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STATE OF
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Department of
Environmental
Conservation

Long Island Sound Tropospheric Ozone Study (LISTOS)

Dirk Felton
Bureau of Air
Quality Surveillance

MARAMA Workshop
November 20, 2019

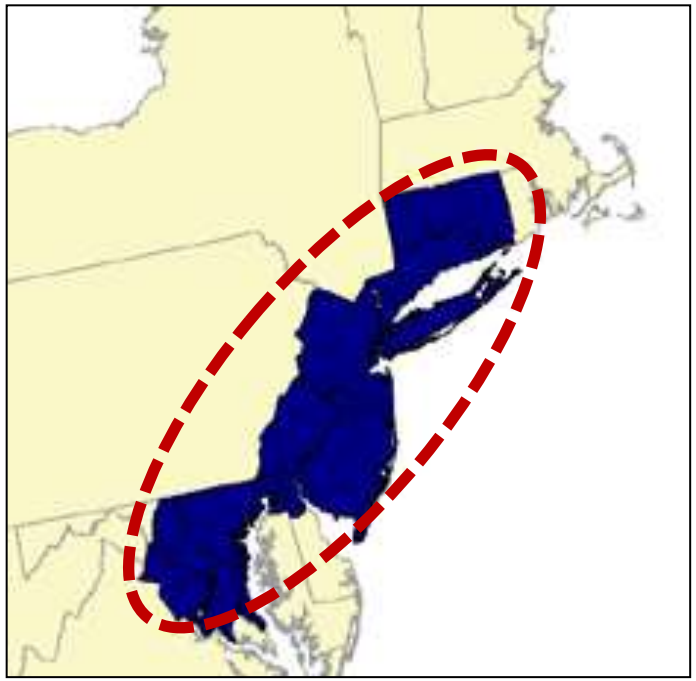
Alternate names that did not make the cut

AWESOME - AreaWide Enhanced Study of Ozone in the Marine Environment

OZONE ENIGMA – Ozone ENhanced Investigation in the Greater Metropolitan Area

NY-METRO Study – New York Marine Enhanced TRopospheric Ozone Study

Ozone is an Attainment Problem



- Nonattainment
- 2015 8-hr NAAQS 0.071 ppm nonattainment across NE Corridor
- 2008 8-hr NAAQS 0.075 ppm "bump-up" for failing to attain by deadline:
  - Serious: New York-Northern New Jersey-Long Island, NY-NJ-CT
  - Serious: Greater Connecticut, CT

  [84 Fed. Reg. 44238 (Aug. 23, 2019)]

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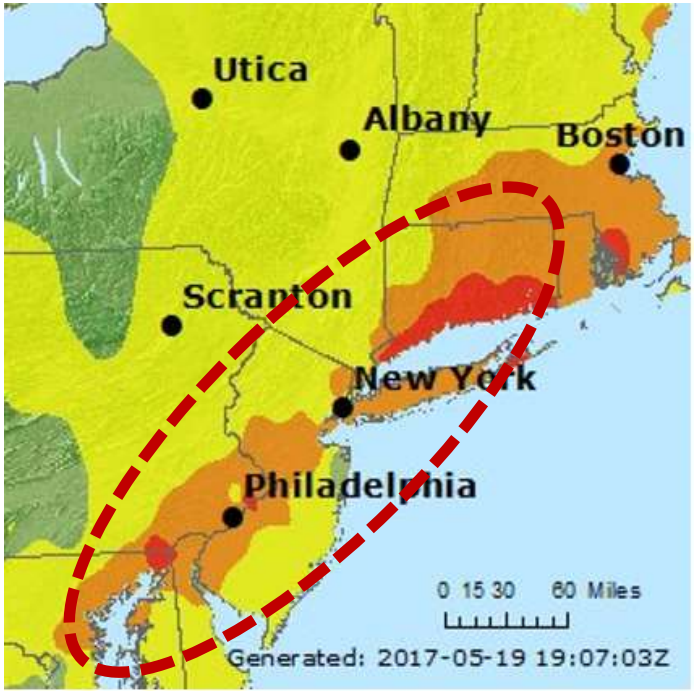
Ozone is a Public Health Problem



Daily Ozone AQI – May 18th 2017

Example of a bad ozone day in the Northeast corridor

Ozone is enhanced downwind of the Chesapeake Bay and Long Island Sound

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May 2017 Workshop at Columbia's Lamont-Doherty Earth Observatory

- Convened research and policy experts in energy & air quality data gaps workshop, May 24-25, 2017

- Follow-up activities

  Whitepaper with research recommendations as basis for future efforts *Retrospective and Future Analysis of Air Quality In and Downwind of New York City*

  Monthly calls with *ad hoc* research group

LISTOS Objectives

1. Improve understanding of urban pollution plume upwind and downwind of NYC metro area
   - Key VOC sources and species (*e.g.,* consumer products, transportation, industrial)
   - Temporal and spatial resolution of NOx emissions
   - Met measurements of Long Island Sound pollutant flows/marine mixing layer
2. Develop new case study of air pollution in NYC region to complement studies elsewhere (e.g., OWLETS, LMOS, DISCOVER-AQ, etc.)
3. Investigate impact of air quality programs and shifting electricity generation patterns on NYC air quality
4. Probe future implications of distant wildfire plumes on NYC air quality

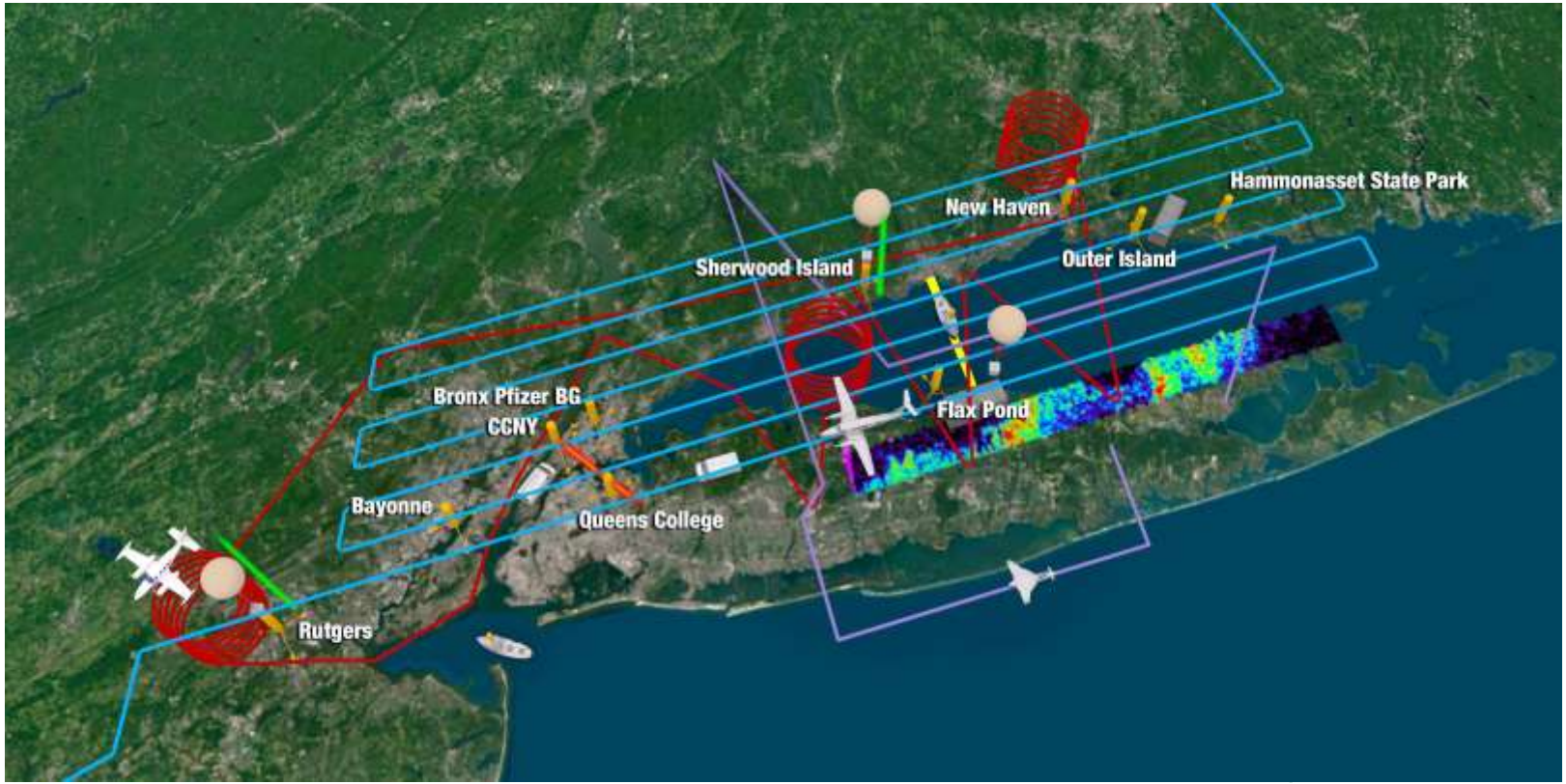
LISTOS draft White Paper: *Retrospective and Future Analysis of Air Quality In and Downwind of New York City (2017),*

http://www.nescaum.org/documents/nyc-metro-lis-ozone-whitepaper-draft-v5.pdf

2018 LISTOS Participants & Activities

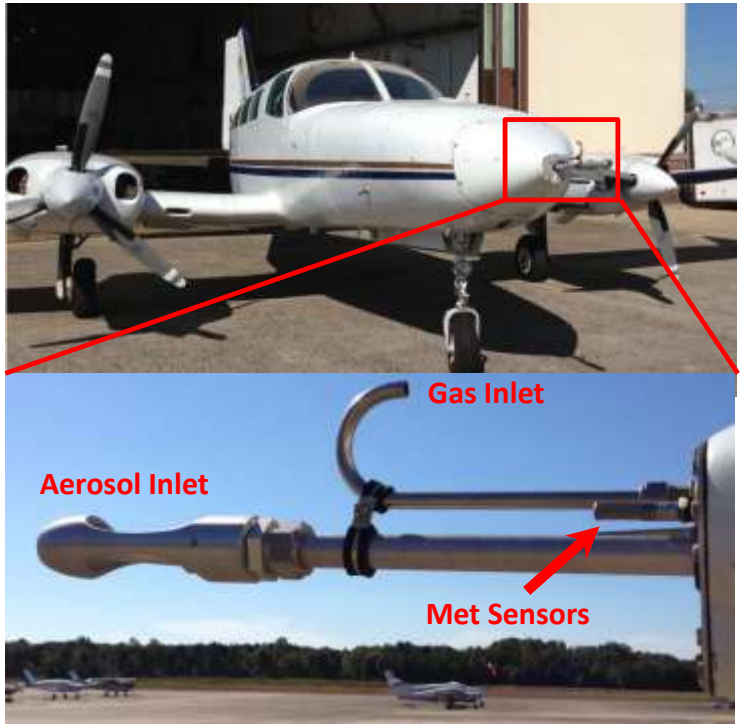
1. State AQI forecasters predicting ozone episodes to launch activities, Establish Flax Pond Site
2. NOAA-ESRL oxygenated/consumer product VOC mobile van measurements in NYC during March and July
3. Univ. Maryland 8-12 flights (depends on episodes, flight durations)
4. Maine DEP and NYS DEC labs VOC canister analysis
5. NASA GeoTASO/GCAS 20-30 high altitude flights; ozonesondes at Rutgers, NJ
6. EPA Pandoras Long Island Sound (LIS) coastline, Rutgers PAMS, NYC; ozonesondes & continuous HCHO at Westport, CT
7. CCNY boat-based air pollution measurements in LIS
8. CCNY aerosol LIDAR in northern Manhattan
9. Stony Brook Univ. oxygenated VOC measurements at Flax Pond PAMS site (Long Island north shore) during summer
10. Stony Brook Univ. aircraft fine resolution wind field measurements over LIS
11. Univ. at Albany O_3, NOx, VOC mobile measurements across Long Island south to north shore transects
12. Univ. at Albany ozonesondes at Flax Pond, Long Island, NY
13. NASA ozone LIDARs upwind at Rutgers Univ., NJ, and downwind on CT's LIS shoreline
14. CT DEEP ozone monitor on LIS ferry between Bridgeport, CT and Port Jefferson, NY
15. PAMS VOC measurements at Rutgers, NJ & the Bronx, with new NYS DEC PAMS site at Flax Pond, Long Island
16. Yale Univ. Coastal Field Station – VOCs on CT coast

LISTOS in One Picture



NASA Langley Research Center

University of Maryland Aircraft



Credit: Xinrong Ren, NOAA; Russ Dickerson, UMD

Continuous Measurements
NO2, HCHO, CO, CH4, O3
Temp, Altitude

Grab Samples
Canister TO-15 and PAMS

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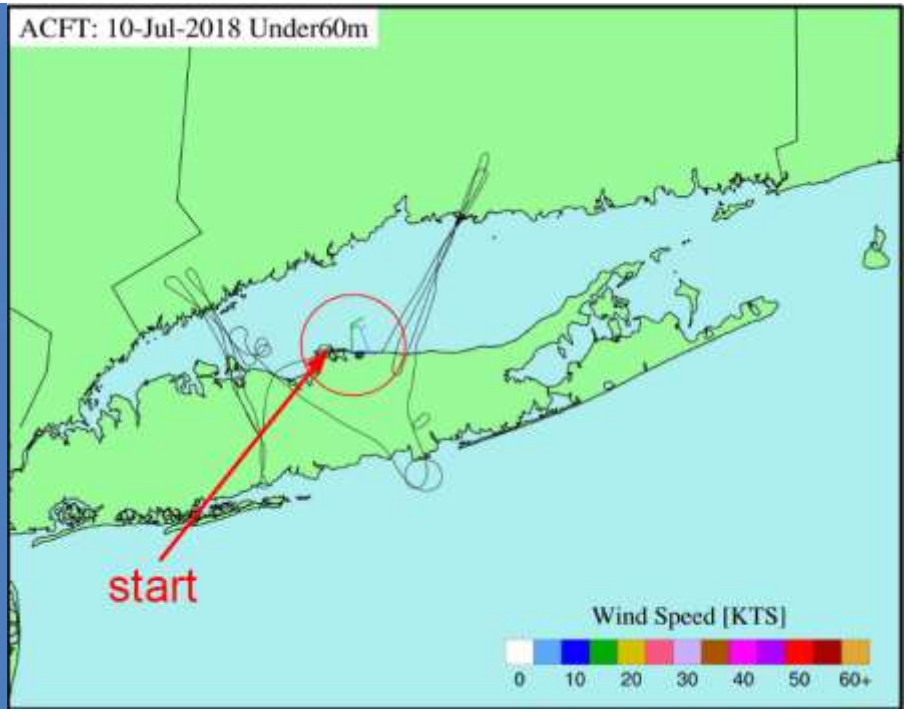
SUNY Stony Brook Wind Field Mapping

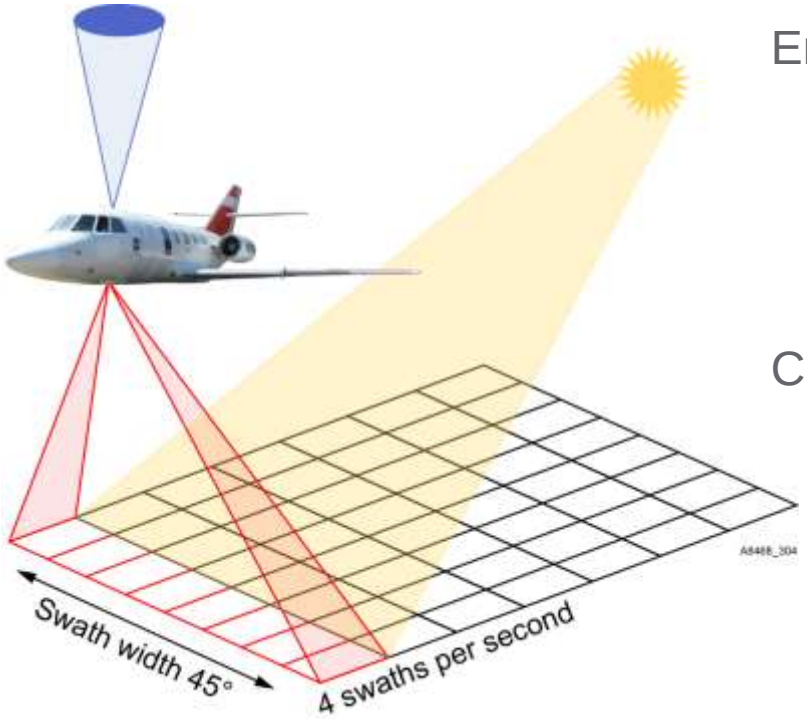


SUNY Albany Mobile Lab & Ozonesondes

Ozone, NOx and VOC transects (N-S) across Long Island

GeoTASO Observations by NASA

Airborne Test Bed for TEMPO Satellite



- Emissions inventory check NOx, VOCs, CH4
  - Transportation sectors including marine
  - Peaking generators
  - VOCs e.g., vehicles, consumer products, coatings
- Characterize spatial and temporal patterns of
  - O3, met and precursors

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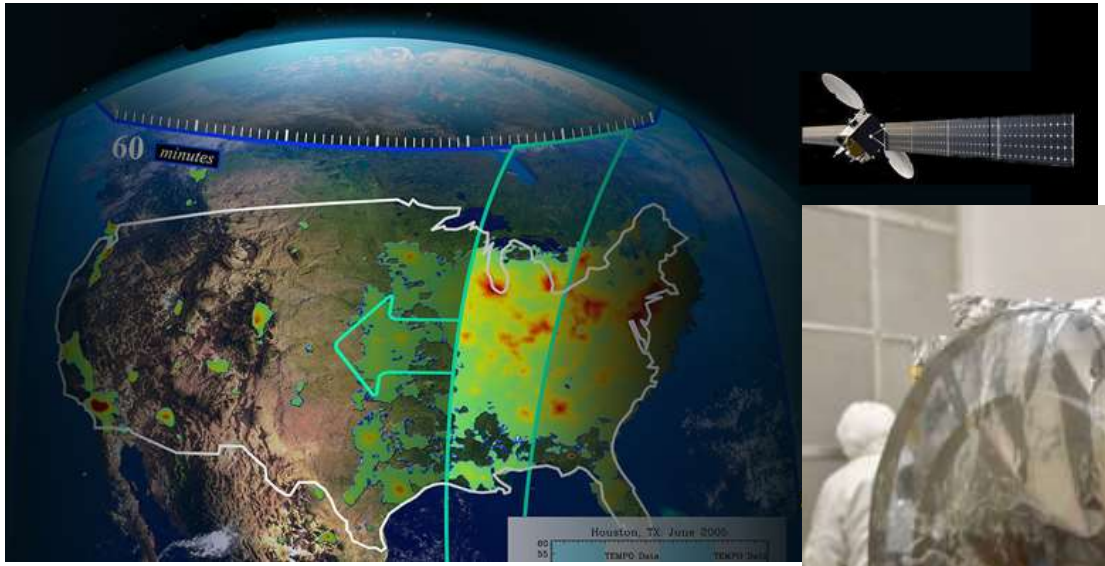
TEMPO – Tropospheric Emissions: Monitoring of Pollution



Launch Scheduled in 2022
Measures backscattered Earth radiance (UV and Vis)

Geostationary Orbit 35,786 km above Earth's equator (Gases and Aerosols)

Pandora Spectrometer

- Solar source spectrometer (280 - 525 nm: 0.6 nm resolution) – column NO_2, O_3, HCHO, and SO_2 every 80 sec.
- Developed as validation instrument for OMI measurements
- EPA working with NASA to site Pandoras at PAMS as research instrument to provide improved characterization of emissions and serve as a U.S. ground-based satellite validation network
- NO_2/HCHO to assess formaldehyde as a radical source (primary and secondary) and O_3 formation in an urban and downwind environment

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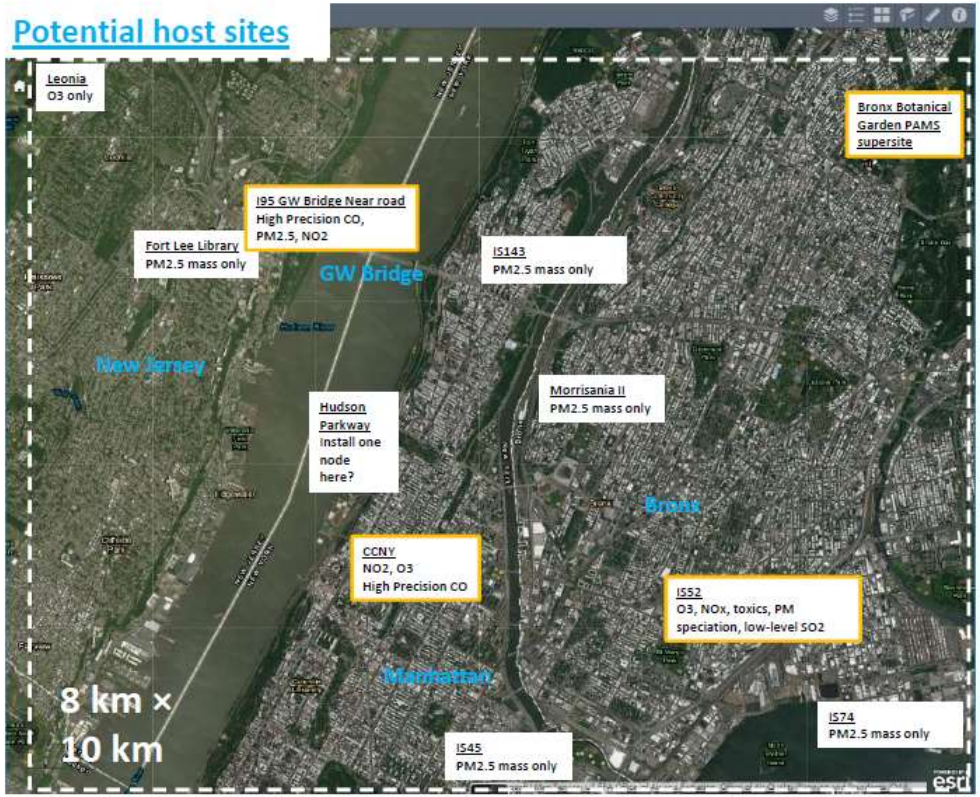
Sensor Nodes located in Source Regions

We have 7 AQ nodes (beacon.berkeley.edu) to deploy from NJ to Bronx, NY. ~$4K/unit for parts

- Research questions: How much NOx and CO are emitted per unit of fuel burned (CO2)? How does growth of boundary layer in morning affect an emitted "conserved" tracer (CO2)? (e.g., Shusterman et al., 2016)
- 4 high priority sites (orange)
- CO2 measurement is robust
- Validation of electrochemical AQ gas measurements (CO, NOx, SO2, O_3, PM) vs suite of FRM measurements is second priority



EPA ORD Ground-based Sensors to look at distribution of emissions

Cohen Group and the BErkeley Atmospheric CO2 Observation Network ($BEACO_2N$).

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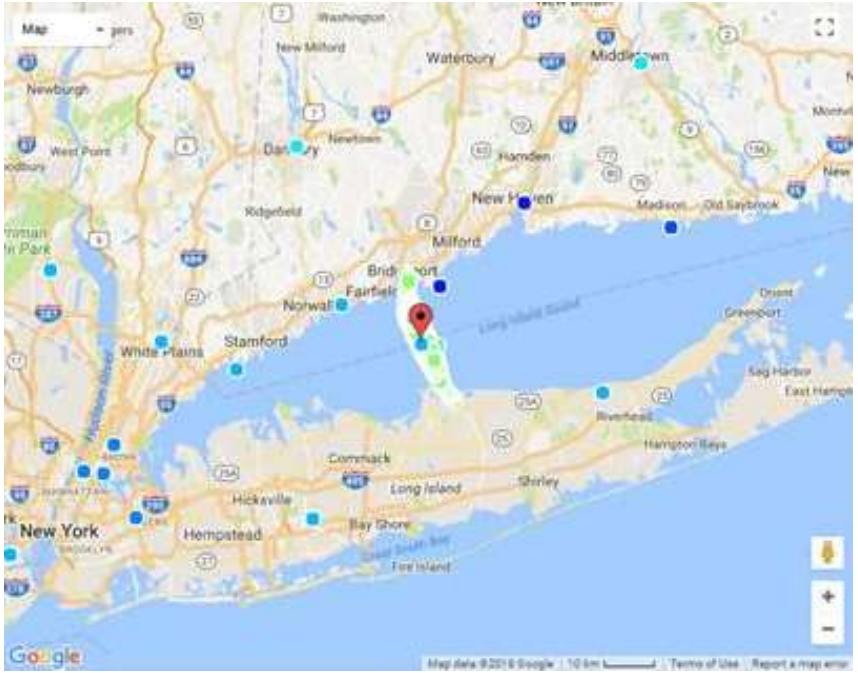
Special Monitoring Sites by CCNY

LI South Shore: U.S. Coast Guard Station, Fire Island

LI North Shore: U.S. Coast Guard Station, Eatons Neck

CT DEEP: Ozone Monitoring on LIS Ferry

M/V Park City: Bridgeport, CT – Port Jefferson, NY



An Ozone monitor was installed in each ferry

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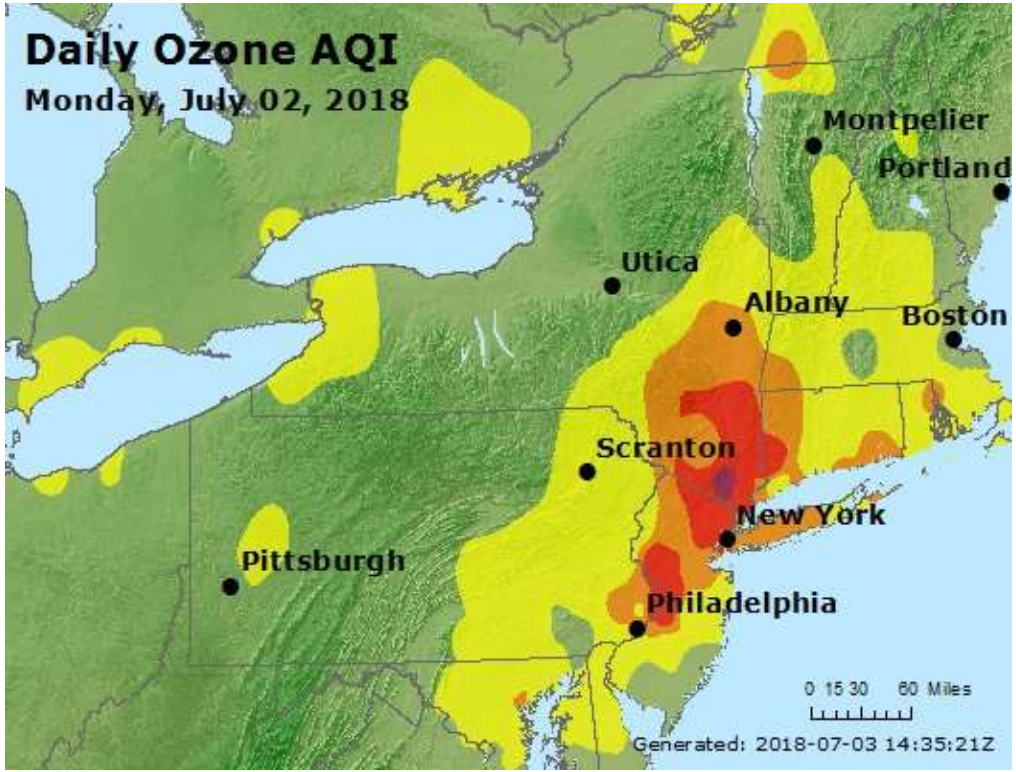
Everything Starts with the Forecasters

- State AQ forecasters call every week-day 2pm local time, sometimes weekend updates
  - Regular state forecasting for AQI public messaging
  - Daily and long range synopsis
- LISTOS participants call immediately following state AQ forecasting calls
  - State forecasts used as launch point for identifying candidate days for research activities
    - For ozone events, typically looked for SW-NE wind flow coupled to high ozone forecasts
    - Also looked for low-cloud days with different wind directions for emissions inventory and other project goals.
- Early morning “go/no go” calls with forecasters to verify cloud forecasts prior to aircraft take-off
- NYS DEC – Bob Gaza, John Kent, Julia Stuart were forecast leads

NYC Bad Air Day: July 2, 2018



Highest ozone since 2006:
- 8 hr: 115 ppb
- 1 hr: 143 ppb

4th Day of a heatwave

A light sea breeze pushed ozone up the Hudson Valley

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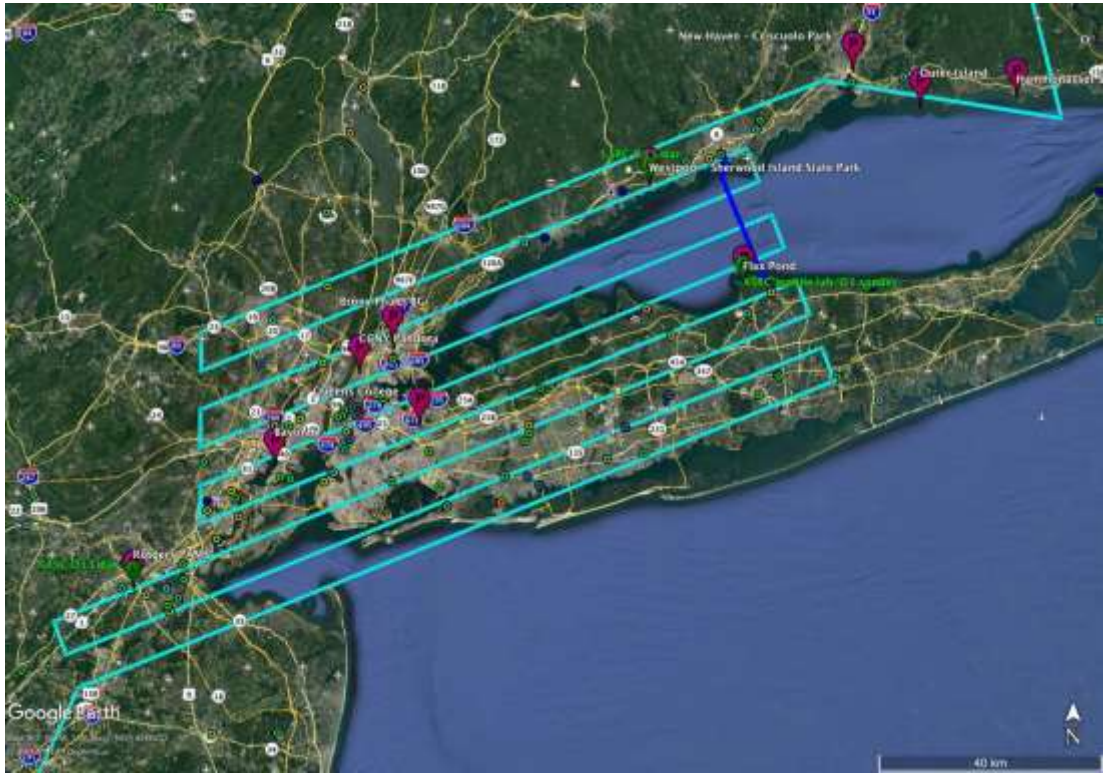
NASA Aircraft Flight Grid July 2



The flight grid was shortened to a “double raster” and moved west to accommodate the forecast ozone flow

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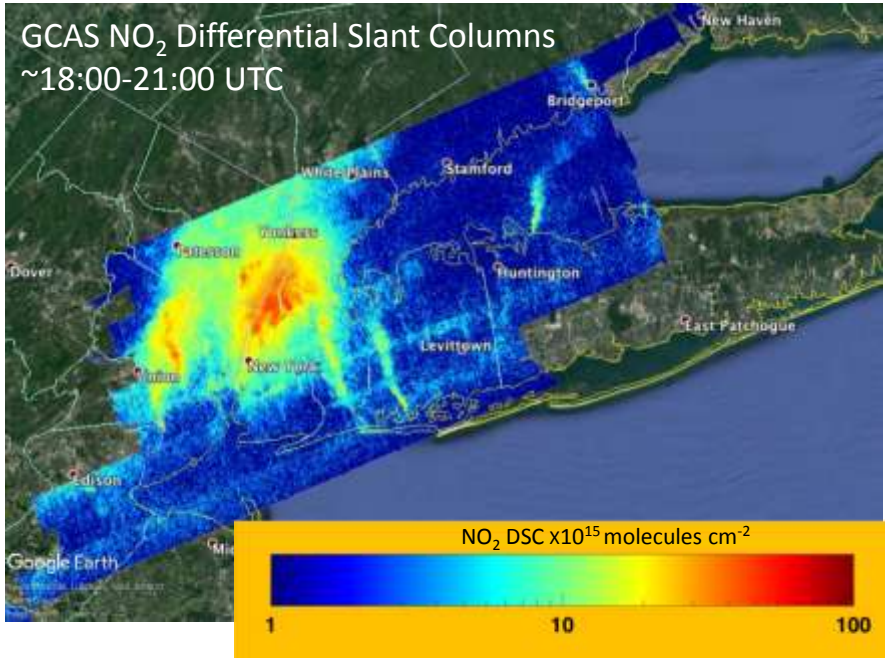
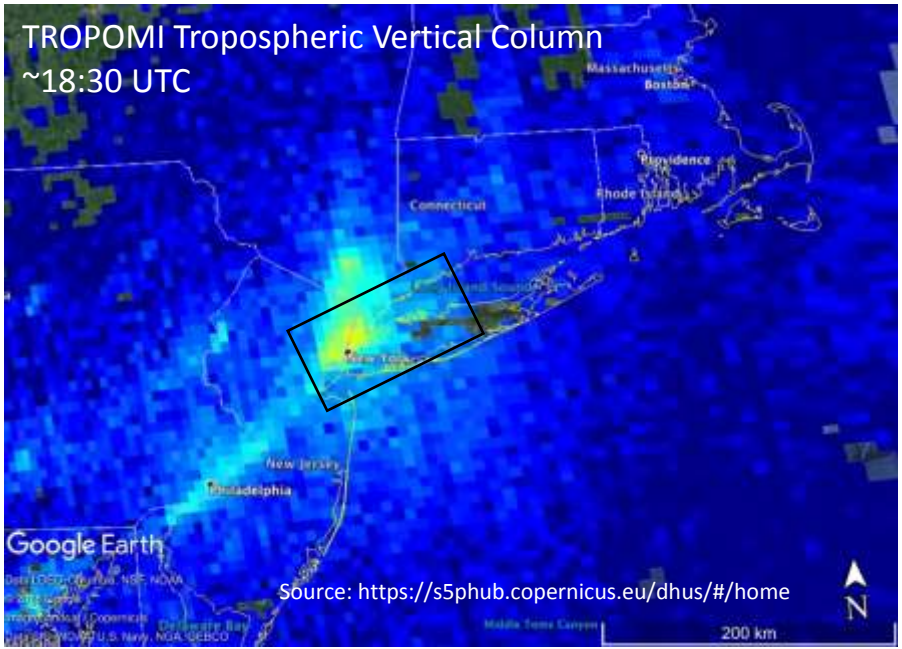
NASA GeoTASO (TEMPO Satellite Test-bed) Aircraft Flight Grid July 2, 2018 (Preliminary Results)





Credit: NASA Langley, NOT FOR DISTRIBUTION

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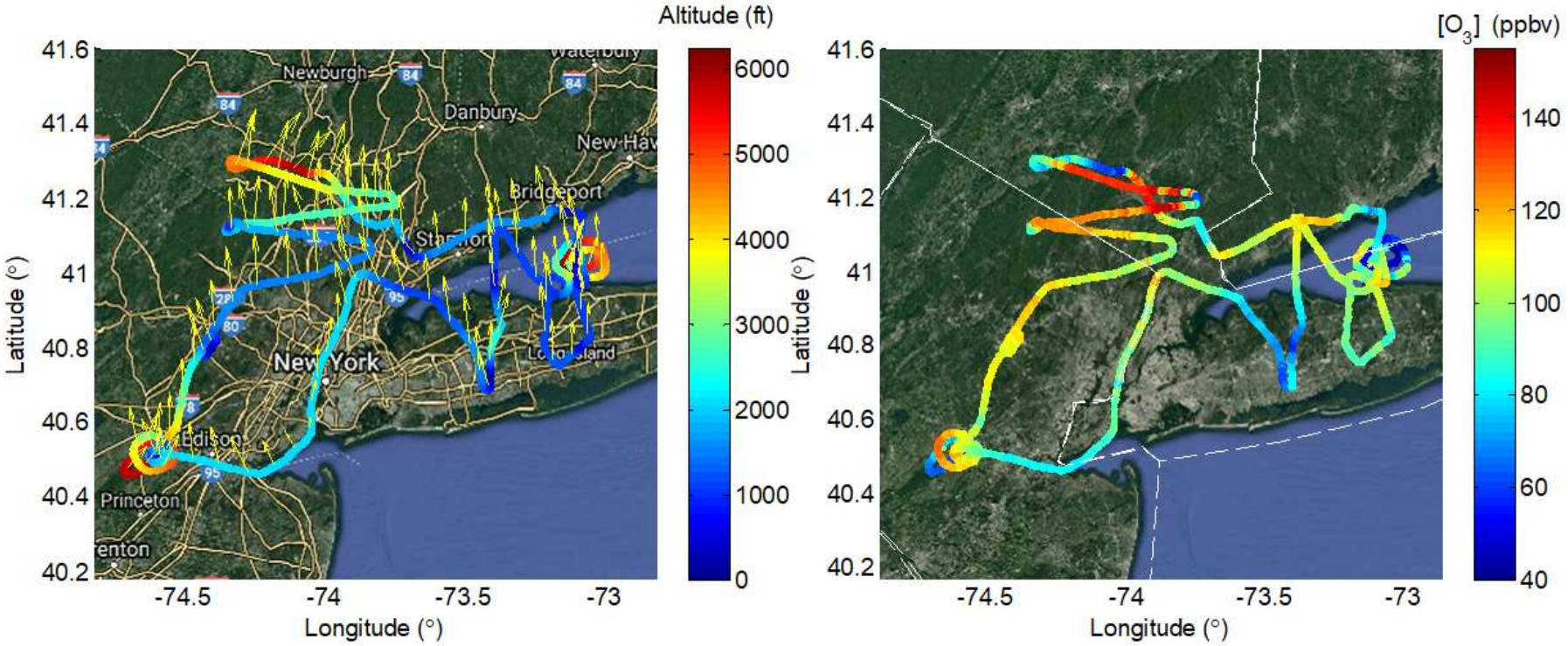
July 2 from Above

Visual confirmation of haze

View from UMD airplane over Manhattan

UMD Aircraft Flight Path July 2 afternoon



July 2, 2018 Compared to Clean Day

HazeCam confirmation

4 Flight Days, 13 Flights, during 2019 Ozone Season

- July 20 – 2 flights late morning and 2 late afternoon
- July 21 – 2 flights late morning and 2 late afternoon
- July 28 – 1 flight (Stony Brook only) late afternoon
- July 29 – 2 flights mid-morning and 2 late afternoon
- Ozonesonde launches from Stony Brook each day
- Mobile van ozone/precursor circuits on Long Island

Planned 2020-2021 LISTOS Activities

1. Operate formaldehyde analyzers at NYS DEC PAMS in the Bronx and Flax Pond, Long Island (NYSERDA funded)
2. Ozone LIDAR in NYC at CCNY (NYSERDA funded)
3. Longer-term (including winter) speciated VOC measurements in NYC by Yale & Stony Brook (NYSERDA funded)
4. Staten Island special monitoring site for VOCs, BC & source apportionment analysis (NYSERDA funded)

Preliminary VOC Data Analysis

- VOC reactivity with OH was not always dominated by Isoprene
- Other VOCs related to petroleum were also significant
- Bronx PAMS Propylene 1-hr 2018

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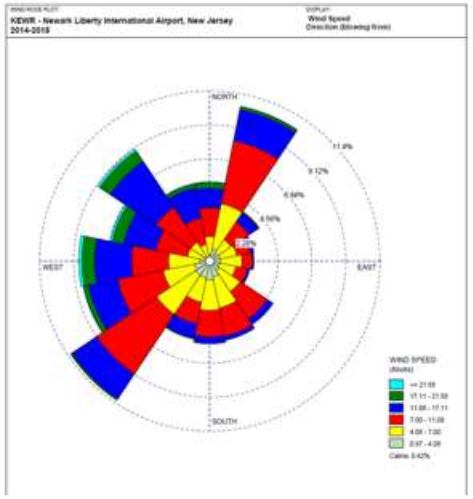
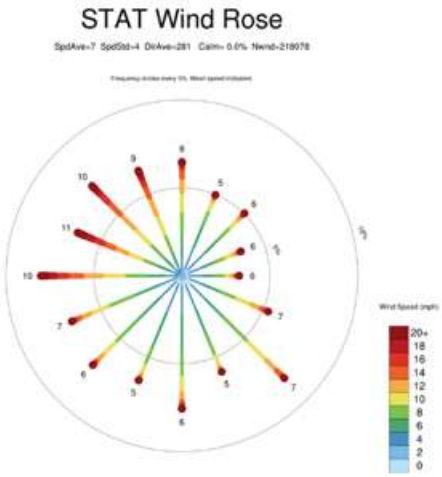
Proposal to Collect Speciated VOC and BC Data on Staten Island





Bayway Refinery produces 775 Million lbs of Propylene each year

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Continuous Formaldehyde

Goal is 1-Hr HCHO data at PAMS sites

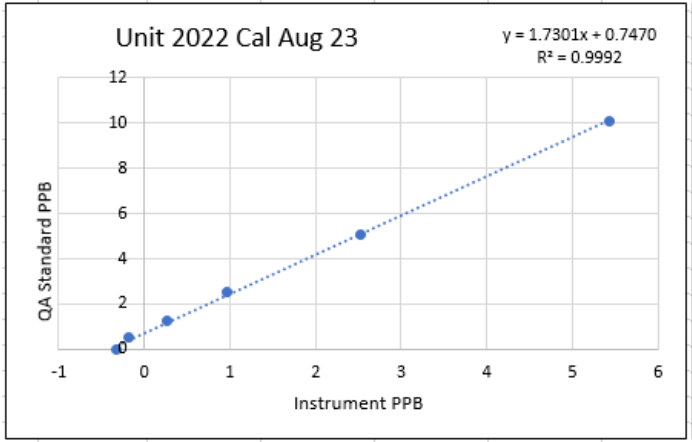
Picarro G2307 CRDS (HCHO, CH4, H2O)

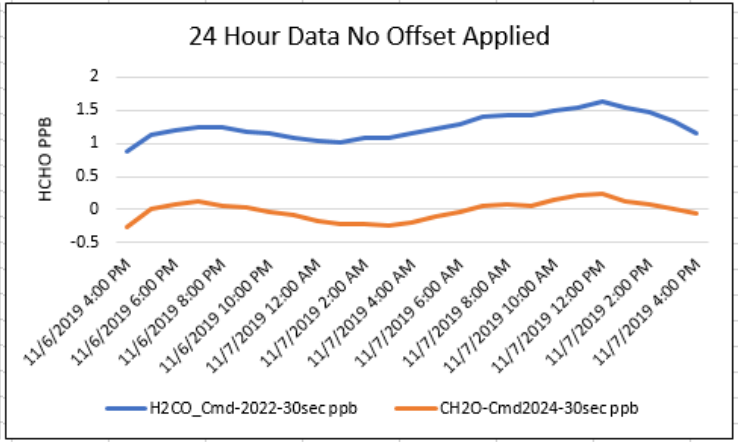
LDL is 0.3 ppb
Zero Drift (24-Hr) 1.5 ppb

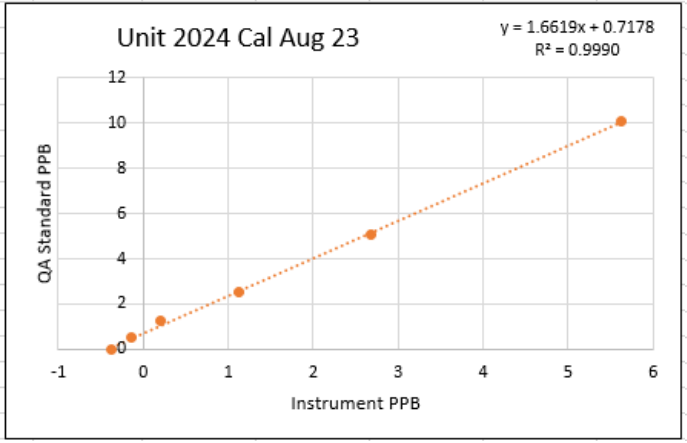
Calibration and Drift

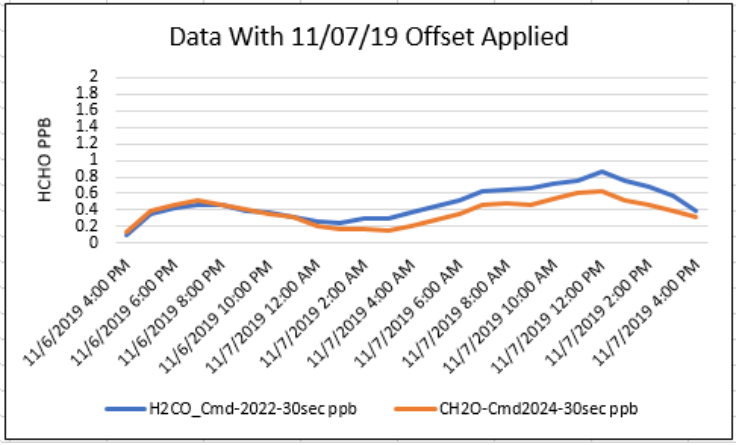
We plan to try a cal cylinder without methane

We are setting up a 10-min hourly zero





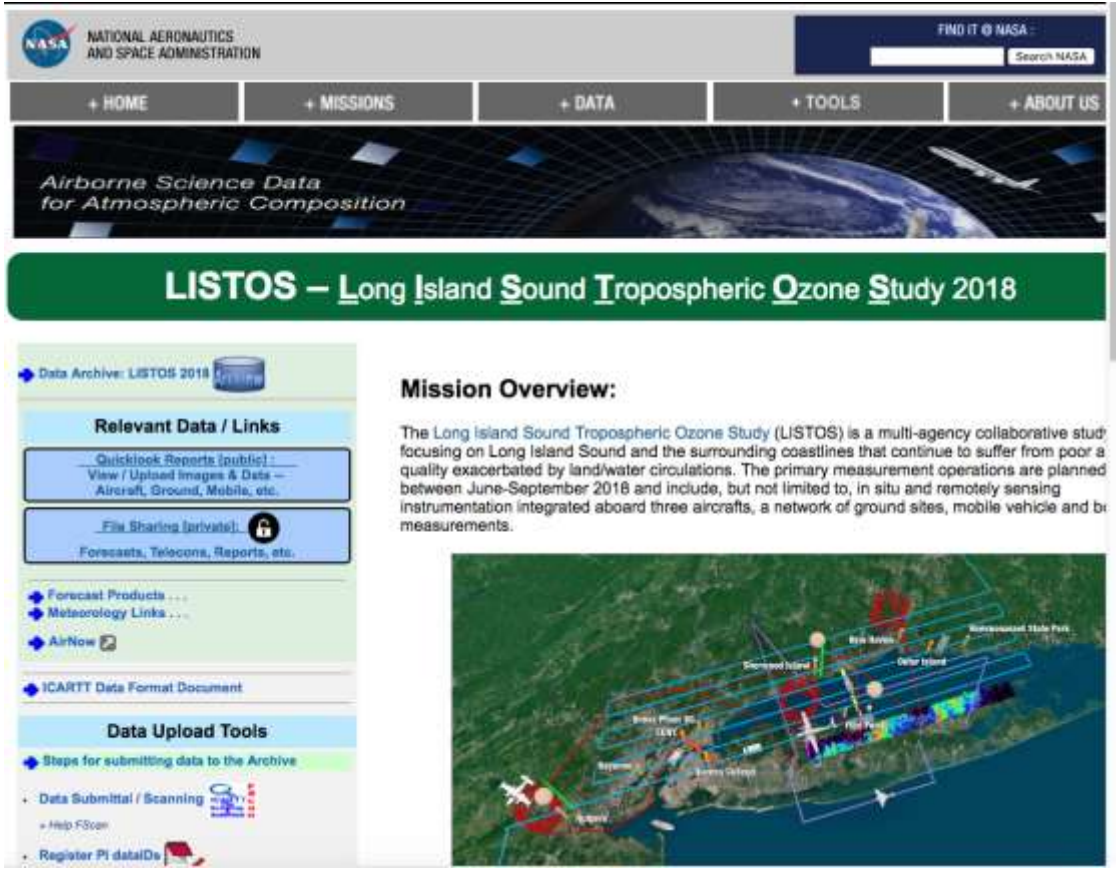




Analysis Plans

- NASA LISTOS archive site to make all data sets easily accessible
- Modeling analysis of results (UMD, EPA-RTP, NOAA-Boulder, NESCAUM)
- NESCAUM: Policy-relevant synthesis paper

http://www.nescaum.org/documents/listos



LISTOS Data Archive

https://www-air.larc.nasa.gov/missions/listos/index.html

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LISTOS Supporters

- NESCAUM – Administration and Coordination
- Funders
  - NY State Energy Research & Development Authority (NYSERDA)
  - CT DEEP
  - NJ DEP
  - NYS DEC
  - National Fish & Wildlife Foundation
- Federal collaborators with own funding
  - NOAA
  - NASA
  - EPA

Thank You

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Intercomparison of methods at Flax Pond

DNPH – NYSDEC PAMS Measurement (1/3 Day 3x 8Hr)

Picarro (Newer version Cavity Ring Down Spectrometer, DEC)

Gasera (Photo acoustic – DEC and JJ Wilbur)

Aeris (Infrared absorption measurement, Harvard)

Aerodyne (Research - Quantum Cascade Laser, EPA)

PTR TOF Mass Spec (Research - Proton Transfer Reaction TOF Mass Spec, SUNY Stony Brook)

LIF (Research - Laser system, Harvard)

Vaporsense – (Research - Nanofiber sensor array)