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Site Scientific Mission Plan for the Southern Great Plains CART Site

July-December 1998

Prepared for the U.S. Department of Energy
under Contract W-31-109-Eng-38

Site Program Manager Office
Environmental Research Division
Argonne National Laboratory
Argonne, IL 60439

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**Site Scientific Mission Plan
for the
Southern Great Plains CART Site
July-December 1998**

July 1998

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NOTATION

ABLE	Argonne Boundary Layer Experiment
AERI	atmospherically emitted radiance interferometer
AES	airborne emission spectrometer
AGL	above ground level
AIA	ARM information architecture
ANL	Argonne National Laboratory
AOS	aerosol observation system
ARESE	ARM Enhanced Shortwave Experiment
ARM	Atmospheric Radiation Measurement
ASD	Analytical Spectral Devices
ASTI	absolute solar transmittance interferometer
AVHRR	advanced very-high-resolution radiometer
AWS	automated weather station
BAMS	<i>Bulletin of the American Meteorological Society</i>
BBSS	balloon-borne sounding system
BCR	baseline change request
BDRF	bidirectional reflectance functions
BF	boundary facility
BLC	Belfort laser ceilometer
BLX	Boundary Layer EXperiment
BNL	Brookhaven National Laboratory
BoM	Australian Bureau of Meteorology
BORCAL	Broadband Outdoor Radiometer CALibration
BRS	broadband radiometer station
BSRN	Baseline Surface Radiation Network
CAR	Corrective Action Report
CART	Cloud and Radiation Testbed
CASES	Cooperative Atmosphere-Surface Exchange Study
CCN	cloud condensation nuclei
CERES	Clouds and Earth's Radiant Energy System
CIMMS	Cooperative Institute for Mesoscale Meteorological Studies
CIRA	Cooperative Institute for Research in the Atmosphere
CLEX	Cloud Layer Experiment
COL	column
CSPHOT	Cimel sunphotometer
CSU	Colorado State University
DIAL	differential-absorption lidar
DOE	U.S. Department of Energy
DQR	data quality report
DSIT	Data and Science Integration Team
EBBR	energy balance Bowen ratio
ECOR	eddy correlation
EF	extended facility
ETL	Environmental Technology Laboratory

NOTATION (Cont.)

FDDA	four-dimensional data assimilation
FTP	file transfer protocol
FY	fiscal year
GCIP	GEWEX Continental-Scale International Project
GCM	general circulation model
GEWEX	Global Energy and Water Cycle Experiment
GFGR	Gagarin, Farruggia, Gibisch, Reis, Inc.
GIST	GEWEX Integrated System Test
GPS	global positioning system
GRAMS	ground-based radiometer autonomous measurement system
GSFC	Goddard Space Flight Center
IDP	Instrument Development Program
IDPC	integrated data processing circuit
IF	intermediate facility
IOP	intensive observation period
IR	infrared
IRF	instantaneous radiative flux
ISLSCP	International Satellite Land-Surface Climatology Project
ISS	integrated sounding system
IT	Instrument Team
JPL	Jet Propulsion Laboratory
LANL	Los Alamos National Laboratory
LBL	line by line
LBLRTM	line-by-line radiative transfer model
LLJ	Low-Level Jet
LMS	Lockheed Missile and Space
MCS	Mesoscale Convective System
MDN	Meta Data Navigator
MDS	Meta Data System
MFR	multifilter radiometer
MFRSR	multifilter rotating shadowband radiometer
MMCR	millimeter cloud radar
MOPA	Master Oscillator Power Amplifier
MOPITT	Measurements of Pollution in the Troposphere
MPL	micropulse lidar
MPL-HR	micropulse lidar-high resolution
MSU	Millersville State University
MSX	Midcourse Satellite Experiment
MTP	microwave temperature profiler
MWR	microwave radiometer
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCSU	North Carolina State University
NEXRAD	next-generation radar

NOTATION (Cont.)

NFOV	narrow-field-of-view zenith-pointing filtered radiometer
NIP	normal-incidence pyrheliometer
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
OCS	Oklahoma Climatological Survey
OKM	Oklahoma Mesonet
ORR	Operational Readiness Review
OU	University of Oklahoma
PARC	Palo Alto Research Center
PBL	planetary boundary layer
PI	principal investigator
PIF	Problem Identification Form
PNNL	Pacific Northwest National Laboratory
PRB	Problem Review Board
PROF	profile
PRR	Pre-Readiness Review
PSU	Pennsylvania State University
QME	quality measurement experiment
R1	Research System
RASS	radio acoustic sounding system
RCF	radiometer calibration facility
RLID	Raman lidar
RSS	rotating shadowband spectrometer
RWP	radar wind profiler
SAC	Site Advisory Committee
SCM	single-column model
SDS	site data system
SGP	Southern Great Plains
SI	International System of Units
SIROS	solar and infrared radiation observing system
SIRS	solar and infrared station (formerly part of SIROS)
SITAC	Spectral Imagery Technology Applications Center
SMOS	surface meteorological observation station
SNL	Sandia National Laboratories
SORTI	solar radiance transmission interferometer
SPM	site program manager
SSFR	solar spectral flux radiometer
SST	Site Scientist Team
SUCCESS	Subsonic Aircraft: Contrail and Cloud Effects Special Study
SWATS	soil water and temperature system
SWS	shortwave spectrometer
TEMP	temperature

NOTATION (Cont.)

TES	tropospheric emission spectrometer
THWAPS	temperature, humidity, wind, and pressure sensors
TIMEX	Thunderstorm Initiation Mobile Experiment
TLCV	time-lapse cloud video
T/RH	temperature and relative humidity sensors
TRMM	Tropical Rainfall Measuring Mission
TWP	Tropical Western Pacific
UAV	unmanned aerospace vehicle
UBC	University of British Columbia
UCAR	University Corporation for Atmospheric Research
UD	University of Denver
UIR	upwelling infrared radiometer
UM	University of Massachusetts
UNAVCO	University NAVSTAR Consortium
UoM	University of Maryland
UoMi	University of Miami
USDA	U.S. Department of Agriculture
USR	upwelling solar radiometer
UTC	universal time coordinated
UU	University of Utah
UV	ultraviolet
UW	University of Wisconsin
VAP	value-added product
Vceil	Vaisala ceilometer
VORTEX	Verification of the Origins of Rotation in Tornadoes Experiment
WPL	Wave Propagation Laboratory
WSI	whole-sky imager
WVR	water vapor radiometers

**SITE SCIENTIFIC MISSION PLAN
FOR THE SOUTHERN GREAT PLAINS CART SITE
JULY-DECEMBER 1998**

1 INTRODUCTION

The Southern Great Plains (SGP) Cloud and Radiation Testbed (CART) site was designed to help satisfy the data needs of the Atmospheric Radiation Measurement (ARM) Program Science Team. This *Site Scientific Mission Plan* defines the scientific priorities for site activities during the six months beginning on July 1, 1998, and looks forward in lesser detail to subsequent six-month periods. The primary purpose of this document is to provide scientific guidance for the development of plans for site operations. It also provides information on current plans to the ARM functional teams (Management Team, Data and Science Integration Team [DSIT], Operations Team, and Instrument Team [IT]) and serves to disseminate the plans more generally within the ARM Program and among the members of the Science Team. This document includes a description of the operational status of the site and the primary site activities envisioned, together with information concerning approved and proposed intensive observation periods (IOPs). The primary users of this document are the site operator, the site program manager, the Site Scientist Team (SST), the Science Team through the ARM Program science director, the ARM Program Experiment Center, and the aforementioned ARM Program functional teams. This plan is a living document that is updated and reissued every six months as the observational facilities are developed, tested, and augmented and as priorities are adjusted in response to developments in scientific planning and understanding.

This report and all previous reports are available on the SGP CART site World Wide Web home page at

<http://www.arm.gov/docs/sites/sgp/sgp.html> ,

at the link "Site Scientific Mission Plan."

2 SUMMARY OF SCIENTIFIC GOALS

2.1 Programmatic Goals

The primary goal of SGP CART site activities is to produce data adequate to support significant research addressing the objectives of the ARM Program. These overall objectives, as paraphrased from the *ARM Program Plan, 1990* (U.S. Department of Energy 1990), are the following:

- To describe the radiative energy flux profile of the clear and cloudy atmosphere
- To understand the processes determining the flux profile
- To parameterize the processes determining the flux profile for incorporation into general circulation models (GCMs)

To address these scientific issues, an empirical data set must be developed that includes observations of the evolution of the radiative state of the column of air over the central facility, as well as the processes that control that radiative state, in sufficient detail and quality to support the investigations proposed by the ARM Science Team. To address the entire 350-km $\times$ 400-km SGP CART site, the ARM Program also relies on models to compute the processes or properties that affect radiative transfer. This set of data includes measurements of radiative fluxes (solar and infrared [IR]) and the advective and surface fluxes of moisture, heat, and momentum occurring within the column and across its boundaries. Other entities to be described are cloud types, composition, and distribution (depth, fractional coverage, and layering); thermodynamic properties of the columnar air mass (temperature, pressure, and concentrations of all three phases of water); the state and characteristics of the underlying surface (the lower boundary condition); processes within the column that create or modify all of these characteristics (including precipitation, evaporation, and the generation of condensation nuclei); and radiatively significant particles, aerosols, and gases. Basic continuous observations must be made as often as is feasible within budgetary constraints. For limited periods of time, these observations will be supplemented by focused IOPs providing higher-resolution or difficult-to-obtain *in situ* data.

Beyond simply providing the data streams, determining their character and quality as early as possible in the observational process is imperative. This evaluation provides the basic

operational understanding of the data necessary for an ongoing program of such scope. Although both reason and ample opportunity will exist to develop a further understanding of the ARM observations over the course of the program, the task of investigating and ensuring the data quality is extremely important. In this regard, routine instrument mentor and SST data quality assessments, definitive quality measurement experiments (QMEs), and value-added products (VAPs) help establish confidence in the measurements.

The SGP CART site is the first of three global locations chosen and instrumented for data collection. As summarized in the *Science Plan* for the ARM Program (U.S. Department of Energy 1996), the scientific issues to be addressed by using data from a midlatitude continental CART observatory include the following:

- Radiative transfer in cloudless, partly cloudy, and overcast conditions
- Cloud formation, maintenance, and dissipation
- Parameterizations of nonradiative flux
- The role of surface physical and vegetative properties in the column energy balance
- Other complications in the radiative balance in the atmosphere, particularly those due to aerosols, cloud condensation nuclei (CCN), and cloud-aerosol radiative interactions
- Feedback processes between different phenomena and different domains

The variety, surface density, and atmospheric volumetric coverage of the SGP instrumentation will be more comprehensive than those at any other ARM site, and the SGP site will experience a wider variety of atmospheric conditions than will the other sites. The resulting data will accordingly support a greater range and depth of scientific investigation, making it imperative for the ARM Program to develop and maintain a high-quality, continuous data stream from the SGP site.

The measurements required by Science Team proposals, the DSIT, and the science director are categorized into areas or groups of scientific applications within ARM. The DSIT

and other teams coordinate activities to develop integrated, well-focused data sets for these groups. Focus areas include shortwave radiation, longwave radiation, water vapor, aerosols, clouds, surface fluxes, and the single-column model (SCM). A goal is to facilitate development of an algorithm that prescribes geophysical phenomena as products of multiple data streams.

2.2 Priorities for Site Activities

Priorities for site activities for July through December 1998 include the following:

- Facilitate all data quality assessment efforts, particularly those focused on the development of a full suite of data quality analysis tools, participation in the development of an ARM data user interface, implementation of QMEs and VAPs, and better dissemination of information on data quality.
- Conduct an assessment of the measurement capability of the SGP CART site relative to Science Team needs.
- Plan and implement key IOPs and campaigns.
- Finish implementation of the Okmulgee extended facility.
- Support the Instrument Development Program (IDP).
- Continue the review of routine site operations.

The IOPs focus on providing critical data sets on an episodic basis for the Science Team, as well as field support for instrument development and testing and for collaborative campaigns. The IOPs scheduled for this six-month period are detailed in Section 5.3.

Operation of the radiometer calibration facility (RCF) has matured, with site operations personnel, as trained by staff of the National Renewable Energy Laboratory (NREL), currently performing most of the work. Successful calibration was carried out in September 1996 and July-September 1997, with the completion of two Broadband Outdoor Radiometer CALibrations (BORCALs). Achieving optimal use of the facility is an ongoing task, as more BORCALs will be performed in 1998.

The phased implementation of the Okmulgee extended facility (the wooded site) is nearly complete. The walk-up tower, shelter, and infrastructure were in place in spring 1998. Instruments are planned for installation in fall 1998. A Memorandum of Understanding with the U.S. Department of Agriculture (USDA), signed in 1997 in support of Global Energy and Water Cycle Experiment (GEWEX) studies at the El Reno extended facility, allows the costs of installation to be shared with ARM for phased implementation and completion of that energy balance Bowen ratio (EBBR) site. A solar-powered EBBR and a soil water and temperature system (SWATS) with cellular phone data communications were installed there temporarily. Completion of the permanent site occurred in May 1998.

The installation of four Vaisala 25-km ceilometers and four atmospherically emitted radiance interferometers (AERIs) at boundary facilities was postponed until fiscal year (FY) 1999 because of problems with the delivery schedule for the AERIs. However, one such Vaisala ceilometer (Vceil) was operated at the central facility during the spring 1998 Cloud/SCM IOP. Although an extended facility is not planned for Ft. Cobb at this time, the optimal location for another eddy correlation (ECOR) site is yet to be determined. One auxiliary facility needs to be established to accommodate the installation of a second day-night whole-sky imager (WSI) as soon as another WSI is provided. In addition, an administration trailer was installed in the compound area of the central facility, and phased implementation of three trailers is taking place at IDP No. 4, for a storage area. This area could also be developed to accommodate IOP participants should the need arise.

In summary, goals for this six-month period continue to be to provide the Science Team with a suite of measurements that will support a wide range of research, to establish solid procedures for instrument calibration and maintenance (particularly for broadband radiometry), to operate the series of VAPs and QMEs, to provide input for the scientific applications groups, and to install required instrumentation and facility support. Quality assessment efforts also remain central to the success of the entire program.

3 ROUTINE SITE OPERATIONS

3.1 Overview

The overwhelming majority of the measurements with the highest priority, on which the existing experimental designs are based, are regular routine observations, as specified in the *ARM Program Plan, 1990* (U.S. Department of Energy 1990). Scientifically and logistically, routine operations also serve as the basis and background for all nonroutine operations, including instrument development activities, IOPs, and collaborative campaigns directed toward obtaining difficult-to-gather or expensive *in situ* data. Consequently, development and validation of the basic observations remain high priorities. Site development has progressed sufficiently to support IOPs addressing key scientific areas of study.

The SST will continue to work to ensure the scientific productivity of the site by providing guidance to the site operations manager and his staff on scientific matters. This includes monitoring instrument performance via the analysis of the quality of the data stream, reviewing schedules and procedures for instrument maintenance and calibration, reviewing designs for the infrastructure supporting new instruments, contributing to the design of the standard operating procedures, reviewing and developing plans for IOPs, and helping to obtain near-real-time data displays during IOPs. The SST, in cooperation with instrument mentors and the DSIT, will continue to lead the data quality assessment effort at the CART site, an ongoing activity that includes monitoring of the CART data streams in collaboration with the staff at the central facility and the development of data quality performance metrics and graphic tools that address data quality. The site program manager will help coordinate these activities.

Routine operations are the activities related to the operation and maintenance of instruments, the gathering and delivery of the resulting data, and the planning for scientific investigations, including IOPs, campaigns, VAPs, and QMEs. Although the site is essentially complete, instrumentation will be evaluated continuously to assess the possible need to eliminate instruments or replace them with different or new sensors. This reevaluation is discussed in Section 7, "Looking Ahead." The process that leads to implementation of CART instruments continues to be the Pre-Readiness Review (PRR). The PRR includes the identification of requirements for instrument design and installation and the development of the documentation, procedures, and training needed to maintain CART instrumentation and integrate data streams into the site data system (SDS). The PRR also provides a forecast of when these instruments will

be fully operational (i.e., ready for operational handoff to site operations via the Operational Readiness Review [ORR]) and delivering data to the Experiment Center and the Data Archive.

The design expectation for the routine operation of instruments is that they will continue to require servicing by site operators only once every two weeks. The exception to this is the central facility, which is staffed. If an instrument failed during a two-week period at an extended facility, data streams could be lost, although every effort is made to ensure adequate data-logging capacity at each such site. Such loss of data is unfortunate but is unavoidable because of manpower and budget constraints. The instruments at all extended, intermediate, and boundary facilities are polled frequently each day by the SDS at the central facility, and data are packaged and delivered to the Experiment Center and the Data Archive once daily. The Experiment Center generally delivers data to Science Team members and other data requesters once weekly via an Experimental Operations Plan and sends data sets to the ARM Data Archive as well. The VAPs and QMEs are implemented and operated at the Experiment Center.

Site operations staff conduct additional instrument "triage" during IOPs and campaigns. The triage plan calls for IOP scientists to identify instruments, individual sensors, and communication links that are critical to the operation and goals of the IOP, so that these instruments can receive more frequent servicing than is prescribed by the routine operational requirements mentioned above. The priority of triage efforts is determined by IOP scientists, the SST, and the site program manager, who take into consideration the scientific importance of a particular data stream and its expense. The triage plan has been very successful, as demonstrated during recent IOPs.

Handling of instruments that must be returned to the vendor for calibration and servicing is also part of routine operations. Replacement instruments and sensors are rotated regularly to meet these requirements. Calibration and maintenance information is compiled, both to operate and maintain site instruments properly and to provide pertinent information to data users. Changeouts of all sensors and instrumentation are recorded in the site operations log.

Initial checks of data quality after instrument installation are provided by the instrument mentors. After the mentor reviews the data stream to ensure that the acquired instrument is performing properly and that the data are identified accurately by the Experiment Center, the mentor approves a "beta" release of the data. The beta release provides data to selected Science Team members who have requested them and are willing to work with the instrument mentor on data quality issues. Beta releases are established after the instrument mentor and an appropriate

member of the DSIT have created a general statement on data quality for the Experiment Center. When the data quality relative to proper instrument functionality is consistently acceptable and well documented, the mentor approves a full release of the data.

3.2 Routine Operations

3.2.1 Functional Instruments and Observational Systems

Figure 1 is a map of the SGP site showing the locations of the developed extended, intermediate, and boundary facilities. The status of the systems and instruments anticipated by December 31, 1998, is summarized in Table 1.

Accomplishments in the area of site development are most evident at the central facility (Table A.1 in the Appendix), with its functioning power, fiber-optic infrastructure, and near-complete array of instruments. Of the 26 planned extended facilities (Table A.2 in the Appendix), 23 (including one at the central facility and one at the Cement location) are operational at the beginning of this period; one ECOR site (formerly Ft. Cobb, EF-23) is yet to be identified and is a placeholder site for possible expansion, if required.

In addition, ARM has developed a mission-critical Meta Data System (MDS) that will enable all information to be provided at a common location (supplemental to the instrument data streams). The MDS database enhances the scientific utility of the instrument data streams. Such information is available at the ARM MDS Web site:

<http://www.db.arm.gov/MDS/> .

3.2.2 Launch Schedule for Balloon-Borne Sounding Systems

Until the full suite of remote sensing systems is deployed to perform deep, detailed soundings of the wind, temperature, and moisture of the troposphere under a wide range of conditions, the balloon-borne sounding system (BBSS) will continue to be an expensive workhorse. Because of budget constraints, the number of BBSS launches sitewide was reduced in 1997 to the minimum needed to support routine cross-checks on the remotely sensed measurements. The frequency of routine launches at the central facility was reduced from five per day to three, and routine launches were eliminated at all four boundary facilities.

TABLE 1 Instruments and Observational Systems Anticipated at the Central, Boundary, Extended, and Auxiliary Facilities on December 31, 1998^a

Central Facility

Radiometric Observations

AERI
 AERI X
 SORTI
 BRS (formally BSRN)
 Pyranometer (ventilated)
 Pyranometer (ventilated, shaded)
 Pyrgeometer (ventilated, shaded)
 NIP on tracker
 MFRSR
 SIRS (formally known as SIROS)
 Pyranometer (ventilated)
 Pyranometer (ventilated, shaded)
 Pyrgeometer (ventilated, shaded)
 NIP on tracker
 Pyranometer (upwelling, above pasture at 10 m)
 Pyrgeometer (upwelling, above pasture at 10 m)
 MFRSR
 MFR (upwelling, above pasture at 10 m)
 Pyranometer (upwelling, above wheat at 25 m on 60-m tower)
 Pyrgeometer (upwelling, above wheat at 25 m on 60-m tower)
 MFR (upwelling, above wheat at 25 m on 60-m tower)
 CSPHOT
 RSS
 NFOV
 GRAMS
 SWS
 RCF instrumentation, including cavity radiometers
 UV spectrometer

Wind, Temperature, and Humidity Sounding Systems

BBSS
 915-MHz profiler with RASS
 50-MHz profiler with RASS
 MWR
 Heimann IR thermometer
 Raman lidar
 THWAPS

TABLE 1 (Cont.)

Cloud Observations

WSI (daytime/nighttime)
 BLC (interim)
 MPL (IDP) ceilometer
 MPL-HR
 MCCR
 Vceil
 TLCV

Others

Temperature and humidity probes at 25-m and 60-m levels on tower
 Heat, moisture, and momentum flux at 25-m and 60-m levels on tower
 EBBR
 ECOR
 SMOS
 AOS (samples at 10 m)
 SWATS

Extended Facility Components

SIRS (formally known as SIROS)
 Pyranometer (ventilated)
 Pyranometer (ventilated, shaded)
 Pyrgeometer (ventilated, shaded)
 NIP on tracker
 Pyranometer (upwelling, at 10 m)
 Pyrgeometer (upwelling, at 10 m)
 MFRSR
 EBBR or ECOR
 SMOS
 SWATS

Auxiliary Facilities

None in preparation

Boundary Facilities

BBSS
 MWR
 THWAPS
 Vceil
 AERI

TABLE 1 (Cont.)

Intermediate Facilities

915-MHz profiler and RASS

- ^a AERI, atmospherically emitted radiance interferometer; AOS, aerosol observation system; BBSS, balloon-borne sounding system; BLC, Belfort laser ceilometer; BRS, broadband radiometer station; BSRN, Baseline Surface Radiation Network; CSPHOT, Cimel sunphotometer; EBBR, energy balance Bowen ratio; ECOR, eddy correlation; GRAMS, ground-based radiometer autonomous measurement system; IDP, Instrument Development Program; IR, infrared; MFR, multifilter radiometer; MFRSR, multifilter rotating shadowband radiometer; MMCR, millimeter cloud radar; MPL, micropulse lidar; MPL-HR, micropulse lidar-high resolution; MWR, microwave radiometer; NFOV, narrow-field-of-view zenith-pointing filtered radiometer; NIP, normal-incidence pyrheliometer; RASS, radio acoustic sounding system; RCF, radiometer calibration facility; RSS, rotating shadowband spectrometer; SIROS, solar and infrared radiation observing system; SIRS, solar and infrared station; SMOS, surface meteorological observation station; SORTI, solar radiance transmission interferometer; SWATS, soil water and temperature system; SWS, shortwave spectrometer; THWAPS, temperature, humidity, wind, and pressure sensors; TLCV, time-lapse cloud video; UV, ultraviolet; Vceil, Vaisala ceilometer; WSI, whole-sky imager.

The new schedule for routine operations is in Table 2. The new routine radiosonde launch times, approved by the Science Team Executive Committee, were chosen to complement the National Weather Service (NWS) standard launch times of 0000 and 1200 UTC (universal time coordinated) and to support the daytime satellite advanced very-high-resolution radiometer (AVHRR) overpass at approximately 2030 UTC. In addition, the 2030 UTC launch is during the maximum daytime boundary layer height and therefore supports instantaneous radiative flux (IRF) and IDP research. Remote sensing of virtual temperature profiles at all boundary facilities is performed by the nearby National Oceanic and Atmospheric Administration (NOAA) profilers, which are being outfitted with ARM-provided radio acoustic sounding system (RASS) units. The RASS units have already been installed at the Purcell, Oklahoma, and at the Haviland, Kansas, NOAA profilers. The Lamont, Oklahoma, NOAA profiler will not receive a RASS unit because it would be located too close to a residence, but the nearby SGP CART site central facility collects a relative abundance of thermodynamic data. In addition, global positioning system (GPS) instruments were recently installed at the Purcell, Vici, Haskell, Haviland, Lamont, Neodesha, and Hillsboro NOAA profiler locations to provide estimates of precipitable water. This information, along with the NOAA profiler data, has become available to the ARM Program as external data.

**TABLE 2 Radiosonde Launch Schedule
for July 1-December 31, 1998 (Times in UTC)^a**

<u>Central Facility</u>	<u>Boundary Facilities</u>
<i>Routine Operations, July 1-December 31, Monday-Friday</i>	
0000	
1200	
2030	

^a UTC, universal time coordinated. Launch time is 30 min earlier; the stated time represents the approximate midpoint of the flight.

The central facility will be staffed from 0430 to 1630 and from 2230 to 0230 local time, Monday through Friday (including holidays). During appropriate SCM IOPs, the central facility and the four boundary facilities will be staffed 24 hours per day, 7 days per week (including holidays), to facilitate round-the-clock radiosonde releases every 3 hours.

3.3 Instruments

A CART instrument is any instrument that is approved by the ARM Program and for which the site operations management has accepted responsibility for operation and maintenance. The PRR and ORR forms represent requests for information that facilitates the installation and operation of instruments or facilities at the SGP CART site. The purpose of these reviews is to achieve an efficient handoff of instruments and facilities from instrument mentors to site operators. Figure 2, the SGP CART instrumentation implementation flowchart, represents information obtained from the PRR and ORR documentation. When all procedures, operation manuals, and training pertaining to an instrument have been completed, the instrument is accepted by site operations management. If sufficient documentation is available to operate an instrument, even though more will ultimately be required for full acceptance, the instrument may be operated in a degraded mode.

Instruments recently installed or expected to be installed include the following:

- *Cimel Sunphotometer (CSPHOT) at the Central Facility, Installed.* A CSPHOT was acquired for installation at the central facility. The CSPHOT provides measurements of aerosol optical depth to supplement the multifilter

FIGURE 2 SGP CART Instrumentation Implementation Flowchart

rotating shadowband radiometer (MFRSR) readings and to tie in with a global network of sunphotometers supported in part by the National Aeronautics and Space Administration (NASA). In addition to measuring optical depths, the system is used to observe the sky radiance along the solar almucantar and along the solar principal plane, including the solar aureole. The resulting data can be used for inferring aerosol size distribution and to study the scattering phase function. A prototype instrument was installed in the expanded central cluster in late summer 1997 for the Fall 1997 Integrated IOP. The permanent instrument was installed in spring 1998.

- *Shortwave Spectrometer (SWS), Installed.* A field spectral radiometer system for wavelength ranges of 350-2,500 nm in three wave bands was acquired. Initially, only global radiation will be detected. A prototype was operated during the Fall 1997 Integrated IOP. The permanent version was installed in spring 1998.
- *Establishment of Instruments on an Extended Facility at a Forested Site, in Progress.* A walk-up scaffolding tower (approximately 55 ft) was erected in the summer of 1997 at the Okmulgee extended facility. The tower supports an ECOR system, a surface meteorological observation station (SMOS), and a solar and infrared station (SIRS) above the forest canopy. All infrastructure support was completed in May 1998. Phased implementation of instrumentation continues. This site may not be fully operational until summer or fall 1998.
- *Ceilometers and AERIs at Boundary Facilities, in Progress.* Four Vaisala ceilometers have been acquired for installation at the boundary facilities this year. These ceilometers are capable of detecting cloud base to a height of about 2.5 km. They are intended primarily to provide data for algorithms to retrieve profiles of temperature and humidity in the lower troposphere from AERI data. For efficiency and to decrease costs, installation of the AERIs has been delayed until all four units are acquired. Although the ceilometers are in hand, they will also be installed when the AERIs are available, which is anticipated in late fall 1998. Funding for the installations will be available in FY 1999.

- *Upgrades of the BBSS, in Progress.* Steps have been taken to upgrade the CART BBSSs to use GPS-based rather than loran-based tracking for determining position, a necessity during the next few years as Loran-C transmitters are phased out. In addition, a new type of Vaisala radiosonde, which uses the RS-90 sonde instead of the RS-80 version presently used, is expected to become available this year. The humidity sensor on the RS-90 sonde is reported to have a faster response and to recover more quickly after emerging from clouds. The temperature sensor is smaller and thus is probably considerably faster in response and less susceptible to the effects of heating by solar radiation. In addition, reference temperature, humidity, wind, and pressure sensors (THWAPS) were installed in 1997 at the balloon launch site at the central facility to provide surface reference values. A THWAPS was installed at each of the boundary facilities in April 1998.
- *Narrow-Field-of-View (NFOV) Zenith-Pointing Filtered Radiometer, in Progress.* An uplooking, near-IR, shortwave radiance instrument (the NFOV) is now available with a field of view overlapping or nearly coincident with that of the microwave radiometer (MWR) and possibly the cloud radar. The wavelengths detected are in a fairly narrow band near 0.9 μm . Such a device is needed to improve understanding of the relationships between the liquid water path and shortwave radiation. This instrument is expected to be installed early in this six-month period.
- *Ultraviolet (UV) Spectrometer, in Progress.* A UV spectrometer (Lee Harrison, State University of New York-Albany, with funding from the USDA) will be available for installation in August 1998. This instrument will measure total horizontal irradiance at 290-360 nm.
- *Optical Transmissometer, in Progress.* A commercially available transmissometer will be acquired to detect fog, dust, and drizzle too light to be recorded by rain gauges. Such phenomena are best detected by open-path devices rather than through a large sampling stack like that being used with the aerosol observation system (AOS). The data will be useful for evaluation of signals from radars, lidars, and the MWR.

- *Absolute Solar Transmittance Interferometer (ASTI) and Solar Radiance Transmission Interferometer (SORTI).* Operation of the ASTI will continue to occur in IOP mode as requested. Implementation of the SORTI at the central facility also occurred. Data are being collected, but the data ingest has not been achieved. The ASTI instrument will be operated during relevant IOPs.

Measurement issues currently under consideration but unresolved by ARM infrastructure include the following:

- *Continuous Direct-Beam Solar Irradiance Measurements with a Cavity Radiometer.* Documentation for the Baseline Surface Radiation Network (BSRN) specifies that an all-weather, windowless cavity radiometer be operated at a BSRN site. This task is not feasible at the SGP CART site central facility because of dusty conditions. Operation of a windowed cavity radiometer, one of which has already been purchased for this purpose, might be possible at the RCF, but considerable effort would be necessary for continuous operation. Some compromise for part-time or discontinuous operation might have to be developed. Cavity radiometers were operated during the Fall 1997 Integrated IOP and during BORCAL operations.
- *Local Observations of Surface Vegetative Conditions at Extended Facilities.* The interpretation of data on, and the modeling of, surface latent and sensible heat fluxes at extended facilities would be assisted by routine observation of leaf area index and surface optical reflectance properties represented by the nondimensional vegetative index. Local leaf area index measurements might be too variable to be of much use, but local measures of nondimensional vegetative index are believed to be particularly important for interpretation of nondimensional vegetative index values derived from remote sensing data from satellites. The satellite data could then be used to help infer the values and variability of surface heat fluxes for the overall SGP CART site. Relatively simple devices that measure nondimensional vegetative index can be obtained at a modest cost and are currently being investigated.
- *Additional Extended Facilities at the SGP CART Site.* Some concern has been expressed that the spatial coverage of extended facilities for measuring air-surface exchange rates of heat and moisture seems to be incomplete,

particularly to the south and southeast of the central facility. A review of the current site distribution is underway.

- *Surface Bidirectional Reflectance.* Measurements of surface bidirectional reflectance have been suggested at times for the SGP CART site. A commercial portable apparatus for rapid acquisition of bidirectional observations of the land and the atmosphere (PARABOLA) is available, but this system is not suitable for routine observations. Such observations would be quite useful in interpretation of solar reflectances seen from satellites. A Science Team project is now addressing this observational need.
- *Profiling with Passive Microwave Systems.* A passive MWR for obtaining profiles of temperature through clouds could augment or supplant profile measurements made with the AERIs at the boundary facilities. The primary advantage of microwave profiling is that it penetrates clouds, unlike any of the water vapor remote sensing systems currently in operation at the SGP CART site. Radiometrics has been developing such a system. Vertical resolution appears to be about 100 m near the surface, increasing gradually to more than 2 km at a height of about 10 km, near the maximum range. A less expensive Russian system with slightly greater vertical resolution and a maximum range of about 600 m is currently being evaluated. If funding were provided, a passive system for water vapor profiling might also be developed successfully.

3.4 Baseline Change Request

Once site operations personnel have accepted instruments, their design and configuration are "locked in" by using a configuration management system that is controlled by site operations. Any modifications to instruments or data systems that could affect more than one ARM functional group require a baseline change request (BCR). The BCR process is in a secure Web-based system. A BCR submittal form can be found at

<http://www.arm.gov/docs/sites/sgp/forms/bcr.html> .

The BCR requests usually come from instrument mentors. The site program manager, the control point for the BCR process, assigns infrastructure support for review and approval.

Individuals participating in the review and approval process are given passwords for access to the BCR database. A critical BCR requires response within 24-48 hours, a very important BCR within 3-5 working days, and an important BCR within 5 working days.

3.5 Development of the Site Data System

Several installed instruments and all new instruments require software to transfer the data from the instrument platforms to the SDS via a pathway referred to as the integrated data processing circuit (IDPC). The IDPC includes communications between the instrument and data loggers and the data ingest system (described more fully in Section 4.1), reporting on instrument status to site operations staff and others, and transmission of data to the Experiment Center and the Data Archive. Usually, data transfer is accomplished by coded switches at the extended facilities and intermediate facilities or by T-1 lines at the boundary facilities. Most of the ARM SGP instruments have their data collected (or delivered) to the SDS regularly, with data processed through the IDPC and passed on to the Experiment Center and the Data Archive. Some exceptions to this paradigm will continue to occur during the next six months.

The IDPC development schedule and the status of instruments can be found at the SGP CART Web site:

http://www.res.sgp.arm.gov/trav/stat_IDPC.html .

Further work is being undertaken to facilitate routine operations, particularly to assess instrument performance, by including a broader suite of data display capabilities. When the SDS is near completion, procedures for system management and maintenance need to be written and transferred to site operations staff.

The SDS continues to address the need to make near-real-time data available through the Research System (R1) for instrument mentors, for selected scientists during IOPs and campaigns, and for educational outreach efforts in conjunction with outreach projects of the Oklahoma Climatological Survey (OCS).

3.6 Observations, Measurements, and External Data

External data being delivered to the ARM Program can be found on the Web at:

<http://www.xdc.arm.gov/> .

The availability of data from a particular platform on any given day is a function of the quality assurance process; some segments are temporarily unavailable during evaluation or correction of problems.

3.7 Site Development Activities

Full implementation of the permanent El Reno extended facility will take place during this six-month period with the establishment of infrastructure and instruments.

Implementation of the Okmulgee extended facility is taking place in five phases. The first phase was installation of the access roadway and power. The second was installation of the walk-up tower. The third phase was installation of the infrastructure (cement pads, data communication lines, gravel, etc.). The fourth phase was installation of the shelter and security fence. All four of these phases were completed by May 1998. The fifth phase will be installation of the instruments. Full implementation is not expected until near the end of this six-month period.

The number of radiometers deployed at the central cluster has required expansion; an additional area was designated as the optical trailer cluster. Instruments critical to the Fall 1997 Integrated IOP were installed and operational there by August 1997. These instruments include the ground-based radiometer autonomous measurement system (GRAMS), the time lapse cloud video (TLCV), the rotating shadowband spectrometer (RSS), and CSPHOT (spring 1998). An NFOV will be deployed near the EBBR in summer 1998. The SWS was installed in the optical trailer in spring 1998, and the ASTI will be installed in or near the optical trailer for IOPs. Each of the cluster areas has been upgraded relative to electronics and communications to allow for expansion of yet unspecified instruments. A UV spectrometer will be installed in August 1998.

In anticipation of the need for additional IDP area facilities, IDP No. 4 is being implemented. This 150-ft $\times$ 175-ft graveled area is located at the site formerly occupied by the farmhouse at the extreme southeast corner of the central facility. This area has a double-wide

trailer (24 ft $\times$ 55 ft) for storage and a 12-ft $\times$ 50-ft office trailer. Finally, an administration trailer has been situated at the north end of the central facility, parallel to the conference trailer. This trailer houses the on-site operations manager (Jim Teske), the site safety officer (John Schatz), and the on-site scientist (Chad Bahrmann).

4 DATA QUALITY

Data quality issues are addressed at several levels within the ARM Program and at the SGP CART site. One of the primary goals of the ARM Program is to provide data streams of known and reasonable quality. Maintaining data quality for a program of this size and complexity is a significant challenge. Data quality assurance within the ARM Program infrastructure has matured over the past few years and will continue to evolve, with the SST continuing to play a significant role. Data flagging issues and addressing the data quality of new instruments continue to be the focus for this six-month period.

4.1 Instrument Mentors

Instrument mentors are charged with developing the technical specifications for instruments procured for the ARM Program. The instrument mentor then tests and operates the instrument system (either at his or her location or at the SGP CART site). In addition, the mentor works with SDS personnel on data ingest software requirements as part of the IDPC. Data ingest involves the conversion of data streams to the International System of Units (SI), as well as the acquisition of parameters that can be used to monitor instrument performance (e.g., monitoring an instrument's output voltage for a 5-V power supply or the continuity of the wire in a hot-wire anemometer). Data collection and data ingest, then, are the focus of the first level of data quality assurance. Quality at this level is monitored routinely by instrument mentors and site operators.

The next level of data quality assurance involves beta release of data streams from individual instruments. The mentor receives the data from the instrument to determine whether the technical specifications of the instrument are being met. When the mentor is satisfied that the instrument is functioning properly and that the technical specifications have been met, the data are formally released to the Science Team and other data users. After this release, the instrument mentor is also charged with reviewing the instrument data streams at least once every two weeks, an action monitored at the Experiment Center. This information is forwarded to the SST.

Instrument mentors provide all calibration, operations, and maintenance documents and lists of spare parts to site operations. Typically, the mentor provides additional detailed documentation and hands-on training so that appropriate support can be offered by site operators. This activity is part of the ORR process.

4.2 Site Scientist Team

The SST helps to ensure that the scientific productivity of the SGP CART site is maximized by both the routine and special (IOP) operations at the site. The SST acts as a resource for the site operations manager and his staff on scientific matters by doing the following:

- Working with site operations personnel and instrument mentors on potential instrument problems
- Reviewing proposed instrument siting and deployment strategies, including the needs of the instrument mentors and instrument requirements for IOPs and campaigns
- Reviewing schedules and procedures for instrument calibration and maintenance
- Providing an early assessment of suspected instrument or data problems through the use of performance metrics, graphic display techniques, and data quality research investigations, as well as distributing the findings so that corrective actions can be taken
- Planning and conducting IOPs and campaigns

These activities require constant communication with site operations staff, including routine visits to the central facility and occasional trips to extended, intermediate, and boundary facilities. These activities are also highly coordinated with the site program manager and, when appropriate, with instrument mentors and DSIT personnel. Ongoing focus activities of the SST will contribute to the goals of data quality assessment for the SGP CART site and ensure that the operation of the site meets, as nearly as possible, the overall scientific goals of the ARM Program.

In the past, data quality assessment efforts of the SST largely involved evaluation of individual and multiple sets of data streams as needed, on an exploratory or developmental basis (data quality investigations); participation in QMEs; and participation in the creation and workings of the VAP Working Group.

Now that operational activities have shifted from deployment to support of ongoing, continuous operation of a wide variety of instrumentation at many locations, a more comprehensive, systematic data quality assessment effort has been undertaken by the SST. This effort is manifested in several ways, including evaluation of the calibration and maintenance information, the development of automated graphic display techniques for use by the SST in daily monitoring of data quality (work began in October 1995), and the development of performance metrics that systematically determine the percentage of the collected data falling within given quality tolerances (work began in February 1996).

The development of performance metrics is aimed at determining the "health" of the site data via time series (numerical and graphic) of the metrics. In late 1996, the SST began issuing assessments of the data from several instruments with the goal of attaining quicker resolution of instrument and data quality problems. In 1998, a Web site containing graphic displays of performance metrics and other quality assessment techniques was established at

http://www.res.sgp.arm.gov/sst/dq_monitor/DISPLAYS.html .

Plans for this six-month period include continued development of graphic display techniques for more data streams, continued development and display of performance metrics, continued evaluation of the calibration and maintenance information, and participation in an ARM-wide data user interface initiative that will make information on data quality more readily available to data users. Thus, with the assistance of the site operations staff and instrument mentors, the SST will be able to serve the ARM Program goals better by laying a foundation for improving data credibility. See Pepler and Splitt (1998) for more detail about ARM SGP data quality techniques.

Revisiting the charge given to the SST and its roles and responsibilities within ARM will clarify SGP CART site operation and sources of help with issues related to the site. The SST's main role, as mentioned above, is to ensure the integrity of the scientific products of the SGP CART site. This role is embodied in the following broad task areas: (1) provide on-site scientific guidance for day-to-day operational decisions affecting ARM's research programs; (2) monitor, analyze, and document data quality and provide regular, frequent assessments of the results; (3) develop the site scientific mission; (4) conduct an ARM-approved research program focused on the SGP site and designed to further the objectives of the ARM Program; (5) participate as a full member to the ARM Science Team; and (6) direct an educational

outreach program designed to interest precollege, undergraduate, and graduate students in scientific and technical disciplines.

The SST, defined as a "neutral" position within ARM, acts as the scientific liaison among the other parts of ARM, including science and infrastructure, to ensure the scientific integrity of SGP CART site operations. The SST must be proactive in communicating with ARM's various science and infrastructure groups to collect information on issues and help determine optimal solutions. Maximizing the scientific potential of the SGP CART site, whether during routine daily operations or focused periodic experiments (IOPs), should be the main goal of the SST. The current makeup of the SST allows effective achievement of this goal.

The SST is the group within the ARM Program that assesses whether the site is providing the data that will allow the program to achieve its goals. This role involves evaluating the routine, daily operations, as well as suggesting and planning the most productive IOPs possible. Ensuring data quality is at the heart of the SST's responsibilities. The SST achieves these goals by interacting with all of ARM's various functional groups to collect information that will support informed decisions and appraisals.

This coordinated activity will be particularly important during the next three years, because the SGP CART site is essentially complete according to original plans. Now the SST must focus on a critical assessment of the current instrumentation suite at the SGP CART site. The important question is whether the SGP CART site is truly satisfying the needs of the ARM Science Team. The SST must also consider how ARM data will be compiled in a permanent record, and whether the data in their current state are of sufficient quality to satisfy researchers 10 or 20 years in the future. The SST must continue to plan and operate IOPs in the next three years that will help to solve the key scientific and measurement problems that the various scientific applications groups will encounter. The ARM Program, with strong participation by the SST, will address these priorities by operating a research facility (the SGP CART site) that can accommodate the evolving needs of the scientific community.

During the last six years, ARM Program participants have learned much that can be applied to future problems. The routine deployment of instrumentation has generated a tremendous amount of knowledge about what works and how to remedy problems. Routine operations have led to improved broadband radiometry and procedures for launching radiosondes. The focused IOPs have taught Science Team members much about the measurement of atmospheric state parameters such as water vapor. In the future, we must use

our experience to better understand such issues as spectral radiometry and cloud radar measurements and must conduct IOPs that lead to further discoveries in the areas of solar radiation and aerosols and their relationships to clouds. By optimizing the operation of the SGP CART site during both routine and intensive operations, the SST can contribute to these goals.

The personnel making up the SST have various responsibilities. The site scientist, Peter Lamb, oversees the SST and contributes to the discussion and resolution of higher-level issues with ARM Program management. His interactions involve the development of both short-term responses to ongoing problems and longer-range planning to accomplish the ARM Program's overall scientific objectives. He does this by participation in the ARM Science Executive Committee and selected meetings and teleconferences, as well as by acting as a liaison for ARM to other federal and state agencies concerning the broader scientific and funding potential of the SGP CART site.

The associate site scientist, Randy Peppler, is the SST's primary daily contact point to the ARM Program at large. He oversees the tasks of the assistant site scientists and helps coordinate scientific issues facing the site with others in the ARM Program. He has primary contact with the site program manager and the site operations manager and has become part of the daily decision-making process at the site. He is also the SST's chief contact to the Science Team, IT, and DSIT. With the site program manager, site operations manager, and ARM technical director, he is a key part of the process of planning, developing, and operating IOPs.

The assistant site scientists (Mike Splitt and Chad Bahrmann) have the vital role of data quality analysts for the SGP site. They are focal points for the development of algorithms to perform data quality analyses, with the goal of achieving known quality (instruments are working to expectations) and reasonable quality (measurements are the best possible for a given geophysical parameter) for all ARM data streams. Splitt and Bahrmann also interface with others in the ARM Program who deal with data quality (particularly the IT and DSIT) and are part of a broad ARM initiative to build a data user interface that will communicate ARM data quality to anyone wishing to use the data. The senior assistant site scientist (Splitt) also helps to plan and implement IOPs and participates in decision-making discussions on science issues facing the site. The junior assistant site scientist (Bahrmann) works daily at the SGP central facility as the ARM Program's on-site scientific presence. He daily assists the site operations manager in running the SGP CART site smoothly. He also acts as the site's local goodwill ambassador, representing ARM to the local community.

The SST Research Team (Peter Lamb, Yefim Kogan, Zena Kogan, Mikhail Ovtchinnikov, Scott Richarson, Claude Duchon, Mike Splitt, and colleagues) conducts research on scientific and measurement issues facing the SGP CART site. This research is subject to approval by the ARM Program and is based on the stated goals and perceived needs within the program and on the expertise of the participating scientists. The areas of particular interest during the next three years include microphysics, radar meteorology, and measurement of the atmospheric state (particularly water vapor), soil moisture, and solar radiation.

The SST Educational Outreach Team (Ken Crawford, Renee McPherson, Andrea Melvin, and colleagues) directs the ARM SGP thrust pertaining to the U.S. Department of Energy's (DOE's) educational outreach priorities. This program is designed (1) to interest precollege and undergraduate and graduate students in scientific and technical disciplines and (2) to provide easy access to ARM data and to coordinated, pedagogically sound lessons. Over the next three years, this team will promote ARM outreach beyond Oklahoma and Kansas to the national educational community.

Scientific priorities for operation of the SGP CART site during the next three years include, in particular, the following:

- Continue facilitation of all data quality assessment efforts, particularly those focused on the development of a full suite of data analysis tools, participation in the development of an ARM data user interface, implementation of new QMEs and VAPs, and better dissemination of information on data quality
- Conduct a complete assessment of the measurement capability of the SGP CART site as it pertains to the needs of the ARM Science Team
- Conduct a complete assessment of current instrument calibration and maintenance procedures and the way they are implemented
- Finish the establishment of routine SGP CART site operations
- Plan and implement key IOPs and campaigns
- Continue beneficial collaboration with other national programs and explore new ones

- Support the IDP

To operate the site, numerous individual subtasks are performed daily by the SST, site program manager, and site operations manager. The purpose of these activities is to allow all scientific and infrastructure groups within ARM to achieve the goals and objectives the ARM Program has set for the SGP CART site in the years to come.

4.3 Value-Added Products and Quality Measurement Experiments

Unlike many other scientific projects, ARM collects data in an ongoing, continuous manner. Because of the volume of the perpetual data streams, traditional case study methods for analyzing the data are not very effective. To fit the need for an automatic analytical approach, the concept of a VAP (value-added product) has been defined. A VAP creates a "second-generation" data stream by using existing ARM data streams as input and applying algorithms or models to them. A VAP is run continuously in the ARM Experiment Center, and the output generated is treated as a new ARM data stream.

Many of the scientific needs of the ARM project are met through VAPs. Physical models that use ARM instrument data as input are implemented as VAPs and can help to fill some of the unmet measurement needs of the program. A special class of VAPs called QMEs compare different data streams for consistency and allow for continuous assessment of the quality of the data streams. These data streams may come from direct measurements, measurements derived from instrument observations via other VAPs, or model output that is currently created by other VAPs.

New VAPs or suggestions for improvements or modifications to existing VAPs come from all areas of the ARM program: the Science Team, instrument mentors, the DSIT, the Data Archive, the SST, etc. However, because of the limited resources available, VAP development must be prioritized to be meaningful. To this end, the VAP Working Group was established. This group consists of members of the infrastructure across the program, with representatives from each of the major scientific areas of ARM. This group discusses the scientific objectives of each VAP in the development queue, looks for common threads among the VAPs, assigns priorities, estimates completion dates, and assists in developing the VAPs. The SST is represented on the VAP Working Group. The VAPs currently available are listed in Table 3.

TABLE 3 Value-Added Products in Place at the SGP CART Site^a

Value-Added Product	Description
LBLRTM	Line-by-line radiative transfer model; used for longwave and microwave radiance calculations
QME AERI/LBL	Comparisons of observed (AERI) vs. calculated (LBLRTM) longwave downwelling radiation
QME MWR/LBL	Comparisons of observed (MWR) vs. calculated (LBLRTM) microwave radiance at two frequencies
QME AERI/LBL CLOUDS	State-of-the-atmosphere data to facilitate QME AERI/LBLRTM analysis
RWP TEMP	Merged and quality-controlled RASS virtual temperature profiles
MWR PROF	Retrievals of water vapor, liquid water, and temperature profiles from a suite of ground-based instruments
QME MWR PROF	Comparisons of retrieved water vapor and temperature profiles from MWR PROF with BBSS profiles
AERI PROF	Retrievals of temperature and water vapor from the AERI data
QME AERI PROF	Comparisons of retrieved water vapor and temperature profiles from AERI PROF with <i>in situ</i> measurements
QME MWR COL	Comparisons of the MWR with an instrument performance model
RL PROF	Profiles of water vapor mixing ratio, aerosol scattering ratio, and depolarization ratio from the Raman lidar

^a AERI, atmospherically emitted radiance interferometer; BBSS, balloon-borne sounding system; COL, column; LBL, line by line; LBLRTM, line-by-line radiative transfer model; MWR, microwave radiometer; PROF, profile; QME, quality measurement experiment; RASS, radio acoustic sounding system; RL, Raman lidar; RWP, radar wind profiler; TEMP, temperature.

More information is available on the Web at

http://www.arm.gov/docs/research/vap_homepage/vap.html .

In September 1997, DSIT Experiment Center staff introduced, in beta release, the Shortwave Radiation Best Estimate data product for the central facility. The goal of this product is to create one data stream that holds all (or most) of the central facility data products of interest to the shortwave research community. Multiple measurements of the same parameter (e.g., SIRS and broadband radiometer station [BRS] sensors) are handled by designating one as the primary measure and using the other(s) to fill any gaps. Some data quality comparisons between like measurements are also included. Components of this tracking system cover ten measurement components: downward hemispheric flux, direct broadband component, diffuse broadband component, direct spectral component, diffuse spectral component, optical depth, net shortwave surface radiation, broadband albedo, spectral albedo, and calculated quantities (zenith angle, effective top of atmosphere horizontal flux). This data product remains under development as more of the ten measurement areas are added. This shortwave data product will be followed by one for water vapor and then others for other key ARM geophysical parameters (Section 2.1). These products are available from the ARM Experiment Center.

4.4 ARM Information Architecture

The main focus for this six-month period continues to be the incorporation of what is known about data availability and data quality and to link this knowledge directly to individual measurements in a way that is easily identifiable by data users, such as by data flagging. This task is accomplished through the ARM information architecture (AIA) and the Meta Data Navigator (MDN). Generally, four levels of data quality inspection exist. The first level is part of the data ingest routine, where minimum/maximum and delta limits, if exceeded, are stamped. The second level is provided by the instrument mentors. Although each may have a unique methodology for data inspection, it is their expert view that identifies suspect data points for their particular instrument. The third level of review looks for consistency of data between instruments by using data quality metrics and data stream comparisons. This level is provided by the SST. The fourth level of data quality inspection is the VAPs and QMEs, which have been driven by Science Team needs and implemented by the ARM Science Applications working group.

Communication about data availability and quality interface will be accomplished by color-coding measurements obtained from a particular instrument, with different colors to indicate the availability of data and the quality of the data for a daily aggregate. Pointers will be developed to direct the data user to details of the particular data quality inspection methodology for each measurement. For example, all existing data will be color-coded white. Missing data will be color-coded black. Data reviewed by an instrument mentor and judged to be of acceptable quality will be color-coded green. Suspect data values will be color-coded yellow. Data identified as not usable will be color-coded red. The color of the data will change to reflect the most current view of the quality of the measurement. The entire process is intended to be automated with a manual override capability. A plan is also being defined to assign a data quality flag to each existing data value. The flagging system will determine the color of the data. The AIA project, a cooperative one across ARM, will continue to be a prime focus during this six-month period. Data coloring, data flagging, or both will either be integrated into the netcdf parametric data file or be generated as a separate data file to be sent with the parametric data file. The potential impacts of these two methods are being evaluated.

Quick-looks plots are currently under discussion. These plots are intended to provide the data user with a visual data inspection capability, especially if data are color-coded yellow and require further inspection and interpretation. Who will generate the quick-look plots and where and how the plots will be maintained are currently under discussion.

Activities that fall under the AIA address all three ARM CART sites. Ryan Hohimer, who leads this activity, is working with the SSTs from all three CART sites to develop requirements for the first construct of the MDN. Deliverables at the end of this six-month period include the following:

- Data availability will be captured. (That is, available parametric data will be color-coded white; data that do not exist will be color-coded black.)
- The instrument mentors and SSTs will be able to color-code the parametric data manually.
- Data quality reports will be received along with parametric data.
- The MDN will provide for viewing of available quick-look plots.

Suspect measurements may still be usable data to some or even most of the data users. The ARM Program provides the searchable Meta Data System (MDS) database that provides (1) information about the scientific utility of the data gathered at the SGP and the other two CART sites and (2) information to enhance the operation and assist in the maintenance of the SGP and other CART site systems. Information in the SGP MDS can be produced by the processes that collect data from instruments and generate ARM data streams; by site operators as they perform their duties; or by anyone in the ARM community via electronic mail messages that are forwarded to the MDS entry-processing software. Specifically, information provided by the SGP site operators includes hourly weather observations, general operator entries with subjects chosen from a list (data system, suspect data, site general, revision, other), general instrument maintenance reports on specific instrument corrective maintenance, reports on surface conditions at extended facilities, weather alert status reports, and instrument preventative maintenance procedure summary reports. The contents of the MDS database and its location are discussed in Section 3.2.

4.5 Problem Review Board

A system for problem identification/resolution in ARM was established as a mechanism to permit anyone to easily report a real or perceived problem found to be affecting, or to have the potential to affect, the overall quality of an ARM data stream or product. The origin could be a faulty instrument; the way an instrument is sited, maintained, calibrated, or operated; or software errors in processing the instrument's data or perhaps in some external data acquired for ARM data products from other programs. The person reporting the problem does not need to understand it or have a solution in mind. However, the person reporting the problem must be able to describe the symptoms or provide sufficient evidence to allow others to solve the problem. The overall goal is to identify problems in a timely way so that they can be assessed, prioritized, and resolved as quickly as resources allow.

The problem-reporting system has several components. The process begins with the completion and submission of a Problem Identification Form (PIF). The PIFs are received by the Problem Review Board (PRB), which is composed of representatives from the DSIT, the IT, and the site program managers. The PRB meets weekly via teleconference and assigns responsibility for analysis and resolution. Resolution is documented in a Corrective Action Report (CAR). A copy of the CAR is sent to the originator of the PIF to ensure that resolution of the problem is communicated.

In addition, a Data Quality Report (DQR) may be required. A DQR is a statement about the quality of data from a particular instrument. The information could be quite simple (e.g., stating that an instrument system was turned off and the data do not exist) or quite complex, giving detailed analyses and equations that should be used to adjust the instrument's data. Hence, the description of the problem and the solution must be complete, so that someone can accurately correct the data.

The PIF, CAR, and DQR forms are accessible from multiple points on the ARM Web site. The PIF/CAR/DQR database can be found on the Web at

<http://www.db.arm.gov/PIFCARDQR/> .

5 SCIENTIFIC INVESTIGATIONS AND OPPORTUNITIES

In 1994, the ARM Program identified a need for the creation of a Site Advisory Committee (SAC) to provide assistance to the ARM Program Science Team, the SGP CART SST, and the SGP CART site program manager. The SAC's charter is to

- Evaluate the SGP CART site's scientific mission,
- Provide scientific mission guidance for SGP CART site operations,
- Evaluate the research program of the site scientist,
- Evaluate the potential for collaboration with other research programs, and
- Provide recommendations for the SGP CART site's educational outreach program.

The seven-member SAC is composed of ARM and non-ARM Program scientists who meet formally at least once per year. The first such meeting was held in November 1995 at the University of Oklahoma (OU), and a follow-up meeting was held there in June 1996. Written reports summarizing the SAC's recommendations on the basis of these two meetings were distributed to the ARM Management Team, the SST, the site operations manager, and the site program manager. The SST responded in writing. Individual committee memberships last for three years.

5.1 Intensive Observation Periods

The SGP CART site operates a vast suite of instrumentation that routinely provides continuous data streams at a prescribed rate. These rates, however, can be changed upon request. Requests from inside and outside the ARM Program can be made through the SGP CART site program manager's office either (1) to operate an ARM instrument or instruments at a different data collection rate or in a different mode of operation or (2) to support and compare non-ARM instruments with ARM instruments. Such periods of special operation are referred to as IOPs.

Requests for IOPs can be made by the ARM Science Team, ARM Program infrastructure staff, or the scientific community at large. Preference for IOPs is given to the ARM Science

Team and infrastructure staff. The ARM Program has a limited budget for IOP support. However, funding from sources other than the ARM Program can be accepted to support IOPs or campaigns.

The BBSS is the instrument most frequently requested for operation at an accelerated data collection rate and is the primary driver for the timing of IOP requests. The SGP CART site has five locations where BBSS instruments are operated routinely. To achieve an accelerated data collection rate, simultaneous radiosonde launches can be made every three hours at all five locations for a 21-day period or longer.

The ARM Program provides funding for two or three of these three-week-long, accelerated BBSS launch periods per year, which are referred to as SCM IOPs. Two SCM IOPs are held in fixed time periods, one in spring and one in summer. The third SCM IOP alternates between winter and fall. Although the ARM Program supports and encourages multiple, concurrent IOPs during SCM IOP periods, IOPs involving accelerated BBSS launches at other times of the year are considered as the budget allows.

Requests for IOPs come through the SGP CART site program manager's office. The initial requests can be made informally, but an abstract of the goal(s) of the experiment(s) being requested, a list of the potential instruments and platforms involved, and the time period of the experiment(s) must be provided for approval. The requester must identify points of contacts for coordination.

Approval of an IOP is an external process that requires (1) review for resources and relevancy and (2) approval by the ARM Program technical director, the SGP CART site program manager, the SST, and site operations staff. After approval, the management of the detailed operational planning, setup, conduct, and shutdown of the IOP is the responsibility of the site program manager.

An IOP is given a title and assigned a DSIT representative, who has the responsibility to obtain the relevant scientific information about the proposed activity, typically obtained in a science plan. The DSIT representative informs ARM Science Team members of the proposed activity for the purpose of potential collaboration. The SST has taken an increasing leadership role in this activity, beginning with the fall 1996 Water Vapor IOP.

The site program manager obtains from the DSIT representative a list of potential principal investigators (PIs) and the instruments or systems that are intended to be located at the SGP CART site. The site program manager then sends an IOP questionnaire to the PIs to collect information about the operational, safety, and data requirements of the IOP. The IOP questionnaire is returned to the site program manager's office and is distributed to the appropriate ARM infrastructure personnel for review. The IOP questionnaire can be entered electronically by a PI on a Web site at

http://www.arm.gov/stdocs/internal/iop_form.html .

The ARM infrastructure groups include the SGP CART site program manager, the SGP CART site SDS team, the DSIT representative, the SST, and site operations staff. Each of the ARM infrastructure groups has a specific role in the planning and implementation of the IOP.

The SDS representative assesses the data requirements, both those requested by the participating PI from ARM and those to be provided to ARM by the PI. A schedule of data delivery is established. The DSIT maintains a Web site that provides information about IOP planning and status, as well as day-to-day operations activities during the IOP; these data are provided by the SST. The main elements of the IOP Web site include a science plan, each PI's IOP questionnaire, the IOP operations plan, and a daily log during the IOP that identifies and discusses each day's scientific mission.

The SGP CART site SDS team assists PIs who have requested Internet connections at the SGP CART site's central facility. The SDS team assists in establishing the actual interface, as well as limits on the size of data files and the time of data file transfers, so that the PI's data transfers do not affect the SGP CART site's data transfer schedule.

The SST has overall responsibility for coordinating scientific interactions at the SGP CART site. The SST personnel work with the DSIT representative to identify IOP lead scientists. The SST assists the site program manager and site operations staff in locating instrumentation at the SGP CART site. The SST personnel assist in identifying real-time display requirements during IOP operations and identify mission-critical data streams that must be maintained during the IOP. The SST also assists in the creation of a science plan for the IOP and in making operational decisions during the IOP.

Site operations personnel provide IOP safety oversight and support installation of all guest instruments in accordance with requirements identified in the IOP questionnaire. The site operations personnel maintain the operational status of SGP CART site instrumentation and provide triage (quick-response maintenance) for instruments whose data have been identified as critical to the IOP. The operations staff provide PIs with additional logistic support (e.g., liquid nitrogen supplies, phone lines, safety briefings, and power) in accordance with requirements identified in the IOP questionnaire.

The site program manager's office coordinates all activities associated with the IOP. The office produces an IOP operations plan that (1) identifies all of the activities associated with IOPs, including roles and responsibilities; (2) specifies mission-critical instruments and outlines an instrument triage plan; (3) designates the locations of instruments and the SGP CART site facilities to be used; (4) specifies safety and emergency actions; (5) outlines IOP termination and start-up procedures; and (6) lists participants.

The progress of IOP planning activities is monitored via the weekly SST coordination teleconference that takes place on Tuesdays at 11:00 a.m. central time and through other conference calls with IOP participants and ARM infrastructure personnel as needed. The IOP Web interface page functions as a tool to facilitate the coordination and flow of information during all phases of IOP planning, implementation, and operation. The site program manager provides monthly updates in his internal monthly reports. Past, present, and known future IOPs are listed in Table 4.

5.2 Preliminary Results of and Plans for IOPs and Campaigns Conducted during the Past Six-Month Period

The IOPs and campaigns that occurred during January-June 1998 are discussed below. Some were either in progress or had not yet taken place at press time, so planning information is provided for them (see also Table 4).

The Winter 1998 Single-Column Model IOP. A Single-Column Model (SCM) is a physical parameterization package extracted from a GCM or other large-scale model. The SCM is a primary test of our current understanding of clouds and radiative transfer. The SCM IOP series is designed to provide, as boundary conditions, the advective tendencies and vertical velocities that represent the dynamic forcing normally calculated by a GCM. The BBSS is the only technology currently capable of providing the range and resolution of wind and

TABLE 4 Intensive Observation Periods and Campaigns

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
11/92	Field Test of NCAR Flux Profiler	D. Parsons (NCAR)	R. Cederwall	Enhanced soundings at the central facility and profiler site on 11/10-11/19; boundary layer flights on a few days	Completed; data available
4/93	AERI Field Test	H. Revercomb (UW)	J. Liljegren	Enhanced soundings at the central facility requested during the field acceptance test of the AERI instrument	Completed 4/29/93
5/93-6/93	Using the GPS for the Measurement of Atmospheric Water Vapor	Collaborative (UNAVCO and NCSU)	J. Liljegren	Intended to test the investigators' technique for inferring total precipitable water vapor in the atmosphere column by using GPS signals	Completed 6/8/93; data available
6/93	Warm-Season Data Assimilation and ISS Test	D. Parsons (NCAR)	R. Cederwall	Enhanced sampling (in time and space) of the SGP domain for a 10-d period with profilers and sondes; goals were (1) to study the performance of FDDA under thermodynamic conditions typical of the continental warm season and (2) to evaluate the estimates of divergence and vorticity from the prototype NCAR ISS with interferometric techniques, the triangle of three 915-MHz profilers, and the results of FDDA	Completed; all data available at the Experiment Center except for FDDA, which is available upon request at NCAR

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
1/94; 4/94; 7/94; 10/94; 4/95; 7/95; 9/95; 4/96; 7/96; 4/97; 6/97; 9/97- 10/97; 1/98- 2/98; 4/98-5/98	Seasonal SCM IOP	D. Randall (CSU)	R. Cederwall	Seasonal IOP with enhanced frequency of observations, particularly vertical soundings of temperature, water vapor, and winds at central facility and boundary facilities for periods of 21 d; required sounding frequency of 8/d; data required for quantifying boundary forcing and column response	None planned for second half of 1998
4/94; 9/95- 10/95; 4/96; 9/96; 9/97- 10/97	ARM UAV	B. Ellingson (UoM)	D. Rodriguez	Clear-sky flux profiles acquired by a UAV and surface support data; measurements to be used to understand clear-sky heating rates and the ability of models to reproduce observations	First IOP conducted successfully in 4/94; flight for ARESE IOP in 9/95-10/95; first 24-h UAV flight in 10/96

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
4/94- 5/94; 4/95- 5/95	Remote Cloud Sensing Field Evaluation	R. McIntosh (UM); B. Kropfli (NOAA); T. Ackerman (PSU); K. Sassen (UU); A. Heymsfield (NCAR); J. Goldsmith (SNL); others	C. Flynn	Field evaluation and calibration of several remote sensing cloud- observing instruments (some from the IDP project); <i>in situ</i> cloud observations critical to success; enhanced soundings required at central facility	Completed; data analysis in progress
5/94	WB-57 Overflight for the Measurement of Atmospheric Water Vapor at High Altitude	Collaborative (Visidyne and Lockheed PARC)	J. Liljegren	Attempt to infer the vertical distribution of water vapor at high altitudes from solar transmission spectra	Completed; preliminary transmission spectra delivered to ARM
5/94	VORTEX IOP	E. Rasmussen (NSSL)	D. Slater	Special launches in support of VORTEX, testing hypotheses on the development and dissipation of severe storms	Completed 5/31/94
8/94	GEWEX/GCIP/GIST IOP	Collaborative	T. Cress	Special launches in support of the GCIP and GIST as part of effort to improve climate models by improving parameterizations of hydrologic and energy cycles	Successfully conducted in 8/94
9/94- 10/94; 6/95- 7/95	Sampling of Coherent Structures with the 915-MHz Profiler	R. Coulter (ANL)	R. Cederwall	Fluctuations in the vertical wind and index of refraction observed by operating the 915-MHz profiler with RASS in a special mode during the afternoon hours to sample convective plume structures	Completed

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
4/95-5/95	Simultaneous Ground-Based, Airborne, and Satellite-Borne Microwave Radiometric and <i>In Situ</i> Observations of Cloud Optical Properties and Surface Emissivities	W. Wiscombe (NASA-GSFC); E. Westwater (NOAA-ETL)	D. Slater	Observations of cloud optical properties obtained over the CART site simultaneously from ground-based, <i>in situ</i> , and satellite-borne sensors; spatial variability of surface emissivities assessed to attempt retrieval of total precipitable water and cloud liquid water from the special sensor microwave imager	Completed; involved collaboration between Wiscombe and L. Fedor at NOAA
4/95-5/95	VORTEX-ARM	E. Westwater (NOAA-WPL); W. Wiscombe (NASA-GSFC); G. Stephens and P. Gabriel (CSU); J. Schneider (CIMMS-NSSL)	D. Slater	Joint VORTEX-ARM effort; 45 h of P-3 aircraft time to study stratocumulus clouds; work coordinated with Remote Cloud Sensing IOP	Data exchange completed 12/95
6/95-7/95	Surface Energy Exchange IOP	C. Doran (PNNL); R. Coulter (ANL); R. Stull (UBC)	R. Cederwall	Detailed observations of temperature and moisture profiles in the PBL, obtained within 75-125 km of the central facility by using airsondes and profilers, intended to evaluate the variations in the PBL structure in relation to underlying surface fluxes	Completed; airsonde data available as beta release from C. Doran

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
9/95-10/95	ARESE	Collaborative	T. Cress	Intended to study the anomalous absorption of solar radiation by clouds, a phenomenon first noticed when satellite measurements of solar radiation absorbed by the surface atmosphere were compared with solar radiation measured at collocated surface sites	Completed; data are available
4/96-5/96	SUCCESS	Collaborative	R. Peppler	Intended to determine the impact of the current and future subsonic aircraft fleet on Earth's radiation budget and climate	Completed
6/96-9/96	MSX Satellite Overflights	Collaborative	H. Foote	Intended to provide ground truth support for the MSX satellite, with nine MSX sensors operating in the range of 0.12-0.9 μm and with a spectral IR imaging telescope	Launched on 4/24/96; SGP CART site flyovers on 6/17, 7/15, 8/12, and 9/9
6/96-7/96	CLEX IOP	G. Stephens (CSU-CIRA); J. Davis (CSU-CIRA)	R. Cederwall	Intensified satellite data collection (by CSU), airborne cloud radar and <i>in situ</i> microphysical observations, and an array of ground-based measurements; intended to improve understanding of the nature and role of middle-level, nonprecipitating cloud systems	Completed; data exchange in process

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
7/96-8/96	BLX IOP	R. Stull (UBC)	R. Cederwall	Remote sensing surface fluxes measured with instrumentation on the University of Wyoming King Air; CASES site and NCAR mobile profiler involved; in conjunction with 7/96-8/96 SCM IOP	Completed; aircraft data to be available in 1997; BAMS article published June 1997 (Stull 1997)
7/96-8/96	LLJ IOP	D. Whiteman (PNNL)	R. Cederwall	Intended to investigate oscillations in the characteristics of the LLJ over the SGP	Completed; data from 915-MHz profiler run in modified mode ingested in 1997 (available now from R. Coulter at ANL); Wyoming King Air data, in collaboration with R. Clark (MSU), now available
9/96; 9/97-10/97	Water Vapor IOP	H. Revercomb (UW)	D. Turner R. Peppler M. Splitt	Measurement of water vapor profiles with many instrument systems; attempt to define water vapor profile of the site in support of IRF research efforts; first focused on the lowest kilometer; second in series focused up to 12 km	Completed; data analysis in progress; another planned for 1999

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
12/96; 6/97	LMS/SITAC IOP	B. Dillman (Lockheed)	D. Slater	Intended to analyze approaches to atmospheric compensation for hyperspectral and ultraspectral image data obtained from satellite platforms	Completed
4/97	Cloud Radar IOP	B. Martner (ETL); P. Daum (BNL)	D. Rodriguez M.-D. Cheng	Designed to validate retrieval of cloud microphysics by newly installed ARM zenith-pointing MMCR (developed by NOAA-ETL); ETL operated collocated scanning NOAA K-band cloud radar; high-altitude and low-altitude sampling by two aircraft; aerosol components flown in clear-sky conditions by low-altitude aircraft	Completed
6/97- 7/97	SGP '97 (Hydrology) IOP	T. Jackson (USDA); M.-Y. Wei (NASA)	R. Cederwall	Part of USDA and NASA campaign to study three "recharge" events; additional ARM instruments installed at USDA El Reno extended facility; non-ARM aircraft with microwave radiometry sensed soil moisture	Completed; data analysis in progress; data meeting held 3/98

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
9/97-10/97; 4/98-5/98	Cloud IOP	G. Mace (UU)	D. Rodriguez	Designed to obtain on-site measurements of cloud and aerosol properties in cloudy and clear-sky conditions; single microphysics aircraft to be flown in conjunction with ARM UAV high-low set of airborne platforms (1997) measuring radiometric properties; unprecedented opportunity to quantify cloud-aerosol-radiation interactions	Completed; data analysis in progress
9/97-10/97; 8/98	Aerosol IOP	P. Daum (BNL); S. Schwartz (BNL)	M.-D. Cheng P. Daum (aircraft coordinator)	Same as Cloud IOP	Completed; data analysis in progress; planning underway for August 1998 IOP
9/97-10/97; 8/98	Shortwave Radiation IOP	W. Wiscombe (NASA-GSFC); G. Stephens (CSU)	D. Slater B. McCoy	Focused on both broadband and spectrally resolved shortwave measurements, including emphasis on instrument calibration and intercomparison; also evaluated GRAMS and had UAV/aircraft component (1997)	Completed; data analysis in progress; August 1998 IOP planning underway

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
9/97-10/97	Fall 1997 Integrated IOP	G. Mace (UU)	R. Peppler	Ensemble of UAV, SCM, Water Vapor, Cloud, Aerosol, and Shortwave Radiation IOPs	Completed; data analysis in progress
3/98	MOPITT Campaign	J. Wang (NCAR)	D. Slater	Validation of airborne instrument that measures tropospheric CO and CH ₄	Completed; data analysis in progress
6/98	NASA DC-8 Cloud Radar Campaign	B. McIntosh (UM); S. Sekelsky (UM)	D. Rodriguez	Comparison of airborne 95-GHz cloud radar with ground-based radars; about 20 flight hours available	Completed
6/98-10/98	JPL GPS Campaign	S. Keihm (JPL)	D. Turner	Calibration of JPL GPS retrieval algorithms in moist climate	Site visit complete; planning underway
8/98	BDRF Campaign	D. Cahoon (NASA Langley)	D. Slater	Bidirectional reflectance function measurements over the major scene types in and around the central facility; in conjunction with Shortwave Radiation and Aerosol IOPs	Planning underway

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
8/98-10/98	Mini-MOPA Campaign	V. Wulfmeyer (UCAR); W. Eberhardt (NOAA-ETL)	D. Turner	Demonstration of new, compact DIAL capable of high-resolution water vapor measurements	Planning underway
9/98	AES Campaign	F. Murcray (UD); D. Rider (NASA-JPL)	C. Flynn	Demonstration of AES that could give an independent comparison of the AERI and AERI-X	Planning underway
Fall 1998	ETL GPS	M.J. Post (NOAA-ETL)	D. Turner	Joint NOAA-ETL and Russian study to acquire GPS and water vapor data	Unknown
Summer 1998 or 1999	Soil Sampling Campaign	J. Happell (UoMi)	R. Cederwall	Intended to test whether soils are a significant global sink of atmospheric CCl ₄ and CH ₃ CCl ₃	Planning underway
1999	CO ₂ DIAL IOP	J. Jolin (LANL)	D. Turner D. Slater	CO ₂ DIAL on aircraft to overfly the site; potential benefit for water vapor and aerosols measurements	Site visit complete; planning underway
Spring 1999 and 2000	TIMEX Campaign	E. Rasmussen; C. Ziegler; J. Schneider (NSSL)	R. Peppler	Investigate boundaries causing thunderstorm initiation by using airborne and ground-based mobile DIAL and many other mobile platforms	Planning underway

TABLE 4 (Cont.)

Date	Name	Science Team Member ^a	DSIT Contact ^b	Description	Status
Spring or Summer 1999 or 2000	MCS Campaign	P. May (BoM)	R. Peppler	Investigate precipitation microphysics and convective dynamics of MCSs by using wind profilers and dual polarimetric scanning radar	Planning underway

^a Affiliations: ANL, Argonne National Laboratory; BNL, Brookhaven National Laboratory; BoM, Australian Bureau of Meteorology; CIMMS, Cooperative Institute for Mesoscale Meteorological Studies; CIRA, Cooperative Institute for Research in the Atmosphere; CSU, Colorado State University; ETL, Environmental Technology Laboratory; GSFC, Goddard Space Flight Center; JPL, Jet Propulsion Laboratory; LANL, Los Alamos National Laboratory; MSU, Millersville State University; NASA, National Aeronautics and Space Administration; NCAR, National Center for Atmospheric Research; NCSU, North Carolina State University; NOAA, National Oceanic and Atmospheric Administration; NSSL, National Severe Storms Laboratory; PARC, Palo Alto Research Center; PNNL, Pacific Northwest National Laboratory; PSU, Pennsylvania State University; SNL, Sandia National Laboratories; UBC, University of British Columbia; UCAR, University Corporation for Atmospheric Research; UD, University of Denver; UM, University of Massachusetts; UNAVCO, University NAVSTAR Consortium; UoM, University of Maryland; UoMi, University of Miami; USDA, U.S. Department of Agriculture; UU, University of Utah; UW, University of Wisconsin; WPL, Wave Propagation Laboratory.

^b Other definitions: AERI, atmospherically emitted radiance interferometer; AES, airborne emission spectrometer; ARESE, ARM Enhanced Shortwave Experiment; ARM, Atmospheric Radiation Measurement (Program); BAMS, *Bulletin of the American Meteorological Society*; BDRF, bidirectional reflectance functions; BLX, Boundary Layer EXperiment; CART, Cloud and Radiation Testbed; CASES, Cooperative Atmosphere-Surface Exchange Study; CLEX, Cloud Layer EXperiment; DIAL, differential-absorption lidar; DSIT, Data and Science Integration Team; FDDA, four-dimensional data assimilation; GCIP, GEWEX Continental-Scale International Project; GEWEX, Global Energy and Water Cycle Experiment; GIST, GEWEX Integrated System Test; GPS, global positioning system; GRAMS, ground-based radiometer autonomous measurement system; IDP, Instrument Development Program; IOP, intensive observation period; IR, infrared; IRF, instantaneous radiative flux; ISS, integrated sounding system; LLJ, Low-Level Jet; LMS, Lockheed Missile and Space; MCS, Mesoscale Convective System; MMCR, millimeter cloud radar; MOPA, Master Oscillator Power Amplifier; MOPITT, Measurements of Pollution in the Troposphere; MSX, Midcourse Satellite Experiment; PBL, planetary boundary layer; RASS, radio acoustic sounding system; SCM, single-column model; SGP, Southern Great Plains; SITAC, Spectral Imagery Technology Applications Center; SUCCESS, Subsonic Aircraft: Contrail and Cloud Effects Special Study; TIMEX, Thunderstorm Initiation Mobile Experiment; UAV, unmanned aerospace vehicle; VORTEX, Verification of the Origins of Rotation in Tornadoes Experiment.

thermodynamic observations necessary to estimate these boundary conditions. Because derivatives are needed in both horizontal directions, BBSS data from the central facility and the four boundary facilities are the minimum required for reliable estimates.

The winter 1998 SCM IOP was conducted from January 19 through February 9. It was only the second wintertime SCM IOP to be held at the SGP CART site. (The other occurred in January 1994.) Of 840 total sounding launches scheduled, 839 were completed successfully (at 1730 UTC on January 31, the sounding at the central facility was missed), and all but six ascended to at least 10 km (1430 UTC on January 31 at BF4 [boundary facility 4]; 1430 UTC on January 31 and 0530 UTC on February 4 at BF5; 1130 UTC on February 6 at BF1). Only seven soundings required some type of processing. Overall, this was a very successful IOP that should provide the SCM community with additional valuable information on wintertime processes and conditions across the southern Great Plains.

The Measurements of Pollution in the Troposphere (MOPITT) Campaign. The MOPITT campaign was conducted on March 2-6, 1998, at the central facility. The MOPITT is a new instrument that measures CO and CH₄ and needs validation information from a number of ground-based instruments, such as the AERI (analysis of data by Wallace McMillian, University of Maryland), SORTI (analysis by Frank Murcray, University of Denver), and a grating spectrometer (instrument and analysis by Leonid Yurganov, University of Toronto). The MOPITT was flown in a light aircraft to sample up to 30,000 ft (supervised by Paul Novelli, NOAA-Climate Model Diagnostics Laboratory, Boulder). Jinxue Wang (NCAR) was the coordinating scientist for the campaign. Data analysis is ongoing.

Spring 1998 Cloud/SCM IOP. A Cloud IOP, planned as a follow-up to the Cloud IOP held as part of the Fall 1997 Integrated IOP, and a spring SCM IOP were held at the central facility from April 27 through May 17, 1998. Ongoing analysis of data from the fall 1997 Cloud IOP raised several issues that the spring IOP attempted to address. These include insufficient sampling of single-layer cirrus clouds, uncertainties in the calibration of the millimeter cloud radar (MMCR), and significant radar returns in the lower troposphere caused by nonhydrometer targets ("atmospheric plankton").

Thus, the goals of the IOP in spring 1998 were to collect additional cirrus cloud data suitable for basic scientific research and validation of retrieval algorithms applied to the operational SGP data streams. The University of North Dakota Citation aircraft made *in situ* measurements in cirrus clouds with a fleet of instruments similar to those flown during the fall

1997 IOP. Thirty hours of research flight time were reserved, with 25 hours devoted to cirrus and the remainder reserved for liquid and mixed-phased clouds. Only about half were used due to unfavorable sky conditions. In addition, a novel double-blind experiment was performed to address the radar calibration issue. A data system from the Pennsylvania State University cloud radar group collected raw voltages from both the SGP CART site MMCR and the University of Massachusetts MMCR, then converted the voltages to Doppler spectra and moments by using calibration constants provided by Environmental Technology Laboratory (ETL) for the SGP CART site MMCR and by the Massachusetts group for their MMCR. Those spectra and moments will be compared to the products derived from the two radars. The plankton issue was studied by collecting insect samples with a net attached to the University of Colorado parafoil kite/blimp tethered system. Systematic sampling of the boundary layer profile quantified the insect distribution as a function of height. Any insects caught were sent to a Texas A&M University entomologist for identification.

The spring 1998 Cloud IOP will also provide valuable ground-based validation data for NASA and NOAA satellite observation platforms, coordinating specifically with Pat Minnis of NASA-Langley to determine overpass times of the Tropical Rainfall Measuring Mission (TRMM)/Clouds and Earth's Radiant Energy System (CERES) platform. In addition to the Massachusetts radar, the Pennsylvania State data acquisition system, and the Colorado tethered system, other guest ground-based platforms involved in the IOP included the University of Utah polarization diversity lidar, millimeter radar, infrared thermometer (model PRT5), sunphotometer, photography equipment, and time-lapse video, as well as the NCAR ice replicator radiosonde system (for collecting information on the shapes of ice particles in cirrus clouds). Critical SGP CART site instrumentation for this exercise (besides the MMCR) included the Belfort laser ceilometer (BLC), micropulse lidar (MPL), BBSS (central facility), AERI, and MWR. For the SCM IOP, the BBSSs and MWRs at the central facility and at all four boundary facilities were critical for success.

NASA DC-8 Cloud Radar Campaign. Bob McIntosh and Steven Sekelsky (University of Massachusetts) used 20 hours of flight time on June 15-29, 1998, with the NASA DC-8 aircraft to increase the archive of airborne cloud measurements with their 95-GHz radar. These measurements were compared with those of the SGP CART site MMCR on the ground and also with those of the Massachusetts MMCR, which remained at the central facility after the spring Cloud/SCM IOP. The DC-8 had been refurbished, so these flight hours represented valuable shakedown time for NASA. In addition, a new ground-based 94-GHz cloud radar from

Pennsylvania State and the ARM-UAV 95-GHz cloud radar from the University of Massachusetts (Ray Bahmba) participated.

JPL GPS Campaign. Steve Keihm (Jet Propulsion Laboratory [JPL]) brought a GPS receiver-antenna system, two water vapor radiometers (WVRs), one microwave temperature profiler (MTP), and a surface meteorological package to the central facility. The WVRs operate at frequencies of 20.7, 22.2, and 31.4 GHz. The MTP operated at specified frequencies in the range 51-59 GHz. The purpose of the experiment was to refine the model for atmospheric vapor absorption near 22 GHz by using the radiometer brightness temperature measurements in conjunction with the GPS path delay measurement. The GPS measurements provided a direct estimate of the total atmospheric delay, independent of modeling assumptions about the absorption properties of water vapor. The function of the radiometers was to measure the atmospheric water vapor content, temperature profile, and related wet-path delay. The GPS data also provided for retrieval of the wet-path delay after the dry delay obtained from a surface barometer measurement was subtracted. The experiment began at the end of June 1998 and will take about three to six months to complete.

5.3 IOPs and Campaigns Scheduled for This Six-Month Period

The IOPs and campaigns planned for the second half of 1998 are discussed in the following paragraphs. (See also Table 4.)

Shortwave Radiation/Aerosol IOP and Bidirectional Reflectance Function (BDRF) Campaign. These coordinated IOP/campaigns are proposed for the August 3-28, 1998, time period, determined by the availability of the NASA helicopter. The BDRF campaign also requires clear skies. Don Cahoon (NASA-Langley Research Center) is heading the BDRF campaign, which is a CERES (on the TRMM satellite) validation exercise that involves measurements of upwelling radiation made by an Analytical Spectral Devices (ASD) spectrometer and broadband radiometers aboard the helicopter, along with an on-board scanning radiometer that can track a particular pixel in flight (for BDRF). On the ground, surface instruments will be placed close to "targeted" farm fields rented from local farmers, representing a variety of vegetation types. The guest ground instruments will be located at the central facility. Instruments include downwelling and upwelling global pyranometers, downwelling diffuse pyranometers, multifilter rotating shadowband radiometers (similar to the SGP CART site MFRSR), a FieldSpec FR spectroradiometer (350-1,050 nm at 1.4-nm band width and 900-2,500 nm at 2-nm band width), a Microtops photometer (380, 500, 675, 870, 936 nm),

standard meteorological measurements at 2 m, surface pressure instruments, MPL, and Vaisala radiosondes (no winds). Coincident SGP CART site measurements desired include the SIRS, RCF active cavity radiometer, shaded infrared radiometer, and MFRSR. A subset of the target site instrumentation will be on the helicopter as well.

Warren Wiscombe (NASA-Goddard Space Flight Center) will head the second Shortwave Radiation IOP, which will focus on the clear sky because there will be no participating cloud physics aircraft and because the "atmospheric plankton" problem had not been remedied as of this writing. The clear-sky experiment will take place during the August 3-28, 1998, BDRF experimental period. Several uplooking spectrometers are planned for deployment at the central facility. These devices will cover widths of 0.4-1.0 μm and 0.4-2.5 μm . The instruments tentatively include the solar spectral polarimeter from Colorado State University, which measures total flux and zenith radiance and has polarization capability. The SGP CART site SWS measures total flux, while the SGP CART site RSS measures the total and diffuse fluxes separately. The solar spectral flux radiometer (SSFR) from NASA-Ames, available for one week during this IOP period, measures total flux and radiance. Participation by the NASA-JPL spectrometer and the NREL commercial LiCor spectrometer (total flux only) is also possible. In addition, an enhanced level of broadband radiometry will be pursued for this IOP, including a BORCAL and perhaps some UV instrumentation. The GRAMS, SIRS, and cavity radiometer will be highly important. An additional goal will be the cross-calibration of the various spectrometers.

Pete Daum (Brookhaven) will lead the Aerosol IOP, which will be centered on the Gulfstream-1 aircraft. The emphasis is to make clear-sky aerosol flights similar to those during fall 1997. The Gulfstream-1 has been contracted for 25 hours of flight time for the period of August 11-28, 1998, which should allow for approximately eight three-hour flights. Clear-sky flight patterns will be similar to those in 1997, with a series of midday stepped legs over the central facility, beginning at 500 ft above ground level (AGL) and ascending in 500-ft increments to 17,000 ft AGL, followed by a spiral back downward. In addition, some flights into stratus and ice clouds, and perhaps altocumulus clouds from decaying convection, will be attempted as conditions warrant. The measurement probes used during fall 1997 will be used again on the Gulfstream-1, except that no measurements of the CCN spectrum will be made.

The operations of all three efforts will be highly coordinated to maximize the scientific potential of the experimental period.

Mini-MOPA Campaign. Alan Brewer (NOAA-ETL) will lead the mini-MOPA campaign, tentatively scheduled during August-October 1998. The mini-Master Oscillator Power Amplifier (MOPA) is a compact differential-absorption lidar (DIAL) capable of high-resolution water vapor measurements. An earlier airborne version was deployed during the SUCCESS Campaign of April 1996. The main goal of this activity would be to demonstrate the performance and capabilities of the mini-MOPA for improved water vapor measurements and perhaps for eventual incorporation into the SGP instrumentation suite or use during Water Vapor IOPs.

Airborne Emission Spectrometer (AES) Campaign. Dave Rider (NASA-JPL) will lead an exercise to demonstrate the operation of a version of the tropospheric emission spectrometer (TES). The TES is a device similar to AERI-X that could be used for side-by-side comparisons with the AERI-X. This exercise is proposed for September 1998. The TES is an Earth Observing System Chemistry Platform instrument. A demonstration version of the TES, the AES, would be used during the campaign. The AES has made airborne measurements previously and would offer ARM independent comparison of the AERI and AERI-X (because calibration sources for the AERI-X came from the AERI).

The Soil Sampling Campaign. The Soil Sampling Campaign is proposed for the summer of 1998 or 1999. This yet unfunded study would investigate the possibility that soils are a significant global sink of atmospheric CCl_4 and CH_3CCl_3 . Sampling would involve taking soil gas samples over the top 50 cm of soil with a small probe and analyzing the samples at the central facility by gas chromatography.

The CO_2 Differential-Absorption Lidar Campaign. John Jolin (Los Alamos) anticipates conducting a DOE-funded experiment at the SGP CART site. His experiment uses a 10-kHz tunable-frequency lidar system for the 9- to 11- μm wavelength region of interest. This CO_2 DIAL system can be mounted in aircraft or be ground based. Currently, the aircraft system is being considered. The CO_2 DIAL system will be used to identify trace chemical species, as well as to measure water vapor. The system aboard a U.S. Air Force KC-135 aircraft can be used to make spectrally resolved albedo measurements. This IOP has been scheduled tentatively for 1999.

Other Campaigns. Other campaigns possible in 1999 and 2000 include the Mesoscale Convective System (MCS) Campaign (Peter May, Australian Bureau of Meteorology) and the Thunderstorm Initiation Mobile Experiment (TIMEX; Erik Rasmussen, Conrad Ziegler, and

Jeanne Schneider, National Severe Storms Laboratory). More detail on these campaigns will be given in the next *Site Scientific Mission Plan*. At this time, however, we know that the MCS Campaign will make use of wind profilers and dual polarimetric scanning radar. TIMEX will make heavy use of airborne and ground-based mobile DIAL, as well as mobile Doppler weather radars.

5.4 Collaborative Investigations

Argonne National Laboratory has developed a new research facility (Wesely et al. 1997; Coulter et al. 1998) within the existing boundaries of the SGP CART site, to be devoted to studies of the planetary boundary layer (PBL). The Argonne Boundary Layer Experiment (ABLE) facility covers an area approximately 50 km $\times$ 50 km within the Walnut River watershed in Butler County, Kansas, about 50 km (30 mi) east of Wichita and near the Towanda extended facility. New techniques of observation and data fusion will be developed and used to study the nocturnal low-level wind maximum and its relation to synoptic jet features; to develop methods for spatial integration of air-surface exchange of heat, gases, and momentum; and to study horizontal and vertical dispersion in the PBL. The initial set of instrumentation currently available at ABLE includes two 915-MHz profilers with RASS, three minisodars, one surface ECOR flux station, one soil moisture and temperature station, three automated weather stations (AWSs), and one satellite data receiver processor. One central location will house data collection equipment and instrumentation and will provide accommodations for visiting scientists. The data obtained are being provided in real time to a user community of atmospheric scientists and ecologists.

The 915-MHz profilers with RASS and the minisodars have been installed at Oxford and Whitewater, Kansas. A minisodar and an AWS have been added to the ARM Program's Beaumont, Kansas, intermediate facility, which is shared by and provides data streams for both the ARM Program and ABLE. A surface flux site was installed at Smileyburg, Kansas. In addition, an extensive automated high-spatial-resolution soil moisture and temperature network will be installed and remain in place in the Towanda subbasin. A second network (not automated) with larger spacing may also remain in place. All are within the footprint of the Wichita next-generation radar (NEXRAD).

The Cooperative Atmosphere-Surface Exchange Study (CASES) is a collaborative effort to obtain measurements over the entire Walnut River watershed (approximately 100 km $\times$ 100 km), over a somewhat larger domain than ABLE. CASES will include hydrologic,

ecological, and atmospheric chemistry studies, in addition to ABLE research. The principal contacts for CASES are Peggy LeMone (National Center for Atmospheric Research) and Bob Grossman (University of Colorado). Several proposals have been submitted to the NASA Land Surface Hydrology Program to conduct experiments over the CASES-ABLE domain.

5.5 Geophysically Significant Phenomena

The ARM Program is concentrating on the study of geophysically significant phenomena (e.g., water vapor profiles, aerosols, clouds, temperature profiles, and radiation). Algorithm development that describes these phenomena is currently a primary focus.

The algorithm products represent a merging of appropriate instrument measurements into a cohesive product defining a particular geophysical state, for use by the Science Team. These products specifically address problems posed in the *Science Plan* and by various science applications working groups. One product currently under construction prescribes water vapor over the SGP CART site, information sought by the IRF Working Group. As noted in Section 5.3, such an effort involves three IOPs obtaining multiple water vapor measurements at the central facility (e.g., additional measurements on the 60-m tower; use of tethered systems; use of guest instruments and additional instruments, such as chilled-mirror and frost-point hygrometers; use of aircraft; and comparison of these measurements with routine BBSS, Raman lidar, MWR, and 915- and 50-MHz RASS water vapor profiles). The end result of such comparisons will be the generation of an ensemble, site-representative water vapor profile for use in GCMs. Section 4.3 describes a recently constructed product for shortwave radiation at the central facility.

5.6 Educational Outreach

The educational outreach program for the SGP CART site, coordinated by Dr. Ken Crawford, Director of the OCS, combines a range of resources available at OU. Outreach is focused at the precollege, undergraduate, and graduate levels. Efforts in this six-month period will concentrate on professional development activities, staff support for teacher participants, scientific mentorship of students, development of data analysis tools for students and teachers, and application of data in the classroom (McPherson and Crawford 1996; Melvin and McPherson 1998). A two-week workshop involving five Kansas and two Oklahoma teachers was held at OU in July 1997. Instruction on how to use ARM data and related software was given along with lessons on atmospheric radiation, energy transfer, meteorological data,

telecommunications, data visualization, the Web, and the ARM Program. Six EARTHSTORM teachers attended the workshop as the "Storm Team," helping instruct participants and offering insight on ways to modify existing lessons and materials to incorporate ARM data. The five Kansas teachers were given Power Macintosh 5400 computers for their classrooms. Schools can access ARM data on the Web at:

<http://www.arm.gov/docs/education> .

The ARM data are reached through the link "Southern Great Plains Site."

6 DISTRIBUTION OF DATA

Most of the data being requested are received from the SGP CART site or external data sources and are then repackaged for daily and weekly distribution to individual users. In some cases, users can log into the Experiment Center or the R1 System at the central facility and extract data by anonymous file transfer protocol (FTP). All data are sent to the Data Archive, where they are accessible to anyone at the following Web site:

<http://www.archive.arm.gov> .

The status of data streams from CART instruments or external sources has been classified as releasable (released upon request for the data stream), developmental (released only to SDS personnel for development of ingestion programs), under evaluation (released to an investigator for an initial data quality check), beta release (for releasable data of known and reasonable quality), collecting (when raw data are being collected for future processing and distribution), mentor only (provided only to the instrument mentor at the request of the mentor), analysis (released for further processing or analysis, such as for graphic display), or defunct (due to replacement of a prototype instrument data stream with the CART instrument data stream).

7- LOOKING AHEAD

The mature SGP CART site now provides a full range of data streams needed to support the broad spectrum of Science Team research. Research activities are increasingly drawing on multiple SGP data streams to focus on geophysically significant phenomena (water vapor profiles, clouds, aerosols, temperature profiles, radiation, surface fluxes). The operational challenges that will be of greatest importance during 1998 and beyond will therefore include maintaining the performance of the basic instrumentation suite at the highest possible level and improving that performance where possible, enhancing the original CART design through the permanent addition of new instruments, evaluating current instrumentation as to its effectiveness, and mounting focused IOPs and campaigns involving temporary additional instrumentation. Through this mix of activities, the evolving scientific requirements, challenges, and opportunities for the SGP CART site can be met. The present chapter outlines the path ahead, to the extent that it can be identified in mid 1998.

Key developments expected at the central facility during the present 6-month period and the following 18 months include the achievement of stable operation of the SWS and CSPHOT; installation of the UV spectrometer, the NFOV, and possibly an optical transmissometer; and an upgrade to the BBSS. The NFOV, a narrow-field-of-view zenith-pointing sky radiance sensor in the near IR, would have the advantage of a field of view that overlaps or nearly coincides with that of the MWR and possibly the MMCR. The UV spectrometer is scheduled for an August 1998 deployment. Another central facility measurement issue now under consideration is the possibility of acquiring continuous direct-beam solar irradiance measurements with a cavity radiometer. Cavity radiometer measurements were made successfully under close supervision during the Shortwave Radiation IOP in fall 1997. Additional work will continue on refining MMCR returns to eliminate the effects of insects and other particles in the boundary layer ("atmospheric plankton").

Work continues on baffling light sources and on providing a more stable base and a new location for the WSI, to reduce the effects of stray light at night. Operation of the RCF should be safer with the installation of better hail shields in March 1998.

Improved specifications of the water vapor, temperature, and cloud conditions above the boundary facilities are expected to result from several observational enhancements and additions during 1998 and 1999. First, the addition of ceilometers is intended primarily to provide data for algorithms that will retrieve lower tropospheric temperature and humidity profiles from the

output of new, planned AERI instruments. Second, higher-quality BBSS soundings should result from a planned upgrade of the Vaisala sensors being used (from RS-80 to RS-90). The RS-90 humidity sensor has a faster response time and thus recovers more quickly than its predecessor after the sun emerges from clouds. The temperature counterpart of the RS-90 is also smaller and has a faster response time than that of the RS-80 and, in addition, is less susceptible to solar heating. An identical BBSS upgrade will occur at the central facility. Temperature, humidity, and pressure sensors were also added recently at the boundary facilities for a better characterization of surface conditions for BBSS launches. Under consideration for the boundary facilities is a capability to profile with passive microwave systems, which would augment the AERI measurements. Locations and status of the boundary facilities are summarized in Table A.3 in the Appendix.

The anticipated completion of the wooded extended facility at the Okmulgee site will further enhance the basis for spatial integration of turbulent and radiative fluxes over the entire SGP CART site. Measurement issues under consideration at the extended facilities include local observations of surface vegetative conditions and measurements of surface bidirectional reflectance. Stabilization of ECOR operations is an ongoing issue. Work will begin during this period on establishing data ingest for the extended facility ECORs.

The SST will continue to play a strong role in the area of data quality, including an ARM-wide effort in 1998 and 1999 that will see the creation of a formal data user interface to allow data users to view data quality information when they obtain ARM data sets.

During 1998, the SGP CART site observational capabilities are expected to continue to benefit from ongoing interactions between the ARM Program and several other federal and state research programs having an interest in the SGP in general. The federal agency interactions, which until now have particularly involved the GEWEX Continental-Scale International Project (GCIP), were broadened through the leadership of NASA and the USDA in the midsummer 1997 Hydrology IOP. These interactions are also currently manifest in the approximately biannual meeting of a joint ARM-GCIP-International Satellite Land-Surface Climatology Project (ISLSCP) Working Group (on which ARM is represented by J.C. Doran, R.G. Ellingson, and P.J. Lamb); the implementation of the SWATS at the ARM extended facilities, with significant financial support from GCIP; and the USDA's facilitation and partial funding of the El Reno extended facility. The Joint Working Group will be concerned not only with fostering the most cost-effective and efficient observational strategies for the SGP CART site for 1998 and subsequent years, but also with formulating the best possible scientific use of the resulting data

among their programs. Consistent with this latter goal, the Working Group's May 1997 meeting focused on "Value-Added Science," which will likely be a continuing theme of that forum. Interactions with the Oklahoma Mesonet (OKM), which has been an important source of external data for the SGP for several years, increased with the OKM's parallel deployment of approximately 60 SWATs. A joint effort between the NWS and ARM resulted in ARM radiosonde data being made available to the meteorological community at large via the Global Telecommunications System. This availability will be especially valuable for the NWS short-range-prediction efforts during the tornado seasons of the next few years. Further beneficial interactions with the NWS are expected to result from Dr. Eugenia Kalnay's assignment to the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) during 1998 and 1999. Those interactions are expected to focus on "regional reanalysis" issues and to be especially to the advantage of the ARM SCM effort.

Throughout 1998, the scientific operation of the SGP CART site should benefit significantly from guidance provided by the SAC. The fundamental role of the SAC is to ensure that the operation of the site addresses the goals and objectives of the ARM Program (published in the 1996 *Science Plan*) to the fullest possible extent, including through successful adaptation to changing circumstances and opportunities. Such performance will ensure that the flows of data to the Science Team members are appropriate to their needs, of consistently high quality, and as continuous as possible. For example, the recent redoubling of efforts by the SST to help ensure the quality of SGP data is consistent with the strong encouragement offered by the November 1995 SAC review. Because the membership of the SAC is divided approximately equally between ARM Science Team members and nonmembers, its guidance reflects both the inherently more parochial concerns of the ARM Science Team and the broader global-change perspective of the others. The recommendations from the November 1995 and June 1996 SAC meetings are now being acted upon by the SST and will be reflected in the scientific capability of the site during 1998 and beyond. Those recommendations included the need for increased attention to quality assurance and quality control of the SGP instruments and data streams, the necessity to make midcourse corrections (including personnel assignments and funding priorities) to ensure that the configuration and operation of the SGP CART site are in full consonance with the ARM *Science Plan* priorities, the desirability of converting the *Site Scientific Mission Plan* into an article for publication in the *Bulletin of the American Meteorological Society* that would publicize the scientific potential of the site (to be completed during the present six-month period); and the inauguration of an SST Visitor Program that would particularly involve cloud and radiation data analyses and simulations, with the goal of

enhancing the site's observational capabilities in those crucial areas. Thus, from now onward, the SAC guidance will have a continuing effect on the scientific mission of the SGP CART site.

Finally, it is important to review and challenge the SGP CART site operational and instrumentation requirements, especially as programmatic budgets become more constrained. Issues that have been placed on the table for discussion with the Science Team Executive Committee, SAC, and ARM Management Team include the following:

- Do we need the early and late radiosonde launches at the central facility and the noontime radiosonde launches at the boundary facilities during non-IOP/campaign periods?

Radiosonde launches have by far the largest impact on the operation of the SGP CART site. In FY 1998, the number of launches at the central and four boundary facilities were reviewed. Because the SGP CART site's early and late radiosonde launches correspond to the NWS 00 Z and 12 Z radiosonde launches, the former were kept. However, two of the three daytime launches were eliminated from the central facility's launch schedule. The one kept corresponds to a midafternoon satellite overpass. The schedule of launches for the central facility is not expected to change in FY 1999.

The noontime launches at the boundary facilities were eliminated in FY 1998, because no one was using the data. However, with the expected implementation of the AERI and 25-km Vaisala ceilometer at each of the four boundary facilities, the noontime launches may need to be reinstated. In addition, regular boundary facility launches would be of benefit to the NWS, especially during the spring severe weather season. This is an issue for FY 1999.

- Do we need three SCM IOPs per year at the SGP CART site?

As the other CART sites come on-line, IOPs will need to be prioritized, given limited funds. In FY 1998, a decision was made to provide specific funding for only two SCM IOPs for FY 1998 and beyond, unless need could be demonstrated for a third SCM IOP in any one year. A third SCM IOP has

been proposed but not yet formally approved and remains an issue for FY 1999.

- Do SCM IOPs need to be 21 days long?

Typically, 14 days of data are sufficient for SCM IOPs if conditions during that time period are fairly consistent. However, 21-day IOPs are required for frequent air mass changes, which is the normal situation at the SGP CART site. The cost of SCM IOPs in labor and materials is substantial. Therefore, any reduction of the 21-day period represents significant cost savings. This is an ongoing issue for FY 1999 and beyond.

- Do we need all 24 extended facilities to adequately assess surface characterization for GCMs?

The issue here is twofold: (1) How sensitive is a GCM to surface characterization? (2) What spatial coverage is needed to adequately assess surface characterization for the SGP CART site? These questions are also measurement dependent. Nevertheless, the cost of routine and corrective maintenance activities over a 55,000-mi² area is substantial. A 50% reduction in extended facilities has been discussed. The potential impact, which should be resolvable measurement by measurement, is an issue for FY 1999 and beyond.

- Do we need to visit extended facilities every two weeks?

This issue was explored in FY 1997. Costs were projected for responding only when instruments fail versus every two weeks. Corrective maintenance reports for FY 1996 indicate that site operations staff would have had to visit each site more than once per week on average to fix instruments and computer systems and to address communication issues. This statistic has not changed significantly in FY 1998. Nevertheless, the cost of routine and corrective maintenance activities over a 55,000-mi² site is substantial and is an ongoing issue.

- Do we need to maintain the radar wind profilers at the central facility and the three intermediate facilities?

Would remote sensing of virtual temperature and winds only at the central facility provide sufficient accuracy and vertical and horizontal resolution for use in GCM algorithms for boundary layer heights? The scientific value of the intermediate facility data needs to be evaluated. Furthermore, an important question needs to be addressed: Can the wind profilers ever be seen as replacements for the radiosondes? (Locations and status of the intermediate facilities are summarized in Table A.4 in the Appendix.)

- Do we need to operate the Raman lidar continuously?

The preventative and corrective maintenance costs of the Raman Lidar represent more than half of such costs for all other SGP CART site instruments combined. In FY 1998, the instrument was operated as continuously as possible to generate baseline operational history. Continuous operation of this instrument for FY 1999 is an issue.

- Does the AOS provide sufficient information to study the role of aerosols in radiative transfer in GCMs?

The study of the role of aerosols in radiative transfer initially was not a high priority in the ARM Program. The AOS is an expensive system to operate and maintain. Although the value of aerosol measurements is a valid consideration, the correlation between surface measurements of aerosols and tropospheric profiles is questionable. Routine measurements of boundary layer aerosols over the central facility from a small aircraft several times per week would significantly improve the value of the AOS information.

Although the chemical composition of aerosols is beyond the charter for the ARM Program, other programs such as the Atmospheric Chemistry Program could focus some research efforts at the SGP CART site to take advantage of the infrastructure support and meteorological information.

- Should MFRSR instrumentation be removed from the SGP CART site extended facilities?

These instruments have not yet proven to be stable at the extended facilities. The filters degrade more quickly than was expected, and electronic components often need repair or replacement. The instruments' shading arms need constant realignment by field technicians. Alignment procedures can be done only on sunny days near solar noon. Technicians spend an hour or less at each extended facility every two weeks for routine maintenance. Hence, conditions for realignment are often not ideal. Because of the data volume, these instruments require frequent calls per day to each extended facility to acquire the data before data storage capacity is exceeded. For these reasons, the MFRSR was separated from the SIROS in FY 1998 to allow the SIRS instrument data to be collected independently. The cost of maintaining these instruments is significant, and their continued operation at extended facilities is an issue for FY 1999.

- Should ECOR instruments be decreased or eliminated at extended facilities?

Arguments for the use of ECOR at tilled fields and forested sites are sound. Routine stable operation, however, has not been achieved. Because the IDPC is not yet complete, rapid assessment of data quality and repairs in the field have not been possible. Issues for FY 1999 are whether the present ECOR system should either (1) be redesigned with more stable components, especially the humidity sensor, or (2) be reduced to a select few near the central facility, where they can be serviced more frequently. A high priority should be placed on completion of the ECOR IDPC.

This list is not complete, but it does represent issues in operation of the SGP CART site that have significant costs. These issues should be couched in the context of activities that could be eliminated to lessen operational expenses, making an opportunity to address new issues and concerns relative to the goals of the ARM Program. Specifically, the schedule of procurement and installation of new instruments under consideration (mentioned in Section 3.3 of this report) will be affected. All comments will be welcomed by Doug Sisterson (dsisterson@anl.gov) and Randy Peppler (rpeppler@ou.edu).

8 REFERENCES

- Coulter, R.L., G.E. Klazura, B.M. Lesht, J.D. Shannon, D.L. Sisterson, and M.L. Wesely, "Using the ABLE Facility to Observe Urbanization Effects on Planetary Boundary Layer Process," in *Reprints, 10th Joint Conference on the Application of Air Pollution Meteorology with the Air and Waste Management Association, 11-16 January 1998, Phoenix, Arizona*, American Meteorological Society, Boston, pp. J76-J79.
- McPherson, R.A., and K.C. Crawford, 1996, "The EARTHSTORM Project: Encouraging the Use of Real-Time Data from the Oklahoma Mesonet in K-12 Classrooms," *Bulletin of the American Meteorological Society* 77:749-761.
- Melvin, A.D., and R.A. McPherson, 1998, "Southern Great Plains Atmospheric Radiation Measurement (ARM) Educational Outreach Program," in *Preprints, Seventh Symposium on Education, 11-16 January 1998, Phoenix, Arizona*, American Meteorological Society, Boston, pp. 23-26.
- Peppler, R.A., and M.E. Splitt, 1998, "ARM Southern Great Plains CART Site Data Quality Assessment Activities," in *Preprints, 10th Symposium on Meteorological Observations and Instrumentation, 11-16 January 1998, Phoenix, Arizona*, American Meteorological Society, Boston, pp. 355-358.
- Stull, R., 1997, "Boundary Layer Experiment 1996 (BLX 96)," *Bulletin of the American Meteorological Society* 78:1149-1158.
- U.S. Department of Energy, 1990, *ARM Program Plan, 1990*, DOE/ER-0441, Washington, D.C.
- U.S. Department of Energy, 1996, *Science Plan for the Atmospheric Radiation Measurement Program*, DOE/ER-0670T, Washington, D.C.
- Wesely, M.L., R.L. Coulter, G.E. Klazura, B.M. Lesht, and D.L. Sisterson, "A Planetary Boundary Observational Capability in Kansas," in *Reprints, 1st Symposium on Integrated Observing Systems, 2-7 February 1997, Long Beach, California*, American Meteorological Society, Boston, pp. 169-171.

APPENDIX:

STATUS AND LOCATIONS OF INSTRUMENTS

TABLE A.1 Actual and Planned Locations of Instruments at the Central Facility^a

Instrument	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Location
AERI	316	36.606 N 97.485 W	Pasture	Optical trailer
AERI X	316	36.606 N 97.485 W	Pasture	Optical trailer
SORTI	316	36.606 N 97.485 W	Pasture	Optical trailer
MWR	316	36.606 N 97.485 W	Pasture	Optical trailer
WSI	316	36.606 N 97.485 W	Pasture	Optical trailer
BLC	316	36.606 N 97.485 W	Pasture	Optical trailer
MPL	316	36.606 N 97.485 W	Pasture	Optical trailer
SWS	316	36.606 N 97.485 W	Pasture	Optical trailer
GRAMS	316	36.606 N 97.485 W	Pasture	Optical trailer cluster
TLCV	316	36.606 N 97.485 W	Pasture	Optical trailer cluster
RSS	316	36.606 N 97.485 W	Pasture	Optical trailer cluster
BRS	318	36.605 N 97.485 W	Pasture	Central cluster
MFRSR	318	36.605 N 97.485 W	Pasture	Central cluster
SIRS	318	36.605 N 97.485 W	Pasture	Central cluster
10-m MFR	318	36.605 N 97.485 W	Pasture	Central cluster

TABLE A.1 (Cont.)

Instrument	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Location
CSPHOT	318	36.607 N 97.489 W	Pasture	Central cluster
EBBR	318	36.605 N 97.485 W	Pasture	Central cluster
SMOS	318	36.605 N 97.485 W	Pasture	Central cluster
SWATS	318	36.605 N 97.485 W	Pasture	Central cluster
BBSS	313	36.609 N 97.487 W	Grass	Central compound
25-m USR	314	36.607 N 97.489 W	Wheat	60-m tower
25-m UIR	314	36.607 N 97.489 W	Wheat	60-m tower
25-m MFR	314	36.607 N 97.489 W	Wheat	60-m tower
25-m T/RH	314	36.607 N 97.489 W	Wheat	60-m tower
60-m T/RH	314	36.607 N 97.489 W	Wheat	60-m tower
25-m ECOR	314	36.607 N 97.489 W	Wheat	60-m tower
60-m ECOR	314	36.607 N 97.488 W	Wheat	60-m tower
ECOR	315	36.606 N 97.488 W	Wheat, pasture	Aerosol trailer
AOS	315	36.607 N 97.488 W	Pasture, wheat	Aerosol trailer

TABLE A.1 (Cont.)

Instrument	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Location
RCF	313	36.608 N 97.488 W	Pasture, wheat	Calibration trailer
915-MHz RWP	312	36.601 N 97.487 W	Shale, pasture	Profiler trailer
50-MHz RWP	312	36.600 N 97.487 W	Shale, pasture	Profiler trailer
MMCR	316	36.606 N 97.485 W	Pasture, wheat	IDP 2
RL	311	36.609 N 97.487 W	Pasture, wheat	IDP 3

^a AERI, atmospherically emitted radiance interferometer; AOS, aerosol observation system; BBSS, balloon-borne sounding system; BLC, Belfort laser ceilometer; BRS, broadband radiometer station; CSPHOT, Cimel sunphotometer; EBBR, energy balance Bowen ratio; ECOR, eddy correlation; GRAMS, ground-based radiometer autonomous measurement system; IDP, Instrument Development Program; MFR, multifilter radiometer; MFRSR, multifilter rotating shadowband radiometer; MMCR, millimeter cloud radar; MPL, micropulse lidar; MWR, microwave radiometer; RCF, radiometer calibration facility; RL, Raman lidar; RSS, rotating shadowband spectrometer; RWP, radar wind profiler; SIRS, solar and infrared station; SMOS, surface meteorological observation station; SORTI, solar radiance transmission interferometer; SWATS, soil water and temperature system; SWS, shortwave spectrometer; TLCV, time-lapse cloud video; T/RH, temperature and relative humidity sensors; UIR, upwelling infrared radiometer; USR, upwelling solar radiometer; WSI, whole-sky imager.

^b Above sea level.

TABLE A.2 Locations and Status of Extended Facilities^a

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Flux Station ^c	SWATS ^c	SMOS ^c	SIROS + MFRSR ^c	SIRS + MFRSR ^c	Comment
Larned, KS EF-1	632	38.202 N 99.316 W	Wheat	ECOR 9/1/95	Yes 6/96	Yes 9/1/95	Yes 9/1/95	Yes 11/20/97	Power and communication center installed 10/95
Hillsboro, KS EF-2	450	38.306 N 97.301 W	Pasture	EBBR 10/96	Yes 6/96	No	Yes 9/7/95	Yes 11/5/97	Power and communication center installed 8/95
LeRoy, KS EF-3	338	38.201 N 95.597 W	Wheat and soybeans (rotated)	ECOR 12/7/95	Yes 9/96	Yes 12/7/95	Yes 12/7/95	Yes 11/4/97	Power and communication center installed 9/95
Plevna, KS EF-4	513	37.953 N 98.329 W	Rangeland (ungrazed)	EBBR 4/3/93	Yes 3/5/96	Yes 3/28/95	Yes 3/28/95	Yes 11/7/97	Power and communication center installed 3/95
Halstead, KS EF-5	440	38.114 N 97.513 W	Wheat	ECOR (on hold)	Yes 9/96	Yes 5/31/96	Yes; broad- band only 5/31/96	Yes 11/6/97	Power and communication center installed 11/95

TABLE A.2 (Cont.)

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Flux Station ^c	SWATS ^c	SMOS ^c	SIROS + MFRSR ^c	SIRS + MFRSR ^c	Comment
Towanda, KS EF-6	409	37.842 N 97.020 W	Alfalfa	ECOR 12/14/95	Yes 9/96	Yes 12/14/95	Yes 12/14/95	Yes 11/5/97	Power and communication center installed 8/95
Elk Falls, KS EF-7	283	37.383 N 96.180 W	Pasture	EBBR 8/29/93	Yes 3/12/96	Yes 3/9/95	Yes 3/9/95	Yes 10/31/97	Power and communication center installed 2/95
Coldwater, KS EF-8	664	37.333 N 99.309 W	Rangeland (grazed)	EBBR 12/8/92	Yes 6/96	Yes 3/4/93	Yes 5/9/95	Yes 8/20/97	Power and communication center installed 5/95
Ashton, KS EF-9	386	37.133 N 97.266 W	Pasture	EBBR 12/10/92	Yes 2/27/96	Yes 3/13/90	Yes 10/5/93	Yes 2/5/98	Power and communication center installed 10/93
Tyro, KS EF-10	248	37.068 N 95.788 W	Wheat	ECOR 7/21/95	Yes 7/96	No	Yes 7/21/95	Yes 10/30/97	Power and communication center installed 6/95
Byron, OK EF-11	360	36.881 N 98.285 W	Alfalfa	ECOR 6/26/95	Yes 6/96	Yes 6/26/95	Yes 6/26/95	Yes 8/22/97	Power and communication center installed 6/95

TABLE A.2 (Cont.)

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Flux Station ^c	SWATS ^c	SMOS ^c	SIROS + MFRSR ^c	SIRS + MFRSR ^c	Comment
Pawhuska, OK EF-12	331	36.841 N 96.427 W	Native prairie	EBBR 8/29/93	Yes 9/97	No	Yes 6/30/95	Yes 10/29/97	Power and communication center installed 6/95
Lamont, OK EF-13, 14	318	36.605 N 97.485 W	Pasture, wheat	EBBR 9/14/92; ECOR 5/30/95	Yes 2/5/96	Yes 4/9/93	Yes 10/15/93; BSRN 5/15/92	Yes 8/19/97	Power and communication center installed 6/93
Ringwood, OK EF-15	418	36.431 N 98.284 W	Pasture	EBBR 9/16/92	Yes 2/21/96	Yes 3/29/93	Yes 10/12/93	Yes 8/23/97	Power and communication center installed 10/93
Vici, OK EF-16	602	36.061 N 99.134 W	Wheat	ECOR 5/30/95	Yes 7/96	No	Yes 5/30/95	Yes 8/21/97	Power and communication center installed 5/95
EF-17 ^d	—	—	—	—	—	—	—	—	—
Morris, OK EF-18	217	35.687 N 95.856 W	Pasture (ungrazed)	EBBR 7/97	Yes 9/96	No	Yes; broad- band only 5/24/96	Yes 9/30/97	Power and communication center installed 10/95

TABLE A.2 (Cont.)

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Flux Station ^c	SWATS ^c	SMOS ^c	SIROS + MFRSR ^c	SIRS + MFRSR ^c	Comment
El Reno, OK EF-19	Unknown	35.557 N 98.017 W	Pasture (ungrazed)	EBBR	Yes	No	Yes	Yes FY98	Implementation began 5/97
Meeker, OK EF-20	309	35.564 N 96.988 W	Pasture	EBBR 4/5/93	Yes 2/8/96	Yes 4/2/93	Yes	Yes 2/12/98	Power and communication center installed 10/94
Okmulgee, OK EF-21	240	35.615 N 96.065 W	Forest	ECOR FY99	Yes FY99	Yes FY99	No	Yes FY99	Lease signed 2/97; tower, phone, and power installed 5/98
Cordell, OK EF-22	465	35.354 N 98.977 W	Rangeland (grazed)	EBBR 4/5/93	Yes 2/15/96	No	Yes 4/26/95	Yes 11/24/97	Power and communication center installed 3/95
EF-23 ^d	—	—	—	—	—	—	—	—	—
Cyril, OK EF-24	409	34.883 N 98.205 W	Wheat (gypsum hill)	ECOR 8/25/95	Yes 7/96	Yes 8/25/95	Yes 8/25/95	Yes 11/25/97	Power and communication center installed 7/95

TABLE A.2 (Cont.)

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	Flux Station ^c	SWATS ^c	SMOS ^c	SIROS + MFRSR ^c	SIRS + MFRSR ^c	Comment
Seminole, OK EF-25	277	35.245 N 96.736 W	Pasture	EBBR 12/97	Yes 12/97	Yes 12/97	No	Yes 12/10/96	Power and communication center installed 11/96; SIRS + MFRSR installed 12/10/96, activated 4/9/97
Cement, OK EF-26	400	34.957 N 98.076 W	Pasture	EBBR 6/10/92	No	No	No	No	Phone line (only) installed 10/92

^a BSRN, Baseline Surface Radiation Network; EBBR, energy balance Bowen ratio; ECOR, eddy correlation; EF, extended facility; MFRSR, multifilter rotating shadowband radiometer; SIROS, solar and infrared radiation observing system; SIRS, solar and infrared station; SMOS, surface meteorological observation station; SWATS, soil water and temperature system.

^b Above sea level.

^c Date indicates actual or scheduled installation date.

^d This extended facility is a placeholder site for possible expansion, if required.

TABLE A.3 Locations and Status of Boundary Facilities^a

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	BBSS ^c	MWR ^c	Vceil	AERI	Comment
Hillsboro, KS BF-1	441	36.071 N 99.218 W	Grass	Yes 1/18/94	Yes 1/18/94	No	No	Temporary power and communication installed 12/93
Hillsboro, KS BF-1	447	38.305 N 97.301 W	Grass	Yes 9/28/94	Yes 9/28/94	No FY 99	No	Relocated and temporary power and communication installed 9/94; permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96
BF-2	—	Unspecified	—	—	—	—	—	—
BF-3	—	Unspecified	—	—	—	—	—	—
Vici, OK BF-4	648	36.071 N 99.218 W	Grass	Yes 1/18/94	Yes 1/18/94	No	No	Temporary power and communication installed 12/93
Vici, OK BF-4	622	36.071 N 99.204 W	Grass	Yes 10/3/94	Yes 10/3/94	No FY 99	No FY 99	Relocated and temporary power and communication installed 9/94; permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96
Morris, OK BF-5	18	35.682 N 95.862 W	Grass	Yes 1/18/94	Yes 1/18/94	No	No	Temporary power and communication installed 12/93

TABLE A.3 (Cont.)

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	BBSS ^c	MWR ^c	Vceil	AERI	Comment
Morris, OK BF-5	217	35.688 N 95.856 W	Grass	Yes 10/6/94	Yes 10/6/94	No FY 99	No FY 99	Relocated and temporary power and communication installed 9/94; permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96
Purcell, OK BF-6	344	34.969 N 97.415 W	Grass	Yes 9/23/94	Yes 9/23/94	No FY 99	No FY 99	Permanent power, communication, and grounding mat installed 3/96; T-1 line installed 4/96

^a AERI, atmospherically emitted radiance interferometer; BBSS, balloon-borne sounding system; BF, boundary facility; MWR, microwave radiometer; Vceil, Vaisala ceilometer.

^b Above sea level.

^c Date indicates actual installation date.

TABLE A.4 Locations and Status of Intermediate Facilities^a

Site	Elevation ^b (m)	Latitude, Longitude (deg)	Surface Type	915-MHz Profiler and RASS ^c	Comment
Beaumont, KS IF-1	525	37.626 N 96.538 W	Rangeland	Yes 9/96	Power and communication installed 9/96
Medicine Lodge, KS IF-2	585	37.280 N 98.933 W	Rangeland	Yes 9/96	Power and communication installed 9/96
Meeker, OK IF-3	300	35.550 N 96.920 W	Grass	Yes 9/96	Power and communication installed 9/96

^a IF, intermediate facility; RASS, radio acoustic sounding system.

^b Above sea level.

^c Date indicates actual installation date.