EPA Office of Research and Development (ORD) Updates on Air Measurement and Monitoring

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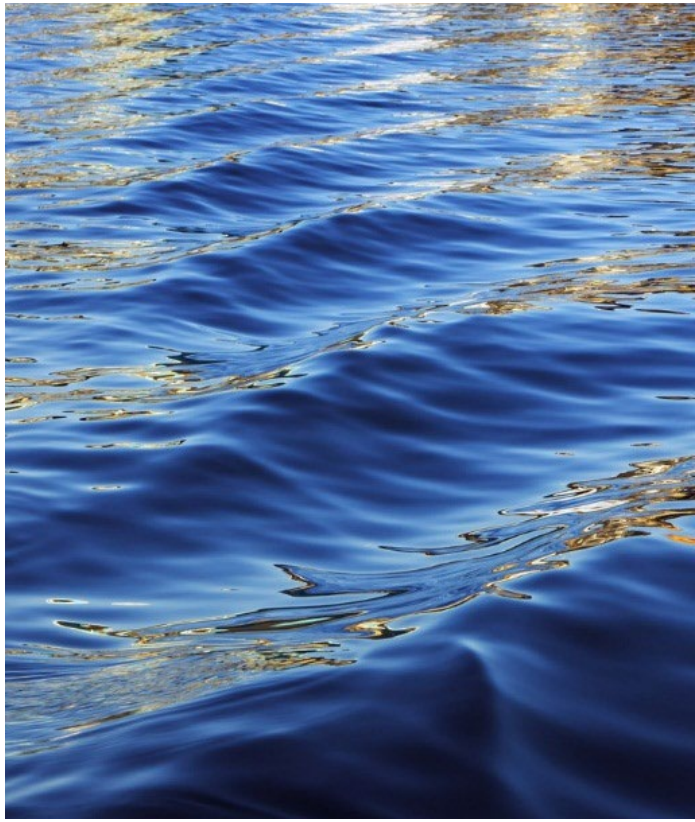
Air Methods and Characterization Division,
Center for Environmental Measurement and Modeling

National Ambient Air Monitoring Conference
August 23, 2022



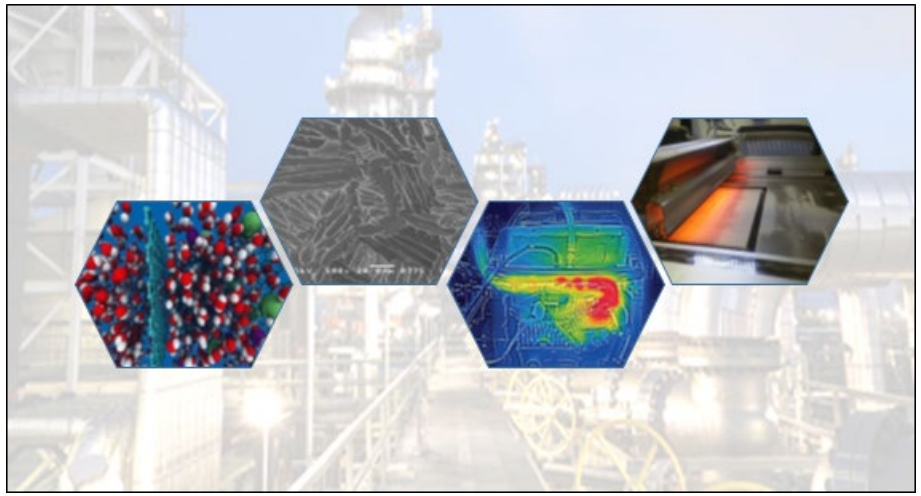
Not a Policy Talk …

RESEARCH

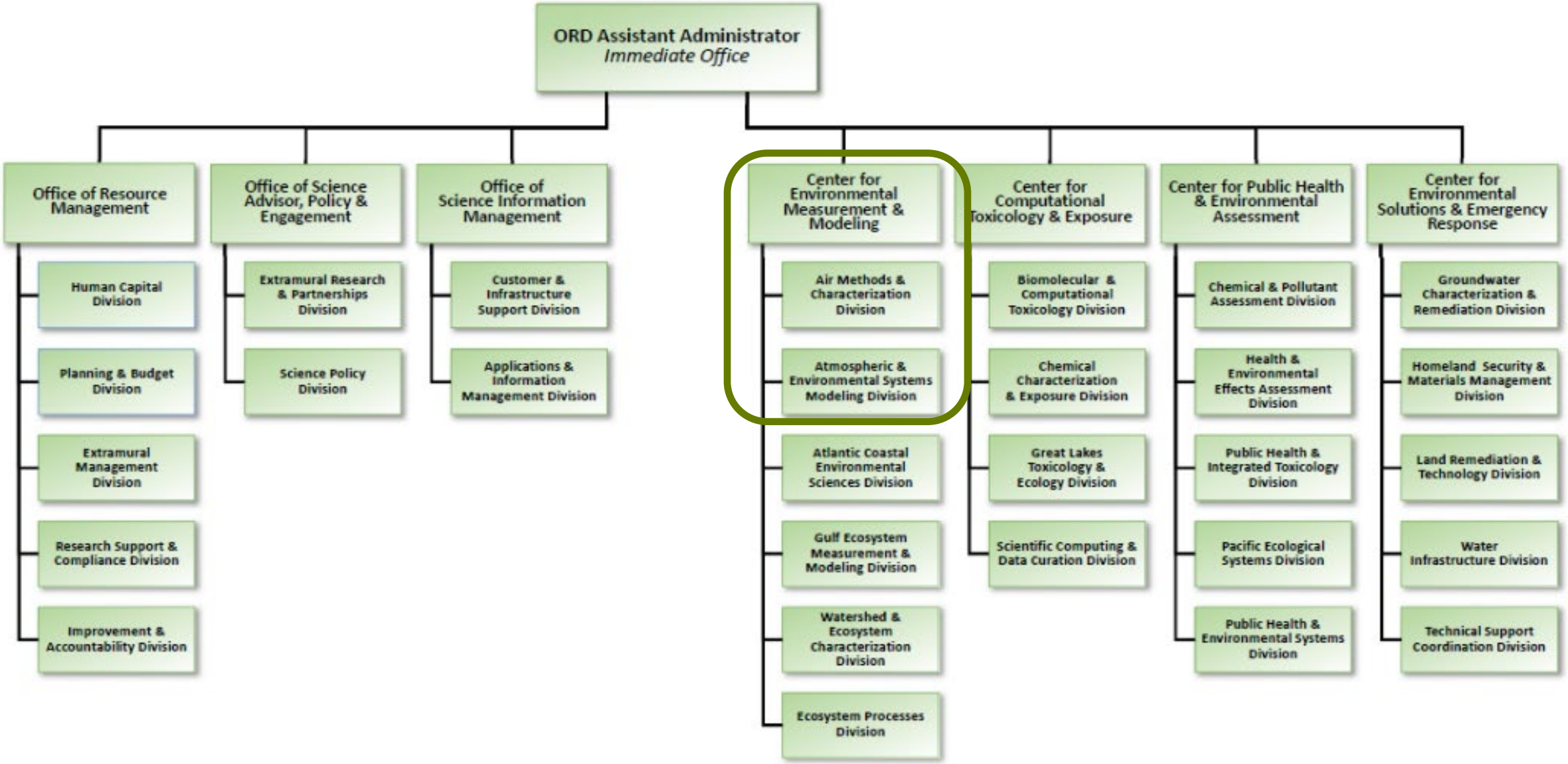
- The science landscape is constantly evolving
- Pollutants measured at lower levels of detection
- Novel, innovative technology unveiled at a rapid pace
- Emerging environmental issues and contaminants of concern

SOLUTIONS

- Development and application of innovative approaches
- Improvement in problem solving capacity
- Formation of successful alliances with stakeholders



Organizational Focus



There are Lots of Science Questions Surrounding these Topic Areas…

Ambient Air

Collaborative Partnerships

Environmental Challenges

Characterization

Innovative Technology

Mitigation Solutions

Source Emissions

Near-source Emissions

Methods Development

Environmental Justice

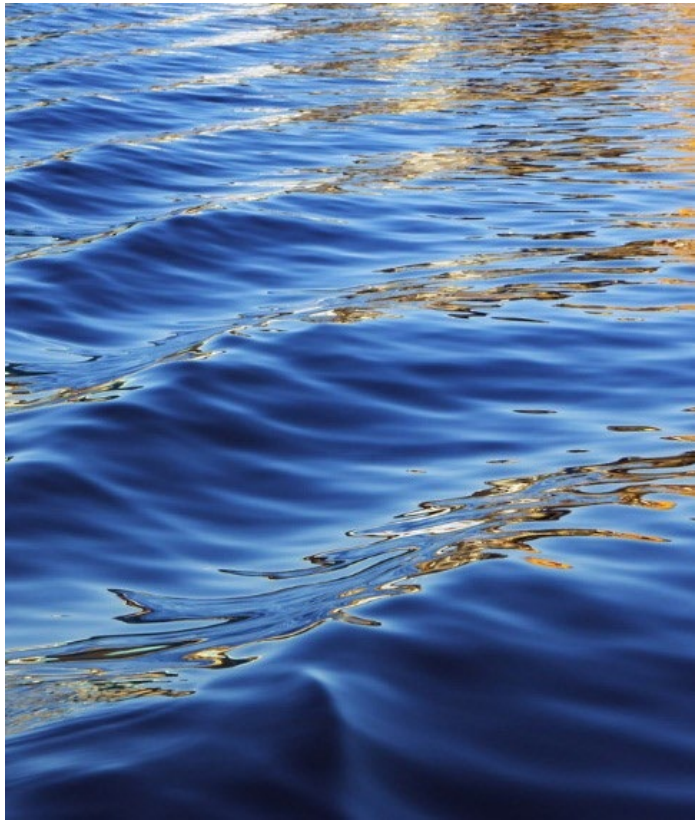
Monitoring

Climate Change

EPA United States Environmental Protection Agency

Environmental Challenges

Some of the Challenges We Face



Ethylene Oxide (EtO)

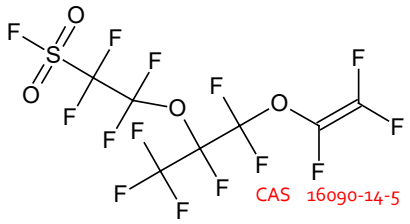
- A complex chemical, which is …
  - a colorless, flammable, and reactive gas
  - one of 188 listed HAPs regulated under CAA
  - used for sterilization (by medical industry, food industry, etc.) and to produce a range of chemicals (by chemical manufacturing industry)
- EPA finalized EtO IRIS assessment in 2016 …
  - characterized as carcinogenic to humans
  - based on lifetime inhalation unit risk estimate (URE), 100-in-a-million cancer risk -> ~11pptv
- EtO is now a major cause for concern in communities across the U.S. with a need to …
  - better understand potential sources
  - develop solutions to measurement and monitoring needs

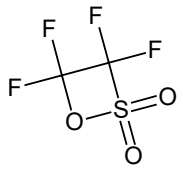
Wildland Fire Emission Measurements and Characterization

Why are wildfire smoke emissions important to EPA?

- Increasing fire size, intensity, footprint
- Community and firefighter health
  - PM, Toxics
  - Susceptible Subpopulations
- Ambient air quality
  - PM, O_3, NOx, NH_3, CO, VOCs
- Global climate
  - CO_2, CH_4, BC, Organic Aerosols, NOx, N_2O

Per – and Polyfluoroalkyl Substances (PFAS)


CAS 16090-14-5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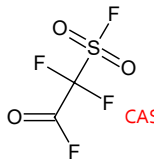
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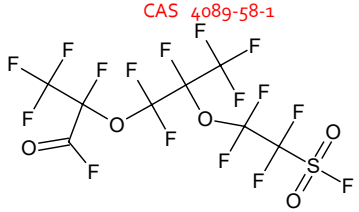
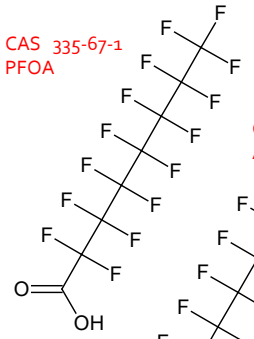
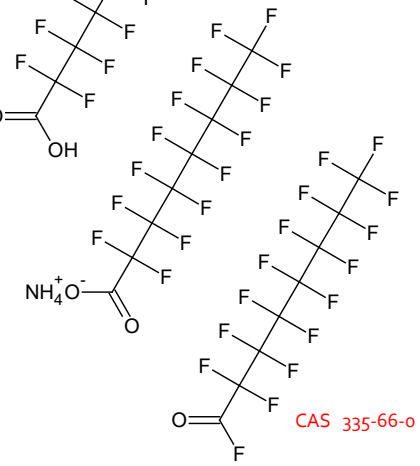
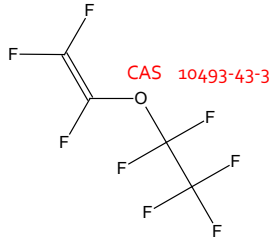
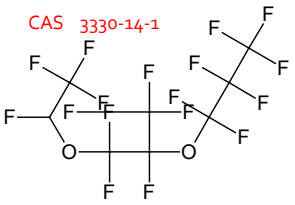

CAS 4089-58-1


CAS 335-67-1
PFOA


CAS 3825-26-1
APFO

CAS 335-66-0


CAS 10493-43-3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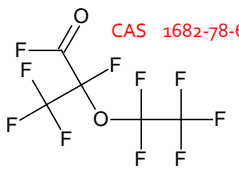
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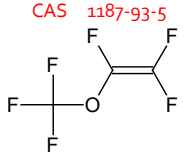
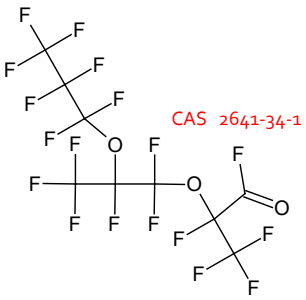

CAS 1187-93-5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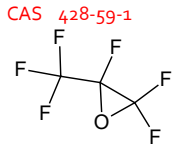
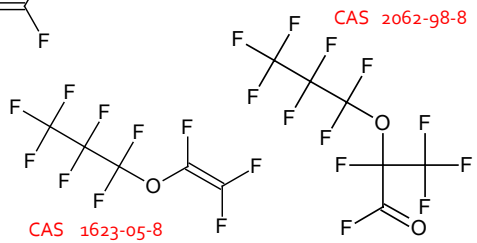
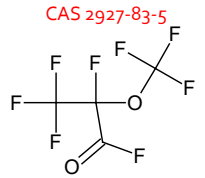

CAS 428-59-1


CAS 1623-05-8

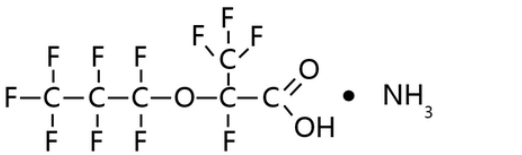
CAS 2062-98-8


CAS 2927-83-5

So Many PFAS Compounds!

How do we measure them?

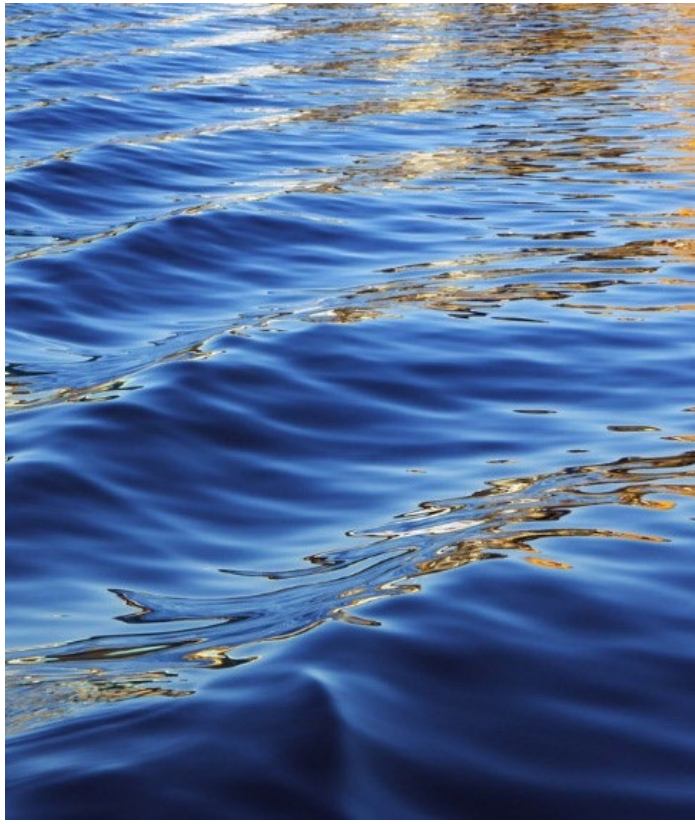
How do we destroy them?


GenX Chemical Structure

EPA United States Environmental Protection Agency

Toolbox

Techniques and Places Used to Seek Answers



FRM / FEM Samplers and Analyzers

Federal Reference Methods (FRMs)

- Designed to provide the most fundamentally sound and scientifically defensible concentration measurement
- FRM measurement principles for each criteria pollutant are published in 40 Code of Federal Regulations (CFR) Part 50
- FRMs serve as the basis of comparison upon which to judge other measurement methods

Federal Equivalency Methods (FEMs)

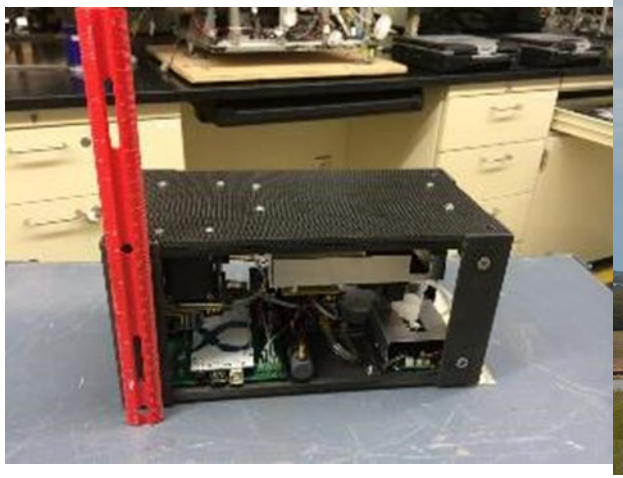
- Intended to provide a comparable level of compliance decision making quality as provided by FRMs
- May include newer, innovative technologies to reduce overall operating cost and to achieve multiple monitoring objectives (e.g., real-time reporting for health studies and for issuing timely public health advisories)

Examples of Emission Measurement Tools

Method Modifications

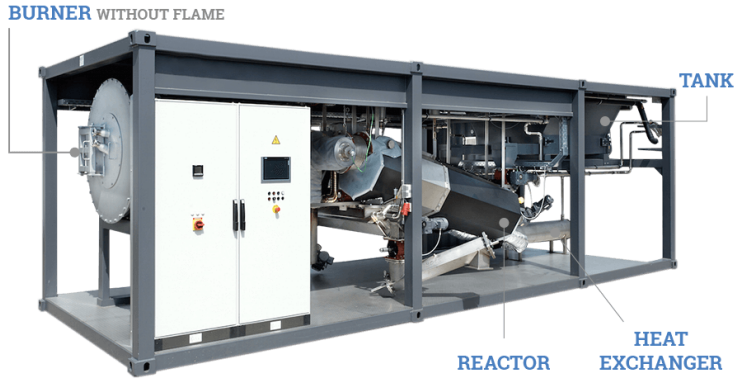
USGS UAS with ORD "Kolibri" Sensor/Sampler

Low-cost PM Sensors

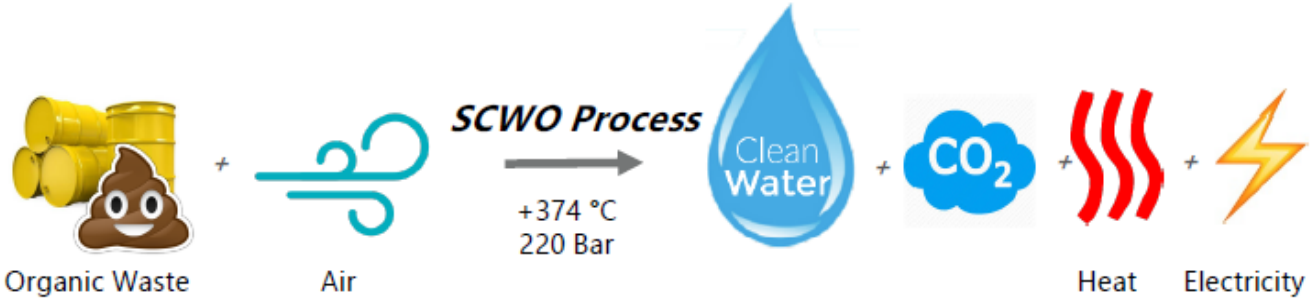


Examples of Pilot and Field Testing

Biosolids Pyrolysis/ Gasification



Supercritical Water Oxidation (SCWO)

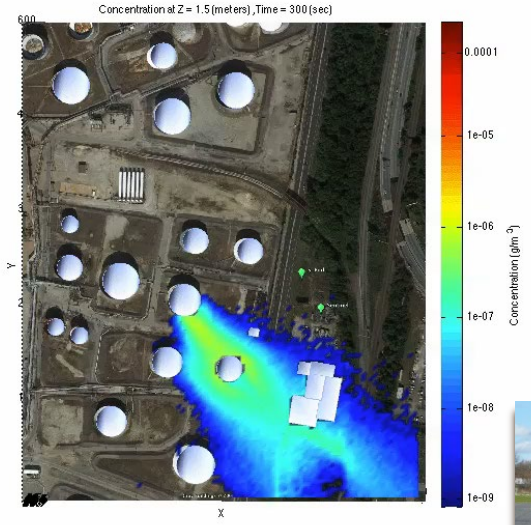


Next Generation Emissions Measurement (NGEM)

Metrology

Facility Sensors

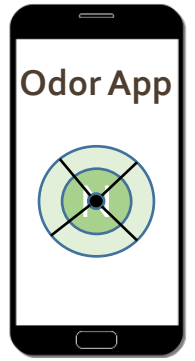
Personal and Community Sensors



Informetrics

Geospatial

Near Source Impacts/ Energy/ Industry Sensors

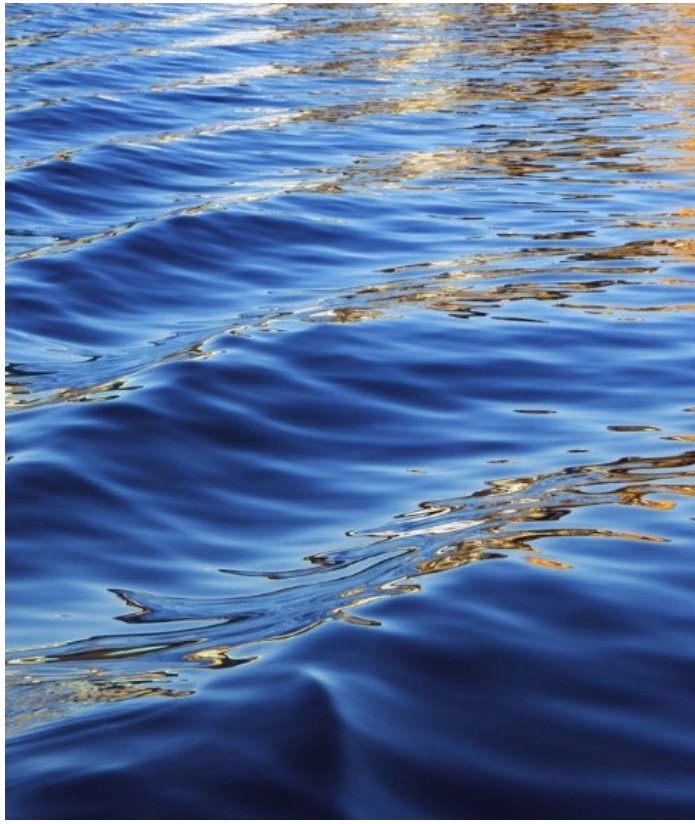


Metadata

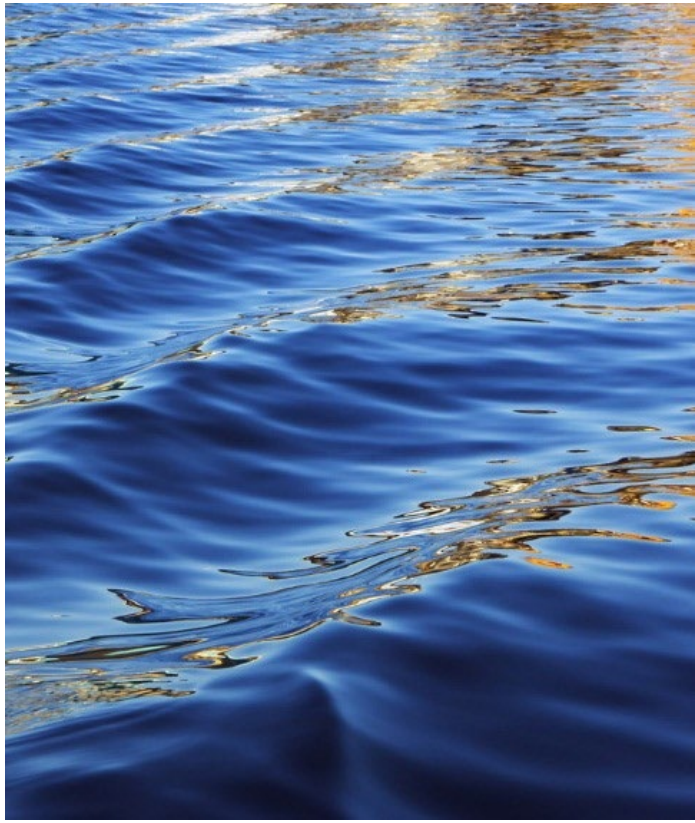
EPA United States Environmental Protection Agency

Explore – Measure, Monitor, Characterize

Innovative Approaches and Applications



Ethylene Oxide



EtO Measurement and Monitoring Challenge

- Development of online, real-time instrumentation and time integrated methodology for any measurement is difficult, but EtO brings with it several additional challenges due to:
  - Interferents
  - Incomplete understanding of sources
  - Need for a wide range of measurement from low-level detection limits (e.g., 11 pptv) to higher source levels (e.g., 5-10 ppm) for stack sampling

Source Emissions

Source emissions characterization of EtO in complex sampling conditions

Fenceline Monitoring

Fast, real-time EtO measurements for fugitive emissions detection and fenceline monitoring

Ambient Monitoring

Sensitive EtO methods (<10 pptv) for ambient air monitoring

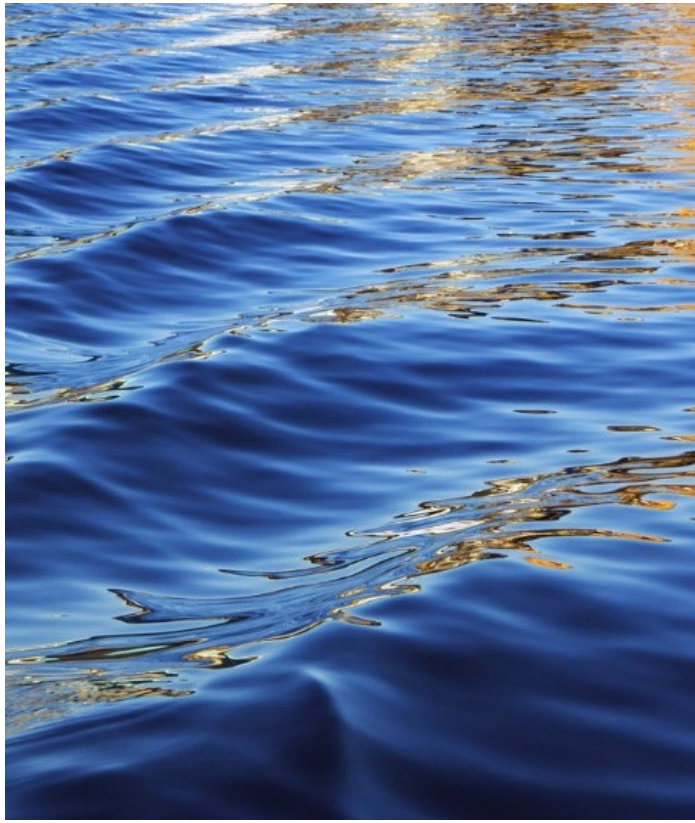
EtO Instrumentation and Methodology

- EPA Method TO-15A (canisters)
  - Sample analysis by VOC Preconcentration/Gas Chromatography (GC)/Mass Spectrometry (MS)
  - MDL ~ 15 pptv
- Modified OSHA Method 1010 (sorbent tubes)
  - Front and back of tube extracted separately, sample analysis by GC/Electron Capture Detector (ECD)
  - MDL ~ 1 ppbv

Instrument Model	Operating Principle	Measurement Rate	MDL (5 min)
Aeris Ultra & Pico	Mid-Infrared Laser Absorption Spectroscopy	1 sec	2 ppb
Aerodyne	Quantum Cascade – Tunable Infrared Laser Differential Absorption Spectroscopy (QC-TILDA)	1 sec	0.1 ppb
AromaVOC	Preconcentration/CRDS	5 min. sampling / 30 min cycle	10 ppt
Picarro G2920 &G2910	Cavity Ringdown Spectroscopy (CRDS)	1 sec	0.1 ppb / 0.2 ppb
MAX Analytical Starboost	Fourier Transform Infrared Spectroscopy	1 min	5 ppb

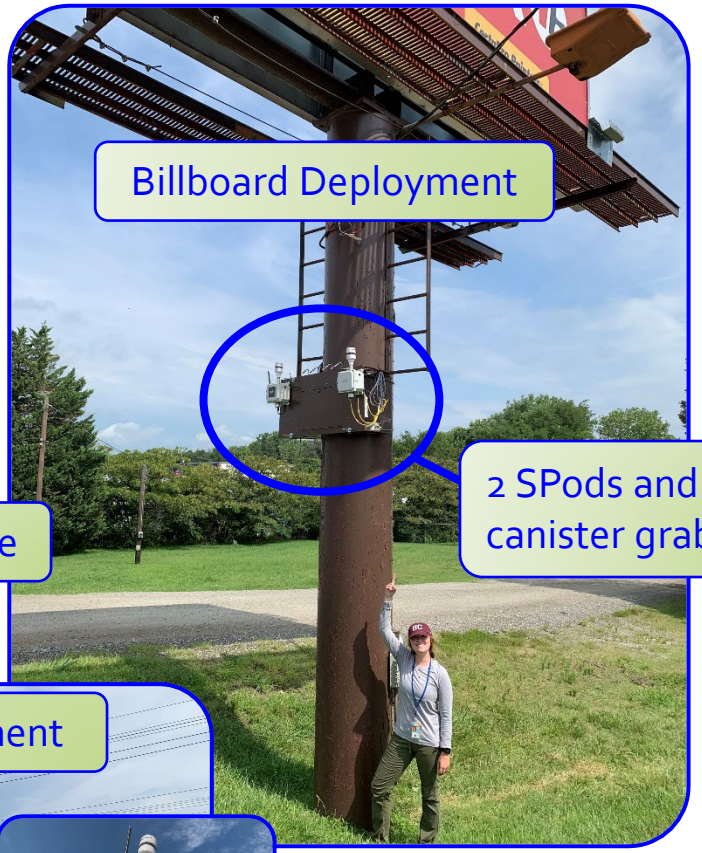
MDL= Method Detection Limit

Fenceline and Ambient Monitoring

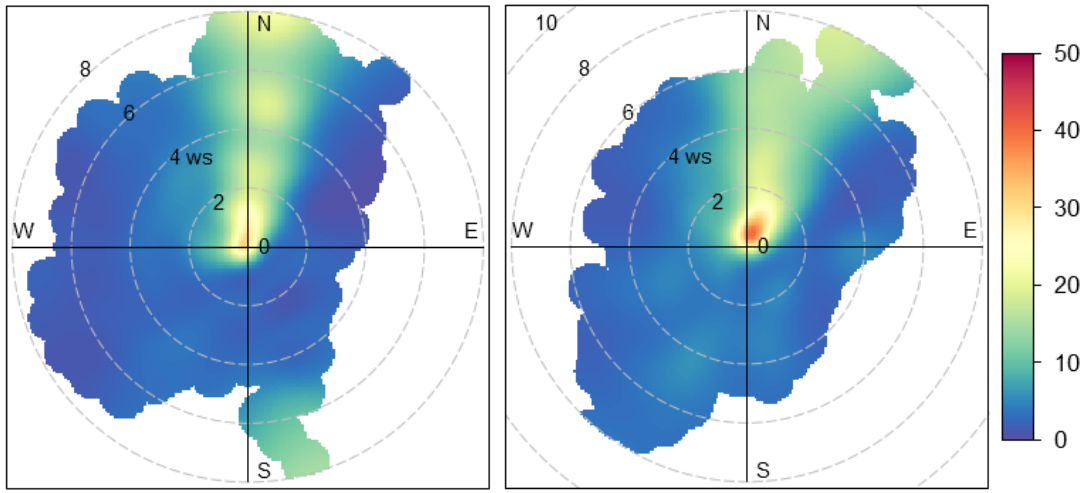


Informing VOC Emissions from Storage Tanks using Next Generation Emission Measurement (NGEM)

- SPod fenceline sensors and triggered grab samples
- Greensboro, NC study in process (4 sites)
- Optical gas imaging (OGI) visualization
- Inverse source modelling



Commercial SPods based on EPA open-source design



SPods provide wind and VOC data on source direction

Passive Sampler Research

- Refinery Fenceline (Benzene 325 A/B)
- Growing list of compounds
- Low deployment cost (no power)
- High spatial coverage

Compound	Estimated MDL (pptv)
Benzene	21
1,2-Dichloro-1,1,2,2-tetrafluoroethane	18
Trichlorofluoromethane	40
1,1-Dichloroethene	18
1,1,2-Trichloro-1,2,2-trifluoroethane	18
1,1-Dichloroethane	27
cis-1,2-Dichloroethene	61
1,2-Dichloroethane	22
1,1,1-Trichloroethane	18
Carbon Tetrachloride	122
1,2-Dichloropropane	22
Trichloroethene	36
Toluene	18
Tetrachloroethene	18
Chlorobenzene	18
Ethylbenzene	18
m,p-Xylene	36
Styrene	20
o-Xylene	18
4-Ethyltoluene	18
1,3,5-Trimethylbenzene	18
m-Dichlorobenzene	18
o-Dichlorobenzene	18
p-Dichlorobenzene	21
1,3-Butadiene	38
Hexane	N/A*

Community Impacts from Transportation

Priority Fixed Measurements

- Particulate Matter ($PM_{2.5}$)
- Ultrafine Particles (UFPs)
- Black Carbon (BC)
- Oxides of Nitrogen (NO/NO_2)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO_2)
- Met Data
  - Barometric Pressure
  - Relative Humidity
  - Temperature
  - Wind Speed
  - Wind Direction

Fixed Measurements

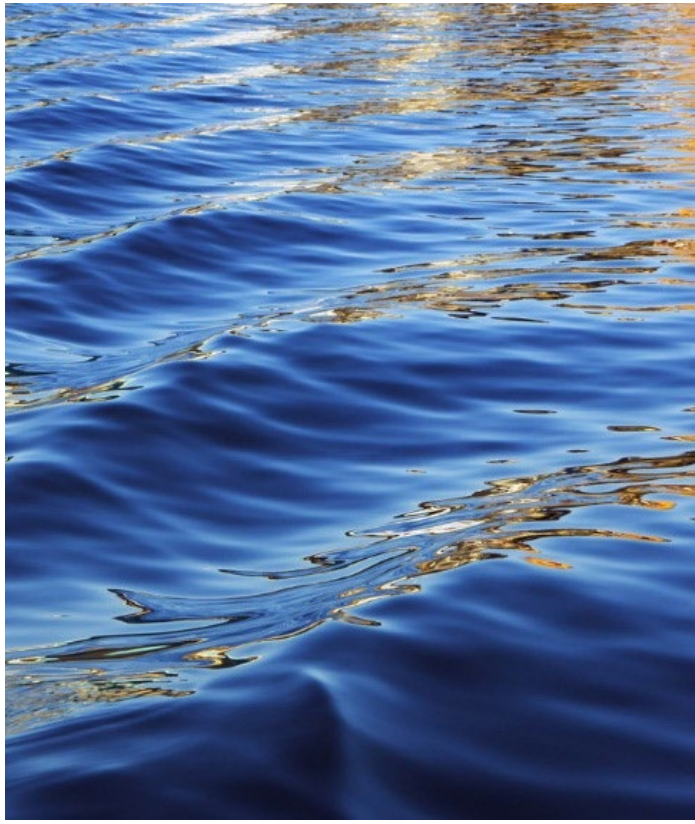
Mobile Measurements

Priority Mobile Measurements

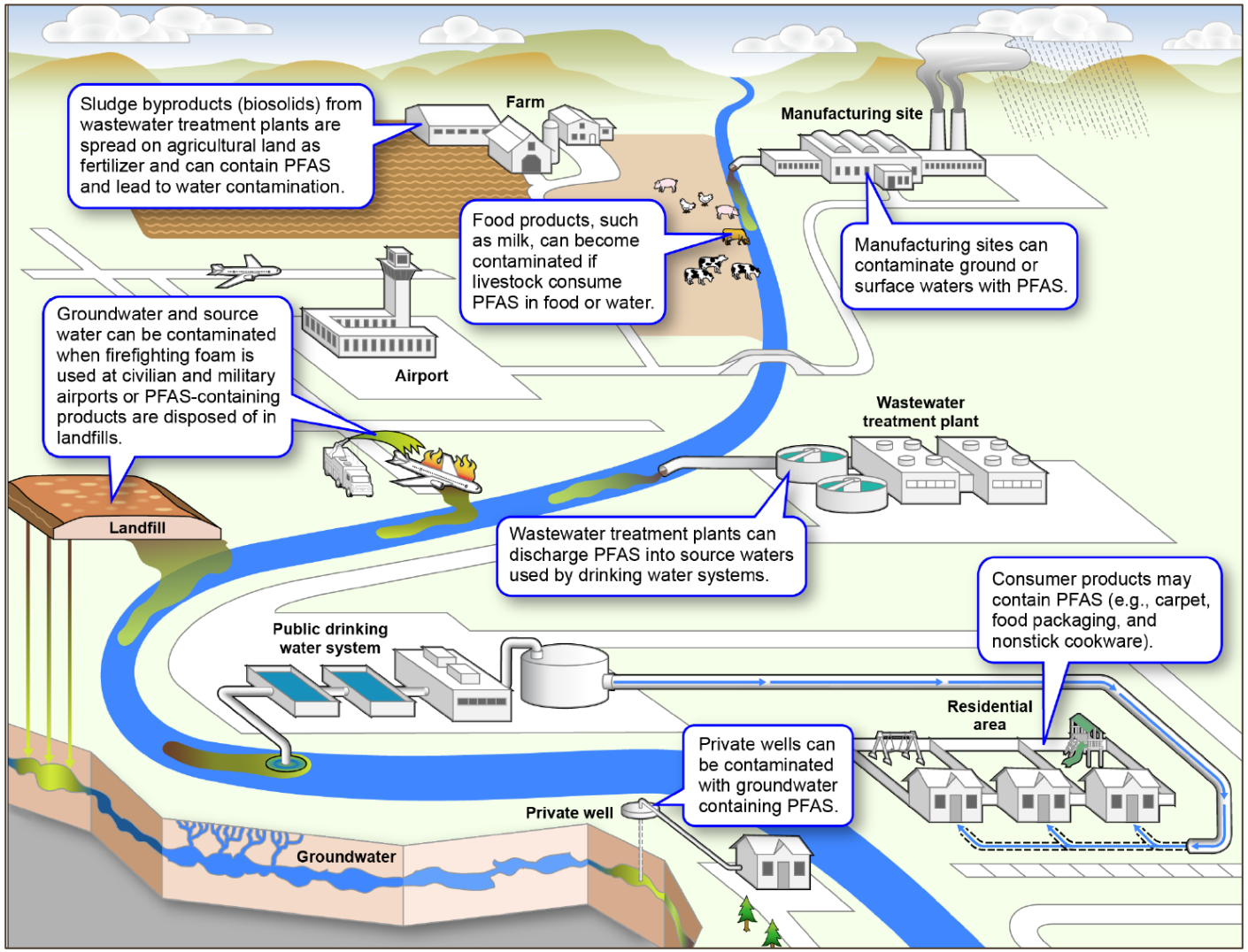
- Particulate Matter ($PM_{2.5}$)
- Ultrafine Particles (UFPs)
- Black Carbon (BC)
- Nitrogen Dioxide (NO_2)
- Carbon Dioxide (CO_2)
- GPS
- Video
- Met Data (remote)
  - Wind Speed
  - Wind Direction

Richard Baldauf – Keynote 2:15 Tues; Presentation 4:00 Wed

Per- and Polyfluoroalkyl Substances



Sources of PFAS in the Environment

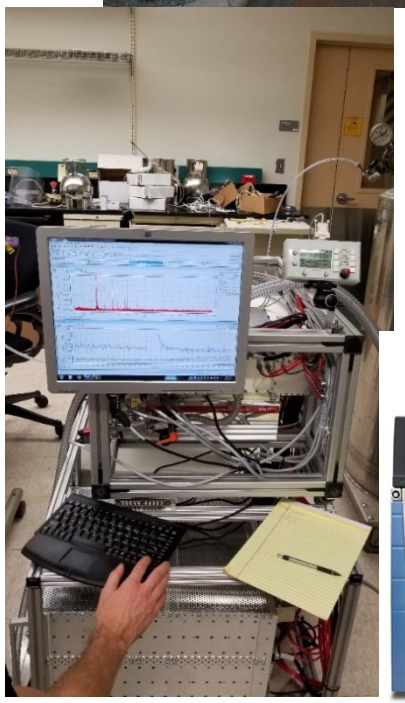


Source: GAO | GAO-21-37

- PFAS emission sources are diverse:
  - chemical manufacturers
  - used in commercial applications
  - emitted during thermal treatment of waste (e.g., AFFF, biosolids, municipal)
  - Products of Incomplete Destruction/Combustion (PIDs/PICs)
    - PICs historical term related to combustion or incineration
    - PIDs include non-combustion degradation species
- Process can alter emission composition
- Validated source and ambient air methods for PFAS do not exist, but some research methods are available
- Current emissions tests often target only a small number of PFAS compounds for analysis while significantly more may be present

PFAS Sampling and Analysis Methods

- Sampling/Analysis Methods
  - Other Test Method (OTM) – 45; Modified SW-846 Method 0010 (MM5) train for polar and nonpolar compounds
  - SUMMA canisters (limits use to nonpolars)
  - Sorbent traps (suitable for polars and nonpolars)
  - Non-targeted analysis with high-resolution mass spectrometry
- Innovative Approaches
  - Field Deployable, Time of Flight-Chemical Ionization Mass Spectrometer (ToF–CIMS)
  - Total Organic Fluorine with combustion/ion chromatography



PFAS in Wet Deposition: Sampling Started September 2020

Current PFAS Sampling Sites (NADP - NTN Locations)
Started - Sept 2020:
- ME96
- NY98
- NJ99
- NC30 – triplicate

Started - Oct. 2021:
- KS97 Kickapoo Tribe

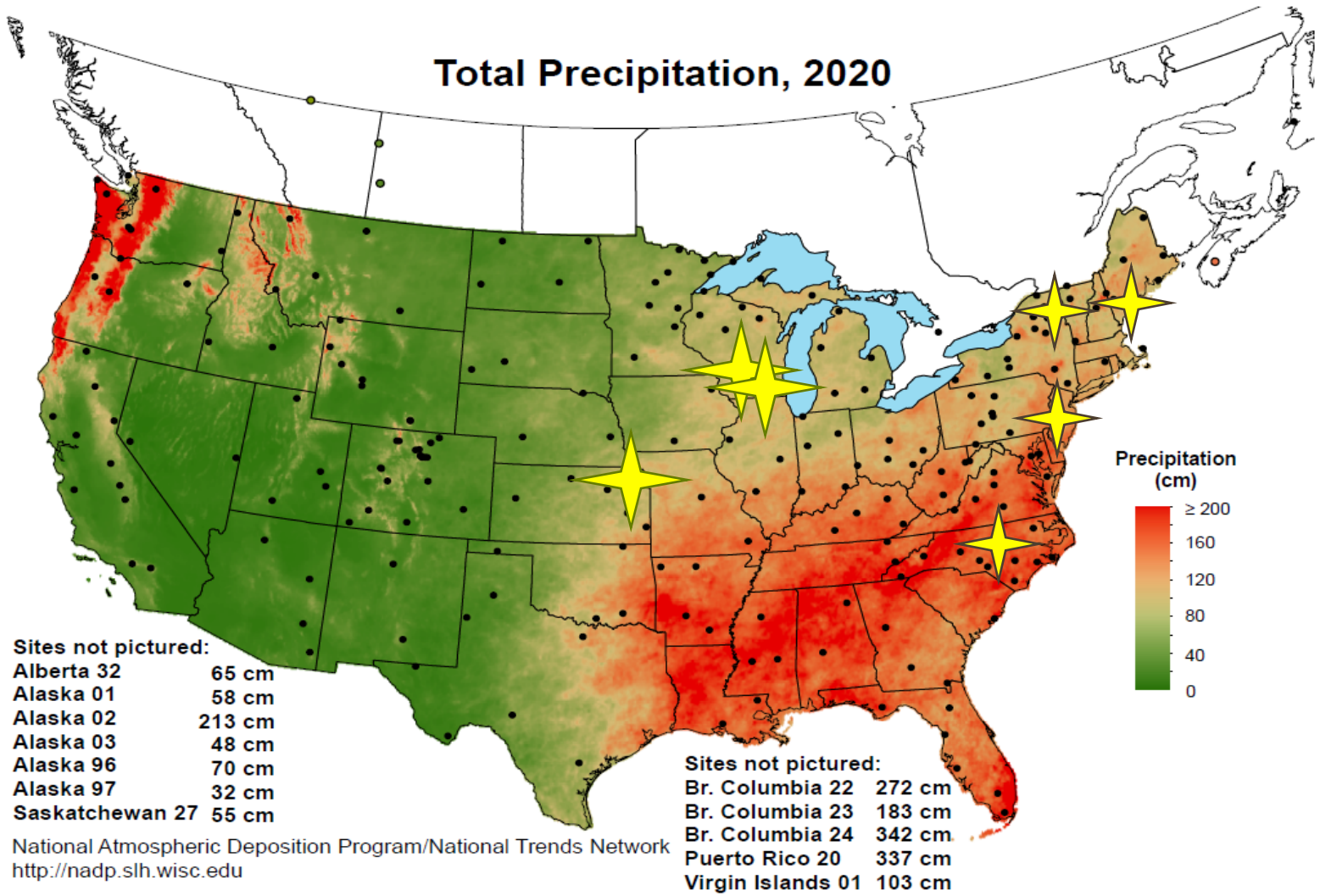
Started - in early 2022:
- UW Arboretum - WI06
- Devils Lake - WI31

Adding 3 more in late 2022…
2 w/ NPS and one more Tribal

Towards collaboration with other states & NADP efforts.
WI, NY (NY06), …

PFAS site:

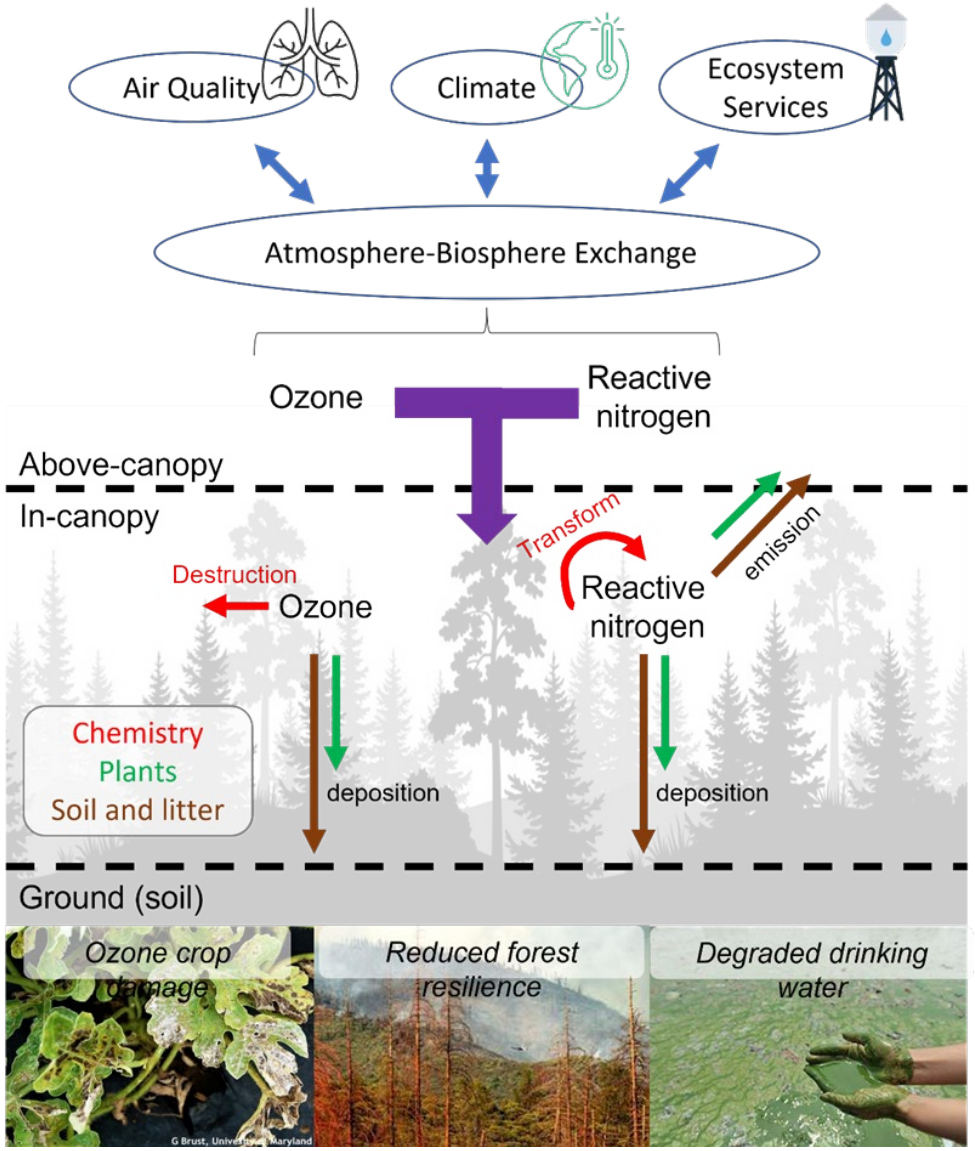
NADP NTN site:



John Offenberg – Presentation 3:30 Wed; Round Table 10:30 Thurs

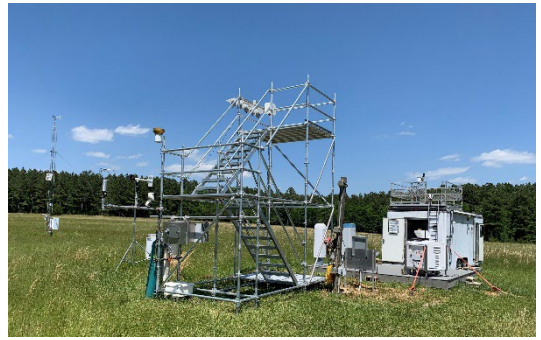
Biosphere-Atmosphere Exchange over Duke Forest

- The U.S. Environmental Protection Agency's Office of Research and Development conducts research at the **Duke Forest Blackwood Division** to better understand the processes by which natural landscapes exchange gases and particles between the biosphere and atmosphere.
- The forest's unique suburban location makes it well suited to study interactions between anthropogenic and biogenic emissions.
- Data collected is used to develop total deposition budgets to assess the relative importance of wet versus dry deposition pathways and the contribution of individual chemicals.
  - Informs development of strategies for managing emissions of anthropogenic pollutants
  - Improves representation of biosphere-atmosphere exchange in atmospheric chemical transport models

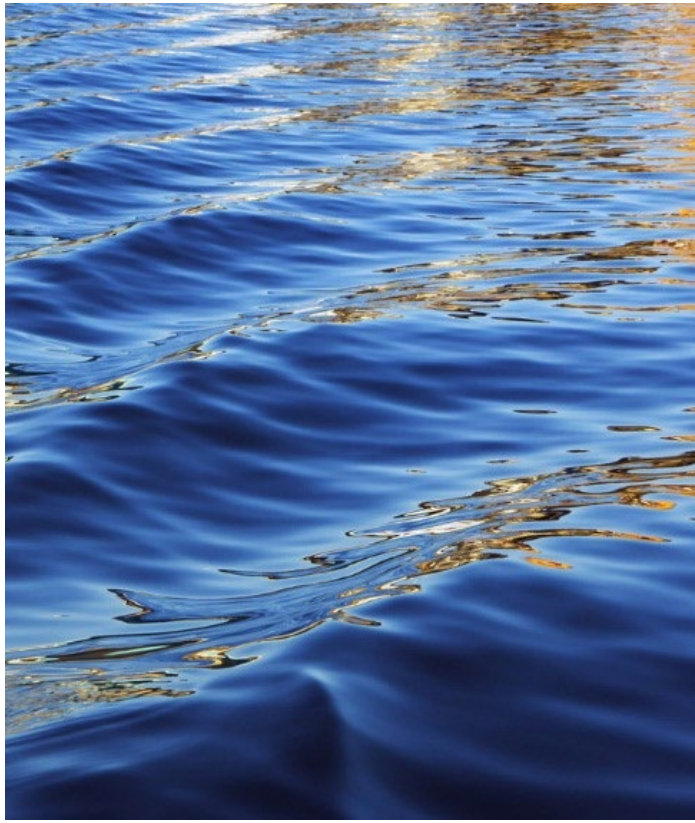


Duke Forest Field Research Laboratory

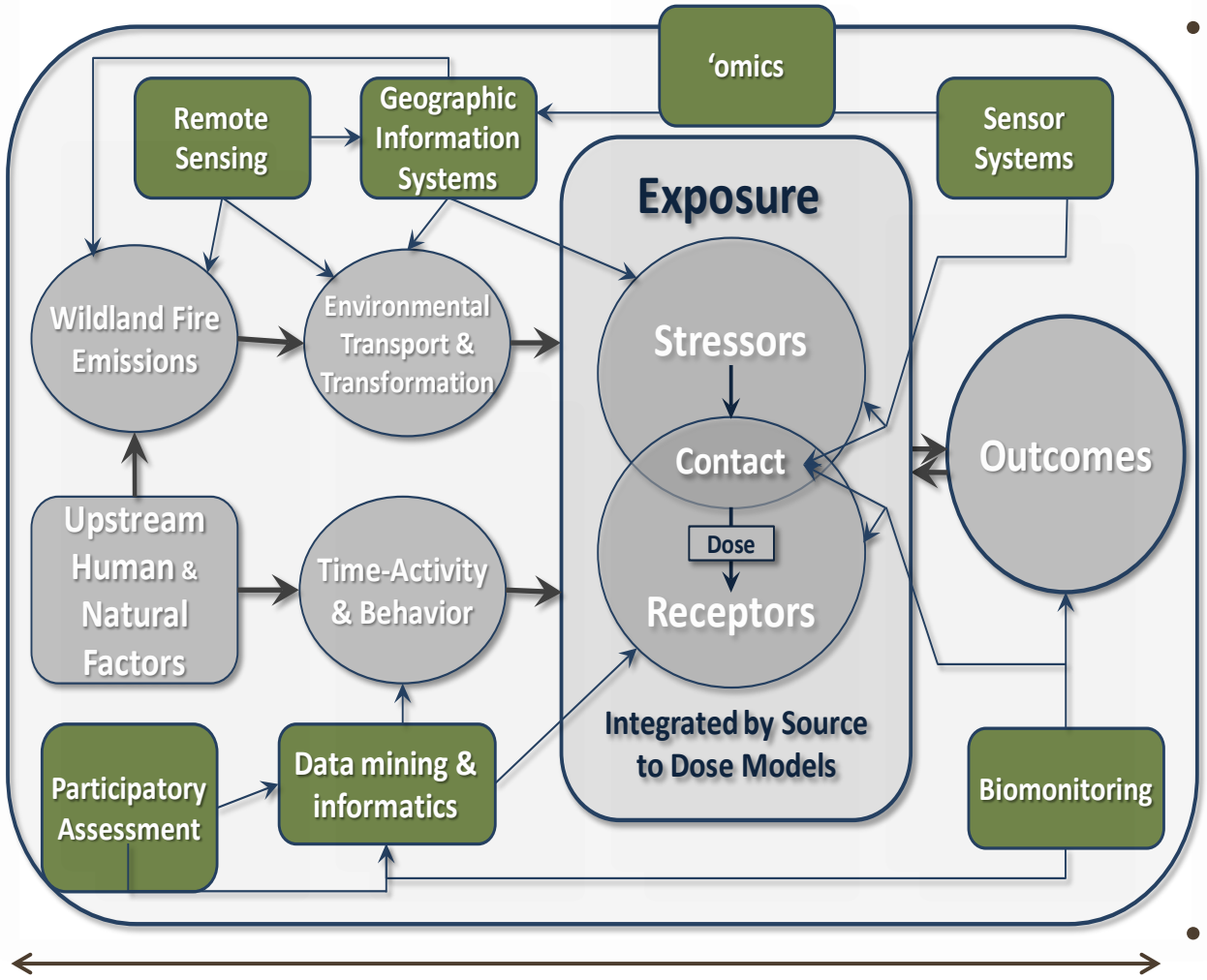
- Mixed hardwood/pine/open field site
  - Active long-term datasets being collected
  - Host for CASTNET, NTN, and AMON sites
- Variety of techniques used to measure air-surface exchange rates from individual leaf to forest canopy
  - Eddy covariance
  - Vertical profiles
  - Throughfall
- Sentinel validation site for NASA TEMPO satellite mission
  - Hosts research on boundary layer dynamics using remote sensing to investigate scale issues between micro- and meso-scale N deposition.



Wildland Fires



Wildland Fire Measurement Needs



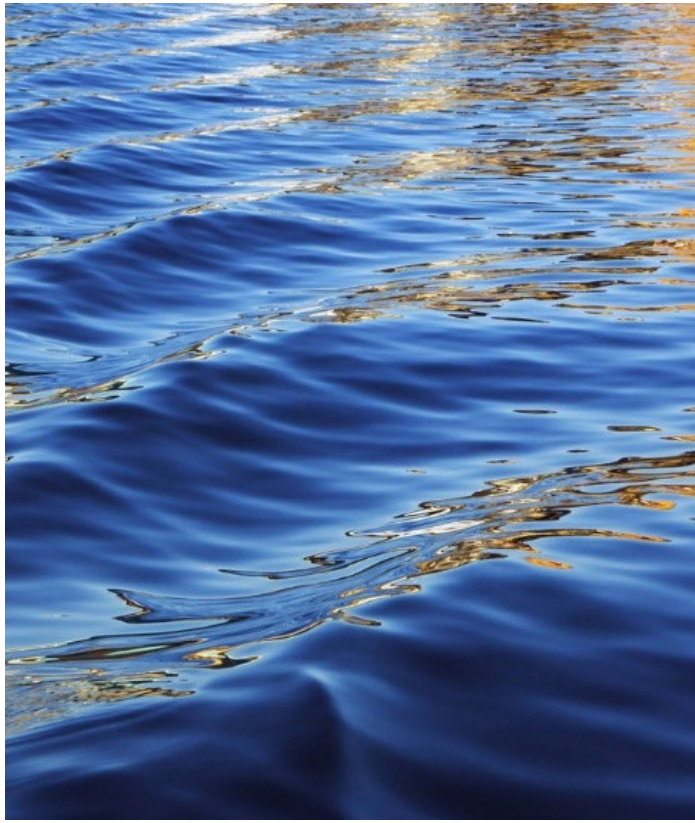
- Elucidating wildland fire smoke impacts on public health
  - Source emission to exposure
    - Emission characterization
    - Transport
    - Atmospheric chemistry
    - Community monitoring (NAAQS)
    - Human exposure
  - Model development & assessment
    - Deterministic modeling (CMAQ)
    - Receptor modeling (PMF, Unmix)
  - Health effects
    - Epidemiological modeling
    - Mechanistic toxicological effects
- Public health communication
  - Data integration & risk assessment
  - Health communication (AirNow, AQI, SmokeSense)

Wildland Urban Interface (WUI)

Justin Sullivan — Getty Images

WUI … where humans and their development meet or intermix with wildland fuel…

Sensors



Federal Reference Methods (FRMs), Federal Equivalency Methods (FEMs), and Sensors

FRMs/FEMs

- Measurements for regulatory use
- Data used for compliance decisions
- Provide high confidence in the data
- Adhere to established data quality control and assurance methods

Sensors

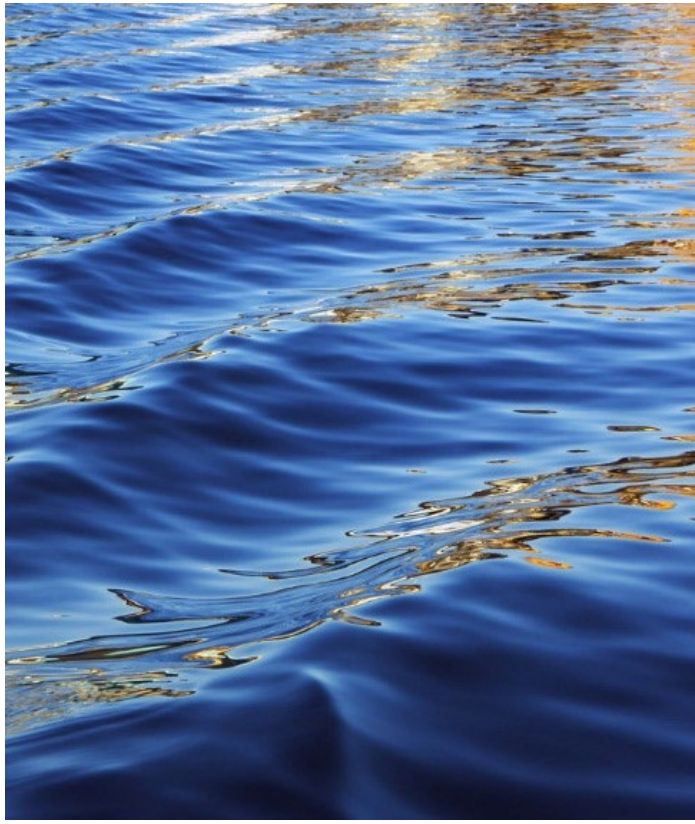
- Measurements for non-regulatory use
- Data used for informational purposes
- Demonstrated accuracy or precision is "good enough" for intended application
- Provide real-time data at high time resolution
- Offer smaller and/or more portable devices at a lower cost

Karoline Barkjohn – Presentation 1:30 Wed; Round Table 10:30 Thurs

EPA United States Environmental Protection Agency

Explore with Collaborations

Leverage Knowledge and Resources



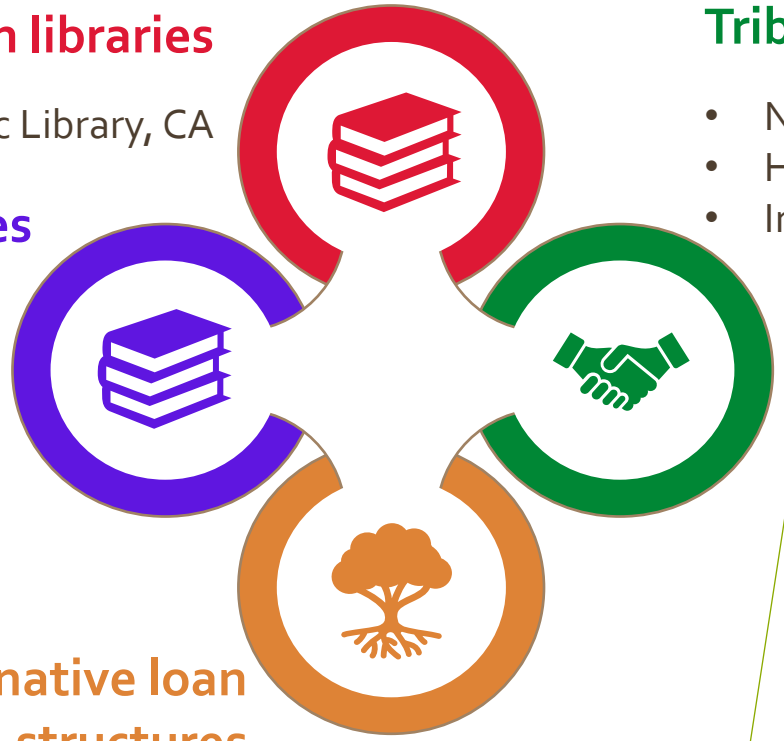
EPA Launched Pilot Programs with 8 Partners

Urban libraries

- Los Angeles Public Library, CA

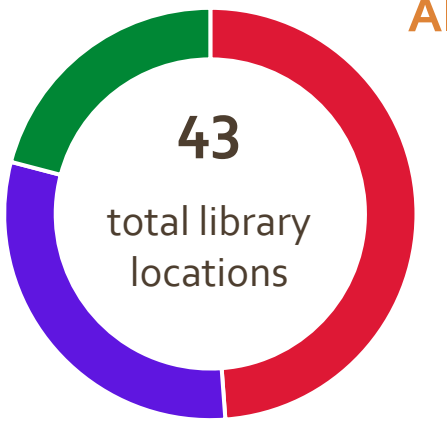
Rural & remote libraries

- Bayliss Public Library & Superior District Library System, MI
- Evansville Vanderburgh Public Library, IN
- L'Anse Area School/Public Library, MI



Tribal communities

- Nez Perce Tribe, ID
- Heritage University on Yakama Reservation, WA
- Institute for Tribal Environmental Professionals (ITEP), AZ



Alternative loan structures

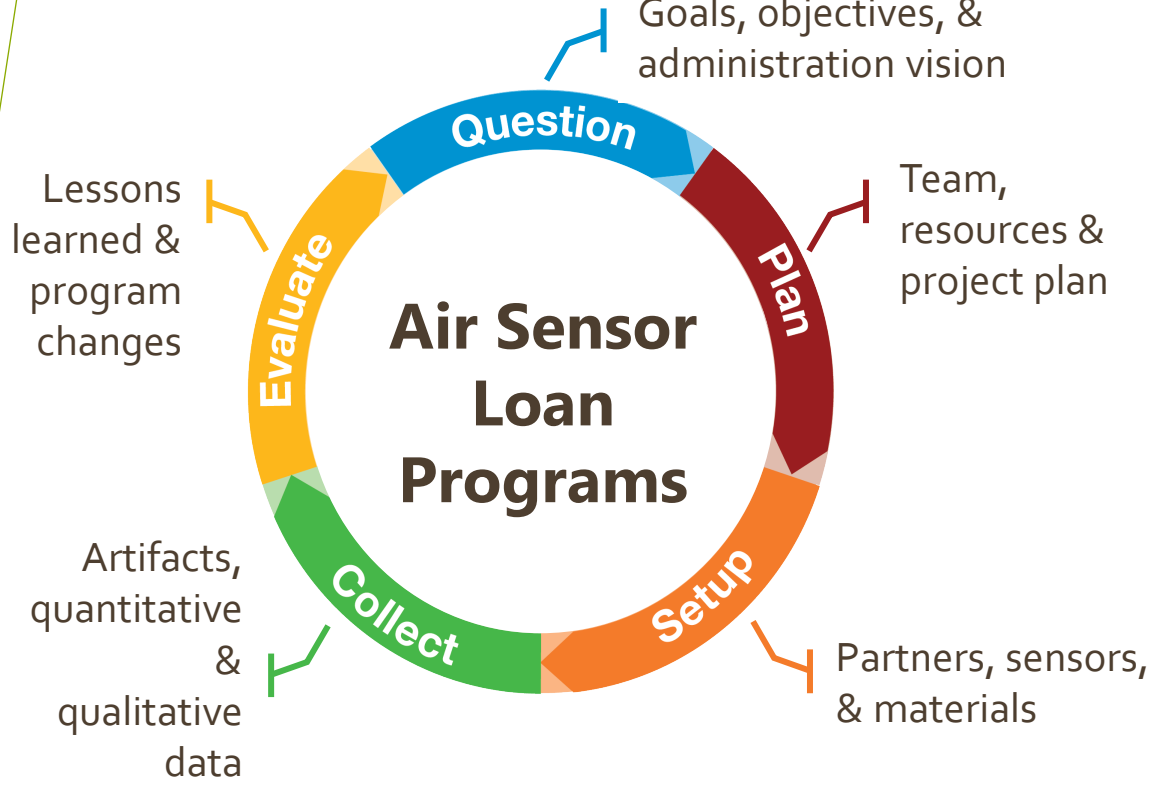
- The Morton Arboretum, IL

EPA participants

- Region 5
- Region 9
- Region 10
- ORD

Pilot programs funded by an EPA internal grant

https://www.epa.gov/air-sensor-toolbox



Andrea Clements – Presentation 3:50 Wed; Round Table 10:30 Thurs

WSMART Technology Loans

Air monitors for supplemental smoke monitoring:

- Stationary sensors: $PM_{2.5;}$ Multipollutant model ($PM_{2.5}$, CO, CO_2, TVOCs)
- Vehicle Add-on Mobile Monitoring Systems (VAMMS): ORD developed mobile $PM_{2.5}$ sensor package

- **Partnering with EPA Regions and OAR**
  - Loan on request to **state, local, and tribal (SLT) air organizations** to meet their supplemental monitoring needs

  SLT loans initiate via a webform request: https://www.epa.gov/air-sensor-toolbox/wildfire-smoke-air-monitoring-response-technology-wsmart-pilot

- **Partnering with the Interagency Wildland Fire Air Quality Response program**
  - Provided supplemental $PM_{2.5}$ sensors directly to the USFS Rocky Mountain Cache.
  - Multipollutant & VAMMS technologies sent to incident through direct request by Air Resource Advisors (ARAs) deployed to incident management teams

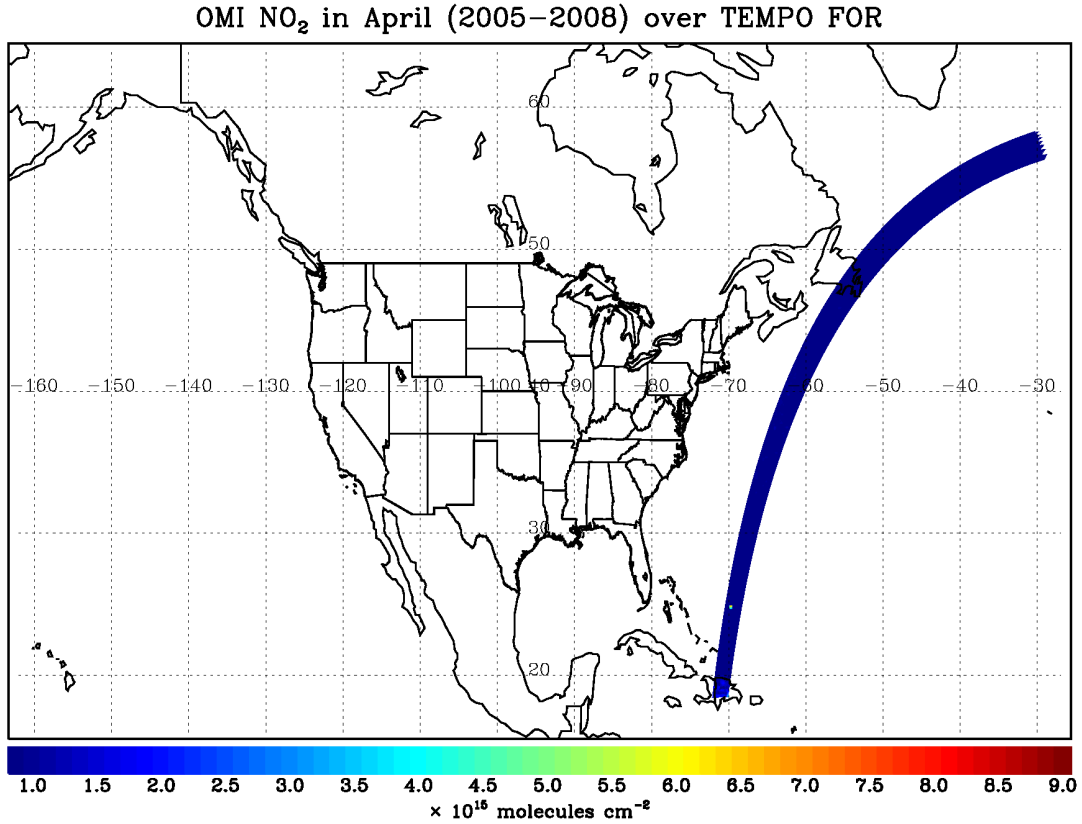
Amara Holder – Information at EPA Booth

Tropospheric Emissions: Monitoring of Pollution – TEMPO
Moving to Time Resolved Observations at Neighborhood Scales

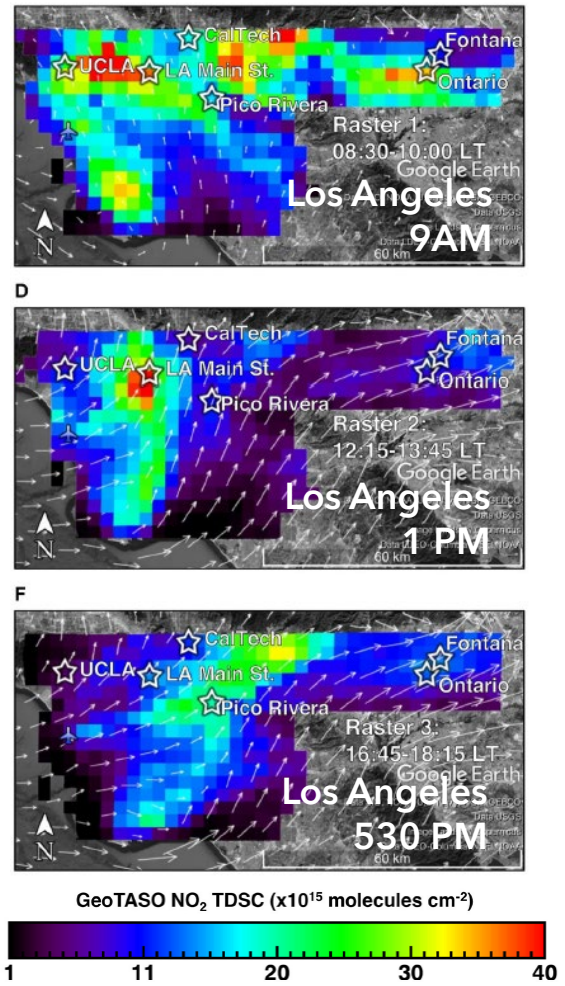
PI: Kelly Chance, Smithsonian Astrophysical Observatory

Current other Institutions: EPA, NASA LaRC, NASA GSFC, NOAA, NCAR, Harvard, UC Berkeley, St. Louis U, U Alabama Huntsville, U Iowa

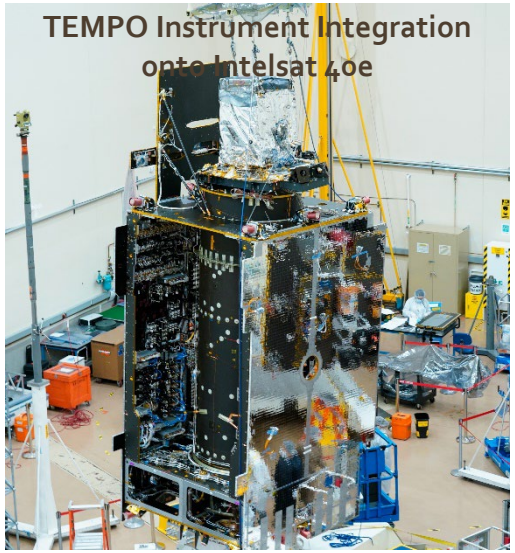
International collaboration: Korea, Mexico, Canada, Europe



NO2 Columns from Airborne TEMPO Risk Reduction Mission

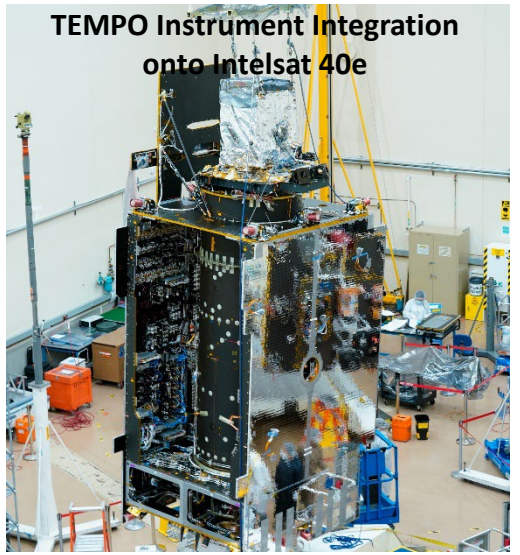


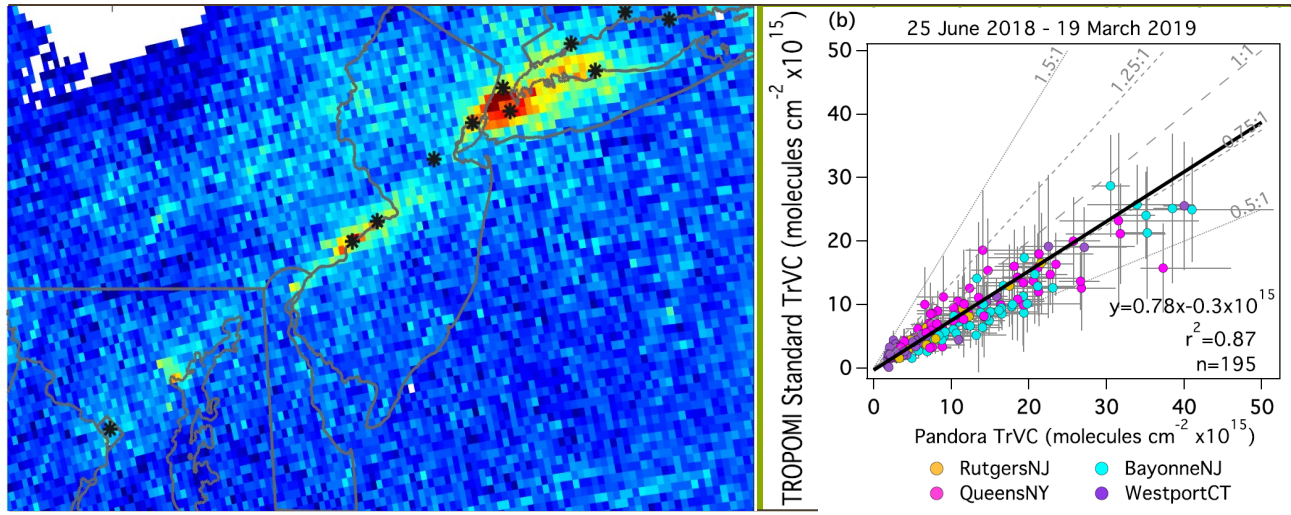
CONUS + parts of Canada and Mexico every hour at ~2.1 km ×4.6 km!



Remote Sensing to support (TEMPO satellite) Air Quality Monitoring

- Collaboration with NASA, European Space Agency and our State and Local partners to improve satellite validation for key trace gases NO_2, HCHO, O_3 measured by TEMPO.
- EPA deployment of ground-based spectrometers (Pandora) will provide for routine and systematic validation of satellite data.
- Objective is improved assessment of TEMPO data.
- Supports PAMS Enhanced Monitoring efforts for pollution aloft.
- EPA efforts to increase use of satellite data as recommended in GAO Report to Congress on Air Pollution, 2020.



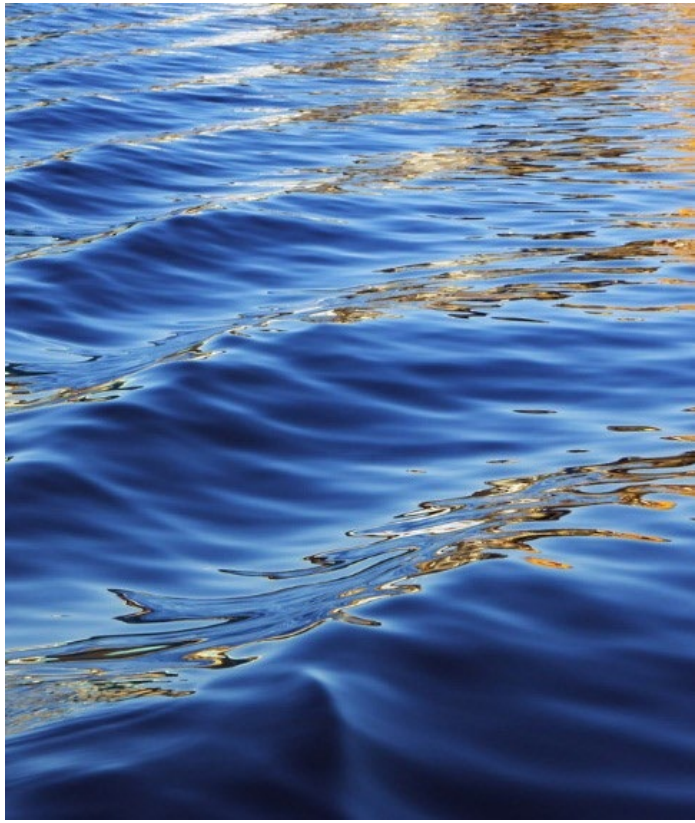


Judd et al, Evaluating Sentinel-5P TROPOMI tropospheric NO_2 column densities with airborne and Pandora spectrometers near New York City and Long Island Sound, AMT, 2020.

Lukas Valin – Presentation 8:40 Thurs; Jim Szykman – Presentation 1:40 Thurs; Baumann Poster

Wrap-Up

Lots of Questions, Lots of Answers, More to Come



There are Lots of Answers Needed for these Areas of Science and More…

Ambient Air

Collaborative Partnerships

Environmental Challenges

Characterization

Mitigation Solutions

Innovative Technology

Near-source Emissions

Source Emissions

Methods Development

Climate Change

Monitoring

Environmental Justice

Summary

- With the ability to measure our environment at previously unseen levels of detection, temporal and spatial resolution, the landscape of science is constantly evolving
- Emerging environmental issues and contaminants of concern are being investigated to answer the immediate questions of uncertainty with regards to public health and exposure
- Novel, innovative technology is being unveiled at a rapid pace and evaluated for relevance in measuring and monitoring priority areas
- The development or application of an innovative approach; improvement in problem solving capacity; and formation of successful alliances with stakeholders are strategic means for advancing our knowledge to the rapidly changing surroundings
- Collaboration is an invaluable tool with opportunities to leverage resources and expertise endless

THANK YOU!!!

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