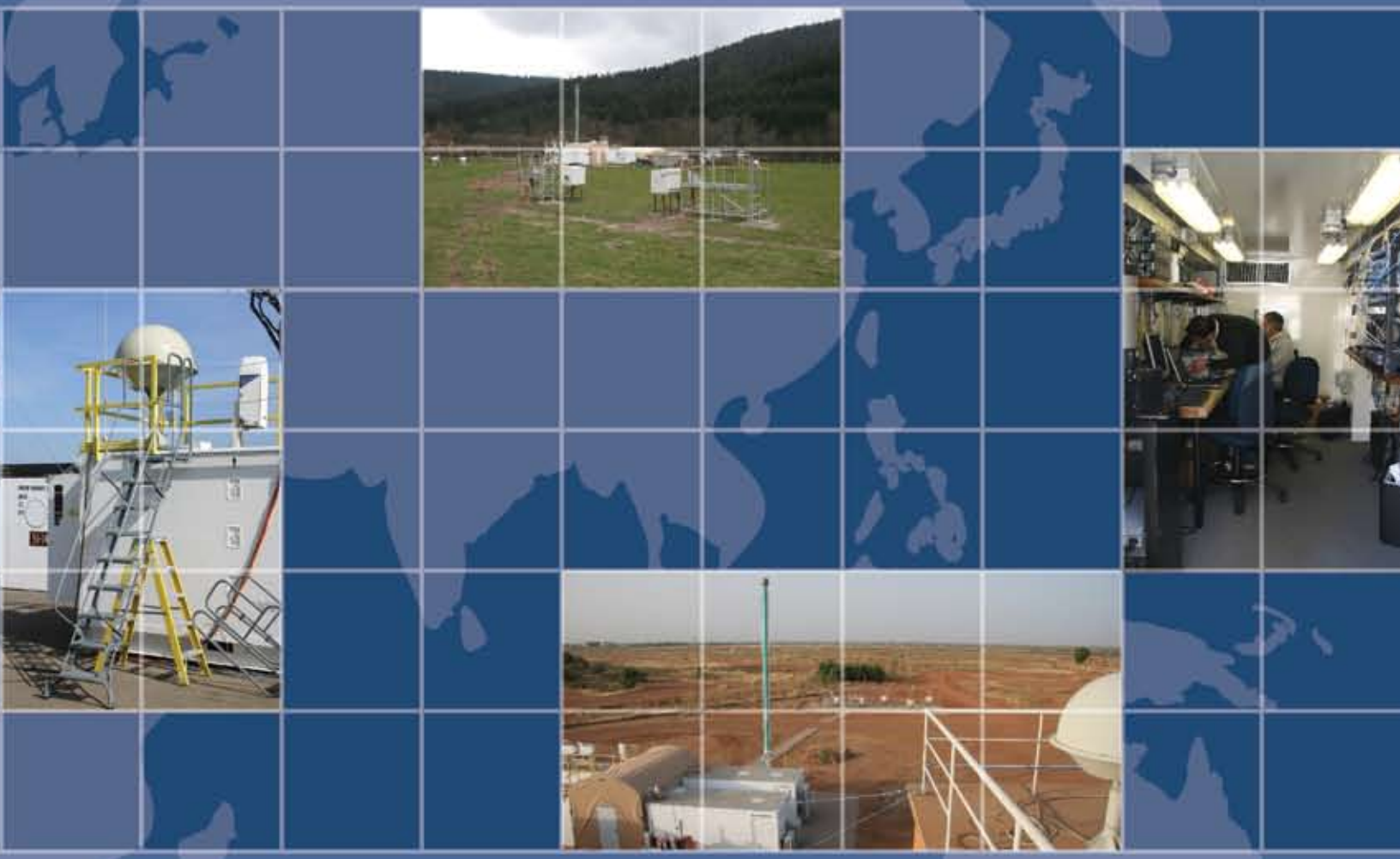
Atmospheric Radiation Measurement
CLIMATE RESEARCH FACILITY
U.S. Department of Energy

# ARM MOBILE FACILITY

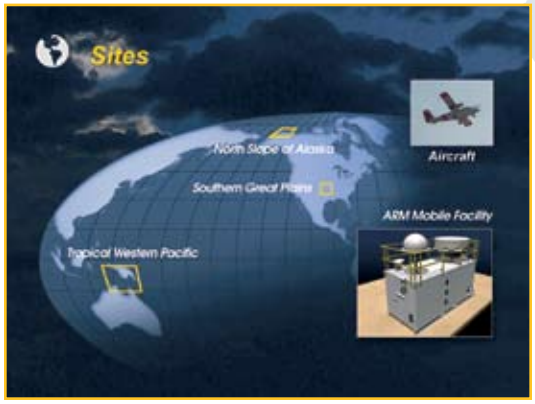


Office of Science
U.S. DEPARTMENT OF ENERGY

## Overview

Sponsored by the U.S. Department of Energy's Office of Science, the Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) maintains field sites in Oklahoma, Alaska, and the tropics to obtain continuous measurements of cloud and radiative properties for improving climate models. In addition, airborne measurements are obtained through the ARM Aerial Vehicles Program. Supplementing these capabilities, the **ARM Mobile Facility (AMF)** provides a flexible instrument platform for conducting atmospheric experiments lasting from 6 to 12 months in any environment, from the cold of the Arctic to the heat of the tropics.

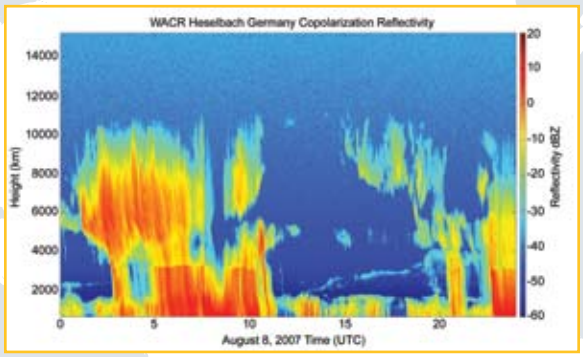
Consisting of a baseline suite of instruments, communications, and data systems, the AMF is easily transported in containers that serve as operations shelters once the system is in place. An experienced two-person team sets up the instruments and shelters; once set up, one or two technicians operate the facility throughout its deployment. ACRF scientists collaboratively plan the deployment with the principal investigators and arrange to provide local onsite or virtual support for using the AMF.




Because of its flexibility and portability, the AMF is an ideal platform for conducting collaborative research anywhere in the world.

## AMF Science

The purpose of the AMF is to collect essential information about cloudy and clear atmospheres in under-sampled climatically important regions. In some of these regions, even the macroscopic cloud structure is relatively unknown. The AMF produces data sets for use by the atmospheric community to test and improve parameterizations in global climate models. Data from the AMF are processed by the ACRF Data Quality Office and then checked by scientific staff. Algorithms have been developed to create higher-level data products for specific science needs. Data from the AMF are made available to the community in near real time through the Data Archive.




Data from the 95-GHz W-band ARM Cloud Radar provide detailed information about cloud structure, including height, water and ice content, precipitation, and lifecycle.

An AMF deployment can involve months to years of planning. Proposals should allow time for planning processes and for the establishment of necessary site infrastructure and data networking systems.

### Proposal Process

Each year, a call for proposals to use the AMF is issued via advertisements in scientific news publications and on the ARM website (***www.arm.gov/acrf/fc.stm***). Proposals to use the AMF are generally due in the spring, and should be received at least 18 months in advance of the anticipated start date.

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

# Baseline Capabilities

Measurement capabilities include standard meteorological instruments, a suite of broadband and spectral radiometers, and remote sensing instruments.

- **95-GHz W-band ARM Cloud Radar**
- **Balloon-Borne Sounding System,** radiosondes launched each day at regular intervals
- **Micropulse Lidar and Laser Ceilometer** for aerosols and clouds
- **Microwave Radiometer** for column water vapor and liquid water
- **Microwave Radiometer Profiler** for temperature and humidity
- **Sky Radiation System** for solar and infrared radiation coming from the sky
- **Ground Radiation System** for solar and infrared radiation coming from the surface
- **Atmospheric Emitted Radiance Interferometer** for spectral infrared radiation
- **Radar Wind Profiler**
- **Total Sky Imager** for photos of the whole-sky hemisphere
- **Aerosol Observing System,** including an aerosol sampling stack and dedicated shelter
- **Surface Meteorology Station** for wind, pressure, temperature, and humidity
- **Eddy Correlation System** for surface fluxes of heat and water vapor
- **Cimel Sunphotometer** for cloud and aerosol properties

Measurements obtained by all these instruments are collected inside an operations shelter. This shelter houses numerous computer stations for data and communication systems. The AMF operates on a continuous 24/7 schedule and is maintained by ACRF staff. Because deployments may often be associated with field campaigns sponsored by other agencies, the AMF was designed to host guest instruments in addition to its baseline collection.

DEPLOYMENTS

# 2005: Point Reyes National Seashore, California

Point Reyes National Seashore, on the California coast 60 miles north of San Francisco, was the location for the first deployment of the AMF. In collaboration with the **Marine Stratus, Radiation, Aerosol, and Drizzle** field campaign, sponsored by the U.S. Office of Naval Research and the U.S. Department of Energy's Atmospheric Science Program, AMF scientists obtained data to study the microphysical characteristics of marine stratus and, in particular, marine stratus drizzle processes. Marine stratus clouds are known to be susceptible to the byproducts of fossil fuel consumption, a multi-agency climate-change priority.

The AMF provided a mature instrument suite to help fill information gaps in the existing surveys of marine stratus microphysical structure.

Marine clouds and fog were observed almost continuously throughout the summer months. Because the cloud base was so low during the study period, scientists concluded that surface aerosols were the same as those nucleating droplets in the clouds above. Under certain conditions, this indicates a direct link between the aerosol and cloud properties at the surface site.

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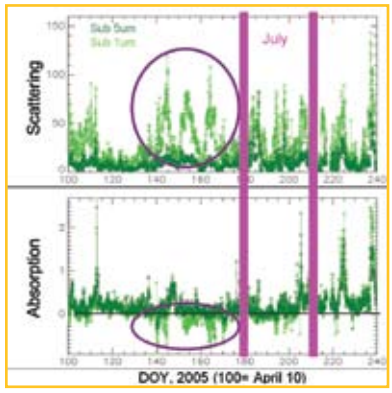
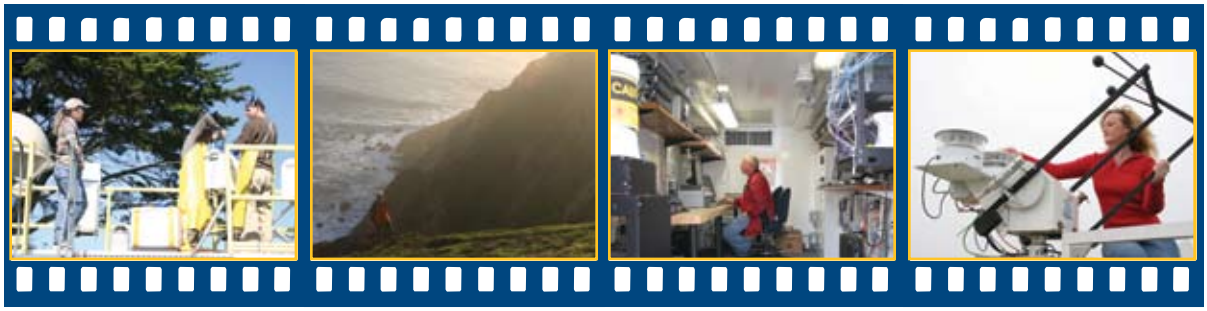
Point Reyes National Seashore was chosen due to its marine environment, as well as its availability for scientific research endeavors. The AMF site was located about 1600 meters from the shoreline.

Between March and September 2005, the AMF and research aircraft were used to obtain data about cloud/aerosol interactions to improve understanding of cloud organization associated with patches of drizzle. During the deployment, the AMF contributed significantly by providing state-of-the-art active and passive remote sensing of the detailed microphysical structure of drizzle patches and the associated clouds as they moved onshore.




The large difference in scattering between aerosols below 5 µm in size, and those below 1 µm in size (top panel), is likely due to large sea salt particles. A standard correction method applied to this region (bottom panel) indicates that it may overcorrect for aerosols dominated by sea salt.

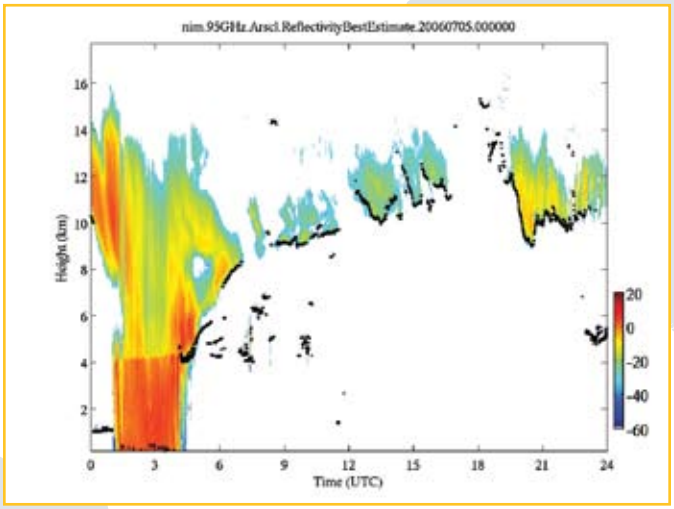


# 2006: Niamey, Niger, West Africa

Located near the airport in Niamey, the AMF obtained measurements from January through December 2006, spanning both the wet and dry seasons. These measurements provided information about radiative feedback of the Earth's atmosphere in the region, including the interaction of local clouds and the West African monsoon with dust and aerosols.

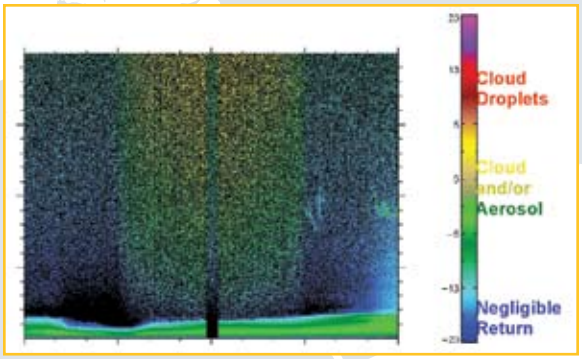
In 2006, the AMF completed a year-long field campaign in Niamey, Niger, as part of an ongoing international study called the African Monsoon Multidisciplinary Analyses, or AMMA. Deployed within view of an overhead geostationary satellite, measurements obtained by the AMF during the **Radiative Atmospheric Divergence using AMF, GERB data, and AMMA Stations** project (better known by the acronym RADAGAST) provided the first well-sampled, direct estimates of the absorption of solar and infrared radiation within the complete atmospheric column from surface to space.

Data from the one-year deployment in Niamey, Niger, will allow scientists to study the impact of Saharan dust storms on incoming solar energy, outgoing thermal radiation, and generation of the monsoon. Because the dust can block incoming solar energy and because solar energy drives weather and climate, scientists around the world are looking for ways to better understand these natural phenomena.

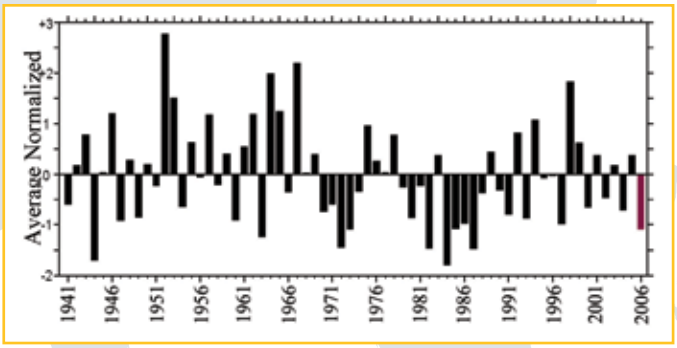



Using a new algorithm to combine observations from the AMF's 95-GHz W-band ARM Cloud Radar, micropulse lidar, and ceilometer, scientists have produced cloud boundaries and time-height profiles of cloud location, radar moments, and linear depolarization ratio fields for the entire Niamey deployment. The temporal resolution is 5 seconds, and the vertical resolution is 42.856 meters.

Sky images recorded by instruments on research ships in the Central Pacific (left) and Sea of Japan (center), versus the AMF site in Niamey (right), provide a visual indication of the difference between aerosol optical depths of 0.08, 0.98, and 2.5, respectively.




In March, the AMF recorded the largest Saharan dust storm in the Niamey area in the previous two years. During the storm, solar radiation reaching the surface decreased by nearly 85 percent. The dust was so thick that on March 9, the return signal from the AMF lidar was effectively undetectable.




Cumulative rainfall records for the Niamey AMF site indicate the 2006 monsoon season was the second driest there in the last 20 years, placing it in the "very bad" category.

## Publications


Miller, MA and A Slingo. 2007. "The Atmospheric Radiation Measurement (ARM) Mobile Facility (AMF) and its first international deployment: measuring radiative flux divergence in West Africa." *Bulletin of the American Meteorological Society* 88: 1229-1244.

Pinker, RT, D Sun, MA Miller, and GJ Robinson. 2007. "Diurnal cycle of land surface temperature in a desert encroachment zone as observed from satellites." *Geophysical Research Letters* 34: L11809.

Slingo, A, TP Ackerman, RP Allan, EI Kassianov, SA McFarlane, GJ Robinson, JC Barnard, MA Miller, JE Harries, JE Russell, and S Dewitte. 2007. "Observations of the impact of a major Saharan dust storm on the Earth's radiation balance." *Geophysical Research Letters* 33: L24817.

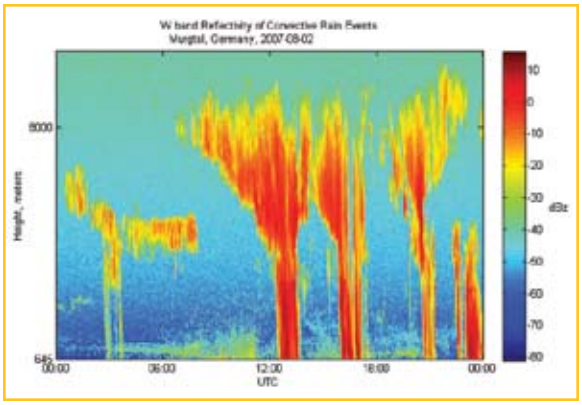
## 2007: Black Forest, Germany

From March through December 2007, the AMF was an integral part of a regional study aimed at improving precipitation forecasting in mountainous regions. Located in the village of Heselbach in the Black Forest region of Germany, the AMF was one of several "supersites" obtaining atmospheric measurements for the **Convective and Orographically Induced Precipitation Study**.

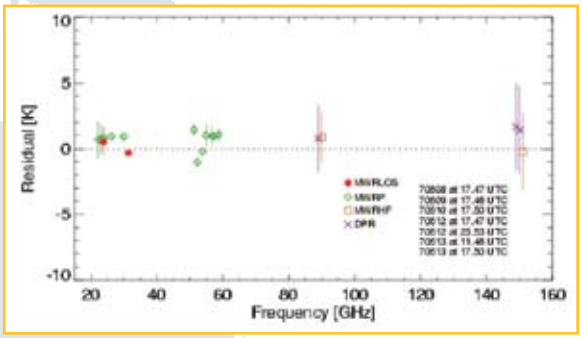
Orographic precipitation is the result of atmospheric uplift and subsequent rainfall induced by mountainous terrain. Because orographic rain forms so differently than "regular" rain, scientists have a difficult time predicting it, which has led to unexpected and catastrophic storms and flooding in Germany.

Measurements obtained by the AMF during the field campaign in Germany encompass the entire lifecycle of precipitation—from pre-convective conditions to the development of clouds, followed by the onset, development, and organization of precipitation. These data will be combined with coincident radar, aircraft, and satellite data to improve how clouds and precipitation in low-mountain regions are represented in weather forecast and climate models, and to develop strategies for determining cloud climatologies in complex terrain.

A light dusting of snow coincided with the official start of the AMF deployment in Germany in March 2007.




Four convective cloud cells passed over the AMF site in Germany on August 2, 2007. Reflectivity measured by the 95-GHz W-band ARM Cloud Radar shows the characteristic deep convection associated with this kind of rain event, with cloud tops reaching above 8000 meters.




In this image (left), clear-sky observations obtained from four different microwave radiometers collocated at the AMF site in Germany are compared against a radiative transfer model. Current model predictions tend to vary significantly, particularly in frequencies above 60 GHz. Observations from the numerous microwave radiometers operating during the AMF deployment in 2007 will help scientists to evaluate the models and improve their accuracy.

## 2008: China

**Study of Aerosol Indirect Effects in China**

## Contacts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