Update on EPA activities on Develop Ground Validation Sites Across the United States Air Quality Network (Supplemental Material)

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Integrated AQ Monitoring Network Spanning Space Satellites to In-situ

SATELLITE BASED MONITORING

Integrated Global Observing Strategy

For the Monitoring of the Environment from Space and from Earth

SATELLITE BASED MONITORING

INTEGRATION OF MONITORING ASSETS

Air Quality Observation Systems in the United States

NOVEMBER 2013

PRODUCT OF THE Committee on Environment, Natural Resources, and Sustainability of the NATIONAL SCIENCE AND TECHNOLOGY COUNCIL
Pandonia Global Network Collaboration with EPA AQ Networks

- High-level agreements in place: In collaboration with the NASA Pandora Project, EPA is implementing a subset of surface air quality sites to host Pandora spectrometer instruments which contribute to larger Pandonia Global Network. Effort facilitated by Agency level EPA-NASA Memorandum of Agreement and EPA as part of validation team for TEMPO mission.

- Demonstrated past success: Demonstrated past success: DISCOVER-AQ, KORUS-AQ, plus other campaigns demonstrated Pandora is highly relevant to air quality and ability to provide observations of NO2 a key O3 precursor (HCHO not a standard PGN product yet, and should not be used to inform AQ policy – QC criteria lacking).

- Early Adopter PAMS/EMP operations, Summer 2018: Initial PAMS-EMP deployment included 9 long-term units (May 2018) within Ozone Transport Region at NYDEP, NYDEC, and CTDEEP sites. This effort also supported the Long Island Sound Tropospheric Ozone Study (LISTOS Summer 2018) and on-going S5P TROPOMI validation (S5P Validation Project 28695).

- PGN-EPA Outlook: ~Formal beginning of new PAMS requirements October 2021. Placement at up to 40 sites possible. Agreement to place Pandora instruments at EPA-operated CASTNet sites (Rural, regional).
Current Status of EPA-NASA Pandoramas with the PGN

- **September 2019** - Upgraded Pandora five 1S-units and redeployed: Bronx, NY; Queens College, NY; Old Field, NY; Rutgers, NJ; New Haven, CT
- **May 2020** - New Pandora 1S-unit deployed to Chiwaukee Prairie - Wisconsin DNR monitoring site on WI/IL border) in collaboration with Dr. Brad Pierce - Space Science and Engineering Center (SSEC) Univ. of Wisconsin
- **Summer 2020** (COVID-19 restrictions dependent) – nine Pandora 1S-units Bayonne, NJ; Westport, CT; Madison, CT; East Providence, RI; Londonderry, NH; Cape Elizabeth, ME; Bristol, PA (and/or City of Philadelphia); Lawrenceville (Pittsburg, PA); McMillian Reservoir, DC
- **July 2020** - Pandora 2S at EPA Duke Forecast Research Site Sept 2019; 145 ft. research tower for deposition research – supports U.S. EPA CASTNet program; Leosphere 200S wind cube, Lufft CHM15K and Vaisala CL-51 ceilometer; Multitude of trace gas and aerosol measurement include NO2 fluxes for new dry deposition research
- **Late 2020** - Five 1S-units under procurement. Target deployments include U.S. CASTNet and western U.S.
- **20 units** to be placed into the PGN Network NLT the end of 2020.
In the U.S. the PAMS-EMP effort will result in an Integrated Ground Observation Network focused on connecting surface air quality and satellite validation.

- **Mixed Layer Height**
  - Ceilometer

- **Pandora**
  - NO2, HCHO, ozone total columns

- **Surface Monitors**
  - 'true' NO2, PM, ozone, HCHO surface mixing ratios
Pandora deployment at a subset of U.S. air quality sites provide validation necessary to make AQ management decisions in defensible manner

- The Pandora and TROPOMI are highly correlated with a consistent low bias of ~30% in relation to Pandora.
- Least polluted bin has median difference $-0.8 \times 10^{15}$ molecules cm$^{-2}$ and an interquartile range $< 1 \times 10^{15}$ molecules cm$^{-2}$
The Enhanced-PAMS (EPAMS) Profiler and Ceilometer Network is a joint research effort between the University of Maryland, Baltimore County (UMBC), EPA, NASA, and the Maryland Department of the Environment (MDE) to help guide the new hourly PBL requirements and supplement a ceilometer testbed.

- Common algorithm for Mixing Layer Heights
- Real-time data display of backscatter plots
- Real-time optics monitoring
- Real-time data processing (MLH, NBL, residual layer (RL), aerosol layers. Clouds, and precipitation screening)
- Data archive with display for retrospective analysis including exceptional events

Operational Procedures:
- Instrumental signal evaluation
- Standardized retrieval development
- Data Archiving and Processing

https://alg.umbc.edu/ceilometer-testbed/
Development of standardized retrieval algorithms for heterogeneous network

Covariance Wavelet Transform Algorithm developed by University Maryland Baltimore County

- **Automated algorithm** corrects for instrument signal quality and **automatically screens for precipitation and cloud layers**
- **Layer attribution** for the planetary boundary layer height with continuation and time-tracking parameters and uncertainty calculations through automatic filtering

Caicedo et al. (2020) under review

"An automated common algorithm for planetary boundary layer retrievals using aerosol lidars in support of the U.S. EPA Photochemical Assessment Monitoring Sites Program"

December 13, 2016 (CWT/C) profiles from CHM15k (a), CL51 (b), CL31 (c), and SkyVue Pro (d) ceilometers. PBLH retrievals from the automated algorithm are displayed in black circles, while CBH retrievals are displayed as white triangles. Radiosonde heights for both PBLHs and CBH are displayed as red squares. Error bars display 10-minute retrieval uncertainties every 30 mins for display clarity purposes although uncertainties are calculated with every retrieval.
Background Ozone: NOx lifetime, NOx emissions, Ozone transport

- Improved understanding of Background NOx in the Boundary Layer and Free Troposphere (e.g., Silvern et al., 2019) \(\rightarrow\) Pandoros at CASTNET

- Measurements in and around source area which can provide improved characterization of spatial and temporal factors to adjust data for hourly inputs on sector emissions for air quality model. (E.g., Schiller Park)

- Dispersion plume modeling from large point sources (permitting issues)

- Ozone transport pathways, particularly dense urban outflow areas to more rural areas with impacted air quality (Western Shore Lake Michigan, NE urban corridor) this includes varying density of measurements to assess regional vs local scale impacts.

- **Goal:** AQ management decisions in defensible manner
NYC Integrated Observing System August 6, 2018: 3 of 10 joint AQ / satellite validation sites shown

A very small amount of NOx (top image) has an outsize impact on the chemistry affecting Westport CT site because its all contained in a very shallow mixing layer (bottom image)
Ozone at coastal Connecticut is being produced locally below 100 m throughout morning hours.

There is rapid growth of ozone in a very shallow layer (<100m) from 8AM to 12PM. There is 60 ppb more at the surface than at 100m.

Data courtesy of Tim Berkoff (NASA LaRC), CT DEEP
Calibrated surface ozone measurements and routine profiling of lowest 100 – 200m critical for connecting LIDAR to surface AQ data
HCHO Column can help fill in details of dynamics overhead

Morning surface increase is not associated with column increase
  → Increase due to entrainment

Afternoon surface decrease is associated with continuing column increases
  → decrease at surface is isolated from what is occurring overhead

Data courtesy of Andrew Whitehill ORD/CEMM, Elena Lind (Va Tech)
LISTOS 2018 Study provides key measurement insights into the 0-2 km ozone variability

Westport, CT Air Quality Site is one of the highest Ozone sites in the NE U.S.

Credit: Langley Mobile Ozone Lidar Team, PI Tim Berkoff