ARM

CLIMATE RESEARCH FACILITY

ARM AERIAL FACILITY

Overview

Sponsored by the U.S. Department of Energy Office of Science's Office of Biological and Environmental Research, the Atmospheric Radiation Measurement (ARM) Climate Research Facility maintains field sites in Oklahoma, Alaska, and the tropics to obtain continuous measurements of cloud and radiative properties for improving climate models. In addition, the ARM Mobile Facility provides flexible instrument platforms for conducting experiments lasting a minimum of six months.

To supplement these capabilities, the **ARM Aerial Facility** (AAF) provides airborne measurements required to answer science questions proposed by the international research community. Data obtained from the aircraft are documented, checked for quality, integrated into the ARM Data Archive, and made freely available in a timely manner for use by the scientific community.

The AAF enhances the utility of long-term ground-based measurements by providing:

- in situ measurements of clouds, aerosols, and gases for evaluating and improving remote sensing retrievals
- spatial sampling not possible from the ground to provide context for and extend ground-based measurements, such as ice crystal habit or aerosol size distributions
- aircraft measurements for data sets used in testing and evaluating high-resolution models and model parameterizations.

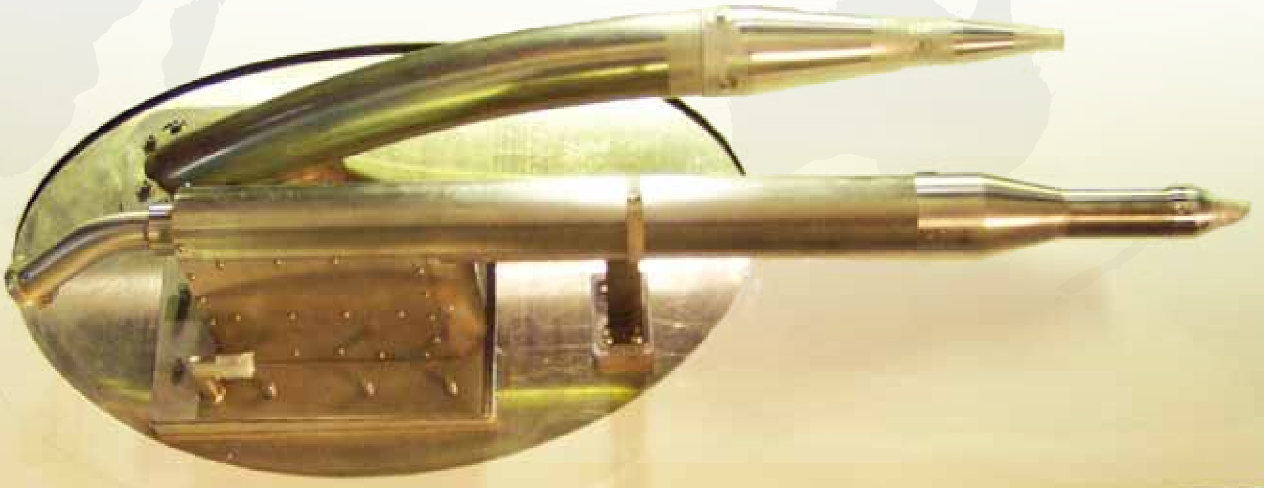
AAF campaigns usually take place in concert with one of the ARM fixed sites or the ARM Mobile Facility.

Aircraft choice for AAF field campaigns is dictated by science requirements—such as the required measurements and desired flight profile—and aircraft availability. Depending on the science objectives, either multiple aircraft platforms or a Gulfstream-1 (G-1) aircraft are available to address the wide range of aircraft measurement requirements associated with atmospheric science issues.

Baseline Instrumentation

The following instruments represent available capabilities of the AAF. The needs of each field campaign will be assessed, and additional instruments may be added upon request.

- 2-Dimensional Stereo Probe (2D-S)
- Aerosol Humidigraph
- Aircraft Integrated Meteorological Measurement System (AIMMS) - 20
- Cavity Ring Down (CRD) System
- Cloud Aerosol and Precipitation Spectrometer (CAPS)
- Cloud Droplet Probe (CDP)
- Cloud Integrating Nephelometer (CIN)
- Cloud Particle Imager (CPI)
- Cloud Spectrometer and Impactor (CSI)
- Counterflow Virtual Impactor (CVI)
- Dual-Column Cloud Condensation Nuclei Counter (CCNC)
- Fast-Cloud Droplet Probe (F-CDP)
- Fast-Forward Scattering Spectrometer Probe (F-FSSP)
- High Volume Precipitation Spectrometer Version 3 (HVPS-3)
- Hygrometers
- Infrared Thermometers
- Multi-Element Water Content System (WCM-2000)
- Multifilter Radiometer (MFR) with a 1.6 µm channel
- Particle in Liquid System (PILS)
- Photo-Acoustic Soot Spectrometer, 3 wavelength (PASS-3)
- Pyranometers (SPN-1)
- Scanning Mobility Particle Sizer (SMPS)
- Single Particle Soot Photometer (SP2)
- Trace Gas System
- Ultra-High Sensitivity Aerosol Spectrometer (UHSAS)



2008: Indirect and Semi-Direct Aerosol Campaign

In April 2008, the Indirect and Semi-Direct Aerosol Campaign (ISDAC) took place at the ARM North Slope of Alaska site in Barrow. The National Research Council of Canada's Convair-580, with more than 40 instruments on board, gathered information about atmospheric state, cloud microphysics, aerosol properties, and visible and infrared radiation. Ground-based instruments at Barrow and Atqasuk, Alaska, gathered complementary data to help understand the impacts that aerosols have on Arctic clouds and climate.

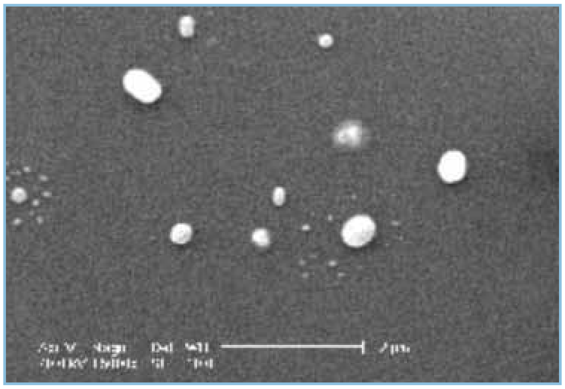
Aerosols—tiny airborne particles from both natural and man-made sources—can affect Earth's climate in two ways: directly, through scattering and absorption of solar and infrared radiation; and indirectly, by influencing the creation (or nucleation) of cloud droplets and ice crystals, leading to increased surface area and reflectivity of clouds.

ISDAC took place during International Polar Year, when other complementary studies occurred, including two sponsored by the National Aeronautics and Aerospace Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA).

This probe "boom" on the wing of a Canadian National Research Council's Convair 580 includes a variety of instruments to measure total water content, liquid water content, temperature, and pressure.

Research flights by the Convair-580 were coordinated with three NASA and one NOAA aircraft when possible, as well as with satellite overpasses.

Two of the 42 instruments onboard the Convair-580 had never flown in an official airborne research mission before. The Single Particle Laser Ablation Time-of-flight mass spectrometer (SPLAT) obtains size-resolved aerosol composition data, while the Continuous Flow Diffusion Counter (CFDC) provides measurements of aerosols and ice nuclei concentration. Information gathered through ISDAC will result in a comprehensive data set that scientists will use to examine the effects of aerosols on clouds and improve the way those processes are represented in climate models.



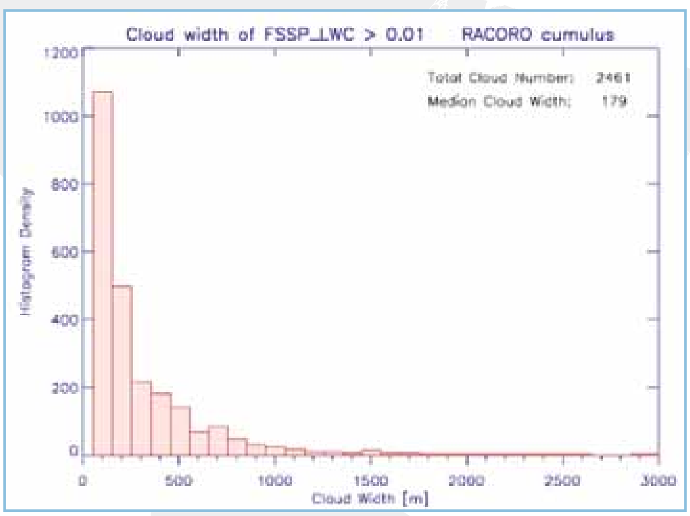
Preliminary screening and analysis of images from the time-resolved aerosol collector indicate particles laden with carbon and sulfur. These data were obtained on April 8, 2008.

2009: Routine AAF Clouds with Low Optical Water Depths (CLOWD) Optical Radiative Observations

Between January and June 2009, the AAF sponsored a first-of-its-kind long-term airborne research campaign to obtain data from low-level clouds above ARM's Southern Great Plains (SGP) site. This campaign, called RACORO, was centered near Lamont, Oklahoma, a mid-latitude region that experiences a wide range of cloud types, including the "thin" clouds that were the focus of this campaign.

Thin clouds contain so little water that the sun can be seen through them. These "clouds with low-optical water depths" are often tenuous and scattered, and ground-based instruments have trouble accurately measuring properties such as water content and water droplet size. These properties determine the amount of sunlight that is transmitted or reflected by the cloud—an important component in modeling Earth's climate.

The CIRPAS Twin Otter aircraft flew 59 flights and 259 research hours, outfitted with instrumentation and sensors to obtain measurements of cloud microphysics, radiometric quantities, atmospheric state, and aerosol properties. Data gathered during this campaign will provide researchers with a statistically relevant data set of boundary-layer clouds and aerosols for future study.



The types of low-level clouds sampled during RACORO are often tenuous and occur in partly cloudy skies, making it difficult to use remote sensing to accurately retrieve the microphysical and radiative properties needed to characterize them and improve their representation in climate models. For example, this figure depicts the frequency distribution of the widths of the cumulus clouds as sampled by the CIRPAS Twin Otter during RACORO. The distribution peaks for the smallest cloud widths, with a median width of 179 m.

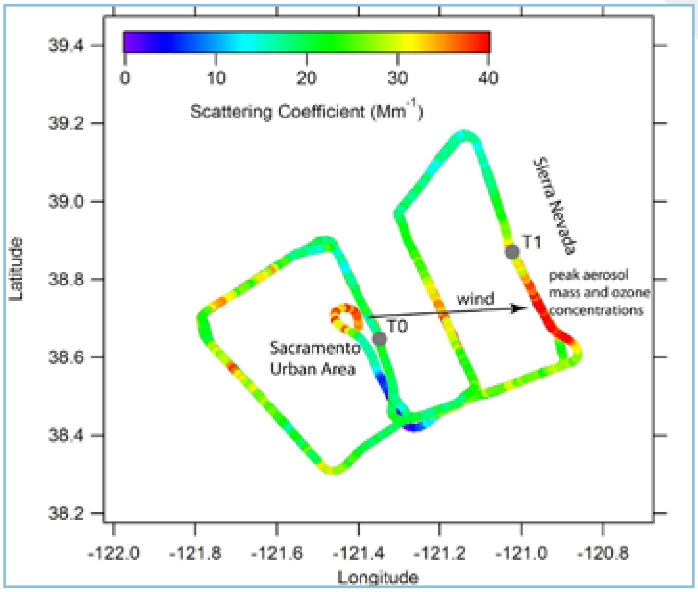
2010: Carbonaceous Aerosols and Radiative Effects Study

In June 2010, as part of the Carbonaceous Aerosols and Radiative Effects Study (CARES), the G-1 research aircraft and two instrumented ground stations were deployed in the area of Sacramento, California. The instruments gathered trace gas, aerosol, and meteorological measurements that will allow researchers to investigate the ways in which atmospheric aerosols and their climate-affecting properties evolve as they travel and age. More than 60 scientists from a dozen institutions participated in the campaign.

An "urban plume" refers to air that becomes distinct from the surrounding air as it passes over and mixes with material from an urban area. During summer, the transport of the urban plume above Sacramento is controlled by regular wind patterns that draw polluted air to the northeast, over oak and pine trees in the Sierra Nevada's Blodgett Forest area, by late afternoon. Because of this consistency, the Sacramento-Blodgett Forest corridor is ideally suited for sampling aerosol and precursor trace gases as they evolve during transit.

Several studies have shown that current models significantly underpredict secondary organic aerosol formation in the urban atmosphere and upper troposphere. Evolution of black carbon aerosol and its optical properties are also poorly represented in current models. The knowledge gained from detailed analysis of the data gathered during CARES will be integrated into regional and global aerosol models used to simulate the ways that aerosols affect climate.

Recovery Act Enhancements: Funding from the American Recovery and Reinvestment Act of 2009 has enhanced the G-1 with an onboard gigabit local area network (LAN) system capable of data transfers up to 125 megabytes per second. The updated data system allows scientists to remain safely seated while monitoring data gathered during flights, while scientists on the ground can monitor real-time data during flight operations and coordinate with onboard scientists using instant messaging.



Spatial distribution of aerosol light scattering coefficient for 550 nm (green) wavelength on the afternoon of June 28, 2010, showing the presence of the Sacramento aerosol plume in the Sierra Nevada foothills area east of the urban source region. The measurements were taken aboard the G-1 aircraft. Also shown in the picture are the locations of the two ground sites–T0 and T1.

Additional Capabilities

Aircraft Coordination

AAF campaigns often involve the coordination of multiple aircraft from multiple agencies. Seven different aircraft, including a helicopter, participated in the Cloud and Land Surface Interaction Campaign (CLASIC), which took place at the SGP site in 2007. CLASIC also collaborated with two additional aircraft from the DOE's Atmospheric Science Program's Cumulus Humilis Aerosol Plume Study (CHAPS), allowing the science team to identify areas of overlap where measurements from one campaign complemented measurements from the other. More recently, the G-1, a NASA King Air B-200, and NOAA's Twin Otter flew coordinated research flights to gather trace gas and aerosol measurements during the CARES campaign in June 2010.

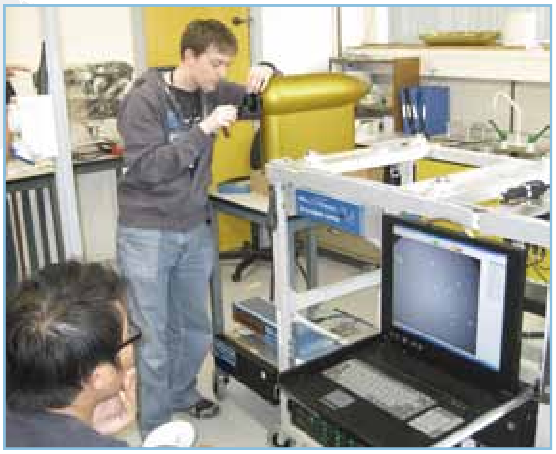
In addition to targeted field campaigns, the AAF also conducts other operations, including routine long-term flights and ground-based instrument calibration.

2008–2011: ARM Airborne Carbon Measurements

As part of a long-term study of atmospheric carbon composition and carbon cycling, a Cessna Turbo 206 is obtaining airborne carbon measurements on a routine basis over ARM's SGP site. Airborne measurements of carbon cycle trace gases will provide data for quantifying regional carbon exchange and tracing the balance between anthropogenic (human-produced) emissions and biogeochemical cycling, which are identified as priorities by the U.S. Climate Change Research Program and the North American Carbon Program.

2009: Cloud Probe Calibration Studies

In 2009, the ARM Climate Research Facility sponsored a series of calibration studies in the United Kingdom and Canada for the cloud extinction probe and the cloud particle imager (CPI). Both instruments were used in past field campaigns and will be used again in future campaigns. The calibration efforts explored the potential for these instruments to provide additional valuable information to the data collected during these campaigns.



Instrument technicians at the University of Manchester participate in the CPI calibration study.

Proposals for conducting field campaigns at ARM sites are welcome from all members of the scientific community.

Each year, a call for proposals to use the ARM Facility is issued via advertisements in scientific news publications and on the ARM website. The proposal cycle generally begins around November.

Full proposals are reviewed each August at the annual meeting of the ARM Science Board. While considering their recommendations, acceptance of the proposal remains at the discretion of DOE program management.

Although ARM does not provide direct funding for scientific research, it may provide limited funding to assist with logistics, development of datastreams and archiving, and other infrastructure activities associated with using the Facility. Research funds for successful proposals will be provided by the Atmospheric System Research program.

http://www.arm.gov/campaigns/propose

http://www.arm.gov/sites/aaf

U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM-10-033