



CAARE at the USS Hornet Sea, Air and Space Museum: *Engagement Possibilities Overview*

June 3, 2024

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Introduction

The Coastal Atmospheric Aerosol Research and Engagement (CAARE) Facility aboard the USS Hornet Sea, Air and Space Museum is a program with two key elements: 1) scientific research on the atmosphere and 2) community engagement and education efforts. The CAARE team chose the Hornet as the location for the program due to its unique ability to support both missions.

As a Smithsonian Affiliate with a mission to utilize the USS Hornet and its collections, exhibitions and educational programming to promote awareness and understanding of history, science, technology, and service, the USS Hornet Museum provides an incredible opportunity to engage with students, educators, and community members. For the CAARE effort, it is highly valuable to leverage the Hornet Museum's highly engaged network of students, educators, youth organizations, visitors, volunteers, and collaborators, and we hope to provide mutual value to their organization through high-quality educational and engagement offerings and the unique opportunity to engage with critical climate research and the world-class scientists who comprise the CAARE team.

The research at the CAARE Facility has also drawn interest from scientists, government officials, Indigenous leaders, youth organizations and members of the public from California and around the world. The unique opportunity to help people engage more directly with advanced climate research with implications for society creates many opportunities for educational experiences and events.

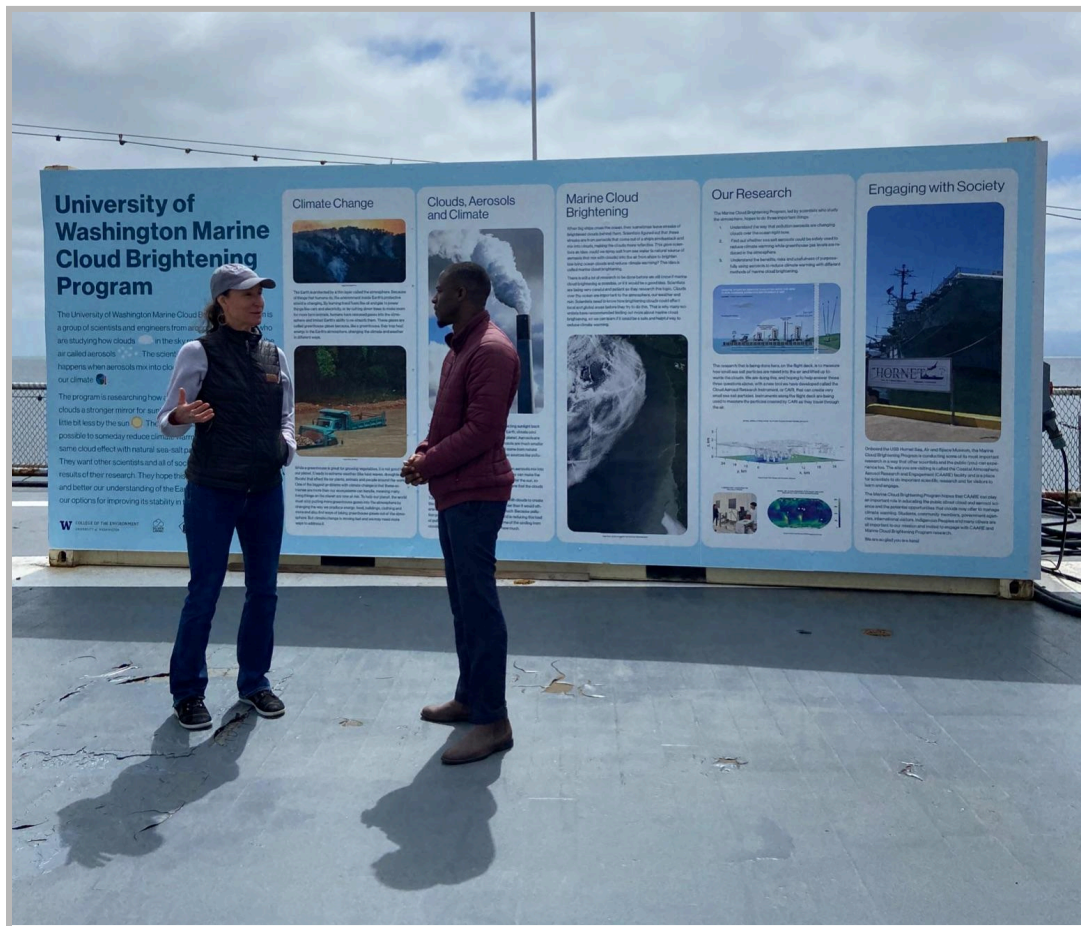
1. Museum Exhibit

The USS Hornet Museum is a spectacular example of an in situ museum experience, where visitors are able to experience the retired aircraft carrier in its original form, augmented and extended by educational exhibits. The CAARE team has deep respect for the Hornet Museum experience and is in the process of crafting a similarly intentioned exhibit, wherein visitors are able to visit the working research elements of the CAARE facility, and engage with educational materials to further their understanding of not only the CAARE research, but of climate change and climate science more broadly. They also can experience what

it's like to be a climate researcher, and engage with the tools and instruments of climate research in a field research setting.

Flight Deck Experiences

The CAARE team developed the beginnings of our Coastal Atmospheric Aerosol Research and Engagement exhibit around the research installation on the Flight deck, beginning with a panel installation describing the real-world relevance, scientific context, and importance of engagement in these studies. This first panel is seen below, installed on the side of a storage container on the flight deck.



Program Director, Dr. Sarah Doherty, with youth climate leader Joshua Amponsem, in front of the CAARE education panel installed on the Hornet Flight Deck.

Coastal Atmospheric Aerosol Research and Engagement

The University of Washington Marine Cloud Brightening Program is a group of scientists and engineers from around the world who are studying how clouds in the sky react to tiny particles in the air called aerosols. The scientists are studying what happens when aerosols mix into clouds and the impact this has on our climate.

The program is researching how aerosols from pollution make clouds a stronger mirror for sunlight so that the Earth is heated a little bit less by the sun. They are investigating if it might be possible to someday reduce climate warming by producing the same cloud effect with natural sea-salt particles from the ocean. They want other scientists and all of society to have access to the results of their research. They hope this will inspire further science and better our understanding of the Earth's changing climate and our options for improving its stability in the coming decades.



Climate Change



The Earth is protected by a thin layer called the atmosphere. Because of the greenhouse effect, the atmosphere traps Earth's temperature, which is changing. By forming heat-trapping clouds and greenhouse gases, the atmosphere is trapping heat in the atmosphere. This is causing the Earth to warm up. Scientists are studying how to reduce the amount of greenhouse gases in the atmosphere. They are also studying how to reduce the amount of greenhouse gases that are being released into the atmosphere.



While a greenhouse is great for growing vegetables, it is not good for our planet. It traps heat in the atmosphere, which makes the Earth warmer. This is causing the Earth to warm up. Scientists are studying how to reduce the amount of greenhouse gases in the atmosphere. They are also studying how to reduce the amount of greenhouse gases that are being released into the atmosphere.

Clouds, Aerosols and Climate

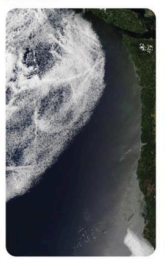


Clouds in the sky are the mirrors for the sun, reflecting sunlight back to space. By reflecting sunlight away from the Earth, clouds cool the planet. This is why clouds are so important. They are also the source of rain. Clouds are made of tiny water droplets. These droplets are held together by tiny particles called aerosols. Aerosols are tiny particles in the air that can be natural or man-made. They can be dust, sea salt, or pollution. They can be good or bad for the environment. They can be good for the environment because they can help cool the planet. They can be bad for the environment because they can cause global warming. Scientists are studying how to reduce the amount of aerosols in the atmosphere. They are also studying how to reduce the amount of aerosols that are being released into the atmosphere.

Marine Cloud Brightening

When bright clouds are in the sky, they sometimes have a cooling effect on the planet. Scientists are studying how to make clouds brighter. This is called marine cloud brightening. Scientists are studying how to make clouds brighter by adding sea salt to the air. This is called marine cloud brightening. Scientists are studying how to make clouds brighter by adding sea salt to the air. This is called marine cloud brightening.

There is still a lot of research to be done before we will know if marine cloud brightening is a good idea. Scientists are studying how to make clouds brighter. This is called marine cloud brightening. Scientists are studying how to make clouds brighter by adding sea salt to the air. This is called marine cloud brightening.

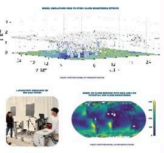


Our Research

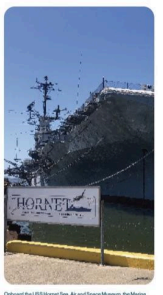
The Marine Cloud Brightening Program has three important things to do. 1. Understand the way that pollution makes our atmosphere warmer. 2. Find out what we can do to reduce the amount of pollution in the atmosphere. 3. Understand the benefits, risks and feasibility of purposely making particles in the air to make clouds brighter with different methods of marine cloud brightening.



The research that is being done here, on the flight deck, is to measure how much aerosol particles are in the air and how they affect the clouds. We are doing this, and trying to help answer these three questions about the way that aerosols affect the clouds. The Cloud Aerosol Research Instrument, or CARI, can create very small sea salt particles. Instruments along the flight deck are being used to measure the particles created by CARI as they travel through the air.



Engaging with Society



Onboard the USS Hornet, the Air and Space Museum, the Marine Cloud Brightening Program is conducting a series of educational activities for the public. These activities include: 1. Public tours of the flight deck. 2. Public lectures on the science of clouds and aerosols. 3. Public discussions on the benefits and risks of marine cloud brightening. We are also doing a lot of outreach to the public. We are doing this by talking to the public about our research. We are also doing this by talking to the public about the benefits and risks of marine cloud brightening. We are also doing this by talking to the public about the science of clouds and aerosols.

The CAARE education panel installed on the Hornet Flight Deck.

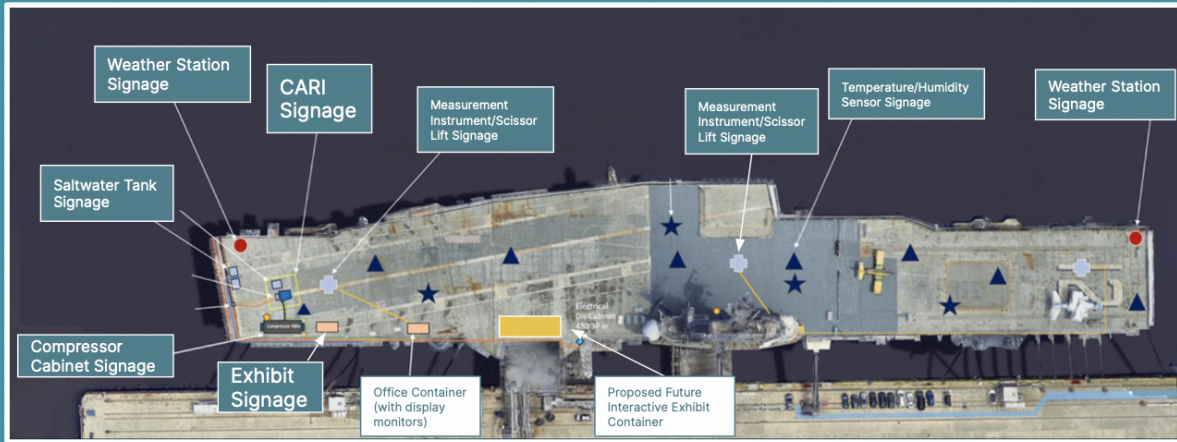
This panel is the first element of a planned, more extensive exhibit of installations across the Flight Deck, including both large panels and signage on instrument stations and on the Cloud Aerosol Research Instrument (CARI) explaining:

- the science behind and the purpose of CARI, the Cloud Aerosol Research Instrument at the heart of the CAARE studies;
- the specialized research instruments collecting the study data along the length of the Flight Deck;
- the program's specialized weather stations distributed throughout the Flight Deck, measuring things such as wind speed, wind direction, and humidity;
- the deep meteorological history of the Hornet, which was an early example of advanced technologies like weather balloons, and how this connects to the research studies of the CAARE program.

These educational supplements will be located at various positions across the Flight Deck, as depicted in the layout shown below. The Flight Deck is the primary focus of our exhibit planning, as it is the site of the CAARE study setup, but unguided programming will also extend into the interior of the ship.



Hornet Flight Deck Content



The proposed layout of educational and interactive content on the Hornet Flight Deck.

Interactive Science


Moving forward, the CAARE Facility hopes to further extend the exhibit component of the program to include an exhibit container, similar to the existing office container, on the Hornet's Flight Deck. This would provide an opportunity for all visitors to the Museum to experience, at their own pace, a scaled-down version of the Field Trip and Experiential Learning opportunities we have developed, featuring a single nozzle from the CARI nozzle matrix, an additional TV screen playing the aforementioned videos, handheld particle counters to contextualize the specialized CAARE research instruments, and additional displays further explaining the importance of atmospheric aerosol research in the current climate science landscape.

Hangar Deck Experiences

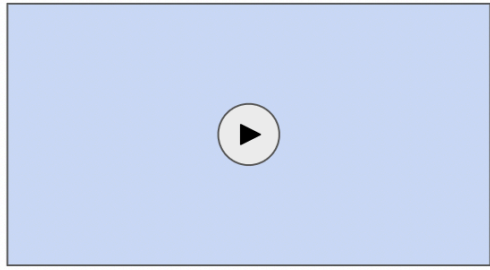
On the Hangar Deck, where visitors enter the USS Hornet Museum, the CAARE exhibit will include video kiosks for individuals and small groups to select videos and a mini-theater featuring a large-scale screen for groups, with options to play short, high-quality educational videos related to the CAARE studies and climate and atmospheric science:

- A TED Talk by the program’s director, Dr. Sarah Doherty, on the science questions and research being explored at CAARE.
- A video short produced by the American Geophysical Union on the University of Washington’s Marine Cloud Brightening Program
- *In production*: A CAARE-produced video with an overview of the scientific research efforts of the CAARE Facility and interactions with visitors
- *In production*: A video produced in collaboration with the Hornet Museum on the meteorological history of the USS Hornet, climate change and the City of Alameda, and the connections to atmospheric and climate science and the CAARE Facility studies.

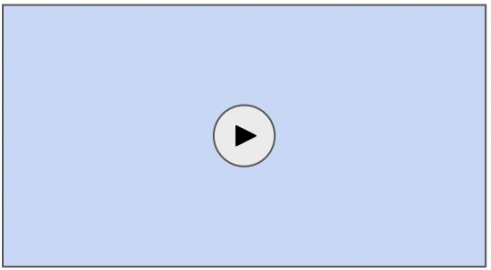
CAARE Exhibit Theater



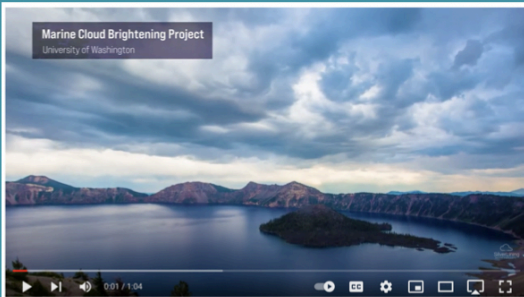
How aerosols brighten clouds — and cool the planet
379,194 views | Sarah J. Doherty | TED2024 • April 2024



Science and Engagement at CAARE



USS Hornet x CAARE: From Analog to Modern Weather Sensing



UW Marine Cloud Brightening Project @ AGU 2021: Short Video

The video selection available for visitors to choose from in the Hangar Deck theater.

Other video content and programming will be explored over time.

2. Educational Experiences and Opportunities

Just as the CAARE Facility aims to engage in high-quality scientific research, it is also a top priority to engage the community with this research. One of the most exciting ways that this will manifest at the Museum is through Educational Experiences aboard the Hornet, in which students are taught history and science concepts in an interactive and fun manner that dives deeper into certain areas of relevant STEM and history learning.

The CAARE team is fortunate to have the opportunity to build off of the incredible work of the Hornet Museum's educational team and have developed additional CAARE-related subjects and activities for educators to choose from when they pick programming for their student visits to the ship. Having received organic outreach from teachers wanting to bring their students to the Museum to witness and experience the CAARE facility, we are delighted to launch this component of the CAARE Facility in the fall, when school groups resume visits to the ship.

K-2 Students:

- As part of the STEM to Stern Junior program, the CAARE Facility will offer "Cool Clouds," an activity station educating the Museum's youngest visitors about clouds, sunlight, and sea salt. Students will learn the basics of cloud reflectivity, how sunlight affects temperature, and how clouds are formed over the ocean by particles like sea salt. *This will include an activity studying how best to reflect a flashlight beam.*
- As part of the existing Flight Deck Module, students will be introduced to the CAARE facility, and the role of climate science in the time of the Hornet's service and now.

3-8 Students:

- As part of the STEM to Stern Junior program, the CAARE Facility will offer "What's Up in the Air?," an activity station designed to familiarize students with the basic concepts of atmospheric aerosols, the differences between greenhouse gas pollution and particulate pollution, and the basic concepts of the CAARE studies. *Students will use handheld particle counters to simulate the data collection of the specialized CAARE instruments, and to better understand the idea of background aerosol content. Students can*

learn about science communication as they self-develop a way to present their findings.

- As part of the existing Flight Deck Module, students will be introduced to the CAARE facility, the role of climate science in the time of the Hornet's service and now, and the importance of sensing and data collection in climate science.

High School Students:

- As part of the STEM to Stern program, the CAARE Facility will offer "Is Your Head in the Clouds?," an introduction to the CAARE studies and the basic science principles underlying the research. Students will learn about the unique coastal advantages provided by the Bay Area climate, and devise new versions of the CAARE study with modifications to certain variables, learning about research design and the creativity of the scientific process.
- As part of the existing Flight Deck Module, students will be introduced to the CAARE facility, the role of climate science in the time of the Hornet's service and now, and the importance of sensing and data collection in climate science. Students will use hand-held instruments and compare these with findings from the computer displays showing the more sophisticated instruments' graphs, in the context of learning more about particulate pollution, and connecting this to California's wildfires. They will learn the differences between particulate and greenhouse gas pollution, and discover the counterintuitive cooling effects of particulate pollution.

Special Student Events:

- For any student or youth group wanting to learn more about the CAARE Facility, our team will work collaboratively to customize our educational offerings to their needs and interests. For certain events, we are excited to offer interactions with the scientists leading the CAARE Facility, and to offer tours of the CAARE Facility Office, the compressor cabinet, and an up close look at the Cloud Aerosol Research Instrument (CARI) and associated measurement equipment.

School and Youth Group Outreach Education:

- The CAARE program has already received requests for its scientists to speak in local schools and to local groups including Girls Inc. of the Island

City. The CAARE Program is women led and diverse in composition, providing opportunities for representation and engagement that supports sensitivity to a wide array of stakeholders.

Adults:

- Adults are also welcome to engage with the CAARE Facility and the CARI system. This opportunity will focus on the distinction between particulate and greenhouse gas pollution, and their respective cooling and heating effects. Visitors will learn more about climate modeling, and how the CAARE studies aim to contribute to higher-resolution models. This activity will culminate in a discussion about open science, and strategies for discussing climate topics in simple and accurate ways.
- The CAARE team has received requests from local communities (Woodstock Homes), Philanthropic Foundations, businesses, Universities and technology groups to arrange guided visits as a group. It has also received requests from international research teams, Indigenous organizations and even a specialty tour company, to arrange group visits. There are many opportunities to support these engagements for local Bay Area groups and interested non-local groups.

3. Field Trips

General Hornet Field Trips

The Hornet operates many field trips for students on school and extracurricular visits. These trips involve multiple stops throughout the USS Hornet including a visit to the Flight Deck. The Flight Deck is a stop on these tours, and as we return to school-focused programming in the fall, a CAARE Facility stop could be rolled into the existing Field Trip stop list. As such, these tours would then include stops for students to:

- Tour the historic Navigation Bridge where the captain commanded
- Learn how aircraft were launched and recovered on the Flight Deck with its catapults and control tower

- ***Learn how the early analog technology of the Hornet connects to the modern day technology of the CAARE Facility research studies***
- Learn how 15 men worked together to fire the big 5-inch guns
- See historic aircraft on the Hangar Deck
- Experience how the crew lived below decks in their own “city”
- Walk on the footprints of the astronauts’ first steps back on earth
- See the Mobile Quarantine Facility used by the Apollo 14 astronauts and an Apollo 11 test capsule.

The flight deck is a beloved part of the Hornet Museum. It is often where school groups choose to eat their lunches and enjoy free time. The CAARE team is thrilled to further enhance this portion of the museum by providing an additional engagement point for students to connect the rich history of the ship with modern science inquiry.

CAARE-Focused Field Trips

We are also excited to offer CAARE-Focused field trips at the Museum, taking advantage of the unique access to the CAARE Exhibit, CAARE Educational Programming, and the CAARE Research Facility. For student groups, extracurricular STEM groups, or any other interested organization, field trip content will be tailored by age group along the lines of the prior descriptions. In general, these tours will include:

- A video introduction to the CAARE Facility and its climate and atmospheric science, featuring CAARE team members in addition to youth climate leaders, discussing the science problem at hand, the research conducted at CAARE, and the importance of engagement with students, community members, and the public in the scientific process.
- A visit to the USS Hornet’s island, the ship’s large turret, where students will learn about the aircraft carrier’s historic connection to weather technology and meteorology. This stop on the trip will expose students to the impressive analog instruments that were used on the Hornet during her service, and their role in contributing to the development of weather technologies that we enjoy today.

- This stop will then transition to the Flight Deck of the ship, where students will learn more about the coastal aerosol studies taking place at the museum. This part of the tour will begin with a look at the CAARE Facility's weather stations, and how these exist as an evolution of the Hornet's weather sensing capabilities.
- After a familiarization with the research set-up on the Flight Deck, students will have the opportunity to take this research into their own hands. With handheld particle counters, the students will have the opportunity to measure the background aerosol present in the Bay air, and to understand how this relates to the very similar use of the Cloud Aerosol Research Instrument and its complementary, specialized measurement instruments. Students will also have an activity opportunity to map the data that they can see on paper, and to compare this to monitor screens showing the data collected from the advanced sensing instruments.
- *Where it is possible to include demonstration of the CARL instrument, students can use their handheld instruments to experience being part of a scientific research study, seeing the generation of salt-spray, measuring particles and viewing the changes in the measurements on the instruments screens, with interactive dialogue on what the measurements — and the science — are saying.*
- The tour will conclude with a contextualization of this research in the climate science space, and a brief video that conveys the exciting careers available in climate science research, and the importance and optimism of such a career in the face of our changing climate.
- All of these special tours will be led by docents specially trained in the CAARE Effort and the basic science that underlies the CAARE Facility research in addition to the rich history of the USS Hornet as a meteorological facility.
- For special programming events, these tours will be led in part by, and concluded by, a talk with the scientists that work on these studies.
 - One example of a key priority group for the CAARE team is young women interested in STEM. The CAARE effort is led by women, and in that vein, some of the first experiences that we are working to arrange are with Girls Inc. of the Island City and with the Hornet Museum's Women in STEM events.



Two particle sensing instruments to be used for student and engagement activities at the CAARE Facility.

4. Community Engagement Events

The CAARE Facility is delighted to operate within the engaged communities of the USS Hornet Sea, Air and Space museum and the broader City of Alameda. While climate science, climate research, and climate interventions can be polarizing topics, the CAARE team values the opportunity to collaborate with the local community to engage in learning and dialogue with one another, alongside CAARE leadership, visiting scientists, and global climate leaders.

The USS Hornet Museum offers a special opportunity for events big and small — the ship can comfortably host an intimate dialogue with ten people, or a lecture series seating hundreds. The CAARE team is excited to collaborate with local organizations, alongside the City leadership, to determine what events are of interest and value to the local community — from parent/child activity days, to panel discussions with visiting experts, to climate science career events.

The CAARE team understands that engagement and dialogue is crucial to the human side of the studies being undertaken, and to climate science more broadly. We hope that the Alameda community will see this facility as a foundation to explore, educate, and discuss these important and challenging issues.

Proposed events include:

- July 2024: CAARE Exhibit Grand Opening — coinciding with the Hornet's Celebration of the Apollo Splashdown, an official opening of the CAARE Exhibit recognizing city leaders and their team and including a cross section of community members, supporters and climate science stakeholders.
- September 2024: Climate Resiliency Dialogue — this will be a convening of local and global experts to discuss relevant topics in climate resiliency research and policy at the local and global level. With a dialogue for adults and science activity for children, this event will be open to all community members and focus on the context of Alameda's resiliency efforts while maintaining a view to similar conversations globally.



CAARE team members speaking at the 2024 Woodstock Homes Earth Day Fest.

5. Expert Visits and Workshops

The CAARE Facility is a very unique platform globally. There are very few real-world research studies on this crucial topic in climate science: cloud aerosol

interactions. Equally importantly, no similar projects operate in an open, publicly accessible format that encourages public participation and engagement.

This facility was designed with transparency and collaboration at its core, and this means exposing the facility to global experts in science and engagement beyond the core CAARE team. We are excited, throughout the lifespan of the CAARE Facility, to host global experts, government agencies, youth climate leaders, Indigenous Peoples, emerging career researchers, and more, at the Museum. Not only do we know that they will add value to our research, but we hope to offer useful and innovative programming to further this field of research both globally and domestically.

This will also be a unique opportunity for the Alameda community to engage with these stakeholders. Those experts who we have spoken to about the CAARE efforts are deeply impressed by the open nature of this science, and hope to connect meaningfully with the local community when they visit the CAARE Facility.

Proposed events include:

- November 2024: Global Young Leaders Workshop — coinciding with the Hornet's youth science fair, bringing together young climate leaders from different parts of the world to engage with the CAARE Facility and CAARE scientists together with local youth.
- Fall 2024: Atmospheric science workshop — convening scientific research experts from leading institutions and government agencies in the US and other countries to engage with studies and meet on atmospheric science.