Implementation of Instruments and Facilities at the Southern Great Plains Cloud and Radiation Testbed Site

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Considerable progress has been made in installing instruments and trailers at the Southern Great Plains (SGP) Clouds and Radiation Testbed (CART) site (Figure 1). While initial activity concentrated on the central facility, planning proceeded for installation of extended facilities, which will begin operations in 1993. Observations at the central facility were started in June 1992, and a site operator began work in August 1992. Members of the site operations team assisted in the implementation during the first year, helping to develop the site, coordinate installation of instrumentation, and provide safety procedures. In addition, the representatives of the site scientist, the instrument team, and the data management team were frequently on site.

To reduce the number of problems associated with installing and operating instruments at the SGP CART site, a number of procedures were developed for CART instruments, Instrument Development Program (IDP) systems, and instruments of opportunity. A key role is held by the on-site instrument coordinator, who conducts a checklist review before an instrument is brought to the site.

The purpose of the checklist is to identify installation and operational requirements of the instrument. This pre-readiness review generates work orders at the site based on requirements for electrical, trailers, the site data system, operation, safety, etc. Instrument representatives or "mentors" are informed of any deficiencies.

When the checklist is sufficiently complete, an operational readiness review is conducted by site operations. This review uses a checklist to determine requirements for training, documentation, operational support, safety, etc. Again, deficiencies are identified.

On the basis of the number and severity of the deficiencies, site operations either accepts the instrument, does not accept the instrument but operates it in a degraded mode until the problems are fixed, or does not operate the instrument. Similar procedures are followed for other types of equipment and some aspects of the site data system.

Central Facility

Table 1 shows the progress to date on implementation of instruments, facilities, and general aspects of the site data system at the central facility. The 160 acres of the central facility, which is located between the towns of Lamont and Billings, Oklahoma, contain the greatest concentration of SGP CART instrumentation. The site data system and the base of operations for the site operations are also located at the central facility. Instrumentation at the central facility includes systems that address all of the Atmospheric Radiation Measurement (ARM) Program's measurement strategies: instantaneous radiative transfer (IRF), single-column modeling (SCM), four-dimensional data assimilation (4DDA), and hierarchical diagnosis (HD). During initial phases of implementation, instrumentation for IRF studies has been emphasized.

In the near future, several instrument systems in addition to those listed in Table 1 will be installed. The atmospherically emitted radiance interferometer (AERI) from the University of Wisconsin will undergo initial testing as an IDP instrument in March 1993, followed by occasional operation to produce data for the Science Team. A commercially produced laser ceilometer will be installed in summer 1993, and a more powerful micropulse lidar from the Goddard Space Flight Center of the National Aeronautics and Space Administration will undergo IDP testing later in the year. A 50-MHz radar wind profiler and radio acoustic sounding system (RASS) is expected to be

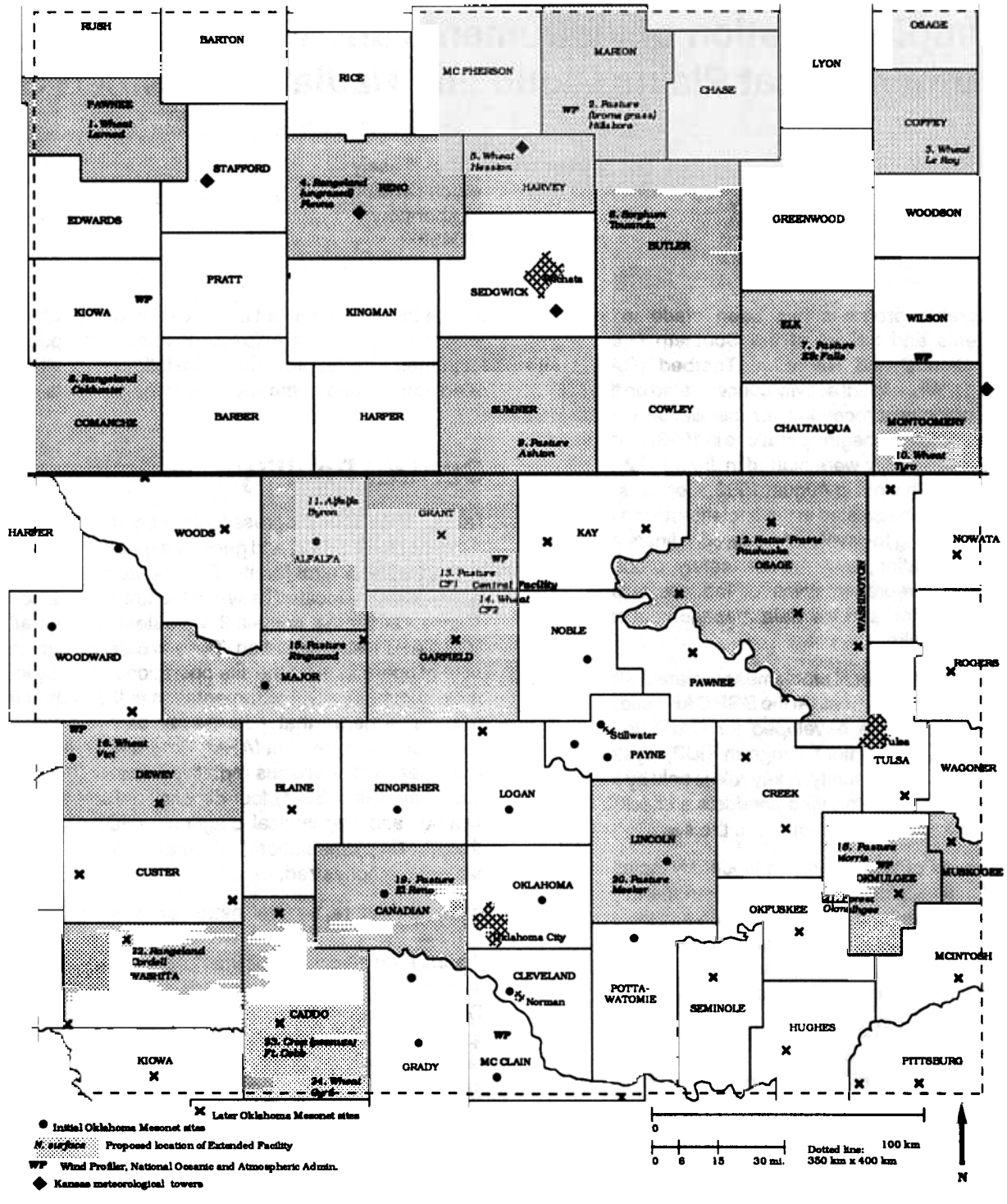

Figure 1. Overall view of the SGP CART site in Oklahoma and Kansas. Individual counties are outlined.

Table 1. Dates of installations of instrumentation, side data system versions, and facilities at the SGP CART central facility.

Date	Equipment or Qualifier	Observation or Function
Solar Radiation and Infrared Radiation Observation Station (SIROS) Components		
6/12/92	Multifilter rotating shadowband radiometer (MFRSR)	Total, direct, and diffuse solar irradiances in selected wavebands
6/13/92	Pyranometer (PSP-1)	Total downwelling solar irradiance
6/13/92	Pyranometer with solar occulting disk (PSP-2)	Diffuse solar irradiance
6/13/92	Pyrheliometer on solar tracking mount (NIP)	Direct-beam solar irradiance
6/13/92	Pyrgeometer with solar occulting disk (PIR)	Downwelling diffuse infrared irradiance
Portable Automated Mesonet II (PAM-II) System[a]		
5/16/92	Primary observations	Wind speed and direction at 10 m
	Primary observations	Temperature and relative humidity at 2 m
	Primary observations	Barometric pressure
	Primary observations	Precipitation rate
Energy Balance Bowen Ratio (EBBR) Surface Flux Station		
9/15/92	Primary observations	Latent and sensible heat fluxes
	Supporting observations	Net radiation
	Supporting observations	Soil heat flux
	Supporting observations	Air temperature and relative humidity
	Supporting observations	Soil moisture content (top 5 cm)
	Supporting observations	Soil temperature (top 5 cm)
	Supporting observations	Wind speed and direction at 3m
Microwave Radiometer (MWR)[b]		
6/11/92	Primary observations	Vertically integrated water vapor and liquid
915-MHz Wind Profiler and Radio Acoustic Sounding System (RASS)		
10/6/92	Primary observations	Vertical profiles of wind speed and direction
	Primary observations	Vertical profiles of virtual temperature
Balloon Borne Sounding System (BBSS)		
5/27/92	Primary observations	Vertical profiles of wind speed and direction
	Primary observations	Vertical profiles of air and dewpoint temperatures
	Primary observations	Vertical profiles of pressure and altitude

Table 1. (contd)

60-Meter Tower Platform		
12/10/92	Tower	Support for instruments
2/12/93	Sensors	Air and dewpoint temperature at 60-m level
Site Data System (SDS)		
5/21/92	Version 1, development system	
9/17/92	Version 2, development and production systems; T-1 lines	
1/31/93	Version 3, development and production systems, upgraded plotting capabilities	
Utilities and Facilities		
6/92	Telephone service	
8/92	Electrical service	
8/92	Water service	
8/92	Improved roadway to site	
8/92	Tornado shelter	
8/92	Septic field	
8/92	Grounding field for all trailers	
8/92	All trailers	
2/93	Fiber and telephone communications plant	

(a) PAM-II systems are to be replaced by surface meteorological observation systems (SMOS) in late March 1993. SMOS also include a measure of snow depth.
(b) SIROS instruments and the MWR were initially located near the calibration trailer but were moved to the central cluster location on 10/17/92.

installed in mid-summer. For whole-sky imaging, a system on loan from the Scripps Marine Physical Laboratory will become operational in fall 1993, then will be replaced with a dedicated CART unit from the same source in 1994. Instrumentation for observing aerosol properties and ozone concentration near the surface will be installed in early 1994. An infrared radiometer to view the sky temperature directly above the microwave radiometer will come on line during fall 1993. Finally, a cloud profiler radar system being developed by the University of Massachusetts for the IDP will undergo tests in 1993 at the central facility.

Extended Facilities

At extended facilities, surface meteorological observation stations (SMOS) measure surface meteorological conditions; solar and infrared observation stations (SIROS) detect broadband and selected narrowband irradiances; and either energy balance Bowen ratio (EBBR) or eddy correlation (EC) stations evaluate the air-surface exchange rates of heat, moisture, and momentum (Figure 2).

Between 20 and 25 locations, including the central facility, will be used for extended facilities (Figure 1). These observations are necessary for SCM experiments but are alone inadequate to provide a complete sampling of the overall CART area. As Table 2 shows, several sources of external data will be used, providing information to the Science Team to properly estimate the surface boundary conditions representative of large portions of the SGP CART site.

Three extended facilities now contain EBBR stations and SMOS. This number will gradually increase to the numbers indicated in Table 2 by July 1993. Ten SMOS and EBBR stations will be operational by early 1994, and installation of EC stations will begin in early 1994.

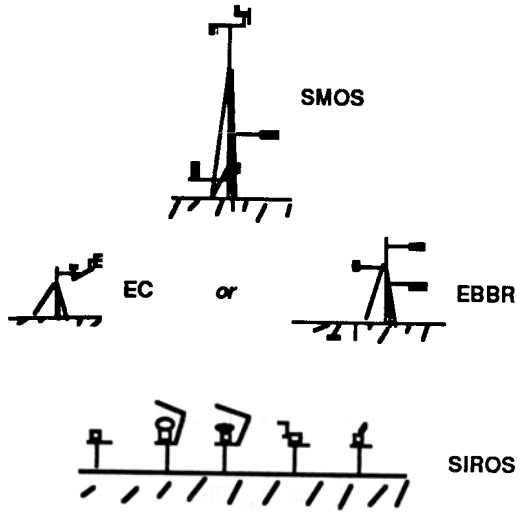

Figure 2. A schematic view of extended-facility components.

Boundary and Auxiliary Facilities

The CART boundary facilities are designed to measure winds, temperature, and humidity in vertical columns, providing information necessary for SCM and other investigations. The boundary facilities will generally be located near one of the six sites indicated by "WP" in Figure 1, where 404-MHz wind profilers are operated by the National Oceanic and Atmospheric Administration/ National Weather Service. Three areas near the six sites have been chosen for installation of CART boundary facility instruments in 1993: Hillsboro, on the northern edge; Vici, on the southwest edge; and Morris (formerly Haskell), on the southeastern edge. Extended facilities will be collocated or stationed within 10 km of these three initial boundary facilities.

The three selected boundary facilities will be equipped in late fall 1993 with CART balloon-borne sounding systems (BBSS) to observe vertical profiles of wind, temperature, and humidity, and with microwave radiometers to sense the total integrated column of water liquid and vapor. In addition, AERIs may be deployed there later to obtain estimates of vertical profiles of temperature and humidity on a more continuous basis than is possible with the BBSS. Continuous moisture profiling in the presence of clouds remains an unmet measurement need.

Auxiliary facilities are needed to map cloud characteristics as seen from the surface with whole-sky imagers (WSI). With a WSI at the central facility, several auxiliary facilities located approximately 5 km away will provide the needed cloud observations. Installation of the first auxiliary facility is expected in 1994, simultaneously with implementation of a WSI at the central facility. After evaluation of the systems and the associated algorithms, several other stations may be installed in 1994 and 1995.

Acknowledgments

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Table 2. Routine network observation stations in the SGP CART domain. Each CART extended facility consists of one SIROS; one SMOS if a KSU, NOAA/NWS, or OK Mesonet station is not located within 10 km; and an EBBR station for untilled fields or an EC station for tilled fields. Data are usually reported as hourly or half-hourly averages.

Type of station	No. Installed by October 1993	Total No. Expected	Observations
CART energy balance Bowen ratio	8	12	H, LE, supporting variables
CART eddy correlation	0	13	H, LE, τ, turbulence statistics
CART solar and infrared observation	3	23	R_s^i, R_s^o, R_L^i, R_L^o, D, I, MFRSR data
CART surface meteorological observation system	5	15	V_H, dd, T_a, RH, pp, P, d_s
Kansas State University network	4	4	V_H, dd, T_a, RH, pp, T_g, R_s^i,
National Oceanic and Atmospheric Administration/National Weather Service (site of 404-MHz wind profilers)	6	6	V_H, dd, T_a, RH, pp, Tg
Oklahoma Mesonet	~20	~50	V_H, dd, T_a, RH, pp, P, T_g, R_s^i, others

D: incoming diffuse hemispherical solar irradiance
dd: mean wind direction (usually at 10-m height)
d_s: local snow depth
H: sensible heat flux density
I: direct-beam solar irradiance
LE: latent heat flux density
MFRSR data: total, direct, and diffuse total irradiances and six filtered bandwidths of solar irradiances
P: barometric pressure
pp: liquid precipitation rate (SMOS have heaters; other systems do not)
RH: mean relative humidity
R_s^i: incoming total hemispherical solar irradiance
R_s^o: outgoing total hemispherical solar irradiance
R_L^i: incoming total hemispherical infrared irradiance
R_L^o: outgoing total hemispherical infrared irradiance
V_H: horizontal mean wind speed (usually at 10-m height)
T_a: mean air temperature
T_g: soil temperature in upper 5 or 10 cm
τ: momentum flux
Others: soil heat and moisture properties planned for perhaps 10 stations in the CART site
Supporting variables: net radiation, soil heat flux, V_H and dd at 3-m height, Ta, RH, T_g, and water potential in upper 5-10 cm
Turbulence statistics: measures of wind components, temperature, and humidity fluctuations