ARM

CLIMATE RESEARCH FACILITY

ARM MOBILE 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, airborne measurements are obtained through the ARM Aerial Facility (AAF). Supplementing these capabilities, the ARM Mobile Facility (AMF) provides flexible instrument platforms for conducting atmospheric experiments lasting from 6 to 12 months in any environment, from the cold of the poles to the heat of the tropics.

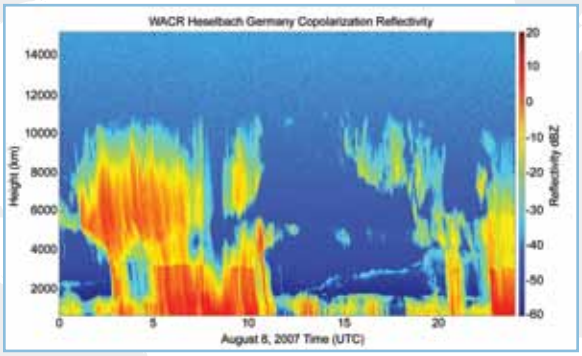
Consisting of a baseline suite of instruments, communications, and data systems, each AMF is easily transported in containers that serve as operations shelters once the system is in place. An experienced team sets up the instruments and shelters; once set up, one or two technicians operate the facility throughout its deployment.

ARM scientists collaboratively plan the deployment with the principal investigators and arrange to provide local onsite or virtual support for using the AMF. AMF deployments may often be associated with field campaigns sponsored by other agencies. Both AMFs were designed to host guest instruments in addition to their baseline collections, and an AMF can deploy in either an existing facility or other suitable shelters.

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 ARM 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.



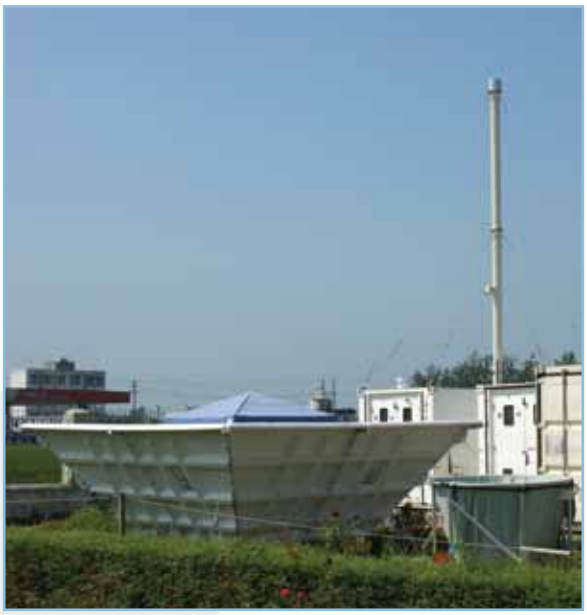
Data from the 95-GHz W-band ARM Cloud Radar provide detailed information about cloud structure, including height, water and ice content, precipitation, and life cycle.

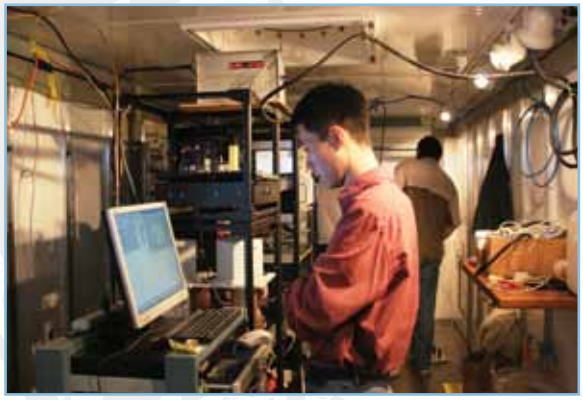
Portability and flexibility are the keys to the design of the AMF that help ensure successful deployments.

Baseline Capabilities

Measurement capabilities of both AMF1 and AMF2 include standard meteorological instruments, a suite of broadband and spectral radiometers, and remote sensing instruments. Because AMF2 is designed to support shipboard deployments, marine-focused instruments are included in its baseline instrument suite.

- **95-GHz W-band ARM Cloud Radar**
- **Balloon-Borne Sounding System,** radiosondes launched each day at regular intervals
- **Doppler Lidar, 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 Sun Photometer** for cloud and aerosol properties
- **W- and Ka-Band Scanning ARM Cloud Radar** for cloud reflectivity and velocities (AMF1)
- **X- and Ka-Band Scanning ARM Cloud Radar** for cloud reflectivity, velocities, and precipitation (AMF2)
- **Ocean Meteorology Instruments** (AMF2)

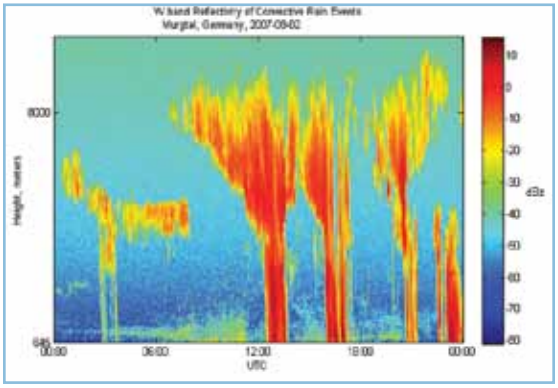
Measurements obtained by all these instruments are collected through integrated data and communication systems. The AMF operates on a continuous 24/7 schedule and is maintained by ARM staff.

2007: Black Forest, Germany

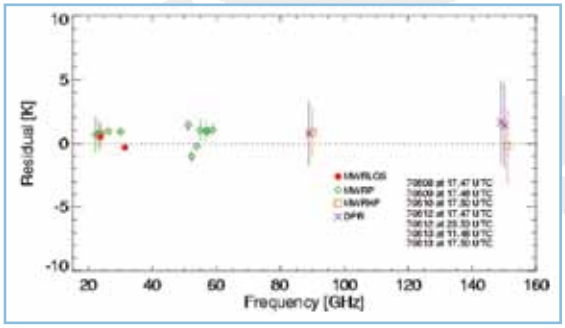
From March through December 2007, the AMF was an integral part of a regional study aimed at improving precipitation forecasting in mountainous regions. Located in the village of Heselbach in the Black Forest region of Germany, the AMF was one of several "supersites" obtaining atmospheric measurements 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 from "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 life cycle of precipitation—from pre-convective conditions to the development of clouds, followed by the onset, development, and organization of precipitation. These data are being 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.



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, 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.

"The AMF data set embedded in the European summer experiments is a treasure for atmospheric science," stated Dr. Volker Wulfmeyer, professor at the University of Hohenheim and chair of the COPS International Science Steering Committee. "It will be essential for improving the quality of precipitation forecasts in complex terrain. This is a prerequisite for extending the lead time of flash-flood forecasting, which is of great economic and societal relevance."

Publications:

Kneifel S, S Crewell, U Löhnert, and J Schween. 2009. "Investigating water vapor variability by ground-based microwave radiometry: Evaluation using airborne observations." *Geoscience and Remote Sensing Letters,* 6(1), doi:10.1109/LGRS.2008.2007659.

Turner DD, MP Cadeddu, U Loehnert, S Crewell, and A Vogelmann. 2009. "Modifications to the water vapor continuum in the microwave suggested by ground-based 150 GHz observations." *IEEE Transactions on Geoscience and Remote Sensing,* 47(10), 3326–3337.

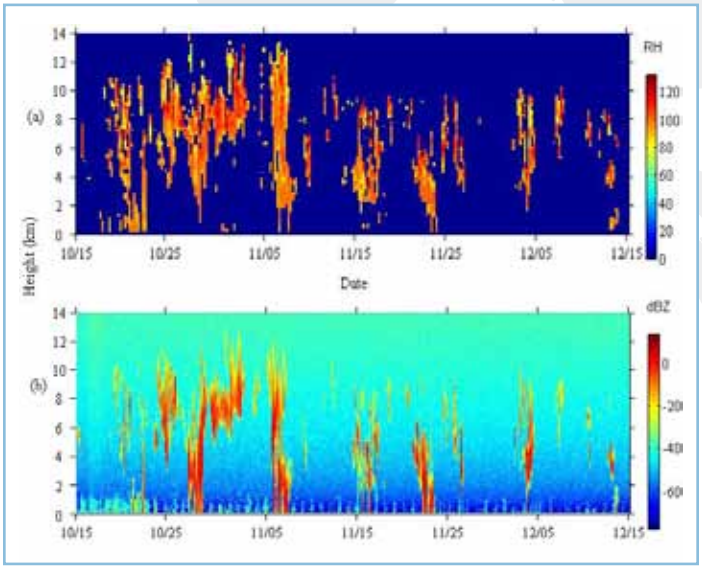
Wulfmeyer V, A Behrendt, H Bauer, C Kottmeier, U Corsmeier, A Blyth, G Craig, U Schumann, M Hagen, S Crewell, P Di Girolamo, C Flamant, M Miller, A Montani, S Mobbs, E Richard, MW Rotach, M Arpagaus, H Russchenberg, P Schlussel, M Konig, V Gartner, R Steinacker, M Doringer, DD Turner, T Weckwerth, A Hense, and C Simmer. 2008. "The convective and orographically induced precipitation study: A research and development project of the world weather research program for improving quantitative precipitation forecasting in low-mountain regions." *Bulletin of the American Meteorological Society*, 89(10), doi:10.1175/2008BAMS2367.1.

2008: Shouxian, China

In 2008, the AMF was deployed in China to acquire essential cloud, aerosol, radiative, and meteorological measurements for the **Study of Aerosol Indirect Effects in China**. High concentrations of aerosol particles in the region may influence the atmosphere across the Pacific Rim, especially the radiation balance and cloud properties. Preliminary analyses of multiple satellite data sets over China indicate complex and unique aerosol indirect effects, which impact cloud reflectivity and precipitation processes. Both in situ measurements and independent ground-based remote sensing data are needed to verify the satellite findings and gain a deeper understanding of these effects.

The primary AMF site was located at Shouxian, approximately 500 km west of Shanghai. A supplemental facility with a reduced complement of AMF instruments obtained measurements at an observatory on the shores of Lake Taihu, just 96 km west of Shanghai. Both of these facilities operated from May through December 2008. In addition, an ancillary facility with a subset of AMF instruments was established to the north, to obtain comparative measurements for several months at a time in locations with different environmental conditions. From April through May, the ancillary facility operated at a location in the semi-desert conditions of Zhangye, in north-central China. The ancillary facility then moved to Xianghe on the northeast coast. It operated in this primarily agricultural environment from June through the end of the AMF deployment in December.

Measurements obtained at all the AMF sites during the 8-month deployment in China will help scientists to validate satellite-based findings, understand the mechanisms of the aerosol indirect effects in the region, and examine the roles of aerosols in affecting regional climate and atmospheric circulation, with a special focus on the impact of the East Asian monsoon system.



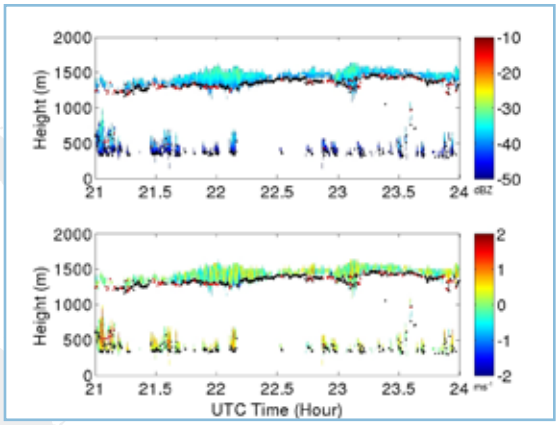
This image shows day-to-day variation of cloud vertical structure over a period of two months. This level of data was gathered for the first time in China by daily radiosonde launches (a) and the AMF 95-GHz W-band cloud radar (b). The deployment of the radar helped develop a method to derive cloud boundaries from radiosonde data.

2009–2010: Graciosa Island, Azores

From May 2009 through December 2010, the AMF is obtaining data from a location near the airport on Graciosa Island to support the **Clouds, Aerosol, and Precipitation in the Marine Boundary Layer (CAP-MBL)** field campaign. Scientists involved in the campaign will use data from the AMF to study processes controlling the radiative properties and microphysics of marine boundary-layer clouds, a high-priority science question. Collaborators from the Regional Directorate of Science and Technology of the Government of Azores, the University of the Azores, and the Portuguese Meteorological Institute are providing key logistical and operations support.

Marine boundary-layer clouds are particularly important in the global climate system, not only as passive modulators of solar energy, but as interactive systems that influence and modulate sea surface temperature and the strength of the trade winds on seasonal-interannual timescales. Their microphysical properties are important, strongly sensitive to manmade aerosol, and poorly understood, especially over remote oceans.

Data from the prolonged AMF deployment will result in the first climatology of detailed vertical structure of cloud and precipitation properties of low clouds at a remote subtropical marine site. These data will provide particularly important new information about the structure and variability of the remote marine boundary-layer system and the factors that influence it. These and other data sets created within the proposed work will be extremely important in the validation and testing of cloud parameterizations for large-scale computer models and improved climate predictions.



Measurements from the ceilometer and cloud radar deployed in the Azores combine to show the decoupled structure of a cloud.

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/amf

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