# TROPOMI as a regional Air Quality Mapping and assessment tool

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# Motivation

- Pollution in Urban Areas during the summer is very complex with variable emission sources coupled to convective expansion as well as potential plume transport.
- Emission Sources can be highly localized as well as dynamically changing in time so multiple types of sensors are needed.
- To illustrate the complexity of these pollution scenarios, we make use of a wide variety of Remote Sensing Tools including:

  - TROPOMI Satellite Sensor. A new instrument from the ESA which targets Emission Trace Gases such as SO2, NO2, CO and O3
  - Pandora: A NASA based Ground Spectrometer targeting Total Column O3 and NO2
  - GOES-ABI. The newest Geostainary Satellite from NOAA built on NASA MODIS Heritage for Aerosol Optical Depth (AOD) and potential smoke dust classification
  - TROPOMI is a useful precursor for the future NASA TEMPO Geostationary for launch ~ 2023 and building experience in it's use for potential NOx emission inventory constraints and signatures is our initial goal within our LISTOS collaboration.

- Preliminary evaluation of NO2 performance as well as time series comparisons with mobile + area NOx emission sources and meteorology are explored.
- Better understanding requires different levels of Chemical Dispersion / Transport Modeling and these data sets are potentially very useful for exploring Emission Inventory Estimates

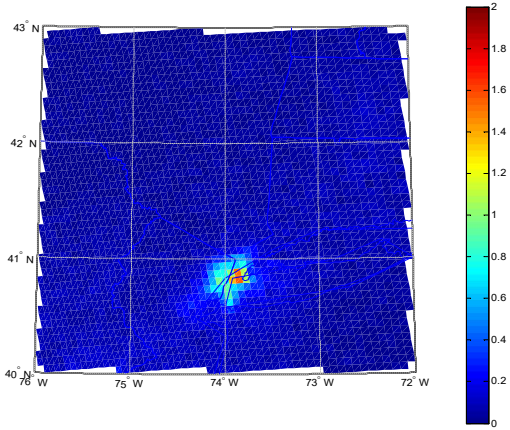
# *TROPOMI Products with focus on Tropospheric NO2*

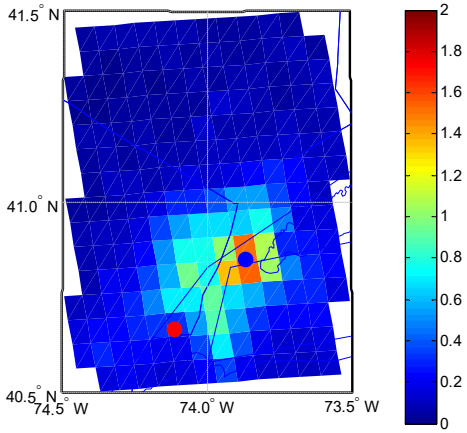
- A UV Satellite Spectrometer that ultimately provide the following L2 products.
- First release was in July 2018.
- Ozone (O3) total vertical column L2__O3____ Near Real Time (NRT).
- Nitrogen dioxide (NO2) vertical column L2__NO2___ Near Real Time (NRT) and Offline (OFFL). Better spatial resolution and SNR in comparison to OMI
- Carbon monoxide (CO) total column L2__CO____ Offline (OFFL).
- Cloud Parameters L2__CLOUD_ Near Real Time (NRT) and Offline (OFFL).
- Aerosol index product L2__AER_AI Near Real Time (NRT) and Offline (OFFL).
- Suomi-NPP cloud product L2__NP_BD3, L2__NP_BD6, L2__NP_BD7 Offline (OFFL).

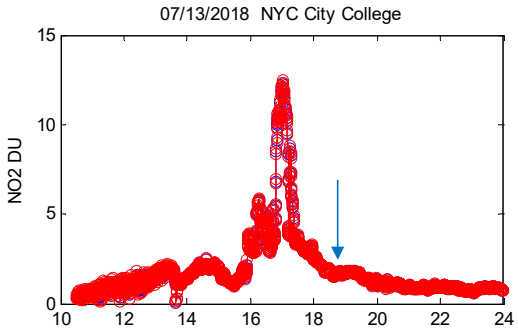
# NO2 Validation Tool NASA PANDORA

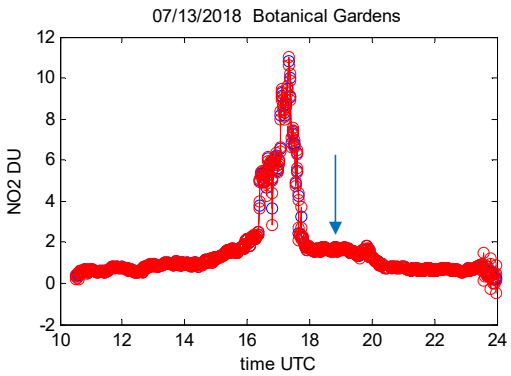
- The Pandora Instrument is a highly accurate spectrometer system that measures columnar amounts of trace gases O3, NO2, CH2O using differential optical absorption spectroscopy (DOAS).
- Using DOAS, Pandora is able to retrieve data with a temporal resolution of 80 seconds.
- While the current Pandora instruments are in direct solar mode, they can also run in scan mode which can in principle extract Tropospheric Column from Total Column but this is not the standard usage. Plans are being made to extend this for CCNY which is valuable support for a recent NYSERDA / NESCAUM supportert O3 lidar project

# Example of Strong NO2 temporal dynamics and PANDORA Validation.



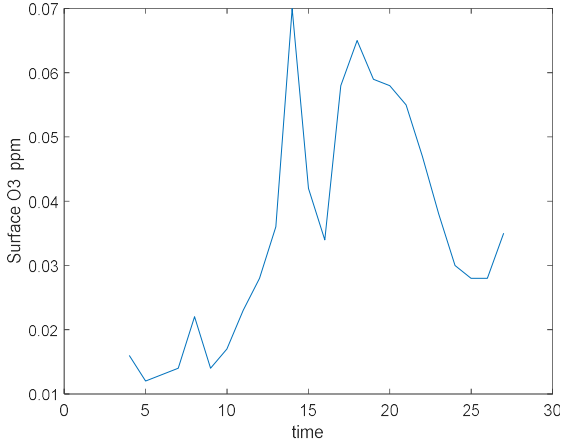



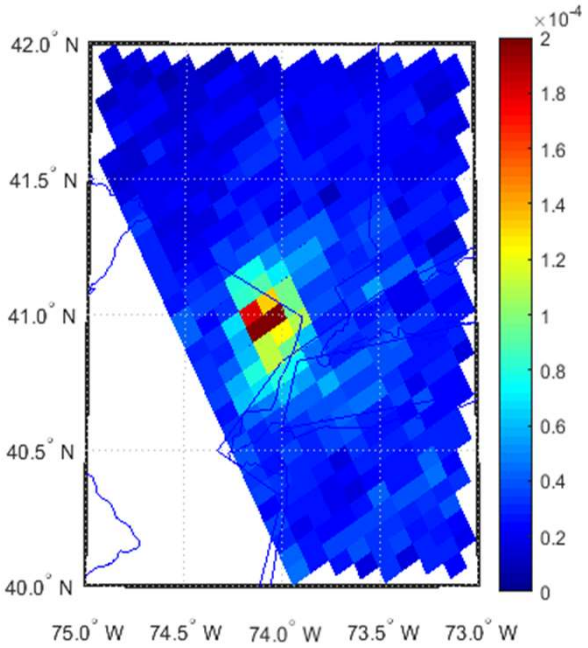

Numerical agreement between TROPOMI and Pandora on simultaneous overpass is Excellent (1.6 DU)

Significant NO2 reduction potentially correlated with increased O3 production

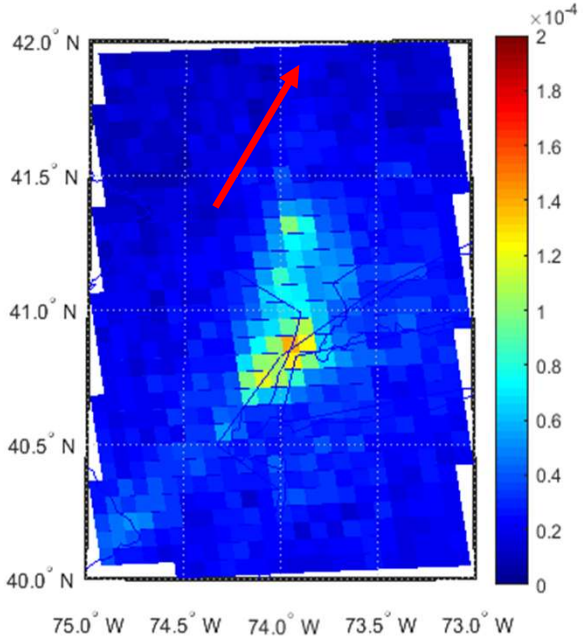


# Dispersion effects to PBL winds

July 3 W Speed ~ 1.12m/s
W dir ~ 48 deg




July 17 W Speed ~ 8.7 m/s
W dir ~ 62 deg

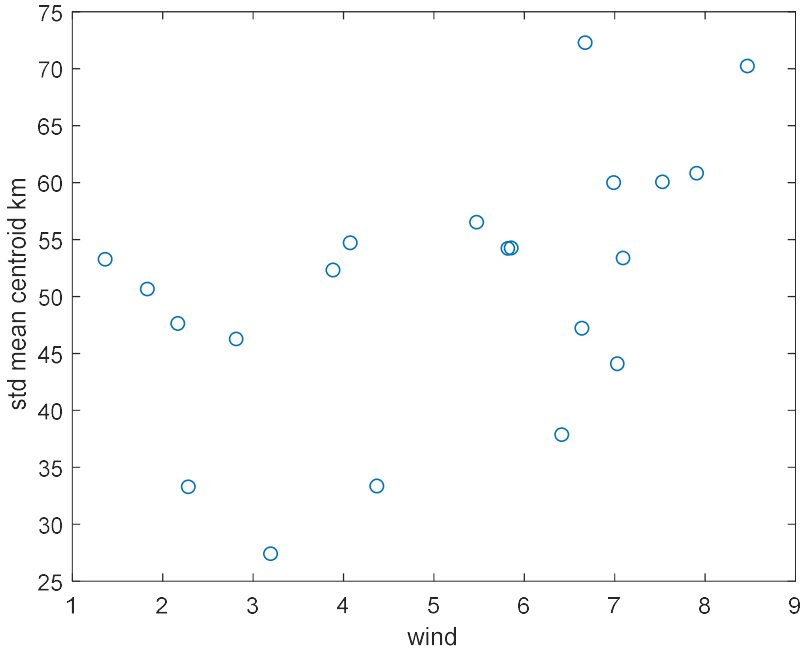



Integration of Rapid Refresh 3KM winds from 1000 mb to 700 mb

# Statistical connection between Trop Wind and NO2 Dispersion (R2~.28)

Wind=$\sqrt{u_{ave}^2 + v_{ave}^2}$

Used Total Integrated Volume Concentration Cutoff




Efforts to assess oriented angle
Failed for 2 reasons

1) Not enough variability
In the direction of the mean fields

2) Non spherical concentrations are expected even without transport due to heterogeneity of sources etc.

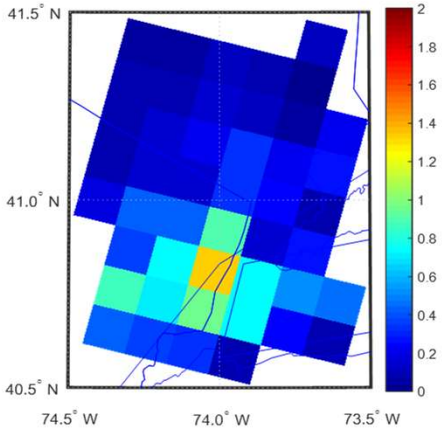
# Connecting Emission Inventories (EI's) to Satellite Observations

- Many efforts to try to connect NEI's to satellite observations using the most sophisticated Chem. Transport Models. (CMAQ, WRF-CHEM) including inverse methods are being made with different levels of success.
- The new high resolution TROPOMI NO2 product should be of particular interest to NOx emissions with both spatial and temporal signatures providing useful tools for constraints.
- TEMPO Geostationary observations are the Holy Grail but some time signals such as weekend/weekday signatures and NO2 effects due to O3 formation affected by cloud cover may be useful
- Some more simple studies may bypass some of the heavy machinery, computing time / resources and lack of flexibility in using the Chem Transport Model approaches.

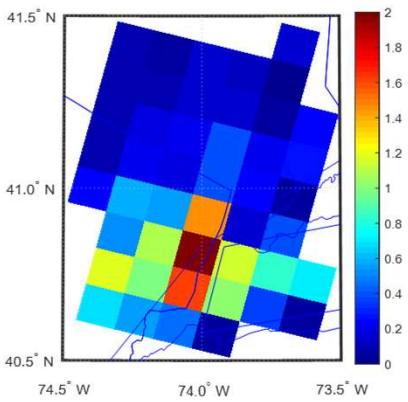
# EPA 2011 NEI version 2.

(area + point) NOx emission data

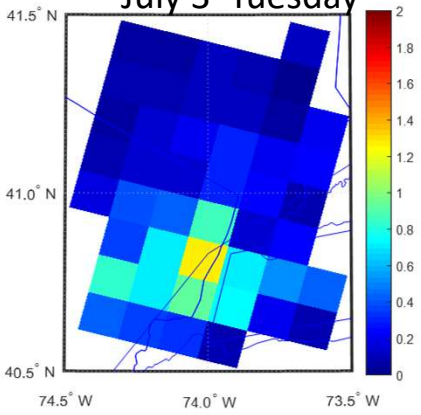
July 1 Sunday



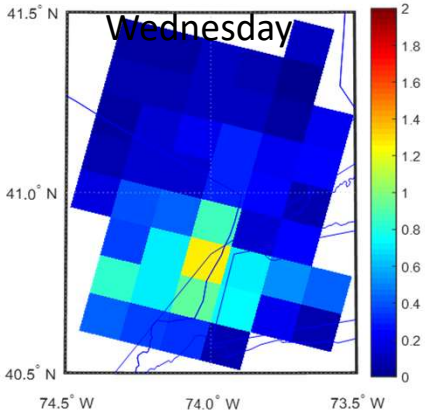

July 2 Monday



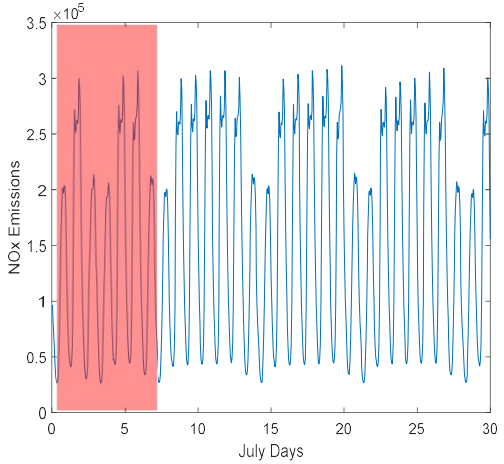

July 3 Tuesday



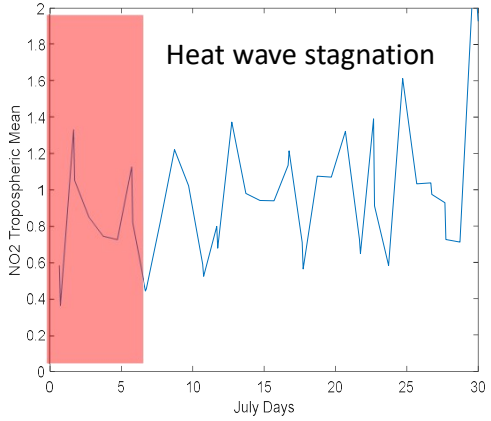

July 4 Wednesday




***Time Series Showing Diurnal and Weekday Cycles***




TROPOMI Urban Averaged Tropospheric NO2



# Summary / Future Work

- TROPOMI is proving to be a versatile tool for observing high resolution Tropospheric NO2 on urban / suburban scales.
- Validation with Pandora has been made with reasonable results
- Spatial resolution of TROPOMI allows for some observations of PBL winds on the dispersion of the NO2 events
- Some temporal signatures such as weekend/weekday show some agreements with NOx emission signatures but much more sophisticated models are needed
- Future short range studies will explore the Downwelling Radiation affects based on GOES-ABI Cloud Property retreival on daytime photoassisted O3 formation and NO2 reductions
- A smaller subset of chemistry reactions within the CMAQ CCTM without spatial dispersion/turbulence may provide reasonable models to study the long term temporal signature of NO2 and to better tune time dependant model processes.
- Extending the CCNY located PANDORA instrument to scan mode for TROPOSPHERIC Ozone providing valuable support of the O3 lidar.

# Acknowledgements

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