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GEWEX CONTINENTAL-SCALE INTERNATIONAL PROJECT (GCIP)

TACTICAL DATA COLLECTION AND MANAGEMENT PLAN for the 1996 ENHANCED SEASONAL OBSERVING PERIOD (ESOP-96)

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1. INTRODUCTION

The Global Energy and Water Cycle Experiment (GEWEX), as one of the major programs of the World Climate Research Programme (WCRP), aims to determine global distributions of water and energy fluxes from observations and to compute their values from predicted atmospheric properties. The GEWEX Continental-scale International Project (GCIP), the first major project under GEWEX, has the Mississippi River basin as its primary region of interest.

1.1 The GCIP Project

The overall objectives of the GCIP are to improve scientific understanding of, and to model on a continental scale, the coupling between the atmosphere and the land surface for climate prediction purposes. This includes the determination of the temporal and spatial variability of the hydrological and energy budgets on the continental scale as well as the development and validation of macroscale hydrological models, related high resolution atmospheric models, and coupled hydrologic and atmospheric models. The operational or Enhanced Observing Period (EOP) of GCIP commenced in October 1995 and will run for approximately five years.

The GCIP Science Plan [World Meteorological Organization (WMO), 1992] poses science questions that need to be addressed to advance knowledge of the hydrological and energy cycles involved in the complex land-atmosphere-ocean interactions for a major river basin. The GCIP research involves a systematic multiscale approach to accommodate physical process studies, model development, data assimilation, diagnostics, and validation topics [International GEWEX Project Office (IGPO), 1994a]. This multiscale research effort employs a four-tiered developmental studies framework laid out as follows:

Continental-scale area (CSA) activities span the entire domain of the Mississippi River basin (3.2 x 10^6 km^2). These operate at a more or less steady level throughout the EOP.

Large-scale area (LSA) activities cover areas of about 10^5 to 10^6 km^2. Four such areas were defined for GCIP that in aggregate cover most of the GCIP domain (Figure 1-1). These activities occur in a phased timetable (Figure 1-1), examining each regions special characteristics over a two year period.

Intermediate-scale area (ISA) activities cover areas of about 10^3 to 10^4 km^2 and occur in conjunction with LSA activities. They serve as the basis for the regionalization of the parameters and coefficients of land surface hydrological models. Activities at ISA scales include the analysis of existing basin-scale hydrological models and the analysis of relationships between LSA and ISA scales.

Small-scale area (SSA) activities cover areas of about 10^2 km^2. These activities typically occur in association with efforts requiring Intensive Observation Periods (IOPs) over concentrated regions to study a focused set of issues.

The data collection and operational model upgrades needed for GCIP were addressed in Volume I of the GCIP Implementation Plan (IGPO, 1993). The issues of data management for GCIP are divided into strategic and tactical planning efforts. The strategic portion of the data management planning was covered in Volume III of the GCIP Implementation Plan (IGPO 1994b). A tactical data collection and management plan will be completed for each definable dataset compiled by GCIP. Following the data collection phase of each definable GCIP dataset a tactical data collection and management report will be completed.

1.2 GCIP Initial Datasets

A number of GCIP Initial Datasets (GIDS) were prepared to provide data services support during the 2-yr buildup period prior to the start of the 5-yr EOP in October 1995. GIDS-1 covered the period from 1 February to 30 April 1992 and included data from the STorm-scale Operational and Research Meteorology (STORM)-Fronts Experiment Systems Test (FEST) augmented by an additional six weeks of atmospheric, hydrological, and land surface data from existing data centers for the central Mississippi River basin. GIDS-2 is planned to consist of two

abnormal climate events in the Mississippi River basin, i.e. the 1988 drought and the 1993 floods. GIDS-3 consists of data collected during the GCIP Integrated Systems Test (GIST) which took place from 1 April to 31 August 1994, with a concentrated effort during the summer season of June, July, and August. The GIST took place in the LSA-SW (see Figure 1-1). GIDS-4 consists of data collected during the GCIP 1995 Enhanced Seasonal Observing Period (ESOP-95) which was also conducted in the LSA- SW (1 April - 30 September 1995). The GIDS-4 CD-ROM is scheduled to be completed by approximately July 1996. A GCIP Reference Dataset (GREDS) was completed in early 1995. The 17 different datasets on this CD-ROM contain data that are expected to change little if any during the next two to three years. A summary of the contents of each of the above datasets is given in the GCIP Major Activities Plan for 1996, 1997 and Outlook for 1998 (IGPO 1995). Specific information about each dataset is available on the Internet World Wide Web (WWW) via the GCIP home page at the following URL (Uniform Resource Locator):

http://www.ncdc.noaa.gov/gcip/gcip_home.html

1.3 1996 Enhanced Seasonal Observing Period (ESOP-96)

The ESOP-96 will be conducted from 1 April through 30 September 1996 and will continue the ongoing program of observations in support of the LSA-SW focus as shown in Figure 1-1. A major objective for ESOP-96 is to contribute to a comprehensive dataset for diagnostic, evaluation, and modeling studies and it is the first ESOP dataset to be collected during the 5-yr EOP. GCIP has no IOPs planned to occur during the ESOP-96 period. The months of May and July 1996 are scheduled to be opportunities to develop Quick Response Datasets. These datasets are described in Section 4.2. The LSA-SW has four environmental features that are significant to GCIP: A large east-west variation in climate, a large water vapor transfer via a low level jet, a large portion of the precipitation is due to convective activity, and there is a large diurnal variability in the summer season for hydrologic components such as water vapor transport and convective regimes. The scientific objectives and approach for these studies are described in the GCIP Major Activities Plan for 1996, 1997 and Outlook for 1998 (IGPO 1995).

The GCIP LSA-SW domain is shown in Figure 1-2. The geographical area of responsibility for the National Oceanic and Atmospheric Administration (NOAA)-National Weather Service (NWS) Arkansas-Red Basin River Forecast Center (ABRFC) in Tulsa, Oklahoma, is used to define the areas of the Arkansas-Red River basins as the irregular shaped polygon in Figure 1-2. For atmospheric modeling and other applications a more regular-shaped area is defined by the boundaries of 33° to 40° N latitude and 91° to 107° W longitude, and this is used as the latitude-longitude boundaries for the LSA-SW. The meteorological and hydrological networks covering the Mississippi River basin are currently being enhanced by new Weather Surveillance Radar - 1988 Doppler (WSR-88D) radars, wind profilers, and automatic weather stations. Most of these systems are already operating in the LSA-SW. In addition, mesoscale networks including the Department of Energy (DOE) Atmospheric Radiation Measurements (ARM) Program at the southern Great Plains Cloud and Radiation Testbed (CART) facility and the United States Department of Agriculture (USDA)/Agricultural Research Service (ARS) Little Washita experimental watershed are contained in the LSA-SW domain (see Figure 1-2). The linkages between ESOP-96 and the ARM/CART are discussed in section 2.

1.4 Purposes of Document

This document is entitled the Tactical Data Collection and Management Plan for ESOP-96 and is intended to serve three purposes:

(i) A summary of the approach to the data collection efforts during the period of 1 April through 30 September 1996 in lieu of an operations plan covering this period. Some of the specialized efforts for enhanced observations (i.e. ARM/CART described in section 2) have operations plans which are prepared by the persons contributing those enhanced observations to the ESOP-96.

(ii) The data collected during ESOP-96 will provide the basis for the first ESOP dataset from the 5-yr GCIP EOP. The ESOP-96 will contain all of the same data types as were collected for ESOP-95 in 1995 and compiled as

GIDS-4. Enhancements such as soil moisture measurements will also be available during at least a portion of ESOP-96.

(iii) Provide a description of a special near-surface observation dataset for land surface process studies and modeling. The characteristics of this special dataset are described in Section 4.3.

The approach to ESOP-96, a description of the data collected, and how it will be disseminated are described in the remainder of this document.

2. OBJECTIVES AND APPROACH

The research objectives to be achieved from the ESOP-96 datasets are described in the GCIP Major Activities Plan (IGPO, 1995). The purpose of compiling the ESOP-96 dataset is to create the first GCIP ESOP dataset during the GCIP 5-yr EOP which began in October 1995 and it will enable GCIP investigators to conduct focused studies (i.e. coupled model and diagnostic) unique to the LSA-SW during the spring and summer seasons. The approach taken by the GCIP is to rely on existing operational observing programs over the continental United States while taking advantage of special collection of higher resolution data. Also, as additional improvements are made to the operational observing systems [i.e. Automated Surface Observing System (ASOS) and WSR 88-D] they are incorporated. These operational networks include the traditional meteorological and hydrological networks in addition to WSR-88D radars, wind profilers, ASOS, satellites, and operational model output. The LSA- SW region was selected in part because many of these additional systems were already available. Also, within this domain, there are the enhanced special observational networks associated with the ARM/CART.

The primary objective of the ARM program is to characterize the radiative processes in the earth's atmosphere with improved accuracy and resolution. The strategy is to deploy, for at least a decade, a sufficiently complete set of observing systems that, when combined with other operational or experimental systems, will obtain a continuous representation of the radiative and meteorological fields over a volume of space equivalent to the minimum spatial resolution of a typical global climate model (GCM). The goal of CART is to generate a dataset that is sufficiently complete to enable diagnosis of the performance of GCM subgrid scale parameterization schemes that are important to representing cloud and radiation properties in these models.

The sensor systems and measurements at the ARM/CART site (Figure 1-2) were described in Volume I of the GCIP Implementation Plan (IGPO, 1993). Commonality of research interests between GCIP, ARM, and ISLSCP (International Satellite Land-Surface Climatology Project) form the basis for unique observational and data analysis opportunities within the ARM/CART site. From the GCIP perspective, the ARM/CART site is large enough (almost 10^5 km^2) and is well enough instrumented for approximate closure of the atmospheric energy and water budgets. The size of the ARM/CART area places it between the LSA and ISA ranges. Therefore, some LSA studies can be done over the ARM/CART area as well as over the entire LSA-SW.

Within the ARM/CART site, the opportunities to conduct ISA studies are numerous. At the ISA scale, precipitation and streamflow can be measured accurately and, although it is not possible to measure areal average evapotranspiration and soil moisture, extensive in situ surface measurements related to evapotranspiration or soil moisture will be made as part of ARM, ISLSCP, the Oklahoma Mesonet, NOAA/NWS observations, and other programs. The ARM/CART site also includes a range of climate, soils, and vegetation regimes and is therefore an attractive location for the development and validation of remote sensing algorithms. The densely instrumented USDA/ARS Little Washita/Chickasha experimental watershed provides an opportunity for studies of an SSA where significant historical data are available. This watershed is on the southern boundary of the ARM/CART site (See Figure 1-2). The characteristics of this watershed were described by Allen and Naney (1991).

The ARM program in addition to its continuous observational base often conducts periods of more intensive data collection. These IOPs are conducted for observations that are too expensive for continuous operation or require instrumentation that cannot be continuously deployed. IOPs can also be used to examine issues of data quality or representativeness through intercomparisons. During the ESOP-96 period, ARM will be conducting several IOPs.

Single-Column Model (SCM) IOPs will be conducted in April, July, and September 1996. An SCM is a physical parameterization package extracted from a GCM. The primary purpose of the SCM IOPs is to test the current understanding of clouds and radiative transfer. These SCM IOPs provide, as boundary conditions, the advective tendencies and vertical velocities that are the dynamic forcing normally calculated with a GCM. The balloon-borne sounding system is the only technology able to provide the necessary observations to estimate these boundary conditions. Thus, these IOPs include an enhanced frequency of vertical soundings of temperature, water vapor and winds, as well as other observations. The sounding frequency will be increased to eight per day at the central and boundary facilities (see Figure 3-9). These SCM IOPs also serve as useful background data collection efforts for simultaneous IOPs.

A Sensible Heat Flux IOP will be conducted from February to June 1996. Its primary purpose is as a data evaluation IOP for sensible heat flux measurements. This includes comparing data from one or two scintillometers with data from the EBBR (Energy Balance Bowen Ratio) and ECOR (Eddy Correlation) systems at the ARM central facility. This IOP is designed to improve the level of confidence in the ARM EBBR and ECOR sensible heat flux data. The IOP start and end times are scheduled to coincide with the beginning of the winter wheat growth and the mature stages respectively.

During the April SCM IOP, the SUCCESS (Subsonic Aircraft: Contrail and Cloud Effects Special Study) IOP will also occur. The primary purpose of SUCCESS is to determine the impact of the current and future subsonic aircraft fleet on the Earth's radiation budget and climate. In particular, the fleets impact on contrails, cirrus clouds, and homogeneous chemistry are to be examined. The base of operations for this IOP is Salina, Kansas and the aircraft flights will be concentrated in Kansas and northern Oklahoma, with some excursions to the Rocky Mountains near Boulder, Colorado to examine wave clouds. A lidar and cloud radar will be located at the central facility. The aircraft associated with SUCCESS include the National Aeronautics and Space Administration (NASA) ER-2, DC-8, T-39, and possibly the 757 and the National Center for Atmospheric Research (NCAR) Electra.

During June 1996 the Atmospheric Emission Sounder Overflights IOP will take place as will the MSX (Midcourse Satellite Experiment) Satellite Overflights IOP. The Atmospheric Emission Sounder Overflights IOP will include special ozone sonde launches. The purpose of the MSX IOP is to provide ground truth support for the MSX satellite.

Finally, during the September SCM IOP, a Water Vapor Comparison Test IOP will take place. The primary objective of this IOP is intercomparisons of water vapor measurements from a variety of instrumentation.

In summary, ARM/CART in conjunction with ESOP-96 will provide a dataset that: (1) includes atmospheric and hydrological data obtained in a major river basin; (2) includes a hydrologically important time of year (i.e. early spring through summer); (3) includes routine operational data as well as special research observing platforms combined for a six month period; and (4) provides quality controlled surface and upper air composite datasets as required by the GCIP EOP.

3. DATA SOURCES AND DATA COLLECTION

The ESOP-96 data can be divided into three major data categories: In situ, satellite, and model. The responsibility in data collection will fall under each module of the GCIP Data Management and Service System (DMSS). Although most of the data sources are operational in nature, special arrangements will be made to obtain these data in the highest resolution possible. Table 3-1 summarizes the individual datasets comprising the ESOP-96. A brief description of each dataset is then provided in the following subsections with information regarding data collection, processing, and final archival. Acronyms within the table are defined within each dataset summary section and in Appendix B. Information on dataset dissemination is provided in section 5. As this is a planning document, not all datasets described herein may be collected. Conversely, additional datasets may be discovered at a later date and added. Information on the final ESOP-96 datasets will be provided in the ESOP-96 Tactical Data Collection and Management Report to be completed after the data collection phase of ESOP-96 is complete.

TABLE 3-1 Datasets comprising the ESOP-96

IN-SITU DATA

Surface Data

Automated Surface Observing System (ASOS) Data
FAA Automated Weather Observing System (AWOS) Data
Surface Aviation Observations (SAO) Hourly Data
SAO Special Observation Data
High Plains Climate Network (HPCN) Data
Oklahoma Mesonet Data
USDA/Agricultural Research Service (ARS) Little Washita Watershed Micronet
CoAgMet Hourly Data
Missouri Commercial Agriculture Weather Station (CAWS) Network Data
Missouri Department of Conservation Fire Weather Network Data
NMSU Monitored Climate Station Network Data
NOAA Profiler Network (NPN) Surface Observations
DOE ARM/CART Surface Meteorological Data
DOE ARM/CART Radiation Data
DOE ARM/CART EBBR and ECOR Data
DOE ARM/CART SWATS Data
USDA/ARS Little Washita Soil Moisture Data
USDA/NRCS Soil Moisture Data
NOAA/GEWEX Long-term Flux Monitoring Site Data
NWS Cooperative Observer Daily Observations
NWS Cooperative Observer Precipitation Data
ABRFC Precipitation Data
US Army Corps of Engineer (USACE) Precipitation and Streamflow Data
USGS Precipitation and Streamflow Data
USGS Reservoir Data
ESOP-96 Hourly Surface Composite
ESOP-96 5-min Surface Composite
ESOP-96 Hourly Precipitation Composite
ESOP-96 15-min Precipitation Composite
ESOP-96 Daily Precipitation Composite

Upper Air Data

NWS Upper Air Rawinsonde Data (6-sec vertical levels)
NWS Upper Air Rawinsonde Data (mandatory/significant levels)
DOE/ARM CART Site Upper Air Data
NOAA Profiler Network Data
UW AERI Data

Radar Data

WSR-88D Data
WSR-88D NIDS Data
WSI Reflectivity Composite Imagery
ABRFC Stage III WSR-88D Data (including daily GIF imagery)
NASA/MSFC National Reflectivity Composite

Land Characterization Data

PSU 1-km Multi-Layer Soil Characteristics Dataset
Little Washita River Basin Soils and Land Cover

SATELLITE DATA

GOES-8/9 Satellite Imagery (Infrared, Visible, and Water Vapor)
GOES-8/9 VAS Data/Derived Products
NOAA POES AVHRR Imagery
NOAA POES TOVS Data
DMSP SSM/I Data/Imagery
NOAA Weekly Northern Hemisphere Snow Cover Analysis
GOES/ASOS Cloud Observations
CLAVR Clouds
Satellite Radiation Datasets
EDC Bi-weekly Vegetation Index
CAGEX Products

MODEL OUTPUT

Atmospheric Model Output

AES/CMC RFE Model Output
NOAA/NCEP Eta Model Output
NOAA/NCEP Eta Model 12 UTC Initial Analysis Daily GIFs
NOAA/FSL MAPS Model Output
MOLTS Output
MOLTS Derived Sounding Output
MORDS Output

Hydrologic Model Output

ABRFC Hydrologic Model Output

3.1 IN-SITU DATA

The following in-situ datasets will be collected, processed, quality assured, archived, and disseminated at the In-Situ Data Module at the University Corporation for Atmospheric Research (UCAR)/Office of Field Project Support (OFPS). The OFPS was recently (Summer 1996) merged with the UCAR/Joint International Climate Projects/Planning Office (JICP/PO) to form the UCAR/Joint Office for Science Support (JOSS). Dataset details are provided in the following subsections. Information on data and metadata retrieval is provided in Section 5.

3.1.1 Surface Data

Automated Surface Observing System (ASOS) Data - These data include 5-minute observations of temperature, dew point, station pressure, precipitation type (rain, snow, and freezing rain), precipitation amount, wind speed, wind direction, visibility to 10 miles, and sky condition to 12,000 feet. These data are available at 67 uncommissioned and 17 commissioned sites within the LSA-SW (Figure 3-1). Data will be merged, quality controlled, and archived at the OFPS. Commissioning means that the ASOS station has passed all operational and quality assurance specifications and replaces the manual observations with 24-hour automated observations at that station. NOTE - Caution should be exercised by the researcher when using uncommissioned ASOS data.

FAA Automated Weather Observing System (AWOS) Data - These Federal Aviation Administration (FAA) AWOS data include 20-minute (except one site in Norman, OK which has 5-minute) observations of temperature, dew point, station pressure, precipitation type (rain, snow, and freezing rain), precipitation amount, wind speed, wind direction, visibility to 10 miles, and sky condition to 12,000 feet. These data are available at 33 sites within the LSA-SW (Figure 3-1). Data will be merged, quality controlled, and archived at the OFPS.

Surface Aviation Observations (SAO) Hourly Data - These data include hourly SAOs of temperature, dew point, station and sea level pressure, altimeter setting, precipitation type and amount, wind speed, wind direction, visibility, ceiling, and cloud type, height, and amount, and remarks. Data are routinely recorded at 99 sites within the LSA-SW (Figure 3-2) and will be processed and archived at National Climatic Data Center (NCDC). Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

SAO Special Observation Data - These data include the "special" SAOs. These are SAOs that are reported at off-hour times and report significant changes in conditions from the previous hourly reports. These reports can include all of the information shown above for the hourly SAOs, but more typically, report only portions of the data. A complete listing of the requirements to issue a "special SAO" are included in the Federal Meteorological Handbook No. 1 (1988). Data are routinely recorded at 99 sites within the LSA-SW (Figure 3-2) and will be processed and archived at NCDC. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

High Plains Climate Network (HPCN) Data - The HPCN mesonet routinely collects and archives hourly observations of temperature, dew point, station pressure, precipitation amount, wind speed, and wind direction to support agricultural operations on the high plains. These data are available from 19 sites in the LSA-SW (Figure 3-3). The data are collected, processed, and archived by the High Plains Regional Climate Center at the University of Nebraska/Lincoln. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

Oklahoma Mesonet Data - The Oklahoma Mesonet sites routinely collect and archive 5- minute observations of temperature (2 levels), relative humidity, station pressure, precipitation amount, wind speed (2 levels), wind direction, solar radiation, leaf wetness (selected sites), and soil temperature/moisture (selected sites). These data are available from 111 sites (at least one per Oklahoma county) in the LSA-SW (Figure 3-4). The data are collected, processed, and archived by the Oklahoma Climate Survey at the University of Oklahoma. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

USDA/ARS Little Washita Watershed Micronet - The USDA/ARS operates a 45 station micronetwork (ARS Micronet) on the Little Washita watershed (see Figure 1-2). The stations are on a 5 km by 5 km grid. All stations collect 15-min observations of temperature, relative humidity, precipitation, incoming solar radiation, and soil temperature at four depths. Three of the stations also collect 15-min observations of wind speed, wind direction, and barometric pressure. This network along with a companion network of streamflow and soil moisture sensors, provides detailed coverage of an entire watershed in southwest Oklahoma. The data are collected, processed, and archived by the USDA/ARS in Durant, OK and the Oklahoma Climate Survey at the University of Oklahoma. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

CoAgMet Data - The Colorado Climate Center routinely collects hourly observations of temperature, relative humidity, vapor pressure, solar radiation, wind speed, wind direction, precipitation, soil temperature at 2 levels, and leaf wetness. These data are available from 26 sites within Colorado (Figure 3-5). The data are from a variety of local agricultural networks and are archived by the Colorado Climate Center at Colorado State University. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

Missouri Commercial Agriculture Weather Station (CAWS) Network Data - The University of Missouri Extension operates the CAWS network of 16 automated stations over the northern and southeastern sections of Missouri (Figure 3-6). They routinely archive hourly observations of temperature, relative humidity, bare soil temperature at 2 inches, wind speed, wind direction, incoming solar radiation, and precipitation. Data for the ESOP-96 period will be extracted by the Department of Soil and Atmospheric Science at the University of Missouri and forwarded to the OFPS.

Missouri Department of Conservation Fire Weather Network Data - The Missouri State Department of Conservation (DOC) operates a network of eight (the US Forest Service and US Park Service operate an

additional three) automated stations over the southern sections of Missouri (Figure 3-7). They routinely archive hourly observations of temperature, relative humidity, wind speed, wind direction, and precipitation. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

NMSU Monitored Climate Station Network Data - The New Mexico State University (NMSU) operates a network of 23 automated stations over the state of New Mexico (Figure 3-8). They routinely archive hourly observations of temperature, relative humidity, precipitation, wind speed, wind direction and solar radiation. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

NOAA Profiler Network (NPN) Surface Observations - The NPN routinely record hourly and 6-minute surface observations of temperature, dew point, station pressure, precipitation amount, wind speed, and wind direction at 13 of its 16 profiler sites in the LSA-SW (see Figure 3-17). The data are routinely collected and processed by NOAA/Forecast Systems Laboratory (FSL) and archived at NOAA/NCDC. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

DOE ARM/CART Surface Meteorological Data - The DOE ARM Program routinely obtains surface measurements from its Surface Meteorological Observation Stations (SMOS) at the Southern Great Plains CART site in Kansas and Oklahoma. These measurements include radiometric, wind, temperature, humidity, clouds, and surface flux at 15 extended facilities in the LSA-SW (Figure 3-9). The data are collected and processed by the DOE ARM Program and archived at DOE Oak Ridge National Laboratory (ORNL). Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

DOE ARM/CART Radiation Data - The DOE ARM Program has a variety of radiation instrumentation located at the Southern Great Plains CART site in Kansas and Oklahoma. These instruments include the Solar and Infrared Radiation Observing System (SIROS) which provides measurements of up and down-welling hemispherical solar irradiances, direct-beam solar irradiance, diffuse hemispherical solar irradiance from the sky and up- and down-welling hemispherical infrared irradiances via its collection of instruments including the Multifilter Rotating Shadowband Radiometer (MFRSR), pyranometer, pyrheliometer, and pyrgeometer at 19 of the ARM extended facilities, including the central facility (see Figure 3-9). There is a MultiFilter Radiometer (MFR) at the central facility which provides measurements of upwelling radiation at 10 m. The Atmospheric Emitted Radiance Interferometer (AERI) provides measurements of infrared irradiances at zenith at the central facility. A 60 m tower at the central facility provides measurements of upwelling hemispheric infrared irradiance as well as upwelling hemispherical solar radiation from 25 m using a pyranometer, pyrgeometer, and a MFR. The ARM Broadband Solar Radiation Network (BSRN) at the central facility provides measurements of infrared and solar irradiances as well as direct solar irradiance and direct, diffuse, and total solar irradiances at six selected wave bands and a wide band. Also at the central facility there is a pyrometer at 10 m above pasture that measures 10 micron upwelling radiation and a similar instrument at 25 m above a wheat field. The data are collected and processed by the DOE ARM Program and archived at DOE ORNL. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

DOE ARM/CART EBBR and ECOR Data - The DOE ARM/CART program operates a network of Eddy Correlation (ECOR) systems that provide measurements of the surface momentum and latent and sensible heat fluxes. By 1 April, 1996 ECOR systems are planned to be operational at nine of the ARM extended facilities (Figure 3-10) located over wheat and other crops. The ARM/CART program also operates a network of Energy Balance Bowen Ratio (EBBR) systems that provide measurements of sensible and latent heat fluxes. By 1 April 1996 EBBR systems are planned to be operational at 11 of the extended facilities (all but one are located at the extended facilities which do not have the ECOR system) located over pasture and rangeland. Ten of the EBBR stations are also equipped to provide soil moisture and temperature profiles in the 3 to 5 cm range at five points around each station. The EBBR soil moisture profiles provide information for correcting the thermal conductivity of the soil so the soil heat fluxes can be determined. The accuracy of these measurements may not be sufficient for some model evaluation purposes. The data are collected and processed by the DOE ARM Program and archived at DOE ORNL.

DOE ARM/CART Soil Water and Temperature System (SWATS) Data - The DOE ARM/CART program operates a network of eight SWATS sites located at eight of the extended facilities (see Figure 3-10). The

Campbell Scientific Heat Dissipation Soil Moisture Sensor is used to provide soil moisture and temperature measurements at eight depths: 5, 15, 25, 35, 60, 85, 125, and 175 cm. Each site will have two profiles located one meter apart. The data are collected and processed by the DOE ARM program and archived at DOE ORNL.

USDA/ARS Little Washita Soil Moisture Data - The USDA/ARS is installing soil moisture and temperature sensors at several locations within the Little Washita watershed. The soil moisture sensors are being installed at six depths: 5 (3 sensors), 10, 15, 20, 25, and 60 cm. The three sensors at 5 cm are installed 10 cm apart. By May 1996 10 sites are to be operational. The data are collected, processed, and archived by the USDA/ARS in Durant, OK and the Oklahoma Climate Survey at the University of Oklahoma. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

USDA/Natural Resource Conservation Service (NRCS) Soil Moisture Data - Limited soil moisture data is available for the LSA-SW from the USDA/NRCS. Most soil moisture measurements are manually performed and are not routinely scheduled until the spring planting season (i.e. April and May). These data are collected, processed, and archived by the NRCS in Portland, OR. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

NOAA/GEWEX Long-Term Flux Monitoring Site Data - The NOAA/GEWEX long-term flux monitoring site is operated by NOAA/Air Resources Laboratory (ARL) and is located in the Little Washita watershed (see Figure 1-2). It provides measurements of air temperature, humidity, precipitation, surface momentum and sensible and latent heat fluxes, net radiation, incoming and outgoing Photosynthetically Active Radiation (PAR) and infrared irradiances. The data are collected, processed and archived by NOAA/ARL.

NWS Cooperative Observer Daily Observations - Data are routinely collected at approximately 2700 sites operated by cooperative observers over the conterminous United States and are processed and archived by NOAA/NCDC. This network records daily observations of maximum and minimum temperature, precipitation, snowfall, snow depth, and snow/ice cover at approximately 100 km spacing over the conterminous United States. Daily observations of evaporation are available at approximately 200 km spacing and daily observations of soil temperature and moisture are available at about 500 km spacing. Data for the 1389 stations within the LSA-SW (Figure 3-11) will be extracted and forwarded to the OFPS.

NWS Cooperative Observer Precipitation Data - Data are routinely collected at approximately 2700 sites operated by cooperative observers over the conterminous United States and are processed and archived by NOAA/NCDC. For the LSA-SW these data include 15-minute (431 sites) or hourly (27 sites) observations of precipitation from Fisher-Porter and Universal rain gages operated by Cooperative Observers (Figure 3-12). Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

ABRFC Precipitation Data - These data include real-time precipitation observations from 949 ABRFC stations. The frequency of the observations varies from 15 min (185 stations) to hourly (257 stations) to stations that collect data with no set schedule (507 stations). A map of the ABRFC precipitation stations is shown in Figure 3-13. These data are archived by the NWS Office of Hydrology (OH) in Silver Spring, MD. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

US Army Corps of Engineer (USACE) Precipitation and Streamflow Data - These data include hourly observations of precipitation and daily observation of streamflow from USACE operational gages. Approximately 50 stations are located within the LSA-SW and all data are available through the United States Geological Survey (USGS) National Water Data Exchange (NAWDEX) Office in Reston, VA as well as the USGS and USACE district offices. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

USGS Precipitation and Streamflow Data - These data include daily observations of precipitation and streamflow from USGS gages. A total of 759 streamflow stations (Figure 3-14) are located within the LSA-SW and all data are available through the USGS NAWDEX Office in Reston, VA as well as the district (state) offices. Preliminary data are received monthly at the OFPS from all districts in the ESOP-96 domain. These preliminary data will be replaced by final quality assured data by the USGS nine months after the completion of the water year (October 1996). Data for the ESOP-96 period will be extracted and forwarded to the OFPS. NOTE - The streamflow data are generally not adjusted for diversions or reservoir storage.

USGS Reservoir Data - These data include daily observations of reservoir capacity for 103 reservoirs within the LSA-SW (Figure 3-15). All data are available through the USGS NAWDEX Office in Reston, VA as well as the USGS and USACE district offices. Data for ESOP-96 period will be extracted and forwarded to the OFPS. The USGS also collects well water height data. Available well water height data for sites within the LSA-SW will be extracted and forwarded to OFPS.

ESOP-96 Hourly Surface Composite - This composite will contain surface and sea level pressure, temperature, dew point, wind speed and direction, and precipitation hourly observations from surface observing sites in the LSA-SW as well as visibility, present weather, ceiling and cloud type heights and amounts for those stations that report them (generally SAO and ASOS). This composite will not contain the precipitation data from those sites that collect only precipitation data (i.e. the site must also collect meteorological observations to be included). The precipitation only sites will be contained within the precipitation composites which are described below. The composite will be produced by the OFPS and contain hourly data from the following networks: ASOS, AWOS, SAO's, HPCN, Oklahoma Mesonet, ARS Micronet, CoAgMet, CAWS, Missouri DOC Fire Weather Network, NMSU Climate Network, NPN surface observations, and DOE ARM/CART. These data will be quality controlled by OFPS (see section 4.1.1).

ESOP-96 5-minute Surface Composite - Similar to the ESOP-96 hourly surface composite (above) but only the 5-min data from Oklahoma Mesonet and DOE ARM/CART surface stations will be merged and quality controlled (see section 4.1.1) to form this composite.

ESOP-96 Hourly Precipitation Composite - The hourly precipitation composite will contain precipitation data from all real-time and recording gages in the LSA-SW. The composite will be produced by the OFPS and contain hourly totals from gages in the following networks: ASOS, AWOS, SAO's, HPCN, Oklahoma Mesonet, CoAgMet, CAWS, Missouri DOC Fire Weather Network, NMSU Climate Network, DOE ARM/CART, NWS Cooperative Observer, ABRFC, and USDA/ARS. These data will be quality controlled by OFPS (see section 4.1.2).

ESOP-96 15-minute Precipitation Composite - The 15-min precipitation composite will be formed from data from four sources, the ABRFC 15-min precipitation data, NCDC 15-min precipitation data, Oklahoma Mesonet precipitation data, and the precipitation data extracted from the 5-min surface composite. Data from these four sources will be quality controlled (see section 4.1.2) and merged to form the composite. The composite will be produced by OFPS.

ESOP-96 Daily Precipitation Composite - The daily precipitation composite will contain precipitation data from all real-time and recording gages in the LSA-SW. The composite will be produced by the OFPS and contain daily totals from gages in the following networks: ASOS, AWOS, SAO's, HPCN, Oklahoma Mesonet, CoAgMet, CAWS, Missouri DOC Fire Weather Network, NMSU Climate Network, DOE ARM/CART, NWS Cooperative Observer, ABRFC, USGS, USACE, and USDA/ARS. These data will be quality controlled by OFPS (see section 4.1.2).

3.1.2 Upper Air Data

NWS Upper Air Rawinsonde Data (6-sec vertical levels) - These data will contain 12-hourly (occasionally more frequent at the request of the NWS) vertical profiles of time, pressure, temperature, altitude, relative humidity, wind speed and direction, complete with quality flags, at 6-sec intervals from the surface to the top of each sounding, usually about 25 mb. These high resolution data will be obtained from 12 NWS sites in the LSA-SW (Figure 3-16). All data will be processed by the OFPS.

NWS Upper Air Rawinsonde Data (mandatory/significant levels) - These data include 12- hourly vertical profiles of pressure, altitude, temperature, dew point, and wind speed and direction at all mandatory and significant levels. Data are routinely collected at 72 sites (approximately 400 km spacing) over all of the conterminous United States and archived at NOAA/NCDC. Data for the LSA-SW (see Figure 3-16) will be archived and available at NCDC.

DOE ARM/CART Site Upper Air Data - The DOE ARM Program routinely obtains upper air observations, at 2-sec vertical resolution, at the Southern Great Plains CART site in Kansas and Oklahoma. These measurements include up to 3-hourly soundings of pressure, temperature, humidity, and wind at a central site and 4 boundary facilities in the LSA-SW (see Figure 3-9). The data are collected and processed by the DOE ARM Program and archived at the DOE/ORNL. Data for the ESOP-96 period will be extracted and forwarded to the OFPS.

NOAA Profiler Network (NPN) Data - The NPN routinely collects vertical profiles of hourly component winds (u, v, and w) and six-minute radar return spectral moments, both with 250 meter resolution. These data are taken at about 200 km spacing over Oklahoma and Kansas and about 450 km spacing over the central U.S. for a total of 28 sites. Three of the NPN sites (Haviland, KS; Purcell, OK; and White Sands NM) have collocated Radio Acoustic Sounding Systems (RASS) and two others (Morris and Vici, OK) will have them by June 1996. RASS allows for the calculation of vertical profiles of virtual temperature at 250 m vertical resolution every 6 min. The data are routinely collected and processed by NOAA/FSL and archived at NOAA/NCDC. Data for the LSA-SW (Figure 3-17) will be extracted and forwarded to the OFPS.

University of Wisconsin AERI Data - The University of Wisconsin is operating an Atmospherically Emitted Radiance Interferometer (AERI) system at the ARM/CART central facility (see Figure 3-9). AERI is a ground-based high resolution interferometer which provides measurements of infrared radiation yielding radiance spectra which are then transformed to vertical temperature and water vapor profiles in the planetary boundary layer. The profiles are generated every 10 minutes. The data are collected and processed by the DOE ARM program and archived at DOE ORNL.

3.1.3 Radar Data

WSR-88D Data - Data from the WSR-88D network (Figure 3-18) are divided into a number of archive levels depending upon the level of processing performed. Archive I is the raw engineering data; Archive II contains reflectivity and radial velocity information at the highest resolution and over each full volume scan of the radar; and Archive III contains operational products as graphics meta files from commissioned radars. Archive II provides the basis for all high level products while Archive III includes a variety of products including base level reflectivity and velocity data at 1 km by 1° resolution and hourly precipitation at 4 km by 4 km. Since Archive III data are stored as graphics meta files, they are extremely difficult to work with digitally and are best used as hardcopy browse products. Included in the Archive III are some digital products, in particular the Digital Precipitation Array of hourly data on a 4 km by 4 km grid and the Supplemental Precipitation Product giving information on the performance of the precipitation algorithms and coarser resolution precipitation data. Archive II and III data are routinely archived and available at the NOAA/NCDC.

WSR-88D NIDS Data - The NEXRAD (now WSR-88D) Information Dissemination Service (NIDS) will be provided to OFPS from Weather Services International (WSI) through the Cooperative program for Operational Meteorology, Education, and Training (COMET). NIDS products consist of selected information from the Level III database from each WSR-88D site (Table 3-2). Data for the ESOP-96 period (Figure 3-18) will be extracted and forwarded to OFPS for archival.

TABLE 3-2 WSR-88D NIDS Products and Descriptions

Reflectivity
The first four tilt angles are available. The resolution is 1 km by 1°.

Composite Reflectivity
The maximum reflectivity observed at any level above a given part of the earth. The range is 460 km.

Echo Tops
The height in feet above mean sea level of the highest detected echo above a given location.

Vertically Integrated Liquid
Displays integrated liquid water values summed for all elevation angles within the volume scan. The range is 460 km.

Surface Rainfall Accumulation (1-hr)
One hour running total of surface rainfall accumulation. The resolution is 2 km by 2 km.

Surface Rainfall Accumulation (3-hr)
Three hour total surface rainfall accumulation (updated hourly). The resolution is 2 km by 2 km.

Storm Total Rainfall
Rainfall accumulated until no precipitation is detected for one continuous hour. The resolution is 2 km by 2 km.

Hourly Digital Rainfall Array
An hourly running total precipitation accumulation estimate in a derived array format.

Radial Velocity
The speed toward or away from the radar antenna. The first four tilt angles are available. The resolution is 1 km by 1°.

Velocity Azimuth Display
Vertical wind profiles for up to ten time periods.

Layer Composite Reflectivity
Composites of reflectivity through a layer of the atmosphere. Three layers are available with the depths controlled by adaption data. The range is 450 km.

NOTE: Unless otherwise noted, the resolution is 4 km by 4 km and the range is 230 km.

WSI Reflectivity Composite Imagery - The WSI routinely produces and distributes a mosaic of reflectivity from all NWS radars in the conterminous United States. The product, called NOWRAD, is available at a variety of resolutions and coverages in real time. For ESOP-96, 2 km data will be recorded at 15 minute intervals in a fixed sector overlaying the LSA-SW. From this dataset a representative daily image will be selected at 12 UTC, or the closest available time, to coincide with the NOAA/National Centers for Environmental Prediction (NCEP) Eta model daily weather map imagery and the GOES-8 infrared image. The selected daily images will be translated to GIF (Graphical Interchange Format). These will be available online for browsing purposes. The full 15-min dataset in its original format will be available directly from OFPS. These images will be obtained at the OFPS from the NOAA/National Severe Storms Forecast Center (NSSFC) in Kansas City, MO.

ABRFC Stage III WSR-88D Data - The ABRFC routinely produces an hourly composite derived precipitation product from all the WSR-88D radars covering the Arkansas-Red River basins. These data are on a 4 km by 4 km grid and are in GRIB (GRId point values expressed in Binary format). These data are archived by NOAA/OH together with the digital precipitation array and the supplemental precipitation product (Stage I) and the Stage II hourly precipitation processing system products. Data for ESOP-96 period will be extracted and forwarded to OFPS. The OFPS will provide daily 24-hr total precipitation estimate GIF imagery for online browse purposes.

NASA/MSFC National Reflectivity Composite - The NASA/Marshall Space Flight Center (MSFC) ingests 15-min 2 km NOWRAD composite data for the whole US. The 2 km data are available in HDF (Hierarchical Data Format) only. These files will be translated to 8 km GIF and provided to OFPS. OFPS will select representative daily imagery at 1200 UTC (or the closest available time) and they will be available for online browse purposes. A daily continental US composite precipitation summary is also being derived from the composite radar data. These daily rainfall data are also available in 2 km HDF or 8 km GIF format from NASA/MSFC/Global Hydrology and Climate Center (GHCC) Distributed Active Archive Center (DAAC).

3.1.4 Land Characterization Data

PSU 1-km Multi-Layer Soil Characterization Dataset - The Pennsylvania State University (PSU) is developing a 1-km Multi-Layer Soil Characterization Dataset based on the USDA State Soil Geographic Database (STATSGO). As of this writing this includes STATSGO mapunit coverage defined for the 48 conterminous states, soil texture class coverages (for 11 layers from the surface to 250 cm below ground), and depth-to-bedrock coverage. Planned additions to these parameters include particle size distribution, rock fragment class, rock fragment volume, porosity, hydrologic soil groups, and available water capacity. Data are available in either vector (Arc/Info polygon format) or gridded (Arc/Info GRID format or as two-dimensional binary arrays). Data are processed and archived at the PSU Earth System Science Center.

Little Washita Basin Soils and Land Cover - These data are still in production by the USDA/ARS at the time of this writing.

3.2 SATELLITE DATA

The following satellite datasets will be coordinated through the Satellite Data Source Module (NASA/MSFC). Further details by dataset are provided below:

GOES-8/9 Satellite Imagery (IR, VIS, 6.7 micron) - Most of the satellite data for ESOP-96 will be obtained from two geosynchronous Geostationary Operational Environmental Satellites (GOES-8/9) positioned near 75° and 135° longitude. The primary instrumentation on GOES-8/9 is the Visible (VIS) and Infrared (IR) Spin-Scan Radiometer (VISSR) which produces both day and night IR [10.5 to 12.5 micrometers] and day VIS [0.5 to 0.7 micrometers] radiometric images of the full disk at 30-min intervals. In addition, the VISSR Atmospheric Sounder (VAS) sensor has four IR detectors and 12 narrow band filters that produces multi-spectral data [from 14.73 to 3.95 micrometers]. During ESOP-96, image frequency may be increased by placing the satellites into Rapid Interval Scan Operations Plan (RISOP) mode or "Rapid Scan". Under RISOP, up to 60 VIS/IR images per hour can be obtained depending on location of interest. Note that during RISOP, normal, scheduled VAS operations can be suspended or changed. These data are routinely archived by NOAA/National Environmental Satellite, Data, and Information Service (NESDIS)/NCDC at the University of Wisconsin's Space Science Engineering Center (SSEC). For the ESOP-96 domain, OFPS collected VIS and IR imagery every 30-min, and water vapor (6.7 micrometers) imagery every hour from the NOAA/NSSFC.

GOES-8/9 VAS Data/Derived Products - The GOES-8/9 VISSR Atmospheric Sensor (VAS) provides IR radiance observations at 12 wavelengths between 3.9 and 14.7 micrometers as well as two imaging modes (6.9 to 13.8 km resolution) and a sounding mode (13.8 km resolution). Meteorological parameters derived from VAS (for clear and partly cloudy areas) includes: cloud cover, earth/cloud temperatures, cloud type, cloud motion derived winds, stereo derived cloud-top heights, water vapor fields, temperature fields, improved surface temperatures, and temperature and moisture profiles (dwell soundings). The interval and number of dwell soundings and derived products depend upon whether the satellites are in normal operation or RISOP mode. VAS data is routinely archived by NOAA/NESDIS/NCDC at the University of Wisconsin's SSEC.

NOAA POES AVHRR Imagery - Two NOAA series Polar Orbiting Environmental Satellites (POES; NOAA-12 and NOAA-14) carry the Advanced Very High Resolution Radiometer (AVHRR). AVHRR is a cross-track scanning system with five spectral channels in the visible, near-infrared, and infrared [0.58 to 12.50 micrometers]. The normal operating mode of the satellites results in continuous High Resolution Picture Transmission (HRPT) to earth, where the data are recorded by a network of ground stations. AVHRR data include 1-km resolution HRPT or LAC (Local Area Coverage) and 4-km resolution GAC (Global Area Coverage) resolution imagery (1600 km swath) during subsequent sun-synchronous morning/evening ascending and descending passes (up to 4 passes daily). AVHRR data are routinely collected, processed, and archived at NOAA/NESDIS/NCDC.

NOAA POES TOVS Data - Two NOAA series polar orbiting satellites (NOAA-12 and NOAA-14) carry the microwave Television and Infrared Observation Satellite (TIROS) Operational Vertical Sounder (TOVS). The TOVS system consists of four separate sensors: (1) High Resolution Infrared Radiation Sounder (HIRS/2), which measures incident radiation primarily in the infrared; (2) Microwave Sounding Unit (MSU), a passive scanning microwave spectrometer with 4 channels (5.5 micrometer region); (3) Stratospheric Sounding Unit (SSU), a step-scanned far-infrared spectrometer with three channels (15 micrometer region); and (4) Solar Backscattered

Ultraviolet system (SBUV/2), which maps total ozone concentrations and vertical ozone distributions. Data are collected (1600 km swath) during subsequent sun-synchronous morning/evening ascending and descending passes (up to 4 passes daily). TOVS data are routinely collected, processed, and archived at NOAA/NESDIS/NCDC.

DMSP SSM/I Data/Imagery - The United States Air Force (USAF) operates the Defense Meteorological Satellite Program (DMSP) which is a system of near polar orbiting satellites (F12 and F13) that provide global microwave data from the Special Sensor Microwave Imager (SSM/I). The SSM/I sensor provides water vapor measurements (1400 km swath) at three frequencies (19.35, 37.0, and 85.5 GHz). DMSP data are routinely archived at the National Snow and Ice Data Center (NSIDC) at Boulder, CO.

NOAA Weekly Northern Hemisphere Snow Cover Analysis - NOAA weekly snow cover analyses are created on a hemispheric map and faxed to the NCDC from the NESDIS Synoptic Analysis Branch. The analysis is done over a 7-day period and extends from 35o north latitude to 67o north latitude. Because of the use of satellite techniques, the analysis is not done beyond 67o north latitude since there are mostly dark hours. The categories in the analysis are snowcover, patchy snowcover, ice, and open. Each analysis clearly indicates which imagery sources were used to identify the ice. Satellite imagery used includes GOES, POES, DMSP, METEOSAT (Meteorological Satellite), and GMS (Geostationary Meteorological Satellite). These analyses are archived at NCDC and are available via FAX subscription.

GOES/ASOS Cloud Observations - The GOES/ASOS cloud height and amount data are being archived by NESDIS. ASOS stations have been installed and commissioned at many surface sites across the United States. It will eventually replace manual observations at as many as 1700 locations. ASOS collects meteorological data from a suite of instruments, merges the data into SAO format, and transmits it to various communications circuits such as the NWS Automated Field Operations and Services (AFOS) and Family of Services (FOS) networks. A limitation of ASOS is that it does not detect cloud bases above 12,000 feet. To compensate for this limitation, a satellite-based ASOS processing system has been developed to detect cloud height and fractional cloud amount for the middle and upper levels of the atmosphere. The GOES-8 ASOS processing system will use data from the GOES-8 sounder instrument and will be generated on an IBM RS/6000 workstation at hourly intervals.

Extraction of cloud height and amount is accomplished by means of the "CO2 slicing" technique which calculates the cloud information from radiative transfer equations. The technique uses multi-spectral IR data in the CO2 and longwave window channels, as well as ancillary surface and numerical forecast temperature and moisture profiles. Solution of the radiative transfer equations results in the determination of cloud top pressure and effective cloud amount. Application of empirical decision trees results in a composite cloud height and amount for a 40 by 40 km area centered on a particular ASOS station. These data are being produced at NOAA/NESDIS routinely in real-time. They can be accessed via the Satellite Data Source Module (SDSM) home page (see Section 5.1.2). These data are also available in McIDAS area format, please contact the SDSM for data access.

CLAVR Clouds - The CLouds from AVhRr (CLAVR) product is currently in development within NESDIS. Version 1 has been developed and used within NESDIS. A Version 2 is being produced for developmental purposes as well. Users wanting access to this data should contact the GCIP SDSM.

Satellite Radiation Datasets - These products use five channels of GOES-8 data, Eta model forecasts, and USAF snow cover analyses to create gridded one degree resolution products in the domain from 20°N to 50°N and 65°W to 125°W. These images are available hourly in GIF and binary formats and are online via the GCIP SDSM home page. The products will be reviewed and validated during the ESOP-96 period. A list of the available products is in Table 3-3.

TABLE 3-3 Satellite Radiation Datasets

Mean radiance (channel 1)
Mean radiance (channel 2)
Mean radiance (channel 3)

Mean radiance (channel 4)
Mean radiance (channel 5)
Clear sky composite radiance
Number of clear pixels
Number of cloudy pixels
Snowcover
Standard deviation of channel 1
Standard deviation of channel 4
Precipitable water
Temperature at first level above surface
Surface pressure
Surface downward flux (clear + cloudy)
Surface upward flux (clear + cloudy)
Top of atmosphere downward flux (clear + cloudy)
Top of atmosphere upward flux (clear)
Surface downward flux (clear)
Surface downward flux (cloudy)

EDC Bi-Weekly Vegetation Index - Satellite-derived values of vegetation index are routinely produced at NOAA/NESDIS and the Earth Resources Observation Systems (EROS) Data Center (EDC) at Sioux Falls, SD. One set of data at 1 km resolution is available bi-weekly from the EDC while another set at 15 km resolution is available weekly from the NOAA/NESDIS in Washington, D.C. The land cover imagery will be produced bi-weekly from 1 km resolution AVHRR and translated to GIF by the USGS EDC. The full land characteristics database will be available on CD-ROM from EDC. GIF imagery data for ESOP-96 will be extracted and forwarded to the OFPS from the EDC.

CAGEX Products - The CERES (Clouds and the Earth's Radiant Energy System)/ARM/ GEWEX Experiment (CAGEX) is intended to foster the development of algorithms for the retrieval of vertical profiles of broadband radiative fluxes with satellite data. CAGEX provides satellite-based cloud properties, atmospheric sounding data, and other necessary input parameters that are sufficient for broadband radiative transfer calculations. Version 1 of CAGEX occurred in April 1994, Version 2 in October 1995. These were on a 3 by 3 0.3° grid over the ARM central facility. During ESOP-96, Version 3 of CAGEX will occur from 1 April to 30 September. The geographical areal extent will be a 28 by 20 0.5° grid spanning a large portion of the continental US. The Version 3 data are planned to be in half hour time steps with 24 hour coverage. The vertical resolution will be variable, with 45-50 levels depending on the surface pressure. From the surface to 40 mb above the surface the levels will be at 10 mb increments, from 40-100 mb above the surface the levels will be at 20 mb increments. Then from 100 mb above the surface to 700 mb the levels will be at 25 mb increments. Then from 700-100 mb the levels will be at 25 mb increments (i.e. start constant pressure level data). Above 100 mb there will be eight variously spaced levels. Satellite products include cloud retrievals from the Layered Bi-spectral Thresholding Method applied to GOES-8 VIS and IR images (Minnis et al. 1995). These include low, middle, high, and total values for cloud fraction, cloud center and top temperature and height, cloud thickness, VIS and IR optical depths, cloud reflectance, cloud albedo, and cloud IR emissivity. These data are archived at the NASA/Langley Research Center. Further information and data are available from the following URL:

http://snowdog.larc.nasa.gov:8081/cagex.html

3.3 MODEL OUTPUT

3.3.1 Atmospheric model output

The following atmospheric model output will be coordinated through the Model Output Source Module [NCAR/Scientific Computing Division (SCD)]. Further details by output set are provided below:

The emphasis for model output during ESOP-96 is on the regional mesoscale models with output from the following three models:

(i) Atmosphere Environment Service/Canadian Meteorological Center (AES/CMC) Regional Finite Element (RFE) Model
(ii) NOAA/NCEP Eta Model
(iii) NOAA/FSL Mesoscale Analysis and Prediction System (MAPS) Model

The outputs from these models follow the guidelines of the GCIP Implementation Plan, Vol I, Section 5 (IGPO, 1993) and are divided into three parts:

(1) One-dimensional vertical profile and surface time series at selected locations, referred to as Model Location Time Series (MOLTS).
(2) Gridded two-dimensional fields, especially ground surface state fields, ground surface flux fields, top-of-the-atmosphere flux fields, and atmospheric fields, referred to as Model Output Reduced Datasets (MORDS).
(3) Gridded three-dimensional atmospheric fields containing all of the atmospheric variables produced by the models.

AES/CMC RFE Model Output (6 hourly) - The AES/CMC will provide operational output from the RFE model including output from its data assimilation system. The RFE operates in analysis (6-hr intervals) and forecast (12-hr intervals) cycles with forecasts up to 24 hours. Table 3-4 provides characteristics of the model. The vertical levels are at a variable spacing, with higher resolution in the lower levels. Model output will be archived by the AES/CMC.

NOAA/NCEP Eta Model Output - The NOAA/NCEP will provide operational output from its regional Eta model including output from the Eta Data Assimilation System (EDAS). The Eta operates in analysis and forecast cycles at 6-hr intervals with forecasts provided up to 24 hours. The EDAS is also run at the intermediate 3-hourly intervals to produce eight analyses per day. Table 3-4 provides characteristics of the model. The horizontal resolution for GCIP is constant regardless of the resolution of the model. These data will be archived by NCAR/SCD.

NOAA/FSL MAPS Model Output - The NOAA/FSL will run the MAPS model every 3 hours with up to 6 hour forecasts during the ESOP-96. Characteristics of the model are provided in Table 3-4. The data cutoff for model runs is approximately 1 hour, and the output format is GRIB. These data will be archived by NCAR/SCD.

TABLE 3-4 Regional Model Characteristics

Model	Analysis Cycles	Forecast Cycles	Forecast Length (h)	Resolution (km)	Vertical Levels	MOLTS in LSA-SW	MOLTS parameters Upper Air/Surface
Eta	3 hourly	6 hourly	48	40	38	64	12/40
RFE	6 hourly	12 hourly	24	35	28	53	27/28
MAPS	3 hourly	3 hourly	6	40	40	64	16/30

MOLTS Output - The NOAA/NCEP Eta, NOAA/FSL MAPS, and AES/CMC RFE models will be providing vertical and surface hourly time series of model output at selected locations (MOLTS). The fundamental output variables for the MOLTS are shown in Table 3-5. The MOLTS list from a specific model may add other parameters depending on the choice of physics package or other non-GCIP user requirements. Some examples for the surface parameters could include turbulent kinetic energy and other diabatic heating and moistening rates, such as those due to vertical and horizontal diffusion. Some examples of the non- profile variables could include canopy water content, boundary layer depth, convective storm stability indices, precipitation type, etc.

The NOAA/NCEP Eta model MOLTS output will be available from 299 locations over North America. Within the LSA-SW there will be 64 locations (Figure 3-19). This output will contain 40 surface state and flux parameters and 12 parameters at each of the 38 vertical levels. Output will be provided from the 00 and 12 UTC runs from the initial analysis time out to 48 hours.

The AES/CMC RFE model MOLTS output will be available from 217 locations over North America. Within the LSA-SW there will be 53 locations (see Figure 3-19). This output will contain 28 surface parameters and 27 parameters at each of the 28 vertical levels. Output will be provided from the 00 and 12 UTC runs from the initial analysis time out to 36 hours.

The NOAA/FSL MAPS model MOLTS output will be available from 270 locations over North America. Within the LSA-SW there will be the same 64 locations as the NOAA/NCEP Eta model (see Figure 3-19). This output will contain 30 surface parameters and 16 parameters at each of the 40 vertical levels. Output will be provided from each 3- hourly MAPS run from the initial analysis time out to 6 hours. All of these output will be archived in BUFR (Binary Universal Form for data Representation) format at NCAR/SCD.

TABLE 3-5 Fundamental Output Variables for the MOLTS

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1) Identifiers

Location ID
Valid date/time
Latitude/Longitude/Elevation

2) Surface Parameters

Mean sea level pressure
Surface pressure
Skin temperature
Total precipitation in last hour
Convective precipitation in last hour
Latent heat flux
Sensible heat flux
Snow phase-change heat flux
Short-wave radiation flux downward and upward
Long-wave radiation flux downward and upward
Net long-wave radiative flux at top of atmosphere
Net short-wave radiative flux at top of atmosphere
Soil temperature
Soil moisture
Snow water equivalent
Snow melt
Surface runoff
Baseflow-groundwater runoff
U-wind and V-wind components at 10 m
Temperature at 2 m
Specific humidity at 2 m

3) Atmospheric Variables at Each Model Vertical Level

Pressure
Geopotential height
Temperature

U-wind component
V-wind component
Specific humidity
Omega (vertical motion)
Convective precipitation latent heating rate
Stable precipitation heating rate
Shortwave radiation latent heating rate
Longwave radiation latent heating rate
Cloud water mixing ratio
Cloud fraction in a layer

MOLTS Derived Sounding Output - OFPS will extract from the MOLTS output from the locations within the LSA-SW for each of the three models described above (see Figures 3-19 and 3-19). These output will then be processed and converted to a format similar to that used for the actual atmospheric sounding data (i.e. NWS and ARM/CART). This will be done by stripping out the state parameters at the surface and each model level. Only the 00 hour initial analysis time will be processed. Output will be available from each model analysis time. This output is provided to allow intercomparison studies. These output will be archived at OFPS.

MORDS Output - An analysis of the different GCIP requirements for the gridded two- and three-dimensional fields indicates that most of the requirements can be met by a selected set of two-dimensional gridded fields. [NOTE: Some of the requirements for three-dimensional fields can also be met with the MOLTS, e.g. by placing the locations around the boundaries of a river basin to do budget studies. Some of the other three-dimensional field requirements can be met by a vertical integration through the atmosphere, e.g. vertically integrated atmospheric moisture divergence needed to calculate water budgets]. GCIP will make use of this concentration of requirements to further tractability of the model output handling problem. A Model Output Reduced Dataset (MORDS) will be produced as two-dimensional fields with the expectation that the MORDS can meet most of the GCIP requirements at a significantly reduced data volume over that needed to provide the information as three-dimensional fields. GCIP is proposing a total of 60 output variables for MORDS separated into the following four components:

(1) Near-surface fields which will include all the sub-surface and surface land characteristics and hydrology variables plus the surface meteorological variables including wind components at 10 m.
(2) Lowest-level atmospheric fields which includes the lowest model level and the mean value in a 30 hPa layer above the surface.
(3) Upper atmosphere fields at a few standard levels plus the tropopause height and the top-of-the-atmosphere radiation as a time average.
(4) Metadata fixed fields as one-time companion file to the MORDS.

The specific model output variables in each of the four components are listed in Table 3-6. The output from the three models may not include all of the variables listed in Table 3-6, and this fact will be a part of the metadata provided with the specific model output. The output from each of the three models will be provided on a standard AWIPS (Advanced Weather Interactive Processing System) 212 grid (Figure 3-20) in GRIB format.

TABLE 3-3 MORDS Output Variables

Near-Surface Fields

Mean sea level pressure
Surface pressure at 2 m
Temperature at 2 m
Specific humidity at 2 m
U component of the wind at 10 m

V component of the wind at 10 m
Surface latent heat flux (time average)
Surface sensible heat flux (time average)
Ground heat flux (time average)
Snow phase change heat flux (time average)
Surface momentum flux (time average)
Vertically integrated moisture convergence (time average)
Vertically integrated energy convergence (time average)
Total precipitation (time accumulated)
Convective precipitation (time accumulated)
Surface runoff (time accumulated)
Subsurface runoff (time accumulated)
Snow melt (time accumulated)
Snow depth (water equivalent)
Total soil moisture (within total active soil column)
Canopy water content (if part of surface physics)
Surface skin temperature
Soil temperature in top soil layer
Surface downward shortwave radiation (time average)
Surface upward shortwave radiation (time average)
Surface downward longwave radiation (time average)
Surface upward longwave radiation (time average)
Total cloud fraction (time average)
Total column water vapor
Convective Available Potential Energy

Lowest-Level Atmospheric Fields

Temperature (lowest model level)
Specific humidity (lowest model level)
U component of the wind (lowest model level)
V component of the wind (lowest model level)
Pressure (lowest model level)
Geopotential (lowest model level)
Temperature (mean in 30 hPa layer above ground)
Specific humidity (mean in 30 hPa layer above ground)
U component of the wind (mean in 30 hPa layer above ground)
V component of the wind (mean in 30 hPa layer above ground)

Upper Atmospheric Fields

1000 hPa height
700 hPa vertical motion
850 hPa height
850 hPa temperature
850 hPa specific humidity
850 hPa U component of the wind
850 hPa V component of the wind
500 hPa height
500 hPa absolute vorticity
250 hPa height
250 hPa U component of the wind
250 hPa V component of the wind
Tropopause height (or pressure)

Top-of-the-atmosphere net longwave radiation (time average)
Top-of-the-atmosphere net shortwave radiation (time average)

Metadata Fixed Fields (as one-time companion file to MORDS)

Model terrain height
Model roughness length
Model maximum soil moisture capacity
Model soil type
Model vegetation type

3.3.2 Hydrologic model output

The NOAA/OH will provide operational model output from the National Weather Service River Forecast System (NWSRFS) from the River Forecast Centers (RFC) in the Mississippi River basin. The NWSRFS is a system which integrates a variety of hydrological models into a comprehensive river forecast system. It includes models of runoff-generating processes and runoff and streamflow routing. For ESOP-96, model output from the ABRFC will be archived and made available by NOAA/OH.

The NWSRFS Sacramento model output to be provided include values every six hours of all of the available elements of the daily water budget: precipitation, runoff (surface runoff and baseflow), evaporation and soil moisture storage for individual soil moisture accounting (SMA) areas and the downstream routed streamflows. These output sets will enable surface water budgets to be made over large areas for verification of atmospheric and coupled atmospheric-hydrological models. Table 3-7 lists the RFC model outputs proposed by the NOAA/OH.

TABLE 3-7 RFC Hydrological Six-hour Sacramento Model Outputs Proposed by NOAA/OH for GCIP

Mean Areal Precipitation
Mean Areal Air Temperature
Mean Areal Snow Water Equivalent1
Percent of Areal Extent of Snow Cover
Heat Deficit in the Snow Pack
Mean Areal Rain Plus Melt from Snowmelt Model
Mean Areal Potential Evaporation2
Upper Zone Tension Water Storage
Upper Zone Free Water Storage (UZFW)
Lower Zone Tension Water Storage
Lower Zone Primary Free Water Storage
Lower Zone Secondary Free Water Storage
Additional Impervious Area (fraction of basin area)
Impervious runoff from permanent impervious areas and direct runoff from temporary impervious areas
Surface runoff when UZFW is full and precipitation intensity exceeds the rate of percolation and interflow
Interflow resulting from the lateral drainage of the UZFW
Supplementary Baseflow
Primary Baseflow
Subsurface Outflow
Total Runoff
Streamflow from SMA at outlet
Routed Streamflow from Areas Above SMA
Forecast Streamflow After Blending with Observed Streamflow

Computed SMA Daily Evaporation for Model Water Balance3

1Snow water equivalents and snowmelt may be calculated for several contour increments within an SMA in mountainous areas.
2Mean areal potential evaporation is computed on a daily basis and the six-hour values are simply 1/4 of the daily total.
3Because the potential evaporation forcing is a daily average, the six-hour evaporation amounts do not include diurnal variability and a daily sum is given.

4. SPECIAL PROCESSING

This section includes summaries of some of the special processing that will occur relative to data to be collected during ESOP-96.

4.1 In-Situ

This section discusses the quality control (QC) of the surface and precipitation composites to be created for ESOP-96. Detailed descriptions of the components of the composite datasets are provided in Section 3. Uniform QC procedures will be applied during the compositing process. Brief descriptions of the QC processes follow.

4.1.1 QC of ESOP-96 Surface Composites

The ESOP-96 5-min and hourly surface composites will be formed by an aggregation of datasets from several surface meteorological networks (Figure 4-1). This figure is for the hourly surface composite, the 5-min composite is similar except it only uses the ARM surface data and Oklahoma Mesonet data. Selected parameters from each dataset will be quality controlled by the use of horizontal quality control procedures.

During the OFPS Horizontal Quality Control (OFPS HQC) processing, station observations of pressure, temperature, dew point, wind speed and wind direction will be compared to "expected values" computed using an objective analysis method adapted from that developed by Cressman (1959) and Barnes (1964). The OFPS HQC method allows for short term (>= 30 day) variations by using 30 day standard deviations computed for each parameter when determining the acceptable limits for "good", "questionable", or "unlikely" flags. Expected values will be computed from inverse distance weighted station observations within a 300 km radius of influence (ROI) centered about the station being quality controlled (the station being quality controlled is excluded); i.e.**X_e = [(w_i)(X_o)]/[w_i]** Where [...] represents the summation over all stations within the ROI that have valid observations of the parameter at the time in question, *X_e* is the "expected value" of the parameter at the site in question, *w_i* is the weighting factor for site *i* (here the inverse of the distance between site *i* and the station being quality controlled), and *X_o* is the observed value of the parameter at site *i*.

To determine an observation's HQC flag setting, the difference between the actual observation and its "expected value" will be compared to that parameter's normalized standard deviation. Normalizing factors (also called the sensitivity coefficients) were chosen to control the "good", "questionable", and "unlikely" limits for each parameter. See Table 4-1 for ESOP-96 (the same as were used for ESOP-95) normalizing factors. Table 4-2 contains the HQC flag limit ranges derived from the normalizing factors given in Table 4-1 and estimated standard deviations for each parameter so that 95% of the QC limits applied to the ESOP-95 data fell within these ranges. For example, 95% of the observed station pressure values that were flagged as "good" were within 1.5 mb of the expected value. Values for ESOP-96 are expected to be similar. The significant overlap of the ranges seen in Table 4-2 is partially due to seasonal and station differences in standard deviations. The actual HQC limits applied at any particular time depend upon the dynamic nature of the particular station's parameter values over time.

Data will never be changed, only flagged.

HQC will only be applied to station pressure, sea level pressure, calculated sea level pressure, temperature, dew point, wind speed and wind direction. If the calculated sea level pressure quality control information is available, its flag is applied to the station and sea level pressures. If the calculated sea level pressure can not be quality controlled, the sea level pressure quality control flag is applied to the station pressure. If the sea level pressure can not be quality controlled, the station pressure quality control flag is not overridden.

Table 4-1 Normalizing factors used for ESOP-96 Surface Composites

Parameter	Good	Questionable	Unlikely
Station Pressure	0.2	0.2	0.5
Sea Level Pressure (SLP)	0.2	0.2	0.5
Calculated SLP	0.4	0.4	1.0
Dry Bulb Temperature	0.5	0.5	1.0
Dew Point Temperature	0.5	0.5	1.0
Wind Speed	2.25	2.25	4.0
Wind Direction	1.22	1.22	2.2

Table 4-2 Ranges of HQC flag limit values for the ESOP-95 Surface Composites

Parameter	Good	Questionable	Unlikely
Station Pressure (mb)	< 1.5	[0.7-3.9]	> 1.7
Sea Level Pressure (mb)	< 1.7	[0.5-4.3]	> 1.2
Calculated SLP (mb)	< 3.9	[0.9-9.8]	> 2.2
Dry Bulb Temperature (°C)	< 2.9	[1.2-5.8]	> 2.4
Dew Point Temperature (°C)	< 3.2	[1.2-6.3]	> 2.4
Wind Speed (m/s)	< 7.4	[3.2-13.2]	> 5.6
Wind Direction(°)	< 156.8	[94.6-180.]	> 170.5

General consistency checks will also be applied to the dry bulb temperature, wind direction, and the relationship between precipitation and cloud amount/cloud cover. If the dew point temperature is greater than the dry bulb temperature both values will be coded "questionable". Also, wind direction for observed "calm" winds will be given the same QC code as the wind speed. If precipitation is reported, but the cloud amount is "none" or "clear", then both the cloud amount and precipitation values will be coded "questionable".

Several impossible values will also be checked. Negative wind speeds will be coded "unlikely". Negative squall/gust wind speeds will be coded "unlikely". Wind directions of less than 0° or greater than 360° will be coded "unlikely". If these consistency checks would upgrade the quality control flags previously set by HQC or gross limit checks they will not be applied. However, if these consistency checks would degrade the previously set QC flags, they will be applied.

The OFPS HQC scheme relies on spatial and temporal continuity to flag the data. It has been shown that the method works very well for temperature, dew point, pressure, and wind speed, but is not a very good scheme for the wind direction. The flags appear to be overly lax and perhaps could be tightened.

4.1.2 QC of ESOP-96 Precipitation Composites

The ESOP-96 15-min, hourly, and daily precipitation composites will be formed from an aggregation of datasets from several surface precipitation networks (Figure 4-2). The schematic shows the processing steps involved in

the preparation of the hourly precipitation composite. The 15-min and daily composites are produced in a similar fashion except that they use other segments of the data as described in section 3.1.1. Each dataset will be quality controlled by the use of a series of global limit checks .

Gross limit checks will be used to flag the precipitation values. The gross limits are shown in Table 4-3. Certain "questionable" and "unlikely" data values will also be manually inspected. After inspection, the quality control flag may be manually modified to better reflect the physical reasonableness of the data. Data will never be modified, only flagged. Negative precipitation will also be coded "unlikely".

TABLE 4-3 QC limits applied to precipitation values for ESOP-96 precipitation composites

Parameter	Good	Questionable	Unlikely
5-minute Precipitation	< 3 mm	3-6 mm	>= 6 mm
15-minute Precipitation	< 8 mm	8-18 mm	>= 18 mm
Hourly Precipitation	< 20 mm	20-50 mm	>= 50 mm
Daily Precipitation	< 101.6 mm	101.6-127 mm	>= 127 mm

4.2 GCIP Quick Response Datasets

The GCIP quick response datasets are primarily for use in comparative model evaluations of the NOAA/NCEP Eta, NOAA/FSL MAPS, and CMC/AES RFE regional models. The major focus of the comparative evaluation is on the new land physics package recently installed in each of the regional models. May and July 1996 are to be the quick response dataset periods during ESOP-96. Quick response datasets are scheduled to be available within two months after the month of data collection. The datasets to be available in these quick response datasets during ESOP-96 have not yet been finalized, but can be expected to include subsets of the full ESOP-96 dataset described in Section 3.

4.3 Near Surface Observation Dataset

A special dataset for land surface and boundary layer studies and modeling will be collected as part of the ESOP-96. The geographical area for this special dataset will be concentrated in the ARM/CART site and the Little Washita Watershed (see Figure 1-2) to take advantage of the new sensor systems for soil moisture and soil temperature profile measurements. The special dataset will consist of two types of data. The first type will consist of data from conventional observations such as precipitation and temperature and the second type will consist of data from newer sensors such as the surface flux measurements and the soil moisture measurements.

The network of soil moisture and soil temperature profile sensor systems are only partially completed. Furthermore, these are new sensor systems and the data from them needs to be validated as part of the efforts during this initial period. For these reasons the initial data collection period will include only the six months of ESOP-96.

The network of sensors are scheduled to be completed and operating by March 1997. A second period for the data collection is planned to start on 1 April 1997 and continue for one year.

A complete description of the Near Surface Observation Dataset is given in Appendix A.

5. DATA DISSEMINATION

Data for the ESOP-96 will be primarily distributed to the GCIP community in two ways: (1) through on-line access, providing on-line transfer and off-line media; and (2) CD- ROM. Further details are provided in the following subsections.

5.1 ESOP-96 On-line Data Access

The ESOP-96 data will be available on-line from the GCIP Data Management and Service System (DMSS). The DMSS provides a central information source for GCIP. It provides overviews and up-to-date information regarding GCIP and the DMSS. Also provided are links to the four GCIP data source modules that specialize the GCIP datasets by type. The modules include the in-situ data, model output, satellite remote sensing, and special GCIP dataset modules. Figure 5-1 depicts the DMSS structure. The World Wide Web (WWW) home page for GCIP and the DMSS resides at NOAA/NCDC at the following URL:

http://www.ncdc.noaa.gov/gcip/gcip_home.html

It contains overview information and scientific objectives on GCIP and the DMSS, references and published papers, access to selected on-line GCIP publications, and electronic links to each of the GCIP data source modules.

The locations of each of the modules are discussed in the following subsections, except for the special GCIP datasets module which does not as yet exist.

5.1.1 The In-situ Data Source Module

The ESOP-96 In-situ data will be available through the UCAR/OFPS Distributed Data Management System also known as CODIAC. CODIAC is an on-line, interactive data management system that consists of a data catalog, data inventories, station descriptions, and an order entry system. CODIAC is a distributed system that allows the user to link to other centers with on-line data systems (e.g. NCDC) for further information on datasets and data delivery. CODIAC provides information about each field projects' datasets by title, abstract, time, location, and frequency of observations. Detailed information on stations and observing platforms include station name and location as well as observed parameters.

The user may browse selected datasets. This includes time series plots for surface parameters, skew-T/log-p diagrams for soundings, as well as GIF images for radar composites, model analyses, and satellite imagery.

CODIAC also allows users to directly retrieve data. On-line datasets may be downloaded immediately via the Internet or can be sent via magnetic media (i.e. 9-track, Exabyte, or Digital Audio tape). Off-line data are available only via magnetic media. The user can use WWW "forms" to order the data on-line. Data may be selected by time and/or location and are available in several formats depending on the dataset in question. Any documentation concerning the data itself, processing steps, or quality control procedures used is automatically included.

CODIAC System Access via the WWW

The In-situ Data Source Module Home Page resides at UCAR/OFPS at the following URL:

http://www.joss.ucar.edu/gcip/gcip_in_situ.html

It provides information on availability of various GCIP datasets, on-line documentation, links to WWW pages related to GCIP in situ data, and an interactive electronic link to the CODIAC system. This link includes the ability to display specific dataset information (metadata), a graphical display browse of user selected data, and WWW "forms" for the user to order data. Users that do not have forms-capable browsers may continue to use the CODIAC system. All WWW displayed information is interactively extracted from the CODIAC database to ensure the information is up-to-date.

5.1.2 The Satellite Remote Sensing Data Source Module

The GCIP Satellite Remote Sensing Data Source Module (SDSM) was identified to be the NASA/Marshall Space Flight Center Distributed Active Archive Center (MSFC-DAAC). The DAAC concentrates its data holdings in the discipline of the hydrologic cycle and currently contains mostly satellite-derived datasets. The GCIP SDSM at the DAAC coordinates and identifies datasets relevant to GCIP efforts such as the ESOP-96. Additionally, ESOP-96 users and data producers may contact the module with inquiries or additional requirements. The SDSM home page builds upon the available data and coordinating efforts. The SDSM home page is currently linked to the GCIP home page and the In-situ and Modeling Modules. The SDSM URL is:

http://ghrc.msfc.nasa.gov/gcip/sdsm.html

The NASA/MSFC DAAC at the Global Hydrology and Climate Center continues its efforts to support GCIP. Comments from users and data producers of ESOP-96 data are welcomed at brian.motta@msfc.nasa.gov or 205-922-5798.

5.1.3 The Model Output Source Module

The GCIP Model Output Source Module resides at the National Center for Atmospheric Research/Scientific Computing Division (SCD), Data Support Section. This module is the primary point of contact for the model output. This module does not currently have a WWW home page, but one has been proposed. The contact at NCAR for the model module is Roy Jenne. Available via telephone at (303)-497-1215, or via e-mail (Internet) at jenne@ncar.ucar.edu. The NCAR/SCD/Data Support Section has a home page on the WWW at the following URL:

http://www.scd.ucar.edu/dss/index.html

The National Centers for Environmental Prediction (NCEP) has a GCIP home page that provides detailed information on the various Eta model output including the MOLTS, MORDS, and gridded three-dimensional fields as well as the MOLTS. It also provides information on retrieval of the model output. On-line data access is limited to the previous 24 hours of data. The WWW URL for the NCEP GCIP home page is:

http://nic.fb4.noaa.gov:8000/research/gcip.html

5.2 ESOP-96 CD-ROM

A subset of the datasets that will be available through CODIAC will be published on a CD-ROM. Table 5-1 provides a summary of these datasets. Detailed descriptions of the datasets are provided in Section 3.0. Companion software tools will be available to browse and display the data (i.e., areal plots, time series plots, altitude plots, image displays). These tools will be available for DOS, MacIntosh, and UNIX based systems.

A companion CD-ROM to GCIP has been produced by the USGS. This CD-ROM contains geographic information for the entire GCIP domain. Datasets contained on this CD- ROM are summarized in Table 5-2. Software to extract and view data have been included.

TABLE 5-1 PROPOSED ESOP-96 CD-ROM DATASET CONTENTS

Surface

ESOP-96 Hourly Surface Land Composite Data
ESOP-96 15-min Precipitation Composite Data
ESOP-96 Hourly Precipitation Composite Data
ESOP-96 Daily Precipitation Composite Data
NCDC Cooperative Observer Network Data (Summary of the Day)

USGS Streamflow Data
USGS Reservoir Data
ABRFC Precipitation Data
NCDC SAO "Specials" Data

Upper Air

NWS high resolution (6-sec) soundings*
NOAA Profiler Network Hourly Data (405 MHz)
ARM/CART Soundings*

Imagery

ABRFC Stage III Daily Accumulated Precipitation Estimate Composites
Daily 1200 UTC GOES-8 4-km Infrared Satellite Image
Daily 2100 UTC GOES-8 2-km Visible Satellite Image
Daily 1200 UTC GOES-8 8-km Water Vapor Image
Daily Eta Model 1200 UTC 1000 mb Synoptic Analyzed Map
Daily Eta Model 1200 UTC 850 mb Synoptic Analyzed Map
Daily Eta Model 1200 UTC 500 mb Synoptic Analyzed Map
EROS Data Center Bi-weekly AVHRR Vegetation Composites
MSFC 1200 UTC National Reflectivity Composite
WSI 1200 UTC NOWRAD Composites

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* Datasets published in compressed format.

TABLE 5-2 CONTENTS OF USGS GEOGRAPHIC REFERENCE (GREDS) CD-ROM

Meteorological and Hydrological Station Locations

Digital Elevation Model (DEM) at 500-m resolution

Geology of the Conterminous United States (1:2,500,000 scale)

Land Use of the Conterminous United States (1:7,500,000 scale)

Environmental Protection Agency (EPA) River Reach File for the Conterminous United States (Version 1)

Locations of Large Reservoirs of the United States

Average Annual Runoff in the Conterminous United States for 1951-1980 (1:7,500,000 scale)

Climatology of the United States, 1961-1990 (Normal Temperature, Precipitation, and Degree Days)

LANDSAT Nominal Row and Path Boundaries and Center Points (Index to LANDSAT Scenes)

Eta Model Grid Node Locations and description of Parameters

State and County Boundaries (1:2,000,000 scale)

USGS Quadrangle Map Index (1:250,000, 1:100,000, and 1:24,000 scales)

Hydrologic Unit Boundaries of the Conterminous United States (1:250,000 scale)

Listing of Long Term Climatological Stations

GIF Imagery of above Datasets (Browse purposes)

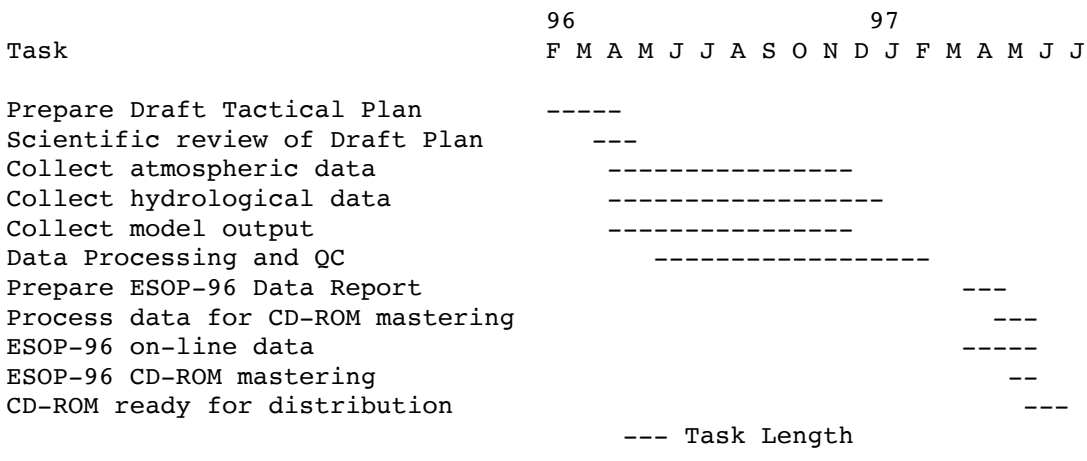
Miscellaneous Documentation of above Datasets

Software and Source Code for Dataset Projection Translation

6. IMPLEMENTATION AND SCHEDULE

Since GCIP, and therefore ESOP-96, aims to make maximum use of existing data sources, the first step in the planning and development effort must be identification of potential sources of data pertinent to the program. The OFPS has conducted an investigation of potential datasets and the results are summarized in this document. The OFPS then conducted an extensive investigation of potential datasets and sources of in-situ data and, in conjunction with the GCIP Data Collection and Management Committee (DACOM), developed the list of ESOP-96 datasets. For each data source, the OFPS will then: determine the quality, limitations, and problems with the data; assess the level of functionality possible at the responsible center; and determine the most cost-effective data access mechanism. The comments on the draft Tactical Data Collection and Management Plan from DACOM, the GCIP science sub panels and community, will be used to develop the Final ESOP-96 Tactical Data Collection and Management Plan. Following the data collection period, an ESOP-96 Tactical Data Collection and Management Report will be developed identifying that data which was included within the ESOP-96 dataset.

A summary of tasks to be performed and schedules are presented below:



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APPENDIX A

NEAR SURFACE OBSERVATION DATASET

BACKGROUND

The GEWEX Continental-scale International Project (GCIP) has an overall objective to improve scientific understanding and to model on a continental scale the coupling between the atmosphere and the land surface for climate prediction purposes. GCIP research involves a systematic multiscale approach to accommodate physical process studies, model development, data assimilation, diagnostics, and validation topics.

The GCIP research activities have both a phenomenological and a geographic focus. During the early part of GCIP the geographical focus is on that area of the southwest Great Plains, encompassing the Arkansas-Red River basins as shown in Figure 1-2. The phenomenological focus is on various aspects of the warm-season hydrologic cycle.

Since 1993, GCIP has been working in cooperation with other projects and activities in the Arkansas-Red River basin to compile datasets for GCIP research activities. These include the Atmospheric Radiation Measurement (ARM) program, the USDA/Agriculture Research Service in Durant, OK and the Oklahoma Mesonet operator. GCIP has also supported enhancements to existing observation networks to obtain observations crucial for studying and modeling land surface processes and the coupling of these processes with the atmosphere. The support for soil moisture and soil temperature profile measurements in the ARM/CART site and the Little Washita Watershed (shown in Figure 1-2) is particularly noteworthy.

The implementation of this enhanced observation capability has advanced to where it is now feasible to begin compiling a special dataset for land surface and boundary layer studies and modeling. The GCIP Data Collection and Management (DACOM) committee has compiled a set of data requirements that will be suitable for:

** Land surface process studies
** Validation and verification of land surface processing schemes
** Detailed validation and verification of model output from regional land-atmosphere coupled models.
** Derivation of surface energy and water budgets.

NEAR-SURFACE OBSERVATION DATASET

A special dataset will be compiled for the geographical area which includes both the ARM/CART site and the Little Washita Watershed as shown in Figure 1-2. The vertical dimension will include from 3000 meters above the surface to two meters below the surface. The specific types of observations are listed in Table A-1 which is divided into three parts:

1. Boundary Layer ($Z < 3000$ meters)
2. Surface Layer ($0 < Z < 10$ meters)
3. Subsurface Layer ($-2 < Z < 0$ meters)

A short description about the source of the observations for each type of observation follows the table.

The land surface studies and models can use the data at point locations to force land surface models or can make use of the observations to complete an area analysis for different size areas within the ARM/CART site and the Little Washita Watershed. The difficulty in achieving a consensus on the techniques for an area analysis has necessitated a decision to compile data as close as possible to an observational measurement. This will enable an investigator to use whatever analysis techniques are deemed appropriate for their specific research.

DATA COLLECTION SCHEDULE

It is recognized that a full year data collection period is the most desired by the persons surveyed. However, due to the implementation schedule of the full complement of enhanced observations it was decided to postpone the start of a one-year data collection period until 1 April 1997. It was recognized that a partial dataset containing the critical measurements would be useful to GCIP investigators as soon as possible. For these reasons we are proposing to divide the data collection into two phases.

Phase I - The six-month period of 1 April through 30 September 1996 encompasses the scheduled data collection period for the Enhanced Seasonal Observing Period (ESOP-96) for the LSA-SW shown in Figure 1-2. The first phase of the Near-Surface Observation Dataset will make use of data from this same period. During ESOP-96 we expect to obtain a reasonably complete set of data at about eight locations in the ARM/CART site (see SWATS facilities in Figure 3-10) and Little Washita Watershed. The remaining locations will not have some of the observation types including particularly, soil moisture and soil temperature profiles. It is proposed to make this a special subset of the ESOP-96 dataset. The compilation of this dataset is scheduled to be completed by June 1997.

Phase II - The full complement of observing systems needed for the Near-Surface Observation Dataset are scheduled to be operating by the end of March 1997. We are therefore proposing to start the Phase II data collection period on 1 April 1997 and continue for one full year.

The preparation of the archive data for streamflow by the U.S. Geological Survey (USGS) is done on a Water Year (1 October to 30 September) basis. The streamflow data for the Water Year are archived the following April and May. This will necessitate the compilation of the one-year Near Surface Observation Dataset in two parts. The period from 1 April through 30 September 1997 can be completed by June 1998 and the last six months of the one year dataset will be completed by June 1999. It may be possible to compile a full year dataset earlier (June 1998)

using operational streamflow data and replacing this with the archived data when it becomes available. This will depend upon the needs of the GCIP investigators.

TABLE A-1 Types of Observations in each Layer

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1. Boundary Layer Z < 3000 meters

1.1 Temperature profiles
1.2 Water vapor profiles
1.3 Wind profiles
1.4 Clouds

2. Surface (0 < Z <10 meters)

2.1 Temperature, Specific Humidity, Wind Component, and Surface Pressure

U & V component wind speed at 10 m
Temperature at 2 m
Specific humidity at 2 m
Surface pressure

2.2 Surface momentum flux

Surface U wind stress
Surface V wind stress

2.3 Surface sensible and latent heat fluxes

Surface latent heat flux
Surface sensible heat flux
Soil heat flux to Surface

2.4 Surface skin temperature
2.5 Precipitation (including snow)
2.6 Surface Radiation

Downward shortwave
Upward shortwave (albedo)
Downward longwave
Upward longwave
Net radiation (measured)
Photosynthetically Active Radiation (PAR)

2.7 Surface and ground water
2.8 Vegetation type and characteristics
2.9 Site Description

3. Sub-surface (-2 < Z < 0 meters)

3.1 Soil moisture (profiles)
3.2 Soil temperature (profiles)
3.3 Soil physical and hydraulic properties
3.4 Wilting point

3.5 Rooting zone
3.6 Field capacity

OBSERVATION SOURCES

1.0 Boundary Layer (Z < 3000 m) Observations

1.1 Temperature Profiles

There are three types of systems within the ARM/CART region that measure vertical profiles of temperature within the boundary layer, rawinsondes, Radio Acoustic Sounding Systems (RASS), and the Atmospheric Emitted Radiance Interferometer (AERI). The only rawinsonde stations within the ARM/CART domain are those from the Department of Energy (DOE) ARM program and the National Weather Service (NWS). The ARM rawinsondes routinely collect temperature observations at a vertical resolution of 2-sec. Soundings will be released 5 times each weekday at the central facility (6, 12, 15, 18, and 21 UTC) and once each weekday at each of the four boundary facilities (18 UTC) during regular operations (see Figure 3-9 for ARM facility locations). During IOPs (e.g. April 1996) soundings are released every three hours, seven days a week, at all five facilities. The NWS has one rawinsonde location within the ARM/CART domain at Norman, OK. The NWS provides 6-sec vertical resolution observations at two release times (00 and 12 UTC). Occasionally more frequent releases occur at the request of the NWS.

The RASS are collocated with some of the wind profiler systems within the ARM/CART domain (see Figure 3-17). Two facilities (Purcell, OK and Haviland, KS) already have RASS and two others (Vici and Morris, OK) will have them by June 1996. The Lamont, OK profiler site will not have a RASS unit. RASS allows for the calculation of vertical profiles of virtual temperature at 250 m vertical resolution every 6 min. The ARM program operates two RASS units at their central facility.

The AERI unit is located at the ARM central facility (see Figure 3-9) and measures infrared radiation yielding radiance spectra which are transformed to vertical temperature and water vapor profiles. Profiles are generated every 10 minutes.

1.2 Water Vapor Profiles

Water vapor profiles are obtained from the rawinsonde and AERI systems described above at the same temporal and vertical resolutions as for the temperature.

1.3 Wind Profiles

Wind profiles are from the ARM rawinsondes (described above) at 10-sec vertical resolution and the NWS rawinsondes at 6-sec vertical resolution.

The NOAA Profiler Network provides 6-min and hourly observations of the wind profiles at a vertical resolution of 250 m.

The WSR-88D Doppler radars record velocity spectra information in the Level II archive as well as velocity products in the Level III archive. GCIP will use the Level III wind data products only. There are no plans to include wind data products from the Level II archive.

1.4 Clouds

The ASOS provides 1, 5, or 60 min observations of ceiling and cloud heights up to 12,000 feet at 20 stations within the ARM/CART domain. The AWOS provides similar observations at 20-min intervals at two stations and 5-min intervals at one station within the ARM/CART domain. The SAOs provide hourly and occasional special observations of ceiling and cloud heights and amounts with no upper limit on the observational height at 13 locations within the ARM/CART domain.

2.0 Surface Layer (0 < Z < 10 m) Observations

2.1 Temperature, Specific Humidity, Wind Components, and Surface Pressure

Several systems provide measurements of each of these parameters. The ASOS provide 1, 5, or 60 min observations at 20 stations within the ARM/CART domain. The AWOS provide 20-min observations at 2 stations and 5-min observations at one station within the ARM/CART domain. The SAOs provide hourly and occasional special observations at 13 stations within the ARM/CART domain. The High Plains Climate Network provides hourly observations at 6 locations within the ARM/CART domain. The Oklahoma Mesonet provides 5-min observations at 48 stations within the ARM/CART domain. The NOAA Profiler Network provides 6-min observations at its 5 locations within the ARM/CART domain. The DOE ARM/CART provides surface data from its extended facilities (see Figure 3-9). Data from 15 of the 26 proposed ARM/CART extended facilities should be available. The 45- station ARS Little Washita Watershed Micronet provides 15 min observations of temperature and relative humidity. Three of the Micronet stations also provide wind speed, wind direction, and barometric pressure at 15 min intervals.

The NOAA/GEWEX long term flux monitoring site, operated by Tilden Meyers (NOAA/ARL), located in the Little Washita Watershed provides measurements of temperature and humidity.

The humidity variables collected from each system (typically dew point) can be converted into specific humidity.

OFPS will also develop hourly and 5-min composites of the data from these observing systems. The 5-min composites will include data only from those sites that routinely archive data at 5-min or higher frequencies. No special data collections are planned for ESOP-96 unlike for GIST and ESOP-95.

2.2 Surface Momentum Flux

The ARM program Eddy Correlation (ECOR) systems provide measurements of surface momentum flux within the ARM/CART domain. These are planned to be operating at nine of the ARM/CART extended facilities over wheat and other crops (see Figure 3-10).

The NOAA/GEWEX long term flux monitoring site provides measurements of surface momentum flux in the Little Washita Watershed.

2.3 Surface Sensible and Latent Heat Fluxes

Two systems within the ARM domain provide measurements of the surface heat flux. The ECOR system mentioned above and the Energy Balance Bowen Ratio (EBBR) system. The EBBR systems are planned to be at 11 extended facilities over pasture and rangeland, all but one (at the central facility) of which are located at the extended facilities which do not have the ECOR system (see Figure 3-10).

Also, the NOAA/GEWEX long term flux monitoring site provides measurements of the sensible and latent heat fluxes in the Little Washita Watershed.

The soil heat flux to the surface is provided by the EBBR system.

2.4 Surface Skin Temperature

The skin temperature is derived from measurements provided by the SIROS (Solar and Infrared Radiation Observing System) upwelling hemispherical irradiances at 18 of the ARM/CART extended facilities (including the central facility).

The NOAA/GEWEX long term flux monitoring site also provides measurements of the skin temperature.

2.5 Precipitation

Observations of precipitation are collected from each of the station varieties mentioned in section 2.1 at the same observational frequencies. Additional precipitation observations come from the NWS Cooperative observers at either 15-min or hourly frequency, the 45 station ARS Micronet provides 15-min precipitation observations, the Arkansas-Red Basin River Forecast Center (ABRFC) collects data at 15-min (approximately 45 stations within the ARM/CART domain), hourly (approximately 95 stations), or with no set schedule (approximately 135 stations), the US Army Corps of Engineers (USACE) collects hourly observations and the USGS collects daily observations for a total of approximately 115 stations within the ARM/CART domain. The NOAA/GEWEX long term flux monitoring site also provides precipitation measurements in the Little Washita Watershed. OFPS also will develop 15-min and hourly composites of precipitation from all of the observing systems.

The NEXRAD Information Dissemination Service (NIDS) 1-hr surface rainfall accumulation product will be archived by OFPS. This is a one hour running total of surface rainfall accumulation. The resolution is 2 km by 2 km and the range is 230 km. This product will be archived from nine radars near the ARM/CART domain (see Figure 3-18).

The ABRFC routinely produces an hourly composite derived precipitation product from all WSR-88D radars covering the Arkansas-Red River basins. These data are on a 4 km by 4 km grid.

2.6 Surface Radiation

The ARM/CART SIROS provides measurements of up and down welling hemispherical solar irradiances, direct-beam solar irradiance, diffuse hemispherical solar irradiance from the sky and up- and downwelling hemispherical infrared irradiances via its collection of instruments including the Multifilter Rotating Shadowband Radiometer (MFRSR), pyranometer, pyrheliometer, and pyrgeometer at 19 of the ARM extended facilities (including the central facility).

The 45 ARS Micronet stations provide measurements of incoming solar radiation.

A MultiFilter Radiometer (MFR) at the central facility provides measurements of upwelling radiation at 10 m.

The AERI system provides measurements of infrared radiances at zenith at the central facility.

A 60-m tower at the central facility provides upwelling hemispheric infrared irradiance measurements as well as upwelling hemispherical solar radiation measurements from 25 m using a pyranometer, pyrgeometer and an MFR.

The ARM Broadband Solar Radiation Network (BSRN) at the central facility provides measurements of infrared (pyrgeometer) and solar (pyranometer) irradiances as well as direct solar irradiance (pyrheliometer) and direct, diffuse, and total solar irradiances at six selected wave bands and a wide band (MFRSR).

Also at the central facility is a pyrometer at 10 m that measures 10 micron upwelling radiation and a similar instrument at 25 m elevation over a wheat field.

The NOAA/GEWEX long term flux monitoring site also provides measurements of net radiation, incoming and outgoing Photosynthetically Active Radiation (PAR) and infrared irradiances in the Little Washita Watershed.

2.7 Surface and ground water

Observations of streamflow within the ARM/CART domain are available from the US Army Corps of Engineers (USACE) and the USGS from a total of about 130 sites within the ARM/CART domain.

The USGS collects daily observations of reservoir capacity for nine reservoirs within the ARM/CART domain.

Available USGS well water height data from the area around the ARM/CART domain will be collected.

Some of the NWS Cooperative observer network sites collect daily observations of evaporation. There are 207 cooperative observation locations within the ARM/CART domain a subset of which collect evaporation measurements.

2.8 Vegetation type and characteristics

Satellite derived values of the Normalized Difference Vegetation Index (NDVI) are routinely produced at the EROS Data Center (EDC) at Sioux Falls, SD. One set of NDVI data is made available bi-weekly. The land cover imagery will be produced bi-weekly from 1 km resolution Advanced Very High Resolution Radiometer (AVHRR) and translated to GIF by the USGS EDC. The full land characteristics data files will then be published on CD-ROM by EDC. The GIF imagery will serve as the browse for the full data base during this time.

2.9 Site Description

This will start with the generally provided station list information provided by OFPS and be augmented with a list of measurements made at each station. The typically provided information includes site identifiers (3-4 letter ids, site names), type of instrumentation (i.e. ASOS etc.), frequency of observation, latitude, longitude, elevation, and beginning and end dates of operation.

For point measurements this should include soils, vegetation type, surrounding geophysical features (ponds, lakes, rivers, pavement, forest, etc.).

A detailed description will be cataloged for each of the sites which have the soil moisture and soil temperature profile sensor systems operating during this initial phase. The detailed description of the other sites will be postponed until the second data collection phase.

3. Sub Surface (-2 m < Z < 0)

3.1 Soil Moisture Profiles

An extensive array of soil moisture sensor systems are being installed in the ARM/CART site, Little Washita Watershed, and the Oklahoma Mesonet over the next two years. Installation plans for these sensor systems at more than 100 locations are now being implemented. We shall distinguish the shallow (< 10 cm) from the deep (> 50 cm) profile measurements.

Deep Soil Moisture Profiles: Seven locations in the ARM/CART site and at least six locations in the Little Washita Watershed will be operating during the course of the ESOP-96 from April through September 1996. The Campbell Scientific Heat Dissipation Soil Moisture Sensor (Model 229-L) is the sensor system of choice for this composite network. This newly developed sensor measures water potential by heating a needle embedded in a porous ceramic cylinder, and then observing the temperature change of the cylinder itself, which is linearly related to the amount of water permeating the porous cylinder. Since this is a new sensor system, its ability to provide soil moisture measurements in an operational environment needs to be validated.

The ARM/CART sensors are being installed at eight different depths: 5, 15, 25, 35, 60, 85, 125, and 175 cm unless bedrock is reached prior to the lower depths. Each site will have two profiles located one meter apart. Eight site locations are scheduled to be operating by the start of ESOP-96 on 1 April 1996.

The Little Washita Watershed sensors are being installed at six different depths: 5 (3 sensors), 10, 15 , 20, 25, and 60 cm. The three sensors at 5 cm are installed 10 cm apart. Five site locations are installed as of 3/11/96 with an additional five planned to be installed by 5/96. The deepest level of 60 cm is expected to be near the lowest level of the rooting zone in the Little Washita Watershed.

The Oklahoma Mesonet has installed one sensor system at Norman, OK as a test facility. Additional sensor systems are to be delivered by mid April with initial installation starting in May. Some soil moisture profiles are expected during the latter half of ESOP-96. Each location will have four probes per site with depths from 5 cm to 50 cm.

Shallow Soil Moisture Profiles: The 10 Energy Balance Bowen Ratio (EBBR) flux stations in the ARM/CART site are equipped to provide soil moisture in the 3 to 5 cm range at five points around each flux station. These provide information for correcting the thermal conductivity of the soil so the soil heat fluxes can be determined. The accuracy of these measurements may not be sufficient for some model evaluation purposes.

3.2 Soil Temperature Profiles

Soil temperature profiles or subsurface heat flux profiles are being measured in the ARM/CART, Little Washita micronetwork, and Oklahoma mesonetwork. We shall distinguish between deep (>50 cm) and shallow (<10 cm) temperature profile measurements.

Deep Temperature Profiles: The Campbell Scientific Heat Dissipation Soil Moisture Sensor (Model 229L) provides soil temperature at the same eight levels as the soil moisture in the ARM/CART network: 5, 15, 25, 35, 60, 85, 125, and 175 cm. Each site will have two profiles locations spaced about one meter apart.

Three sensor systems at each of the Little Washita sites will provide either soil temperature or heat flux measurements:

* Campbell Scientific 229L at the same depths as the soil moisture given above, i.e. 5, 10, 15, 20, 25, and 60 cm.
* Campbell 107B Soil thermistors at the depths of 2.5, 5, 10, 15, 20, 25, 60, and 100 cm.
* Rebs HFT-3 Heat flux plates at the depths of 5, 25, and 60 cm.

Note: The Campbell Scientific Model 229L will also need to be validated for soil temperature in an operational environment as noted above for soil moisture.

Shallow Temperature Profiles: The 10 Energy Balance Bowen Ratio (EBBR) flux stations in the ARM/CART site are equipped to provide soil temperature (average 0 to 5 cm) at five points around each flux station.

Some of the NWS Cooperative observer network sites collect daily observations of soil temperature. There are 207 cooperative observation locations within the ARM/CART domain a subset of which collect evaporation measurements.

3.3 Soil Physical and Hydraulic Properties

Soil physical and hydraulic properties for the Near-Surface Observing Period will be available from two sources: field observation and spatial datasets derived from USDA/NRCS National Cooperative Soil Survey Databases.

Field Observation - Observations based on soil core analysis at the soil moisture monitoring sites for soil moisture. This will be a combination of profile descriptions and laboratory soil characterization in Little Washita Watershed, ARM/CART site, and the Oklahoma Mesonet.

There are also existing soils databases for at least portions of this region, e.g. the ARS at Durant, OK has a relatively detailed soils database for the Little Washita Watershed.

Digital soils information derived from the USDA-NRCS State Soil Geographic Database (STATSGO) and the Soil Survey Database (SSURGO) will provide spatially distributed soils data for the ARM/CART area. GCIP will use the 1-km Multi-Layer Soil Characteristics Dataset developed by D. Miller at Penn State's Earth System Science Center. This dataset, developed from the STATSGO database, covers the 48 conterminous United States at a resolution of 1-km and contains soil physical and hydraulic properties including: texture, depth-to-bedrock, particle size distribution, rock fragment class and volume, porosity, hydrologic soil groups, and available water capacity. Details on the dataset may be found on the WWW at the following URL:

http://eoswww.essc.psu.edu/soils/1km.html

3.4 Wilting point

The point at which the vegetation can no longer access the minimum amount of soil moisture needed to survive. It is dependent on the type of vegetation to a great extent. The ARM/CART and Little Washita sites are mainly concerned with wheat, pasture, rangeland, and forest as vegetation types. Observational data for the different types of vegetation in the ARM/CART site and the Little Washita Watershed will be provided in this dataset.

3.5 Rooting zone

This variable is interpreted as the depth to which roots penetrate the soil and this is vegetation type dependent. Observations will be available from the sites where the soil moisture profile sensors are being installed. Observations from six locations in the ARM/CART site place the rooting zone in the range of 45 to 60 cm.

3.6 Field capacity

NOTE: This was listed as one of the parameters needed in setting up an experiment in land process modeling. Based on comments received we include the following statement: It's really not a measurable quantity and, due to hysterisis may not always be the same for the same soil. Within Variable 3.3 Soil Physical and Hydraulic Properties, there is a value of "available water capacity". This is essentially the volume of water that would be available to plants if the soil, exclusive of rock fragments, were at field capacity. It is expressed both as a volume fraction and as a thickness of water in the profile.

APPENDIX B

ACRONYMS

ABRFC
: Arkansas-Red River Basin Forecast Center

AERI
: Atmospherically Emitted Radiance Interferometer

AES
: Atmospheric Environment Service (Canada)

AFOS
: Automated Field Operations and Services

ARL
: Air Resources Laboratory (NOAA)

ARM
: Atmospheric Radiation Measurements (DOE)

ARS
: Agricultural Research Service (USDA)

ASOS
: Automated Surface Observing System

AVHRR
: Advanced Very High Resolution Radiometer

AWIPS
: Advanced Weather Interactive Processing System (NOAA)

AWOS
: Automated Weather Observing System

BSRN
: Broadband Solar Radiation Network

BUFR
: Binary Universal Form for Data Representation

CAGEX
: CERES/ARM/GEWEX Experiment

CART
: Clouds and Radiation Testbed (DOE/ARM)

CAWS
: Commercial Agriculture Weather Station network (University of Missouri)

CD
: Compact Disk

CERES
: Clouds and the Earth's Radiant Energy System (NASA)

CLAVR
: Clouds from AVhRr

CMC
: Canadian Meteorological Center

COMET
: Cooperative program for Operational Meteorology, Education, and Training (UCAR)

CSA
: Continental Scale Area

DAAC
: Distributed Active Archive Center (NASA)

DACOM
: Data Collection and Management Committee (GCIP)

DEM
: Digital Elevation Model

DMSP
: Defense Meteorological Satellite Program

DMSS
: Data Management and Service System (GCIP)

DOC
: Department of Conservation

DOE
: Department of Energy

EBBR
: Energy Balance Bowen Ratio

ECOR
: Eddy Correlation

EDAS
: Eta Data Assimilation System

EDC

EROS Data Center (USGS)

EOP
: Enhanced Observing Period

EPA
: Environmental Protection Agency

EROS
: Earth Resources Observation Systems

ESOP
: Enhanced Seasonal Observing Period

FAA
: Federal Aviation Administration

FAX
: Facsimile

FEST
: Fronts Experiment Systems Test (STORM)

FSL
: Forecast Systems Laboratory (NOAA)

FOS
: Family of Services

GAC
: Global Area Coverage

GCIP
: GEWEX Continental-scale International Project

GCM
: Global Climate Model

GEWEX
: Global Energy and Water Cycle Experiment

GHCC
: Global Hydrology and Climate Center (NASA)

GIDS
: GCIP Initial Data Sets

GIF
: Graphic Image Format

GIST
: GCIP Integrated Systems Test

GMS
: Geostationary Meteorological Satellite (Japan)

GOES
: Geostationary Operational Environmental Satellite

GREDS
: Geographic Reference Data Set (USGS)

GRIB
: GRId point values expressed in Binary form

HDF
: Hierarchical Data Format

HIRS
: High Resolution Infrared Radiation Sounder

HPCN
: High Plains Climate Network

HQC
: Horizontal QC

HRPT

High Resolution Picture Transmission

IBM
: International Business Machines

IGPO
: International GEWEX Project Office

IOP
: Intensive Observation Period

IR
: InfraRed

ISA
: Intermediate-Scale Area

ISLSCP
: International Satellite Land-Surface Climatology Project

LAC
: Local Area Coverage

LSA
: Large-Scale Area

MAPS
: Mesoscale Analysis and Prediction System

METEOSAT
: METEOrological SATellite (Europe)

MFR
: MultiFilter Radiometer

MFRSR
: Multifilter Rotating Shadowband Radiometer

MOLTS
: Model Location Time Series

MORDS
: Model Output Reduced Dataset

MSFC
: Marshall Space Flight Center (NASA)

MSU
: Microwave Sounding Unit

MSX
: Midcourse Satellite Experiment

NASA
: National Aeronautics and Space Administration

NAWDEX
: NAtional Water Data EXchange (USGS)

NCAR
: National Center for Atmospheric Research

NCDC
: National Climatic Data Center (NOAA)

NCEP
: National Centers for Environmental Prediction (NOAA)

NDVI
: Normalized Difference Vegetation Index

NESDIS
: National Environmental Satellite, Data and Information Service (NOAA)

NEXRAD
: NEXt generation RADar (now WSR-88D)

NIDS
: NEXRAD Information Dissemination Service

NMSU
: New Mexico State University

NOAA
: National Oceanic and Atmospheric Administration

NPN
: NOAA Profiler Network

NRCS
: Natural Resource Conservation Service (USDA)

NSIDC
: National Snow and Ice Data Center

NSSFC
: National Severe Storms Forecast Center (NOAA)

NWS
: National Weather Service

NWSRFS
: NWS River Forecast System

OFPS
: Office of Field Project Support (UCAR)

OH
: Office of Hydrology (NOAA)

ORNL
: Oak Ridge National Laboratory (DOE)

PAR
: Photosynthetically Active Radiation

POES
: Polar Orbiting Environmental Satellite

PSU
: Pennsylvania State University

QC
: Quality Control

RASS
: Radio Acoustic Sounding System

RFC
: River Forecast Center

RFE
: Regional Finite Element

RISOP
: Rapid Interval Scan Operations Plan

ROI
: Radius Of Influence

ROM
: Read Only Memory

SAO
: Surface Airways Observation

SBUV
: Solar Backscattered Ultra Violet System

SCD
: Scientific Computing Division (NCAR)

SCM
: Single Column Model

SDSM
: Satellite Data Source Module (GCIP)

SIROS
: Solar and Infrared Radiation Observing System

SLP
: Sea Level Pressure

SMA
: Soil Moisture Accounting

SMOS
: Surface Meteorological Observation System

SSA
: Small-Scale Area

SSEC
: Space Science and Engineering Center (UW)

SSM/I
: Special Sensor Microwave Imager

SSU
: Stratospheric Sounding Unit

SSURGO
: Soil Survey Geographic Database (USDA)

STATSGO
: State Soil Geographic Database (USDA)

STORM
: STorm-scale Operational and Research Meteorology

SUCCESS
: Subsonic Aircraft: Contrail and Cloud Effects Special Study

SW
: South West

SWATS
: Soil Water and Temperature System

TIROS
: Television and Infrared Observation Satellite

TOVS
: TIROS Operational Vertical Sounder

UCAR
: University Corporation for Atmospheric Research

URL
: Uniform Resource Locator

USACE
: United States Army Corps of Engineers

USAF
: United States Air Force

USDA
: United States Department of Agriculture

USGS
: United States Geological Survey

UTC
: Universal Time Coordinated

UW
: University of Wisconsin

UZFW

Upper Zone Free Water

VAS
: VISSR Atmospheric Sounder

VDUC
: VAS Data Utilization Center

VIS
: Visible

VISSR
: Visible and Infrared Spin-Scan Radiometer

WCRP
: World Climate Research Programme

WMO
: World Meteorological Organization

WSI
: Weather Services International

WSR-88D
: Weather Surveillance Radar - 1988 Doppler

WWW
: World Wide Web