

BER Workshop Brief: Observing Marine Aerosols & Clouds from Ships

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for Atmospheric System Research

BERAC Fall Meeting
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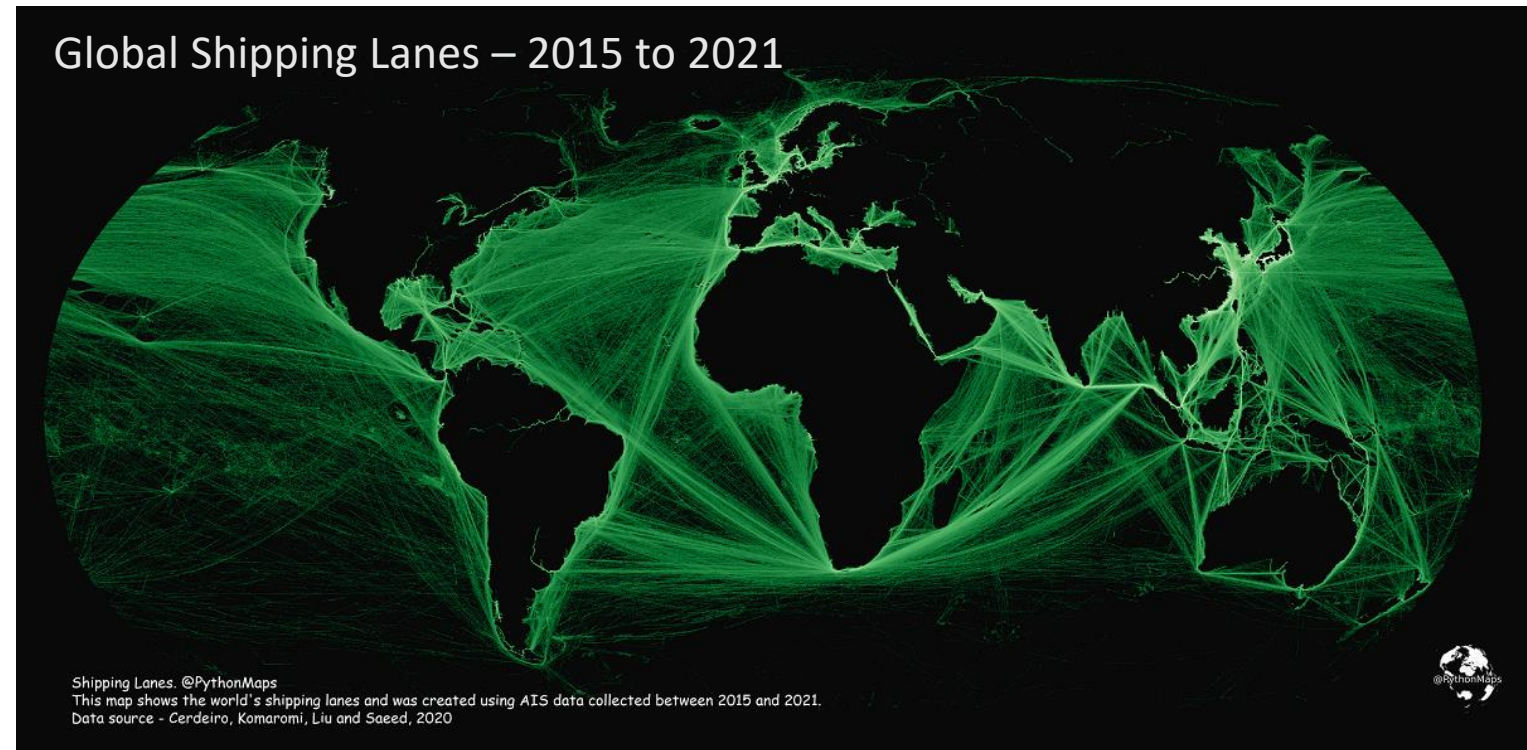
Office of Science

[Energy.gov/science](https://energy.gov/science)

Motivation: there are few surface-based observations of aerosols and clouds over oceans

- Marine aerosol and cloud observations are critical to understanding the Earth's response to climate change
- Surface-based observations are limited
- Typically collected during targeted campaigns (short-term/localized) by research vessels
- Advanced instruments require oversight and operators

What if we could take advantage of commercial ships to make opportunistic measurements?



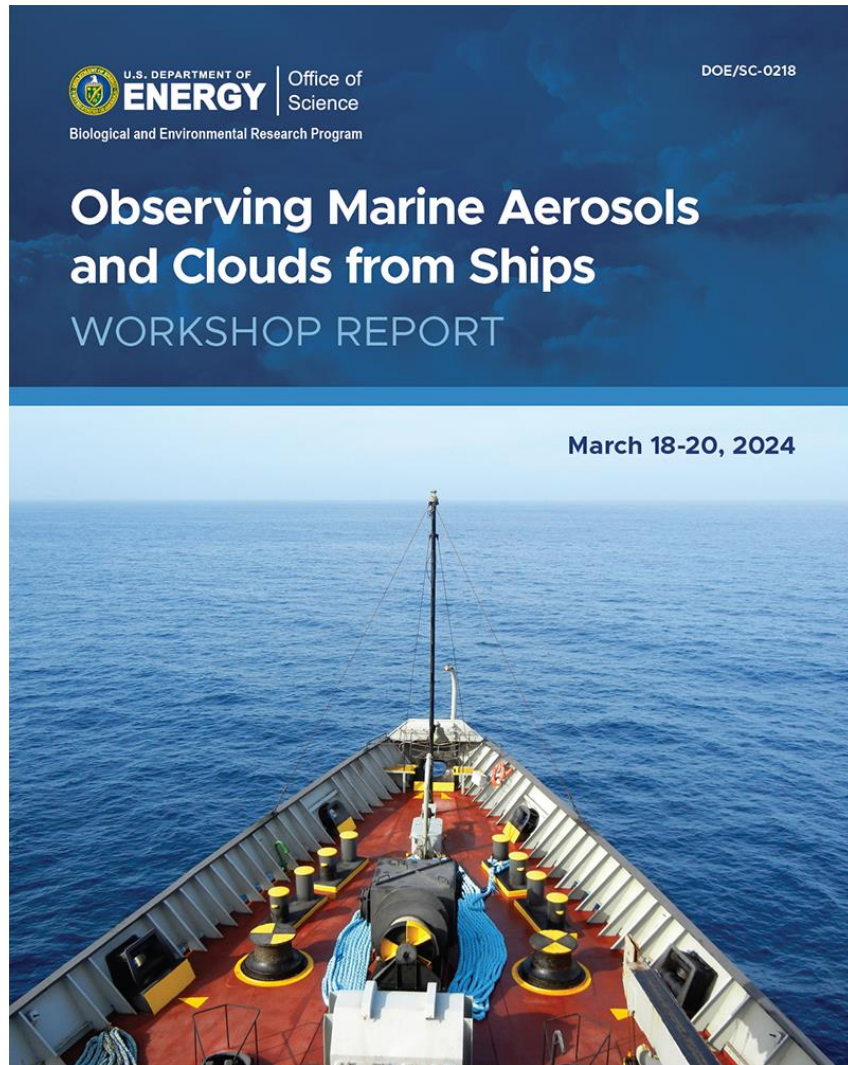
Map by Adam Symington <https://www.visualcapitalist.com/cp/mapping-shipping-lanes-maritime-traffic-around-the-world/>

New direction for BER and ASR in shipborne observations

2024 Congressional appropriations encouraged BER, “to implement a **pilot program** providing instrumentation for observing marine aerosols, greenhouse gases, and other environmental factors as relevant, deployed on commercial or other non-dedicated ocean vessels, and to evaluate a sustained observing network using such platforms”.

- Programmatically within Atmospheric System Research (ASR)
- \$3M in FY24 funds for a pilot project
- New direction for BER and ASR, necessitating a workshop
- Opportunity to take advantage of expertise within ARM for instruments and deployments
- Need to coordinate with other agencies, especially NOAA

Observing Marine Aerosols and Clouds from Ships



Three-day virtual workshop March 18-20, 2024

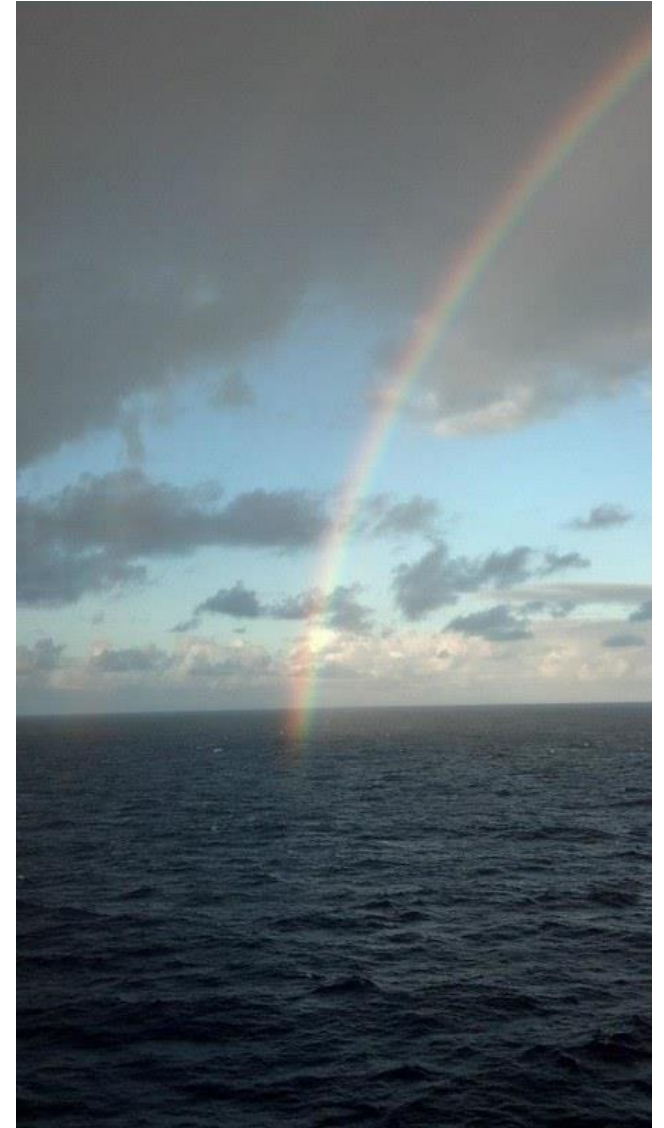
Organized by BER program managers
Shaima Nasiri and Sally McFarlane

26 participants from universities, DOE labs,
NOAA labs, and instrument companies

3 program manager observers from NOAA
and NASA

Developing the workshop

- Initial list of invitees – worked with colleagues in NOAA’s Earth Radiation Budget program
- Shared background information and pre-workshop questions with invitees. (see Appendix E of the report)
- Summarized and synthesized pre-workshop question responses to develop agenda
- Invited additional attendees based on responses
- Invited speakers and breakout session chairs based on the responses
- Developed worksheets for breakout sessions to guide discussion toward outcomes and capture key points – foundation of the workshop report



Workshop Charge

Enable BER to identify high priority targets for a potential pilot program focused on **aerosol, cloud, GHG, and other environmental measurements** from commercial or other non-dedicated ocean vessels traveling in regular shipping lanes.

- Document primary logistical challenges to be addressed for any pilot project and note potential solutions
- Understand the feasibility and challenges of deploying given instrument types on commercial ships and rank instrumentation in terms of feasibility/readiness for commercial ship deployment
- Describe a set of high-priority BER-relevant science questions that might be well-suited to an initial pilot project, the measurements necessary to address them, and logistical challenges that may need to be overcome
- Publish a report of the workshop - May 2024

Agenda



Day 1: Framing and Instruments

- Framing goals of the workshop and how it relates to DOE BER
- Understanding “Ships of Opportunity” & their associated challenges
- Differences between targeted and opportunistic observations
- Feasibility and challenges of deploying unattended meteorology, cloud, and aerosol instruments on commercial ships

Day 2 – Science Questions

- Identifying and discussing pressing aerosol and cloud science questions that are well-suited to feasible instrumentation and opportunistic measurements

Day 3 – Key Elements

- Identifying topics for further discussion: science with a limited set of measurements and key elements of a pilot program
- Planning the workshop report

Logistical challenges

- Developing and maintaining good relationships with shipping companies
- Plans for instrument installation and maintenance in port
- Hardening of instrumentation for marine environments
- Instrument location on the ship, impacts of ship motion and exhaust on measurements
- Data quality control; data transfer and remote monitoring of instruments
- Legal considerations
- Potential hazards and risks



High priority feasible measurements

- Surface meteorology
- Aerosol size distribution from optical particle counter
- Carbon monoxide mixing ratios
- Aerosol number concentration
- Aerosol optical properties (aerosol extinction, scattering, and/or absorption)
- Broadband shortwave and longwave radiation
- Ship position/navigation
- Cloud-base height from ceilometer
- Cloud-base temperature
- Bulk surface fluxes
- Sky conditions/cloud fraction from sky imager
- Liquid water path/integrated water vapor from microwave radiometer
- *Turbulence/updrafts from Doppler lidar (more development needed)*
- *Mobility-based aerosol size distributions (more development needed)*



Workshop Science Question Discussion

Identification of scientific research topics that could be addressed with shipborne measurements, including:

- environmental controls on cloud properties
- aerosol-cloud interactions (many sub-topics)
- marine boundary-layer structure and organization
- marine aerosol formation and growth
- aerosol variability in different ocean regions
- direct radiative impacts of aerosols

Ways shipborne measurements could be used synergistically with satellite observations and targeted field campaigns

Pilot program elements of success (summary)

- Science team with necessary expertise
- Comprehensive science plan with testable hypotheses and analyses of measurements
- Plans for instrument development: hardening, modularization, operational configuration, phased testing and autonomous operations
- Plans for instrument maintenance, calibration, data processing, archiving, and distribution
- Collaboration with or leveraging of existing activities
- Communication plan for engaging the broader scientific community
- Metrics for success



Workshop participants

Breakout Session Facilitators/Lead Report Authors

Allison Aiken, Los Alamos National Lab.

Tim Bertram, Univ. of Wisconsin, Madison

Matthew Christensen, Pacific Northwest National Lab.

Virendra Ghate, Argonne National Lab.

Nicki Hickmon, Argonne National Lab.

Ernie Lewis, Brookhaven National Lab.

Markus Petters, Univ. of California, Riverside

Lynn Russell, Scripps Institution of Oceanography

Adam Theisen, Argonne National Lab.

Robert Wood, Univ. of Washington

Federal Agency Observers

Victoria Breeze, NOAA

Gregory Frost, NOAA

Hal Maring, NASA

Workshop Participants/Additional Report Authors

Magdalena Andres, Woods Hole Oceanographic Inst.

Sarah Brooks, Texas A&M Univ.

Christopher Cox, NOAA, Physical Sciences Lab.

Jessie Creamean, Colorado State Univ.

Darielle Dexheimer, Sandia National Labs.

Graham Feingold, NOAA, Chemical Sciences Lab.

Sonia Kreidenweis, Colorado State Univ.

Raghavendra Krishnamurthy, Pacific Northwest National Lab.

Gourihar Kulkarni, Pacific Northwest National Lab.

Gavin McMeeking, CloudSci, LLC

Timothy Onasch, Aerodyne Research

Patricia Quinn, NOAA, Pacific Marine Environmental Lab.

Shawn Smith, Florida State Univ.

Armin Sorooshian, Univ. of Arizona

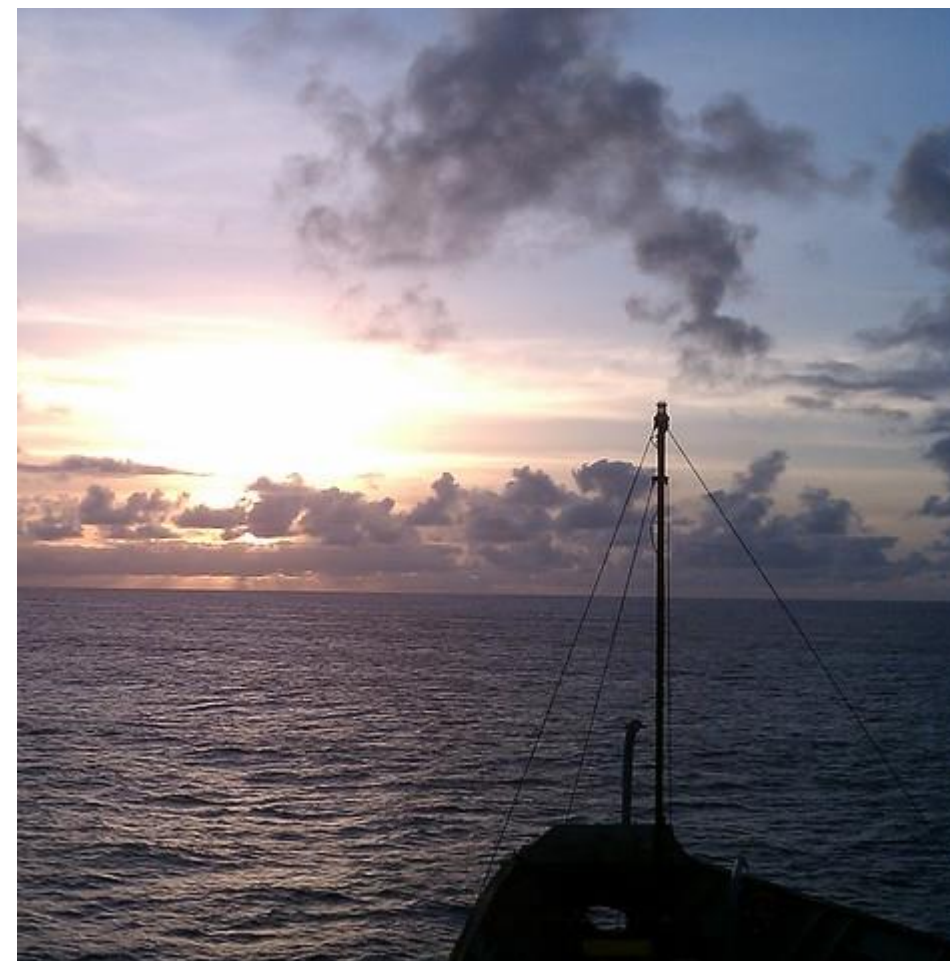
Kerry Strom, Woods Hole Oceanographic Inst.

Janek Uin, Brookhaven National Lab.

Xiaoli Zhou, Univ. of Colorado and NOAA, Chemical Sciences Lab.

Laboratory Funding Opportunity 24-3330

- Pilot Study: Observing Marine Clouds and Aerosols from Ships
- Released May 24, 2024
- Received 5 proposals by 24 July, 2024 submission deadline
- \$3M in FY24 funds available to support a single 3-year research activity
- Scope of Lab Call was informed by the workshop including the “Pilot Program elements of success”
- Required elements: unattended autonomous deployment of instrumentation on a non-research marine vessel for at least one week and a vision for a sustained observation program

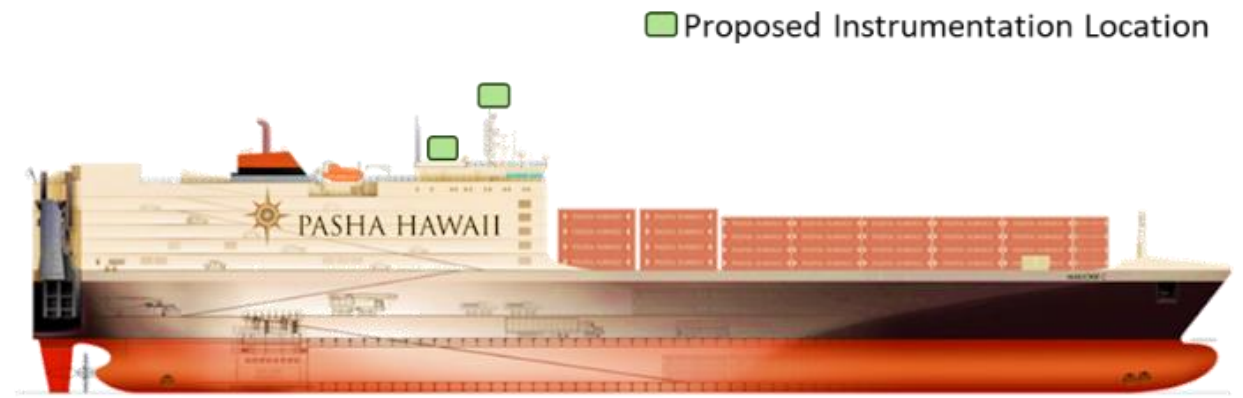


Boundary layer Exploration of Aerosols and Clouds ON ships (BEACONS)

- New ASR Pilot Project (Lab 24-3330)
- Led by Raghavendra Krishnamurthy, Pacific Northwest National Laboratory
- Institutional team members
 - PNNL
 - University of Notre Dame
 - Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES)
 - Woods Hole Oceanographic Institute
 - Scripps Oceanographic Institute
 - NOAA
 - NASA
 - The Pasha Group



Raghavendra Krishnamurthy, PNNL



BEACONS Project Objectives

To demonstrate the *autonomous and unattended deployment* of a shipborne system for making routine observations of key atmospheric, cloud, and aerosol properties that can be used by the scientific community to address key questions relevant to *aerosol-cloud interactions* of interest to DOE.

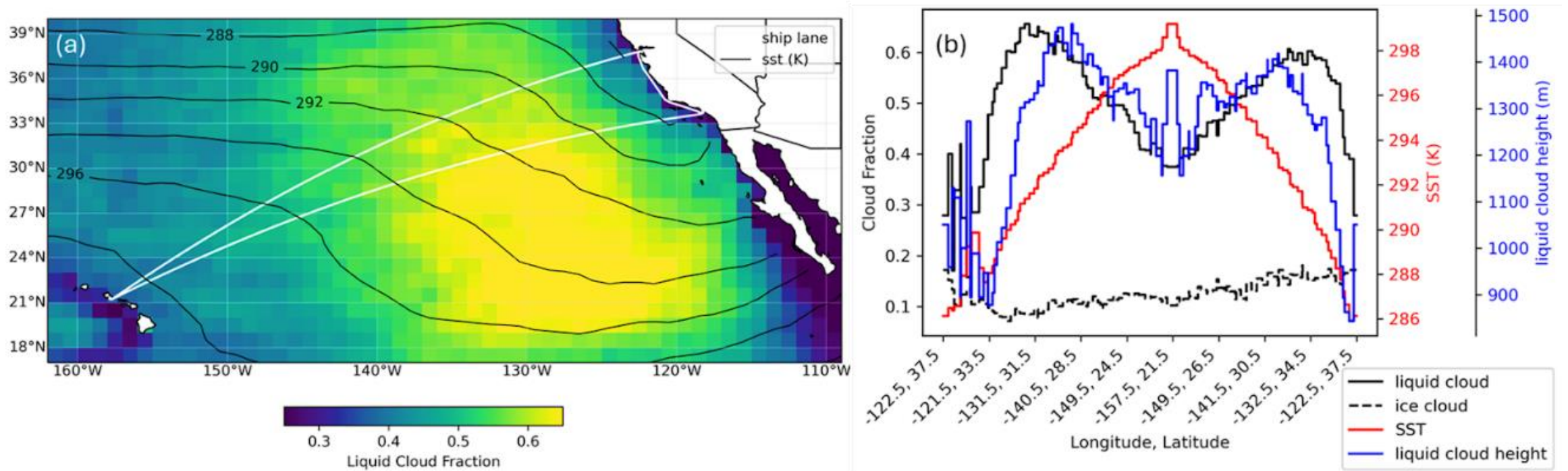


Fig. (a) Annual (2008) daytime mean liquid cloud fraction over the U.S. West Coast and contours of sea surface temperature (black lines) from MODIS and MERRA-2, and with the planned ship route (white lines) between Oakland, Long Beach, and Hawaii and (b) liquid and ice cloud fraction, sea surface temperature, and liquid cloud height along the planned ship route.

Aerosol, Cloud, and Aerosol-Cloud Interactions Hypotheses

BEACONS

BEACONS plans to test 5 hypotheses focusing on outstanding questions about:

Marine aerosol sources, formation, and growth

Assumptions about how marine cloud properties vary throughout the depth of the cloud

Marine aerosol size distribution

The susceptibility of cloud brightness to aerosol properties

Uncertainties in aerosol and cloud radiative effects

Thank you

Workshop report:

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

BEACONS:

<https://www.pnnl.gov/news-media/beacons-sets-sights-data-commercial-ships>

Observing Marine Aerosols and Clouds from Ships

WORKSHOP REPORT

March 18-20, 2024

