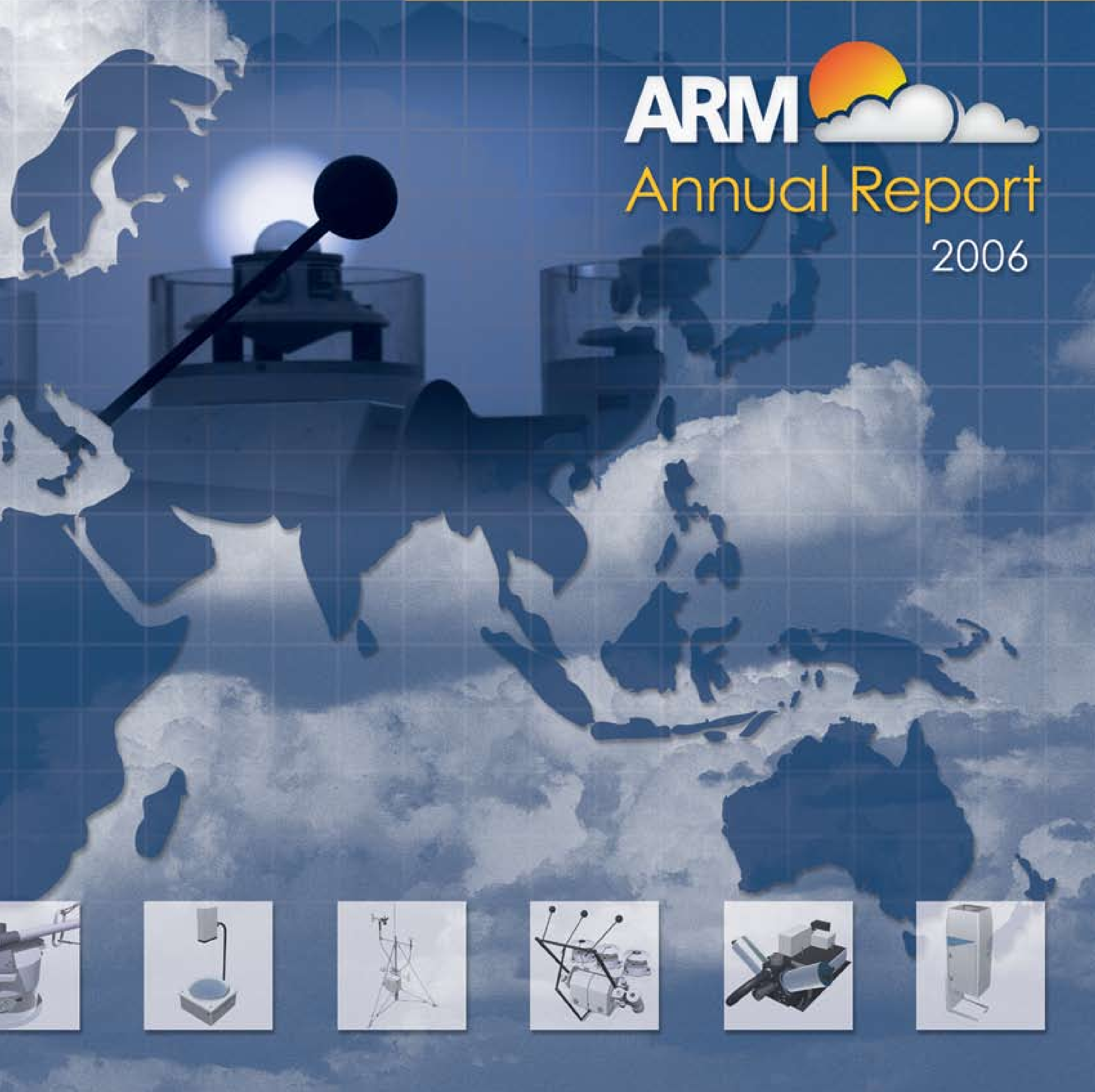
DOE/SC-ARM-0606

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

# ARM Annual Report 2006



**Department of Energy**
Washington, DC 20585

December 1, 2006

**Subject: Annual Report for the Atmospheric Radiation Measurement (ARM) Program and ARM Climate Research Facility**

The ARM Climate Research Facility continues to assist the global change research community by providing state-of-the-art scientific infrastructure for interdisciplinary studies of earth systems. Continuous data from permanent sites in Alaska, Oklahoma, and the Tropical Western Pacific, supplemented with data obtained from temporary ARM Mobile Facility deployments, are providing critical information for improving the treatment of cloud and radiative properties in both global and regional climate models.

Prominent leadership changes marked 2006, beginning with a new ARM Chief Scientist at the helm of the ARM Science Team. In June, a new ARM Science Program Director joined the program, providing needed oversight of ARM Science Team research activities as the trend for user facility access continues to escalate.

Noteworthy scientific and infrastructure accomplishments in 2006 include:

- Collaborating with the Australian Bureau of Meteorology to lead the Tropical Warm Pool-International Cloud Experiment, a major international field campaign held in Darwin, Australia
- Successfully deploying the ARM Mobile Facility in Niger, Africa
- Developing the new ARM Aerial Vehicles Program (AVP) to provide airborne measurements
- Publishing a new finding on the impacts of aerosols on surface energy budget in polar latitudes
- Mitigating a long-standing double-Intertropical Convergence Zone problem in climate models using ARM data and a new cumulus parameterization scheme.

Members of ARM's international science team are major contributors to advances in cloud and radiative research. In 2006, ARM scientists authored or co-authored 96 journal articles containing ARM research results. Notably, the *Journal of Geophysical Research-Atmospheres* devoted an entire issue to 18 papers containing ARM research examining the properties and radiative influences of aerosols on climate.

Thank you for interest in and support of DOE's important climate research efforts.

Wanda R. Ferrell, PhD
Program Director
ARM Climate Research Facility

Kiran Alapaty, PhD
Program Director
ARM Science Program

Rickey Petty
Program Director
ARM Aerial Vehicles Program

# Table of Contents



***On the cover:*** A setting sun provides the backdrop for a collection of radiometers recording data from the hazy desert sky in Niamey, the capitol of Niger, Africa. The ARM Mobile Facility was stationed there from January through December 2006 to obtain measurements of absorbing aerosols from desert dust in the dry season, and deep convective clouds and associated moisture loadings during the summer monsoon.

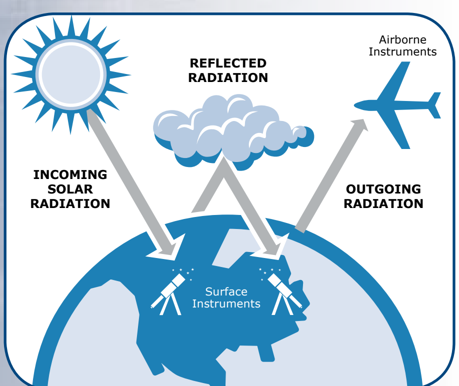
# Program Overview

## The Role of Clouds in Climate

Sophisticated computer models of the earth's climate system are the principal tools used by scientists for simulating climate and predicting its change. The credibility and validity of these models are dependent upon, among other things, their ability to correctly represent physical processes, such as the exchange of energy between Earth and the atmosphere. The representation of cloud processes and their impact on this energy exchange—referred to as Earth's radiation balance—has been recognized for decades as the source of much uncertainty surrounding the prediction of climate variability and change.

***Research has shown that cloud radiative forcing and feedbacks are one of the major sources of uncertainty in simulations of climate change over the next century. The ARM Program focuses on obtaining continuous field measurements of atmospheric properties and processes, and from these measurements, developing data products that promote the advancement of climate models.***

The U.S. Global Change Research Act of 1990 established an interagency program within the Executive Office of the President to coordinate U.S. agency-sponsored scientific research designed to monitor, understand, and predict changes in the global environment. To address the need for new research on clouds and radiation, the U.S. Department of Energy (DOE) established the **Atmospheric Radiation Measurement (ARM) Program**, managed through the Office of Science. As part of the DOE's overall Climate Change Science Program, a primary objective of the ARM Program is improved scientific understanding of the fundamental physics related to interactions between clouds and radiative feedback processes in the atmosphere.




*ARM researchers use data collected from ground-based and airborne instruments to study the natural phenomena that occur in clouds, and how those cloud conditions affect incoming and outgoing radiative energy.*

## ARM Science Goals

A major emphasis of the DOE Climate Change Research program is on understanding climate forcing, especially the radiation balance from the surface of the Earth to the top of the atmosphere and how changes in this balance due to increases in the concentration of greenhouse gases in the atmosphere may alter climate. Much of the research is focused on improving the quantitative models necessary to predict possible climate change at global and regional scales.

Research in the ARM Program focuses on resolving the greatest scientific uncertainty in climate change prediction—the role of clouds and their interactions with solar radiation. ARM seeks to develop a better quantitative understanding of how atmospheric properties, including the extent and type of cloud cover and changes in aerosols and greenhouse gas concentrations, affect the solar and infrared radiation balance that drives the climate system. It also includes support to archive and analyze climate change data, including data from the ARM sites, and data on greenhouse gas emissions and concentrations and to make such data available for use by the broader climate change research community.

ARM's goal is addressed through a combination of continuous ground-based observations, data analysis, modeling of local and regional physics, and development of parameterizations for global models. Through these activities, the ARM Program seeks the answers to two principal 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?

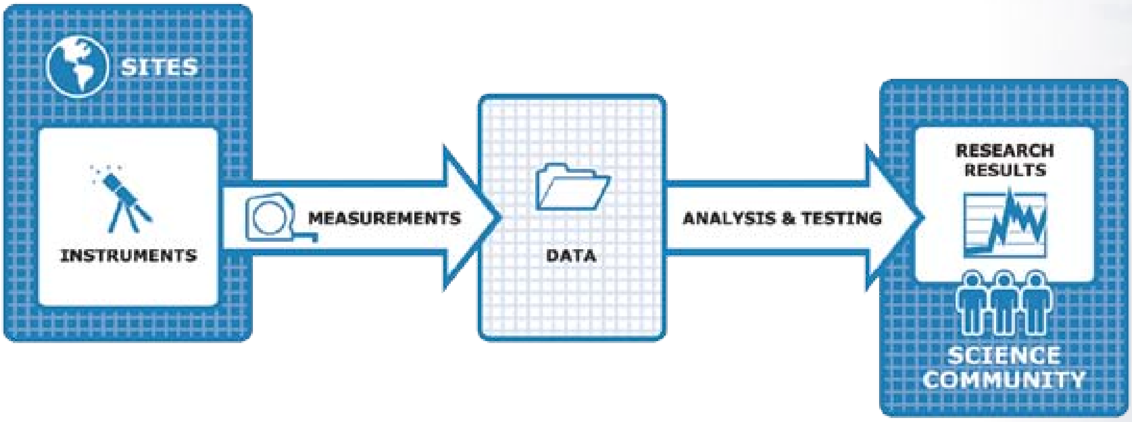
Because of the complexity and global scope of the research involved in answering these questions, the ARM Program collaborates extensively with other laboratories, agencies, universities, and private firms in gathering and sharing data. This collaborative approach allows ARM to leverage its investment in **research sites, instruments, data, and science** to gain the knowledge necessary to improve the accuracy of the computer models used to simulate global and regional climate changes.

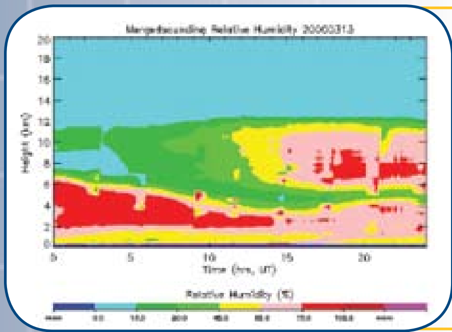
***Publications Feature ARM Research:*** *In addition to papers appearing in peer-reviewed journals, several areas of ARM research were featured in high-profile publications within the atmospheric science community in 2006. Examples include:*

- *The Bulletin of the American Meteorology Society included short feature articles about the 2006 deployment of the ARM Mobile Facility in Niger, Africa, and sky imaging techniques developed by ARM researchers to assist with analyses of cloud macrophysical properties. The articles were published in the April and June 2006 issues, respectively.*
- *The ARM Mobile Facility deployment in Africa was also featured in a longer article published in the Global Energy and Water Cycle Experiment (GEWEX) newsletter in February (Vol.16, No.1). In addition, the opening commentary of the August GEWEX newsletter (Vol.16, No.3) cited the use of data acquired from the ARM Climate Research Facility Southern Great Plains site, describing the detailed datasets as a "benchmark against which [global climate model] GCM developers can compare their model codes for cloud-free, liquid cloud, and ice cloud conditions."*

# ARM Climate Research Facility: Successful Science Program Leads to User Facility Designation

Through the ARM Program, the DOE funded the development of several highly instrumented ground stations for studying cloud formation processes and their influence on radiative transfer, and for measuring other parameters that determine the radiative properties of the atmosphere. This scientific infrastructure, and resultant Data Archive, is a valuable national and international asset for advancing scientific knowledge of earth systems. In fiscal year (FY) 2003, the DOE designated the ARM infrastructure as a national scientific user facility: the **ARM Climate Research Facility (ACRF)**. The ACRF has enormous potential to contribute to a wide range of interdisciplinary science in areas such as meteorology, atmospheric






*Continuous high-resolution time series datasets of water vapor vertical profiles for selected 30-day periods at each of the fixed ACRF sites are now part of the PI holdings in the ARM Data Archive.*

***Principal Investigator Datasets Now Available:*** *Principal Investigator (PI) data products are datasets generated by PI algorithms, which complement existing data holdings at the ARM Data Archive. To increase the visibility and availability of these data for use by the global scientific community, ACRF initiated a campaign to collect and archive them. Ten PI datasets were added to the ARM Data Archive in 2006, including preliminary data for the Broadband Heating Rate Profile Project, and continuous water vapor profiles and cloud microbase profiles for each of the ACRF sites. For a complete list of PI data products, see* ***http://www.arm.gov/data/pi_products.stm.***

aerosols, hydrology, biogeochemical cycling, and satellite validation, to name only a few.

Three primary locations—the Southern Great Plains (SGP), Tropical Western Pacific (TWP), and North Slope of Alaska (NSA)—and the portable ARM Mobile Facility (AMF) are heavily instrumented to collect massive amounts of atmospheric measurements needed to create data files. Using these data, ARM scientists are studying the effects and interactions of sunlight, radiant energy, and clouds to understand their impact on temperatures, weather, and climate. As part of this effort, ARM scientists and ACRF infrastructure staff analyze and test the data files to create enhanced data products. Software tools are provided to help open and analyze these products, which are made available for the science community via the ARM website to aid in further research.

## Sites Around the World Enable Real Observations

A central feature of the ACRF is a set of instrumented field research locales for measuring atmospheric radiation and the properties controlling this radiation, such as the distribution of clouds and water vapor. To obtain the most useful climate data, three locales were chosen that represent a broad range of weather conditions.

*The SGP site in Oklahoma provides a wide variability of climate cloud types and surface flux properties, and large seasonal variation in temperature and specific humidity.*

### Southern Great Plains

The SGP site was the first field measurement site established by ARM. The SGP experiences a wide variety of cloud types and surface flux properties, as well as large seasonal variations in temperature and specific humidity. The site consists of a highly instrumented Central Facility near Lamont, Oklahoma, and smaller "satellite" facilities scattered over approximately 142,450 square kilometers in north-central Oklahoma and south-central Kansas.

Cooperative partnerships have evolved with a variety of government laboratories and agencies, and with universities, permitting collaborative use of several state-of-the-science radar and climate-observing systems and networks. Collection of continuous measurements at this location began in 1994, with a complete suite of instruments operating since 1996. This site is now the largest and most extensive climate research field site in the world.

*Deep atmospheric convection is one of many characteristics in the TWP locale that combine to drive global climate.*

### Tropical Western Pacific

The TWP locale spans an area roughly between 10°N to 10°S of the equator from Indonesia to the dateline. This area—referred to as the Pacific "warm pool"—is characterized by warm sea temperatures, deep and frequent atmospheric convection, high rain rates, strong coupling between the atmosphere and ocean, and substantial variability associated with El Niño.

Three instrumented sites operate in the TWP locale. The first of these sites was established in 1996 on Manus Island, Papua New Guinea. Site operations on Manus are conducted in collaboration with the Papua New Guinea National Weather Service. The second TWP site was established on Nauru Island in 1998. Nauru operations are performed with the cooperation of the Nauru Department of Island Development and Industry. A third TWP facility began operating in April 2002 at Darwin, Australia, in partnership with the Australian Bureau of Meteorology. This facility collects data typical of tropical land convection and monsoon circulations.

*The NSA locale provides data about cloud and radiative processes in the Arctic, which has been identified as one of the most sensitive regions to climate change.*

## North Slope of Alaska

The NSA locale is situated on the edge of the Arctic Ocean. This area provides important information for ARM research because fundamentally different climate processes—such as planetary heat loss from the poles and extensive sheets of ice that affect solar absorption and sea level—occur at high latitudes. Due to generally cold temperatures, atmospheric water vapor concentrations in the Arctic are quite low, allowing heat energy from the surface to escape through the atmosphere more easily than in other regions.

The NSA's principal instrumented facility was installed near Barrow in 1997, followed by a smaller remote site at Atqasuk in 1999. Routine operations at these sites are conducted in partnership with employees of Ukpeagvik Iñupiat Corporation/Science Division.

*In 2006, the AMF was stationed in Niger, Africa, to collect data on desert dust and summer monsoons. The AMF moves to Germany in 2007 as part of a precipitation study in the Black Forest region.*

## ARM Mobile Facility

The AMF was developed to address science questions beyond those addressed by the "fixed" measurement sites. The AMF is similar to the permanent ACRF sites in that it contains many of the same instruments and data systems, but is designed to be deployed around the world for campaigns lasting 6–12 months.

The AMF consists of several portable shelters, a baseline suite of instruments, data communications, and data systems. Designed to collaborate with other agency experiments (particularly those with aircraft), it also has the ability to host instruments other than the baseline collection. Datastreams produced by the AMF are available to the atmospheric community for use in testing and improving parameterizations in global climate models.

*The high-altitude Proteus aircraft flew eight missions during the Tropical Warm Pool-International Cloud Experiment, held in Darwin, Australia, in January and February 2006.*

## Unmanned Aerospace Vehicle Program

The ARM Unmanned Aerospace Vehicle (ARM-UAV) Program complements ARM's long-term ground-based measurements of cloud and atmospheric properties by emphasizing instrumented airborne measurement campaigns. UAVs and piloted aircraft may be used to obtain key climate measurements that cannot be made by other means. In situ data obtained from instrumented aircraft at various altitudes provide critical data for studying how clouds interact with solar and thermal radiation. In 2007, the UAV Program will be restructured as the ARM Aerial Vehicles Program.


***Where in the World is ACRF?*** *The online ACRF site map was integrated with Google™ Maps API technology in 2006 to enhance ARM website users' experience. Web visitors and data subscribers can now easily see where ACRF sites are located around the world, and use the Google map feature to zoom in—sometimes close enough to actually see the site facilities in the satellite images! Google map technology also makes it easy to add site markers as the AMF continues its worldwide travels.*

## State-of-the-Art Instrumentation Yields Comprehensive Datasets

ARM's approach to instrument development and procurement began with a fundamentally new idea in mind: carry out continuous and simultaneous ground-based observations of the atmospheric column using a suite of passive and active sensors. Previously, most sensors used to investigate atmospheric properties and compositions were strictly research instruments and, in many cases, inadequately understood and calibrated. The goal of ARM's instrument development initiative was to bring existing research instrumentation to the advanced state of development required to allow routine, highly accurate operation in remote areas of the world, and to develop new instrumentation as required.

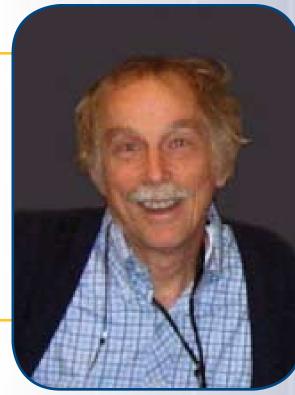
Because side-by-side comparisons and calibration techniques are critical to instrument understanding, the ACRF routinely sponsors and hosts field campaigns focused on this subject. As a result, the new generation of ground-based, remote sensing instruments include millimeter-wave cloud radar, Raman lidar, infrared interferometers using electronic coolers (instead of cryogens), and updated sky imagers, among others. These instrument arrays represent some of the most sophisticated tools available for conducting atmospheric research.

In addition to the instruments, data on surface and atmospheric properties are also gathered through aircraft, forecast models, satellites, field campaigns, and value-added processing. Once collected, the information is sent to site data systems and reviewed for quality. Approved data are then stored in the ARM Data Archive for use by the atmospheric science community.

## Science Team Approach Encourages Collaboration

ARM's Science Team is a unique collaboration of laboratory, university, agency, and private partners from around the globe. From the United States and abroad, cloud and radiation scientists ranging from senior scientists to post-docs and students make up the team. Though diverse in geographic location, these science representatives provide the most direct channel through which ARM research results can affect development and evaluation of global climate models. Key support is provided by software and hardware engineers who maintain the infrastructure necessary for advancing ARM Science Team research.

*__New Leader for ARM Science Team:__ The ARM Science Team is led by a Chief Scientist, who is selected by DOE for a 3-year term. In 2006, Dr. Warren Wiscombe took the helm as ARM's new Chief Scientist. As one of the founding members of the ARM Program, Dr. Wiscombe helped develop the original ARM Science Plan and has conducted collaborative ARM research since 1990. His research has centered on remote sensing and radiative transfer of clouds, single-scattering theory, and the development of new satellite system concepts.*



## Working Groups Provide Leadership, Focus on Specific Problems

To enable focused research on the various pieces of the cloud physics puzzle, the ARM Program divides its research into key areas, or Working Groups. These groups are the principal organizational structure within the ARM Science Team. Each Working Group concentrates on a specific set of issues related to climate modeling. The Working Groups include:

- **Aerosols** – relate observations of radiative fluxes and radiances to atmospheric composition, and use these relationships to develop and test parameterizations to accurately predict atmospheric radiative properties
- **Cloud Parameterizations and Modeling** – relate observations and data analysis to climate model development and evaluation to improve cloud parameterizations in global climate models
- **Cloud Properties** – develop and implement algorithms that characterize the physical state of the cloudy atmosphere, including cloud occurrence, cloud condensed water amount, and cloud optical properties
- **Clouds with Low Optical [Water] Depth** – determine the best strategy for measuring clouds with low optical depths and low liquid water paths at ACRF locales
- **Instantaneous Radiative Flux** – test radiation parameterizations, particularly for shortwave radiation and cloudy-sky conditions, at the accuracy required for climate studies.

*__Well Deserved Recognition:__ In September, Dr. Robert Ellingson, a member of the ARM Science Team since 1990 and leader of the Instantaneous Radiative Flux Working Group since 1992, received the prestigious DOE Distinguished Associate Award. This is the DOE's highest award and is given only to those who have made significant accomplishments in their fields. Dr. Ellingson was recognized for his role as one of the leading architects in the creation of the ARM Program. The award cited his tenure as Chair of the ARM Science Team Executive Committee, as well as his unselfish service and strong scientific leadership in charting the path forward in achieving ARM Program goals.*

## Oversight Ensures Relevant Science, Promotes Facility Use

Oversight of the ACRF is provided by the ACRF Program Director. The ACRF Program Director routinely conducts programmatic reviews using subcommittees of the Biological and Environmental Research Advisory Committee. In addition, all proposals for facility use undergo a rigorous review process. The review process has two primary dimensions—a science peer review and a review of costs, logistics, and schedule, performed by the ACRF Infrastructure Management Board (IMB). Proposals that are projected to incur costs between $101K to $300K are forwarded to the ACRF Science Board for review.

The IMB assesses the availability and resource requirements of the proposed facility usage. The objective of the IMB is to provide fair and equitable distribution of available funds between the fixed-site facility infrastructure costs, field campaigns (also known as intensive operational periods, or IOPs), and special projects. A primary objective of ACRF is to increase external (non-ARM) use of the facility without inhibiting the achievement of ARM scientific progress.

Based on input by the science community, recommendations for future development of the ACRF are developed annually. These recommendations are presented to the ACRF Program Director for consideration and potential inclusion in budget and spending plans.

***ACRF Science Board Welcomes New Chair:*** *In January, Dr. Sally Benson was appointed to a 2-year term as the new chair of the 11-member ACRF Science Board. As the chair, Dr. Benson will lead the Board—composed of highly respected ARM-supported scientists and representatives from the external climate research community—in reviewing scientific proposals for use of the ACRF.*

***New Director for ARM Science Program:*** *In June, Dr. Kiran Alapaty joined the Climate Change Research Division within DOE's Office of Biological and Environmental Research to manage the ARM Science Program. Prior to Dr. Alapaty's appointment, both the ARM Science Program and ACRF infrastructure were directed by Dr. Wanda Ferrell. Dr. Alapaty will direct and oversee the research and planning of the ARM Science Team, and will work closely with Dr. Ferrell, Program Director for the ACRF.*

## Global Program Managed by Many

Eight national laboratories and numerous government agencies, universities, private companies, and foreign organizations are involved in the ARM Program and ACRF. Each entity serves a vital role in managing and conducting the research, operations, and administration of the science program and user facility. Representatives of the ARM Program make up the majority of ACRF users.

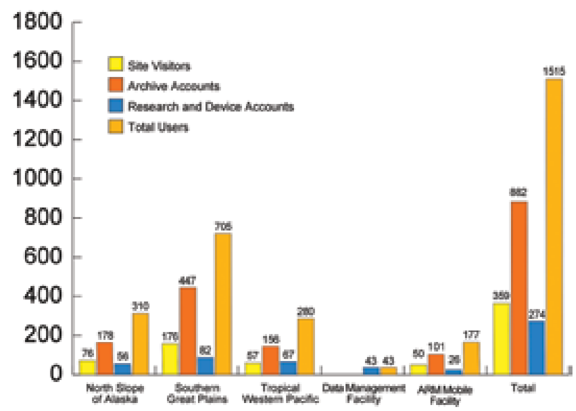
For ARM Program science activities, direction and oversight is the responsibility of **DOE Headquarters**. A **Science Team Executive Committee** reviews scientific progress and provides recommendations for future research. **Working Group** representatives coordinate the ARM research agenda as appropriate. The site infrastructure that enables ARM science is managed through the ACRF.

The ACRF is also directed by **DOE Headquarters**. An **Infrastructure Management Board** coordinates the scientific, operational, data, financial, and administrative function of the ACRF. An 11-member **Facility Science Board**, selected by the ACRF Program Director, serves as an independent review body to ensure appropriate scientific use of the ACRF.

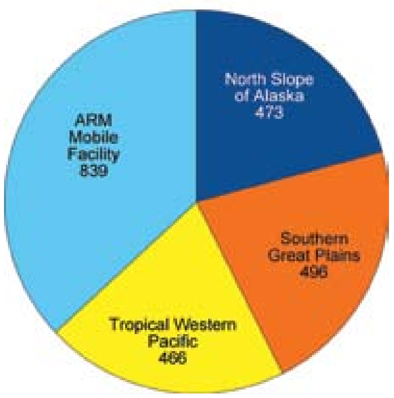
## Fiscal Year 2006 Budget Summary and User Statistics

| Atmospheric Radiation Measurement Program FY 2006 Budget ($K) | |
|---|---|
| **Total ARM Program** | **46,274** |
| Infrastructure | 31,443 |
| Science | 14,831 |

**User Statistics for the Period of October 1, 2005 - September 30, 2006**




User Summary




Visitor Days by Site

| Operational Statistics for the Period October 1, 2005 - September 30, 2006 | | |
|---|---|---|
| | Data Availability | |
| **SITE** | **GOAL** | **ACTUAL** |
| NSA | 0.90 | 0.94 |
| SGP | 0.95 | 0.97 |
| TWP | 0.85 | 0.95 |
| **Site Average** | **0.90** | **0.95** |
| AMF* | 0.95 | 0.98 |

**Because the AMF is a temporary site, its data availability is based on operational days during field deployment, not 24 hours a day/365 days a year like the fixed sites.*

# Key Accomplishments

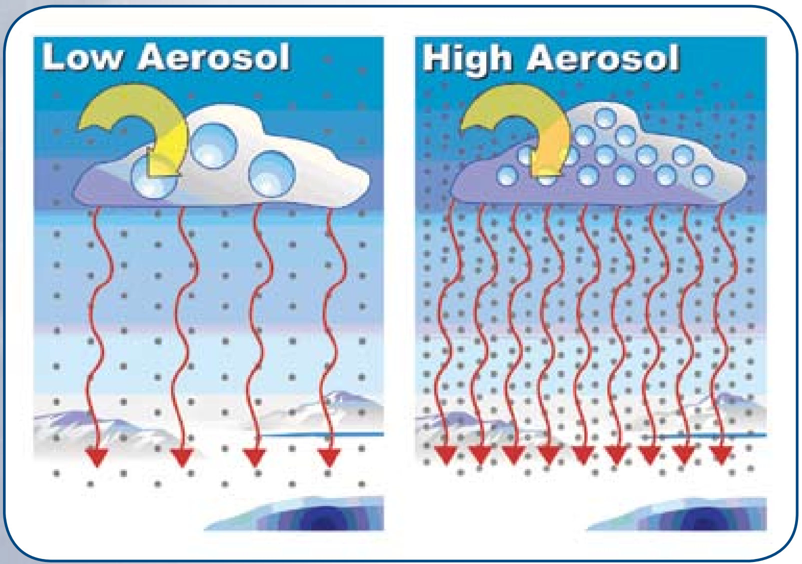
The following pages highlight a selection of research results, field campaigns, and infrastructure achievements from FY 2006 (October 2005 through September 2006). A complete list of FY 2006 field campaigns and publications is provided in the back of this report. More detailed information can be found on the following web pages:

- *http://www.arm.gov/publications/pub_database.stm* for Publications
- *http://www.arm.gov/science/fc.stm* for Field Campaigns
- *http://www.arm.gov/acrf/updates.stm* for Operations Updates.

## Research Highlights

Members of ARM's Science Team publish an average of 150 refereed journal articles per year, and ARM data are used in many studies published by other scientific organizations. In addition, ARM investigators present their research at key conferences each year. These documented research efforts represent tangible evidence of ARM's contribution to advances in almost all areas of atmospheric radiation and cloud research, and their relevance to climate change modeling efforts.

### Aerosols Help Clouds Warm Up Arctic




*In a process known as the first aerosol indirect effect, enhanced aerosol concentrations cause the droplets in a cloud to be smaller and more numerous within a cloud of fixed water amount. This study found that this process can make many clouds more opaque and emit more thermal energy to the surface.*

In a process known as the first aerosol indirect effect, an increase in aerosol amount causes an increase in cloud droplet concentration and a decrease in droplet size within a cloud of fixed water amount. Until now, scientists knew little about how this process would affect the cloud's emission of thermal energy to the surface. In January 2006, scientists supported by the ARM Program reported in *Nature* magazine that enhanced aerosol concentrations increase the amount of thermal energy emitted by many Arctic clouds to the surface, augmenting the increase caused by greenhouse gas warming. The increase is comparable to the surface-warming effect from established greenhouse gases, suggesting it plays a significant role in the Arctic energy balance.

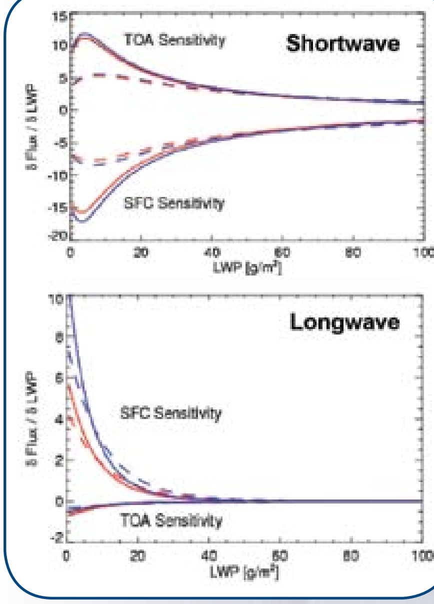
The key to understanding this process lay in the long-term measurements obtained from the ACRF site in Barrow, Alaska. In concert with aerosol measurements made by the adjacent National Oceanic and Atmospheric Administration (NOAA) Climate Modeling and Diagnostics Laboratory, 6 years of data from the Barrow site were analyzed to determine the impact of aerosol on Arctic clouds and the surface thermal energy budget. The study focused on thin, single-layer clouds close to the surface, with temperatures that would favor them containing liquid water (as opposed to ice). Liquid water was recently discovered to largely govern Arctic cloud radiative properties during spring and summer, with liquid water found in clouds at temperatures as low as –34°C.

The analysis showed that the first aerosol indirect effect operates in these clouds that frequently occur in the Arctic, causing cloud droplets to be smaller when the aerosol concentrations are high. At the same time, there is a significant increase measured in the clouds' downwelling thermal energy. The portion of the energy that can be attributed solely to the systematic changes in the cloud droplet size is an average of 3.4 W/m$^2$, comparable to the surface warming effect from established greenhouse gas enhancements. Because the cloud amount during the Arctic spring generally exceeds 80 percent, this implies that the observed enhancement is significant to the Arctic energy balance.

(Reference: Lubin, D, and AM Vogelmann, 2006: "A climatologically significant aerosol longwave indirect effect in the Arctic," *Nature*, 439, 26 January, 453-456, doi:10.1038/nature04449.)

## "Thin" Liquid Water Clouds are Heavy in Radiative Importance

Liquid water path, or LWP, is a term used to quantify the total amount of liquid water in column through a cloud. If the LWP is less than about 100 gm$^2$, the cloud becomes tenuous and can be referred to as "thin." In a paper accepted by the *Bulletin of the American Meteorological Society*, ARM scientists show that shortwave and longwave radiative fluxes are very sensitive to small changes in the LWP for "thin" clouds. Further, their research shows that methods currently used to observe cloud LWP for climate studies are challenged to achieve the accuracy needed to accommodate this large sensitivity.

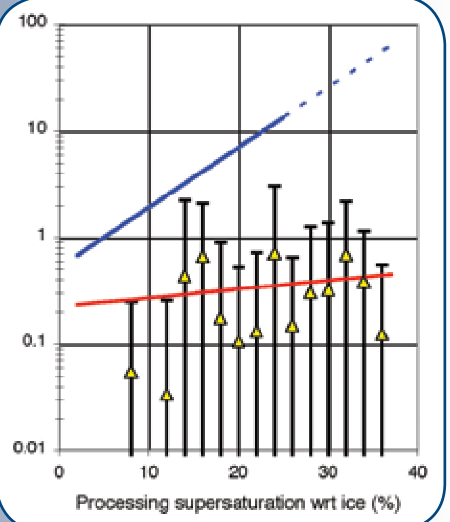



*Model calculations show changes to the daily averaged broadband flux (W/m$^2$) per unit LWP change at the surface (SFC) and top of atmosphere (TOA). The simulated sky is overcast, and the cloud is placed in the lower 1 kilometer of atmospheres typical of mid-latitude summer (red) and mid-latitude winter (blue). The cloud uses common average, effective drop sizes of 6 microns (solid) and 12 microns (dashed).*

Over the climate regimes encompassed by all the ACRF sites—the Arctic, mid-latitudes, and tropics—approximately 50 percent of the clouds containing liquid water are "thin." Because thin clouds occur so frequently in the world's main climate regimes, their influence on the Earth's radiative energy balance must be accurately quantified in order to understand our climate. Observations from radiometers at the surface or on satellites, via sophisticated methods, are used to determine cloud LWP. These observations are essential for obtaining the type of long-term observations needed for cloud and climate studies. ARM scientists used data from the SGP site to ascertain the accuracy of these measurements by evaluating the results from 18 state-of-the-art methods, which span the spectrum of techniques currently used.

ARM researchers used model calculations to illustrate the large sensitivity of broadband fluxes to small changes in cloud LWP, as would be seen at the surface and at the top of atmosphere. Data plots from the model calculations showed that the change in flux per unit LWP change were greatest for small LWPs, and decreased as LWP increased. In addition, shortwave fluxes were shown to be more sensitive than longwave fluxes. The surprising result is that, even for the simplest cloud, very large discrepancies were found among the different determinations of cloud LWP. The differences carry significant implications for the broad climate community's ability to observe and subsequently represent these clouds in climate models.

(Reference: Turner, DD, AM Vogelmann, R Austin, JC Barnard, K Cady-Pereira, C Chiu, SA Clough, CJ Flynn, MM Khaiyer, JC Liljegren, K Johnson, B Lin, CN Long, A Marshak, SY Matrosov, SA McFarlane, MA Miller, Q Min, P Minnis, W O'Hirok, Z Wang, and W Wiscombe, 2006: "Thin liquid water clouds: Their importance and our challenge." *Bull. Amer. Meteor. Soc.*, accepted.)




*Project-average IN concentration data from M-PACE are shown, processed in finite bin intervals as a function of ice supersaturation. A best fit for the current binned and weighted data is shown as a solid red line; for comparison, the blue line shows a standard ice nucleation parameterization used in many models for the same supersaturation range.*

## Low Ice Nuclei Concentrations Contribute to Cold Liquid Clouds

Clouds play a particularly important role for the surface energy balance in the Arctic, but are difficult to model. One possible reason for this is the difference in the aerosol properties of the Arctic atmosphere compared to lower latitudes. Global climate models used to assess climate change use the same cloud and aerosol descriptions in the Arctic as anywhere else on Earth, and are calibrated to provide a reasonable global climate. However, applying formulations optimized for mid-latitude and tropical conditions to the Arctic—where conditions are clearly different—results in a poor representation of this region.

To better understand cloud processes in this region, the Mixed-Phase Arctic Cloud Experiment (M-PACE), conducted from late September 2004 through October 2004 in the vicinity of the NSA locale, successfully documented the microphysical structure of Arctic mixed-phase clouds. Liquid was found in clouds with cloud-top temperatures as cold as -30°C, the coldest cloud-top temperature warmer than -40°C sampled by the aircraft. Observations in widely different forcing conditions indicated that the cause of the persistent liquid in these cold, ice-precipitating clouds was not in their dynamical characteristics, but rather was microphysical in origin. The prevalence of liquid down to these low temperatures could be explained by the relatively low ice nuclei (IN) concentrations measured.

Concentration measurements of IN (shown in the figure) included a substantial contribution (~87 percent) from measurements for which no IN were detected, and average concentrations were much lower than are measured at lower latitudes. These data were compared to a parameterization commonly used in many models, often without regard to the location, season, or altitude being modeled. The parameterization was clearly not representative of average IN behavior as assessed during M-PACE flights in the vicinity of lower level Arctic stratiform clouds. These results indicate that continued use of this parameterization will impair scientists' ability to predict cloudiness and related radiative forcing in this region, and emphasize the need to include realistic treatments of aerosols and aerosol/cloud interactions in future climate simulations. These results also suggest that global models which under-predict liquid-water clouds may feature a larger shift from ice to liquid clouds as the model climate warms. This constitutes an enhanced, unrealistic, positive feedback on climate change and may partly explain the large model sensitivity to such features as projected ice cover.

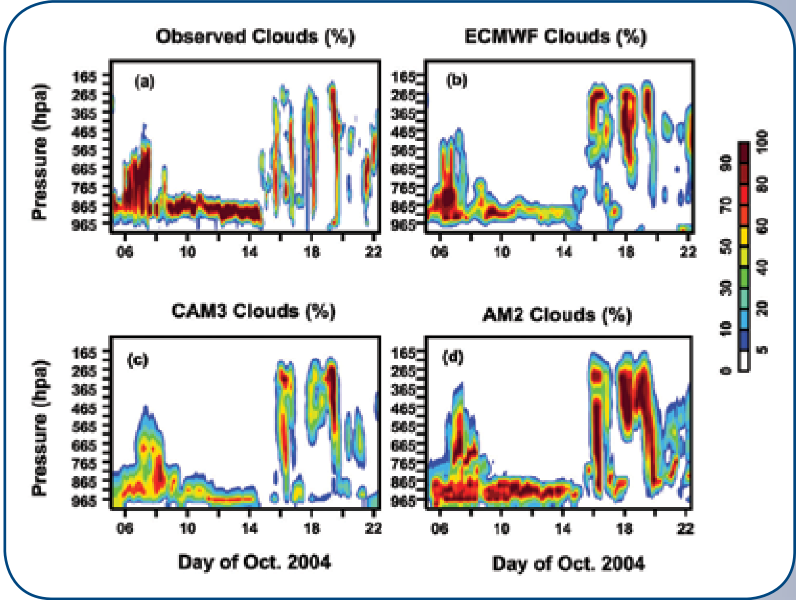
(References: (1) Prenni, A, JY Harrington, M Tjernström, PJ DeMott, A Avramov, CN Long, SM Kreidenweis, PQ Olsson, J Verlinde, 2006: "Can ice-nucleating aerosols affect Arctic seasonal climate?" *Bull. Amer. Meteor. Soc.*, accepted. (2) J Verlinde, JY Harrington, GM McFarquhar, VT Yannuzzi, A Avramov, S Greenberg, N Johnson, G Zhang, MR Poellot, JH Mather, DD Turner, EW Eloranta, BD Zak, AJ Prenni, JS Daniel, GL Kok, DC Tobin, R Holz, K Sassen, D Spangenberg, P Minnis, TP Tooman, MD Ivey, SJ Richardson, CP Bahrmann, M Shupe, PJ DeMott, AJ Heymsfield, R Schofield 2006: "The Mixed-Phase Arctic Cloud Experiment (M-PACE)." *Bull. Amer. Meteor. Soc.*, in press.)

***Special Issue of JGR Features Aerosol Field Campaign***

*The ARM Aerosol Intensive Operational Period in 2003 yielded an unprecedented 18 peer-reviewed papers published in a special issue of the Journal of Geophysical Research. These papers capture the state of the science in terms of measurement of the optical properties of ambient-state aerosols. This special issue includes results from successful "first-ever" instrument deployments and provides measurement comparisons involving both redundant and independent determinations of key aerosol optical properties that govern the direct and indirect effects of aerosols on climate.*

## Models Evaluated for Consistency, Accuracy in Simulating Arctic Cloud Systems

The effects of climate change have been shown to first appear in the sensitive Arctic environment. However, accurately representing Arctic clouds and interactions between clouds and radiation in global weather forecast and climate models has been a challenging task in the modeling community. This is mainly due to a lack of sufficient observations and basic cloud studies in the Arctic.




*Temporal and vertical distributions of observed and simulated clouds from ECMWF, CAM3, and AM2 at Barrow, Alaska, during M-PACE, show good consistency in cloud occurrence, but wide variability in cloud microphysical properties.*

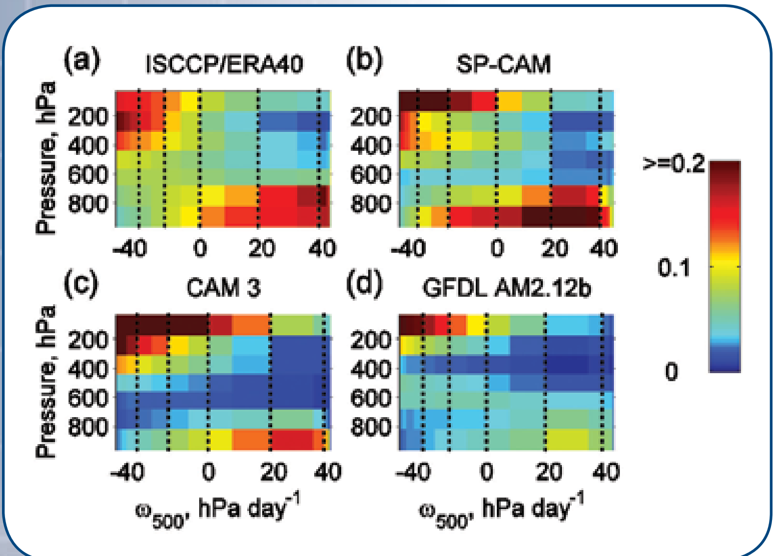
With the data collected from M-PACE (see previous highlight), ARM scientists evaluated the performance of three major models in simulating the Arctic cloud systems observed during the experiment. Two major U.S. climate models were evaluated: the Community Atmosphere Model (CAM3) of the National Center for Atmospheric Research, and the Atmosphere Model (AM2) of the NOAA Geophysical Fluid Dynamics Laboratory. These climate models were evaluated using a framework developed through a joint effort between the DOE's Climate Change Prediction Program and ARM Program, called the CCPP-ARM Parameterization Testbed (CAPT). This testbed is a diagnostic tool that allows running climate models in weather forecast mode so that climate models can be directly assessed using ARM data. The third major model—the weather forecast model of the European Center for Medium-Range Weather Forecasts (ECMWF)—was directly assessed using the M-PACE data.

As described in the *Journal of Geophysical Research*, their study revealed that though the models simulated the overall occurrence of clouds fairly consistently, the microphysical properties of the clouds were widely varied and were in substantial error. In particular, the two climate models simulated cloud bases that were too low, and significantly underestimated the observed cloud liquid and ice water contents in the mixed-phase boundary-layer clouds. These problems are closely related to potential deficiencies with the parameterizations of clouds and cloud microphysical processes in these models. The errors with the simulated cloud fields directly affect the simulation of radiative fluxes.

All three models overestimated the outgoing longwave radiation at the top of the atmosphere, and the ECMWF and CAM3 models substantially underestimated the incoming longwave radiation when boundary-layer clouds were present. Such biases in simulated radiation impact the simulated surface energy budget. The fine resolution of the ECMWF model allowed a further comparison with ARM observations, and showed that the ECMWF model had a much larger energy loss than observed at the surface during the M-PACE period. ARM data from MPACE will be used to suggest improvements for these models.


(Reference: Xie, S, SA Klein, JJ Yio, ACM Beljaars, CN Long, and M Zhang, 2006: "An assessment of ECMWF analyses and model forecasts over the North Slope of Alaska using observations from the ARM Mixed-Phase Arctic Cloud Experiment," *J. Geophys. Res.*, 111, D05107, doi:10.1029/2005JD006509.)

## Superparameterization Shows Promise for Cloud and Climate Modeling




*Comparison of (a) ISCCP cloud fraction for 30S-30N sorted by ECMWF ERA40 with ISCCP-simulator cloud fraction of (b) SP-CAM model climatology, (c) CAM 3 (Eulerian core) Atmospheric Model Intercomparison Project (AMIP), and (d) GFDL AM2.12b AMIP simulations. The cloud fraction is summed over all optical thickness categories.*

Based on a combination of theory and observation, scientists use approximations of various cloud properties as input, or parameters, to global climate models (GCMs). These approximations, called parameterizations, are what drive the results simulated by the models. The better the parameterization, the better the model can simulate reality. Taking this a step further, the use of a cloud-resolving model (CRM) to replace traditional cloud parameterizations represents a potential breakthrough to more realistically simulate subgrid-scale motions and thus more accurately simulate cloud fraction. This new approach is called superparameterization.

In *Geophysical Research Letters*, ARM researchers present the first calculations of the climate sensitivity of an atmospheric GCM that uses a CRM as a convective superparameterization. The climate sensitivity was analyzed by comparing the top-of-atmosphere radiation budgets of 3.5-year simulations with specified climatological sea surface temperature (SST) and with the SST increased by 2K. Their analysis showed weak climate sensitivity primarily due to an increase in low cloud fraction and liquid water in tropical regions of moderate subsidence, as well as substantial increases in high-latitude cloud fraction. These increases were primarily associated with boundary-layer clouds, which are not well resolved by the horizontal and vertical grid of a superparameterization or a GCM. At the same time, the model showed comparable climate sensitivity to recent aqua-planet simulations of a global CRM. This somewhat surprising conclusion encourages further study, especially using a more diverse range of high-resolution global modeling frameworks.

In addition, the researchers compared global features of the low-latitude (30N-30S) cloud climatology of the superparameterized model (SP-CAM) against satellite observations from NASA's International Satellite Cloud Climatology Project (ISCCP). The two major U.S. climate models—NCAR's Community Atmospheric Model (CAM) with the traditional parameterization and NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) climate model (AM2.12b)—were also included in the comparison. The observations included top-of-atmosphere cloud radiative forcing, cloud LWP from passive microwave radiometry, and the joint distribution of cloud-top temperature and cloud optical depth. GCM grid columns and observations were binned based on their monthly-mean 500 hPa vertical velocity. This sorts the model output into dynamical regimes with different characteristic cloud types that range from strong deep convection in regions of mean ascent to boundary-layer clouds in regions of persistent mean subsidence. The goal was to see whether the clouds were more realistically represented in the superparameterized GCM than in the leading conventional GCMs from the United States.

The superparameterized GCM simulated the cloud radiative forcing and LWP with fidelity comparable to current GCMs. This is an encouraging result because little tuning has been done to constrain poorly-known parameters in the superparameterized GCM as compared to current GCMs, which do so using cloud radiative forcing observations. Even more encouraging is that the superparameterized GCM simulated the ISCCP-derived distribution of cloud heights and thicknesses better than current GCMs, even in boundary-layer cloud regimes, where superparameterization might be expected to perform less favorably. The ARM datasets will provide future opportunities to evaluate and improve this exciting new approach for parameterizing cloud processes in GCMs.

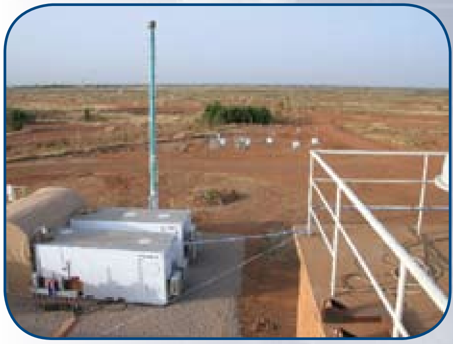
(Reference: Wyant, MC, M Khairoutdinov, and CS Bretherton, 2006: "Climate sensitivity and cloud response of a GCM with a superparameterization," *Geophys. Res. Lett.*, 33, L06714, doi:10.1029/2005GL025464.)

# Featured Field Campaigns

ACRF users—whether sponsored by ARM or other scientific organizations—regularly conduct field campaigns to augment routine data acquisitions and to test and validate new instruments. A field campaign that is proposed, planned, and implemented at one or more research sites is also referred to as an intensive operational period, also known as an IOP, as during this time, increased activities to support additional data acquisition occur. These concentrated efforts direct focused resources on a specific research area, resulting in valuable data to further scientific understanding of cloud and radiative processes.

## Influence of West African Monsoon on Global Climate

Dust from Africa's Sahara desert—the largest source of dust on the planet—reaches halfway around the globe. During its travels through Western Africa, Europe, and across the Atlantic Ocean to Central and North America, the dust particles absorb sunlight, warming the atmosphere and providing condensation nuclei for raindrops. Unfortunately, Africa is one of the most under-sampled climate regimes in the world, leaving scientists to wonder about the dust's contribution to global climate.

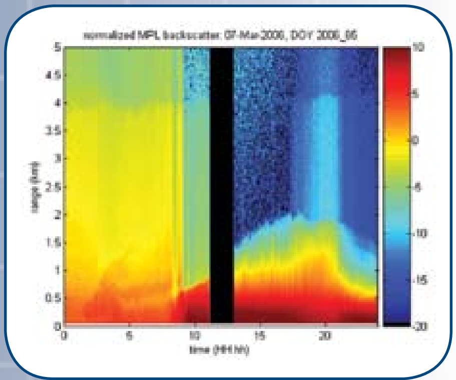


*Located at the airport in Niamey, the capitol of Niger, Africa, the AMF collected atmospheric data from January through December 2006.*

In January, the AMF began collecting atmospheric data on absorbing aerosols from desert dust in the dry season, and moisture loadings from deep convective cloud systems during the summer monsoon. Deployed in Niamey, Niger, and within view of an overhead geostationary satellite, measurements obtained by the AMF will provide information about radiative feedback of the Earth's atmosphere in the region, the interaction of clouds with dust and aerosols, and West African monsoons.

A valuable part of the dataset will be complementary measurements obtained from an ancillary site located approximately 60 km away from the airport. Reflecting the natural environment of the Sahel region, the site was chosen as the most representative of the countryside, and the location was deemed suitable for making radiometric and meteorological observations. "Sahel" is an Arabic word for "border" or "margin" and accurately describes the transition zone between the arid Sahara to the north, and the wetter, more tropical area to the south.

Combined with associated satellite data, measurements from the 1-year AMF deployment in Niamey will allow scientists to study how dust storms start, how far they spread, and what impact they have on incoming solar energy and the generation of monsoons. Also, in providing the first well-sampled direct estimates of the

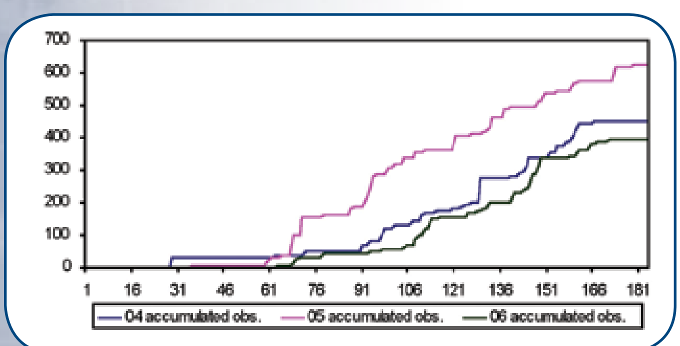


In this lidar (pulsed laser) image of the dust storm, the red color indicates significant scattering of the laser light. Note the very dark red color appearing at about 0930 as the dust storm arrives. The layer grows in height with time. Because the dust attenuates the laser light, the actual height of the layer cannot be accurately determined at times, but it extended to about 2 km.

energy balance across the atmosphere, it will lead to a greater understanding of the atmosphere than could be gained from either dataset alone. Ultimately, this information will help to improve model simulations of global climate, as well as increase scientific understanding of the influence of the West African Monsoon on the physical, chemical, and biological environment, both regionally and globally.

**Results:** On March 7, the AMF recorded the onset of the largest Saharan dust storm recorded in the Niamey area in the past 2 years. The dust storm approached the site at about 0930 UTC and rapidly reduced visibility. A thicker dust cloud, several kilometers in height, rolled in about 1230 UTC, reducing visibility even further. The dust storm continued unabated for 2 more days and then gradually dissipated over the next several days. Measurements of optical depth—which indicates how much a specific layer in the atmosphere attenuates solar radiation—during the first 2 months of 2006 were around 0.3 to 0.5 in Niamey. During the March dust storm, optical depths were in excess of 3, which decreased the solar radiation reaching the surface by about 150 W/m$^2$, or 15 percent of its usual value. Optical depth was approximately constant with visible wavelength, indicating the dust particles were relatively large in size. Average dust particle size decreased with time, suggesting the larger particles fell to the surface, leaving a smaller size distribution.

In June, the monsoon season began. After below-average rainfall in June and July, August rainfall was slightly above the 1941–2000 mean. Thus, the various AMF measurements made in August should be fully representative for the peak month of the monsoon season. However, by the end of August, the accumulated rainfall was even less than in 2004, after which famine conditions occurred in southern Niger east of Niamey and received considerable international publicity. September received barely half of the 1941–2000 average rainfall, and cumulative rainfall for the monsoon season was the second lowest in the last 20 years. Preliminary results indicate that the 2006 monsoon season at Niamey will fall into the "very bad" category on an overall basis.




Accumulations of daily rainfall in Niamey, Niger, for the months of April through September for the last 3 years indicate a dry monsoon season for 2006.

These are just a few examples of the data collected by the AMF in Niamey. Development of a comprehensive seasonal cycle background for the entire 2006 AMF deployment is planned, including meteorological parameters such as daily maximum and minimum temperature, dew point, vapor pressure, and visibility.

## Tropical Clouds Probed for Climate Clues

For almost 4 weeks in January and February, simultaneous air, sea, and ground measurements were obtained during the Tropical Warm Pool-International Cloud Experiment (TWP-ICE) in Darwin, Australia. In a collaborative effort led by the ARM Program and the Australian Bureau of Meteorology, more than 200 researchers, graduate students, and infrastructure staff from the Unites States, Canada, the United Kingdom, Japan, and Australia took part in the complex experiment. Timed to coincide with maximum rainfall and convective activity during the summer monsoon season across northern Australia, the experiment focused on cirrus clouds associated with tropical convection, and their impact on the environment.

Cirrus clouds are ubiquitous in the tropics but the properties of these clouds are poorly understood. Therefore, a crucial product from the experiment was the collection of a dataset to produce the necessary link between tropical cirrus cloud properties and computer models used to simulate them. To collect these data, a fleet of aircraft, a research ship, and a network of strategically located surface sites were operated to supplement the continuous data collected at the ACRF site in Darwin.

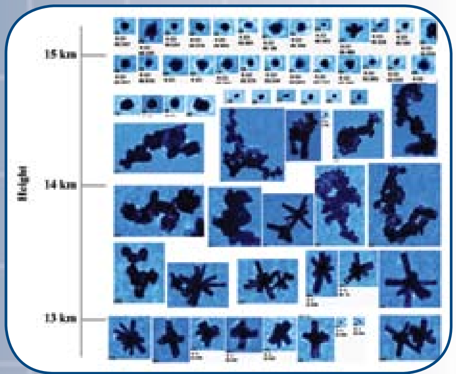
The aircraft flew below, in, and above the clouds in various patterns to collect cloud property data. Weather balloons were launched every 3 hours from outlying surface sites to collect measurements of wind speed, wind direction, pressure, temperature, and humidity. These measurements provided a detailed record of meteorological conditions within the experiment domain throughout the course of the experiment. Additional surface sites were equipped with passive instrumentation and lightening detection systems to measure turbulent and radiant energy exchange between land and the atmosphere. Radars at the surface sites were used to obtain profiles of cloud properties and wind speed, and to provide 3-dimensional distributions of precipitation for daily mission planning and analysis. Finally, the Southern Surveyor research vessel, located about 97 kilometers offshore in the Timor Sea, was equipped with a full complement of surface-based instrumentation for measuring atmospheric properties. The ship also served as one of the sites for launching weather balloons and measuring energy fluxes at the surface.

*While on the ground, the Twin Otter (left) and Proteus (right) shared hangar space at the Royal Australian Air Force base for the duration of TWP-ICE field operations.*

Daily activities and logistics for this complex experiment were conducted out of operations headquarters, located at Charles Darwin University. In addition to ensuring the overall safety of the participants, each day involved monitoring the data and operational status of the outlying ground sites and aircraft, conducting a series of briefings to review current weather forecasts and the desired science goals, and making a decision as to the suitability of weather conditions for successful science flights. On flight days, science team members guided the aircraft missions from the Bureau of Meteorology's Forecast Center in Darwin.

**Results:** During TWP-ICE, a progression of weather systems provided researchers with a broad range of conditions for studying cloud properties. The experiment began with an active monsoon period with widespread convection, cloud cover, and precipitation. During this period, a large storm system passed directly through the experiment array, providing a unique look at a tropical storm. After the system passed, the region settled into a less active period. However, the storm continued to produce cirrus over the area for several days, providing an excellent opportunity to study the evolution of tropical cirrus layers. This period was followed by several days of clear skies. The experiment ended with a week of so-called "break" conditions when convection tended to be localized in coastal regions and exhibited a strong diurnal cycle.

Twenty missions with multiple aircraft flying at altitudes ranging from 60 feet to 55,000 feet were completed throughout the course of the experiment, providing critical in situ cloud observations combined with observations of the atmospheric environment. Because high-altitude tropical clouds impact the energy exchange between earth and space, they have a large impact on climate and global weather patterns. In addition to showing researchers the composition of high-altitude




*Approximately midway through the experiment, images from instrumentation on the high-altitude Proteus aircraft showed distinct differences in ice particle shape and size as a function of temperature and altitude. These factors influence the longevity of the cloud, and therefore the amount of radiative energy both reaching and escaping the earth.*

*As part of the Aircraft Carbon field campaign, a set of carbon-cycle instruments and sample collection systems were added to the aircraft that routinely collect aerosol measurements at the ACRF SGP site. The airplane at upper left was collecting flasks at the same time as they were being collected at the 60-meter tower.*

clouds, the in-cloud observations will be used to refine cloud properties derived from long-term data obtained at the permanent site in Darwin.

While the aircraft provided detailed measurements of cloud properties, weather balloons and surface flux measurements provided critical data for constraining computer simulations of the convection during the TWP-ICE period. With these observations used as inputs, cloud model simulations will be performed to generate cloud fields, which will then be compared with the cloud observations. In this way, the experiment dataset can be used to evaluate cloud models in a tropical environment. The dataset obtained in Darwin will be used for years to come as scientists seek to refine computer models for forecasting regional weather and simulating climate change.

To facilitate ongoing data analysis and collaboration between the various groups associated with the experiment, a pair of workshops was held in November. The first workshop was hosted by the ACTIVE/SCOUT teams—the European component of the Darwin experiment—and was held in Cambridge, United Kingdom. ARM representatives attended this workshop to present results from the TWP-ICE and obtain detailed information about the status of the ACTIVE/SCOUT measurements. The following week, a TWP-ICE workshop was held in New York City. This workshop also included an ACTIVE/SCOUT component, but focused on TWP-ICE. At both meetings, details of measurements were presented and roundtable discussions provided a forum to develop focused plans for the next stage of analysis.

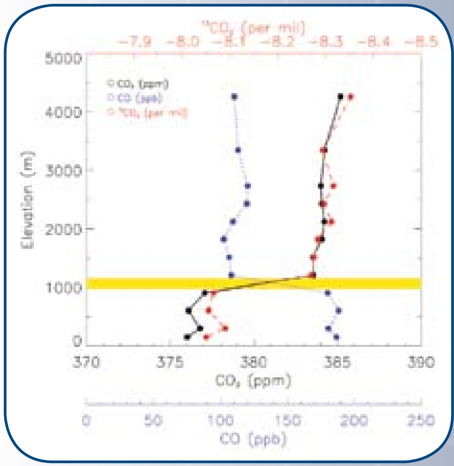
## Aircraft Carbon Field Campaign Measures Carbon Dioxide Concentration Profiles

July 2006 marked the beginning of a 2.5-year field campaign at the SGP site to obtain airborne trace-gas measurements. Trace gases include harmless inert gases, such as helium and neon, but also radiatively active gases, like methane and carbon dioxide. These latter gases, especially carbon dioxide, have been shown to enhance earth's natural greenhouse effect. As such, their contribution to global climate change is the focus of much research.

During the first year of the Aircraft Carbon field campaign, ARM researchers will focus on developing the capability to measure continuous carbon dioxide concentration profiles from the surface to mid-troposphere (i.e., 5–7 kilometers). Such measurements will facilitate calibration of the Orbiting Carbon Observatory—a satellite mission sponsored by the National Aeronautics and Space Administration (NASA)—and improve computer models that simulate Earth's carbon budget. They will also augment existing flask-based collection of trace gases (carbon monixide, methane, and stable isotopes of carbon dioxide, or $^{13}CO_2$) by sampling at more heights and adding a sampler for radiocarbon ($^{14}CO_2$). This suite of trace gases, enhanced by the continuous carbon dioxide profiles, will provide comprehensive data for inverse methods that infer ecosystem carbon exchange and quantify anthropogenic (manmade) combustion emissions.

After the first year, researchers plan to add two other temporary measurement systems: (1) a collection system for large air volumes (to capture $^{222}$Radon, a tracer for atmospheric transport), and (2) equipment for trapping water vapor for isotopic analysis. Additional collaborators will support developing the instrument systems and analyzing the data. Trace gas measurement obtained at the SGP site during this campaign will provide valuable data for addressing carbon-cycle questions stressed by the U.S. Climate Change Science Program and the North American Carbon Program.

**Results:** The suite of carbon cycle gases being measured at the SGP site reflect the regional sources and sinks—natural or manmade contributors or removers—of atmospheric $CO_2$. In particular, they provide a powerful constraint on estimates of the size of emissions and uptake of $CO_2$. As an example, atmospheric profiles of $CO_2$, $^{13}CO_2$, and CO from flasks collected by aircraft from 10 a.m. to noon local time, June 15, 2006, showed the free troposphere to be well mixed (no vertical structure in concentration) with concentrations matching the regional background values. In contrast, the boundary layer has a sharp reduction in $CO_2$ concentration, due to net ecosystem uptake (i.e., net photosynthesis) of $CO_2$.




*Data collected by aircraft for 2 hours on June 15, 2006, at the SGP site show atmospheric profiles of various carbon species. The yellow shading shows the approximate height of the boundary layer at the time.*

The large increase in $^{13}C$ values between the free troposphere and mixed layer corroborates that the decrease in $CO_2$ concentration was due to photosynthetic uptake. This is because the process of photosynthesis favors $^{12}C$ and discriminates against the heavier (i.e., $^{13}C$) isotope—thus leaving the atmosphere with more of the heavier isotope. Different types of plants and groundcover have varying levels of efficiency with respect to photosynthetic pathways, so isotopic measurements can help estimate when certain crops are taking up carbon.

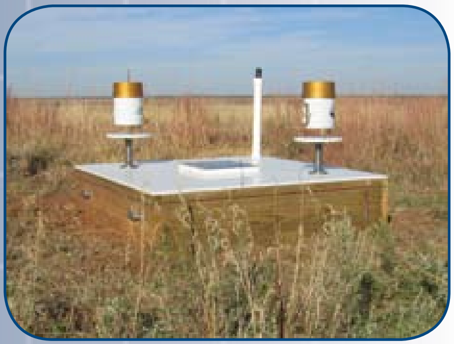
Another gas species, carbon monoxide, was shown to be elevated in the boundary layer relative to the free troposphere, indicating an anthropogenic (manmade) combustion source of CO and $CO_2$. Thus, the magnitude of the drawdown of $CO_2$ near the surface is the net effect of ecosystem sinks and combustion emissions.

The Aircraft Carbon field campaign continues through 2008, with the previously noted enhancements to the carbon collection instrumentation in 2007. These enhancements will also contribute to another ACRF field campaign at the SGP site called the Combined Land Surface Interaction Campaign, or CLASIC. This field campaign will focus on the impact of landscape changes affecting energy balance/flux partitioning and their impact on cloud/atmospheric dynamics. Using several aircraft and surface sites to collect data, CLASIC begins in May 2007 and will last for 3 months.

## HydroKansas Follows Water Flowing Through Space and Time

In May 2006, a 3-year field campaign called "HydroKansas" began in the Whitewater River basin in south-central Kansas. HydroKansas is an interdisciplinary effort to predict atmospheric, hydrologic, landscape, and ecological responses to natural hydro-climate fluctuations and human-induced changes. A primary goal of HydroKansas is to develop a predictive understanding of runoff and floods on multiple spatial and temporal scales, using high-resolution rainfall and streamflow data collected throughout the 1100 square-kilometer basin.

The study considers the role topography, land use, and vegetation play in controlling statistics of floods. With respect to topography, the Whitewater River basin is

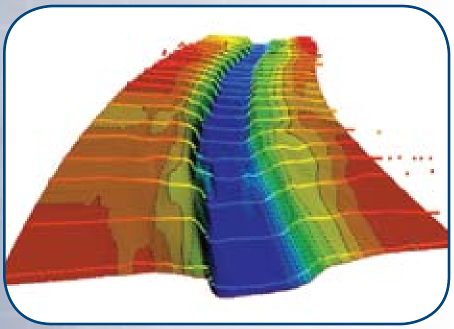


*Sets of rain and stream gauges like this one are providing information about water level and flow rates from sites throughout the Whitewater River watershed during the HydroKansas field campaign.*

located in a transition zone between dry and wet climates, and its soils are characterized by low infiltration; thus, the basin responds quickly to rainfall. Land use in the basin is mainly agricultural, with minimal urban development. However, numerous atmospheric experiments have been conducted in the area, resulting in a well developed observational infrastructure.

With hydrological instrumentation strategically distributed throughout the basin, HydroKansas will focus on the primary variables relevant to studies of flooding and runoff generation. These variables include rainfall, stream discharge, infiltration, soil moisture, and evaporation and transpiration—called evapotranspiration—from hillslopes and riparian vegetation along the rivers. Evapotranspiration from riparian zones (the wetlands adjacent to a stream or river) is an important component of land-atmosphere interaction, and HydroKansas will be one of the first experiments to directly account for moisture loss from riparian zones in the context of other hydrological and ecological measurements.

Scientists involved with the HydroKansas project developed and implemented a new fluid mechanics-based stream gauging method, which determines channel roughness from field measurements of the channel geometry, the physical roughness of the bed and banks, and the vegetation density on the floodplain. In support of the field campaign, 28 rain gauges at 14 sites, and 12 stream gauges at 12 sites were deployed within the basin.



*Digital elevation models are being developed for each site in the Whitewater River basin. This example, from a channel in the basin's East Branch, was generated from survey data mapped to a curvilinear grid.*

**Results:** In 2006, surveying was completed for all of the sites, including a detailed characterization of the channel and floodplain topography and the bed, bank, and floodplain roughness elements. For the real-time streamflow network, 20 submergible pressure transducers were installed at sites throughout the basin, ranging from small headwater channels to the basin outlet. These transducers were coupled with barometric sensors to capture atmospheric pressure fluctuations. In spring 2007, these pressure transducers will be connected to a real-time network, after which estimates of discharge from the 12 Whitewater sites will be available remotely from the internet.

Numerical modeling of discharge for each stream reach is currently underway, and rating curves have been developed for 6 of the initial 12 sites. Each site uses the flow depths from the transducers with the calculated rating curves to convert the flow depth information to stream discharge. The discharge is determined for each water stage using the process-based, fully predictive model. This new method drastically reduces the amount of time required to produce discharge rating curves compared to the many years often required by standard empirical approaches.

# Infrastructure Achievements

Infrastructure activities include management of site operations at the research facilities, instrumentation and engineering support, data quality and storage, and communication and education/outreach. All of these areas are key components of enabling ARM science and promoting the capabilities of the ACRF for new users.

## Site Operations

### *Increased Weather Balloon Soundings Begin at Barrow*

In April 2006, operations staff began launching balloon-borne sounding systems—better known as weather balloons—two times per day at the NSA site in Barrow, Alaska. Based on the recommendation of both the ARM Cloud Properties and Instantaneous Radiative Flux Working Groups, and approval by the IMB, the frequency of balloon soundings at Barrow increased from once to twice each day. The additional wind data from the soundings will provide climate scientists with more information about atmospheric conditions in the sensitive Arctic environment.

Each weather balloon is equipped with a radiosonde package for measuring air pressure, temperature, and humidity, as well as a global positioning system to provide profiles of wind speed and direction. The balloons are launched at 6 a.m. and 6 p.m. GMT, offsetting launches from the National Weather Service research station in Barrow by 6 hours.

*The balloon-borne sounding system consists of a small sensor package—called a radiosonde—attached by a long string to a large balloon. As the balloon rises, atmospheric measurements recorded by the radiosonde are picked up via an antenna on the ground.*

### *New Operations Status System Improves Tracking, Reporting*

Though some ACRF operations activities are site-specific, many—such as routine maintenance, corrective maintenance, shipping and receiving, inventory, spares, and calibrations—are common elements found at all the ACRF sites. Because these tasks have a large impact on budget planning and operational efficiency, the need was identified to standardize the cross-site elements into a common database. In 2006, a comprehensive Operations Status System (OSS) was developed to better track and report the status of operations capabilities at the widely disbursed ACRF sites. By serving as a central collection point for all ACRF site status information, the OSS enables timely and cost-effective decisions about site operations, particularly with respect to instrument performance issues.

The OSS was designed for tracking the states of various instrument and computer systems and components at each ACRF site. It was also designed to have the capability as an inventory tracking system. Now, site operators enter notable operational events into the OSS. These statistics are then used to develop diagnostic metrics, such as “accumulated time in service” and “mean-time to repair.” This information allows site managers to objectively and promptly identify any necessary actions and consider future budget expenditures.

## Instrument Enhancements

### *New Instrument "Counts" Cloud Particles*

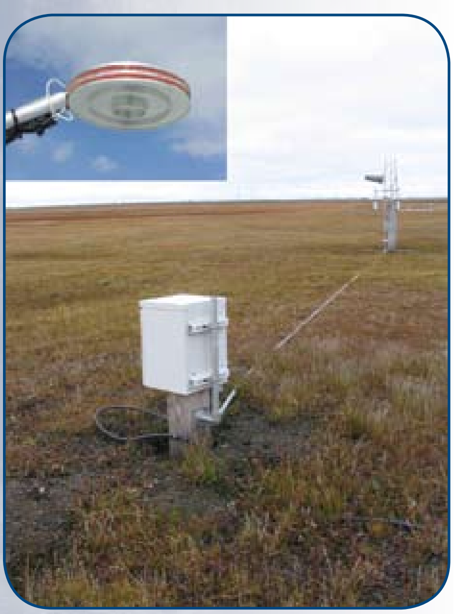

*The CCN Counter consists of a vertical column with wetted walls, which provides the water vapor necessary to produce supersaturations. Particles activate into droplets when exposed to the supersaturated conditions, and the droplets are then counted by an optical particle counter.*

Microscopic airborne particles are commonly referred to as "aerosols." Every one of the trillions of droplets in a cloud originates on one of these tiny "cloud condensation nuclei" (CCN). Through their role as CCN, aerosols affect cloud properties by altering the concentration of cloud droplets, and the brightness (reflectivity) and lifetime of clouds. To characterize how changes in CCN concentrations may be changing the properties of clouds observed at the SGP site, a CCN Counter was added to the suite of instruments that compose the site's Aerosol Observing System (AOS). This instrument measures CCN number concentration at supersaturations between 0.1–2 percent. Its optical particle counter measures the size distribution of the droplets that grow from CCN, collecting data every second in 20 particle-size bins from 0.75 to 10 microns.

Datasets from the CCN Counter at the SGP site will be available on a quarterly basis, following data quality review by the AOS instrument mentor team. Ultimately, the goal is for AOS systems at each ACRF site to use identical components, including the CCN Counter. An identical CCN instrument was deployed as part of the AOS during the AMF field campaign at Point Reyes, California, in 2005, and in Niamey, Niger, Africa in 2006.

### *Precipitation Sensor on Duty at North Slope of Alaska*

Because the impacts of climate change are shown to occur most rapidly in the sensitive Arctic environment, accurate precipitation measurements are needed for characterizing boundary layer (surface to 1000-meter altitude) conditions and simulating cloud formation as input to climate models. To obtain these measurements, a new precipitation sensor was installed at the NSA site in Barrow. This instrument provides measurements of snow-fall amounts, snow depth (and density), and snow temperature. The sensor's electrical components are designed to operate in temperatures spanning ±50°C.



*The precipitation sensor at Barrow was installed about 2 meters above the surface on the piling in the foreground, with power connected through a nearby Climate Reference Network box (background).*

Manufactured by Yankee Environmental Systems, the "hot plate" precipitation sensor head consists of two isolated plates positioned one on top of the other. It measures the rate of rain or snow based on how much power is needed to evaporate precipitation on the upper plate to keep its surface temperature constant. The second plate is positioned directly under the evaporating plate; it is heated to the same temperature to factor out cooling from the wind. Data collected by the sensor—situated approximately 0.4 kilometers south and east of the site's primary instrument facility—is transferred via fiber optic cable. The sensor's proximity to a nearby rain gauge allows hour-by-hour comparisons of measured snow rate.

### *Out with the Old, In with New: Micropulse Lidars Replaced*

In 2006, all the ACRF sites were outfitted with upgraded micropulse lidars (MPLs) equipped with new polarization capability. Each MPL provides critical backscatter measurements used to derive cloud-base heights, including high cirrus clouds (~18–20 kilometers). The backscatter measurements are also used in several value-added products to provide additional cloud and aerosol properties.

Representatives from Sigma Space Corporation—the MPL manufacturer—accompanied the initial MPL deliveries and provided extensive training sessions to technicians for each ACRF site. The training covered installation, initial set up, operation, problem diagnosis, and field repairs. Because the lidar is a sophisticated laser instrument, it requires laser safety training, special laser goggles, and a baseline eye examination for all technicians authorized to replace the laser diode module. The comprehensive training permits the technicians to assume responsibility for tasks that previously required either the instrument to be shipped offsite or the instrument mentor to travel to the site. The training is expected to dramatically reduce the time and expense required to repair the systems and return them to operation.

*A representative from Sigma Space Corporation trains ACRF operations staff in Darwin, Australia, on various components of the new MPL. The lidar, shown at left, will be placed in one of the outdoor instrument shelters, below a hole in the roof for the laser to pulse through.*

### *New Shortwave Spectroradiometer Deployed at SGP*

Based on a successful test period in 2004, a new shortwave spectroradiometer (SWS) began operating at the SGP site in late April as part of the permanent instrument suite. The instrument measures the zenith (1.4° field of view) solar spectral radiance between 300–2200 nanometers. Two Zeiss miniature monolithic spectrometers, with a spectral resolution of 8 nanometers in the range 300–975 nanometers, and 12 nanometers in the range 975–2200 nanometers, are part of the SWS. These measurements of visible and near infrared radiation will be used for testing shortwave radiation transfer models, as well as input to retrievals of cloud and aerosol properties.

Technicians at the SGP site will calibrate the instrument biweekly, using a dedicated 31-centimeter diameter LabSphere integrating sphere. This task involves removing the optic element from the roof port and placing it in a fixture designed to align it with the integrating sphere. To perform these routine calibrations without moving the sensitive spectrometer, SGP site operations staff created a "darkroom" by partitioning the east end of the SGP Optical Trailer (where the spectrometer is located) and painting it black.

*A ceiling port in the SGP Optical Trailer houses the optic element of the SWS, which connects to the spectrometer inside the trailer via fiber optic cable.*

### *Upgrades to Darwin Radar Double Data Delivery*

The millimeter wavelength cloud radar (MMCR) is the only source for obtaining detailed information about cloud location and internal structure in the atmospheric columns above the ACRF sites, and can be operated in almost any atmospheric condition. In November, a major upgrade to the 35-GHz MMCR at the TWP site in Darwin, Australia, increased the time resolution and associated data rates by an order of magnitude (i.e., x 10) over the previously installed radar. This upgrade also involved replacing obsolete computers and removing components that caused maintenance problems over the years, greatly increasing the reliability of the radar. This improvement came just in time to support TWP-ICE (see the Featured Field Campaigns section of this report).

During the past few years, MMCRs at the SGP and NSA sites were upgraded with C40 Digital Signal Processors. However, for the TWP, the science team opted to deploy a PIRAQ-III processor design for several reasons, including minimal hardware modifications, compatibility with other meteorological radars, availability of parts and technical support, enhanced performance, increased reliability, and minimal risk and costs. In just a few days of operation, data comparisons between

*The new processor for the MMCR (antenna shown in upper right of photo) at Darwin collects spectral data in four different modes, resulting in approximately 3.4 gigabytes of signal output per day.*

the SGP and NSA MMCR processors (C40 upgrade) and the Darwin MMCR processor (PIRAQ) showed a nearly two-fold increase in data rates for both raw moment files and spectra files. As an essential contributor to cloud and radiation research, the upgraded MMCR will help the ARM Program remain a leader in remote sensing of the atmosphere.

## Data Delivery

### *Increased Server Power Pumps Up Data Management Performance*

In 2006, a collection of new computer servers joined the production system at the ACRF Data Management Facility (DMF). The new Sun servers use the most current operating system available, Solaris 10, which ensures maximum reliability and security. These servers provide much needed processor power to handle the ever-increasing processing load.

The DMF is responsible for collecting and processing hourly data from all the ACRF sites each day. Processing involves the application of algorithms for performing simple averaging routines, qualitative comparisons, or more complicated experimental calculations. The previous systems experienced overloading problems on backlogged data. With the new servers online, primary data ingesting and value-added product processing services were transferred over with very noticeable, positive performance results. All the old server systems were retired, and processing software for the data systems were recompiled and optimized for Solaris 10 and the new hardware.

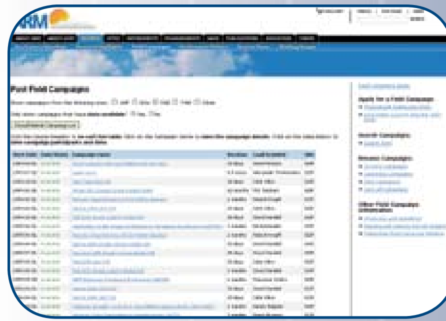
### *One-Stop Data Shopping Expanded to Include Field Campaigns*

In 2005, the ARM website was integrated with the ARM Data Archive to allow users to browse and order data using a data shopping cart feature. This ability, however, only applied to "routine" data—data that are collected continuously from the ACRF sites—leaving a large holding of special field campaign data at the Archive inaccessible via the shopping cart. Working with data managers at the Archive, ARM website developers added the ability to order field campaign data through the instruments and measurements webpages via the shopping cart.

Users can now browse for field campaign data after selecting an instrument or measurement and entering the shopping cart. Once in the cart, users will see a list of field campaigns that used the specified instrument or collected the specific measurement. This information appears alongside the routine ARM data. Field campaign data of interest can then be downloaded directly from the cart just as easily as routine ARM data.

### *Navigating the Landscape of Field Campaign Pages*

Continuing on the website design work accomplished in 2005, the ARM field campaign web pages underwent additional renovation in 2006 to further improve navigation and accessibility. While the pages remain consistent with the overall design of the ARM website, the right-hand navigation was redesigned to aid users in finding current, upcoming, and past field campaigns quickly and easily. As part of this usability improvement, a filter was added that allows users to “hide” field campaign web pages that do not include data. Once users select a category of field campaigns, the newly designed interface allows users to quickly scan the summary table and select the column of interest. This generates a sorted table that makes it easy to locate the desired data. Information in all the data status columns was color coded to aid in scanning for data availability, with a direct link to the ARM Data Archive for downloading. A new guided search form and interactive timeline were also added to provide users with additional ways to search for a field campaign.



*Field campaign information was previously presented in a fixed hierarchy that was tedious to search. This information is now presented in a tabular display that is easily scanned and sorted.*

In a related activity, the preproposal form for submitting a field campaign request was redesigned. To assist lead scientists in preparing their request, all the questions are now provided on one page for review, rather than a progression of questions. Questions were reworded to clarify intent, and instructions and guidance were provided for all questions.

## Communication, Education, and Outreach

### *Hands-On Activities Help Interest Kids in Science*

Education and outreach activities sponsored by the ACRF are geared toward K–12 students and teachers, as well as the communities that host ACRF sites. In January, education and outreach staff participated in WeatherFest, a public science fair that kicks off the annual meeting of the American Meteorological Society. During the 4-hour event, visitors to the ACRF education and outreach booth inquired about the online ACRF Education Center, checked out the NSA interactive DVD, and picked up lesson plans. In addition, education and outreach staff handed out more than 400 climate change activity and coloring books to teachers and students.

*Kids attending the Chickasaw Nation Aviation and Space Camp learned to decode station model plots, contour temperature maps, create tornadoes in a bottle (shown here), and build wind-resistant houses.*

June was also a busy month for ACRF education and outreach staff. During a day camp held outdoors at Reeves Park in Norman, Oklahoma, they helped nearly 100 local Girl Scouts earn their weather badges. Seven “learning stations” were staffed by female volunteers ranging from professional meteorologists to graduate and undergraduate students. Station topics included pressure and temperature, weather maps, fronts, tornadoes, lightning, heat, and seeing the instruments of a weather station. Later in June, additional education and outreach staff presented half-day weather sessions at two Chickasaw Nation Aviation and Space Camps. Students were given weather maps to chart the formation of a small tornado, and watched video of the tornado as it tore through an abandoned airplane hangar at the El Reno, Oklahoma, airport. Students were also supplied with Styrofoam meat trays, straws, popsicle sticks, tape, cardboard, and construction paper to build a wind-resistant structure. A total of 75 students attended the space camps, held at the Ada Municipal Airport in Ada, Oklahoma.

### *Interactive Kiosk and School Visits Promote Climate Education in the Tropics*

Several ARM scientists involved in the TWP-ICE field campaign took time out from their research for a very important purpose—to talk to students about climate


*Titled* Climate Change: Science and Traditional Knowledge*, ACRF's latest education kiosk is now on permanent display at the Museum and Art Gallery of the Northern Territory in Darwin, Australia.*

change. As a preview to the new interactive climate education kiosk at the Museum and Art Gallery of the Northern Territory in Darwin, they made visits to Darwin area schools, plus a remote school for Aboriginal children. To kick off each visit, ACRF education and outreach staff gave an introduction about the ARM Program and provided information about climate education resources in their area. This was followed with a presentation by ARM scientists and graduate students about clouds, solar radiation, instrumentation, data, and the ongoing field campaign. All teachers were given packets with ARM lesson plans, newsletters, and a copy of the kiosk program on DVD, and the young students received stickers and ARM activity books with puzzles, coloring pages, and mazes.

At the end of the field campaign, a dedication ceremony was held at the museum to present the new educational kiosk display to community leaders. Titled *Climate Change: Science and Traditional Knowledge*, this hands-on learning tool provides information about climate change in the global "warm pool"—the equatorial western Pacific region which features the warmest sea surface temperatures on earth. The kiosk components include footage of interviews with atmospheric scientists, local fishermen, traditional land owners, and members of Australia's Aboriginal community. The interviews focus on the science and impacts of climate change in Darwin, as well as general information about climate change research. Copies of the kiosk DVD are available free of charge to educators around the world for classroom use.

*Exhibit staff provided background information about the ARM Science Program and the ACRF to visitors at the 86th Annual Meeting of the American Meteorological Society.*

### *Exhibit Draws Interest from Scientific Community and Youth*

More than 2,200 academics, government officials, private researchers, and leading atmospheric scientists gathered in January at the American Meteorological Society's 86th Annual Meeting in Atlanta, Georgia. Between sessions, they perused the adjoining exhibit hall, where ACRF staff shared information about ARM science with interested attendees and answered questions about using the ACRF. Visitors to the ACRF display booth were most interested in learning about the latest AMF deployment, the ongoing field campaign in Australia, ordering ARM data, how to submit a proposal to conduct their own field campaign, and the 2005 Annual Report.

ACRF also staffed its exhibit at the 2005 American Geophysical Union (AGU) Fall Meeting held in San Francisco in December. As a record-setting 11,904 scientists gathered to discuss the latest issues affecting all areas of earth and space sciences, ACRF staff shared information about the program's mission and goals with attendees. Many conference attendees inquired about data availability and accessibility, and some participants requested more information about using the AMF. On the last day of the meeting, ACRF exhibit staff participated in the first-ever Student Exploration of Research in the Earth and Space Sciences program. Local middle school students were invited to visit the AGU exhibit hall to learn about research and careers in earth and space sciences, meet scientists, view demonstrations, and gather take-home activities. The ACRF Education and Outreach climate change coloring and activity book was received with enthusiasm by interested teachers and students.

## *Media Day and Open House Provide a Public Peek at Experiment*

Members of the TWP-ICE science team and Australian officials hosted a media day to provide an opportunity for reporters to learn about the experiment, touted as one of the largest scientific experiments ever conducted in Australia. In addition to briefings, they provided tours of the aircraft on base and the ship at Darwin Harbor. Attended by more than a dozen reporters, photographers, and film crews, plus a handful of documentary teams, the media day resulted in numerous news articles by Australian and European media. Several of the documentary teams remained on location to provide more extended coverage of the complex field campaign, and Australian radio programs aired brief updates throughout the 21-day experiment. A comprehensive list of media coverage resulting from the experiment is available at http://science.arm.gov/twpice/media.stm.

The TWP-ICE science team also took part in an "Open Day" at Charles Darwin University, where experiment headquarters was located. The Open Day, similar to an "open house" in the United States, was coordinated with university staff to thank them for providing technical support and free use of the university facilities and infrastructure during the experiment. Geared toward the general public and prospective students, the 2-hour morning and afternoon sessions consisted of a series of presentations and question-and-answer sessions. Turnout for the event was excellent, with each session ending in standing-room-only space in the lecture theater (capacity of about 125). In addition, the visitors browsed with interest through various informational displays and materials situated in the hall leading to the lecture theater. ARM science team members were on hand at the TWP-ICE and ARM display throughout the day, answering questions from visitors both young and old.

*A film crew for the Discovery Channel-United Kingdom interviews ARM scientist Jim Mather, co-lead for the TWP-ICE field campaign.*

# 2006 Field Campaigns

| Dates | Name | Status | Description |
|---|---|---|---|
| **North Slope of Alaska** | | | |
| January 2004 – June 2006 | Extended Range Atmospheric Emitted Radiance Interferometer (AERI-ER) Intercomparison IOP | Completed | This intercomparison was conducted to verify the reproducibility of calibration on the AERI-ER and to identify the source of a small bias identified in AERI-ER data in clear-sky, low precipitable water vapor situations. To meet these objectives, two AERI-ER systems (one provided by the University of Wisconsin) were operated side-by-side at the NSA site in Barrow for a 6-week period during the cold, dry season. Preliminary results indicate the AERI-ER calibration can be reproduced using an out-of-band correction procedure, however the bias in clear, dry conditions remains unresolved. |
| April 2005 – April 2006 | Atmospheric Infrared Sounder (AIRS) Validation Soundings, Phase IV and V (Also at TWP and SGP) | Completed; awaiting data | A special series of radiosonde launches were conducted at all the ACRF sites in support of validation studies for the AIRS instrument aboard NASA's Aqua satellite. The AIRS instrument is intended to make highly accurate measurements of air temperature, humidity, clouds, and surface temperature. The data collected by AIRS during the past several years will be used by scientists around the world to better understand weather and climate. |
| January 2005 – January 2006 | High-Latitude Optical Turbulence Characterization | Completed | The University of Alaska-Fairbanks and U.S. Army Research Laboratory (ARL) implemented this joint proposal at the NSA site in Barrow. The scientific objective of this 9-month campaign was to characterize the near-surface atmospheric optical turbulence over a flat, relatively low-humidity, high-latitude location. Results from the data collection effort will be compared to those from an equivalent flat, relatively low humidity, mid-latitude desert site. Ultimately, these comparisons will be used to improve the ARL Surface Layer Stability Transition Forecast Model, which was shown to display a strong seasonal contribution in diurnal atmospheric stability transition patterns. |
| June 2006 – Ongoing | National Science Foundation (NSF) Ultraviolet (UV) Monitoring Support | In Progress | In this ongoing field campaign, ACRF is providing onsite support to the NSF UV monitoring network, which measures solar UV radiation at six high-latitude sites and at San Diego, California. This network was founded in 1987 in response to severe ozone depletion reported in Antarctica and is operated by Biospherical Instruments, Inc. Instrumentation installed at network sites includes high-resolution, ultraviolet-visible spectroradiometers (measuring spectral irradiance between 280 and 600 nanometer) as well as multi-channel filter radiometers. The network site at Barrow, Alaska, was established in 1991, with instrumentation located in the Ukpeagvik Iñupiat Corporation building. In 2005, ACRF took over site operations support previously provided by by NOAA's Climate Monitoring and Diagnostics Laboratory. Preliminary data from the network are available within 1 week after collection and can be accessed via the project's website at http://www.biospherical.com/NSF. The project's website also provides additional information on the network, its data, and applications. |
| June 2006 – Ongoing | Global Positioning System (GPS) Base Station – Atqasuk | In Progress | A GPS base station in Atqasuk provides a local source of geodetic quality differential corrections for GPS data post-processing by scientists and others operating in the Atqasuk area of the North Slope. The station, located at the ACRF's Atqasuk site, provides security, power, and ethernet communications. The station runs continuously, and 15-second sample rate data are archived at UNAVCO (http://facility.unavco.org) and available to the public. Higher sample rate data are also recorded on the receiver in hourly files, and will be made available to users as needed. Because all data are available via the Internet users do not need to have physical access to the receiver. |
| August 2006 – July 2007 | Pyranometer Infrared (IR) Loss Study | In Progress | This field campaign will provide a long-term (1-year) set of measurements needed to investigate and refine the IR loss correction methodology for data obtained at the NSA sites. An extensive effort will be directed toward gaining an understanding of what effects the current ventilator heaters might be having on the basic measurements. The IOP will also involve investigating the various permutations of the amount of ventilation and heating to perhaps optimize ARM's broadband measurement strategy for NSA. These latter studies may evolve as early results are obtained. Overall, the IOP is targeted at improving both the understanding, and the quality and accuracy, of NSA measurements. |

| Southern Great Plains | | | |
|---|---|---|---|
| February 2005 – Ongoing | Near Real-Time GPS Water Vapor Data Availability | In Progress | The SGP site hosts the worlds' largest concentrations of GPS receivers dedicated to atmospheric research. Since 1993, the facilities and resources of the SGP site have been used by NOAA's Forecast Systems Laboratory (FSL), other government agencies, and universities to develop ground-based GPS water vapor observing systems and perform data intercomparisons to assess their characteristics and evaluate their suitability for climate research and observing system (primarily radiosonde and satellite) calibration and validation. In addition to their use in research and climate studies, GPS water vapor measurements have proven to be extremely useful in improving short-range weather forecasts accuracy over the contiguous United States, providing situational awareness under rapidly changing conditions, verifying other moisture observations, and validating weather model predictions. Another promising GPS application developed by FSL displays 1-hour, 2-hour, and 3-hour changes in IPW at each site. This provides forecasters with current information about moisture convergence zones and where thunderstorms are most likely to first break out. At the request of FSL, the ACRF evaluated and upgraded the communications at these sites to provide data in near real-time for operational forecasting. |
| March 2005 – February 2006 | Precision Gas Sampling (PGS) Validation | Completed; awaiting data | Accurate prediction of the regional responses of $CO_2$ flux to changing climate, land use, and management requires models that are parameterized and tested against measurements made in multiple land cover types and over seasonal to inter-annual time scales. In an extension of earlier work on crop systems, this 12-month campaign investigated the effects of burning on the cycles of carbon, water, and energy in an example of grazed land in the SGP region. |
| March 2006 – February 2007 | PGS Validation Field Campaign | In Progress | This collaboration with the U.S. Department of Agriculture Grazing Lands Research Laboratory (GRL), involves a treatment-control experiment comparing fluxes and other ecosystem properties in adjacent burned and unburned fields containing native prairie at GRL near El Reno, Oklahoma. Our hypotheses, specific to the burning experiment, are that burning will (1) affect the timing and amount of above-ground production, but (2) not affect the total carbon exchange when the carbon lost during the burn is accounted for. |
| January – March 2006 | Aura/Thermal Emission Sounder (TES) Validation | Completed | This field campaign involved validation of the TES on the Aura satellite to provide improved global measurements of ozone and temperature. Ozone is a radiatively active gas with upper-atmospheric concentrations expected to decline in the next decade. Climate investigation and validation of satellite data are important for the measurement of this ozone decline and to ascertain satellite accuracy. The validation consisted of balloon-borne ozonesondes released from the SGP site on a schedule compatible with the ephemerides of Aura/TES. Six segments were scheduled with a 5-day period of no ozonesondes between each segment. NASA Accurate Temperature Measuring (ATM) radiosondes were released with ARM RS92 radiosondes for temperature comparisons. |
| February 2006 | RS92 – NASA ATM Radiosonde Temperature Intercomparison | Completed | Bias in upper-air temperature and relative humidity measurements affect estimates of the radiative properties of the atmosphere. Improving the accuracy of these measurements is a goal of the ARM Program. Analysis of data collected during earlier ARM radiosonde IOPs suggested a possible day-night temperature bias in the RS92 sensor. This IOP piggybacked a series of dual-radiosonde flights with ATM radiosondes during the Aura validation IOP to check temperature errors in RS92 radiosondes. The goal was to compare the temperature measurements of the RS92 with the well-characterized NASA ATM sensor. |
| March 2006 – June 2011 | Magnetic Field Observations at Purcell, Oklahoma | In Progress | Collaborators from the University of California installed a magnetometer at the SGP boundary facility at Purcell, Oklahoma, and for the next 5 years will collect continuous measurements of the magnetic field. These data can be used to study a wide range of physical processes of the sun-Earth system, including magnetic storms, ionospheric currents, and other phenomena whose source energy originates from enhanced solar activity. |
| April 2006 | Sun and Aureole Measurement (SAMNET) Validation | Completed | Reliable ground-based measurements of cloud optical depth and particle-size distribution provide important truth data for the post-launch calibration and validation of environmental satellite cloud algorithms, as well as consistent datasets for long-term climate change research. To obtain these measurements, a new instrument named SAM, for Sun and Aureole Measurement, makes precise measurements of the radiance profile of the solar disk and aureole. The radiance of the solar disk affords a definitive measure of the column optical depth when corrected for forward scattering. The aureole profile is a measure of the forward scattering properties of the particles in the column. It can be used to correct the optical depth, as well as to derive the size distribution of particles in the column. Validation of the SAM instrument and processing algorithms will make use of coincident datasets from a number of other instruments at the SGP site, as well as retrievals from sensors aboard NSA satellites. |

| | | | |
|---|---|---|---|
| April 2006 | $CO_2$flx-Ameriflux-Intercomparison | Completed | Sites conducting $CO_2$ flux measurements in North America can participate in the DOE Ameriflux network, thereby increasing the use of site data by the carbon cycle community, and the value of the site to the North American Carbon Program. Participating sites are ranked in the Ameriflux program according to (1) the breadth and intensity of supporting data collected, and (2) the quality of the flux data, as judged by periodic intercomparisons with the Ameriflux Roving Instrument System. The SGP Central Facility qualifies as a Tier 1 site in all respects except for the lack of an intercomparison with the Roving Instrument. In this IOP, the Ameriflux team visited the SGP Central Facility for a 1-week flux measurement intercomparison during the wheat-growing season. |
| May 2006 – October 2009 | HydroKansas | In Progress | For 3.5 years, the Whitewater River (Kansas) watershed will serve as the focus of a NSF long-term study intended to develop and field-test new innovative theoretical approaches for better understanding the non-linear coupling among atmospheric processes, the landscape, vegetation and important elements of the hydrological cycle, especially as they relate to changes in climate and in the occurrence of extreme events such as floods. |
| May 2006 – July 2007 | Combined Wind Profiler and Polarimetric Radar Study of Precipitation | In Progress | In this campaign, a 915-MHz boundary-layer radar (BLR) at the SGP boundary facility (BF-6) located in Purcell, Oklahoma, is being used to study the vertical structure of rain under various meteorological conditions. Unlike many remote sensing instruments, a vertically pointing BLR can directly measure the size distribution of rainfall particles. The so-called drop size distribution (DSD) is a crucial parameter used in radar rainfall retrieval techniques; however, the DSD typically must be assumed to follow a prescribed analytic form. If the actual precipitation does not match the assumed form of the DSD then the rainfall estimates provided are biased. Precipitation data obtained using the 915-MHz BLR will be compared against measurements made using a ground-based disdrometer and from the National Severe Storms Laboratory polarimetric WSR-88D radar. Additionally, data from the NOAA Profiler Network 404-MHz radar will be used in the study. |
| May 2006 – August 2006 | Disdrometer and Polarimetric Radar Measurements of Precipitation Microphysics | Completed | Accurate quantitative precipitation estimation and forecast require characterization of rain microphysics, which in turn requires information regarding DSD. During this 3-month campaign at the SGP site, rain DSD was measured by disdrometers and retrieved from polarimetric radar observations, fielded by researchers from Oklahoma University. |
| June 2006 – August 2009 | Observation-based Precipitation Microphysics Study | In Progress | Understanding precipitation microphysics is important in accurate quantitative precipitation estimation and forecast. A two-dimensional video disdrometer (2DVD) measures size, shape, orientation and falling speed of each precipitating particle. A polarimetric radar provides information about cloud/precipitation physics with a large spatial coverage. The University of Oklahoma purchased and deployed a 2DVD at the SGP BF-6 to measure hydrometeor DSD. An 2DVD from the National Center for Atmospheric Research will also be placed side-by-side with the university's 2DVD, providing data to improve the understanding of precipitation microphysics for the SGP region of the United States, to develop radar retrieval algorithms/forward operators, and to verify polarimetric radar measurements. |
| July 2006 – December 2008 | Aircraft Carbon | In Progress | The goals of this IOP are to acquire the ability to measure carbon dioxide concentrations and sample for a suite of trace gases from the surface to mid-troposphere. Airborne measurements of trace gases will (a) provide valuable data for addressing carbon cycle questions that have been identified by the U.S. Climate Change Research Program and the North American Carbon Program, (b) facilitate the calibration of the NASA Orbiting Carbon Observatory, and (c) provide a basis from which to develop inverse methods to infer ecosystem carbon exchange and quantify anthropogenic combustion emissions. |
| September 2006 | Summer 2006 Aerosol/ CCN Study | Completed | This field campaign was conducted to evaluate the relative abilities of different classes of aerosols to act as cloud condensation nuclei (CCN). To do so, the science team used a new CCN probe that couples a supersaturating column with a phase dopler interferometer. The supersaturating column exposes ambient particles to a specified supersaturation for a known duration, and the phase dopler interferometer measures droplet diameter at a resolution of <1 micron. The precision of these measurements allows mass accommodation coefficient to be estimated. In addition, the science team collected filter samples of fine aerosols for future chemical analysis, and to measure their adsorption and scattering coefficients. This will enable them to relate the kinetics of the measured aerosols to their composition. |

| Tropical Western Pacific | | | |
|---|---|---|---|
| December 2004 – January 2006 | Darwin Lightning Detection | Completed | The objective of this IOP is to characterize convection produced from lightning by using a VHF broadband digital interferometer (VHF BDITF) at the TWP Darwin site. Because electrical storms are common in the Darwin area and lightning is a useful indicator of convective strength, the instrument would (a) monitor the evolution and activity of a thunderstorm system; (b) add to the convective characterization component of lightning; and (c) complement the existing scanning centimeter radars. The VHF BDITF will enable the characterization of the lightning at a high resolution (1 microsecond) and will provide a new convective characteristic component that will complement existing measurements. |
| September 2005 – November 2010 | Orbiting Carbon Observatory (OCO) – Fourier Transform Spectrometer (FTS) Validation | In Progress | The NASA OCO Science Team will deploy, operate, and maintain ground-based solar-viewing FTS mobile laboratories at the TWP site in Darwin, Australia, to validate space-based $CO_2$ retrievals. Long-term operation of both FTSs will continue through the end of the OCO mission (2010). |
| January – February 2006 | Tropical Warm Pool – International Cloud Experiment (TWP-ICE) | Completed; awaiting data | This intense month-long field campaign took place between January and February, centered on the ACRF site in Darwin, Australia. TWP-ICE was aimed at describing the properties of tropical cirrus and the convection that leads to their formation. A crucial product from this experiment will be a dataset suitable to provide the forcing and testing required by CRMs and parameterizations in global climate models. This dataset will provide the necessary link between cloud properties and the models that are attempting to simulate them. The campaign was a collaborative effort between the ARM Program, the Australian Bureau of Meteorology, NASA, the European Commission DG RTD-1.2 and several United States, Australian, Canadian, and European universities. |
| June 2006 – June 2011 | Geoscience Australia Continuous Global Positioning System (GPS) station | In Progress | The TWP site in Darwin is hosting a new GPS station that will form part of the Australian Regional GPS Network and South Pacific GPS Network. These networks consist of more than 30 continuous GPS stations operating within Australia and its territories (including Antarctica) and the Southwest Pacific. They support a number of different science applications, including but not limited to, the maintenance of the Geospatial Reference Frame (both national and international), continental and tectonic plate motions, sea-level rise, and global warming. |
| **ARM Mobile Facility** | | | |
| January – December 2006 | RAdiative Divergence using AMF, GERB and AMMA STations (RADAGAST) | In Progress | The primary purpose of this 1-year deployment in Niamey, Niger, Africa, was to combine an extended series of measurements from the ARM Mobile Facility (AMF) with those from satellite instrumentation to provide the first well-sampled, direct estimates of the divergence of solar and thermal radiation across the atmosphere. The deployment is timed to coincide with the field phases and special observing periods of the African Monsoon Multidisciplinary Analyses and related experiments in 2006. |
| **Special Data Set Requests** | | | |
| June 2004 – June 2009 | Cooperative Atmosphere Surface Exchange Study (CASES) Data Analysis | In Progress | Two field programs—CASES-97 (morning and evening) and CASES-99 (evening, night, morning)—from the National Center for Atmospheric Research provide a robust dataset for looking at the diurnal changes of the wind, temperature, humidity, and their vertical transports near the ground and through the lowest few kilometers where surface effects are directly felt—the atmospheric boundary layer. Combined with data from the International $H_20$ Project, CASES-97 will provide a description accurate and comprehensive enough to isolate and mitigate problems in land-surface models (the "piece" of weather and climate models that describes heat and moisture transports) and to test and improve the inner workings of the interacting land-surface and boundary-layer models in a fully operating numerical weather forecast model. |
| Fall 2005 – Ongoing | Study of Environmental Arctic Change (SEARCH) Data Archival | In Progress | NOAA is deploying a climate-monitoring site in Eureka, Canada, as part of the SEARCH Program in an effort to duplicate the ACRF site in Barrow, Alaska, in terms of instruments, datastreams, and data formats. Because datasets would be similar to those in the ARM and SEARCH datasets, a combined archive will be used to create a comparison to facilitate Arctic research. |

# FY 2006 Publications

## Journal Articles


Andrews, E, PJ Sheridan, M Fiebeg, A McComiskey, JA Ogren, WP Arnott, D Covert, R Elleman, R Gasparini, D Collins, H Jonsson, B Schmid, and J Wang. 2006. "Comparison of methods for deriving aerosol asymmetry parameter." *Journal of Geophysical Research* 111, D05S04, doi:10.1029/2004JD005734.

Arnott, WP, JW Walker, H Moosmuller, RA Elleman, H Jonsson, G Buzorius, W Conant, RC Flagan, and JH Seinfeld. 2006. "Photoacoustic insight for aerosol light absorption aloft from meteorological aircraft and comparison with particle soot absorption photometer measurements: DOE Southern Great Plains climate research facility and the coastal stratocumulus imposed perturbation experiments." *Journal of Geophysical Research* 111, D05S02, doi:10.1029/2005JD005964.

Augustine, JA, GB Hodges, CR Cornwall, JJ Michalsky, and CI Medina. 2005. "An update on SURFRAD – The GCOS surface radiation budget network for the continental United States." *Journal of Atmospheric and Oceanic Technology* 22:1460-1472.

Bauer, M, and AD Del Genio. 2006. "Composite analysis of winter cyclones in a GCM: Influence on climatological humidity." *Journal of Climate* 19:1652-1672.

Berg, LK, and S Zhong. 2005. "Sensitivity of MM5-simulated boundary layer characteristics to turbulence parameterizations." *Journal of Applied Meteorology* 44:1467-1483.

Chang, F-L, and Z Li. 2005. "A new method for detection of cirrus overlapping water clouds and determination of their optical properties." *Journal of the Atmospheric Sciences* 62:3993-4009.

Chen, Y, F Aires, JA Francis, and JR Miller. 2006. "Observed relationships between Arctic longwave cloud forcing and cloud parameters using a neural network." *Journal of Climate* 19:4087-4104.

Chen, Y, and JE Penner. 2005. "Uncertainty analysis for estimates of the first indirect aerosol effect." *Atmospheric Chemistry & Physics* 5:2935-2948.

Chiu, JC, A Marshak, Y Knyazikhin, WJ Wiscombe, HW Barker, JC Barnard, and Y Luo. 2006. "Remote sensing of cloud properties using ground-based measurement of zenith radiance." *Journal of Geophysical Research* 111, D16201, doi:10.1029/2005JD006843.

Cole, JNS, HW Barker, W O'Hirok, EE Clothiaux, MF Khairoutdinov, and DA Randall. 2005. "Atmospheric radiative transfer through global arrays of 2D clouds." *Geophysical Research Letters* 32, L19817, doi:10.1029/2005GL023329.

Coulter, RL, MS Pekour, DR Cook, GE Klazura, TJ Martin, and JD Lucas. 2006. "Surface energy and carbon dioxide fluxes above different vegetation types within ABLE." *Journal of Agricultural and Forest Meteorology* 136:146-158.

Daniel, JS, RW Portmann, HL Miller, S Solomon, AO Langford, CS Eubank, R Schofield, DD Turner, and MD Shupe. 2006. "Cloud property estimates from zenith spectral measurements of scattered sunlight between 0.9 and 1.7 μm." *Journal of Geophysical Research* 111, D16208, doi:10.1029/2005JD006641.

Deeter, MN, and J Vivekanandan. 2006. "New dual-frequency microwave technique for retrieving liquid water path over land." *Journal of Geophysical Research* 111, D15209, doi:10.1029/2005JD006784.

Dong, X. 2005. "The impact of surface albedo on the retrievals of low-level stratus cloud properties: An updated parameterization." *Geophysical Research Letters* 32, L10802, doi:10.1029/2005GL022548.

Dong, X, and B Xi. 2006. "A climatology of midlatitude continental clouds from the ARM SGP Central Facility. Part II: Cloud fraction and surface radiative forcing." *Journal of Climate* 19:1765-1783.

Doran, JC, JC Barnard, and WJ Shaw. 2006. "Modification of summertime Arctic cloud characteristics between a coastal and inland site." *Journal of Climate* 19:3207-3219.

Evans, KF, D O'Connor, P Zmarzly, and RP Lawson. 2006. "In situ cloud sensing with multiple scattering lidar: Design and validation of an airborne sensor." *Journal of Atmospheric and Oceanic Technology* 23:1068–1081.

Feingold, G, R Furrer, P Pilewskie, L Remer, Q Min, and H Jonsson. 2006. "Aerosol indirect effect studies at Southern Great Plains during the May 2003 Intensive Operations Period." *Journal of Geophysical Research* 111, D05S14, doi:10.1029/2004JD005648.

Feldman, DR, KN Liou, YL Yung, DC Tobin, and A Berk. 2006. "Direct retrieval of stratospheric CO2 infrared cooling rate profiles from AIRS data." *Geophysical Research Letters* 33, L11803, doi:10.1029/2005GL024680.

Ferrare, RA, DD Turner, M Clayton, B Schmid, J Redemann, D Covert, R Elleman, J Ogren, E Andrews, JEM Goldsmith, and H Jonsson. 2006. "Evaluation of daytime measurements of aerosols and water vapor made by an operational Raman lidar over the Southern Great Plains." *Journal of Geophysical Research* 111, D05S08, doi:10.1029/2005JD005836.

Ferrare, R, G Feingold, S Ghan, J Ogren, B Schmid, SE Schwartz, and P Sheridan. 2006. "Preface to special section: Atmospheric Radiation Measurement Program May 2003 Intensive Operations Period examining aerosol properties and radiative influences." *Journal of Geophysical Research* 111, D05S01, doi:10.1029/2005JD006908.

Francis, JA, E Hunter, JR Key, and X Wang. 2005. "Clues to variability in Arctic minimum sea ice extent." *Geophysical Research Letters* 32, L21501, doi:10.1029/2005GL024376.

Garrett, TJ, and C Zhao. 2006. "Increased Arctic cloud longwave emissivity associated with pollution from mid-latitudes." *Nature* 440:787-789.

Gasparini, R, R Li, D Collins, RA Ferrare, and V Brackett. 2006. "Application of aerosol hygroscopicity measured at the Atmospheric Radiation Measurement Program's Southern Great Plains site to examine composition and evolution." *Journal of Geophysical Research* 111, D05S12, doi:10.1029/2004JD005448.

Gasparini, R, DR Collins, E Andrews, PJ Sheridan, JA Ogren, and JG Hudson. 2006. "Coupling aerosol size distributions and size-resolved hygroscopicity to predict humidity-dependent optical properties and cloud condensation nuclei spectra." *Journal of Geophysical Research* 111, D05S13, doi:10.1029/2005JD006092.

Ghan, SJ, and T Shippert. 2006. "Physically based global downscaling: Climate change projections for a full century." *Journal of Climate* 19:1589-1604.

Ghan, S, TA Rissman, R Elleman, RA Ferrare, DD Turner, C Flynn, J Wang, J Ogren, J Hudson, H Jonsson, T VanReken, RC Flagan, and JH Seinfeld. 2006. "Use of in situ cloud condensation nuclei, extinction, and aerosol size distribution measurements to test a method for retrieving cloud condensation nuclei profiles from surface measurements." *Journal of Geophysical Research* 111, D05S10, doi:10.1029/2004JD005752.

Hallar, AG, AW Strawa, B Schmid, E Andrews, J Ogren, P Sheridan, R Ferrare, D Covert, R Elleman, H Jonsson, K Bokarius, and A Luu. 2006. "Atmospheric Radiation Measurements Aerosol Intensive Operating Period: Comparison of aerosol scattering during coordinated flights." *Journal of Geophysical Research* 111, D05S09, doi:10.1029/2005JD006250.

Hawkinson, JA, W Feltz, and SA Ackerman. 2006. "A comparison of GOES sounder – and cloud lidar – and radar-retrieved cloud-top heights." *Journal of Applied Meteorology* 44:1234-1242.

Hogan, RJ, N Gaussiat, and AJ Illingworth. 2006. "Stratocumulus liquid water content from dual-wavelength radar." *Journal of Atmospheric and Oceanic Technology* 22:1207-1218.

Iacobellis, SF, and RCJ Somerville. 2006. "Evaluating parameterizations of the autoconversion process using a single-column model and Atmospheric Radiation Measurement Program measurements." *Journal of Geophysical Research* 111, D02203, doi:10.1029/2005JD006296.

Ivanova, K, HN Shirer, and EE Clothiaux. 2006. “Internal variability and pattern identification in cirrus cloud structure: The Fokker-Planck equation approach.” *Journal of Geophysical Research* 111, D07203, doi:10.1029/2005JD006364.

Iziomon, MG, U Lohmann, and PK Quinn. 2006. “Summertime pollution events in the Arctic and potential implications.” *Journal of Geophysical Research* 111, D12206, doi:10.1029/2005JD006223.

Jensen, EJ, and AS Ackerman. 2006. “Homogeneous aerosol freezing in the tops of high-altitude tropical cumulonimbus clouds.” *Geophysical Research Letters* 33, L08802, doi:10.1029/2005GL024928.

Jensen, MP, and AD Del Genio. 2006. “Factors limiting convective cloud-top height at the ARM Nauru island Climate Research Facility.” *Journal of Climate* 1910:2105-2117.

Kancler, E, C Gautier, P Ricchiazzi, and S Yang. 2005. “Spectral observations and modeling of the Arctic surface radiation environment.” *Journal of Geophysical Research* 110, D23203, doi:10.1029/2005JD005813.

Khvorostyanov, VI, and J Curry. 2005. “Fall velocities of hydrometeors in the atmosphere: Refinements to a continuous analytical power law.” *Journal of the Atmospheric Sciences* 62:4343–4357.

Khvorostyanov, VI, and JA Curry. 2006. “Aerosol size spectra and CCN activity spectra: Reconciling the lognormal, algebraic, and power laws.” *Journal of Geophysical Research* 111, D12202, doi:10.1029/2005JD006532.

Khvorostyanov, VI, H Morrison, JA Curry, D Baumgardner, and P Lawson. 2006. “High supersaturation and modes of ice nucleation in thin tropopause cirrus: Simulation of the 13 July 2002 Cirrus Regional Study of Tropical Anvils and Cirrus Layers case.” *Journal of Geophysical Research* 111, D02201, doi:10.1029/2004JD005235.

Klein, SA, X Jiang, J Boyle, S Malyshev, and S Xie. 2006. “Diagnosis of the summertime warm and dry bias over the U.S. Southern Great Plains in the GFDL climate model using a weather forecasting approach.” *Geophysical Research Letters* 33, L18805, doi:10.1029/2006GL027567.

Kogan, YL. 2006. “Large-eddy simulation of air parcels in stratocumulus clouds: Time scales and spatial variability.” *Journal of the Atmospheric Sciences* 63:952-967.

Kuang, Z, and CS Bretherton. 2006. “A mass-flux scheme view of a high-resolution simulation of a transition from shallow to deep cumulus convection.” *Journal of the Atmospheric Sciences* 63:1895-1909.

Liu, Y, P Daum, and S Yum. 2006. “Analytical expression for the relative dispersion of the cloud droplet size distribution.” *Geophysical Research Letters* 33, L02810, doi:10.1029/2005GL024052.

Liu, Y, P Daum, R McGraw, and M Miller. 2006. “Generalized threshold function accounting for effect of relative dispersion on threshold behavior of autoconversion process.” *Geophysical Research Letters* 33, L11804, doi:10.1029/2005GL025500.

Liu, Y, PH Daum, and R McGraw. 2006. “Parameterization of the autoconversion process. Part II: Generalization of Sundqvist-type parameterizations.” *Journal of the Atmospheric Sciences* 63:103-1109.

Long, CN, TP Ackerman, K Gaustad, and JNS Cole. 2006. “Estimation of fractional sky cover from broadband shortwave radiometer measurements.” *Journal of Geophysical Research* 111, D11204, doi:10.1029/2005JD006475.

Long, CN, JM Sabburg, J Calbo, and D Pages. 2006. “Retrieving cloud characteristics from ground-based daytime all-sky images.” *Journal of Atmospheric and Oceanic Technology* 23:633-652.

Mace, G, M Deng, B Soden, and E Zipser. 2006. “Association of tropical cirrus in the 10–15-km layer with deep convective sources: An observational study combining millimeter radar data and satellite-derived trajectories.” *Journal of the Atmospheric Sciences* 63:480–503.

Mace, G, S Benson, and E Vernon. 2006. “Cirrus clouds and the large-scale atmospheric state: Relationships revealed by six years of ground-based data.” *Journal of Climate* 19:3257-3278.

Mace, G, S Benson, K Sonntag, S Kato, Q Min, P Minnis, C Twohy, M Poellot, X Dong, C Long, Q Zhang, and D Doelling. 2006. “Cloud radiative forcing at the Atmospheric Radiation Measurement Program Climate Research Facility: 1. Technique, validation, and comparison to satellite-derived diagnostic quantities.” *Journal of Geophysical Research* 111, D11S90, doi:10.1029/2005JD005921.

Mace, G, S Benson, and S Kato. 2006. “Cloud radiative forcing at the Atmospheric Radiation Measurement Program Climate Research Facility: 2 Vertical redistribution of radiant energy by clouds.” *Journal of Geophysical Research* 111, D11S91, doi:10.1029/2005JD005922.

Marsden, DC, FPJ Valero, and BC Bush. 2005. “Continental aerosol properties inferred from measurements of direct and diffuse solar irradiance.” *Journal of Geophysical Research* 110, D20204, doi:10.1029/2004JD005660.

Marshak, A, S Platnick, T Varnai, G Wen, and R Cahalan. 2006. “Impact of three-dimensional radiative effects on satellite retrievals of cloud droplet sizes.” *Journal of Geophysical Research* 111, D09207, doi:10.1029/2005JD006686.

May, P, C Jakob, J Mather, and G Vaughan. 2006. “Characterizing oceanic convective cloud systems.” *Vaisala News* 171:16-17.

McComiskey, A, P Ricchiazzi, and C Gautier. 2006. “Assessment of a three-dimensional model for atmospheric radiative transfer over heterogeneous land cover.” *Geophysical Research Letters* 33, L10813, doi:10.1029/2005GL025356.

McGraw, R, and Y Liu. 2006. “Brownian drift-diffusion model for evolution of droplet size distributions in turbulent clouds.” *Geophysical Research Letters* 33, L03802, doi:10.1029/2005GL023545.

Mecikalski, JR, KM Bedka, DD Turner, WF Feltz, and SJ Paech. 2006. “Ability to quantify coherent turbulent structures in the convective boundary layer using thermodynamic profiling instruments.” *Journal of Geophysical Research* 111, D12203, doi:10.1029/2005JD006456.

Michalsky, JJ, GP Anderson, J Barnard, J Delamere, C Gueymard, S Kato, P Kiedron, A McComiskey, and P Ricchiazzi. 2006. “Shortwave radiative closure studies for clear skies during the Atmospheric Radiation Measurement 2003 Aerosol Intensive Observation Period.” *Journal of Geophysical Research* 111, D14S90, doi:10.1029/2005JD006341.

Miloshevich, LM, H Vomel, DN Whiteman, BM Lesht, FJ Schmidlin, and F Russo. 2006. “Absolute accuracy of water vapor measurements from six operational radiosonde types launched during AWEX-G and implications for AIRS validation.” *Journal of Geophysical Research* 111, D09S10, doi:10.1029/2005JD006083.

Min, Q, and M Duan. 2005. “Simultaneously retrieving cloud optical depth and effective radius for optically thin clouds.” *Journal of Geophysical Research* 110, D21201, doi:10.1029/2005JD006136.

Minnis, P, Y Yi, J Huang, and K Ayers. 2005. “Relationships between radiosonde and RUC-2 meteorological conditions and cloud occurrence determined from ARM data.” *Journal of Geophysical Research* 110, D23204, doi:10.1029/2005JD006005.

Morrison, H, JA Curry, and VI Khvorostyanov. 2006. “A new double-moment microphysics parameterization for application in cloud and climate models. Part 1: Description.” *Journal of the Atmospheric Sciences* 62:1665-1677.

Morrison, H, and JO Pinto. 2006. “Intercomparison of bulk cloud microphysics schemes in mesoscale simulations of springtime arctic mixed-phase stratiform clouds.” *Monthly Weather Review* 134:1880-1900.

Oreopoulos, L, and RF Cahalan. 2005. “Cloud inhomogeneity from MODIS.” *Journal of Climate* 18:5110–5124.

Ovtchinnikov, M, T Ackerman, R Marchand, and M Khairoutdinov. 2006. "Evaluation of the multiscale modeling framework using data from the Atmospheric Radiation Measurement Program." *Journal of Climate* 19:1716-1729.

Pahlow, M, G Feingold, A Jefferson, E Andrews, JA Ogren, J Wang, Y-N Lee, RA Ferrare, and DD Turner. 2006. "Comparison between lidar and nephelometer measurements of aerosol hygroscopicity at the Southern Great Plains Atmospheric Radiation Measurement site." *Journal of Geophysical Research* 111, D05S15, doi:10.1029/2004JD005646.

Pekour, ML, ML Wesely, DR Cook, and TJ Martin. 2006. "Study of the recursive filter for computing scaler eddy covariances." *Journal of Agricultural and Forest Meteorology* 136:101-107.

Porch, WM, S Olsen, P Chylek, M Dubey, BG Henderson, and W Clodius. 2006. "Satellite and surface observations of Nauru island clouds: Differences between El Niño and La Niña periods." *Geophysical Research Letters* 33, L13804, doi:10.1029/2006GL026339.

Raisanen, P, H Barker, and JNS Cole. 2005. "The Monte Carlo Independent Column approximation's conditional random noise: Impact on simulated climate." *Journal of Climate* 18:4715–4730.

Ramaswamy, V, MD Schwarzkopf, WJ Randel, BD Santer, BJ Soden, and GL Stenchikov. 2006. "Anthropogenic and natural influences in the evolution of lower stratospheric cooling." *Science* 311:1138-1141.

Reda, I, J Hickey, C Long, D Myers, T Stoffel, S Wilcox, JJ Michalsky, EG Dutton, and D Nelson. 2005. "Using a blackbody to calculate net longwave responsivity of shortwave solar pyranometers to correct for their thermal offset error during outdoor calibration using the component sum method." *Journal of Atmospheric and Oceanic Technology* 2:1531-1540.

Ricchiazzi, P, C Gautier, JA Ogren, and B Schmid. 2006. "A comparison of aerosol optical properties obtained from in situ measurements and retrieved from sun and sky radiance observations during the May 2003 ARM Aerosol Intensive Observation Period." *Journal of Geophysical Research* 111, D05S06, doi:10.1029/2005JD005863.

Rissman, TA, TM VanReken, J Wang, R Gasparini, DR Collins, HH Jonsson, FJ Brechtel, RC Flagan, and JH Seinfeld. 2006. "Characterization of ambient aerosol from measurements of cloud condensation nuclei during the 2003 Atmospheric Radiation Measurement Aerosol Intensive Observational Period at the Southern Great Plains site in Oklahoma." *Journal of Geophysical Research* 111, D05S11, doi:10.1029/2004JD005695.

Rossow, WB, G Tselioudis, A Polak, and C Jakob. 2005. "Tropical climate described as a distribution of weather states indicated by distinct mesoscale cloud property mixtures." *Geophysical Research Letters* 32, L21812, doi:10.1029/2005GL024584.

Schmid, B, RA Ferrare, C Flynn, R Elleman, A Strawa, E Welton, D Turner, H Jonsson, J Redemann, J Eilers, K Ricci, G Hallar, M Clayton, J Michalsky, A Smirnov, B Holben, and J Barnard. 2006. "How well do state-of-the-art techniques measuring the vertical profile of tropospheric aerosol extinction compare?" *Journal of Geophysical Research* 111, D05S07, doi:10.1029/2005JD005837.

Scholl, T, K Pfeilsticker, AB Davis, H Klein, S Crewell, U Lohnert, C Simmer, J Meywerk, and M Quante. 2006. "Path length distributions for solar photons under cloudy skies: Comparison of measured first and second moments with predictions from classical and anomalous diffusion theories." *Journal of Geophysical Research* 111, D12211, doi:10.1029/2004JD005707.

Shupe, MD, SY Matrosov, and T Uttal. 2006. "Arctic Mixed-phase cloud properties derived from surface-based sensors at SHEBA." *Journal of the Atmospheric Sciences* 63:697-711.

Shupe, MD, T Uttal, and SY Matrosov. 2005. "Arctic cloud microphysics retrievals from surface-based remote sensors at SHEBA." *Journal of Applied Meteorology* 44:1544-1562.

Song, J, K Liao, RL Coulter, and BM Lesht. 2005. "Climatology of the low-level jet at the Southern Great Plains atmospheric boundary layer experiments site." *Journal of Applied Meteorology* 44:1593-1606.

Song, J, ML Wesely, DJ Holdridge, DR Cook, and J Klazura. 2006. "Estimating the long-term hydrological budget over heterogeneous surfaces." *Journal of Hydrometeorology* 7:203-214.

Strawa, AW, R Elleman, AG Hallar, D Covert, K Ricci, R Provencal, T Owano, HH Jonsson, B Schmid, AP Luu, K Bokarius, and E Andrews. 2006. "Comparison of in situ aerosol extinction and scattering coefficient measurements made during the Aerosol Intensive Operating Period." *Journal of Geophysical Research* 111, D05S03, doi:10.1029/2005JD006056.

Thorncroft, CD, PJ Lamb, and P Houser. 2006. "US contributions to the 2006 AMMA field campaign." *GEWEX Newsletter* 16:11-13.

Thurairajah, B, and JA Shaw. 2006. "Cloud statistics measured with the infrared cloud imager (ICI)." *Geoscience and Remote Sensing, IEEE Transactions* 43:2000-2007.

Tobin, DC, H Revercomb, RO Knuteson, FA Best, WL Smith, NN Ciganovich, RG Dedecker, S Dutcher, SC Ellington, RK Garcia, HB Howell, and DD LaPorte. 2006. "Radiometric and spectral validation of atmospheric infrared sounder observations with the aircraft-based scanning high-resolution interferometer sounder." *Journal of Geophysical Research* 111, D09S02, doi:10.1029/2005JD006094.

Tobin, DC, HE Revercomb, CC Moeller, and TS Pagano. 2006. "Use of atmospheric infrared sounder high-spectral resolution spectra to assess the calibration of moderate-resolution imaging spectroradiometer on EOS Aqua." *Journal of Geophysical Research* 111, D09S05, doi:10.1029/2005JD006095.

Trishchenko, AP. 2006. "Solar irradiance and effective brightness temperature for SWIR channels of AVHRR/NOAA and GOES imagers." *Journal of Atmospheric and Oceanic Technology* 23:198-210.

Tselioudis, G, and W Rossow. 2006. "Climate feedback implied by observed radiation and precipitation changes with midlatitude storm strength and frequency." *Geophysical Research Letters* 33, L02704, doi:10.1029/2005GL024513.

Turner, DD, RO Knuteson, and H Revercomb. 2006. "Noise reduction of atmospheric emitted radiance interferometer (AERI) observations using principal component." *Journal of Atmospheric and Oceanic Technology* 23:1223-1238.

Wang, J, SA Christopher, US Nair, JS Reid, EM Prins, J Szykman, and JL Hand. 2006. "Mesoscale modeling of Central American smoke transport to the United States: 1. "Top-down" assessment of emission strength and diurnal variation impacts." *Journal of Geophysical Research* 111, D05S17, doi:10.1029/2005JD006416.

Wang, J, D Collins, D Covert, R Elleman, R Ferrare, R Gasparini, H Jonsson, J Ogren, P Sheridan, and S-C Tsay. 2006. "Temporal variation of aerosol properties at a rural continental site and study of aerosol evolution through growth law analysis." *Journal of Geophysical Research* 111, D18203, doi:10.1029/2005JD006704.

Wang, Z, GM Heymsfield, L Li, and AJ Heymsfield. 2005. "Retrieving optically thick ice cloud microphysical properties by using airborne dual-wavelength radar measurements." *Journal of Geophysical Research* 110, D19201, doi:10.1029/2005JD005969.

Wu, X, and X-Z Liang. 2005. "Effect of subgrid cloud-radiation interaction on climate simulations." *Geophysical Research Letters* 32, L24806, doi:10.1029/2005GL024432.

Wu X, J Li, WP Menzel, A Huang, K Baggett, and H Revercomb. 2005. "Evaluation of AIRS cloud properties using MPACE data." *Geophysical Research Letters* 32, L24819, doi:10.1029/2005GL024400.

Wu, X, and X-Z Liang. 2005. "Radiative effects of cloud horizontal inhomogeneity and vertical overlap identified from a month long cloud-resolving model simulation." *Journal of the Atmospheric Sciences* 62:4105-4112.

Wyant, MC, M Khairoutdinov, and CS Bretherton. 2006. "Climate sensitivity and cloud response of a GCM with a superparameterization." *Geophysical Research Letters* 33, L06714, doi:10.1029/2005GL025464.

Xie, S, S Klein, J Yio, ACM Beljaars, C Long, and M Zhang. 2006. "An assessment of ECMWF analyses and model forecasts over the North Slope of Alaska using observations from the ARM Mixed-Phase Arctic Cloud Experiment." *Journal of Geophysical Research* 111, D05107, doi:10.1029/2005JD006509.

## Conference Proceedings


Ackerman, T, S McFarlane, J Mather, and C Long. 2005. "How well can we simulate the effect of clouds on surface radiative fluxes?" In *Fall Meeting of the American Geophysical Union (AGU)*, American Geophysical Union, San Francisco, California.

Adhikari, L, Z Wang, and D Whiteman. 2006. "Cloudy assessment within an atmospheric infrared sounder pixel by combining moderate resolution spectroradiometer and ARM Program ground-based lidar and radar measurements." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Alexandrov, M, A Lacis, B Carlson, and B Cairns. 2006. "New developments in multi-filter rotating shadowband radiometer data analysis." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Andrews, E, J Ogren, P Sheridan, A McComiskey, A Jefferson, and M Fiebig. 2006. "New insights into aerosol asymmetry parameter." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Austin, R, N Wood, G Stephens, and S Cooper. 2006. "Extended validation of an optimal estimation cloud property retrieval algorithm." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Ayers, J, H Yi, P Minnis, L Nguyen, R Palikonda, Q Trepte, M Nordeen, M Khaiyer, D Phan, D Spangenberg, and D Doelling. 2006. "Overview of National Aeronautics and Space Agency Langley Atmospheric Radiation Measurement Project cloud products and validation." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Bedka, K, W Feltz, J Mecikalski, R Petersen, and C Velden. 2006. "Statistical relationships between satellite-derived mesoscale atmospheric motion vectors, rawinsondes, and NOAA wind profiler network observations." In Proceedings of the American Meteorological Society (AMS) Annual Meeting, American Meteorological Society, Atlanta, Georgia.

Berg, L, E Kassionov, C Long, and W Gustafson. 2006. "A climatology of fair-weather cloud cover at the Atmospheric Radiation Measurement Southern Great Plains site: Temporal and spatial variability." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Cairns, B, K Knobelspiesse, M Alexandrov, A Lacis, and B Carlson. 2006. "ALIVE polarization measurements." In P*roceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Chuang, C, and S Chin. 2006. "Study of aerosol/cloud/radiation interactions over the Atmospheric Radiation Measurement Program Southern Great Plains Site." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Cialella, A, and R Wagener. 2006. "Updated and improved atmospheric radiation." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Cimini, D, E Westwater, A Gasiewski, M Klein, and V Leusky. 2006. "Millimeter- and submillimeter-wave observations of low vapor and liquid water amounts in the Arctic winter." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

de Boer, G, and E Eloranta. 2006. "Lidar-based retrievals of the microphysical properties of mixed-phase Arctic stratus clouds and precipitation." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

DeMott, P, A Prenni, S Kreidenweis, C Twohy, and D Rogers. 2006. "Ice nuclei variability and ice formation in mixed-phase clouds." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Deeter, M, and J Vivekanandan. 2006. "New method for retrieving liquid water path over land using AMSR-E observations." In *Proceedings of the American Meteorological Society (AMS) Annual Meeting*, American Meteorological Society, Atlanta, Georgia.

Ferrare, R, D Turner, M Clayton, M Chin, S Guibert, M Schulz, C Chuang, M Krol, S Bauer, G Myhre, I Seland, D Fillmore, S Ghan, X Liu, S Gong, P Ginoux, and T Takemura. 2006. "The vertical distribution of aerosols: Lidar measurements versus model simulations." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Freer, M, and G McFarquhar. 2006. "Algorithms for processing cloud microphysical data acquired by Atmospheric Radiation Measurement Unmanned Aerospace Vehicle applications to TWP-ICE." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Fridland, A, and A Ackerman. 2006. "Using field measurements and numerical simulations to constrain mechanisms of ice formation during the mixed-phase arctic cloud experiment intensive operational period." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Futyan, J, and A Del Genio. 2006. "The evolution of deep convection over Africa and the tropical Atlantic." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Ghan, S. 2006. "Droplet number prediction in the National Center for Atmospheric Research Community Atmosphere model." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Guo, H, and J Penner. 2006. "Investigation of the aerosol indirect effect during the Atmospheric Radiation Measurement Program's March 2003 Aerosol Intensive Operational Period at the Southern Great Plains: Sensitivity tests." In *Proceedings of the Sixteenth Atmospheric Radiation (ARM ) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Hodges, G. 2006. "The multi-filter rotating shadowband radiometer – A look ahead." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Holz, R, and S Ackerman. 2006. "Arctic winter high spectral resolution cloud height retrievals." In *Proceedings of the American Meteorological Society (AMS) Annual Meeting*, American Meteorological Society, Atlanta, Georgia.

Iacono, M, R Pincus, and C Hannay. 2006. "Representing sub-grid scale cloud variability with Monte-Carlo Independent Column Approximation and RRTMG in the National Center for Atmospheric Research Community Atmosphere Model, CAM3." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Ivanova, K, N Shirer, and E Clothiaux. 2006. "Internal variability and pattern identification in cirrus cloud structure within the Fokker-Planck equation framework." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Kanniah, K, N Tapper, J Beringer, X Zhu, and C Long. 2006. "Preliminary investigations of the role of smoke aerosols on carbon uptake of a Northern Australian Tropical Savanna." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Kassianov, E, T Ackerman, J Barnard, and C Flynn. 2006. "Dust properties derived from multi-filter rotating shadowband radiometer data in Niamey." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Kehoe, K, R Peppler, K Sonntag, S Moore, T Thompson, N Hiers, and C Schwarz. 2006. "Atmospheric Radiation Measurement program Data Quality Office – Real-time assessment of instrument performance." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Khaiyer, M, P Minnis, D Doelling, H Yi, M Nordeen, R Palikonda, and D Phan. 2006. "Derivation of improved surface and top of the atmosphere broadband shortwave and longwave fluxes over Atmospheric Radiation Measurement Program domains." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Kiedron, P, and J Schlemmer. 2006. "Spectrally resolved shortwave flux at Atmospheric Radiation Measurement Program: History and the present status of rotating shadowband spectroradiometer." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Kogan, Y, Z Kogan, and D Mechem. 2006. "Assessing the errors of microphysical retrievals based on Doppler radar parameters." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Lamb, P, and M Lele. 2006. "Background climatology for the Atmospheric Radiation Measurement Program mobile facility deployment in Niamey: Mean annual cycle and 2004-2005 interannual variability." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Li, Z, R Chen, and F Chang. 2006. "The impact of the vertical variation of cloud droplet size on the estimation of cloud liquid water path and its potential for rain detection." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Liljegren, J, and M Cadeddu. 2006. "Retrievals of atmospheric temperature and water vapor in the Arctic." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Liu, Y, P Daum, M Miller, and R McGraw. 2006. "Relating aerosol properties to cloud condensation nuclei spectra and cloud properties." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Long, C, T Ackerman, K Gaustad, D Turner, and J Barnard. 2005. "Interannual variability in radiative cloud effects and cloud macrophysical properties from surface measurements." In *EOS Transactions, American Geophysical Union (AGU) 86(52) Fall Meeting Supplement*, Abstract A54D-06, American Geophysical Union, San Francisco, California.

Long, C, T Ackerman, K Gaustad, J Barnard, and D Turner. 2005. "The nature of clouds and their effects on the surface radiative energy budget." In *EOS Transactions, American Geophysical Union (AGU) 86(52) Fall Meeting Supplement*, Abstract B32A-01 Invited, American Geophysical Union, San Francisco, California.

Long, C, and K Gaustad. 2006. "An evaluation of cloud cover, cloud effect, and surface radiation budgets at the Tropical Western Pacific Darwin Atmospheric Radiation Measurement site." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Long, C, J Mather, N Tapper, J Beringer, and B Atkinson. 2006. "Surface radiation analyses from TWP-ICE." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Mace, D, and S Benson. 2005. "The variability of cloud occurrence and cloud forcing as revealed by 8 years of continuous ground-based remote sensing measurements at the ARM SGP Site." In *EOS Transactions, American Geophysical Union (AGU) 86(52) Fall Meeting Supplement*, Abstract A43D-0122, American Geophysical Union , San Francisco, California.

Mather, J, and S McFarlane. 2006. "Analysis of cloud distributions and radiative heating rates over the Tropical Western Pacific Atmospheric Radiation Measurement Program sites." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Matrosov, S, M Shupe, and P May. 2006. "Rainfall profiling using ARM millimeter wavelength cloud radars." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

McFarlane, S, J Mather, and T Ackerman. 2006. "Analysis of tropical radiative heating profiles in the multi-scale modeling framework: A comparison to Atmospheric Radiation Measurement Program observations." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

McFarquhar, G, M Freer, J Um, G Kok, R McCoy, T Tooman, and G Mace. 2006. "Horizontal and vertical profiles of in-situ cloud properties measured during the Tropical Warm Pool – International Cloud Experiment." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Mechem, D, and Y Kogan. 2006. "Improving the representation of aerosol-cloud-precipitation interactions in numerical models." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Minnis, P, L Nguyen, W Smith, R Palikonda, J Ayers, D Doelling, M Nordeen, D Spangenberg, D Phan, and M Khaiyer. 2006. "Large-scale cloud properties and radiative fluxes over Darwin during the Tropical Warm Pool – International Cloud Experiment." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Mitchell, D, D Ivanova, P Rasch, G McFarquhar, and T Nousianen. 2006. "Impact of forward scattering spectrometer probe measured ice crystals in the community atmosphere model." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Moore, S, R Peppler, K Kehoe, and K Sonntag. 2006. "Using historical Atmospheric Radiation Measurement Program measurements to systematically improve quality control limits." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Morris, V, C Long, and D Nelson. 2006. "Deployment of an infrared thermometer network at the Atmospheric Radiation Measurement Program Southern Great Plains Climate Research Facility." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Moy, L, D Turner, E Kassianov, and W Arnott. 2006. "Retrieving the relative number of fine to course mode aerosol from ground-based visible and infrared observation." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Naud, C, and A Del Genio. 2006. "Cloud overlap dependence on atmospheric dynamics." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

O'Hirok, W, P Ricchiazzi, and C Gautier. 2006. "The sensitivity of cloud field structure to three dimensional radiative effects." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Oreopoulos, L, and S Platnick. 2006. "Investigation of broadband radiative flux changes due to increases in cloud droplet number concentrations." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Orr, B, D Sisterson, and D Rusk. 2006. "Developments and accomplishments at the ARM Climate Research Facility Southern Great Plains site during 2005." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Panchenko, M, V Kozlov, Yu Balin, S Sakerin, G Kokhanenko, I Penner, D Kabanov, E Makienko, S Terpugova, S Turchinovich, and V Shmargunov. 2006. "Comparison of the data of airborne, lidar, and photometric sensing of aerosol parameters in the cloudless atmosphere." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Petty, D, J Comstock, and D Turner. 2006. "Cirrus extinction and lidar ratio derived from Raman lidar measurements at the Atmospheric Radiation Measurement Program Southern Great Plains site." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Poellot, M, and D Brown. 2006. "A case study of horizontal variability in arctic cloud microphysical properties." In *Proceedings of the Sixteenth ARM Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Polonsky, I, A Davis, S Love, and S Brumby. 2006. "Active cloud probing with the wide-angle imaging lidar: Status and outlook." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Prenni, A, P DeMott, S Kreidenweis, and D Rogers. 2006. "Continuous flow ice thermal diffusion chamber measurements of ice nuclei in the Arctic." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Ritsche, M, and D Holdridge. 2006. "Atmospheric Radiation Measurement surface meteorological measurements." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Rutan, D, F Rose, T Charlock, E Mlawer, T Shippert, and S Kato. 2006. "Broadband heating rate product flux profiles compared to clouds and the earth's radiant energy system radiation transfer data product." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Sakerin, S, and D Kabanov. 2006. "Spectral dependences of the atmospheric aerosol optical depth in the extended spectral region of 0.4-4 µm." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Schaaf, C, A Strahler, J Salomon, M Roman, J Hodges, and J Liu. 2006. "Assessment of albedo derived from moderate-resolution imaging spectroradiometer at the Southern Great Plains site." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Schmid, B, R Ferrare, D Turner, C Flynn, B Cairns, R Dominguez, W Gore, D Groff, B Herman, B Hovelman, A Jefferson, R Johnson, K Knobelspiesse, A Mendoza, J Ogren, D Petty, E Russell, P Russell, L Roeder, and N Truong. 2006. "The Aerosol lidar Validation Experiment - ALIVE." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Sheridan, P, J Ogren, E Andrews, A Jefferson, and D Collins. 2006. "The Atmospheric Radiation Measurement Program aerosol observing systems: Status and planned upgrades." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Shi, Y, and C Long. 2006. "Surface radiation measurement data quality assessment at the Atmospheric Radiation Measurement Program Tropical Western Pacific and North Slope of Alaska Sites." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Spangenberg, D, P Minnis, Q Trepte, M Shupe, and M Poellot. 2006. "Characterization of mixed-phased clouds during Mixed-Phase Arctic Cloud Experiment from satellite, ground-based, and in situ data." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Spangenberg, D, P Minnis, MD Shupe, MR Poellot, and Z Wang. 2005. "Detection of mixed-phase clouds over the Arctic using MODIS 6.7-12 micron data." In *EOS Transactions, American Geophysical Union (AGU) 86(52) Fall Meeting Supplement*, Abstract A33E-08, American Geophysical Union, San Francisco, California.

Stoffel, T, I Reda, J Hickey, E Dutton, and J Michalsky. 2006. "Pyrgeometer calibrations for the Atmospheric Radiation Measurement Program: Updated approach." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting,* U.S. Department of Energy, Richland, Washington.

Taniguchi, K, and Z Wang. 2006. "Boundary layer water vapor variation at the Southern Great Plains site derived from multiyear Raman lidar measurements." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting,* U.S. Department of Energy, Richland, Washington.

Taylor, P. 2006. "A study of the probability of clear line of sight through single-layer cumulus cloud fields in the Tropical Western Pacific." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Turner, DD, E Eloranta, and J Delamere. 2006. "Microphysical properties of thin clouds retrieved from ground-based infrared observations." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Um, J, and G McFarquhar. 2006. "Determination of thermodynamic cloud phase and dominant ice crystal habit from radiance measurements." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Veron, DE, and M Foster. 2006. "Linking cloud-radiation parameterization performance to large-scale dynamics." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Wang, Z. 2006. "The seasonal interannual variations of mixed-phase cloud properties observed at the North Slope of Alaska Site." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Westwater, E, D Cimini, V Mattioli, M Klein, A Gasiewski, and V Leusky. 2006. "The 2004 North Slope of Alaska Arctic winter radiometric experiment: overview and recent results." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Widener, K, and K Moran. 2006. "Millimeter-wave cloud radar upgrades: Review, status, and plans." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Wiscombe, W, A Marshak, JC Chiu, EJ Welton, and SC Valencia. 2006. "Cloud optical depth retrievals from solar background 'signal' of micropulse lidars." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Xi, B, X Dong, B Wielicki, Y Hu, S Benson, and J Mace. 2005. "The impact of deep convective cumulus clouds on surface, TOA, and atmosphere radiation budgets at the DOE ARM TWP and SGP sites." In *EOS Transactions, American Geophysical Union (AGU) 86(52) Fall Meeting Supplement*, Abstract A23A-0917, American Geophysical Union, San Francisco, California.

Xie, S, S Klein, A Beljaars, J Boyle, M Fiorino, J Hnilo, C Long, T Phillips, G Potter, and M Zhang. 2005. "An assessment of the ECMWF model simulations of the arctic clouds observed during the ARM mixed-phase arctic cloud experiment." In *EOS Transactions, American Geophysical Union (AGU) 86(52) Fall Meeting Supplement*, Abstract A34B-04, American Geophysical Union, San Francisco, California.

Yue, Q, P Yang, and G Mace. 2005. "A fast thin cirrus radiative transfer model applied to AIRS spectra for cloudy data assimilation." In *EOS Transactions, American Geophysical Union (AGU) 86(52) Fall Meeting Supplement*, Abstract A43B-0075, American Geophysical Union, San Francisco, California.

Yang, F. 2006. "Parameterizing the dependence of surface albedo on solar zenith angle using Atmospheric Radiation Measurement Program observations." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Zhang, G. 2006. "Test of an improved convection scheme in the National Centers for Atmospheric Research Community Climate System Model (CCSM3)." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Zhang, G, G McFarquhar, J Verlinde, M Poellot, G Kok, and A Heymsfield. 2006. "Contrasting properties of single-layer and multi-layer arctic stratus sampled during the Mixed-Phase Arctic Cloud Experiment." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

Zhuravleva, T, T Rasskazchikova, T Sklyadneva, and S Smirnov. 2006. "A climatology of cloud amount of midlatitude continental clouds in Tomsk region: Preliminary results." In *Proceedings of the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Richland, Washington.

## Conference Presentation Abstracts

Adhikari, L, Z Wang, and D Whiteman. 2006. "Cloudy assessment within the atmospheric infrared sounder pixel by combining moderate resolution spectroradiometer and ARM Program ground-based lidar radar measurements." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Albrecht, B, and P Kollias. 2006. "Using ACRF Tropical Western Pacific (TWP) Nauru observations to evaluate a simple thermodynamic model of the subcloud layer under fair-weather cumulus conditions." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Alexandrov, M, A Lacis, B Carlson, and B Carins. 2006. "New developments in MFRSR data analysis." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Andrews, E, J Ogren, A Jefferson, P Sheridan, A McComiskey, and M Fiebig. 2006. "New insights into aerosol asymmetry parameter." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Austin, R, N Wood, G Stephens, and S Cooper. 2006. "Extended validation of an optimal estimation cloud property retrieval algorithm." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Axisa, D, D Collins, D Rosenfeld, and W Woodley. 2006. "A new research aircraft for the documentation of the impacts of pollution aerosols on clouds and precipitation." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Ayers, J, H Yi, M Nordeen, P Minnis, L Nguyen, R Palikonda, M Khaiyer, D Phan, D Spangenberg, D Doelling, and Q Trepte. 2006. "Overview of NASA Langley ARM cloud products and validation." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Barker, H, J Cole, P Raisanen, R Pincus, J-J Morcrette, J Li, G Stephens, P Vaillancourt, L Oreopoulos, P Siebesma, A Los, E Clothiaux, D Randall, and M Iacono. 2006. "The Monte Carlo Independent Column Approximation Model Intercomparison Project." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Bartholomew, M. 2006. "Measuring the raindrop size distribution, ARM's efforts at Darwin and SGP." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Bedka, K, W Feltz, J Mecikalski, R Petersen, and C Velden. 2006. "Statistical relationships between satellite-derived mesoscale atmospheric motion vectors, rawinsondes, and NOAA wind profiler network observations." Presented at the American Meteorological Society (AMS) Annual Meeting. Atlanta, Georgia.

Berg, L, E Kassianov, C Long, and W Gustafson. 2006. "A climatology of fair-weather cloud cover at the ARM SGP site: Temporal and spatial variability." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Berry, J, W Riley, S Biraud, M Torn, and M Fischer. 2006. "Spatially distributed CO2, sensible, and latent heat fluxes over the Southern Great Plains." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cadeddu, M. 2006. "Measurements and retrievals from a new 183-GHz water vapor radiometer in the Arctic." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cady-Pereira, K, M Shephard, S Clough, E Mlawer, and D Turner. 2006. "Validation of TES temperature and water vapor retrievals with ARM observations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cairns, B, K Knobelspiesse, M Alexandrov, A Lacis, and B Carlson. 2006. "ALIVE polarization measurements." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Chang, F-L, Z Li, R Chen, and R Ferraro. 2006. "Understanding the relationship between cloud liquid water path, droplet size, and precipitation using satellite and ground observations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cheng, A, and K-M Xu. 2006. "Sensitivity of boundary-layer and deep convective cloud simulations to vertical resolution." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Chuang, C, and S Chin. 2006. "Study of aerosol/cloud/radiation interactions over the ARM SGP site." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cialella, A, and R Wagener. 2006. "Updated and improved ACRF GIS data and maps." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cimini, D, E Westwater, V Leuski, M Klein, and A Gasiewski. 2006. "Millimeter- and submillimeter-save observations of low vapor and liquid water amounts in the Arctic winter." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cole, J, H Barker, J Li, and K Salzen. 2006. "The impact of using different parameterizations of unersolved horizontal variability of cloud water in the CCCma GCM." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Collins, D, and C Spencer. 2006. "An overview of the SGP tandem differential mobility analyzer." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Comstock, J, R-F Lin, D Starr, and P Yang. 2006. "Simulations of cirrus clouds using an explicit cloud model: integrating ARM water vapor and forcing data for analysis of cirrus formation and evolution." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cook, D, M Fischer, and D Holdridge. 2006. "Comparison of ECOR, EBBR, and CO2FLX4m system fluxes." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Cook, D, and D Holdridge. 2006. "EBBR-SIRS net radiation difference: An evaluation." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

D'Entremont, R, and D Mitchell. 2006. "The dependence of cirrus cloud-property retrievals on size-distribution shape." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

D'Entremont, R, G Gustafson, and D Mitchell. 2006. "Retrieving cirrus vertical cross sections of extinction, effective particle size, and ice-water content using GOES imager data." Presented at the American Meteorological Society (AMS) Annual Meeting, Atlanta, Georgia.

Davis, A. 2006. "The fundamental limitation of atmospheric remote sensing by dissection of single-photon state space, and the paradigms that lie beyond illustrated with WAIL, O2 A-band/line spectroscopy, etc." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

DeBoer, G, and E Eloranta. 2006. "Development of cloud microphysical property retrievals using the University of Wisconsin Arctic high spectral resolution lidar." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

DeMott, P, A Prenni, S Kreidenweis, C Twohy, and D Rogers. 2006. "Ice nuclei variability and ice formation in mixed-phase clouds." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

DeSlover, D, R Holz, D Turner, and H Revercomb. 2006. "Aircraft S-HIS observations during M-PACE." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

DeVore, J, and R McClatchey. 2006. "Introducing SAM (Sun and Aureole Measurement), a new, ground-based capability for measuring cloud optical properties." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Dedecker, R, R Knuteson, H Revercomb, D Tobin, D Turner, and J Demirgian. 2006. "The ARM atmospheric emitted radiance interferometer (AERI): status and preliminary assessments of instrument deployments in 2006." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Deeter, M, and J Vivekanandan. 2006. "New method for retrieving liquid water path over land using AMSR-E observations." Presented at the American Meteorological Society (AMS) Annual Meeting, Fourteenth Conference on Satellite Meteorology and Oceanography. Atlanta, Georgia.

Delamere, J, E Mlawer, S Clough, D Turner, M Jensen, M Miller, K Johnson, D Troyan, and T Shippert. 2006. "Radiative closure studies at the ACRF NSA locale." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Demirgian, J. 2006. "AERI – What, where, how, and future plans." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Deng, M, and G Mace. 2006. "Tropical anvil cirrus evolution from observations and numerical simulations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Dong, X, B Xi, P Minnis, and M Khaiyer. 2006. "Using ARM data to correct plane-parallel satellite retrievals of cloud properties." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Doty, K, R Wagener, and J Liljegren. 2006. "Instrument mentor monthly summary reporting system." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Dubey, M, P Chylek, J Reisner, and W Porch. 2006. "LES modeling of high resolution satellite cloud spatial and thermal structure at the ACRF SGP site: How well can we simulate clouds from space." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Dykema, J, S Leroy, J Anderson, D Tobin, R Knuteson, and H Revercomb. 2006. "Time series analysis of AERI radiances for GCM testing and improvement." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Ellingson, R, J Gu, and E Takara. 2006. "Initial stages of ICRCCM3: Intercomparison of radiation codes in climate models for clouds in the longwave." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Eloranta, E. 2006. "Cloud properties derived from the high spectral resolution lidar during M-PACE." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Evans, W, and E Puckrin. 2006. "The comparison of radiative surface forcing from ground-based FTS spectra with tropopause radiative forcing from satellites." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Feingold, G, S Frisch, and Q Min. 2006. "Surface-based remote sensing of aerosol-cloud interactions." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Ferrare, R, M Clayton, D Turner, C Flynn, D Petty, A Mendoza, and B Schmid. 2006. "Raman lidar and MPL measurements during ALIVE." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Foster, M, and D Veron. 2006. "Linking cloud-radiation parameterization performance to large-scale dynamics." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Freer, M, and G McFarquhar. 2006. "Algorithms for processing cloud microphysical data acquired by the ARM UAV program: Applications to TWP-ICE." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Fridland, A, and A Ackerman. 2006. "Using field measurements and numerical simulations to constrain mechanisms of ice formation during the M-PACE IOP." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Futyan, J, and A Del Genio. 2006. "The evolution of deep convection over Africa and the Tropical Atlantic." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Gaustad, K, and C Long. 2006. "An evaluation of cloud cover, cloud effect, surface radiation budgets at the TWP Darwin ARM sites." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Gaustad, K, and C Long. 2006. "Methodology for calculating spectral surface albedo using ARM MFSR and MFR data." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Ghan, S. 2006. "Droplet number prediction in the NCAR community atmosphere model." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Gianelli, S, A Lacis, and B Carlson. 2006. "Analysis of Langley optical depth data, with aerosol and gas retrievals, for the RSS 103 instrument in Barrow, Alaska." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Groff, D, and C Duchon. 2006. "Investigation of unusual albedos in the SGP domain." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Guo, H, and J Penner. 2006. “Examining the aerosol indirect effect during the May 2003 intensive operational period at the Southern Great Plains: Sensitivity tests.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Gupta, V, R Mantila, P Furey, W Krajewski, A Kruger, and J Clayton. 2006. “Hydro-Kansas (HK) research project: Tests of a physical basis of statistical self-similarity in peak flows in the Whitewater Basin, Kansas.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Hansell, R, K-N Liuo, S-c Ou, S-C Tsay, and Q Ji. 2006. “Detection and retrieval of mineral dust aerosol using AERI during the UAE2 field campaign: potential application to ARM measurements.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Harrington, J. 2006. “Radiative influences on glaciation time-scales of mixed-phase clouds.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Hartsock, D, G Mace, and S Benson. 2006. “Evaluation of cirrus statistics produced by general circulation models using ARM data.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Hawat, T, and F Murcray. 2006. “New generation of the SORTI instruments.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Haynes, J, and G Stephens. 2006. “Properties of tropical convection observed by ARM millimeter radars.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Hodges, G. 2006. “Current issues facing the MFRSR.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Hoffman, F, W Hargrove, and A Del Genio. 2006. “From measurements to models: Cross comparison of measured and simulated behavioral states of the atmosphere.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Hofmann, O, P Pilewskie, W Gore, P Russell, J Livingston, J Redemann, R Bergstrom, S Platnick, and J Daniel. 2006. “Cloud properties derived from visible and near-infrared reflectance in the presence of aerosols.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Holz, R, and SA Ackerman. 2006. “Arctic winter high spectral resolution cloud height retrievals.” Presented at the American Meteorological Society (AMS) Annual Meeting, Fourteenth Conference on Satellite Meteorology and Oceanography. Atlanta, Georgia.

Horvath, A, and B Soden. 2006. “Lagrangian diagnostics of tropical cirrus over the TWP sites.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Hume, T, and C Jakob. 2006. “Evaluating single-column models using an ensemble approach.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Iacono, M, R Pincus, and C Hannay. 2006. “Representing sub-grid scale cloud variability in the NCAR CAM3 climate model using McICA with RRTMG and a sub-column cloud generator.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Inoue, T. 2006. “Radiosonde observations at Point Reyes and cloud properties retrieved from GOES-WEST.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Ivanova, K, N Shirer, and E Clothiaux. 2006. “Internal variability and pattern identification in cirrus cloud structure within the Fokker-Planck equation framework.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Jefferson, A, and J Ogren. 2006. “Preliminary results of in situ measurements of aerosol optical and water uptake properties from ARM Mobile Facility in Niger.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Jensen, M, P Kollias, A Vogelmann, J Mather, and P May. 2006. “Observations of tropical clouds from upgraded MMCR at Darwin and comparison with C-POL and satellite observations.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Johnson, N. 2006. “A comparison between principal component and self-organizing map analyses.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Jundt, R, C Bates, G Palanisamy, R McCord, and R Wagener. 2006. “Ordering ARM data: A logical integration of the Data Archive and ARM Program website.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kahn, B, and A Eldering. 2006. “Understanding the AIRS, ARM, and MODIS cloud products by cross comparison.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kanniah, K, N Tapper, J Beringer, X Zhu, and C Long. 2006. “Preliminary investigations of the role of smoke aerosols on carbon uptake of a northern Australian tropical savanna.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kassianov, E, T Ackerman, J Barnard, and C Flynn. 2006. “Dust properties derived from MFRSR data in Niamey.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kehoe, K, R Peppler, K Sonntag, S Moore, T Thompson, N Hiers, and C Schwarz. 2006. “ARM Data Quality Office - real-time assessment of instrument performance.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Khairoutdinov, M, and D Randall. 2006. “Evaluation of the intraseasonal and interannual variability of climate as simulated by CSU multi-scale framework.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Khaiyer, M, D Doelling, R Palikonda, D Phan, P Minnis, H Yi, and M Nordeen. 2006. “Derivation of improved surface and TOA broadband shortwave and longwave fluxes over ARM domains.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kiedron, P, and J Schlemmer. 2006. “Spectrally resolved shortwave flux at ARM: History and the present status of the RSS.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kim, B, S Schwartz, M Miller, and Q Min. 2006. “Continental liquid-phase stratus clouds at SGP: meteorological influences and relationship to adiabacity.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Klein, S, and R Pincus. 2006. “Testing statistical cloud scheme ideas in the GFDL climate model.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Knap, W, A Los, and R Boers. 2006. “Measurements and model calculations of radiative fluxes for the Cabauw experimental site for atmospheric research, the Netherlands.” Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Knyazikhin, Y, A Marshak, M Larsen, and W Wiscombe. 2006. "A new model of cloud drop distribution that simulates the observed drop clustering: effect of clustering on extinction coefficient estimates." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kogan, Y, Z Kogan, and D Mechem. 2006. "Assessing the errors of microphysical retrievals based on Doppler radar parameters." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kogan, Y, Z Kogan, and D Mechem. 2006. "Large-eddy simulations of Doppler radar observations of stratocumulus clouds." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Kollias, P, E Luke, K Johnson, M Miller, E Clothiaux, and B Albrecht. 2006. "The new ARSCL-micro value-added product (VAP)." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Koontz, A, C Sivaraman, and T Martin. 2006. "Maintaining history of the ARM Climate Research Facility data." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Lamb, P, and M Lele. 2006. "Background climatology for the Atmospheric Radiation Measurement Program Mobile Facility deployment in Niamey: Mean annual cycle and 2004-2005 interannual variability." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Lewis, E, and S Schwartz. 2006. "Parameterizations for the Kelvin (surface tension) effect on the equilibrium radius and associated optical properties of a hygroscopic aerosol particle." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Li, Z, and M-J Jeong. 2006. "Effect of aerosol humidification on the column aerosol optical thickness over the ARM Southern Great Plains site." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Liljegren, J. 2006. "Retrievals of atmospheric temperature and water vapor profiles in the Arctic." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Liu, G, and E-K Seo. 2006. "Determination of 3D cloud ice water contents by combining multiple data sources from satellite, ground radar, and a numerical model." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Liu, X, S Ghan, M Wang, and J Penner. 2006. "Prediction of ice crystal number in Community Atmospheric Model (CAM3.0)." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Liu, Y, P Daum, M Miller, and R McGraw. 2006. "Relating aerosol properties to CCN spectra and cloud properties." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Lo, C, J Comstock, and C Flynn. 2006. "A comparison of cirrus cloud visible optical depth derived from lidar." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Lo, C, J Comstock, and C Flynn. 2006. "A comparison of cirrus cloud visible optical depth derived from lidar." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Long, C, J Mather, N Tapper, J Beringer, and B Atkinson. 2006. "Surface radiation, cloud effects, and cloud properties: Flux analysis from TWP-ICE." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Luke, E, P Kollias, E Clothiaux, K Johnson, M Miller, K Widener, M Jensen, and A Vogelmann. 2006. "An automatic Doppler spectrum classifier for the MMCRs." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Luo, Z, and G Stephens. 2006. "Convection feedbacks in a super-parameterization GCM." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Mace, G. 2006. "A TWP-ICE high-level cloud case study." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Marchand, R, and TP Ackerman. 2006. "Comparison of cloud top height and optical depth histograms from ISCCP, MISR, and MODIS." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Marshak, A, J-Y Chiu, Y Knyazikhin, J Barnard, J Schmelzer, and W Wiscombe. 2006. "Comparing cloud optical depth retrievals at the Point Reyes deployment of the ARM Mobile Facility." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Mather, J, and S McFarlane. 2006. "Analysis of cloud distributions and radiative heating rates over the TWP ARM sites." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Matrosov, S, P May, and M Shupe. 2006. "Rainfall profiling using ARM millimeter wavelength cloud radars." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

May, P, C Jakob, and J Mather. 2006. "The Tropical Warm Pool-International Cloud Experiment: Overview." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

McComiskey, A, S Schwartz, P Ricchiazzi, J Michalsky, and J Ogren. 2006. "Direct aerosol forcing: Sensitivity to uncertainty in measurements of aerosol optical and situational properties." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

McCord, R, G Palanisamy, D Kaiser, R Cederwall, and S Moore. 2006. "Investigation of new alternatives for data access and distribution from the ARM Archive." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

McCoy, R, T Tooman, and G McFarquhar. 2006. "ARM-UAV TWP-ICE payload instrumentation details." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

McCoy, R, and S Klein. 2006. "Analysis of MMF simulations of the diurnal cycle of deep convection." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

McFarlane, S, J Mather, and T Ackerman. 2006. "Analysis of tropical radiative heating profiles in the multi-scale modeling framework: A comparison to ARM observations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

McGraw, R, and Y Liu. 2006. "Evolution of droplet size distribution and autoconversion parameterization in turbulent clouds." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Mechem, D, and Y Kogan. 2006. "Improving the representation of aerosol-cloud-precipitation interactions in numerical models." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Miller, M, P Kollias, M Bartholomew, P Daum, M Dunn, M Jenson, Y Liu, A Vogelmann, B Andrews, J Ogren, and D Turner. 2006. "Analysis of aerosol indirect effects in California coastal stratus and fog." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Min, Q, M Duan, L Harrison, and E Joseph. 2006. "An observed signature of aerosol effect on cloud droplet radii from a decade of observations at a mid-continental site." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Mitchell, D, and D Ivanova. 2006. "Impact of FSSP-measured ice crystals on the Community Atmospheric Model (CAM)." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Mitchell, R. 2006. "Discrimination between thin cirrus and tropospheric aerosol using multiple measurements from the Darwin ARCS." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Mlawer, E, S Clough, J Delamere, D Rutan, M Miller, K Johnson, D Troyan, M Jensen, T Shippert, C Long, C Flynn, C Sivaraman, D Turner, P Heck, S Xie, S Klein, M Zhang, R Ferrare, L Oreopoulos, R Ellingson, H Barker, J Liljegren, and J Michalsky. 2006. "Status of the broadband heating rate profile (BBHRP) VAP." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Moore, S, R Peppler, K Kehoe, and K Sonntag. 2006. "Using historical ARM measurements for systematically improve QC limits." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Morcrette, J-J. 2006. "A processor to get UV-A and UV-B radiation products from the ECMWF forecast system." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Morris, V, and C Long. 2006. "Deployment of an infrared thermometer network at the Southern Great Plains ARM Climate Research Facility." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Morrison, H, J Pinto, and J Curry. 2006. "Impact of aerosol on mixed-phase stratocumulus during M-PACE in a mesoscale model with two-moment microphysics." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Moy, L, D Turner, E Kassianov, and P Arnott. 2006. "Retrieving the relative number of fine to coarse mode aerosols from AERI and MFRSR observations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Naud, C, and A Del Genio. 2006. "Cloud overlap dependence on atmospheric dynamics." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Neggers, R. 2006. "A dual mass flux framework for boundary layer convection." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Nordeen, M, P Minnis, D Doelling, P Chan, M Khaiyer, D Phan, J Ayers, and R Palikonda. 2006. "Satellite-derived surface radiation fluxes at the ARM SGP and TWP Manus CART sites." Presented at the American Meteorological Society (AMS) Annual Meeting. Atlanta, Georgia.

O'Hirok, W, P Ricchiazzi, and C Gautier. 2006. "The sensitivity of cloud field structure and dynamics to 3D radiative effects." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Oreopoulos, L, and S Platnick. 2006. "Investigation of broadband radiative flux changes due to increases in cloud droplet number concentrations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Orr, B, D Sisterson, and D Rusk. 2006. "Developments and accomplishments at the ACRF Southern Great Plains site during 2005." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Ovtchinnikov, M. 2006. "Cloud model evaluation using radiometric measurements from the NASA multiangle imaging spectroradiometer (MISR)." Presented at the American Meteorological Society (AMS) Annual Meeting. Atlanta, Georgia.

Panchenko, M, V Kozlov, Y Balin, S Sakerin, G Kokhanenko, L Penner, D Kabanov, E Makienko, S Terpugova, V Shmargunov, and S Turchinovich. 2006. "Comparison of the data of airborne, lidar and photometric sensing of aerosol parameters in the cloudless atmosphere." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Pazmany, A. 2006. "Ground-based and airborne (PMS 2D probe canister-mounted) 183-GHz water vapor radiometer." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Petty, D, D Turner, J Goldsmith, and J Comstock. 2006. "Atmospheric Radiation Measurement Program Raman Lidar at Southern Great Plains: Performance and new measurement capabilities." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Petty, D, J Comstock, and D Turner. 2006. "Cirrus extinction and lidar ratio derived from Raman lidar measurements at the Atmospheric Radiation Measurement Program Southern Great Plains site." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Pilewskie, P, J Fontenla, and J Harder. 2006. "A new solar irradiance reference spectrum." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Pincus, R, C Bastone, and L Donner. 2006. "Using information about small-scale variability in water vapor in a convective parameterization." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Poellot, M, and D Brown. 2006. "A case study of horizontal variability in arctic cloud microphysical properties." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Polonsky, I, A Davis, S Love, and S Brumby. 2006. "Active cloud probing with the wide-angle imaging lidar (WAIL): Status and outlook." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico

Pommier, J, W Gore, and P Pilewskie. 2006. "Deployment of a new shortwave spectroradiometer (SWS) at the SGP site." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Popstefanija, I, J Mead, and K Widener. 2006. "W-band ARM cloud radar (WACR) update and status." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Prenni, A, P DeMott, D Rogers, and S Kreidenweis. 2006. "Continuous flow ice thermal diffusion chamber measurements of ice nuclei in the Arctic." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Raisanen, P, S Jarvenoja, and H Jarvinen. 2006. "Tests of Monte Carlo Independent Column approximation in the ECHAM5 atmospheric global climate model." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Reisner, J, M Dubey, C Jeffrey, M Andrejczuk, and D Moulton. 2006. "The LANL cloud-aerosol model." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Revercomb, H, D DeSlover, R Holz, R Knuteson, J Li, L Moy, D Tobin, and D Turner. 2006. "BBHRP assessment using ground and satellite-based high spectral resolution infrared observations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Ritsche, M, and D Holdridge. 2006. "ARM surface meteorological measurements." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Rutan, D, T Charlock, E Mlawer, and T Shippert. 2006. "Broadband heating rate product flux profiles compared to clouds and the earth's radiant energy system radiation transfer data product." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Rutledge, C, and G Schuster. 2006. "An instrument design concept for measuring solar diffuse irradiance." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Sakerin, S, and D Kabanov. 2006. "Spectral dependences of the atmospheric aerosol optical depth of 0.4-4 µm." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Schaaf, C, A Stahler, M Roman, J Salomon, and C Hodges. 2006. "Assessment of albedo derived from the MODIS at the ARM SGP." Presented at Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Schmid, B, R Ferrare, D Turner, C Flynn, A Mendoza, D Petty, L Roeder, B Cairns, W Gore, E Russell, P Russell, N Truong, R Johnson, R Dominguez, D Groff, B Herman, B Hovelman, A Jefferson, and J Ogren. 2006. "The Aerosol Lidar Validation Experiment – ALIVE." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Schumacher, C, R Houze, P May, F Kaycee, J Cetrone, and A Vallgren. 2006. "Radar-observed convective characteristics during TWP-ICE." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Sednev, I, S Menon, and G McFarquhar. 2006. "Simulating Arctic mixed-phase clouds: Sensitivity to environmental conditions and cloud microphysics processes." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Seo, E-K, G Liu, and K-Y Kim. 2006. "A reduction in systematic errors of a Bayesian retrieval algorithm." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Shao, H, and G Liu. 2006. "A new assessment of the aerosol first indirect effect." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Sheridan, P, J Ogren, E Andrews, A Jefferson, and D Collins. 2006. "The ARM aerosol observing systems: status and planned upgrades." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Shi, Y, and C Long. 2006. "Surface radiation measurement data quality assessment at the ARM TWP and NSA locales." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Shupe, M, and P Kollias. 2006. "Towards a characterization of arctic mixed-phase clouds." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Sivaraman, C, C Flynn, and D Turner. 2006. "Determination of vertical profiles of aerosol extinction, single-scatter albedo, and asymmetry parameter at Barrow." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Spangenberg, D, P Minnis, Q Trepte, MD Shupe, and M Poellot. 2006. "Characterization of mixed-phased clouds during Mixed-Phase Arctic Cloud Experiment from Satellite, ground-based, and in situ data." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Richland, Washington.

Spangenberg, D, M Shupe, M Poellot, and P Minnis. 2006. "Retrieval of cloud phase over the Arctic using MODIS 6.7-12 micron data." Presented at American Meteorological Society (AMS) Annual Meeting, Atlanta, Georgia.

Stoffel, T, I Reda, J Hickey, E Dutton, and J Michalsky. 2006. "Pyrgeometer calibrations for the ARM Program: updated approach." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Takara, E, R Ellingson, and Y Ma. 2006. "A comparison of cloudiness measures derived from longwave measurements and shortwave sky imagers." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Taniguchi, K, and Z Wang. 2006. "Boundary layer water vapor variation at the Southern Great Plains site derived from multiyear Raman lidar measurements." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Taylor, P. 2006. "A Study of the Probability of Clear Line of Sight (PCLoS) through single-layer cumulus cloud fields in the Tropical Western Pacific." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Tooman, T, R McCoy, and G McFarquhar. 2006. "ARM-UAV TWP-ICE activities and data." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Troyan, D, M Jensen, M Miller, J Delamere, J Delamere, E Mlawer, D Turner, J Mather, and G Mace. 2006. "An update and status report of the mergesounding VAP." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Tselioudis, G, P Kollias, and B Albrecht. 2006. "An ARSCL-based cloud type climatology from retrievals and it's use in model evaluation studies." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Turner, D, J Delamere, and E Eloranta. 2006. "AERI-Retrieved Cloud Properties from M-PACE and MASRAD." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Um, J, and G McFarquhar. 2006. "Determination of thermodynamic cloud phase and dominant ice crystal habit from radiance measurements." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Vogelmann, A, M Jensen, P Kollias, and E Luke. 2006. "Tropical cloud life cycle and overlap structure." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Wang, X, K-N Liuo, S-c Ou, Y Takano, and Y Chen. 2006. "Remote sensing of cirrus particle size vertical profile using 1.38 µm spectrum and MODIS/ARM data." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Wang, Z. 2006. "The seasonal and interannual variations of mixed-phase cloud properties observed at the NSA site." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Westwater, E, V Leuski, D Cimini, V Mattioli, M Klein, and A Gasiewski. 2006. "The 2005 North Slope of Alaska Arctic Winter Radiometric Experiment: Overview and recent results." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Widener, K, and K Moran. 2006. "MMCR – Review, status, and plans." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Williams, I, W Riley, M Torn, M Fischer, and J Berry. 2006. "Regional scale surface CO2 exchange estimates using a boundary layer budget method over the Southern Great Plains." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Wiscombe, W, A Marshak, J-Y Chiu, JC Liljegren, and D Nelson. 2006. "Measuring low liquid water paths using a new ARM infrared thermometer." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Wiscombe, W, A Marshak, J Chiu, E Welton, and S Valencia. 2006. "Cloud optical depth retrievals from solar background 'signal' of micropulse lidars." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Xie, S, S Klein, J Boyle, M Fiorinio, J Hnilo, G Potter, T Phillips, and A Beljaars. 2006. "Validation of global weather forecast and climate models over the North Slope of Alaska." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Yang, F. 2006. "Parameterizing the dependence of surface albedo on solar zenith angle using ARM observations." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Yue, Q, K-N Liuo, S-c Ou, B Kahn, P Yang, and G Mace. 2006. "Interpretation of AIRS data in thin cirrus atmospheres based on a fast radiative transfer model and ARM data." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Zak, B, M Ivey, J Zirzow, W Brower, J Ivanoff, K Sassen, D Whiteman, and D Truffer-Moudra. 2006. "Expansion of facilities on the North Slope of Alaska in time for the International Polar Year." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Zeng, X, W-K Tao, J Geiger, M Zhang, C Peters-Liddard, S Lang, J Simpson, S Kumar, C-L Shie, J Eastman, and S Xie. 2006. "Evaluation of long-term cloud-resolving modeling with ARM data." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Zhang, G. 2006. "Test of an improved convection scheme in the NCAR Community Climate System Model CCSM3." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Zhang, G, G McFarquhar, J Verlinde, M Poellot, G Kok, and A Heymsfield. 2006. "Microphysical properties of mixed-phase clouds sampled during the Mixed-Phase Arctic Cloud Experiment (M-PACE)." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Zhang, M, and J Wu. 2006. "Simulation of frontal clouds using the NCAR CAM3 during the ARM March 2000 IOP." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Zhuravleva, T, T Rasskazchikova, T Sklyadneva, and S Smirnov. 2006. "A climatology of cloud amount of midlatitude continental clouds in Tomsk region: Preliminary results." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

Zuev, V, N Zueva, and S Bondarenko. 2006. "Influence of long-period variations of total ozone content on climate changes in the twentieth century." Presented at the Sixteenth Atmospheric Radiation Measurement (ARM) Science Team Meeting. Albuquerque, New Mexico.

## Technical Reports

Biraud, S. 2006. Continuous measurements of atmospheric carbon monoxide at the ARM Southern Great Plains site. U.S. Department of Energy. ARM/TR-072.

Hnilo, J, and CAPT group. 2006. A comparison of water vapor quantities from model short-range forecasts and ARM observations. U.S. Department of Energy. ARM-06-006.

Jensen, M, and K Johnson. 2006. Continuous profiles of cloud microphysical properties for the fixed Atmospheric Radiation Measurement sites. U.S. Department of Energy. ARM-06-009.

Jensen, M, and D Troyan. 2006. Continuous water vapor profiles for the fixed ARM sites. U.S. Department of Energy. ARM-06-002.

Lo, C, D Turner, and R Knuteson. 2006. A principal component analysis noise filter value-added procedure to remove uncorrelated noise from atmospheric emitted radiance interferometer (AERI) observations. U.S. Department of Energy. ARM/TR-071.

May, P, J Mather, C Jakob, J Mace, and G McFarquhar. 2006. TWP-ICE operations plan. U.S. Department of Energy. DOE/SC-ARM-0601.

Morris, V. 2006. Infrared thermometer (IRT) handbook. U.S. Department of Energy. ARM/TR-015.

Ritsche, M. 2005. ARM Mobile Facility surface meteorology (AMFMET) handbook. U.S. Department of Energy. ARM/TR-070.

Ritsche, M. 2005. Surface temperature humidity reference system (SURTHREF) handbook. U.S. Department of Energy. ARM/TR-068.

Ritsche, M. 2005. Surface temperature humidity reference system (SURTHREF) user manual. U.S. Department of Energy. ARM/TR-069.

Sisterson, DL. 2005. ACRF operations quarterly report – October – December 2005. U.S. Department of Energy. ARM-06-007.

Sisterson, DL. 2006. ACRF operations quarterly report – January – March 2006. U.S. Department of Energy. ARM-06-008.

Sisterson, DL. 2006. ACRF operations quarterly report – April – June 2006. U.S. Department of Energy. ARM-06-010.

Voyles, J. 2005. ARM Climate Research Facility annual report 2005. U.S. Department of Energy. DOE/SC-ARM-0507.

Voyles, J. 2006. Program for the ARM Science Team Meeting, Albuquerque, New Mexico, March 27-31, 2006. U.S. Department of Energy. DOE/SC-ARM-0604.

Widener, K. 2006. W-band ARM cloud radar (WACR) handbook. U.S. Department of Energy. ARM/TR-073.

## Contacts


**Wanda R. Ferrell, Ph.D.**
Program Director
ARM Climate Research Facility
301.903.0043
wanda.ferrell@science.doe.gov

**Kiran Alapaty, Ph.D.**
Program Director
ARM Science Program
301.903.3175
kiran.alapaty@science.doe.gov

**Rickey Petty**
Program Director
ARM Aerial Vehicles Program
301.903.5548
rick.petty@science.doe.gov


***www.arm.gov***

Office of Science
U.S. Department of Energy