New Aerosol Measurement Techniques Session

Opportunities, Roadblocks, Action Items

DOE ARM AMSG workshop in Salt Lake City - July 9-10

1) Shipborne Measurements
2) Spatially Distributed Measurements

https://science.osti.gov/-/media/ber/pdf/workshop-reports/2024/BER-ShipObservationsReport_final.pdf

Observing Marine Aerosols and Clouds from Ships

March 18-20, 2024

Convened by U.S. Department of Energy
Office of Science, Biological and Environmental Research

ORGANIZERS

Shaima Nasiri and Sally McFarlane, U.S. Department of Energy

BREAKOUT SESSION FACILITATORS/LEAD REPORT AUTHORS

Allison Aiken, Los Alamos National Laboratory
Tim Bertram, University of Wisconsin, Madison
Matthew Christensen, Pacific Northwest National Laboratory
Virendra Ghate, Argonne National Laboratory
Nicki Hickmon, Argonne National Laboratory
Ernie Lewis, Brookhaven National Laboratory
Markus Petters, University of California, Riverside
Lynn Russell, Scripps Institution of Oceanography
Adam Theisen, Argonne National Laboratory
Robert Wood, University of Washington

WORKSHOP PARTICIPANTS/ADDITIONAL REPORT AUTHORS

Magdalena Andres, Woods Hole Oceanographic Institution
Sarah Brooks, Texas A&M University
Christopher Cox, National Oceanic and Atmospheric Administration, Physical Sciences Laboratory
Jessie Creamean, Colorado State University
Darielle Dexheimer, Sandia National Laboratories
Graham Feingold, National Oceanic and Atmospheric Administration, Chemical Sciences Laboratory
Sonia Kreidenweis, Colorado State University
Raghavendra Krishnamurthy, Pacific Northwest National Laboratory
Gourihar Kulkarni, Pacific Northwest National Laboratory
Gavin McMeeking, CloudSci, LLC
Timothy Onasch, Aerodyne Research
Patricia Quinn, National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory
Shawn Smith, Florida State University
Armin Sorooshian, University of Arizona
Kerry Strom, Woods Hole Oceanographic Institution
Janek Uin, Brookhaven National Laboratory
Xiaoli Zhou, University of Colorado and National Oceanic and Atmospheric Administration, Chemical Sciences Laboratory

Objective: Use commercial ships as observational platforms, expanding the reach of shipborne atmospheric observations.

The primary goals of the workshop were to inform BER about:

- scientific priorities for shipborne measurements of marine aerosols, clouds, greenhouse gases, and other environmental factors;
- research opportunities that would be enabled by different types of shipborne measurements;
- past and current shipborne observing technologies, including their challenges and limitations;
- logistical challenges and considerations for deploying instrumentation on commercial/non-research vessels; and
- opportunities for coordination with other federal agencies and/or international efforts.

Introduction/Background to Attendees

- Based on congressional direction, the DOE Office of Science program in Biological and Environmental Research (BER) is identifying high-priority targets for a potential pilot measurement program on commercial or other non-dedicated ocean vessels traveling in regular shipping lanes. Instrumentation would likely be unattended or have only basic maintenance (i.e., cleaning) by unspecialized staff.

- In identifying targets for a potential pilot program, it is important to understand the similarities and differences between making routine observations on non-dedicated research vessels and making targeted (i.e., field campaign) measurements on dedicated ocean research vessels. Important elements to consider include:
    - Quantities/variables that can measured;
    - Types of instrumentation that can be installed;
    - Observation density, frequency, and location;
    - Opportunistic measurements rather than targeted measurements (i.e., measurements are made along the ship's planned path, rather than the path being adapted to target specific events or phenomena);
    - Co-observations needed; and
    - Science questions that can be addressed.

Logistical Challenges (Instrument Related)

- Hazardous materials must follow all regulations, be self-contained, and not interfere with the ship’s International Maritime Dangerous Goods code or any of its certifications.
- Any modifications to the ship must be approved by regulatory agencies such as the American Bureau of Shipping or comparable agencies in other countries

Hazards/Risks (Instrument Related)

- Potential hazardous materials include
    - radioactive or ionization sources for aerosol
    - instruments, chemicals such as butanol (used in aerosol instruments) or HgCl 2
    - gas cylinders, batteries, and nanoplastics in calibration materials.
- Active remote-sensing instruments, such as lasers, lidars, and radars, may create hazards due to eye safety or electromagnetic radiation.
    - Important to develop simple and failsafe shutdown plans for these instruments that do not rely on communications from shore or personnel on the ship and that prevent damage to instruments and loss of data.
- Cybersecurity protocols for ship-to-satellite, ship-to-shore, or port-to-data-archive communications for data transfer
- Risk of loss of instrumentation through theft or accidental damage

Feasibility and challenges of deploying given instrument types on commercial ships.

Feasible

- aerosol size distribution with optical particle counters
- total aerosol number concentration
- aerosol scattering, aerosol absorption, aerosol extinction
- cloud-base height and aerosol profiles from a ceilometer.

Moderately Feasible

- turbulence updraft and backscatter profiles from Doppler lidar
- electric mobility-based size distribution (10-500 nm)
- filter samples for ice nucleating particle concentration and aerosol composition.

General Roadblocks for Aerosol Measurements

- integration into a pod or container
- inlet system that preconditions the sample in various ways, such as providing constant upper size cuts; constant, low, and known sample relative humidity; and constant and known transmission efficiencies as a function of particle size
- shared and networked data acquisition system to log the data and remotely control the instruments

Consensus: Even basic aerosol instrumentation isn’t fully ready yet. Hardening is needed to cope with remote instrument control, automated recovery on power failure, monitoring of instrument performance, corrosion, inlet plugging,

Roadblocks for more Advanced Aerosol Measurements

- Doppler LIDAR
  - Motion stabilization
- Mobility-based size distributions
  - Arcing, flow control, CPC working fluid, fluid refill, software development to ensure unattended deployment, aerosol charging/radioactive sources
- Filter measurements
  - conditional sampling by wind sector, possible, real-time screening of periods with ship exhaust, improved samplers to rotate filters, protocols to store, retrieve, and process the filters.

Consensus: These are solvable but hard problems that require instrument development (see SBIR call)

ARM FY2024 Aerosol Operations Plan

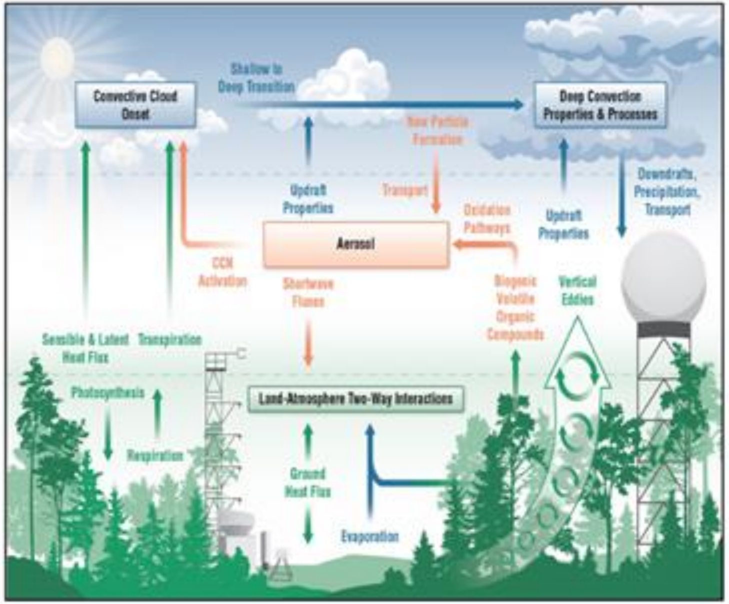
- Need to measure the spatial distribution of aerosol propertie
- ARM is investing in the development of two aerosol nodes
- Initially targeting aerosol size distribution and number concentration
- May be expanded to include optical properties, CCN, INP, trace gases, and potentially more.

2.1.1 Aerosol Nodes

ARM is defining aerosol nodes to cover a range of possible aerosol systems for deployment, from lower-cost standalone systems to research-grade instruments deployed in a small shelter. The measurements deployed will depend on the scientific priorities of the field campaigns but may include, but are not limited to, size distributions, concentrations, and/or trace gases. As noted in the Engineering Development section, ARM is currently investing in two aerosol nodes for the extended AMF3 deployment to the Bankhead National Forest (BNF) in northwest Alabama and is also exploring options for aerosol nodes for the upcoming urban AMF deployment. Neither set of aerosol nodes have yet been fully specified; however, we anticipate that AMF3 systems will have more advanced capabilities than urban systems.

Motivation: Capturing Drivers of Aerosol Spatial Heterogeneity

Spatially-distributed aerosol measurements are needed to resolve land-atmosphere controls on aerosol-climate impacts in the Southeastern US and other environments (e.g., urban, coastal).

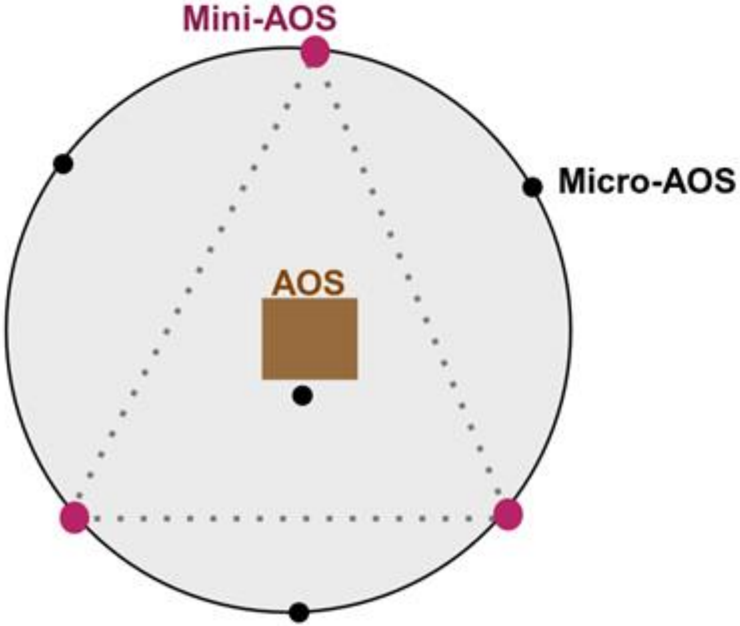


Slide: Ashish Singh

Brookhaven National Laboratory

Approach: Spatially distributed measurement using miniaturized AOS

Miniaturized AOS with varying complexity and footprint can address inquiries related to spatial-temporal scaling constraints.



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A tiered network of AOS and miniaturized AOS

Tier 1: AOS
- Large footprint: 6 m x 3 m x 3 m
- Highest quality instrumentation
- 10-20 instruments
- Process studies

Intermediate Tier: “mini-AOS”
- Small footprint: 1 m x 1 m x 2 m
- Miniaturized instrumentation
- 4-5 instruments
- Budgets, spatio-temporal scaling

Baseline Tier: “micro-AOS”
- Very small footprint: 0.5 m x 0.5 m x 1 m
- Lower-complexity instrumentation
- 1-2 instruments
- Spatio-temporal scaling

example

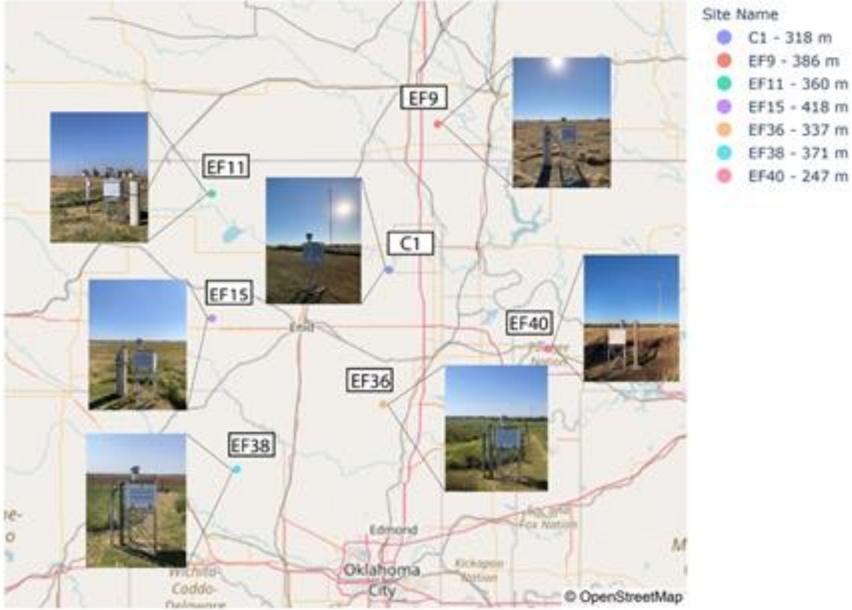
SGP POPsNET

Slide: Ashish Singh

Brookhaven National Laboratory

A Novel Network-Based Approach to Determining Measurement Representation Error for Model Evaluation of Aerosol Microphysical Properties

Elizabeth Asher[1,2], Troy Thornberry[2], David W. Fahey[2], Allison McComiskey[3], Kenneth Carslaw[4], Sophie Grunau[4], Kai-Lan Chang[2], Hagen Telg[5], Ping Chen[6], and Ru-Shan Gao[2]



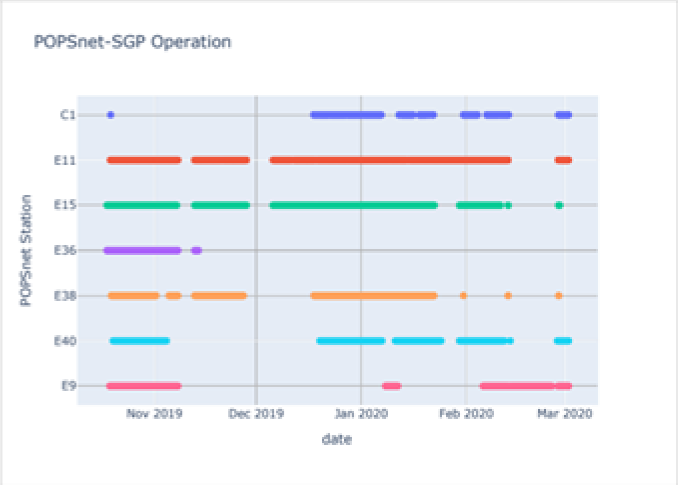


Figure S2
Data coverage of the central facility site (C1) and extended facility sites (E9, E11, E15, E36, E38, and E40) during the period October 15, 2019 to March 15, 2020.

Infrastructural requirements for a mini-AOS similar to AOS

Infrastructure

Enclosure
- Climate-controlled environment
- Power distribution
- Weather-tested design
- Industrial-grade constructions

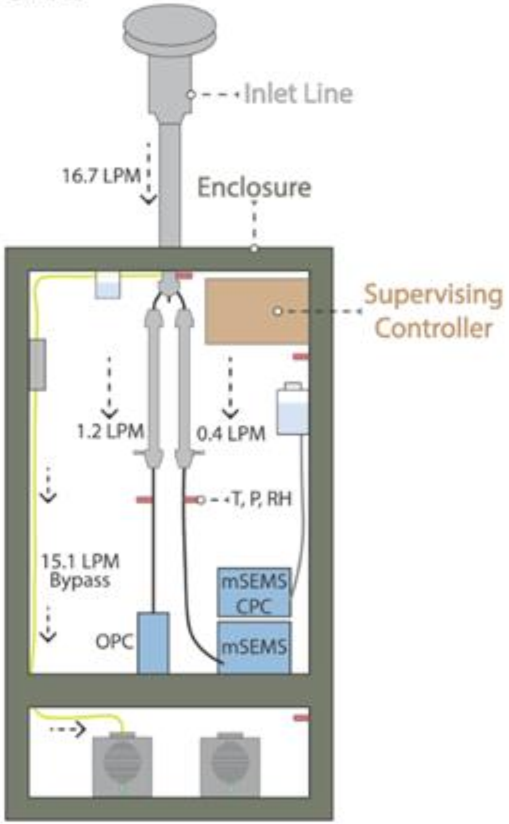
Inlet and sampling system
- Inlet head
- Transmission efficiency
- Sample condition, T/RH
- Regulated flow

Supervising controller (computer)
- DAQ
- Data storage, preprocessing
- Remote connectivity

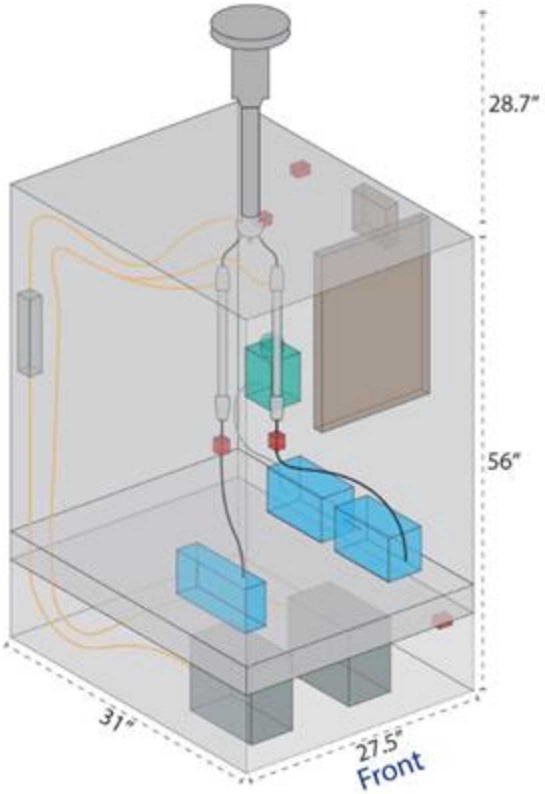
For AOS, infrastructure is ~35% to 40% of total capital expenditure ; **Similar breakdown ... the mini-AOS.**

Slide: Ashish Singh

Mini-AOS view



2d-view



3d-view

Blue box-instruments
Others- infrastructure

ENG0004824:

Distributed Aerosol Measurements for CoURAGE

Design Review

Slides 22-30 modified between 6/11 and 6/14

11 June 2024 | zoom link

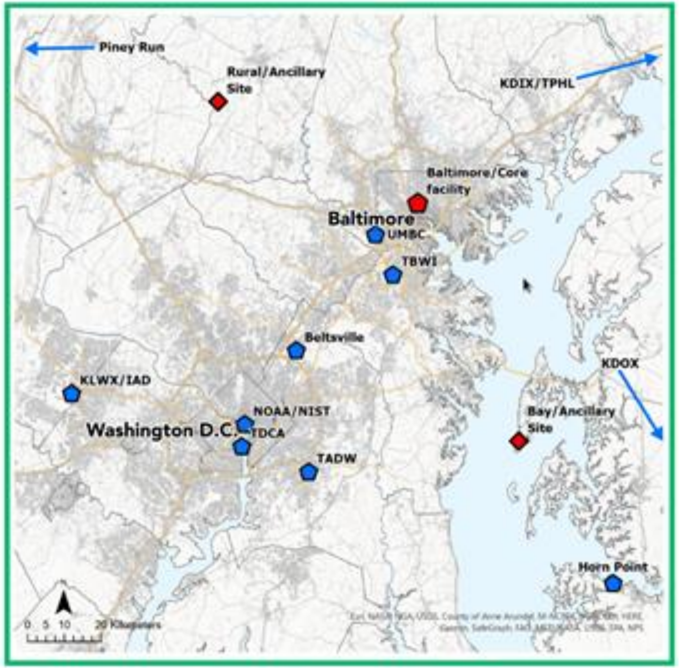
Sarah Petters, PI
Markus Petters, co-PI

Funded through ARM

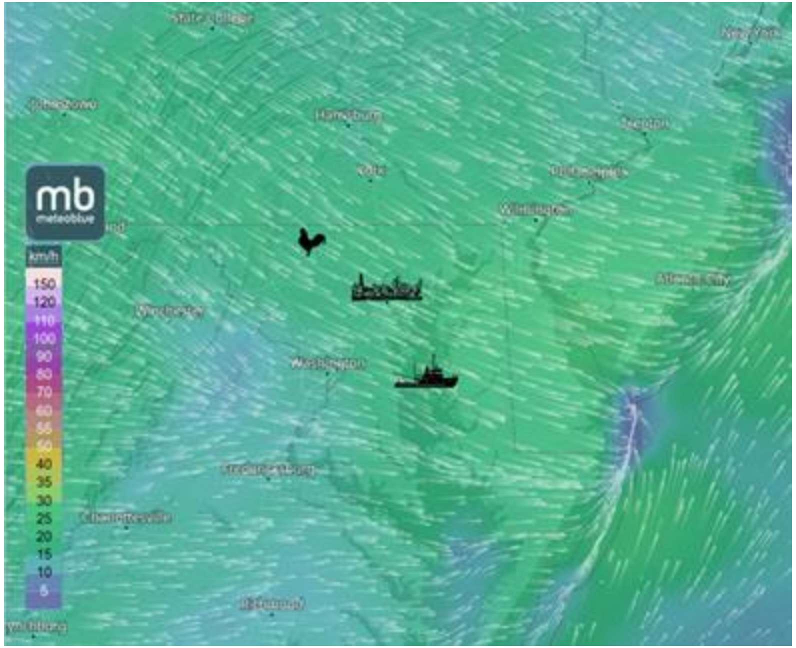
Slide: Sarah Petters

UC RIVERSIDE | College of Engineering – Center for Environmental Research and Technology

Coast-Urban-Rural Atmospheric Gradient Experiment

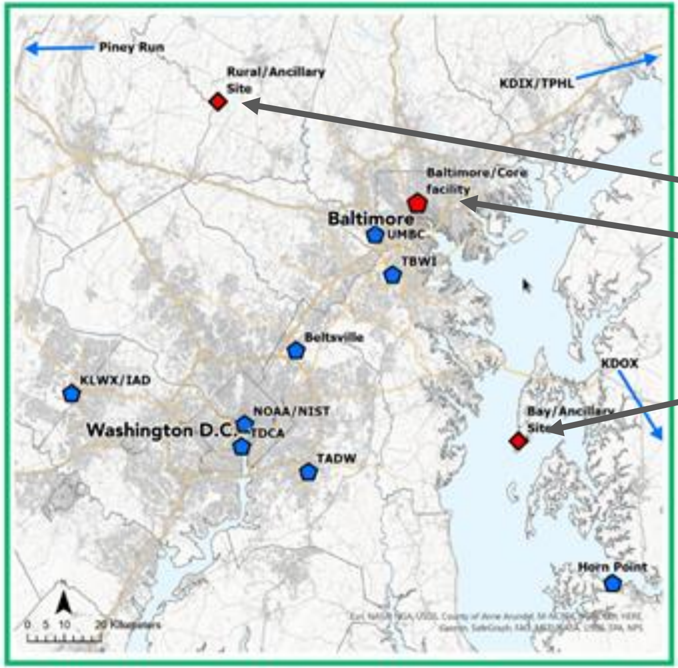


The ARM core facility and ancillary sites (red) will complement an existing regional network of atmospheric profiling and scanning radar stations (blue).



Slide: Sarah Petters

Coast-Urban-Rural Atmospheric Gradient Experiment



The ARM core facility and ancillary sites (red) will complement an existing regional network of atmospheric profiling and scanning radar stations (blue).

- POPS
- RH sensor
- Computer/DAQ
- Vacuum Pump

Roadblocks

- Instrument Uptime
- Temperature (and temperature control)
- Sample RH (measurement and conditioning)
- Clean power and remote access
- Possibility to service instruments/refill fluids
- Instrument calibration drifts
- Remote control