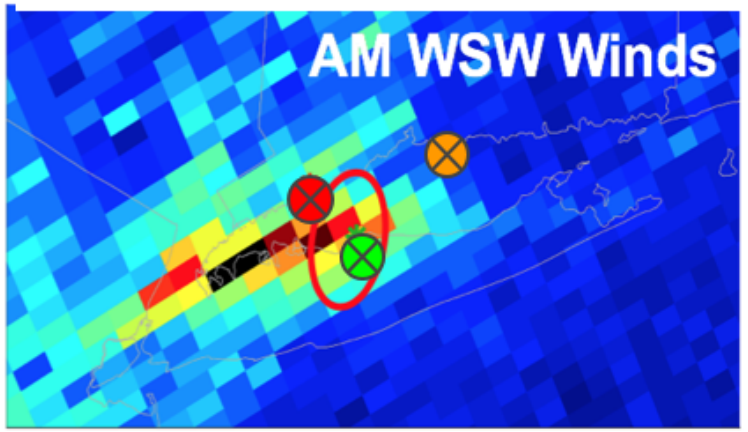
August 27, 2018 1:30pm LT

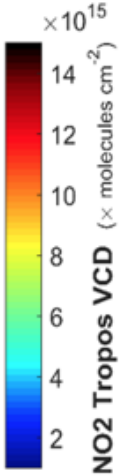


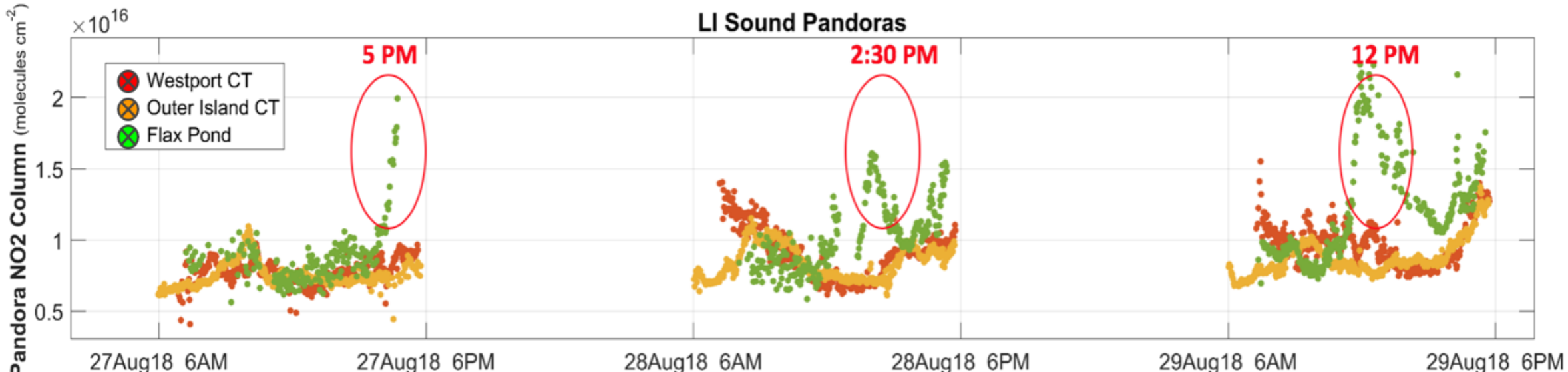
August 28, 2018 1:10pm LT



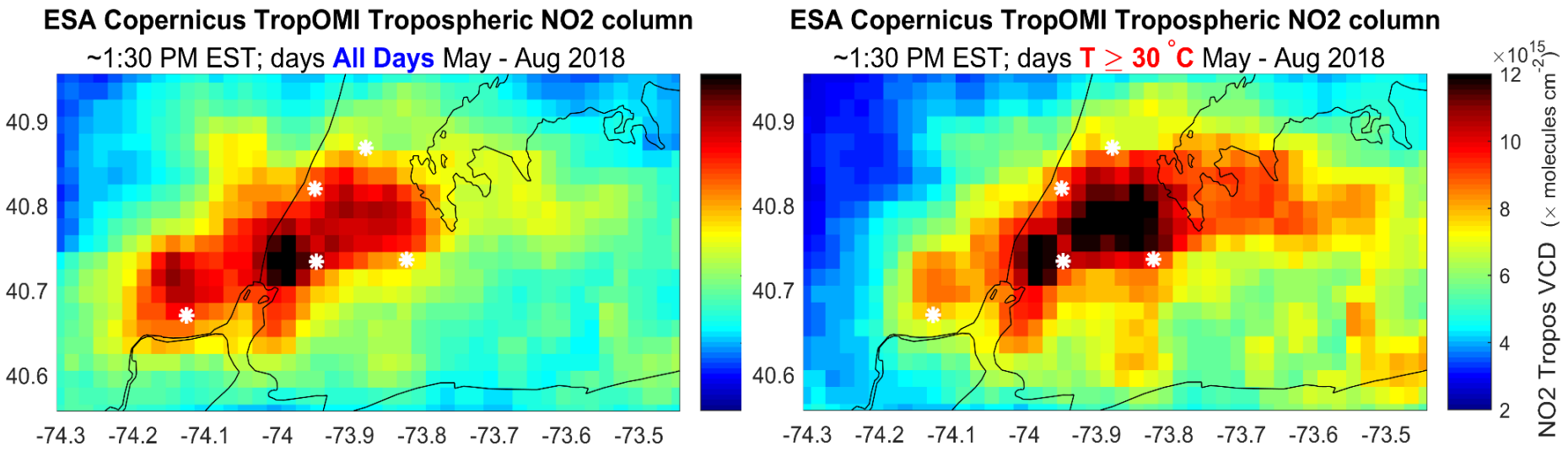
August 29, 2018 12:50pm LT







Doing "experiments" with satellite measurements – one opportunity of many



- Satellite NO_2 measurements indicate a large NO_2 enhancement over Queens and the East River on hot days (T > 30 C). There is no conventional trace gas monitoring network near these sites.

- Pandora network at air quality sites around Long Island Sound will help assess uncertainty in satellite based NO_2 columns. Goal is to improved understanding of emission sources through a more integrated spatial and temporal analysis of NO_2.

Pandonia Global Network (PGN) Collaboration

- As a member of the TEMPO Science Team and TropOMI S5PV Team , EPA is collaborating with NASA, ESA, and Luftblick to develop a subset surface air quality sites to host Pandora spectrometer instruments and contribute to larger Pandonia Global Network.
- Pandonia Global Network (PGN) developed by ESA, NASA and Luftblick to provide global community with standardized long-term measurements for validation of satellite missions
- Initial deployment ~10 long-term instrument across the Ozone Transport Region started in May 2018. Effort directly supports new requirement under National Photochemical Assessment Monitoring Station (PAMS) Program Enhanced Monitoring Instrument under the re-designed PAMS Progam.

Phase II / III PAMS-EMP Pandora Long-Term Deployment Sites

EPA Priority:

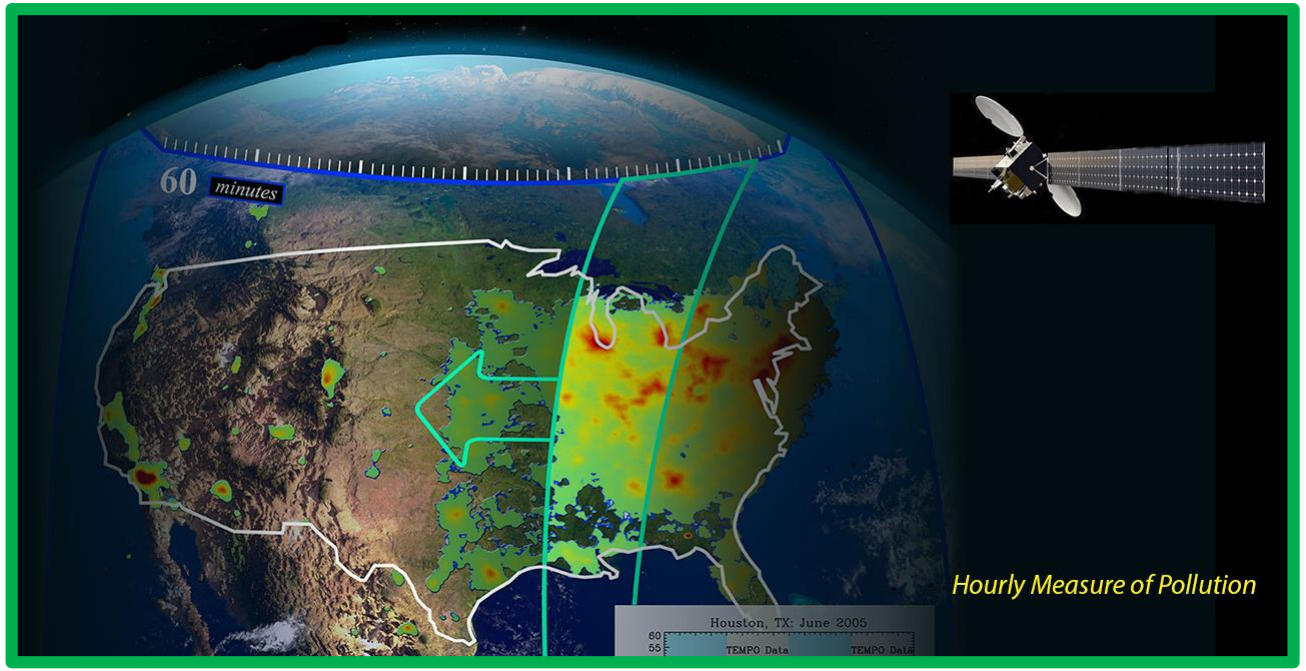
- RI
- NH
- Maine
- Alleghany

NASA GSFC:

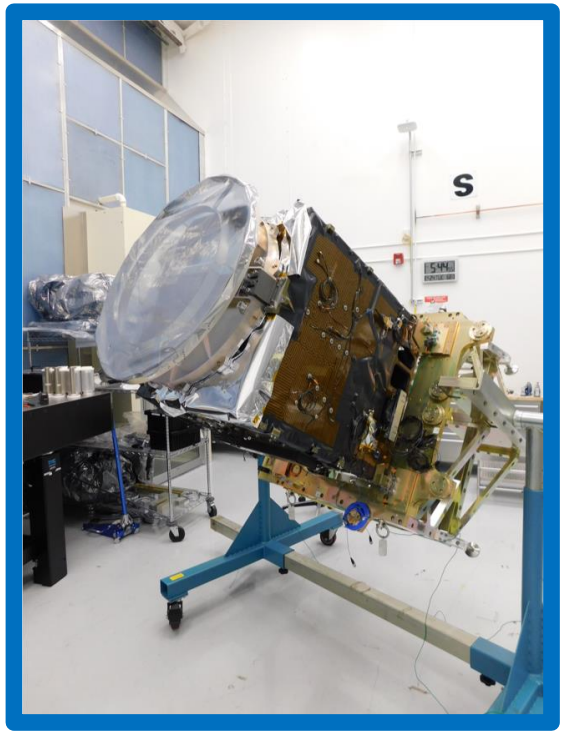
- PADEP
- McMillan (DC)

MA looking to collaborate with Jeff Geddes (Boston University) on deployment of Pandoras

Pandora – A key ground-based remote-sensing measurement for satellite validation



- The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument will make observations from a geostationary vantage point, about 22,000 miles above Earth's equator.
- The TEMPO Field of View (FOV) will provide hourly observations of key pollutants across North America, including the oil sands region in Canada and Mexico City.



Picture of TEMPO UV/VIS Spectrometer instrument; current schedule for instrument delivery to NASA - December 2018

Acknowledgements

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Mike Christopherson
Dirk Felton
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Pete Furdyna
Radcliff Lee
Tosh Mahat
Duane Villafana
David Wheeler

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Luis Lim
Jim Oxley
Jason Standowski

RI DEM:
Darren Austin

CT DEEP:
Pete Babich
Mich Chaffee
Randy Semagin
Dean Tully

NESCAUM:
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Roisin Commane
Jake Margolin
Catherine Newman
Alex Turner
Nick Vaughan
Kevin Worthington

F&WS

Acknowledgements

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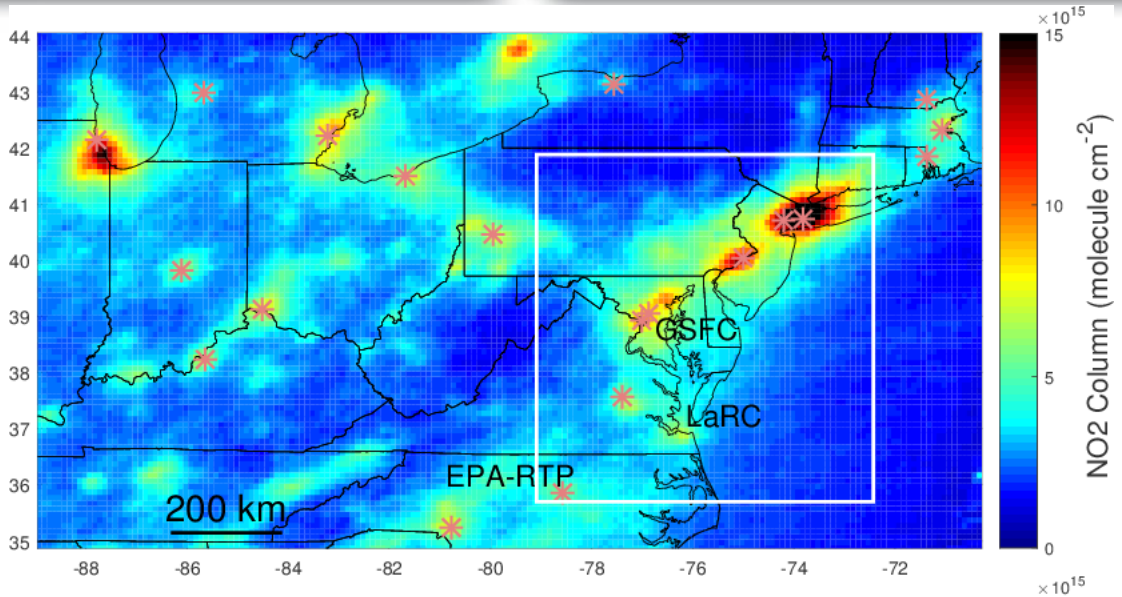

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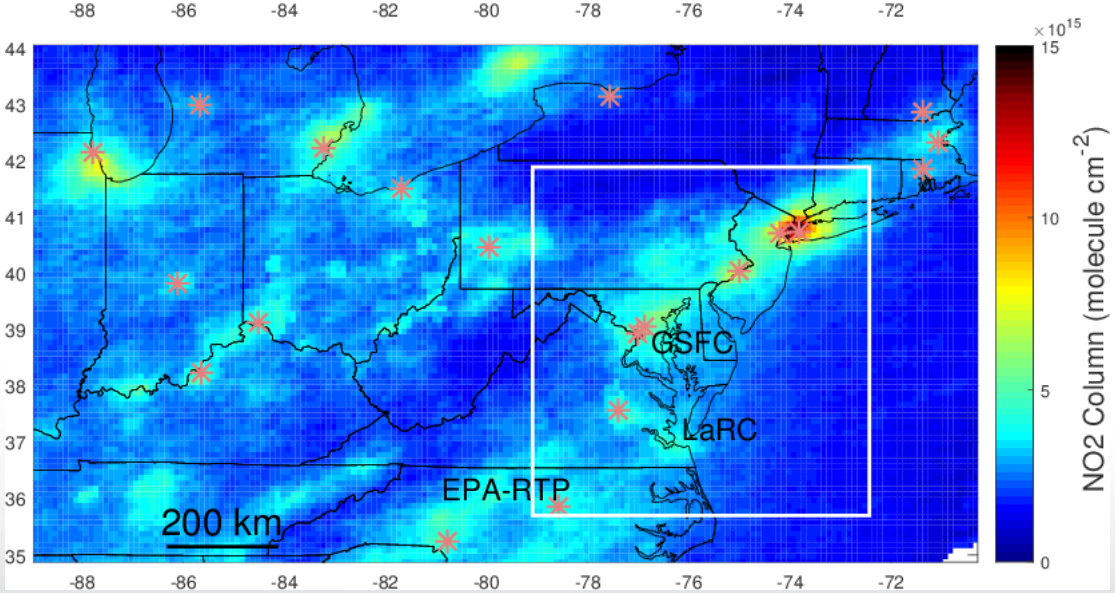

Funding: U.S. EPA Air-Energy Research Program and TEMPO Project

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