Towards a validation network for AQ gases in US

Committee on Earth Observation Satellites

U.S. EPA/ORD/NERL

Jim Szykman, **Luke Valin**

Long Island Sound 2018?

NASA Headquarters

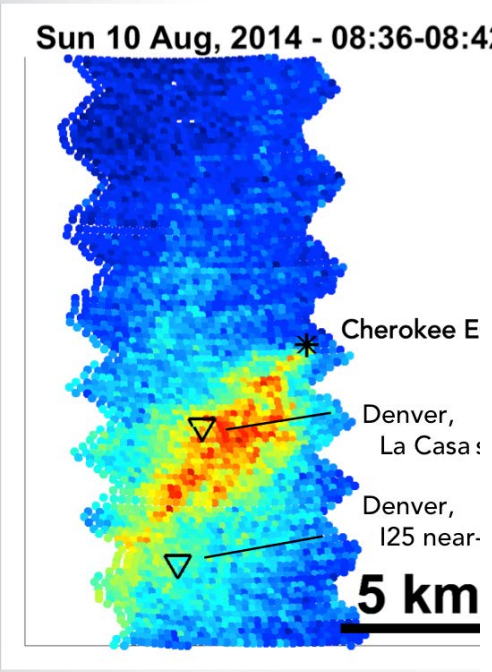
Barry Lefer

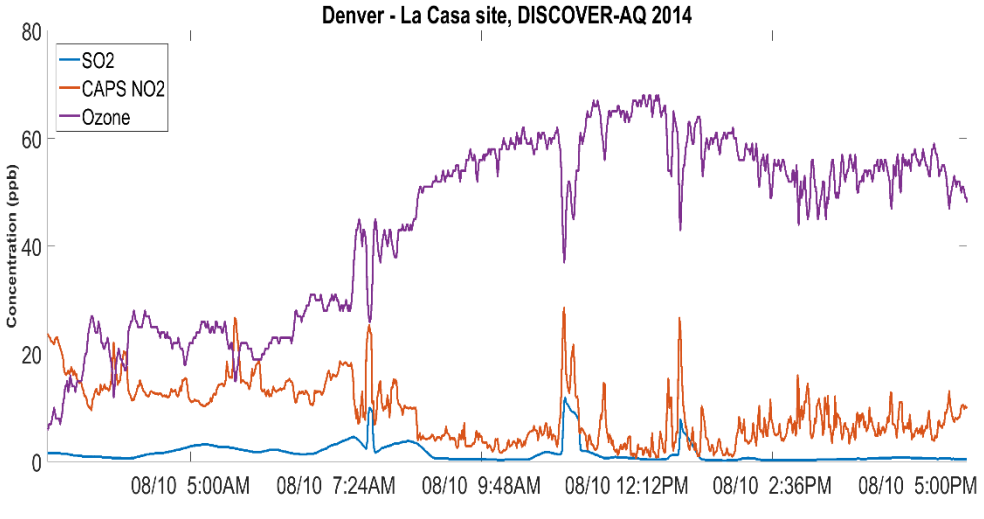
LMOS – Lake Michigan Ozone Study 2017

NASA LaRC

Jay Al-Saadi

SARP 2017

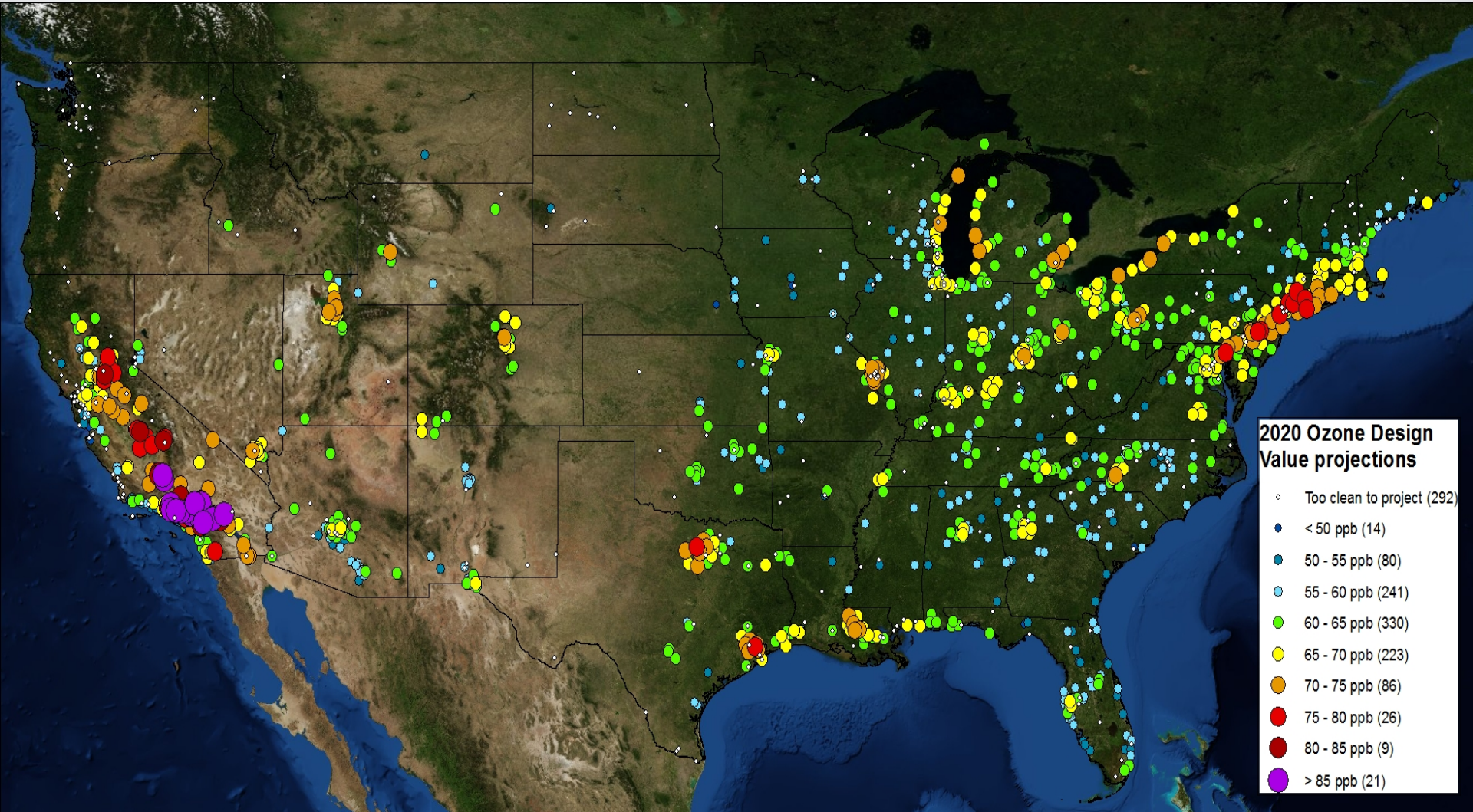




KORUS-AQ

Ozone pollution continues to be a major issue for much of US

O_3 8-hour Design Value Projections to 2020



EPA Photochemical Assessment Monitoring System (PAMS)

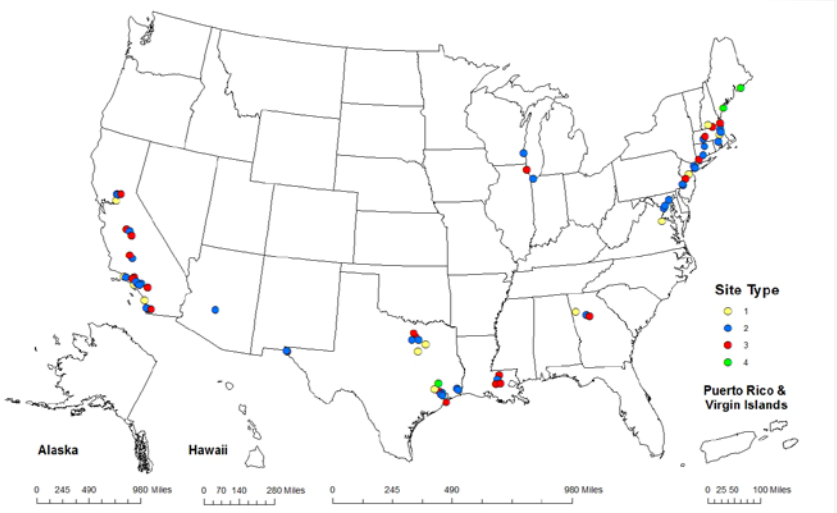
-Established as a result of 1990 Clean Air Act Amendments (CAAA) to better understand high-O_3 locations.

The 2015 revision of the O_3 National Ambient Air Quality Standard from 75 ppb to 70 ppb includes changes that will result in

--A Broader and less dense network, merged with NCORE network with a large set of required measurements

--A requirement for states to propose additional **Enhanced Monitoring Plans,** to better understand the local O3 problem**.**

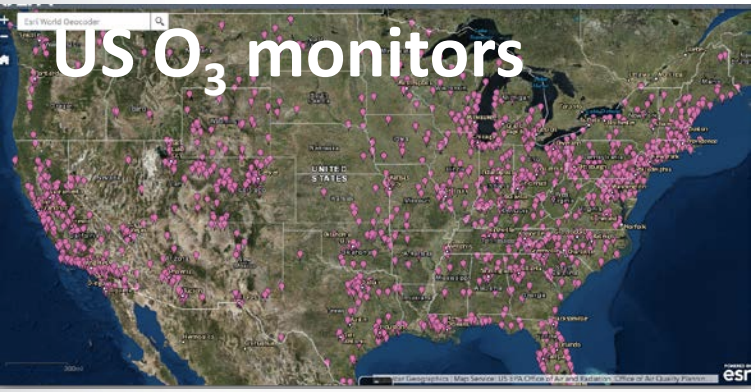
PAMS Network 1995 - Present



PAMS Network by 2019

EPA Photochemical Assessment Monitoring System (PAMS)

Monitoring Locations for combined PAMS/Ncore SItes



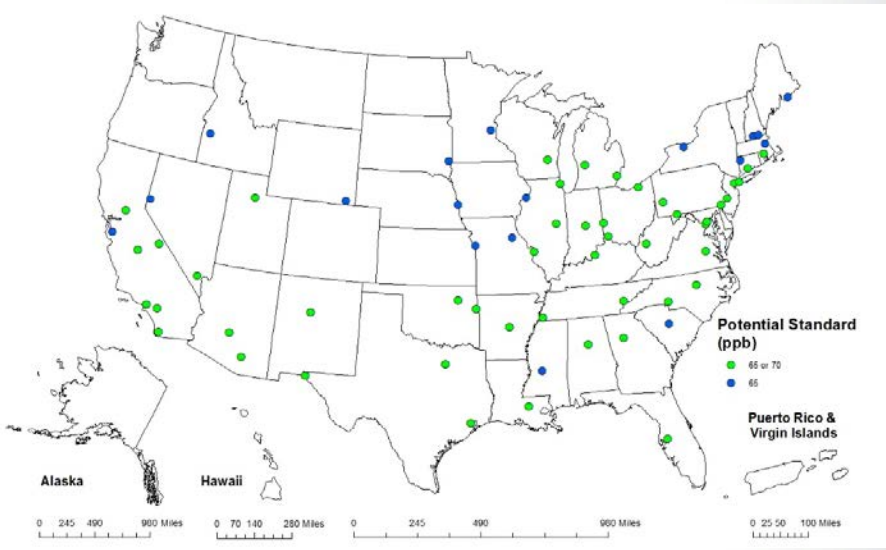
Upcoming changes to the U.S. EPA Photochemical Assessment Monitoring Station (PAMS) Network provides a unique opportunity to:

- Leverage existing/expanding monitoring infrastructure to develop high quality ground-based (correlative data) validation sites across the United States in areas with the worst O_3 pollution.
- Provides a sustainable approach which increase the value of measurement suite at these sites to communities of interest.
- Promote adoption of satellite data products to the air quality community - increasing societal benefit.
- Consistent with The Integrated Global Atmospheric Chemistry Observations (IGACO) Theme Report, 2004.

PAMS will be merged with NCORE network, which is designed for long-term, regional monitoring

- *PAMS merged with NCORE*
  - NO, NO_2, hourly VOC (or high-sensitivity HCHO), NO_y, O_3 (year round). SO_2, ppb-precision CO, $PM_{2.5}$ mass and speciation (At least 1-in-3 day), $PM_{2.5}$ continuous, $PM_{10-2.5}$ mass, basic met. parameters, Mixed layer height measurements (ceilometers or profilers).
  - **Enhanced Monitoring Plans -** A requirement designed to be flexible. States propose measurements in addition to the above list that will be useful for understanding O_3 AQ issue in that region. **This is the mandate where we see total column NO2 and HCHO to fit in PAMS network.**

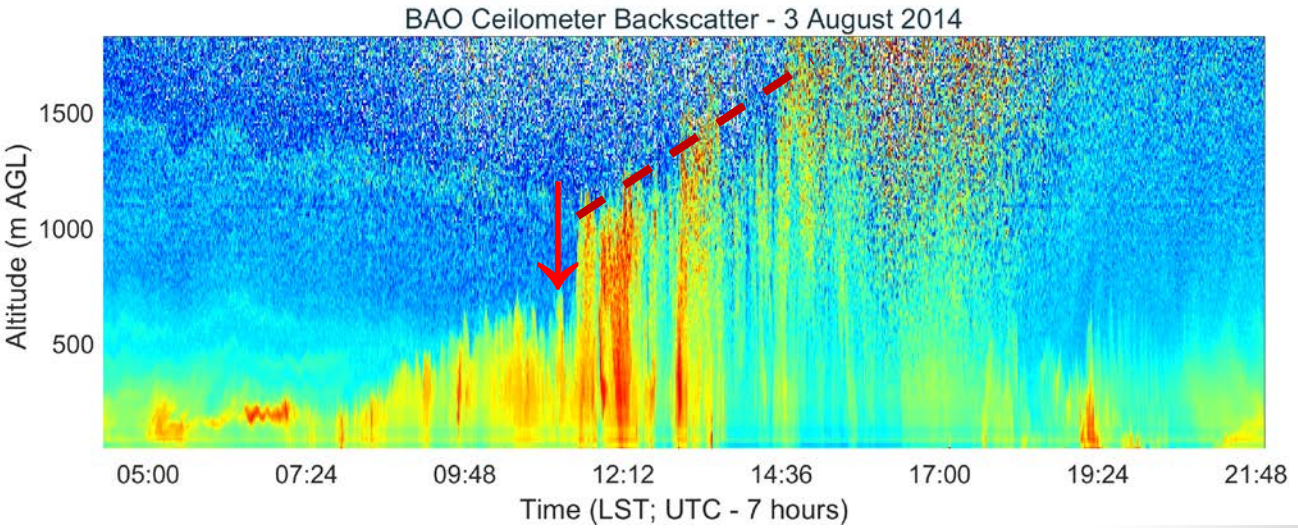
Monitoring Locations for combined PAMS/Ncore SIte

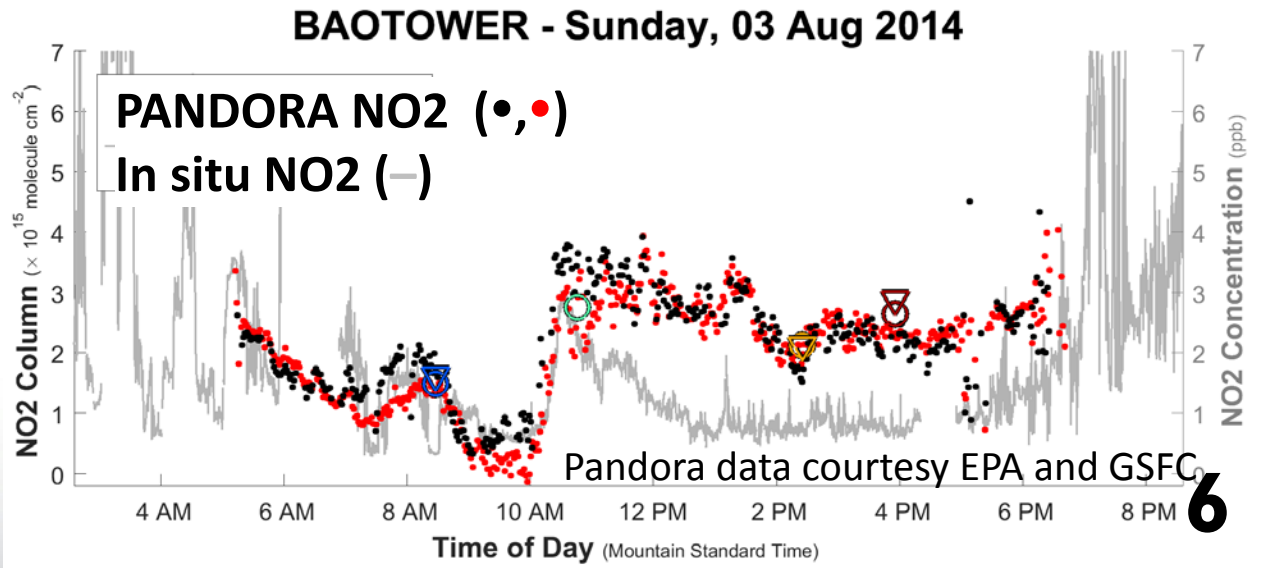


Required PAMS measurement: Mixing Heights

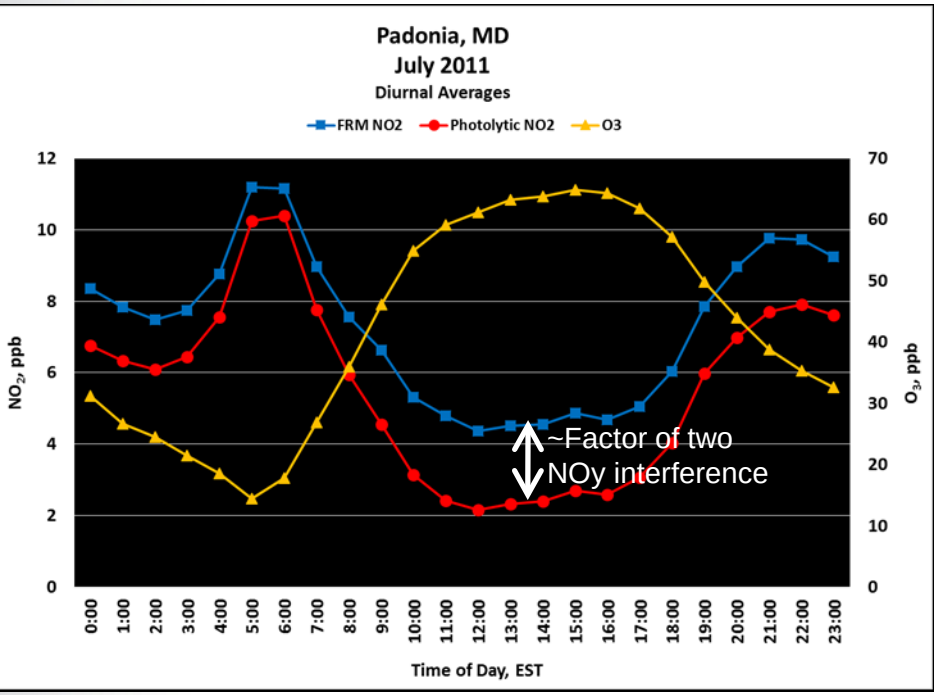
Ceilometers are likely candidate

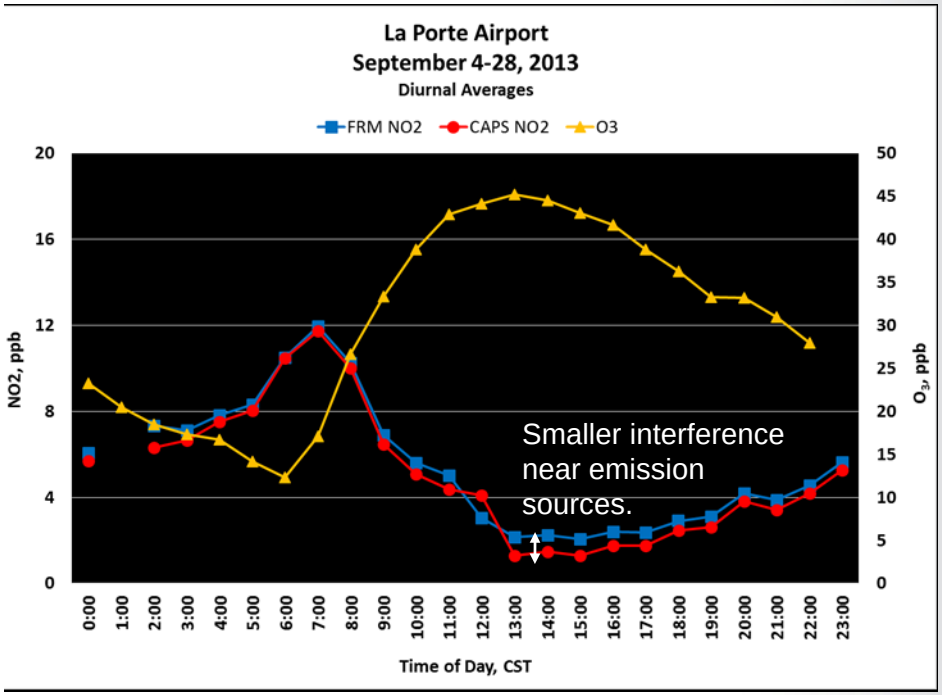
- Attenuated backscatter at 910nm- profiling range: 0-15km with aerosol layer heights at 10 m vertical resolution.
- Mixing heights and QA statisitcs determined via BL-View Software and compared with in-house tools
- Our group has tested these in 3+ AQ field missions





Required PAMS measurement: "True" NO_2





Photochemically aged air

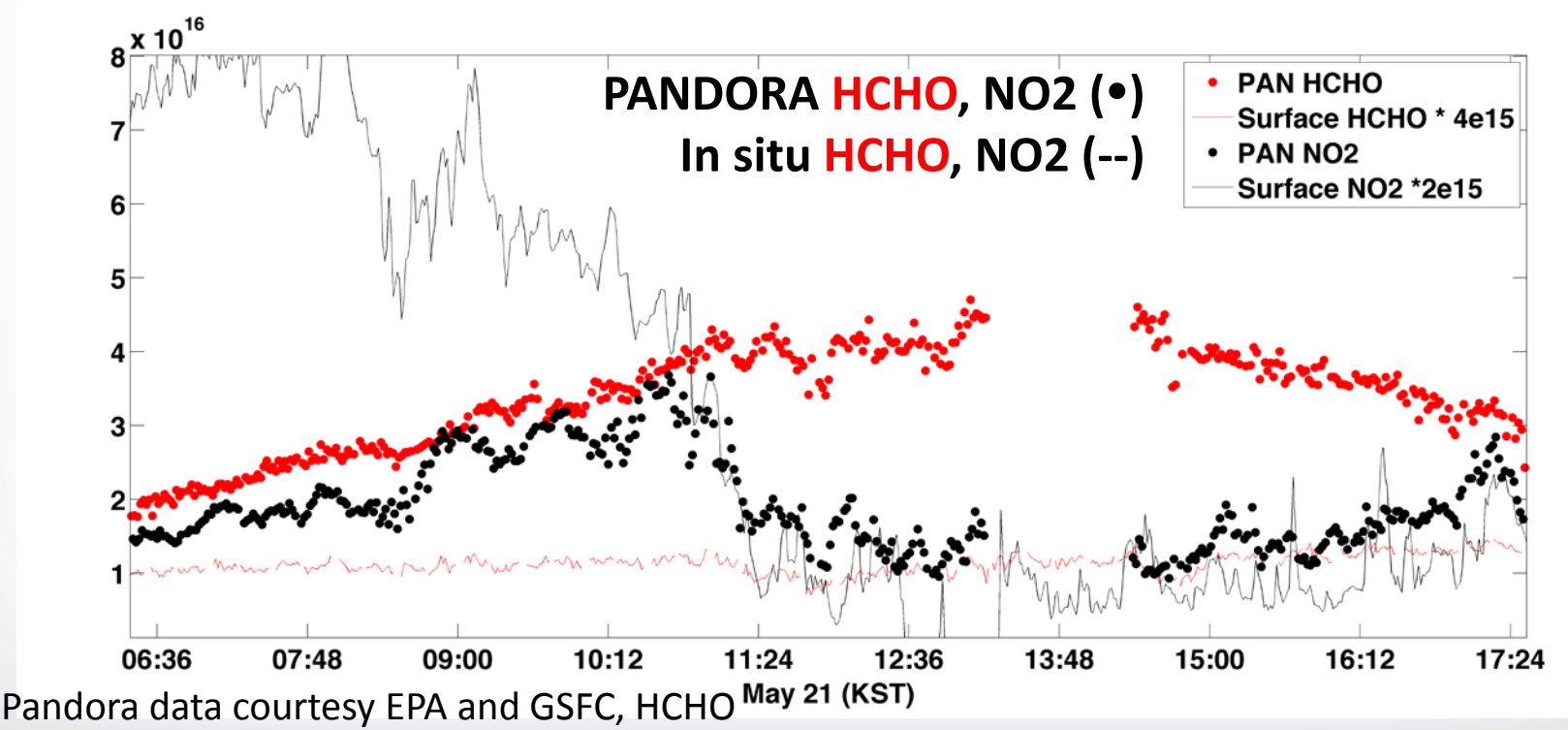
- **The standard US federal reference method (FRM) for measuring NO_2 has chemical interferences due to conversion of higher-oxidized nitrogen species on the molybdenum converter (left panel)**

Fresh Emissions Dominated

- **At sites closer to large NOx sources (right), and in conditions where photochemistry is slow, the interference is much smaller.**

Carbonyl measurements required with option to substitute hourly HCHO measurements

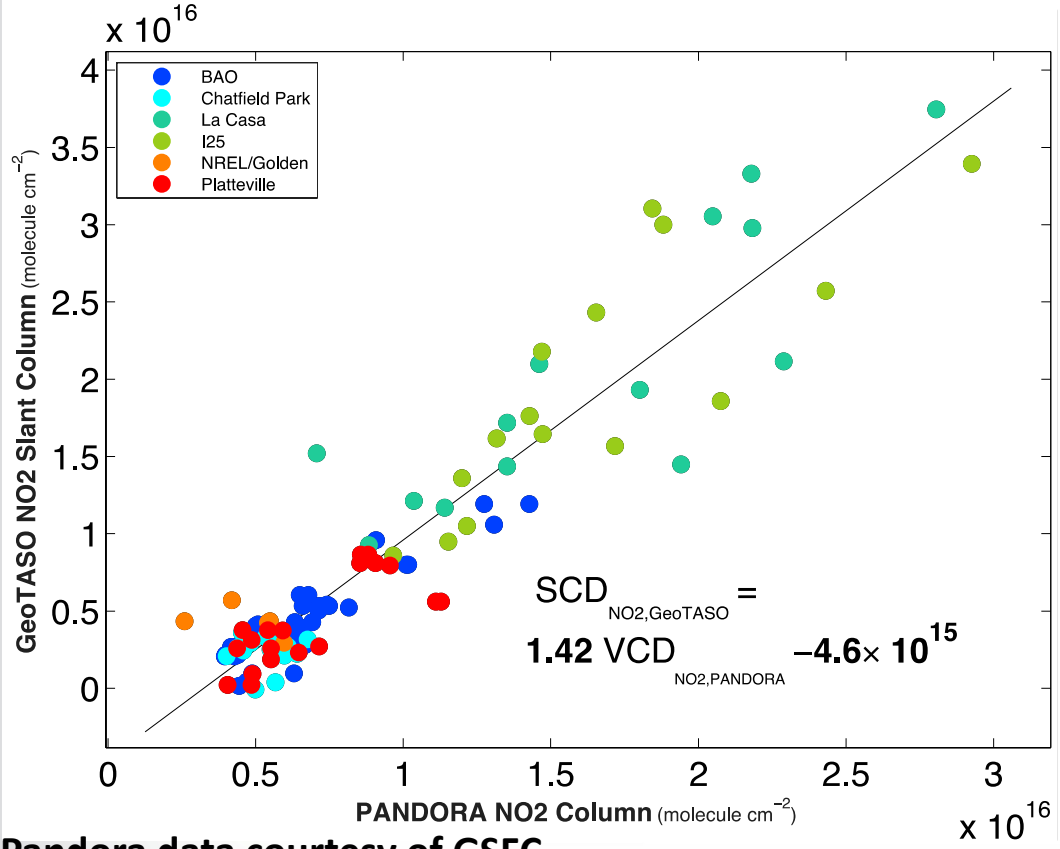
- Formaldehyde (CH_2O) is recognized as an important ozone precursors and a product of other important precursors
- ***New PAMS design requires*** Restarting canister carbonyl measurements, validation utility TBD. Option to add commercial houly, ppb-precision CH_2O measurements instead



Pandora data courtesy EPA and GSFC, HCHO retrieval is preliminary

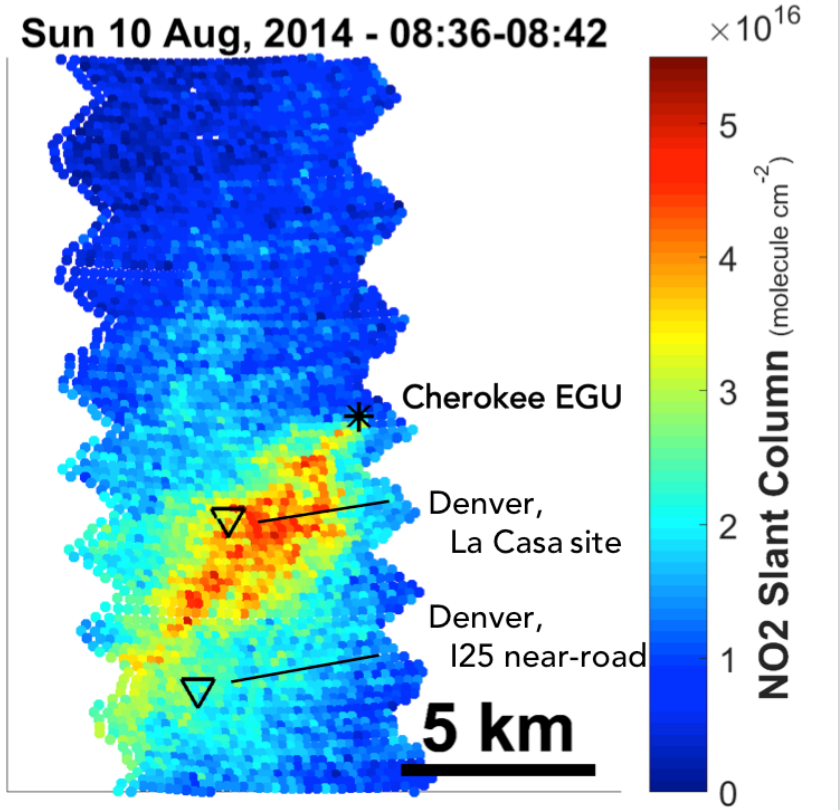
AQ missions have demonstrated direct sun column measurements are very useful validation dataset, which makes imaging data more useful to AQ managers

GeoTASO Slant Column vs. Pandora Vertical



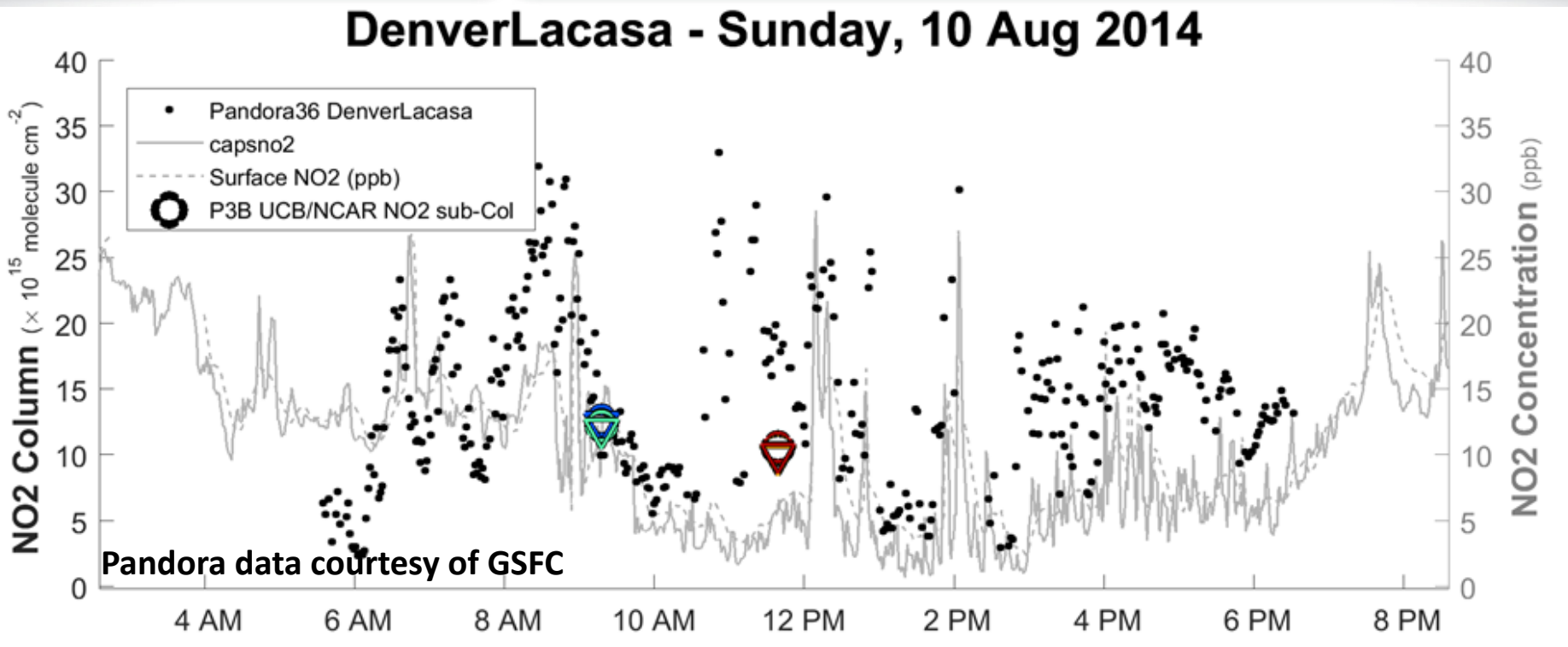
Pandora data courtesy of GSFC

GeoTASO overpass of Denver



Retreival courtesy of Caroline Nowlan (SAO)

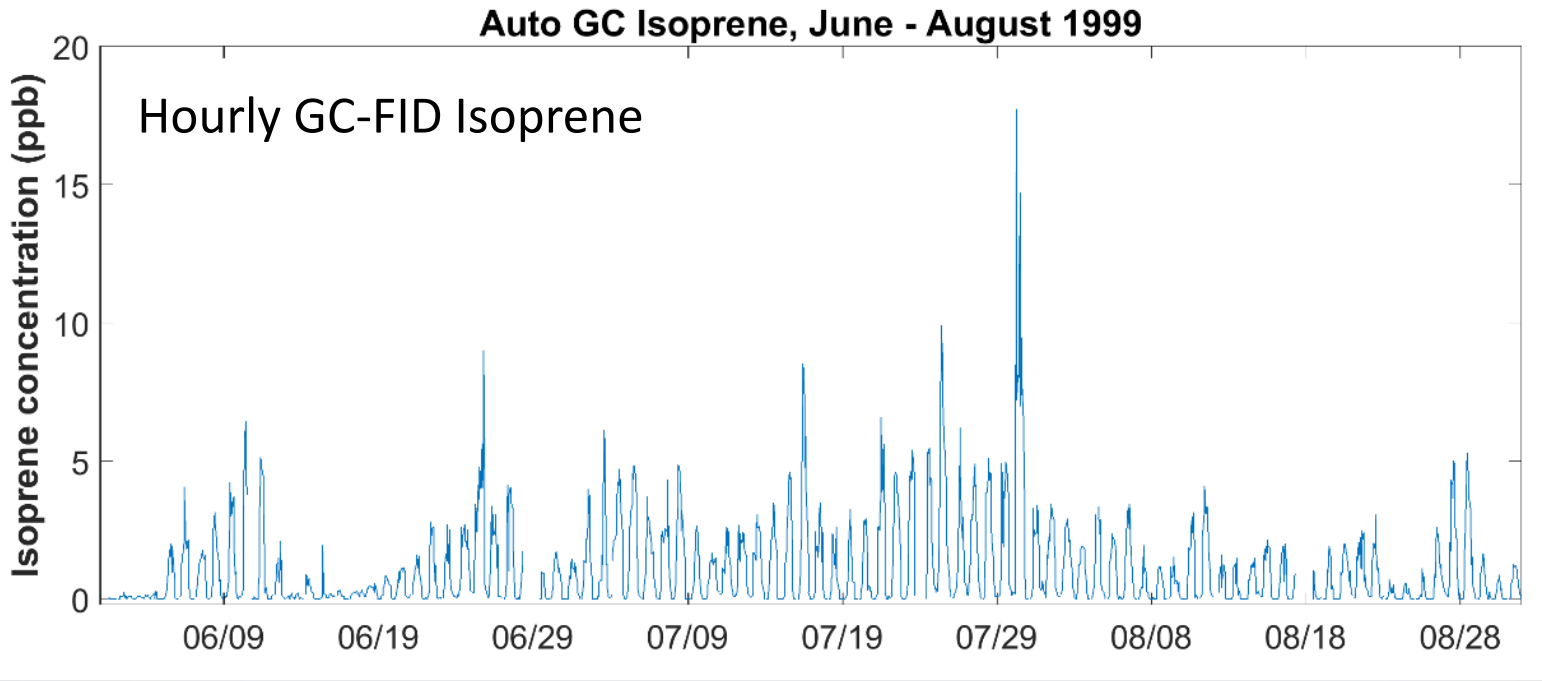
We will work towards encouraging states to report in situ measurements at native-time resolution vs. 1-hour requirement



- The time frequency variation of primary pollutants reflects proximity of sources
- Photolytic NO_2 and O_3 measurements should be self-consistent and a check on calibration (NO emissions rapidly titrate O_3 near sources)
- Data would provide AQ managers a much better picture of O_3 production and titration and would aid source attribution studies (e.g., SO2 and NO2 correlation reflect EGU)

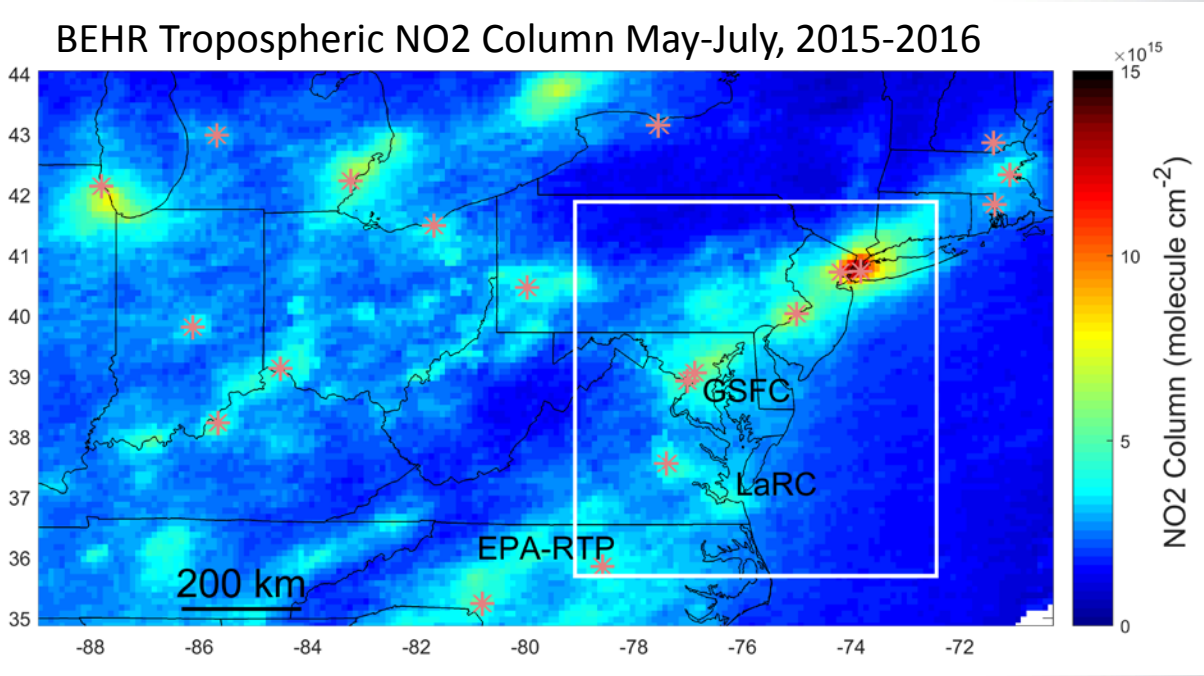
Hourly averaged speciated volatile organic compounds (VOCs) required

- In past states have used hourly automated GC-FID systems to address this requirement
- Very rich data record that will add tremendous science value to understanding HCHO, NO2 and ozone.



From missions to monitoring: Nine EPA-owned Pandoras to PAMS in 2017/2018

- **Enhanced Monitoring Plans (EMPs) required by 2019** enabling states to propose measurements suitable for better understanding their ozone problem
- Cooperative relationship amongst Ozone Transport Region (OTR) states that operate sites. We are currently in discussion on details
- Sites within 1-2 hours of experienced personnel – states will not commit large amounts of resources to instrument maintenance



NASA/ESA JPPG: Pandonia Network and CINDI-2 Campaign

Actions

1. Report on new developments in Pandora and Pandonia network development and report on results from CINDI-2 campaign.

Progress

1. Several ESA/NASA supported Pandora instrument improvements have been made over the past year, including (but not limited to): development and testing of 2S Pandora; anti-reflective coating on optics to improve HCHO retrieval; better characterization of spectrometer slit function; and, new tracker prototype built.
2. Good performance by the Pandora instruments confirmed in ESA CINDI-2 Intercomparison Campaign.
3. NASA and ESA made verbal commitment to jointly fund Pandonia Network using AERONET as a model. A first meeting with both ESA and NASA representatives has taken place during the ACVE workshop in Frascati in October 2016.

Issues

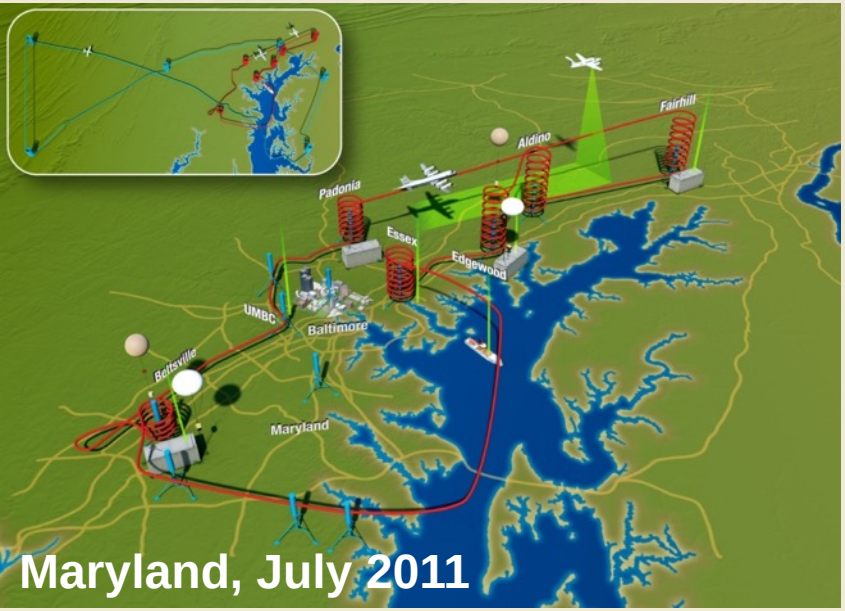
1. Need to finalize design and test the new Pandora tracker so it can be deployed with future Pandora instruments.
2. NASA is working to develop a deployment plan for the U.S. portion of the Pandonia Network that includes 20 Pandora installed at ”permanent” long-term sites by the summer of 2018.

Plans

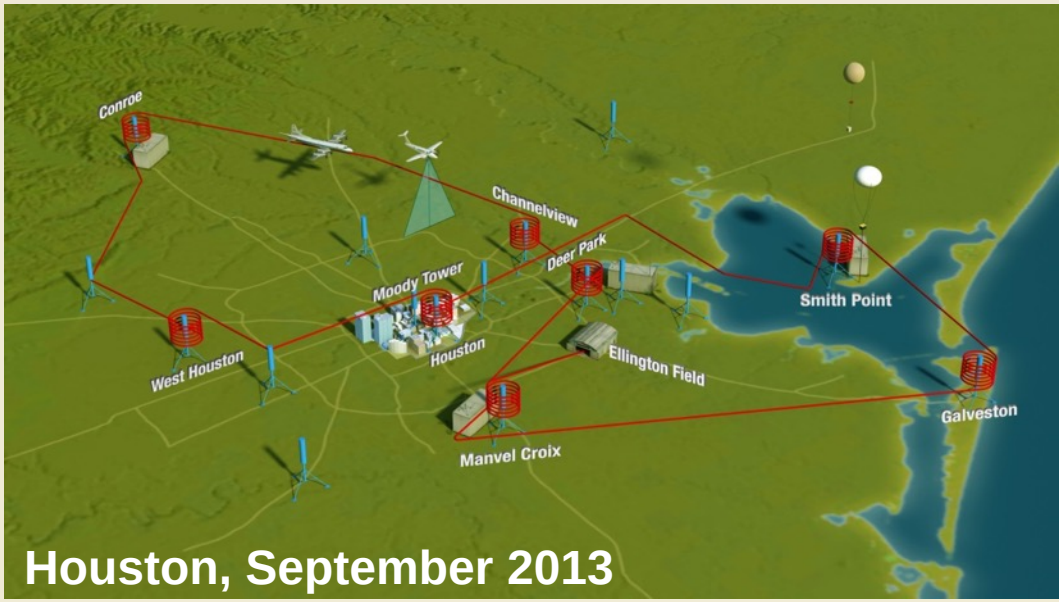
1. NASA plans two Cal/Val field campaigns in summer of 2017 using Pandoras and GeoTASO in Chicago/Great Lakes Region and in the LA Basin.
2. Implement the joint NASA/ESA Pandonia Network and establish joint working group.
   a. extending global coverage,
   b. coordinated web presence and common processing scheme,
   c. Cooperating in quality standards and calibration/validation efforts with calibration centers in both US and Europe
   d. cooperating in instrument evolution
   e. data backup at both NASA/ESA data centers
3. Plan future TROPOMI cal/val projects.

DISCOVER-AQ

Deployment Locations

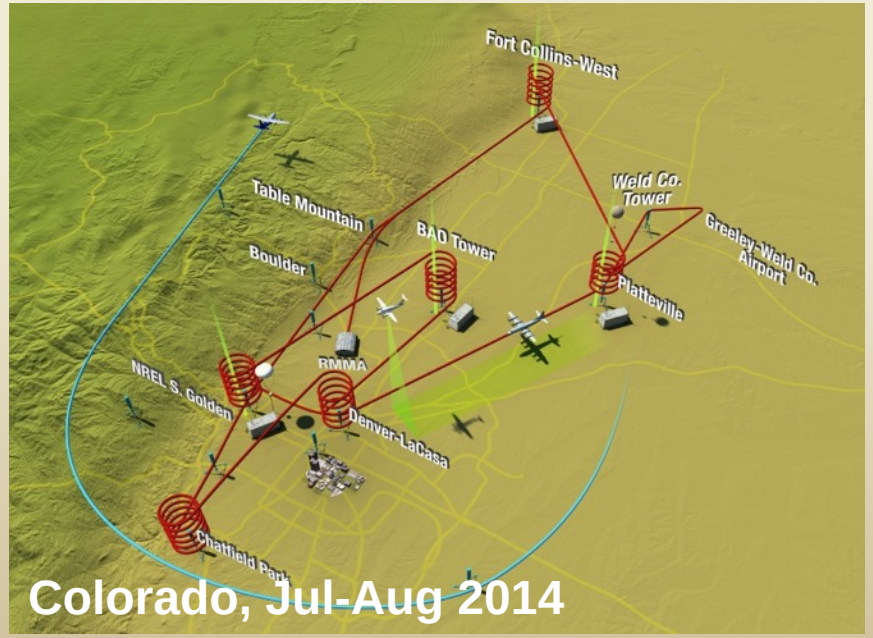


Maryland, July 2011



Houston, September 2013

California, Jan-Feb 2013

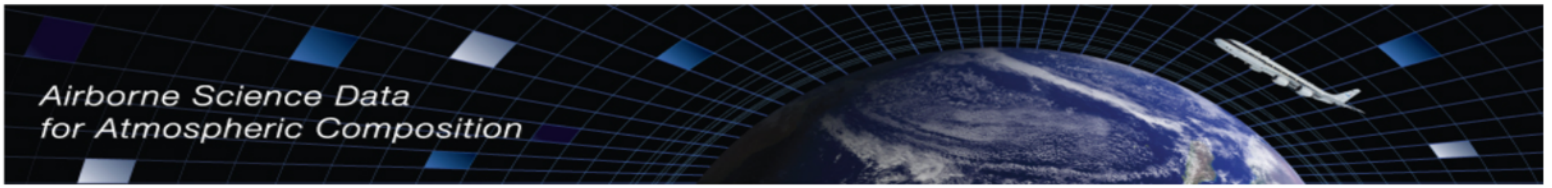


Colorado, Jul-Aug 2014

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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

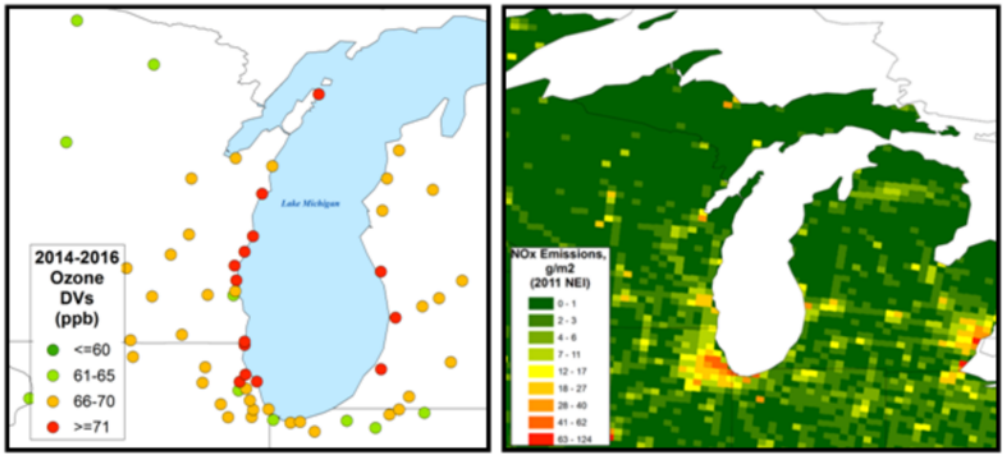
+ HOME | + MISSIONS | + DATA | + TOOLS | + ABOUT US



LMOS – Lake Michigan Ozone Study 2017

Mission Overview:

Elevated spring and summertime ozone levels remain an air quality challenge along the coast of Lake Michigan, with a number of monitors exceeding the 2015 National Ambient Air Quality Standards (NAAQS) for ozone. Production of ozone over Lake Michigan combined with onshore daytime "lake breeze" airflow is thought to increase ozone concentrations preferentially at locations within a few kilometers of the shore. This observed lake-shore ozone gradient motivated the Lake Michigan Ozone Study (LMOS) 2017 during May and June 2017.



Ozone Design Values (DVs) for 2014-2016 in ppb (left) and NEI 2011 NOx area emissions in g/m2 (right). DVs greater than or equal to 71ppbv (red) exceed the 2015 NAAQS for ozone and are primarily found around the shore of Lake Michigan in this region.

LMOS Measurement Suite

UW SSEC SPARC Trailer (HALO Wind Lidar, AERI T/Q profiles, HSRL aerosol extinction, CIMEL aerosol optical depth)

EPA Pandora (Column NO_2, O_3, CH_2O), *in situ* (O_3, NOx, CH_2O)

NOAA Ship (EPA Pandora, ceilometer, *in situ* O_3 and NO_2

EPA Geospatial Measurement of Air Pollution (GMAP) mobile van (O_3)

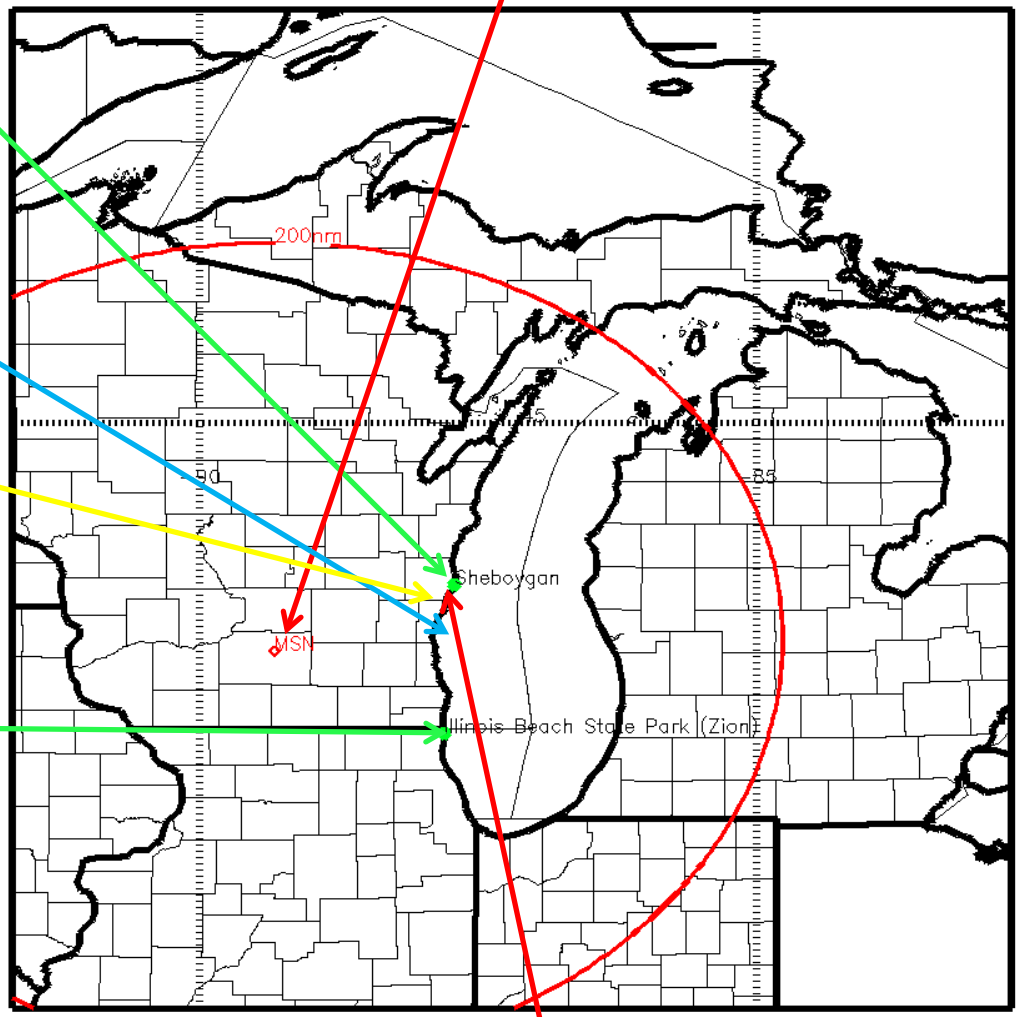
UNI Microwave Radiometer T/Q profiles, SoDAR winds

EPA Pandora (Column NO_2, O_3)

In situ super site (UW-Madison/ UofM NOy/VOC, U-Iowa Aerosol)

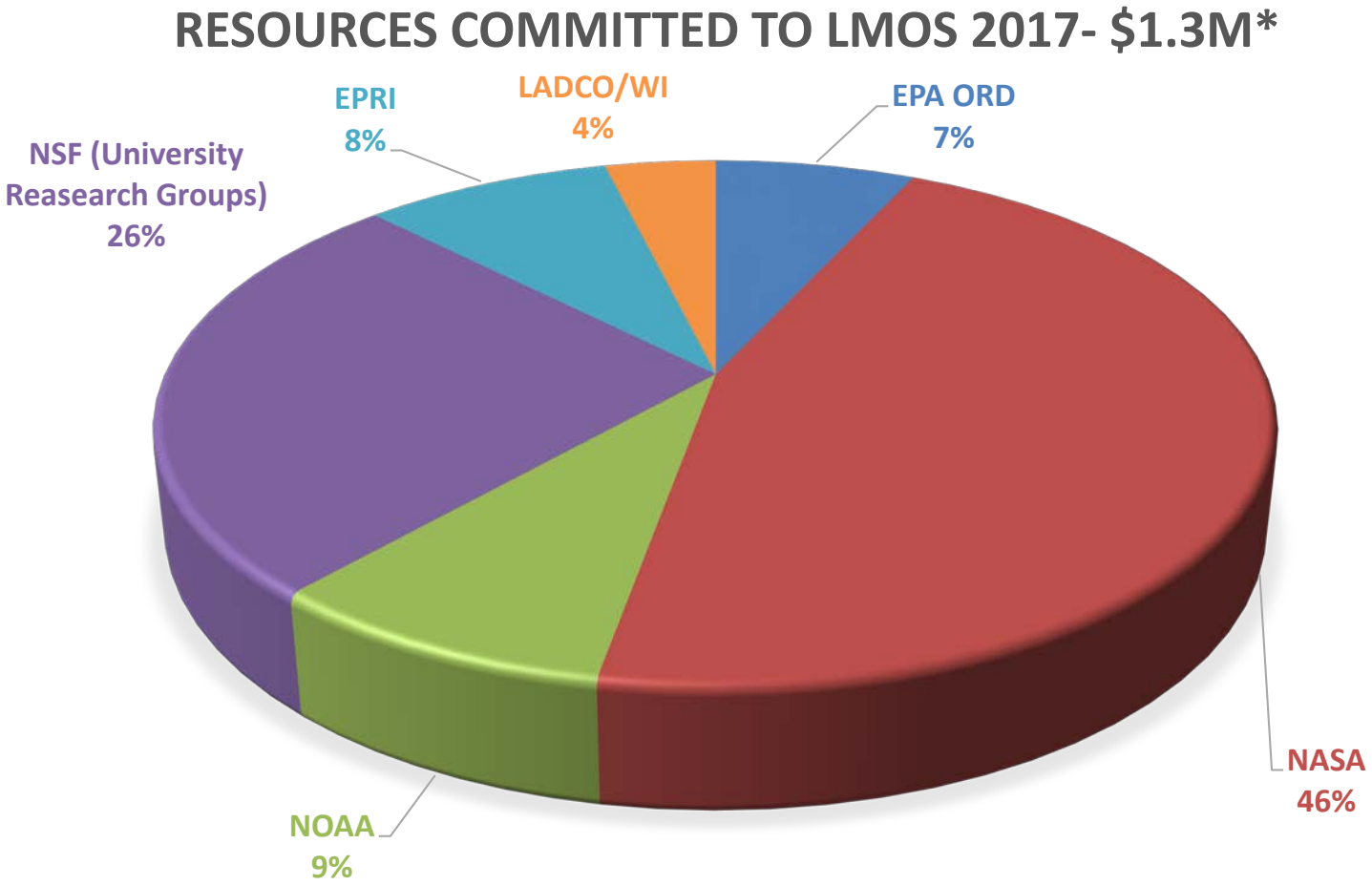
White Paper: http://www.ladco.org/

NASA airborne column NO_2, CH_2O, O_3, aerosols (GeoTASO Airborne UV-VIS Spectrometer, AirHARP Polarimeter)



Scientific Aviation/EPRI *in situ* O_3, NO_2, T, q, wind

Leveraged Resources



*Does not include FTE or travel cost from participating Federal Agencies.

Summary: Sustaining Network and Campaign Activities

- **EPA/NASA partnership on national ground network, combining in-situ and remote measurements, provides long-term baseline for known high-ozone areas in the US**
  - **Membership in network still an evolving discussion amongst stakeholders**
  - **Steering group in formation now**
  - **Framework consistent with NASA/ESA joint program plans (i.e., Pandonia) and easily extensible to other partners**
- **Shorter-term (1 month to 1 year) intensive measurements, i.e. field campaigns, provide focused science-based validation opportunities**
  - **Measurement suites and strategies beyond the long-term baseline**
  - **Studies related to AQ constellation observations will be priorities for science, monitoring, and forecasting programs, especially post-launch**
  - **Partnering among stakeholders will be continue to be crucial**
- **Develop flexible campaign options, from comprehensive (e.g. DISCOVER-AQ, KORUS-AQ, est. $5M-$6M per campaign per year) to very focused (e.g. LMOS, SARP, est. $1M-2M per campaign)**