ARM

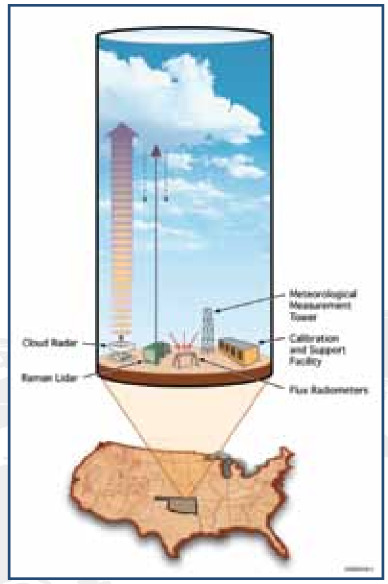
CLIMATE RESEARCH FACILITY

RESEARCH SITES

Overview

Sponsored by the U.S. Department of Energy's (DOE) Office of Science, the Atmospheric Radiation Measurement (ARM) Climate Research Facility was established in 1990 to improve global climate models by increasing understanding of clouds and radiative feedbacks. Through the ARM Facility, DOE funded the development of highly instrumented research sites at strategic locations around the world: the Southern Great Plains (SGP), Tropical Western Pacific (TWP), and North Slope of Alaska (NSA).

For nearly two decades, each fixed site has collected continuous measurements spanning a broad range of atmospheric conditions with large enough sample sizes to allow meaningful statistical analyses. The measurements include surface fluxes and cloud profiles, aerosols, temperature, and humidity. All of these activities are conducted with a goal of providing data needed to improve and validate cloud parameterizations in climate models.



The mission of the ARM Climate Research Facility is to provide the national and international scientific community with the infrastructure needed for scientific research on global climate change.

The ARM Facility also manages the ARM Aerial Facility (AAF), which provides airborne measurements, and the ARM Mobile Facility (AMF), which provides two flexible instrument platforms for observations in data-poor areas at up to 12 months at a time.

ARM operates three fixed research sites, two mobile facilities, and an aerial facility. Each fixed site location was chosen to represent a range of key climate conditions that should be studied.

A National User Facility

In 2003, the DOE designated the ARM sites and infrastructure as a national user facility. The ARM Facility maintains fixed research sites, which were carefully chosen to represent a broad range of climate conditions and answer specific scientific questions:

- How accurate are both longwave and shortwave radiative transfer calculations for any given column of the atmosphere?
- How well can cloud properties in a column of the atmosphere be predicted from knowledge of larger-scale atmospheric properties?
- How do the size, properties, scattering, and extinction of aerosols affect clouds and the global climate?

Each ARM site is equipped with an extensive set of radiometers, tower-mounted instruments, and cloud and aerosol observing instruments. Key instruments include scanning cloud and precipitation radars, radiometers, balloon-borne sounding systems, and several lidars, including one of the few operational Raman lidars in the world. The data obtained from these instruments are stored in the ARM Data Archive (http://www.archive.arm.gov) and made publicly available in near-real-time.

The ARM Facility has enormous potential to contribute to a wide range of interdisciplinary science including, atmospheric science, meteorology, hydrology, biogeochemical cycling, and satellite validation, to name only a few. ARM users from the general climate change science community regularly conduct field campaigns to augment routine data acquisitions and to test and validate new instruments.

Through the American Recovery and Reinvestment Act of 2009, the ARM Facility received funds that enabled upgrades and improvements to instrumentation and infrastructure. The funds allowed ARM to purchase and deploy dual-frequency scanning cloud radars to all the ARM sites, enhance several sites with precipitation radars and energy flux measurement capabilities, and invest in new aerosol sampling and aerial instrumentation. These upgrades will dramatically increase the research capabilities of the ARM Facility and provide the systems to process and archive the data from the new instruments.

RECOVERY.GOV

Purchased with Recovery Act funds, the new Raman lidar at the TWP site in Darwin measures vertical profiles of water-vapor mixing ratio and several cloud- and aerosol-related quantities using pulses of laser radiation to probe the atmosphere.

Southern Great Plains

The Southern Great Plains (SGP) site is the largest and most extensive climate research field site in the world. The SGP was chosen for several reasons including its relatively homogenous geography and easy accessibility, wide variability of climate cloud type and surface flux properties, and large seasonal variation in temperature and specific humidity. Also, the SGP region already had a large existing network of weather and climate research and instrumentation. The broad range of climate conditions, coupled with the extensive instrumentation, provides scientists with the opportunity to study meteorological conditions ranging from hot, humid summers dominated by convective clouds to cold winters with stratus clouds and synoptic-scale storm systems.

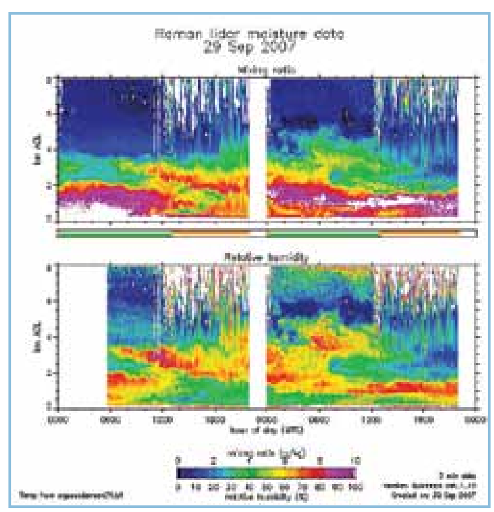
The SGP site consists of a Central Facility and several additional instrument clusters throughout approximately 160 acres in north-central Oklahoma and south-central Kansas.

Scientific Impacts

In 1992, data collection began at the SGP site with observations geared toward relating the surface radiation budget to cloud properties. Radiation measurements include both broadband fluxes and detailed observations of the solar and terrestrial infrared spectra using instruments such as the atmospheric emitted radiance interferometer. Detailed comparisons of spectral infrared measurements with model calculations under clear-sky conditions led to significant improvements in radiation models, radiation measurements, and measurements of the vertical distribution of water vapor, which is critical for calculating infrared fluxes.

A major focus at the ARM sites has been to provide data that facilitate model improvements. Many field campaigns have been conducted at the SGP site to provide boundary conditions for single-column models (representing a single column of grid cells in a climate model) or cloud-resolving models.

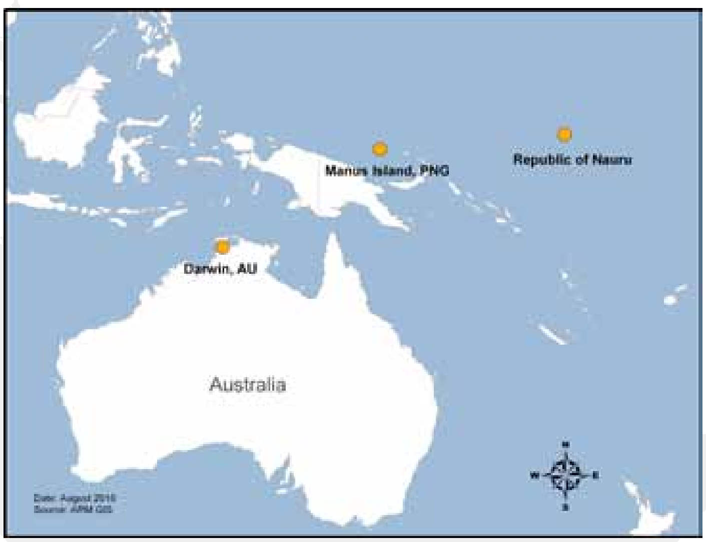
Important instruments for specifying the cloud properties are the millimeter wavelength cloud radar, micropulse lidar, and microwave radiometer. The addition of new scanning precipitation and cloud radars, as well as substantial upgrades to several existing instruments, was made possible by Recovery Act funding and will permit the most detailed documentation of cloud characteristics and their time evolution ever obtained anywhere in the world.



The top panel shows time-height cross sections of water vapor mixing ratio and the bottom panel shows relative humidity. Both parameters were observed by the Raman lidar at SGP from September 28 to September 30, 2007.

Tropical Western Pacific

The ARM Facility began collecting data in the Tropical Western Pacific (TWP) in 1996. The TWP locale consistently has the warmest sea-surface temperatures on Earth and is often called the Pacific "warm pool." This warm body of water supplies heat and moisture to the atmosphere, which forms deep convective cloud systems that affect the amount of solar energy reaching the Earth's surface and the amount of infrared energy that can escape into space. Data collected from TWP help scientists understand the role of the tropics in controlling global circulation and climate. In addition, the TWP locale provides valuable information about cirrus clouds. Cirrus clouds are ubiquitous in the tropics and have a large impact on the environment, but the properties of these clouds are poorly understood. ARM's presence in the tropics allows scientists to collect continuous data on these clouds, as well as conduct focused field campaigns.



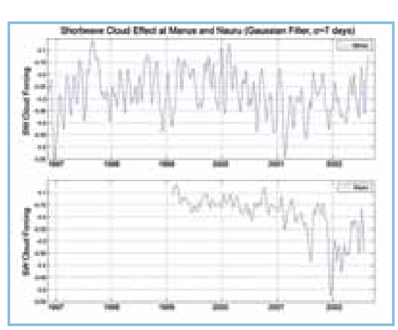
With sites located on the island nation of Nauru; Manus, Papua New Guinea; and Darwin, Australia; the TWP locale was established to obtain data to better understand phenomena such as the El Niño/Southern Oscillation.

Scientific Impacts

Current global climate models have limited success representing the important phenomena that occur in the tropical western Pacific area, let alone their influences over other parts of the Earth, or how they might differ under a changing global climate. In order to improve the representation of this area in models, the underlying physics of these phenomena must first be understood.

Understanding the tropical warm pool regime is essential to fully understanding and modeling the Earth's global circulation and climate. The warm pool region experiences the warmest sea surface temperatures on Earth, producing rigorous convection. This area serves as a gigantic heat engine that is a major driver of the global circulation. As a result, changes to the warm pool regime can be felt over other areas of the Earth. Periodic phenomena such as El Niño/La Niña and the 30–60 day Madden-Julian Oscillation affect not only events such as the Indian and Australian monsoons, but also produce much further-reaching effects over much of the Northern Hemisphere and perhaps the entire planet.

When measurements at the TWP sites began, no long-term records of high-quality, scientifically useful and coordinated cloud, atmospheric composition, and surface radiation budget measurements were available for the equatorial tropical western Pacific area. Answers to fundamental questions such as the magnitude and variability of the surface radiation budget, the basic properties of clouds as measured from the surface, and the impact of clouds on the surface radiation budget needed to be determined. Since that time these fundamental questions have been addressed and have led to more detailed questions needed to further our understanding of the physics and intraseasonal variability of the TWP regime.



Between 1997 and 2002, radiative cloud forcing shows the impact of clouds on solar radiation reaching the surface. Manus displays a great deal of variability associated with intraseasonal tropical waves, while the dominant form of variability at Nauru is the longer-term El Niño cycle.

North Slope of Alaska

In 1997, the ARM Facility began collecting data at its North Slope of Alaska (NSA) locale. Measurements at NSA are vital because dramatic changes are underway across the Arctic and are occurring at rates greater than predicted by any model. Near-surface warming across the Arctic has been observed at approximately twice the global average since the late 1960s, impacting every part of the Arctic environment; perennial sea ice in the Arctic has declined by more than twenty percent since the mid-1970s. The implications of these changes in climate extend around the globe.

The NSA site in Barrow, located on the Arctic Ocean coast, provides data about cloud and radiative processes at high latitudes.

Scientific Impacts

While climate models agree in their projection that these trends will continue through this century, there is no consensus regarding the underlying reasons for this enhanced climate sensitivity in the Arctic. Projected Arctic temperatures vary greatly among models, but even taking this large variation into account, the decline in observed summer sea ice over the last decade exceeds predictions, suggesting that current climate models do not capture the full set of physical processes and feedbacks that determine the state of the Arctic climate.

Recent studies suggest that the retreat of observed Arctic sea ice, as depicted by the summer ice edge, is closely correlated to an upward trend in the downwelling longwave radiative flux in the Arctic. Increasing downwelling longwave flux appears to be driven mostly by increases in clouds and precipitable water vapor, establishing the need to better understand the contribution of clouds in this important feedback process.

A key focus addressed at the NSA is mixed-phase cloud data, which are an important component for correctly modeling cloud properties and the impact of these clouds on the terrestrial, infrared, and solar radiation budget. Field campaigns are also conducted at the NSA to provide additional data about cloud, radiative, and aerosol processes. The NSA data are being used to refine models and parameterizations for this climatically important region.

Milestones

1992
Continuous data collection begins at SGP

1996
Continuous data collection begins at TWP

1997
Continuous data collection begins at NSA

2003
ARM sites and infrastructure designated as a DOE national user facility: the ARM Climate Research Facility

2005
First AMF1 deployment to Pt. Reyes, California

2010
First AMF2 deployment to Steamboat Springs, Colorado

2011
All instruments from American Recovery and Reinvestment Act deployed and gathering data

Publications and Research Highlights

ARM data are used in hundreds of journal articles and scientific studies per year. These documented research efforts represent tangible evidence of ARM's contribution to advances in almost all areas of atmospheric radiation and cloud research. The ARM website maintains two databases that track journal articles, technical reports, conference proceedings, books, and research highlights featuring ARM data.

Publications database:
http://www.arm.gov/publications/db

Research highlights database:
http://www.arm.gov/science/highlights

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

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