GLOBAL ENERGY AND WATER CYCLE EXPERIMENT

WORLD CLIMATE RESEARCH PROGRAMME (WCRP)

INTERNATIONAL GEWEX PROJECT OFFICE (IGPO)

MAJOR ACTIVITIES PLAN FOR

1997, 1998 AND OUTLOOK

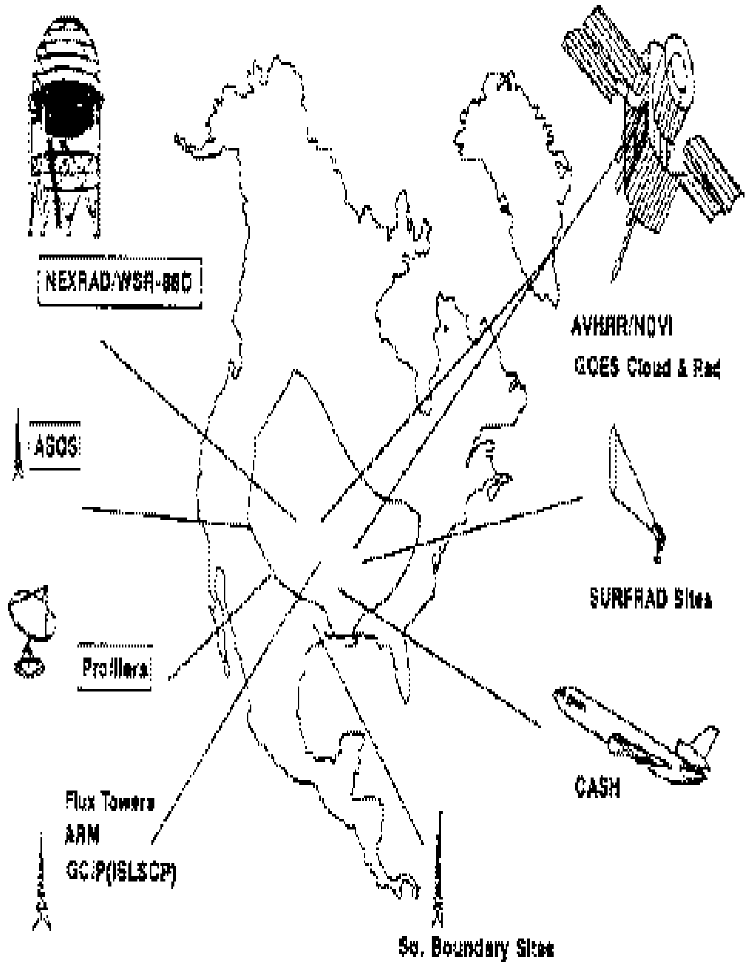
FOR 1999

for the

GEWEX CONTINENTAL-SCALE

INTERNATIONAL PROJECT

(GCIP)



- PART II -

Data Collection and Management

December 1996

IGPO Publication Series

No. 25

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- PART II -

Data Collection and Management

Compiled by

John A. Leese

December 1996

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MAJOR ACTIVITIES PLAN FOR 1997, 1998 AND OUTLOOK FOR 1999 FOR THE GEWEX CONTINENTAL-SCALE INTERNATIONAL PROJECT (GCIP)

PART I - RESEARCH

PART II - DATA COLLECTION AND MANAGEMENT

9. OVERVIEW OF GCIP DATA COLLECTION AND MANAGEMENT

Accomplishment of the GCIP major science objectives involves the development of a comprehensive and accessible observational database for the Mississippi River basin. Volume I of the GCIP Implementation Plan (IGPO,1993) contains information that (1) identifies the sources of observations from existing and planned networks; (2) further enhances those networks where necessary; and (3) assists in developing data sets accumulated from existing observational systems and derived from operational model outputs, such as the NOAA/NCEP Eta regional mesoscale model. The strategic portion of the data management planning (IGPO, 1994b) establishes the implementation strategies needed to achieve the data collection and management objective:

**** Provide access to comprehensive in-situ, remote sensing and model output data sets for use in GCIP research and as a benchmark for future studies.***

A tactical data collection and management plan is prepared for each definable data set compiled by the Project. This plan is converted to a data summary report when the compiled data set is completed.

A number of GCIP initial data sets (GIDS) were prepared to provide the data services support during the build-up period before the Five-year Enhanced Observing Period (EOP). Preparation of the GIDS started in 1993, and the data sets were compiled for on-line access by GCIP investigators to the extent that is technically feasible. They were also published on a CD-ROM) for wide distribution, especially to international persons interested in performing initial diagnostic, evaluation, and modeling studies on GCIP-related topics. A summary description of the four composite data sets which comprised the GIDS series is given in Appendix D.

The EOP started on 1 October 1995 and will continue for five years. The start date of 1 October was in part chosen to correspond to the start of a water year" as used by the Water Resources groups in organizations such as the U.S Geological Survey. The availability of water data including streamflow data from the USGS National Water Information System is based on the water year. Such data are normally available from this system about six to nine months after the end of the water year. The availability date of these data becomes a primary determining factor in the schedule for the completion of EOP data sets by the GCIP data management system. The data collected during each EOP year will be compiled into a number of standard and custom data sets.

The data collection for the first year of the EOP took account of the following general requirements:

(i) The ESOP-96 was scheduled for the period 1 April through 30 September 1996 in the geographical region identified as the LSA-SW for data to conduct focused studies covering the spring and summer seasons.

(ii) The CSA data requirements are primarily for the application of energy and water budget studies with a secondary application of model evaluation for the regional model output from the Eta and RFE models.

(iii) An annual data set for the LSA-SW is required for energy and water budgets over an annual cycle plus model evaluations of the regional model output from the Eta, RFE and MAPS.

(iv) A near-surface observational data set from the Little Washita and ARM/CART site is required for the ESOP-96 for land surface process studies, validation and verification of land processing schemes, detailed validation and verification of model output from regional land-atmosphere coupled models and, derivation of surface energy and water budgets.

The list of data collected during EOP-1 for the CSA with emphasis on the LSA-SW is given in Section 12. The compilation of the ESOP-96 data set is scheduled to be completed in June 1997. Further details on data collection and projected availability of data are provided in the Tactical Data Collection and Management Plan for ESOP-96.

The responsibilities of the GCIP Data Management and Service System (DMSS) are to provide data services for GCIP investigators, adapt to the evolving data requirements, and compile the information on a five-year consolidated data set at the completion of the EOP. Carrying out these responsibilities involves an implementation approach with evolutionary improvements during the different stages of GCIP.

The DMSS implementation strategy makes maximum use of existing data centers which are made an integral part of the GCIP-DMSS through four data source modules that specialize by data types (i.e., in situ, model output, satellite remote sensing, and GCIP special data). These four data source modules are connected to a GCIP central information source that provides "single-point access" to the GCIP-DMSS. The primary responsibilities for the data source modules along with their major functions and activities were described in Volume III of the GCIP Implementation Plan (IGPO, 1994b).

During the buildup period before the EOP, GCIP made use of an existing data management system operated by the UCAR Office of Field Project Support (UCAR/OFPS) to prepare some initial data sets with online accessibility as an early demonstration system of the planned DMSS capabilities for the EOP. GCIP took advantage of capabilities at several existing data centers to implement a prototype DMSS. This system provides a single-point access for search and order of GCIP data. These data centers each have a capability to transfer small data sets electronically to the user. By the start of the EOP the system began collecting information on the data and is adding to the data services capability that exist at the different data centers. The functions of the In-Situ Data Source Module are being carried out by the UCAR/OFPS.

The Scientific Data Services Section of the National Center for Atmospheric Research (NCAR) is supporting the model output data source module with specific applications to the regional models operated by the NMC in NOAA, the CMC in the AES, and the FSL in NOAA . Approaches and techniques were designed to handle the large volumes of model output data from these regional models. Particular attention was given to the issue of achieving "manageable size" data sets without compromising the information content needed by the GCIP investigators.Further details are given in Section 11.

The design work for the satellite remote sensing data source module took into account the plans now being implemented by NASA, NOAA, and USGS to improve the accessibility of satellite remote sensing data and metadata. GCIP is now working with the Data Archive and Access Center (DAAC), operated at the NASA/MSFC as part of the Global Hydrology and Climate Center (GHCC), to function as the Satellite Remote Sensing Data Source Module for the DMSS.

A GCIP home page" is now available through the World Wide Web with a URL address:

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

10. ENHANCED OBSERVATIONS AND DATA PRODUCTS

This section describes the progress and near-term plans for observation enhancements largely supported by GCIP. It also summarizes the plans for data products with emphasis on the critical variables described earlier in section 6.

10.1 Precipitation Measurements and Analysis

It is a goal of GCIP to contribute to the development of a derived product which combines WSR-88D, gauge, and satellite estimates of precipitation resulting in a product with a 4-km spatial and hourly temporal resolution. Such a goal is not expected to be achieved for a routine product until much later in the EOP since it is dependent upon some of the modernization improvements yet to be implemented by the NWS.

OBJECTIVE: *Produce the best possible estimates of spatial and temporal distribution of precipitation at time increments of one hour to one month and spatial increments of 4 to 50 km*.

GCIP requires the best available precipitation products and recognizes the potential value of the WSR-88D radars in meeting this requirement. Combined radar and gauge-based precipitation fields are expected to provide better estimates of precipitation than estimates based on raingauge values only. However, the limitations of radar estimates need to be evaluated because these are not well enough understood to provide research quality data sets over continental-scale areas.

Associated with the measurement of precipitation caught by the gauge is the question of representative exposure of the gauge and the effect of not having wind shields or the characteristics of different shields on gauge catch, evaporation, etc. The systematic correction of gauge errors is a necessary requirement for the development of good-quality precipitation fields. The National Climate Data Center (NCDC) applies basic quality control techniques to the cooperative observer network, but quality control and gauge error correction of all the operational data that might be used in a national precipitation product are major tasks that could require the development of new techniques.

Two task summaries are given for precipitation:

> (1) A precipitation analysis being produced routinely by the NOAA/NMC which is described as Task 10.1.1
>
> (2) A composite of precipitation observations from all available observing networks which is described as Task 10.1.2

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **10.1.1 Precipitation Analysis**

OBJECTIVE -- To provide the precipitation analysis products from the NCEP operational analysis to the GCIP Data Management System

PRODUCT DESCRIPTION -- The current product consists of a national daily precipitation analysis at a 40 km resolution based on the gauge only measurements collected in near real time at the NCEP. This is an operational product produced by the NCEP beginning in the summer of 1994.

PROJECTED IMPROVEMENTS -- Evolutionary changes will occur as part of a Stage IV national precipitation composite mosaic being implemented at the NCEP. An interim real-time Stage IV national product will be produced hourly beginning in the summer of 1996, using real-time Stage I products and gauge data as well as any Stage III products then available. Improvements in the spatial and temporal resolution will also be made during this period.

GCIP DATA SOURCE MODULE-- Model Output (Contact: R. Jenne, NCAR)

SCHEDULE- Operational product sent by NOAA/NCEP each month to the GCIP Data Source Module.

GCIP USER AVAILABILITY - Three months after the end of the analysis month.

RESOURCE SUPPORT- Development support from NOAA GCIP Program through the NWS CORE Project for GCIP. The operational product is a contribution from the NOAA/NCEP

TASK LEADER K. Mitchell, NOAA/NCEP

GCIP PRA COORDINATION - Precipitation

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TITLE -- **10.1.2 Precipitation Observation Composite**

OBJECTIVE -- To provide a quality controlled composite of all available precipitation observations in a common format.

PRODUCT DESCRIPTION -- The precipitation composite contains precipitation data from all real- time and recording gauges in the geographic domain as both hourly and daily totals. The Composite is produced by the In-Situ Data Source Module using data from up to 14 different observing networks. A precipitation observation composite was produced for each of the GCIP Initial Data Sets.

PROJECTED IMPROVEMENTS -- Evolutionary improvements in quality control procedures will be implemented as proven techniques warrant. There are no current plans to correct for measurement errors by the different sensor systems.

GCIP DATA SOURCE MODULE -- In-Situ (Contact: S. Williams)

SCHEDULE -- Continuing as the observation data become available. Data from the NWS Cooperative Network is the last available and determines the completion schedule for a particular month. A Composite for a specific month is expected to be completed about six months later with a nominal collection schedule by all the networks.

GCIP USER AVAILABILITY -- The In-Situ Data Source Module will make the data available on-line through the World Wide Web as composites are completed for monthly periods. The Composite for a complete EOP year is projected to be available about nine months after the completion of the EOP year. The data for the first year of the EOP will be available about June 1997.

RESOURCE SUPPORT -- NOAA/OGP support to the UCAR/OFPS

TASK LEADER -- S. Williams; UCAR/OFPS

10.2 Snow and Snow Water Equivilant

OBJECTIVE: *Develop improved parameterizations of snow processes, develop supporting data sets, and develop improved spatial estimation techniques for orographic precipitation and snow.*

Point snow measurement relies primarily on the Soil Conservation Service (Natural Resources Conservation Survey) SNOpack TELemetry (SNOTEL) network, which is largely to the west of the Mississippi River basin, and a comparatively sparse network of snow depth measurements at NWS synoptic stations. Snow courses are measured by various agencies, but these are limited and are restricted to the higher snowfall areas. Remote sensing offers a more practical approach to assess snow over large areas and this is addressed in the next section. However, the need for new techniques or additional ground truth measurements has to be considered.

The program in NESDIS is focused on the development of an interactive system for producing daily, rather than the current weekly, Northern Hemisphere snow maps on Hewlett Packard 755 UNIX-based workstations from a variety of satellite imagery and derived mapped products in one hour or less. Resolution of the final product will be improved from 190 kilometers to 23 kilometers. Ultimately, the final product will also provide information on snow depth in addition to snow cover.

10.3 Cloud Data Products

Several satellite-based cloud data sets will be generated during the course of the EOP, based on both POES and GOES observations: ASOS (GOES), CLAVR (POES), and high-resolution (time and space) clouds (GOES).

A gridded version of the Automated Surface Observing System (ASOS) clouds will be generated for GCIP as a continental-scale product. The ASOS clouds are produced operationally from GOES at weather station locations to supplement the laser ceilometer observations of the ASOS of the modernized weather service. The ASOS clouds are generated from the GOES sounder using the carbon dioxide slicing technique (Menzel and Strabala, 1989; Wylie and Menzel, 1989). They can also be generated from the image data by substituting the water vapor channel for the carbon dioxide band. Whether the sounder or imager version is implemented depends on which technique is chosen by the NWS for the operational ASOS product. In addition to cloud information, the ASOS-cloud processing system produces clear sky surface temperature as an intermediate product, which will be evaluated for surface energy budget studies and validation of the Eta and other models.

CLAVR stands for clouds from the advanced very high resolution radiometer (AVHRR) on the POES. NESDIS has developed this cloud product over the last few years, and it is currently being generated on a routine basis from the afternoon POES observations (Stowe et al., 1991). This product includes cloud amount, type, and height of each cloud type at a resolution of one degree in latitude. During GCIP it will be produced routinely on a global basis by NESDIS for day and night from both POES spacecraft. The NESDIS will access the product to produce a CONUS sector for the GCIP database.

The ASOS cloud product produced from the GOES data meets the needs of GCIP users better than the CLAVR cloud product produced from POES data. We shall therefore select the ASOS product as the best available now" for GCIP with the CLAVR to be used in the event of difficulties with the ASOS product. A summary of the clouds task is given in Task 10.3.1.

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **10.3.1 Cloud Products**

OBJECTIVE -- To provide the cloud products from the operational NESDIS output to the GCIP Data Management System

PRODUCT DESCRIPTION -- The ASOS cloud product is produced from GOES image and vertical sounder data each hour for the geographical domain of the continental U.S (CONUS).

PROJECTED IMPROVEMENTS -- This is a relatively new satellite derived product so that any improvements need to await reactions from the users.

GCIP DATA SOURCE MODULE -- Satellite Remote Sensing (Contact: B. Motta)

SCHEDULE -- Data are archived on a routine basis

GCIP USER AVAILABILITY -- Within three months after the observation time

RESOURCE SUPPORT -- Development support from the NOAA GEWEX Program through the NESDIS portion of the CORE Project for GCIP. The operational product is a contribution from the NOAA/NESDIS.

TASK LEADER -- D. Tarpley

GCIP PRA COORDINATION -- Clouds and Radiation

10.4 Radiation Data Products

Radiation data sets are required for the GCIP EOP on a continental scale. This information will include top-of-the-atmosphere, surface, and atmospheric radiation data based on both POES and GOES observations.

10.4.1 Outgoing Longwave Radiation (OLR) and Planetary Albedo

The OLR and planetary albedo radiation budget products have been obtained from multispectral, narrowband radiometric scanners for many years. This product is currently being produced using a technique to infer the OLR from four of the channels on the high-resolution infrared sounder (HIRS) flown on the POES(Ellingson et al., 1989; Ellingson et al., 1994a).

The above methodologies for obtaining top-of-the-atmosphere, OLR, and planetary albedo are being applied to GOES-8 data and are being produced for GCIP.

10.4.2 Surface and Atmospheric Radiation Budget Components

In addition to the OLR, methods have been developed to infer the downward longwave radiation (DLR) flux at the surface (Lee and Ellingson, 1990) and the vertical profile of longwave cooling (LC) (Shaffer and Ellingson, 1990; Ellingson et al., 1994b) from POES observations. The DLR and LC estimation techniques require spectral radiance data from the HIRS and the vertical distribution of cloud amount and cloud base height. The NESDIS is implementing the techniques in an experimental operations test in the TOVS sounding system.

Insolation and photosynthetically active radiation (PAR) for the GCIP CSA (and in fact, for the whole U.S.) will be produced from GOES 8/9 imager observations. The insolation algorithm, developed at the University of Maryland (Pinker and Ewing, 1985; Pinker and Laszlo, 1992) is a physical algorithm that uses GOES imager observations of reflected visible radiation. The algorithm uses target clear radiance, target cloudy radiance, fraction of clouds in the target and atmospheric precipitable water (from the Eta model). Other required input to the model is surface albedo (Matthews, 1985) and snowcover. Net solar irradiance at the surface can be derived from the insolation and surface albedo.

This algorithm has been modified at the University of Maryland to use GOES 8/9 data as input. A two threshold cloud detection method has been developed that provides the clear and cloudy radiances and the fractional cloud cover required by the algorithm. Over the past two years the insolation algorithm has been implemented into the GOES sounding system at NESDIS and routine production has begun. The products are not operational, however, but are currently experimental and generated specifically for GCIP.

Because the insolation algorithm is newly developed for GOES 8/9 data, it is vital that the insolation estimates be compared with ground truth and all aspects of the procedure, from cloud detection through insolation production, and be subject to modification and improvement. This way, the accuracy and reliability of the products will increase, thereby meeting one of the main objectives of GCIP.

Outgoing longwave radiation, DLR at the surface, and atmospheric LC rates will be derived from GOES-8 by applying the methodologies used to generate these quantities from POES-HIRS observations. Some development is needed to apply the techniques to GOES data.

In the case of clear skies, surface temperature measurements will be obtained as a byproduct of the ASOS clouds processing. These measurements can be used to obtain upward longwave radiation fields at the surface, which can be combined with the DLR to obtain net longwave irradiance at the surface for clear skies. A summary of satellite radiation budget data setsto be generated for the EOP is contained in Table 10-1.

Table 10-1 Satellite Radiation Budget Data Sets for GCIP Continental-Scale Area during the EOP

PRODUCT	INSTRUMENT	RESOLUTION	FREQUENCY
POES			
Outgoing LW	AVHRR	0.7 Deg	4/day
Planetary Albedo	AVHRR	0.7 Deg	4/day
Downward LW	HRS	1.0 Deg	4/day
LW Cooling Rate	HRS	1.0 Deg	4/day
Outgoing LW	HRS	1.0 Deg	4/day
GOES			
Outgoing LW	Sounder	0.5 Deg	hourly
Downward LW	Sounder	0.5 Deg	hourly
LW Cooling Rate	Sounder	0.5 Deg	hourly
Insolation/PAR	Imager	0.5 Deg	hourly

There is another source of surface temperature that should be considered for GCIP. This is the Derived Product Imagery (DPI) which includes surface skin temperature, lifted index, and total precipitable water. The DPI is a planned operational suite of products from the GOES 8/9 imager that is currently under active development. The resolution of the surface temperature in the DPI is 4 km, so in addition to averages of surface temperature for targets of about 50 km. resolution, histograms of surface temperature could be saved. This could be of considerable interest to the modeling community.

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **10.4.1 Satellite Radiation Data Products**

OBJECTIVE -- To provide the satellite radiation products from the NESDIS to the GCIP Data Management System

PRODUCT DESCRIPTION --Radiation products produced from the POES and GOES satellites

PROJECTED IMPROVEMENTS -- Outgoing longwave radiation , downward longwave radiation at the surface and atmospheric longwave cooling rates from GOES 8 type data is now being developed and will be added by the end of the first year of the EOP. Some limited data sets are projected to be available during the ESOP-96 in the LSA-SW

GCIP DATA SOURCE MODULE -- Satellite Remote Sensing (Contact: B. Motta)

SCHEDULE -- Data are archived on a routine basis

GCIP USER AVAILABILITY -- Within three months after the observation time

RESOURCE SUPPORT -- Development support from the NOAA GEWEX Program through the NESDIS portion of the CORE Project for GCIP. The operational product is a contribution from the NOAA/NESDIS.

TASK LEADER -- D. Tarpley

GCIP PRA COORDINATION -- Clouds and Radiation

10.4.3 SURFRAD Sites for GCIP

Six Surface Radiation (SURFRAD) sites are planned for the contiguous 48 states (three of these are already installed in the Mississippi River basin). This network is intended to provide high quality, long-term solar and infrared radiation measurements for a variety of research needs: to validate satellite-derived surface insolation; to provide a long-term climatology of surface radiation measurements (at least 25 years); to detect trends in surface radiation; and, to verify radiative transfer models. The basic instrumentation set (see Table 10-2) includes radiometers for upwelling and downwelling solar and INFRARED radiation, a sun-tracking normal incident pyrheliometer (NIP) for measuring direct solar irradiance, and a meteorological tower. Other special sensors may be added.

Table 10-2 Basic Instrumentation at a Surfrad Site.

Measurment	Name	Cost ($)	Accuracy
Direct Solar Irradiance	Cavity radiometer (required at BSRN)	18,000	2 W/m^2
	shadow band radiometer NIP	10,000	
		1,800	5 W/m^2
Diffuse Solar	Pyranometer (2pi solar flux) (radiation >2.5 pm filtered out)	1,800	5 W/m^2
Global Solar (direct and diffuse)	Pyranometer (no tracker)	1,800	10 W/m^2
Reflected Shortwave	Inverted pyranometer (shaded from sun)	2,000	10 W/m^2
Downward Longwave	Pyrgeometer (filtered pyranometer)	2,850	6-8 W/m^2
Upward Longwave	Inverted Pyrgeometer	2,850	6-8 W/m^2
Photosynthetically Active Radiation	PAR Instrument (filtered silicon detector)	200	TBD
Surface Meteorology Tower	10-m height: winds, pressure, temperature, humidity	6,000	TBD

The URL http://www.srrb.noaa.gov has detailed information on SURFRAD sites, instrumentation, and access to data. In addition to the instrumentation mentioned on Table 10-2, NOAA has obtained Multi-Filter Rotating Shawdowband Radiometers (MFRSR) for SURFRAD. Operation MFRSR algorithmss retrieve column aerosol optical depth, predictable water, and ozone; research algorithms provide cloud optical depth. The SURFRAD combination of broadband and MFRSR measurments will permit the estimation of aerosol direct radiative forcing to climate over GCIP.

SURFRAD sites have been chosen to be representative of extended regions. Each has reasonably uniform and stable surface properties that are representative of the region. This requirement is the primary concern of those doing verification of satellite-based algorithms. Those who will use SURFRAD data to verify the satellite-derived surface radiation data require that the area surrounding the sites be spatially uniform over at least the area of one GOES-8 sounder pixel, which is 10 km (E-W) by 40 km (N-S).

One SURFRAD site in the GCIP region is at Bondville, Illinois, located approximately eight miles southwest of Champaign, Illinois. It is owned by the University of Illinois Electrical Engineering Department and managed by the Illinois State Water Survey. This site consists of six acres of grassland (being updated to 14 acres) and surrounded by 220 acres of soybeans and corn. This site is currently operational and also contains a suite of aerosol measurement systems operating under a separate NOAA funded aerosol monitoring program. A second SURFRAD site in the GCIP region is the Poplar River site (near Fort Peck, Montana). The Poplar River flows south out of Canada and into the Missouri River. This site has good hydrological data available and the Poplar River is not used for irrigation (because of high levels of alkali). The site is on rangeland with no trees in northeastern Montana. This site was operational in the summer of 1994. A third SURFRAD site in the GCIP region is the Goodwin Creek site (near Oxford Mississippi). The Goodwin Creek Experimental Watershed is an ARS site located in northern Mississippi. It is relatively flat, and its land use is about 14 percent agricultural, 26 percent timber, and 60 percent idle pasture land. Four lakes are in the region. This site was operational in the fall of 1994.

1997-1998 Activities

In addition to the usual radiation and hydrological measurements at the three SURFRAD sites identified earlier, funds have been requested to add instrumentation for the following: soil moisture, snowfall measurements (in the northern sites), ground heat flux, and cloud determination via lidar and/or possibly digitized pictures.

The data from these sites will be quality controlled by NOAA's Air Resource Laboratory (ARL) in Boulder, Colorado. Data will be archived at the ARL facility in Oak Ridge, Tennessee and accessible via the GCIP *in situ* data source module.

1998 Activities

Not all the requested instrumentation will be immediately available at all the GCIP SURFRAD sites. It is expected that further implementation of instrumentation will likely occur as more resources become available and become part of the normal operations at the three SURFRAD sites.

10.5 Soil Moisture Profiles

The few routine soil moisture observations available for GCIP applications is being significantly enhanced during the next two to three years; primarily as a result of sensors installed in the Little Washita Experimental Watershed and the ARM/CART site combined with planned enhancements to the Oklahoma Mesonet. The situation in the LSA-SW is such that GCIP can potentially compile in-situ soil moisture measurements on three different scales using automated soil moisture sensing systems:

Six soil moisture sensing systems were installed in the Little Washita Watershed in the summer of 1995. An additional seven sensor systems were installed in this Watershed during 1996.

A total of 22 soil moisture sensing systems are being installed within the ARM/CART site. The first seven were installed and operating by the beginning of ESOP-96 in April 1996 and an additional 12 installed by the end of Water Year 1996. An example of the relative soil moisture response curves in the ARM/CART site is given in Figure 10-1 which was very dry during the spring and early summer. The Campbell Scientific Heat Dissipation Soil Moisture Sensor (Model 229L) provides data from six different depths as shown in Figure 10- 1. The calibration to convert the sensor is not yet completed. Therefore, the relative response in degrees celsius is given in the figure with lower values wetter and higher values drier. The curves from Ashton in May 1996 are typical of the response from many sites this spring and summer. The soil was very dry throughout the profile, and what little rain fell did not infiltrate very deeply into the profile. At Ashton, the rain on May 10th wetted the top two sensors, with only a slight amount of moisture penetrating as far as the 35-cm sensor.

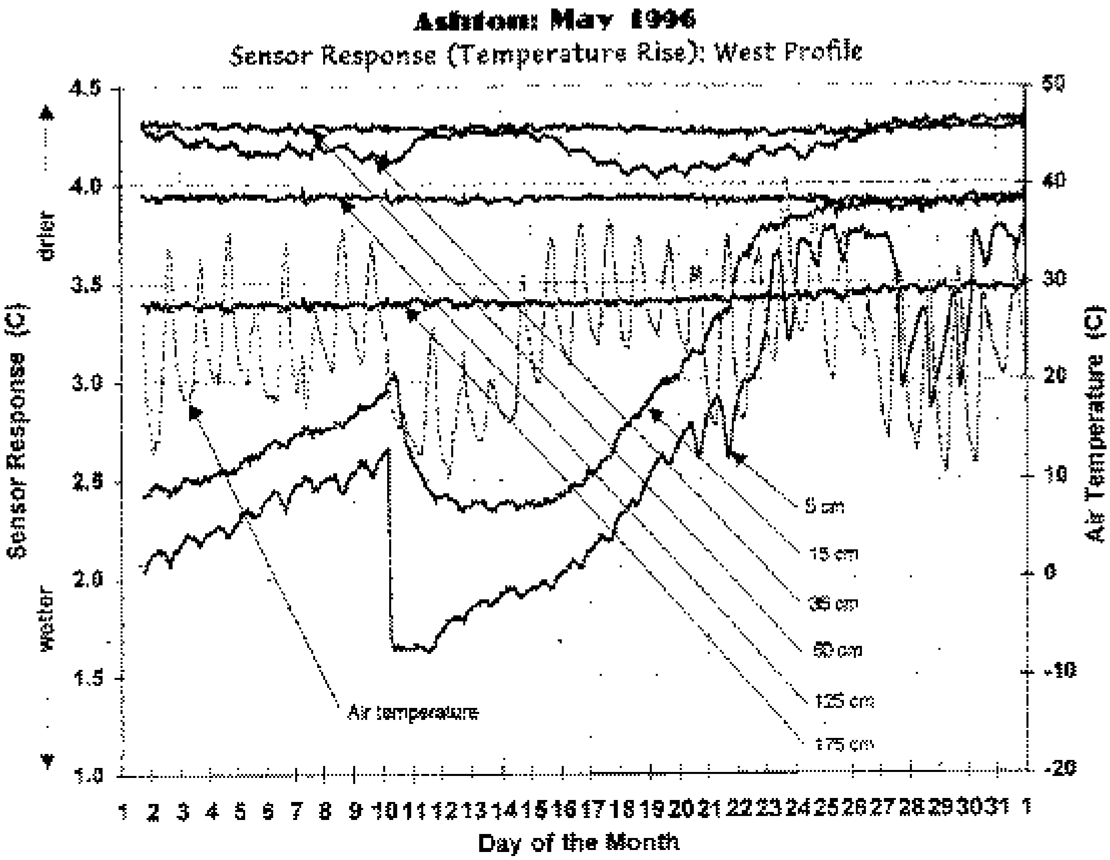

Figure 10-1 Relative soil moisture response curves for Ashton, OK during May 1996 from the Campbell Scientific Heat Dissipation Soil Moisture Sensor.

The Oklahoma Mesonet is planning to install soil moisture sensing systems at about half of their 109 stations in the state-wide mesonetwork.

An initial soil moisture data set for both the Little Washita and the ARM/CART site will be compiled during as part of the ESOP-96 data set. It is projected that in-situ soil moisture measurements on the three different scales noted above will become available in a more complete sense during the second year of the EOP in WY97.

Also during WY97 a soil moisture analysis for at least a portion of the LSA-NC can be made by making use of soil moisture measurements from the Illinois State network plus other sites available in the LSA-NC. Task 10.5.1 outlines the task for providing soil moisture analysis from observations. Task 10.5.2 outlines a task for deriving soil moisture from a hydrologic model for evaluation by the in-situ measurements.

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **10.5.1 Soil Moisture Analysis from Observations**

OBJECTIVE -- To develop an analyzed soil moisture product for portions of the Mississippi River basin in evolutionary steps over the next two to three years.

PRODUCT DESCRIPTION -- A series of analyzed products will be produced for different temporal and spatial scales based on both the GCIP needs and the availability of suitable data for such analyses.

PROJECTED IMPROVEMENTS --The soil moisture analysis will start out with relatively simple procedures over those areas having suitable data. The analysis techniques will become more sophisticated over time. Also, the ability to incorporate remotely sensed data will enable the analysis product to be extended geographically beyond those areas having in-situ measurements.

GCIP DATA SOURCE MODULE -- In-Situ (Contact: S. Williams)

SCHEDULE --to be determined

GCIP USER AVAILABILITY --to be determined

RESOURCE SUPPORT -- In-Situ measurements being supported by several sources. Development of analyzed product support is to be determined.

TASK LEADER -- to be determined

GCIP PRA COORDINATION -- Soil Moisture

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **10.5.2 Soil Moisture from Hydrologic Model**

OBJECTIVE -- To validate a capability of providing soil moisture data from hydrologic model(s)

PRODUCT DESCRIPTION -- It is anticipated that soil moisture analyses can be derived as part of a model output from a model such as the Land Data Assimilation System. Thus, it can be argued that these models will provide a more realistic simulation of the soil moisture changes, both in time and space.

PROJECTED IMPROVEMENTS -- To be determined after demonstration of initial results from model.

GCIP DATA SOURCE MODULE -- to be determined

SCHEDULE --tbd

GCIP USER AVAILABILITY -- tbd

RESOURCE SUPPORT -- Several different models are in different states of development and supported by NOAA/GCIP and other agencies. The development of the LDAS is supported by the NOAA/GCIP Program through the NWS portion of the CORE Project for GCIP.

TASK LEADER -- E. Engman for Soil Moisture PRA, J. Schaake and K. Mitchell for the NOAA/NWS CORE Project for GCIP.

GCIP PRA COORDINATION -- Jointly between the Coupled Modeling and Data Assimilation

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1998 Activities

Temperature and volumetric water content will be made to a depth of 1.3-2.0 meters (site dependent). Eight to ten measurements will be made over that depth. Analysis of this data will be an on-going project.

10.6 Soil Temperature Profiles

Soil temperature profiles or subsurface heat flux profiles are being measured in the ARM/CART, Little Washita micronetwork, and Oklahoma mesonetwork at the locations providing the soil moisture profile measurements.

10.7 Land Surface Data Products

The derived data products for land surface characteristics are described within the categories of vegetation/land cover, soils and topographic data products.

10.7.1 Vegetation and Land Cover Data Products

Some of the sources for vegetation/land cover characteristics data include the global one-degree latitude-longitude modeling data sets recently published on CD-ROM by NASA/GSFC under GEWEX/ISLSCP Initiative No. 1 and various AVHRR data sets produced by NOAA/NESDIS and USGS. For example, NASA's ISLSCP CD-ROM includes monthly one-degree by one-degree calibrated, continental NDVI data (1982 to 1990); enhanced NDVI fields; Fraction of Absorbed Photosynthetically Active Radiation (FPAR) fields derived from enhanced-NDVI data; LAI and canopy greenness resistance fraction calculated from the derived FPAR fields; surface albedo and roughness length fields derived from land process models; and canopy photosynthesis and canopy conductance fields estimated by inverting the Simple Biosphere (SiB) Model 2 land surface parameterization (LSP) with FPAR as the key model input. The CD-ROM also includes a one-degree global land cover data set developed under the leadership of the University of Maryland.

Although these ISLSCP Initiative No. 1 CD-ROM data are of direct interest to GCM and possibly mesoscale modeling, the remote sensing algorithms and approaches for inverting an LSP to derive the land cover characteristics will guide efforts to similar use of higher resolution AVHRR and LANDSAT TM data. NASA/GSFC is currently implementing ISLSCP Initiative No. 2 which focuses on enhanced global land cover characteristics data sets at a 1/2-degree latitude-longitude grid.

The NOAA/NESDIS has developed AVHRR global vegetation index (GVI) data sets. These data sets include weekly satellite image composites consisting of five AVHRR channels, solar zenith and azimuth angles, and the GVI for 1985 to the present. These data are calibrated for sensor drift and intersensor variability, and are available in a 1/6-degree resolution latitude-longitude product. Recently, NOAA/NESDIS produced a five-year climatology of the GVI data, and is now working to derive vegetation fraction from the GVI. The NOAA/NESDIS is also working with NASA/GSFC on the AVHRR Global Area Coverage (GAC) Pathfinder project to develop calibrated 8-km AVHRR data with a period of record beginning in 1981.

The USGS EROS Data Center (EDC) has developed 1-km AVHRR databases for the conterminous United States and is now processing global 1-km AVHRR data for land areas. The databases for the conterminous United States include biweekly AVHRR time-series image composites on CD-ROM (1990-1994) and a prototype land cover characteristics database for 1990 on CD-ROM. This 1990 land cover characteristics database is currently undergoing validation based on field survey data. Ongoing USGS activities also include the preliminary development of experimental, temporally smoothed 1-km seasonal NDVI greenness statistics for test and evaluation. These statistics consist of 12 seasonal characteristics that are associated with each 1-km NDVI seasonal profile for each year during the period 1989 to 1993, as well as the five-year means throughout the conterminous United States. Under the auspices of the International Geosphere Biosphere Project (IGBP)-led 1-km AVHRR global landcover database development activity, the USGS is currently processing global, 10-day AVHRR image composites for land areas. Efforts to develop a 1-km AVHRR North American land cover characteristics database are well under way, with some testing underway in 1995. Several global climate change research modelers are currently testing and evaluating these USGS data sets.

10.7.2 Soils Data Products

The STATSGO database provides the most useful resource for characterizing the role of soil in mesoscale atmospheric and hydrological models. This database was developed by generalizing soil-survey maps, including published and unpublished detailed soil surveys, county general soil maps, state general soil maps, state major land resource area maps, and, where no soil survey information was available, LANDSAT imagery. Map-unit composition is determined by transects or sampling areas on the detailed soil surveys that are then used to develop a statistical basis for map-unit characterization. The STATSGO map units developed in this manner are a combination of associated phases of soil series.

The STATSGO database will be useful for regional-scale analysis; however, GCIP researchers will require, on a selective basis, SSURGO data for detailed watershed studies and intense field observation programs. Although this database will not be complete for the entire United States or even the GCIP study area for many years, selected watersheds within the Mississippi basin should have this, or similar coverage, within the EOP. The SSURGO and STATSGO databases are linked through their mutual connection to the NCSS Soil Interpretation Record (Soil-5) and Map Unit Use File (Soil-6).

Doug Miller at Penn State University is developing a multi-layer soil characteristics dataset based on the STATSGO for application to a wide range of SVAT, climate, hydrology and other environmental models. A more detailed description of this dataset is given on the World Wide Web at the URL address:
http:\\eoswww.essc.psu.edu\soils.html

10.7.3 Topographic Data Products

Topographic information includes surface elevation data and various derived characteristics such as aspect, slope, stream networks, and drainage basin boundaries. In general, the requirements of atmospheric modelers for topographic data (i.e., spatial and vertical resolution and accuracies) are much less demanding than the requirements for hydrological modeling. For example, available DEMs for the conterminous United States (0.5 km and approximately 100-m resolution) are generally adequate for most atmospheric modeling. A 60-m DEM derived by USGS from 2-arc second elevation contours is available for the entire ARM/CART region and other selected quads.

The 100-m DEM is generally appropriate for hydrological modeling in large basins (e.g., greater than 1,000 km2 in area). However, topographic data for small basins down to watersheds are needed at two general hydrological scales: hillslope and stream network. The hillslope scale is the scale at which water moves laterally to the stream network. Available USGS 60 m DEMs derived from 2-arcsecond contour data are generally available for the ARM/CART region.

Hillslope flow distances vary and may be as great as 500 m to 1 km. Definition of hillslope flow paths and the statistics of hillslope characteristics require surface elevation data at about 30 m spatial resolution. Such data have been digitized by the USGS from 1:24,000 scale map sheets for part, but not all of the Mississippi River basin. Also, stream locations (but not drainage boundaries) are available in vector form for these map sheets. Because 30- m resolution data are not available globally nor in some parts of the Mississippi basin, research is needed to see how well hillslope statistics, that are important to some hydrological models, can be estimated from topographic properties of lower resolution terrain data. Research is also needed to determine how important hillslope information is to hydrological response of the land surface. Because 1:24,000 scale maps are not available globally, research is needed on how best to use remote sensing techniques as part of a sampling strategy to develop regionalized hillslope statistics (which may be mapped at an appropriately large scale).

10.8 Surface and Ground Water Measurements

The primary observations of hydrological variables are from in situ networks and consist of stream gauges, measuring wells, measurements of water storage in large reservoirs, soil moisture, evaporation and estimates of snow cover. GCIP is treating soil moisture as a separate variable (see Section 10.5) and also estimates of snow cover. (see Section 10.2). There are few measurements of evaporation available. This leaves stream gauges, measuring wells and measurements of water storage which are needed to provide derived information for computing water budgets. In cooperation with many other Federal, state, and local agencies, the USGS collects water data at thousands of locations throughout the nation and prepares records of stream discharge (flow), and storage in reservoirs and lakes, ground-water levels, well and spring discharge and the quality of surface and ground water. The number of stations collecting such data was summarized in Table 1 of the GCIP Implementation Plan, Volume I (IGPO, 1993), and is updated for each of the data sets compiled by GCIP.

Most of the gauged streams in the Mississippi River basin are affected by various water management activities such as upstream storage and diversion for human activities and irrigation. The USGS has a hydrological benchmark network of 58 stations virtually unaffected by human activity distributed across the United States (Lawrence, 1987). Wallis et al. (1991) prepared a set of 1009 USGS streamflow stations for which long-term (1948-88) observations have been assembled into a consistent daily database and missing observations estimated using a simple closest station" prorating rule. Estimated values for missing data, as well as suspicious observations, are flagged. The data are retrievable by station list, state, latitude-longitude range, and hydrologic unit code from a CD-ROM. This data set is being updated to include the years since 1988 with primary emphasis on those stations important to GCIP. Landwehr and Slack (1992) compiled measured streamflow data for 1659 stations with at least 20 years of complete records between 1874 and 1988. A streamflow data product similar to those described above will be produced for the GCIP EOP. A summary of the Surface and Ground Water Task is given in Task 10.8.1.

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **10.8.1 Surface and Ground Water**

OBJECTIVE -- To provide the Surface and Ground Water data products from the USGS National Water Information System to the GCIP Data Management System.

PRODUCT DESCRIPTION -- The USGS compiles and indexes information on sites for which water data are available , the types of data available , and the organizations that store the data. The surface-water discharge data processed on a water-year basis is a very important data product needed for all the stations in the Mississippi River basin. Other types of data such as that available for lakes and reservoirs are also needed for water budget studies.

PROJECTED IMPROVEMENTS -- Improvements in computer facilities and database design will make these data more readily available through electronic means. Also, preliminary computations of discharge are being made available.

GCIP DATA SOURCE MODULE -- In-Situ (Contact: S. Williams)

SCHEDULE -- Preliminary data, when available within two months after the observation month. Finalized data are available within six to nine months after the end of the water year.

GCIP USER AVAILABILITY - - Preliminary data within two months after the observation month. Finalized data about nine months after the end of the water year.

RESOURCE SUPPORT -- Surface and Ground Water data products are contributed to GCIP by the USGS

TASK LEADER -- W. Kirby

GCIP PRA COORDINATION -- Streamflow

10.9 ISLSCP/GCIP Surface Flux Measurements

The purpose of the ISLSCP initiative within GCIP is to provide data sets that can be used to complement the operational and other research data sets being collected in the Mississippi basin. Particularly needed are sensible and latent heat fluxes and related measurements. The basic science question that the ISLSCP initiative will address is: Can the application of more complete bio-physical models and the development and application of relevant remote sensing algorithms be used to improve the quality of the continental-scale description of surface and water exchanges?

The strategy of the ISLSCP initiative will be to use flux towers to study temporal variability of fluxes at a point over an extended period of time and to use aircraft measurements to study spatial variability near the flux towers for selected times representing different seasons. This strategy will support investigations of scaling properties of land surface models and processes and the development and testing of approaches to estimate effective parameters for large areas.

The GCIP science plan (WMO, 1992) identified one particular field campaign that cut across several GCIP scientific objectives. The year long field effort (with embedded IOPs) would be used to validate the largescale application of surface-atmosphere flux calculation models forced by remote sensing data, standard meteorological observations, and analyses thereof. This project would provide the following missing components, which are directly relevant to the large-scale objectives of GCIP:

- Time-series fields of evaporation, with a spatial-resolution on the order of a few kilometers and temporal resolution of hours to days.
- Time-series fields of the surface radiation budget (same spatial- temporal resolution as above)
- Time-series fields of soil moisture, with a spatial resolution of a few kilometers and a temporal resolution of days to weeks.

The provision of these additional quantities would not only close the water and energy budget equations for the region but would also provide more detailed information on the spatial distributions of moisture and energy sinks and sources within the experimental area. Measurement and modeling techniques developed with ISLSCP over the last five years could be used to address these missing components.

NOAA has already started a contribution to this effort with a new flux tower operating since May, 1995 in the Little Washita area of Oklahoma. Also augmentation of a flux tower at Oak Ridge, Tennessee has occurred and a third flux tower was added in 1996 at Bondville, Illinois.

1997-1998 Activities

In keeping with the philosophy of an effective, directed but economic field effort the following measurements are proposed.

(i) Four to six flux towers should be located within the GCIP area. These will be sited on the basis of a land cover/climatological classification of the GCIP area, conducted well ahead of time, using AVHRR data among other sources. The flux towers should be located near the (monitoring) radiation rigs and should measure:

Latent heat flux
Sensible heat flux
Shear stress
Soil heat flux

These measurements should be made throughout one experiment year, preferably 1996 or 1997.

(ii) Airborne eddy correlation
Eddy correlation aircraft (preferably twin engine aircraft like the NCAR King Air on the NAS/NRC Twin Otter) will be used during a series of Intensive Field Campaigns (IFC); perhaps three or four IFC's each of 10-20 days during the experimental year.

The aircraft will be used to conduct the following tasks:

- Measurement of fluxes over 30x30 km areas of homogeneous surface conditions centered on the flux sites.
- Measurement of fluxes over long low-level transects across gradients of soil moisture/vegetation conditions; preferably between flux sites and in conjunction with Landsat/SPOT/AVHRR acquisitions.
- Measurement of divergence/gradient terms using box pattern' flight lines centered on the flux sites.

These airborne eddy correlation data will be used to validate the large- scale application of surface-atmosphere flux calculation models forced by remote sensing data and meteorological observations or analyses.

(iii) Airborne soil moisture measurements

Aircraft equipped with gamma-ray or microwave sensors should be used to make soil moisture transect measurements. In some cases, these should be validated by a compact ground measurement exercise.

1999 Activities

The routinely-acquired satellite data and the combined surface observations/analysis fields of meteorological conditions will be used to drive regional scale models that will calculate continuous time-series fields of the following quantities:

Radiation:

Insolation, PAR
Absorbed insolation, Absorbed PAR, Albedo
Downward longwave
Emitted longwave
Net radiation

Heat Fluxes:

Latent heat flux (evapotranspiration)
Sensible heat flux
Ground heat flux

Momentum:

Shear stress (roughness length)

Surface conditions:

Soil moisture
Vegetation state (FPAR)

10.10 The Water Vapor Sensing System (WVSS) for Commercial Aircraft

Water vapor is ubiquitous, energetically important and volatile, highly variable in space and time, and unfortunately, poorly measured by current methods. The water vapor information from the twice-per-day radiosonde sites will be marginal for the diagnostic budget studies to be performed for GCIP. Two major systems can be used during GCIP to augment these radiosondes. The first of these is to add ascent and descent profiles from commercial aircraft. These high resolution "soundings" will provide winds, temperature, and water vapor (discussed below). Such profiles will aid the research goals stated in Section 5 concerning the ability to improve water balance calculations with soundings at a far greater frequency than twice per day. Such water vapor profiles will also contribute to the precipitation research discussed in Section 6.

The development of a water vapor sensing system (WVSS) for commercial air carriers was funded by the FAA under the Commercial Aviation Sensing Humidity (CASH) Program. NOAA's Office of Global Programs is now co-funding the procurement phase with the FAA.

1997 Activities

A competitive contract was awarded in July 1995 with FAA certification of the WVSS completed in 1996. After successful certification, six units will fly for two to three months each on a Boeing-757 aircraft. This activity will be a final confirmation that the data are of sufficient quality and that the sensing system operates unattended as expected before implementing contract options for 160 additional aircraft for the FAA and for GCIP.

Evaluation of the data will be performed by NOAA's Forecast Systems Laboratory (FSL) for the FAA. Quality-controlled data sets of wind, temperature, and water vapor from the commercial aircraft will be made available through the GCIP in situ data source module described in Section 13. The 160 aircraft will provide approximately 640 ascent profiles per day. The similar number of descent profiles" are of a different form, and although not like a sounding, do provide additional information for 4DDA.

For the demonstration program in 1998 and 1999 United Parcel Service (UPS) will carry at least 22 units and the balance will be carried by American Airlines and other commercial carriers.

10.11 Cooperative Atmospheric-Surface Exchange Study (CASES)

CASES is a facility of about 5000 km2 to study mesoscale processes of and linkages among meteorology, hydrology, climate, ecology and chemistry, in the upper Walnut River watershed, north of Winfield, Kansas. Boundary layer instrumentation, in conjunction with WSR-88D radars, stream gauges, soil moisture data, topographical and land use data, mesonet surface data, and coupled atmospheric-hydrologic models, will produce data sets useful to GCIP SSA and ISA studies when this facility is fully implemented.

CASES will provide seasonal and interannual information on precipitation, soil moisture, runoff, vegetation, evapotranspiration, and atmospheric thermodynamics, which will allow modelers to not only define the surface hydrology but approach closure on the hydrologic cycle between the atmosphere and the watershed as well. CASES will provide a comprehensive data set on a scale which will allow aggregate testing of model structure and model parameters derived from studies of the Little Washita watershed and the FIFE experiment.

Initial activities are ongoing to prepare a retrospective data set for the Walnut River basin. Further plans exist for implementing some of the sensor systems identified above, and these will be implemented as resources become available.

11. MODEL ASSIMILATED AND FORECAST DATA SETS

11.1 Near-Term Objectives

One of the principal functions of the regional mesoscale models, as was noted in Section 2 is to produce the model assimilated and forecast output products for GCIP research, especially for energy and water budget studies. The production of such data sets was initiated as a GCIP major thrust area in 1995.

The near-term objectives for this thrust area are:

(i) To produce model assimilated and forecast data products for GCIP investigators with an emphasis on those variables needed to produce energy and water budgets over a continental scale with detailed emphasis in 1997 on the LSA-SW and the LSA-NC and beginning the application of such detailed emphasis capability to the LSA-E during 1998, and to the LSA-NW during 1999.
(ii) To produce a quantitative assessment of the accuracy and reliability of the model assimilated and forecast data products for applications to energy and water budgets.
(iii) To conduct the research needed to improve the time and space distribution along with the accuracy and reliability of the model assimilated and forecast data products.

The activities relevant to the third objective above were described in Section 2.

11.2 Regional Mesoscale Model Output

The list of model output fields needed by GCIP researchers was given in Table 3, Volume I of the GCIP Implementation Plan (IGPO,1993). From the beginning of GCIP, it has been the intent to acquire model output from several different models of varying resolution, physics and data assimilation systems. The large volume of data produced by the current generation of atmospheric models has forced a number of compromises in order to achieve a tractable data handling solution for model output data. The data volume is further enlarged by the GCIP need to enhance the traditional model output to include additional fields needed by researchers to perform meaningful studies of the water and energy cycles. The near-term GCIP needs for model output data will be met by concentrating on three regional mesoscale models:

- Eta model operated by NOAA/NCEP
- MAPS model operated by NOAA/FSL
- RFE model operated by AES/CMC

The model output is divided into three types:

(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 (TOA) flux fields, and atmospheric fields referred to as Model Output Reduced Data Sets (MORDS)
(3) Gridded three-dimensional atmospheric fields containing all of the atmospheric variables produced by the models.

Each model output type is described in the following sections.

A summary of the model output tasks is given in Task 11.2.1 for the Eta model, Task 11.2.2 for the RFE model, and Task 11.2.3 for the MAPS model.

ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **11.2.1 Eta Model Output**

OBJECTIVE -- To provide the model output products from the operational Eta model to the GCIP Data Management System.

PRODUCT DESCRIPTION -- A series of analyzed and forecast products are produced each day by the Eta model running in an operational mode at the NOAA/NCEP. During operational production , NCEP significantly expands the number and type of fields produced with emphasis on those needed by GCIP investigators to compute atmospheric and ground surface energy budgets following the guidelines of the GCIP Implementation Plan , Vol I, Section 5 (IGPO, 1993).

PROJECTED IMPROVEMENTS -- A description of the planned improvements to the Eta model is given in Section 2 of Part I. Some GCIP specific improvements expected during the next two to three years are:

> -- Implement the multi-layer Oregon State University (OSU) soil/vegetation, now executing for evaluation purposes in NMC's mesoscale Eta model, in the Eta/EDAS system that is providing Eta output to GCIP (within the next year).
> -- Implement the hourly National "Stage IV" precipitation analysis and assimilate 1-3 hourly precipitation into the EDAS
> -- Implement the so-called "N+1" surface layer approach in the Eta/EDAS system, providing an explicit forecast of u,v, T, Q at 10 meters above the ground.
> -- Implement the Land-surface Data Assimilation System (LDAS) in which the Eta model's land surface physics is executed independently from the Eta/EDAS in order to utilize forcing from observed precipitation and satellite-derived surface radiation
> -- Assimilate new satellite-based atmospheric moisture retrievals.

GCIP DATA SOURCE MODULE -- Model Output (Contact:R. Jenne, NCAR)

SCHEDULE -- Operational product sent by NOAA/NCEP each month to the GCIP Model Output Data Source Module.

GCIP USER AVAILABILITY --Three months after the end of the Eta product month.

RESOURCE SUPPORT -- Development support from NOAA GEWEX Program through the NWS CORE Project for GCIP. The operational product is a contribution from the NOAA/NCEP.

TASK LEADER -- K. Mitchell, NOAA/NCEP

GCIP PRA COORDINATION -- Coupled Modeling and Data Assimilation

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ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **11.2.2 RFE Model Output**

OBJECTIVE -- To provide the model output products from the operational RFE model to the GCIP Data Management System

PRODUCT DESCRIPTION -- A series of analyzed and forecast products are produced each day by the RFE model operated by the AES/CMC in Canada. The focus of the output from the RFE model during the second year of the EOP will be on the MOLTS and the MORDS.

PROJECTED IMPROVEMENTS -- A description of the planned improvements to the RFE model was given in Section 2 of Part I. Some specific improvements expected during the next two to three years are:

1) Modified surface layer treatments for better surface temperature, humidity, and wind forecasts;
2) explicit cloud water and cloud fraction prediction schemes;
3) improved radiation and convection parameterizations; and
4) increasing horizontal and vertical resolution throughout the three year period.

GCIP DATA SOURCE MODULE -- Model Output (Contact: R. Jenne)

SCHEDULE -- Operational product sent by the AES/CMC each month to the GCIP Model Output Data Source Module.

GCIP USER AVAILABILITY -- Three months after the end of the RFE product month.

RESOURCE SUPPORT -- Development support from the Canadian GEWEX Program. The operational product is a contribution from the AES/CMC

TASK LEADER -- H. Ritchie, AES/RPN

GCIP PRA COORDINATION -- Coupled Modeling and Data Assimilation

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ENHANCED OBSERVATIONS AND DATA PRODUCTS TASK SUMMARY

TASK TITLE -- **11.2.3 MAPS Model Output**

OBJECTIVE -- To provide the model output products from the experimental MAPS model to the GCIP Data Management System

PRODUCT DESCRIPTION -- A series of analyzed and forecast products from the MAPS 3- hr cycle are produced each day for the MAPS model running in an experimental mode at the NOAA/FSL. During the second year of the EOP, the focus of the output from MAPS will be on the MOLTS and the MORDS concentrating on the LSA-SW.

PROJECTED IMPROVEMENTS -- A description of the planned improvements to the MAPS model was given in Section 2 of Part I. Some specific improvements expected during the next two to three years are: 1) Addition and improvement of soil/vegetation model for improved flux forecasts;
2) Explicit microphysics, with forecasts of cloud water, rain water, snow and ice mixing ratios;
3) Addition of new data types, including radar reflectivity and radial winds, satellite radiances, Global Positioning System (GPS), and aircraft high-resolution ascent/descent data;
4) Use of surface fields from NMC's LDAS, or implement MAPS-based LDAS, if necessary.
5) Increased horizontal and vertical resolution. GCIP DATA SOURCE MODULE -- Model Output (Contact: R. Jenne)

SCHEDULE -- Experimental products sent by the NOAA/FSL each month to the GCIP Model Output Data Source Module.

GCIP USER AVAILABILITY -- Three months after the end of the MAPS product month.

RESOURCE SUPPORT -- Development support from the NOAA GEWEX Program.

TASK LEADER -- S. Benjamin; NOAA/FSL

GCIP WORKING GROUP COORDINATION -- Coupled Modeling and Data Assimilation

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11.3 Model Location Time Series

Results from the GCIP Integrated Systems Test (GIST) and ESOP-95 indicate that the vertical and surface time series at selected points is a very useful type of output for a number of applications. Indeed, some energy and water budget computations are making use of this type of model output data. GCIP labels this type of model output as Model Location Time Series (MOLTS) which is produced as an enhanced output containing a complete set of the surface" type of state and flux data needed by GCIP in addition to the basic atmospheric data which operational centers produce for normal monitoring use and other applications.

The output variables for the MOLTS are listed in Table 11-1. The variables listed under 2) Surface Variables and 3) Atmospheric Variables are considered a"fundamental" list. The MOLTS list from a specific model may add other variables depending on choice of physics package or other non-GCIP user requirements. Some examples for the surface variables 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 (frozen?), etc.

An assessment of the MOLTS requirements for GCIP, MAGS and other investigators indicates that a maximum number of 300 locations will satisfy these requirements during the period 1997 to 1999. The specific number could be less than this maximum number depending on resources available to the data producers and the changes in requirements for GCIP during the Enhanced Seasonal Observing Periods and outside of these periods. GCIP will provide inputs to the requirements as part of its annual update of the GCIP Major Activities Plan. The distribution of 300 MOLTS locations is shown in Figure 11-1.

```
Table 11-1.   Output Variables for the Model Location Time Series (MOLTS)
_______________________________________________________________________

1)  Identifiers

              Location  ID
              Valid Date/Time
              Forecast Length
              Latitude
              Longitude
              Location  Elevation (in model)

2)  Surface Variables

              Mean sea level pressure
              Ground surface pressure
              Total precipitation in past hour
              Convective precipitation in past hour
              U wind component at 10 m
              V wind component at 10 m
              2-meter specific humidity
              2-meter temperature
```

Skin temperature
Soil temperature (all soil layers)
Soil moisture (all soil layers)
Latent heat flux (surface evaporation)
Sensible heat flux
G round heat flux
Surface momentum flux
Snow phase-change heat flux
Snow depth (water equivalent)
Snow melt
Surface runoff
Sub-surface runoff
Surface downward short-wave radiation flux
Surface upward short-wave radiation flux (gives albedo)
Surface downward longwave radiation flux
Surface upward longwave radiation flux
Top-of-atmosphere net longwave radiative flux
Top-of-atmosphere net shortwave radiative flux
Top-of-atmosphere pressure for above fluxes

3) Atmospheric variables at each model vertical level

pressure
geopotential height
temperature
specific humidity
U wind component
V wind component
Omega (vertical motion -- Dp/Dt)
convective precipitation latent heating rate
stable precipitation latent heating rate
shortwave radiation latent heating rate
longwave radiation latent heating rate
cloud water and/or cloud fraction

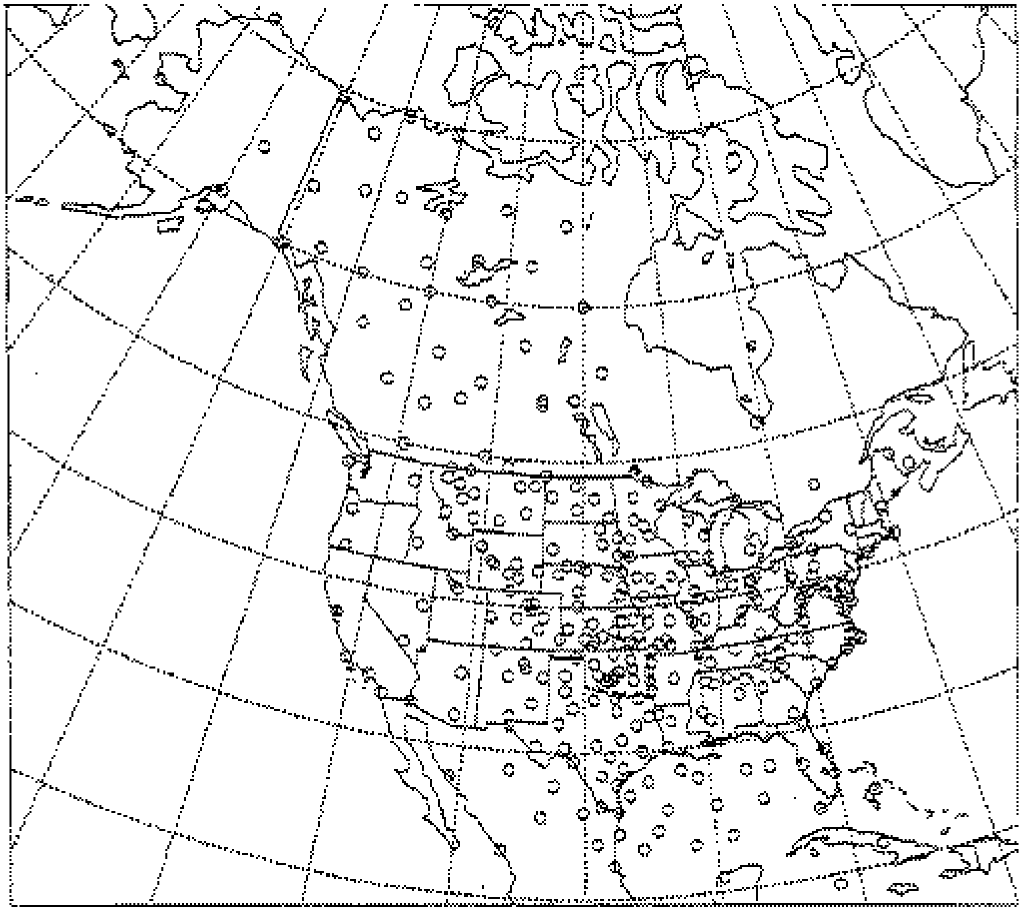

Figure 11-1 Proposed geographical Distributions of 300 MOLTS locations.

11.4 Model Output Reduced Data Set

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 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 3-D field requirements can be met by a vertical integration through the atmosphere, e.g. vertically integrated atmospheric moisture divergence needed to calculated water budgets. GCIP will make use of this concentration of requirements to further the tractability of the model output data handling problem. A Model Output Reduced Data Set (MORDS) will continue to 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:

A. 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 meters.
B. Lowest-level atmospheric fields which includes the lowest model level and the mean value in a 30 hpa layer above the surface.
C. Upper atmosphere fields at a few standard levels plus the tropopause height and the top-of-atmosphere radiation as a time average.
D. 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 11-2. Output from the regional mesoscale models on the AWIPS 212 Lambert Conformal Map base at a 40 km resolution constitutes about 30 Kilobytes per field for each output step. The 55 fields from the list of variables shown in Table 11-2 will produce about 1.5 Mb for a single forecast or analysis valid time. The MORDS output of analysis, assimilation, and forecast fields for both 0000 UT and 1200 UT cycles comes to a daily total of about 40 Mb per day from each of the regional mesoscale models or about 1.2 Gb per month. This is significantly less than the data volume generated from each of the regional models output in three- dimensional fields.

Table 11-2. Output Variables for the Model Output Reduced Data Set

A. Near-Surface Fields

```
1  - Mean sea level pressure
2  - Surface pressure at  2 meters
3  - Temperature at  2 meters
4  - Specific humidity at  2 meters
5  - U component wind speed at 10 meters
6  - V component wind speed at 10 meters
7  - Surface latent heat flux (time avg)
8  - Surface sensible heat flux (time avg)
9  - Ground heat flux (time avg)
10 - Snow phase change heat flux (time avg)
11 - Surface momentum flux (time avg)
12 - Vertically integrated moisture convergence (time avg)
13 - Vertically integrated energy convergence (time avg)
14 - Total precipitation  (time accumulated)
15 - Convective precipitation (time accumulated)
16 - Surface runoff (time accumulated)
17 - Subsurface runoff (time accumulated)
18 - Snow melt (time accumulated)
19 - Snow depth (water equivalent)
20 - Total soil moisture (within total active soil column)
21 - Canopy water content (if part of surface physics)
22 - Surface skin temperature
23 - Soil temperature in top soil layer
24 - Surface downward shortwave radiation (time avg)
25 - Surface upward shortwave radiation (time avg)
26 - Surface downward longwave radiation (time avg)
27 - Surface upward longwave radiation (time avg)
28 - Total cloud fraction (time avg)
29 - Total column water vapor
30 - Convective Available Potential Energy (CAPE)
```

B. Lowest level Atmospheric Fields

```
31 - Temperature (lowest model level)
32 - Specific humidity (lowest model level)
33 - U component wind speed (lowest model level)
34 - V component wind speed (lowest model level)
35 - Pressure (lowest model level)
36 - Geopotential (lowest model level)
37 - Temperature (mean in 30 hpa layer above ground)
38 - Specific humidity (mean in 30 hpa layer above ground)
39 - U component wind speed (mean in 30 hpa layer above ground)
40 - V component wind speed (mean in 30 hpa layer above ground)
```

C. Upper Atmospheric Fields

```
41 - 1000 hpa height
42 -  700 hpa vertical motion (omega -- Dp/Dt)
```

```
43 -  850 hpa height
44 -  850 hpa temperature
45 -  850 hpa specific humidity
46 -  850 hpa U component wind speed
47 -  850 hpa V component wind speed
48 -  500 hpa height
49 -  500 hpa absolute vorticity
50 -  250 hpa height
51 -  250 hpa U component wind speed
52 -  250 hpa V component wind speed
53 -  Tropopause height (or pressure)
54 -  Top-of-atmosphere net longwave radiation  (time avg)
55 -  Top-of-atmosphere net shortwave radiation (time avg)
```

D.   Meta Data Fixed Fields (as one-time companion file to MORDS)

```
a - model terrain height
b - model roughness length
c - model max soil moisture capacity
d - model soil type
e - model vegetation type
```

11.5 Gridded Three-Dimensional Fields

The descriptions given in Section 11.3 on MOLTS and Section 11.4 on MORDS are aimed primarily at reducing the need to handle the full three-dimensional output fields from each of the regional models. This should make the model output more readily accessible for the GCIP investigators. It is also, in part, needed due to the limitations in the data handling capacity for the full model output by the Model Output Data Source Module in the GCIP Data Management and Service System. These limitations means it will be possible to collect the three-dimensional fields at this location for the Eta model only. GCIP encourages the producers of the three-dimensional fields for the other two regional models to store them locally to the extent possible.

The description given above on how GCIP plans to meet the model output data requirements within the data handling limitations experienced is applicable for the near-term requirements. It is expected that these requirements will evolve as the land physics packages of these models demonstrate their utility. GCIP will reevaluate this area on an annual basis as part of preparing updates to the GCIP Major Activities Plan.

11.6 Hydrological Model Output

The NOAA/OH is collecting and archiving operational model output from the National Weather Service River Forecast System (NWSRFS) 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. The NWSRFS data being archived by NOAA/OH 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.

A description of the River Forecast Center (RFC) hydrological model and details of the hydrological model outputs were provided in Table 1 and in Appendix B of the GCIP Major Activities Plan for 1995, 1996 and Outlook for 1997 (IGPO, 1994c).

It is foreseen that these operational hydrological model outputs could be useful in several types of GCIP research studies especially in the computation of water budgets. However, this type of model output has not been archived in the past and there is no experience or infrastructure to make such data readily available to research users. To remedy this situation, the NOAA/OH is developing a pilot data set of Hydrology Model output to provide to potential users of these new types of data for research as part of the NOAA Core Project for GCIP.

12. COMPILATION OF DATA SETS

The intent of GCIP researchers to rely as much as possible on existing data centers as the archive location of GCIP data means that data sets will be geographically distributed among these data centers. The GCIP-DMSS is compiling a centralized set of information on the data sets. In some cases, this set consists of a directory and inventory of the data set, and in other cases it will consist of only directory information with the inventory information available from the data center where the data set is stored.

12.1 Compiled Data Sets

There is an ongoing need to compile data sets for purposes such as publishing on CD- ROMs or for specific periods such as the Enhanced Seasonal Observing Periods. The compiled data sets are any GCIP data compiled for a GCIP user or set of users in such a way as to facilitate ease of accessing and using the data. For purposes of organizing the data compilation activity, three different types of compiled data sets are recognized:

- Standard Data Sets
- Custom Data Sets
- As Requested Data Sets

A *standard data set* is one with specifications that are agreed to before the data collection period starts so that standing orders can be provided to the data centers. Agreement on the specifications will be reached at the project level on a year-by-year basis. Funds will be identified and committed by the Project sponsors for each standard data set at the time the specifications agreement is formalized. The primary purpose of the *standard data sets* is to give wide distribution, especially internationally, to specific GCIP data to encourage analysis, research, and modeling studies. The current plans for compiling GCIP standard data sets are summarized in Figure 12-1. Further details about each of the standard data sets are given in the remainder of this section. A summary of the GCIP data sets compiled to date is given in Appendix D.

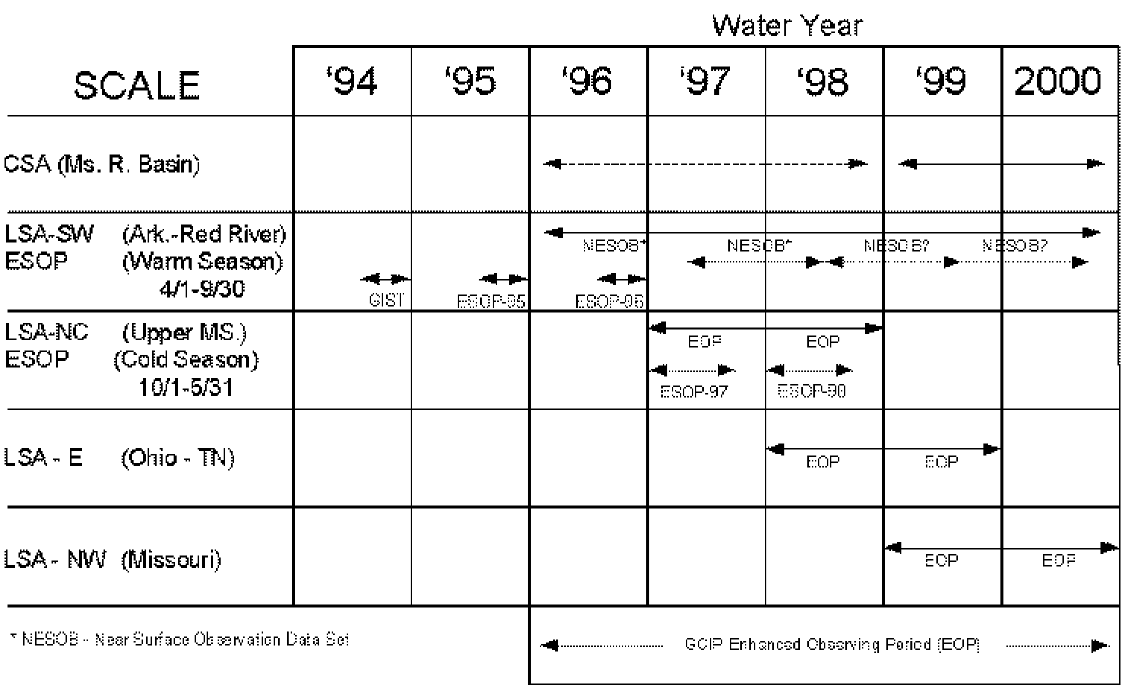

Figure 12-1 Compiled and Planned Standard Data Sets for GCIP Research.

A *custom data set* is one that is either distributed or compiled at a central location and made easily accessible for a group research effort. Applications of custom data sets include validation and/or comparison of algorithms, energy and water budget studies, and model evaluation studies. The primary purpose of custom data sets is to facilitate "group" research efforts on GCIP-relevant topics. The group requesting the data set will agree to the specifications for the custom data sets. Requests will be submitted to the GCIP office for funding the preparation of the custom data set. Funds will be identified and committed by the Project for each custom data set at the time the request is approved.

The primary purpose of the *as requested data set* is to enable any user to order a data set with individual specifications from any of the individual data sets listed in the GCIP master catalog or data set guides. The GCIP-DMSS will provide assistance to the user to compile information about data availability to facilitate ordering data sets to specification. Incremental costs for compiling and distributing an *as requested data set* will in most cases be borne by the user making the request.

12.2 EOP Data Collection Plans for Continental Scale Areas (CSAs)

The list of data to be collected for the complete CSA during each year of the EOP are given in Table 12-1 for In-Situ data, Table 12-2 for Model Output data and Table 12-3 for Satellite Remote Sensing data. Additional datasets may be added as required.

Table 12-1. In-Situ Data Sets for CSA During the EOP

DATA TYPE	DATA AVAILABILITY	
Surface	**Module**	**Center**
EOP Hourly Surface Composite	X	JOSS
EOP Hourly Precipitation Composite	X	JOSS
EOP Daily Precipitation Composite	X	JOSS
1-hr data from the ASOS Network (both comissioned and non-commissioned sites)	X	JOSS
1-hr data from SAO Stations (NWS and FAA)		NCDC
1-hr data from NOAA Wind Profiler Demonstration Network (WPDN) Stations		NCDC
1-hr data from the Oklahoma Mesonet Network		OCS
1-hr data from the Illinois Climate Network (ICN)		ICN
1-hr data from the High Plains Climate Network (HPCN)		HPCC
1-hr data from the USDA SNOTEL Network		USDA
1-hr and daily precipitation data from the NWS Cooperative Observer Network		NCDC
Daily data from the the NWS Cooperative Observer Network		NCDC
Daily streamflow from data from the USGS and USACE Networks		USGS
Daily streamflow and precipitation data from TVA		TVA
1-hr data from the USDA/Agricultural Research Service (ARS)		OCS
1-hr radiation data from the NOAA SURFRAD Network		FSL
Available Soil Moisture data from the USDA/SCS, USDA/ARS, DOE/ARM/CART, and ICN	X	JOSS
1-hr surface observations from the DOE Southern Great Plains ARM/CART site		DOE
Will be others from other LSAs to be determined		
Upper Air		
1-hr data from the NOAA Wind Profiler Demonstration Network (WPDN)		NCDC
12-hr high-resolution (6-sec vertical level) rawinsonde data from the NWS		NCDC
12-hr Eta Model MOLTS Soundings (state parameters only)		NCAR
ACARS and CASH flight data from commercial aircraft		FSL
Radar		
1-hr NIDS 2-km radar reflectivity composite	X	JOSS
1-hr NASA/MSFC 8-km National precipitation composite (derived from reflectivity)		MSFC
1-hr and daily WSR-88D Stage III product composite (all available RFCs)	X	JOSS
WSR-88D Site Level II Archive Data		NCDC

Table 12-2. Model Output Data for CSA During the EOP

DATA DESCRIPTION	DATA AVAILABILITY	
MODEL DATA		
Atmospheric Regional Models	**Module**	**Center**
Eta Data Assimilation System (EDAS) (3-hrly)	X	
Eta Model Forecast (12-hrly)	X	
Eta Model Initialization Analysis GIF Imagery (daily; UTC)		UCAR/JOSS
Eta Model Location Time Series (hrly) (MOLTS)	X	
Eta Model Reduced Data Set (3-hrly) (MORDS)	X	
Eta Fixed Fields (including land surface)	X	
RFE Model Analyses (8-hrly) (MORDS)	X	
RFE Model Forecasts (12-hrly) (MORDS)	X	
RFE 3-D Fields		AES/CMC
RFE Model Location Time Series (hrly)	X	
RFE Fixed Fields (including land surface)	X	
MAPS Model Output 3-D Fields		NOAA/FSL
MAPS Model Output (MOLTS & MORDS)	X	
Atmospheric Global Models		
NMC Medium Range Forecasts (MRF) (12-hrly)		NCAR/DSS
CMC Global Spectral Model (12-hrly)		AES/CMC
ECMWF Medium Range WX Fost Model (Daily)		ECMWF
NMC Climate Data Assimilation System (CDAS) (Daily)		NCAR/DSS
Hydrology Models		
RFC Hydrology Model Data (8-hrly)	TBD	TBD
Derived Data Products		
National Precipitation Analysis (Daily)	X	NCAR/DSS

Table 12-3. Satellite Remote Sensing Data for CSA during the EOP

DATA DESCRIPTION	DATA AVAILABILITY	
SATELLITE DATA	**MODULE**	**CENTER**
POES Radiation Budget Data (4/day)		
– Outgoing longwave (AVHRR)		NCDC
– Planetary albedo (AVHRR)		NCDC
– Downward longwave (HIRS)		NCDC
– Longwave cooling rate (HIRS)		NCDC
– Outgoing longwave (HIRS)		NCDC
GOES Radiation Budget Data (hrly)		
– Outgoing longwave (Sounder)		TBD
– Downward longwave (Sounder)		TBD
– Longwave cooling rate (Sounder)		TBD
– Insolation/PAR		NCDC
– Clear sky surface temperature		NCDC
POES/AVHRR Vegetation Index (Weekly/Monthly)		NCDC
DMSP/SSM/I Snowcover (Daily)		NOHRSC
POES/CLAVR Clouds (2/day)		NCDC
GOES/ASOS Clouds (hrly)		NCDC
GOES Conus Sector Imagery (IR, VIS, WV) (hourly)		UCAR/JOSS
Gridded Areal Snow Cover (Weekly)		NOHRSC
Gridded Areal Snow Cover (Daily)		TBD
Gridded Snow Water Equivalent (Weekly)		NOHRSC
Gridded Snow Water Equivalent (Daily)		TBD

12.3 Data Collection for ESOP-96

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) described in Section 13. Although most of the data sources are operational in nature, special arrangements were made to obtain these data in the highest resolution possible. Table 12-4 summarizes the individual datasets comprising the ESOP-96. In addition, an initial phase of compiling a near surface observational data set from the Little Washita Watershed and the ARM/CART site is being completed for the period of April to September 1996 (see section 12.8 for further details). The ESOP-96 Tactical Data Collection and Management Plan provides more details including a brief description of each dataset with information regarding data collection, processing, and final archival and information on dataset disseminationafter the compilation is completed in June 1997. 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 compilation is complete.

TABLE 12-4 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

12.4 EOP-2 Data Collection During WY 1997

The plans for data collection for the second year of the EOP take account of the following general requirements.
(i) The ESOP-97 is scheduled for the period 1 October 1996 through 31 May 1997 in the geographical region identified as the LSA-NC for data to conduct focused studies on cold season/region hydrometeorology.
(ii) The CSA data requirements are continuing for energy and water budget studies with an increase in emphasis on model evaluation for the regional model output.
(iii) Annual data sets for the LSA-SW and LSA-NC are required for energy and water budgets over an annual cycle plus model evaluations of the regional model output.

Data Collection for ESOP-97

A summary listing of the data collection plans for ESOP-97 is given in Table 12-5.

The ESOP-97 Tactical Data Collection and Management Plan provides more details including a brief description of each dataset with information regarding data collection, processing, and final archival and information on dataset dissemination after the compilation is completed in June 1998.

TABLE 12-5 Datasets comprising the ESOP-97

IN-SITU DATA

Surface Data

National

- Automated Surface Observing System (ASOS) Data
- Automated Weather Observing System (AWOS) Data
- Surface Airways Observations (SAO) Hourly Data
- SAO Special Observation Data
- NOAA Profiler Network (NPN) Surface Data
- Long-Term Ecological Research (LTER) Site Data
- Canadian Surface Observations
- NWS Cooperative Observer Daily Observations
- NWS Cooperative Observer Precipitation Data
- United States Army Corps of Engineer (USACE) Precipitation and Streamflow Data
- United States Geological Survey (USGS) Streamflow Data
- United States Department of Agriculture/Natural Resources Conservation Service (USDA/NRCS) Soil Moisture Data
- USDA/NRCS Soil Moisture/Soil Temperature (SM/ST) Data
- USGS Reservoir Data
- SURFRAD Data

Regional

- High Plains Climate Network (HPCN) Data
- Deparment of Energy (DOE) ARM/CART Surface Meteorological Data
- Great Lakes Meteorological Data
- Management Systems Evaluation Areas (MSEA) Project Data
- North Central River Forecast Center (NCRFC) Precipitation Data
- NCRFC Winter Graphical Products and Data
- DOE ARM/CART Soil Water and Temperature System (SWATS) Data
- Wisconsin and Illinois Gravediggers Network Data
- DOE ARM/CART Radiation Data
- DOE ARM/CART Energy Balance Bowen Ratio (EBBR) and Eddy Correlation (ECOR) Data
- USGS/Scientific Assessment and Strategy Team (SAST) Data
- National Ice Center (NIC) Great Lakes Ice Data
- ESOP-97 Hourly Surface Composite
- ESOP-97 Hourly Precipitation Composite
- ESOP-97 Daily Precipitation Composite

Illinois

- Illinois Department of Transportation (DOT) Network Data
- Chicago Deicing Project Mesonet Data
- Illinois Climate Network (ICN)Data
- Cook County, Illinois Precipitation Network Data
- Imperial Valley Water Authority Precipitation Network Data
- Illinois State Water Survey (ISWS) Soil Moisture Data
- ISWS Wells Data

Indiana

- Indiana Department of Environmental Management (IDEM) Air Quality Network Data

Iowa

- Walnut Creek Watershed (Iowa) Meteorological Data
- Walnut Creek Watershed Precipitation Data
- Davenport Iowa ALERT Network Data
- Iowa State University (ISU) Soil Moisture Survey Data
- Walnut Creek Watershed Surface and Groundwater Data
- Walnut Creek Watershed Energy Balance and Evapotranspiration Monitoring Network Data

Kansas

- Overland Park Kansas ALERT Network Data

Michigan

- Michigan State University Automated Weather Station Network Data

Minnesota

- Minnesota Department of Natural Resources (DNR) Fire Weather Network Data
- Minnesota Road Research Project (Mn/ROAD) Data
- Minnesota Extension Climatology Network Data
- University of Minnesota (UM) Watershed Project Data
- Minnesota Pollution Control Agency (MPCA) Watershed Project Data
- UM Rosemount Experiment Station Data

Other UM Experiment Station Data
USGS Interdisciplinary Research Initiative (IRI) Site Data
Minnesota Precipitation Network Data

Missouri

Missouri Commercial Agriculture Weather Station (CAWS) Network Data
Missouri Department of Conservation Fire Weather Network Data
Missouri Air Pollution Control Program Network Meteorological Data

Nebraska

Papio Basin ALERT Network Data

North Dakota

Grand Forks Air Force Base Network Data
North Dakota Atmospheric Resources Board Cooperative Rain Gage Network Data

Wisconsin

University of Wisconsin (UW) Agricultural Weather Observation Network (AWON) Data
Wisconsin Department of Transportation (DOT) Network Data
Wisconsin DNR Fire Weather Network Data
Wisconsin DNR Air Quality Network Data
Wisconsin Tower Flux Measurement Data
USDA/NRCS Wisconsin Dense Till (WDT) Data

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
Canadian Upper Air Rawinsonde Data (10-sec vertical levels)
Canadian Upper Air Rawinsonde Data (mandatory/significant levels)
NOAA Profiler Network Data
Boundary Layer Profiler Data

Radar Data

WSR-88D Data
WSR-88D NIDS Data
WSI Reflectivity Composite Imagery
NCRFC Stage III WSR-88D Data
NASA/MSFC National Reflectivity Composite

Land Characterization Data

PSU 1-km Multi-Layer Soil Characteristics Dataset
Walnut Creek Watershed Soil Characterization Data

SATELLITE DATA

GOES-8/9 Satellite Imagery and 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
NOAA Airborne Gamma Snow Survey Data
NOAA/NOHRSC Satellite-Derived Snow Extent Data

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

NCRFC Hydrologic Model Output

12.5 EOP-3 Data Collection During WY 1998

The data collection plans during WY 1998 takes account of the following known requirements :

(i) The ESOP-98 is scheduled for the period 1 October 1997 through 31 May 1998 in the geographical region identified as the LSA-NC for data to continue focused studies on cold season/region hydrometeorology. The specific data requirements are expected to be very similar to those for ESOP-97 with some modifications based on items learned during the ESOP-97.

(ii) The CSA data requirements continue for energy and water budget studies with increasing emphasis on interseasonal and interannual variability. Coupled modeling validation and evaluation will begin for the CSA.

(iii) An annual data set for the LSA-NC and LSA-E is required for energy and water budgets over an annual cycle plus model evaluations of the regional model output.

(iv) Data collection requirements for the LSA-SW are projected to continue but the specific requirements are not yet defined.

The proposed data sets for the LSA-E are shown in Table 12-6 for in-situ data and Table 12-7 for satellite remote sensing data. The current plans for model output data for the LSA-E are the same as that given in Table 12-2 for the CSA.

Table 12-6. Proposed In-Situ Data for LSA-E During WY 1998 and WY 1999.

IN-SITU DATA

Surface Data

National

Automated Surface Observing System (ASOS) Data
Automated Weather Observing System (AWOS) Data
Surface Airways Observations (SAO) Hourly Data
SAO Special Observation Data
NOAA Profiler Network (NPN) Surface Data
Long-Term Ecological Research (LTER) Site Data
Canadian Surface Observations
NWS Cooperative Observer Daily Observations
NWS Cooperative Observer Precipitation Data
United States Army Corps of Engineer (USACE) Precipitation and Streamflow Data
United States Geological Survey (USGS) Streamflow Data
USDA/NRCS Soil Moisture/Soil Temperature (SM/ST) Data
USGS Reservoir Data
SURFRAD Data

Regional

Tennessee Valley Authority (TVA) Precipitation and Streamflow Data
TVA Nuclear Power Plant Meteorological Station Data
Regional Atmospheric Monitoring and Analytical Network (RAMAN) Data
USDA/Agricultural Research Service (ARS) Meteorological and Soils Data
Great Lakes Meteorological Data
NOAA River Forecast Center (RFC) Precipitation Data
RFC Graphical Products and Data
Wisconsin and Illinois Gravediggers Network Data
USGS/Scientific Assessment and Strategy Team (SAST) Data
National Ice Center (NIC) Great Lakes Ice Data
LSA-E Hourly Surface Composite
LSA-E Hourly Precipitation Composite
LSA-E Daily Precipitation Composite

Alabama

Alabama Weather Observing Network Data
Redstone Arsenal Mesonet Data

Georgia

Auburn University Mesonet Data

Georgia Automated Environmental Monitoring Network Data
Georgia Forestry Commission Automated Weather Station Network Data

Illinois

Illinois Department of Transportation (DOT) Network Data
Illinois Climate Network (ICN) Data
Cook County, Illinois Precipitation Network Data
Imperial Valley Water Authority Precipitation Network Data
Illinois State Water Survey (ISWS) Soil Moisture Data
ISWS Wells Data

Indiana

Indiana Department of Environmental Management (IDEM) Air Quality Network Data

Kentucky

Kentucky Division for Air Quality Meteorology and Air Quality Station Data
University of Kentucky Research Farm Meteorological Data

Michigan

Michigan State University Automated Weather Station Network Data

North Carolina

North Carolina State University Experiment Station Weather Network Data

Pennsylvania

Pennsylvania Department of Environmental Protection/Bureau of Air Quality Network Data

Tennessee

NOAA/GEWEX Long Term Flux Monitoring Site Data
Walker Branch Watershed Meteorological and Hydrological Data

Virginia

Virginia Department of Environmental Quality Air Monitoring Station Data

Wisconsin

University of Wisconsin (UW) Agricultural Weather
Observation Network (AWON) Data
Wisconsin Department of Transportation (DOT) Network Data
Wisconsin DNR Fire Weather Network Data
Wisconsin DNR Air Quality Network Data
Wisconsin Tower Flux Measurement Data
USDA/NRCS Wisconsin Dense Till (WDT) Data

Other State Surface Meteorological and Hydrological Network Data
TBD following Data Survey

Upper Air Data

NWS Upper Air Rawinsonde Data (6-sec vertical levels)
NWS Upper Air Rawinsonde Data (mand/sig levels)
Canadian Upper Air Rawinsonde Data (10-sec vertical levels)
Canadian Upper Air Rawinsonde Data (mand/sig levels)
Redstone Arsenal Rawinsonde Data
NOAA Profiler Network (NPN) Data
Boundary Layer Profiler Data

Radar Data

WSR-88D Data
WSR-88D NIDS Data
WSI Reflectivity Composite Imagery
RFC Stage III WSR-88D Data
NASA/MSFC National Reflectivity Composite

Land Characterization Data

PSU 1-km Multi-Layer Soil Characteristics Dataset

Table 12-7. Proposed Satellite Remote Sensing Data During WY 1998 and WY 1999 Applicable for the LSA-E

DATA DESCRIPTION	DATA AVAILABILITY MODULE	DATA CENTER

```
----------------------------------------------------------------------
Composite Daily Snow Depth Grid                                NCDC
Composite Daily Snow Cover (GOES, POES, DMSP)       X      NESDIS, NOHRSC
3-Day Composite DMSP SSM/I Snow Cover               X         NOHRSC
Composite Weekly Snow Cover Extent                            NESDIS
Monthly DMSP SSM/I Snow Cover in Percent            X          NCDC

Hourly GOES-8 1 km Visible (for LSA-E)                       UCAR OFPS
Daily POES AVHRR 1 km (Land Cover/Vegeatation)              NOHRSC, EDC

Daily DMSP SSM/I Brightness Temperatures            X        MSFC DAAC
Daily DMSP SSM/T2 Radiances                         X        MSFC DAAC
Daily DMSP OLS Visible Imagery                                 NGDC
Daily DMSP OLS IR Imagery                                      NGDC

POES Radiation Budget Data (4-Day)                             NCDC
POES Radiation Budget Data (hourly)                            NCDC

Composite Gridded Snow Water Equivalent *           X         NOHRSC
Composite Gridded Soil Moisture *                   X         NOHRSC

Landsat Thematic Mapper Imagery                                 EDC
----------
* Data from aircraft, satellite, and surface sources.
```

12.6 EOP-4 Data Collection During WY 1999

The data collection plans for EOP-4 are expected to be very similiar to those for EOP- 3 given in the previous section with the addition of LSA-NW

12.7 Retrospective Data Sets

OBJECTIVE: *Develop high-quality retrospective databases of surface observations, especially precipitation observations, surface meteorological observations, and streamflow for use in calibration of key surface parameters in atmospheric and hydrological models.*

Historical hydrometeorological data are needed to develop, validate, and estimate parameters in improved surface parameterizations for atmospheric models. The required period of hydrological data must include several extreme wet and extreme dry periods in which soil moisture levels reach maximum and minimum values. Usually this period ranges from 10 to 30 years, depending on the local climate and actual occurrence of events. At least 30 years is needed to put the EOP in a climatological context. Spatially, all available precipitation measurements are needed to obtain the best possible water budgets over areas of 10^3 to 10^4 km^2.

For GCIP, long periods of retrospective, high-quality hydrometeorological data are critical because the statistical variability of extremes (that is, flood and drought) is essential in assessing the impact of climate variability on water resources. A portion of the total retrospective data needs is being compiled within the NWS/OH as part of the NOAA Core Project for GCIP. Retrospective data are a critical input to the NWP model upgrades. At present, models of surface hydrology must be calibrated using historical precipitation, evaporation, temperature, and other climatological data, together with streamflow data. Similar calibrations using 30 to 50 years of data are needed to run the models from which will be determined the key hydrological parameters of soil moisture capacity and runoff formulation required by the upgraded NWP models and required to global models.

The data types required include precipitation, air temperature, streamflow, and meteorological observations to estimate water and energy fluxes between the surface and the atmosphere. The primary source of historical data is surface observations, but archived NWP model outputs and some historical satellite data may be required as well.

The preparation of historical data sets is directly linked to the development of the NOAA Hydrological Data System which was described in Appendix E of the GCIP Major Activities Plan for 1995, 1996 and Outlook for 1997 (IGPO, 1994c).

12.8 Near Surface Observation Data Set

The second near-term objective for this GCIP major thrust area for 1996 to 1998 is - - to produce a quantitative assessment of the accuracy and reliability of the model assimilated and derived variables for applications to energy and water budgets. The successful achievement of this objective will entail an extensive evaluation of both the model output and the derived variables. All of the evaluations require a lengthy series of observed data for those variables considered significant . As a start on this evaluation effort, GCIP is compiling a special data set of observations for as many of the variables as reasonably available. In order to maximize the number of observed variables this special data set is focused on the region of the ARM/CART site and the Little Washita Watershed during the period April 1, 1996 through March 31, 1998.

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 El Reno, OK and the Oklahoma Climate Survey. 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 7-1) 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/DACOM 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.

12.8.1 Summary Description of a Near-Surface Observation Dataset

A special dataset is being compiled for the geographical area which includes both the ARM/CART site and the Little Washita Watershed as shown in Figure 7-1. 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 12-8 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)

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.

```
TABLE 12-8.   Near Surface Observation Types in each Layer
____________________________________________________________________________

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
```

12.8.2 Data Collection Schedule for Near Surface Observation Data Set

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. Since a partial dataset containing the critical measurements would be useful to GCIP investigators as soon as possible the data collection is divided 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 7-1. The first phase of the Near-Surface Observation Dataset is making use of data from this same period. During ESOP-96 we obtained a reasonably complete set of data at about eight locations in the ARM/CART site (see SWATS facilities in Figure 10-?) and Little Washita Watershed. The remaining locations do not have some of the observation types including particularly, soil moisture and soil temperature profiles. This is being compiled as part of a special subset of the ESOP-96 dataset. The compilation of this dataset is scheduled to be completed by June 1997. A proposed list of observations contained in this dataset is outlined in Table 12-6. A complete description is included in Appendix A of the ESOP-96 Tactical Data Collection and Management Plan.

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 planning 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.

13. DATA MANAGEMENT AND SERVICE SYSTEM

The GCIP Data Management and Service System (DMSS) is shown in Figure 13-1 as a user service configuration based on accessing the GCIP Home Page on the World Wide Web through the URL address:

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

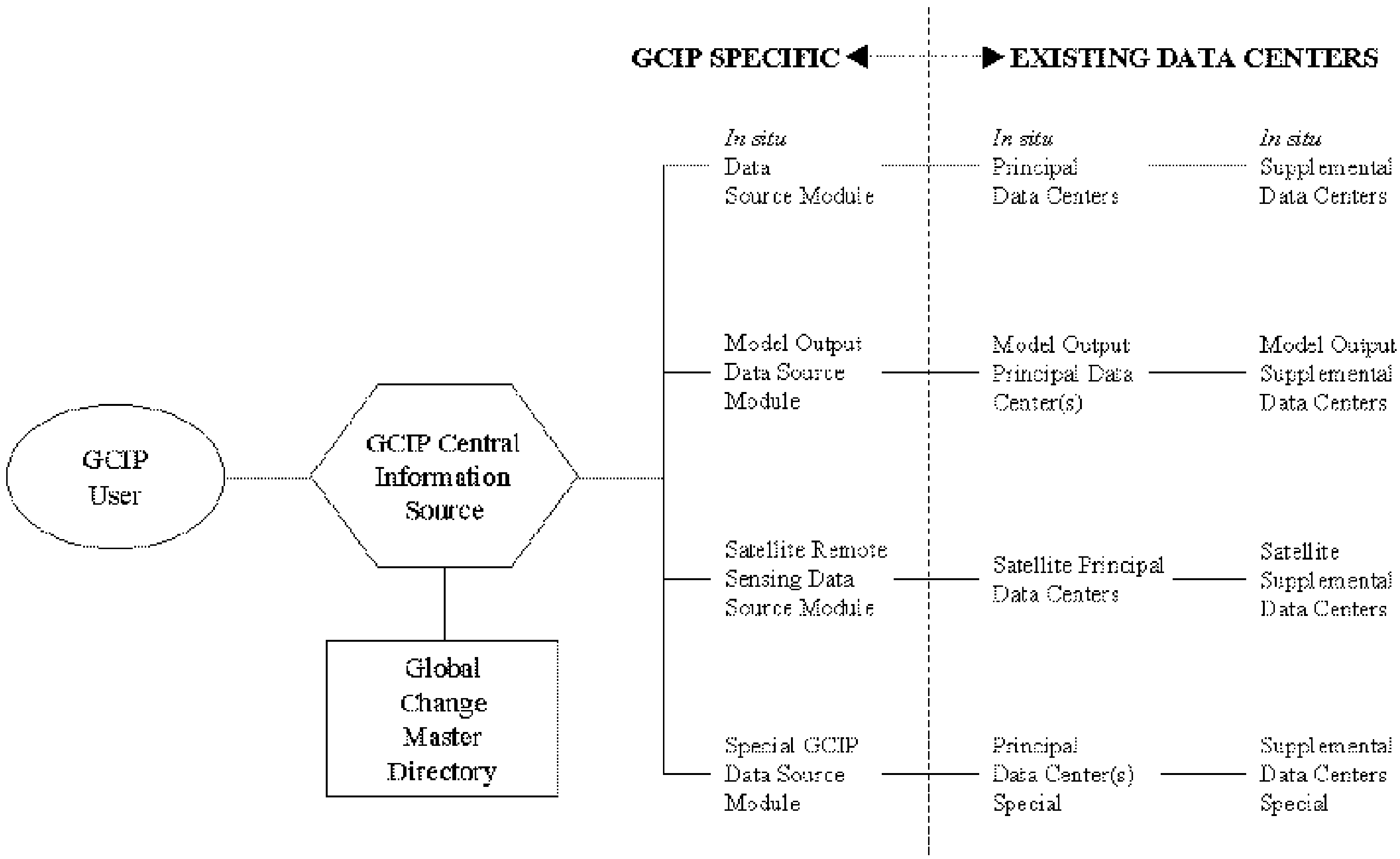

Figure 13-1 GCIP DMSS user services configuration.

13.1 Overall Objectives

The goal of the DMSS is to make GCIP data available to GCIP investigators and to the international scientific community interested in GCIP. The data services are provided through a system which will have multiyear data set information that will be of continuing research use after GCIP is completed. These two items led to the following overall objectives for the DMSS:

(1) During the course of GCIP, the GCIP data management system will compile information on the data that are collected in the data centers to produce special data sets for GCIP users and to provide a single-point access to service user requests for GCIP data.

(2) At the completion of GCIP, the GCIP data management system will turn over the composite data set documentation (metadata) to a permanent archiving agency for continuing use in climate-related studies.

The topic of GCIP data management is divided into strategic and tactical planning efforts. The strategic portion of the GCIP data management plan is covered in Volume III of the GCIP Implementation Plan (IGPO,1994b). A tactical data management plan is prepared for each definable data set produced by the DMSS.

13.2 Data Availability and Costs

The GCIP Science Plan (WMO,1992) recognized that the success of the Project depends on scientists and agency participants sharing their data with each other. The timely archival of data collected or processed by GCIP researchers, along with mechanisms to ensure open and minimal-cost distribution to all researchers, requires a clearly stated and implementable data policy.Such a GCIP data policy concerning access to GCIP data was given in the GCIP Science Plan (WMO, 1992).

Data management will incur costs primarily for the collection of information on the data and the reproduction costs to compile data sets. The costs incurred for the initial compilation of information on the data will be borne by the Project. Costs for data sets that are compiled for general use by researchers involved in the Project will also be borne by the Project. Costs for data sets to individual specifications will, in general, be borne by the user making the request for the data. This topic is described further in Section 12 and was also described in Section 3 of Volume III of the GCIP Implementation Plan (IGPO,1994b).

13.3 System and Services Approach

To the extent possible GCIP relies upon existing or planned operational, or, at least, systematic observing programs operating over the Mississippi River basin, including space-based observations. The essential task is to assemble information about relevant data sets and implement a data management system to support the scientific program.

The DMSS takes advantage of the ongoing data management activities of related projects and programs such as Atmospheric Radiation Measurement (ARM), Earth Observing System Data and Information System (EOSDIS), U.S. Weather Research Program (USWRP), and others. Data sets and data management infrastructure under development for these programs are being used by the DMSS to the fullest extent possible. Each of these programs has, or is developing, data management systems with GCIP-relevant data to access through the GCIP-DMSS.

13.4 DMSS Overall Design

The data management strategy of GCIP relies fundamentally on working with and through existing data centers. A variety of organizations, including the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) and the National Water Information System (NWIS), of the USGS already have extensive capabilities for processing, validating, storing, cataloging, retrieving, and disseminating environmental data.

The DMSS in use during the first two to three years of the EOP is labeled the Prototype system and will not contain all the features that are technically feasible. The DMSS will incorporate improvements and new developments as these become operational at the existing centers to evolve to an Advanced system. It is envisioned that once the system is more fully operational, users will be able to sign onto a central computer and examine the GCIP master catalog to determine the data set(s) that best meet their requirements. If they desire additional information on a selected data set, the access software will route them to the data source module for the particular data type for more specific information. They will then be able to examine detailed data guides or discuss their data needs with someone knowledgeable about the GCIP data sets who can assist them in searching and ordering the data from the correct existing data center. The users can, if desired, go directly from the master catalog to the existing data center to place an order for data.

To develop the distributed data management system envisioned for GCIP in the most cost effective manner the DMSS Data Source Modules will strive to make the best use of current and planned capabilities of each pertinent data center. The DACOM recognized that the specific data service policies and procedures can vary among the existing data centers and the Project will need to adapt its "GCIP specific" portion of the DMSS, shown in Figure 13-1, to these variations.

The principal GCIP data centers form the backbone of the data management system. A principal data center is responsible for a significant volume of data pertinent to GCIP and has the capability to provide on-line access to data catalogs, inventories, and ordering systems. The center's on-line access system will be connected to and accessible through an electronic link to the DMSS. Since a center's designation as a principal data center is dependent upon its technical capabilities, under GCIP some supplementary centers will be changed to principal centers as GCIP evolves during the EOP.

13.5 Near-Term Improvements

The flexibility of the DMSS configuration shown in Figure 13-1 makes it possible for each of the modules to evolve at different rates which can be closely related to the specific data centers connected to the module. A summary of the projected improvements by each of the modules is given in the following paragraphs:

GCIP Central Information Source
Responsible Agency: GCIP Project Office hosted by NOAA Office of Global Programs Silver Spring, MD
Contact: Adrienne Calhoun

The GCIP Central Information Source (GCIS) is responsible for a variety of major functions as listed in Section 5, Volume III of the GCIP Implementation Plan. The DACOM will be asked to review these functions and make recommendations on how they can best be implemented in light of the experience gained from using the World Wide Web as a communications media for information about GCIP data.

The World Wide Web enables the GCIS to make use of this medium for providing information about all the significant items in GCIP in addition to providing the central contact for information about the DMSS. The GCIP Project Office is compiling information about GCIP to provide through the GCIP Home Page.

The GCIS will provide a mechanism for feedback from the users and incorporate these suggestions in its attempts to make this new medium a useful tool for the GCIP users.

In Situ Data Source Module
Responsible Agency: Office of Field Project Support; UCAR Boulder, CO
Contact: S. Williams

The In-situ Module is responsible for providing data management and information resources for surface, upper air, radar, and land surface characteristics data of interest to GCIP. The Module uses the UCAR/JOSS Data Management System (CODIAC) which has been the GCIP DMSS "on-line" demonstration" system. A number of activities are planned for the DMSS In-Situ Module during the next two years:

1) Continue in-situ data collection for the 5-year GCIP Enhanced Observing Period (EOP), scheduled which began in October 1995. Also select and publish appropriate subsets of EOP data using CD-ROM media.

2) Complete the in-situ data collection process for the 1996 Enhanced Seasonal Observing Period (ESOP-96), April through September 1996 in the Arkansas-Red River Basin. Also select and publish appropriate subsets of ESOP data using CD-ROM media.

3) Continue to provide and add preliminary GCIP "Quick Response" data sets (i.e. 2 month lag) to the GCIP Scientific Community via CODIAC. These data sets would be available for both the EOP as well as the ESOP-96.

4) Continue to provide GCIP Initial Data Sets (GIDS) to the GCIP Scientific Community via on-line access and CD-ROM media.

5) Continue development of World Wide Web (WWW) enhancements to the Module and data access links to CODIAC as well as coordination of such development with the other Modules.

6) Continue establishment of on-line data links to other in-situ GCIP primary data centers as well as improved links to other NCDC data sets (i.e. WSR-88D Level II radar data).

7) Set up and execute the in-situ data collection process for the ESOP-97, October 1996 pril May 1997 in the Arkansas-Red River Basin. Also select and publish appropriate subsets of ESOP data using CD-ROM media.

Model Output Data Source Module
Scientific Data Services; NCAR; Boulder, CO
Contact: R. Jenne

The Model Output Data Source Module is responsible for providing data management and information resources for GCIP-relevant model output data and products. The Module uses the NCAR Scientific Data Services as the infrastructure and expertise for GCIP support.

During the next three years this Module will concentrate on establishing a data archive for the output from three different regional models:

Eta Model output from NOAA/NMC
RFE Model output from AES/CMC
MAPS Model output from NOAA/FSL

The data management plans for this large volume of model output are evolving as an ongoing effort to balance the investigator needs with the resources available as described in Section 11.

Satellite Remote Sensing
Responsible Agency: Hydrology Data Acquisition and Archive Center (DAAC); NASA/MSFC Huntsville, AL
Contact: D. McMicken

The GCIP Satellite Remote Sensing Data Source Module is responsible for providing data management and information resources for GCIP-relevant satellite data and products. The satellite module participates in several coordinating functions within the GCIP project primarily through DACOM.

The WWW is the implementation choice of the DMSS and allows the satellite module to provide information and easily link to other existing information at the various data centers. The satellite module continues to compile information about the GCIP data requirements to coordinate readily available data sets as specified by the Principal Research Areas, the DACOM, and other GCIP-related inputs.

The evolution of the satellite home page begins with the initial prototype configuration. The prototype provided an overview, high-level data access to existing archives, CD-ROM information, and links with the other active modules. The prototype home page provides a mechanism to solicit inputs from the entire GCIP science community.

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APPENDIX A

RECOMMENDATIONS OF THE LSA-NC SCIENCE/IMPLEMENTATION TASK GROUP

A.1. Introduction

The Task Group met on March 25-26, 1996 at the Illinois State Water Survey in Champaign, Illinois. The group focused on the existing infrastructure and ongoing projects in the LSA-NC. The recommendations primarily address those scientific issues that relate to snow and frozen ground processes and that can take advantage of the existing infrastructure and ongoing projects.

A.2. Relevant Issues

A series of presentations were given. These presentations highlighted a number of issues that are pertinent to the recommendations. These issues are as follows:

- The GCIP Program Office remains committed to the support of activities in the LSA- NC. However, resources are extremely limited and unlikely to increase substantially in the near term. Therefore, maximum use must be made of existing infrastructure and projects in this region.

- Airborne gamma radiation measurements of snow water equivalent (SWE) are made routinely by the National Operational Hydrologic Sensing Center. These measurements provide rather accurate estimates of SWE (+1 cm) and surface (0-20 cm) soil moisture (+2 -3%). There are several hundred flight lines within the LSA- NC, each covering an area of approximately 5 km2. There are 50 flight lines in the Minnesota River Basin, one proposed focus area of study. Although these data provide a good sample of SWE over the region, they do not provide complete areal coverage of any single sub-basin or model grid square.

- Although WSR-88D data can provide the high resolution precipitation estimates required to intensively study subgrid-scale heterogeneity, the operational algorithms used to estimate precipitation from the radar returns were developed for warm season precipitation systems. A presentation of NEXRAD precipitation totals from the March 19, 1996 snowstorm in the Midwest emphasized that these estimates are completely inappropriate for snowfall accumulations. However, an enhanced software package called the Warning and Decision Support System will be installed at the Minneapolis- St. Paul (MSP) National Weather Service office. This system includes enhanced processing algorithms for WSR-88D data, including those appropriate for snowfall accumulation.

- An intercomparison of two land surface models using Alaska data shows that substantial differences among models can be expected, especially in the disposition of surface water among evapotranspiration, sublimation, and runoff. The freeze-thaw cycle has received little attention in these models.

- The University of Minnesota operates an experimental site near Rosemount, 15 miles south of St. Paul. Detailed measurements are obtained during the cold season at a 40- acre site. These measurements include the surface energy budget, soil moisture and temperature, standard meteorological variables (pressure, wind profile, relative humidity, precipitation), latent and sensible heat flux, and snow pack changes. The list of variables that are now measured includes nearly all those that have been identified as needed for model intercomparison studies. This site thus is a prime candidate for model process studies. The Illinois State Water Survey operates an automated weather station network called the Illinois Climate Network (ICN). The most notable feature of this network is the routine long-term monitoring of soil moisture using the neutron probe technique. One of the ICN sites is at Bondville. This is also a location of a SURFRAD site and is part of the EPA wet/dry deposition network. In addition, NOAA ATDL may soon install an eddy correlation system for routine monitoring of sensible and latent heat fluxes. The combination of these facilities makes the Bondville site a second prime candidate for model process studies.

- Another candidate site is the Walnut Creek ARS facility in the Des Moines River Basin. This site is also well-instrumented. There are a few drawbacks. Part of the basin is urbanized and snowfall is not as dependable as at the Rosemount site. Also, there may be few unique scientific objectives that can be addressed at this site and not at the other two listed above. Nevertheless, since only two cold season observing periods are planned and unusual weather (e.g., lack of snowfall) may make the observations less typical at the Rosemount site, observations at additional sites can decrease that risk and the Walnut Creek site appears to be a viable candidate.

- A fourth site is the Shingobee River watershed in north-central Minnesota. This is the site of the U.S. Geological Survey's Interdisciplinary Research Initiative (IRI). The objectives of the IRI are to provide the "opportunity for fundamental interdisciplinary research of interactions within the hydrologic system on a watershed scale, to increase the basic understanding of watershed hydrology, and to provide information necessary for better management of our nation's water resources." (Water Fact Sheet, 1994, U.S. Geological Survey). The site is mostly forested, providing a contrast with the mostly agricultural (or urban) nature of the other three sites. Standard climatological measurements are routinely obtained. Additional research initiatives at this site are encouraged by USGS.

A.3 Scientific Themes

The scientific issues raised in the two workshops can be organized around the following themes, based on the strategy for experimental design.

A.3.1 Land Surface Model Physics

This includes frozen soil processes, snowpack maturation and melt, and the energy budget at the snow-atmosphere interface. This could also include the issue of small (field)-scale snow patchiness. In situ measurements of relevant variables at one or more sites during ESOP-97 and ESOP-98 can provide the basis for studies to improve model parameterizations and for model intercomparison studies to identify model deficiencies.

A.3.2 Land Surface Modeling of SubGrid

Scale Heterogeneity Effects - this is most relevant during snowmelt when the change in albedo can exert a profound influence on the surface-atmospheric energy exchange. The modeling of the grid-averaged energy budget is a particularly challenging problem during partial snow cover conditions when the albedo may vary from less than 0.20 to greater than 0.80 within a grid square. A model intercomparison study based on data collected in a focus study area the size of a numerical weather prediction (NWP) model grid square (40 km x 40 km) can be envisioned. However, the limited financial resources that are available may make it difficult to collect sufficient data to accurately characterize grid-averaged properties.

A.3.3 Monitoring of the Land-Surface State

Studies of the LAS-NC region as a whole will require accurate measurements of the condition of the land-surface, particularly soil moisture, soil temperature, and snowpack characteristics. NWP models will be able to capitalize on improvements in land-surface modeling only to the extent that accurate operational monitoring of the land-surface condition is available to initialize model runs. Appropriate studies under this theme include removal of biases that are present in situ snow measurement datasets, improvement of satellite snow products, algorithm development for improvement of NEXRAD products, and soil moisture initialization algorithms.

A.4. Recommended Activities

The recommended activities are described the three general areas of land-surface model physics, validation of land surface modeling of sub-grid scale heterogeneity.

A.4.1 Land-Surface Model Physics

The important cold season processes to be modeled include:

(a) radiative, sensible, and latent energy fluxes at the surface-atmosphere interface

(b) snowpack maturation and melt

(c) ground frost, soil temperature, and soil water movement. To foster improvements in modeling, it is recommended that appropriate data sets be collected at more than one site. The validation and development of land surface process modeling will require the set of measurements shown in Table A-1.

```
Table A-1  Variables Required for Land Surface Model Intercomparison Studies
_____________________________________________________________________________


Forcing measurements (30 minute resolution)
     U component wind speed at 10 m
     V component wind speed at 10 m
     Temperature at 2 m
     Specific humidity at 2 m
     Surface pressure
     Surface skin temperature
     Precipitation
     Surface Radiation - downward shortwave
     Surface Radiation - downward longwave
Validation
     Surface Radiation - upward longwave
     Surface Radiation - net radiation (measured)
     Streamflow
     Soil moisture (profiles)
     Soil temperature (profiles)
     Surface latent heat flux
     Surface sensible heat flux
Set up for Experiment
     Vegetation type and characteristics Site
     Site Description
     Surface Radiation - upward shortwave (albedo)
     Soil characteristics
     Wilting point
     Rooting zone
     Field capacity
```

Specific activities that are recommended are:

- During ESOP-97, the above data sets should be collected at one or more sites. Based on information presented at the task group meeting, the Rosemount site and the Bondville ICN site appear to be particularly suitable for such efforts. Only minor improvements in measurement capabilities are necessary to meet all of the above data requirements. There are significant and relevant differences in the climates of these two sites that provide different challenges to process models. The Rosemount site is characterized by an extended cold season with near-surface soil temperatures remaining below 0C for months and snowcover usually remaining intact for that period. By contrast, at Bondville several episodes of snowmelt and ground thawing typically occur through the winter months. Additionally, frost depths are greater at Rosemount than at Bondville; therefore, the spring surface thaw will have different physical processes, i.e., the Rosemount soil will have a thick frozen layer below the thawed surface.
- The above datasets should also be collected during ESOP-98 at the same sites. Other suitable sites such as the Walnut Creek and Shingobee River watersheds can be considered for additional data collection efforts.

- An intercomparison of land surface models should be undertaken, possibly as part of a PILPS initiative, based on the data collected at all of the selected sites.

A.4.2 Validation of Land Surface Modeling of Subgrid-Scale Heterogeneity

The issue of heterogeneous snow cover, soil moisture, and land surface characteristics should be addressed partially by the collection of data in a focus area of the approximate size of a NWP model grid square (40 x 40 km). Two sites in southern Minnesota, the Cottonwood basin and the Le Sueur Basin, may be suitable for such studies. Both are of an appropriate size and shape and there are existing data collection efforts that can contribute to GCIP goals. However, it will be necessary to collect substantial additional data to describe the heterogeneity of the surface. A working group should be formed to establish specific requirements for data collection. A challenge is to design an experiment to effectively study subgrid-scale heterogeneity that is cost efficient. The following issues must be addressed in order to meet relevant scientific objectives:

> (a) One critical element is the measurement of the spatial distribution of SWE within the focus area immediately prior to and at frequent intervals during the spring snowmelt. Airborne gamma radiation measurements can supply data at a resolution of 300 m x 300 m by doing multiple passes over a flight line. However, flight lines cover only a small fraction of any of the candidate focus areas. These will probably need to be supplemented by ground-based in situ measurements of SWE. In addition, satellite measurements of snow areal extent and fractional coverage within the focus area should be obtained.
>
> (b) Another critical element is the surface energy budget. This is likely to depend on a number of variables including snow cover, land use (forest vs. agriculture), topography, soil moisture, etc. The per site cost of the installation and operation of surface energy budget stations is high, effectively limiting the number of sites that can be instrumented. However, it is likely that the dominant factors will be snow cover (albedo) and soil moisture. The influence of the secondary factors can be minimized by choosing a focus area of small topographic variability and one predominant use (i.e., agriculture). In addition, soil moisture variability may have a minor effect on the surface energy budget during the snowmelt phase because meltwater will maintain wet conditions at the top of the soil profile. Thus, representative measurements of grid- averaged surface energy budget properties may be possible by sampling one snow-covered and one bare site during the partial snow cover stage. To accomplish this, there should be two mobile systems. Immediately prior to the expected beginning of the spring snow melt, one can be deployed in an area of high SWE and the other in an area of low SWE.
>
> (c) Soil moisture variability will have a major effect on the disposition of meltwater and the threat of flooding. Airborne gamma radiation measurements may be the most effective technique to sample soil moisture in a grid-scale area.

Specific activities that are recommended include:

- The GCIP should investigate the suitability of several sites, including the Le Sueur and Cottonwood River Basins, for a study of subgrid-scale variability.

- During ESOP-98, the above data collection effort should be undertaken with an emphasis on the spring snowmelt period.

- A second model intercomparison study should be conducted, validated against areally- averaged values of relevant variables.

A.4.3 Monitoring of the Land Surface State

Studies of the water and energy budgets during the cold season in the LSA-NC will require detailed and accurate data on snow distribution and magnitude and on soil moisture. Although WSR-88D precipitation estimates provide the desired high spatial resolution, the operational algorithms used to relate radar return to precipitation rate are not valid for snow events with the exception of the MSP radar. It may be possible to acquire the raw radar data and reprocess through more appropriate algorithms for the ESOP-97 and ESOP-98 time periods of interest. However, the cost of this is substantial and may exceed the limits of expected funds. Thus, when considering the LSA-NC as a whole, data on snow may be limited to in situ measurements by NWS cooperative observers, satellite observations, and airborne gamma radiation measurements. Each of these sources of data has limitations as follows:

> (a) cooperative observer data - the most serious problem is the well-known low bias of liquid water equivalent because of wind-sensitive under-catchment. A second limitation is the low (compared to the scale of spatial heterogeneity) spatial resolution of the network.
>
> (b) satellite - Areal extent of snow cover and fractional cover within a pixel may be feasible, but snow water equivalent is more difficult.
>
> (c) airborne gamma radiation - these measurements cover only a small percentage of the surface area and are not frequent in time. For soil moisture, data sources include airborne gamma radiation measurements, experimental satellite estimates, and a few ground based in-situ measurements. Since existing in situ measurements are few and fiscal constraints will limit the number of additional sites that can be added or upgraded, it will be necessary to rely heavily on remote sensing.

Specific activities that are recommended include:

- A corrected set of the cooperative observer data of snowfall, snowdepth, and SWE should be developed for the LSA-NC both for ESOP-97 and ESOP-98 and for the historical record. It should be feasible to extend it back to 1948. This set should be compatible with the corrected Canadian snow data (i.e., contours should match at the international boundary).
- Optimal methods to combine cooperative observer, satellite, and airborne gamma radiation snow data should be developed. These methods should produce snow fields with acceptable accuracy both for research studies (when all data can be used) and for operational applications (when only a subset of cooperative observer data are available).
- The GCIP office should investigate whether more applicable radar algorithms like those to be used at the MSP radar can be implemented operationally before ESOP-98 for those radar systems covering the LSA-NC.
- NEXRAD data from the MSP site should be archived for ESOP-97 and ESOP- 98. Studies of snow water variability using these and other relevant data should be encouraged.
- The development of methods to combine remotely sensed and in situ soil moisture should be encouraged. Of particular interest are methods that are accurate at the beginning of the cold season, just before the soil freezes and snow cover commences, and just after snow cover has disappeared.
- To the extent possible, GCIP should encourage and support routine soil moisture measurements at several sites within LSA-NC.
- Satellite estimates of fractional snowcover should be obtained for the surface sites of interest (Rosemount, Bondville, Walnut Creek, Shingobee, etc.)

APPENDIX B

SUMMARY OF RESULTS FROM GCIP/LSA-E DETAILED DESIGN WORKSHOP

The GCIP/LSA-E Detailed Design Workshop was held in Huntsville, Alabama on 20 - 22 October, 1996 at the Holiday Inn - Research Park. The primary purpose of this workshop was to provide inputs to the design of the overall experiment for the LSA-E during the water years 1998-1999. The Workshop made use of the document entitled "GCIP Studies in the LSA-E - A Discussion Paper" compiled by Dale Quattrochi as a starting point in developing recommended research activities. This Appendix contains a preliminary summary of the results from the Workshop. A more complete summary is in preparation.

The characteristics of the major river basins in the LSA-E are:

- Upper Ohio River provides semi-humid, Appalachian headwater signature in Mississippi River hydrograph
- Tennessee-Cumberland River provides semi-humid southeast tributary, representative of hydrology in this region.

The features of the Ohio and Tennessee River basins important to the GCIP continental- scale studies include the following:

- Topographic effects of the Appalachian Mountains
- Heaviest precipitation in the entire Mississippi River basin
- Winter-spring precipitation maximum
- Winter-spring floods
- Synoptic weather systems as major precipitation cause
- Some snowmelt effect
- Rivers in deep valleys (gulleys)
- Dominant contribution to Mississippi River runoff
- Few large natural reservoirs, but many manmade [e.g., Tennessee Valley Authority (TVA)]

The features and characteristics losted above led to the emphasis on research studies and modeling for this region to focus on the annual hydrometeorological cycle dynamics and water resources management.

B.1 LSA-E Infrastructure and Related Research

A significant part of the Workshop was a series of presentations on the existing facilities and current research activities in the region which are potentially useful for collecting data needed by GCIP and/or for cooperative research studies with GCIP. D. Quattrochi provided an overview of the potential GCIP studies in the LSA-E region to begin in 1998. His presentation summarized the discussion paper which he had compiled and which was sent to all the participants prior to the workshop. His discussion included an examination of potential important science issues that need to be addressed within the LSA-E. Possible links with other projects were also discussed.

Global Hydrology and Climate Center

R. Greenwood described the Global Hydrology and Climate Center (GHCC) which was established by NASA's Office of Mission to Planet Earth and is a partnership comprised of organizational elements from NASA Marshall Space Flight Center (MSFC), the Space Science and Technology Alliance (SSTA) of the State of Alabama and the Universities Space Research Association (USRA). NASA's main focus is on research, education, flight programs, information systems, and advanced studies. SSTA's main focus is education, research, regional studies, and information systems. USRA's main focus is in research, education programs, and visiting scientist programs.

GHCC's charter is to build a nationally-recognized program in global hydrology. The primary focus of the research center is to understand the Earth's global water cycle, the distribution and variability of atmospheric water, and the impact of human activity as it relates to global climate change. The main research areas of GHCC are climate studies, hydrology, passive microwave measurements, atmospheric electricity, and aerosol/doppler measurements.

Alabama A&M University's Center for Hydrology, Soil Climatology, and Remote Sensing (HSCaRS)

T. Tsegaye described the activities of HSCaRS which was established by NASA's Equal Opportunity Office to conduct research activities that are pertinent to NASA's mission goals and strategic enterprises. The mission of HSCaRS is to develop a comprehensive research program involving hydrologic processes with emphasis on remote sensing measurements and modeling, and to develop an educational curriculum that will increase the productivity of under-represented minorities with advanced degrees in NASA-related fields. This Center is expected to be a source of trained scientists to address research topics of interest to GCIP.

The initial focus of the Center's research is on soil moisture remote sensing and hydrologic modeling, with particular emphasis on the use of remotely-sensed soil moisture data in hydrologic models. An initial experiment in soil moisture was conducted in July 1996 in Huntsville, AL, with passive and active microwave remote sensing instruments deployed from boom-trucks.

USDA/ARS Hydrologic Activities in the Ohio and Tennessee River Basins and Neighboring Areas

C. Alonso informed the participants that the USDA/ARS has three experimental watersheds in the vicinity of the LSA-E: (1) Goodwin Creek watershed,MS; (2) North Appalachian Experimental watershed near Coshocton, OH; and, (3) East Mahantango Creek, PA. Only the North Appalachian Experimental watershed is contained within the boundaries of the LSA-E. Because of the small size of these watersheds with respect to the LSA-E, it is thought that these sites would represent points in a larger-scale data set and could serve as calibration sites. He summarized the physiography of the sites, their climatology and the variables that are measured on a regular basis. Of notable importance, NOAA's Air Resources Laboratory is operating a SURFRAD station in the Goodwin Creek watershed to collect comprehensive surface radiation budget data.

Tennessee Valley Authority (TVA) Research and Facilities

R. Ritschard described the Tennessee River, which drains about 106,000 sq. km, as a heavily managed river system. It is managed by the Tennessee Valley Authority, which contains portions of seven states. TVA's function is two-fold: electric power and stewardship. Stewardship takes place through regional economic development, natural resource conservation, and environmental research.

TVA has over 60 years of operational experience, compiled data bases of long records, has developed and applied models and analytical methods, retains scientists and engineers with expertise in hydrology, water and air pollution, and land cover characterization. TVA runs two different watershed hydrology models, a modified Sacramento model and a statistical watershed model. It operates three different water quality models, two fish habitat and response models, a systems water temperature and water quality model, a reservoir systems model, and a decision support modeling system. TVA collects data from 292 rain gages, 75 streamflow gages shared among various agencies, hourly reservoir data on headwater and tailwater elevation, turbine and total discharge, and meteorological data from three stations. TVA also has a repository of aerial photography, and GIS data from specific projects.

Walker Branch Experimental Watershed at the Oak Ridge National Laboratory

P. Hanson described the research activities in the Walker Branch Experimental Watershed which is a small (97 ha.) tributary to the Clinch river just north of Oak Ridge National Laboratory, TN. The site is covered with deciduous hardwood forest and contains two perennial streams. The watershed is currently the site of a throughfall displacement experiment, carbon flux, watershed evapotranspiration and saturated throughflow research. A 44 m walk-up tower with meteorological instruments is located at the site in conjunction with the carbon flux research. A National Acid Deposition program site is located on the periphery of the watershed.

NWS Ohio River Forecast Center, Wilmington, OH

T. Adams described the operational river forecast activities within the Office of Hydrology in the National Weather Services of NOAA. The NWS River Forecast Center (RFC) system is an operational system that offers interactive capability to monitor river forecast simulations. Embodied within the RFC system is a calibration system and an extended streamflow prediction system. The RFC system offers the capability for flash flood guidance within the Ohio River and Lower Mississippi River RFC areas. Current operation of the Ohio River Forecast Center (ORFC) is 17 hours per day, 7 days a week. The ORFC offers one daily forecast with updates provided as needed. The ORFC produces daily quantitative precipitation forecasts (QPF), lumped modeling, flash flood guidance calculations and routine verification of river stage forecasts. There is no current use of WSR-88D radar in QPF's. The ORFC breaks the Ohio River basin into 29 forecast groups for modeling analysis. Adams noted there are significant challenges in hydrological forecasting. These are related to data availability, poor resolution of data, incomplete or missing data, and quality control. Additionally, the complexity of the overall Ohio River basin hydrology causes problems in river forecasting. The problems here relate to snow melt prediction, river ice (location and extent) and freezing of gages in winter. He provided some idea on where the RFC is going in the future by moving more towards distributed hydrologic modeling, better snow estimations and updating in the Eastern U.S., integrating GIS procedures into forecast modeling, developing an advanced hydrologic prediction system and incorporating problemlistic forecasting, deriving more automated data input - especially from remote sensing.

Incorporating Probablistic QPF into Streamflow Predictions

J.Schaake presented some projections on how streamflow predictions in the future will be handled. There are several fundamental questions driving how probabilistic QPF's will be incorporated into streamflow predictions in the future: 1) What do users want ? 2) What do users need? And, 3) What can we do? Basically, users want us to tell them what can happen and want to know how sure we are that it will happen. He showed a number of illustrations that diagram the hydrologic forecasting scenario. Schaake also illustrated the overall relationship of Ensemble Streamflow Prediction (ESP) in response to observed streamflow through time. He noted that ESP methods are needed to predict future river stages, flows, etc, and that these predictions depend on upstream precipitation patterns over time and space. Schaake identified four approaches that may be used in creating ensembles: 1) Climatology only; 2) Modify climatology using forecasts; 3) Generate short-term forecasts using QPF's and space-time correlation; and 4) Use of an atmospheric ensemble. He stated there are currently two areas that are being used as NWS forecast demonstration projects: The Des Moines and the Monongahela River basins. The Des Moines river basin study will begin in March, 1997 during the spring flood season. Forty-one subbasins within the Des Moines river basin will be used in the study for user definition of flood forecast products. The Monongahela River basin study will begin in the fall of 1997. Here, three headwater basins will be used for modeling in conjunction with 24 hour probabilistic QPF models. The driving factor in this demonstration study is to define alternative strategies to get streamflow and river stage probabilities correctly modeled. Schaake closed with several science questions that must be addressed in QPF probablistic modeling: 1) What are the relationships between modeled and real values?; 2) How can these modeled values be quantified?; 3) How do the values change as the models change?; and 4) What is the role of the forecaster in QPF probabilistic modeling?

B.2 Work Sessions

Work Sessions were held in two phases. The first phase addressed three specialized topics while developing an approach to the major research questions on the annual hydrometeorology and water resources that are significant to the success of GCIP. The three topics were:

1. Coupled Hydrologic/Atmospheric Modeling
2. Diagnostic Studies/Energy and Water Budgets
3. Hydrometeorological Prediction and Water Resources Management

The second phase then further developed the specific research and data issues defined during these initial Work Sessions.

GCIP research addresses activities on two scales in each Large Scale Area (LSA). Intermediate-scale area (ISA) activities at spatial scales on the order of 1,000 to 10,000 sq km are phased in with those for each LSAs. Small-scale area (SSA) activities at a spatial scale on the order of 100 sq km typically involve efforts requiring intensive observing periods over a concentrated region to study focused issues. The Work Sessions were asked to identify candidate ISA and SSA activities in the LSA-E.

B.3 Coupled Hydrologic/Atmospheric Modeling Work Session

The development and validation of coupled hydrological-atmospheric models is a major scientific objective for GCIP that includes improving the representation of land surface components in models. This Work Session was asked to consider how GCIP can make use of the unique features, infrastructure and data available in the LSA-E to develop and evaluate regional coupled hydrologic/atmospheric models for weather and climate prediction. In particular, it addressed questions such as what coupled modeling issues can be addressed in the LSA-E?; what processes pertaining to characteristics inherent to the LSA-E need to be emphasized?; how can we evaluate the capability of coupled models to simulate the causal mechanisms for interseasonal and interannual variability over the LSA-E?; and what is needed to estimate model parameter values over the annual hydrologic cycle?

The Work Session was also asked to identify the types of data needed for hydrological and atmospheric modeling research; to identify where such data are available in the LSA-E; and to recommend enhancements to assure sufficient data are available for the Water Years 1998 and 1999.

The coupled hydrologic-atmospheric modeling Work Session recommended research tasks in four areas and summarized in the remainder of this section.

B.3.1 Model Grids and Coordinate Systems

The current status of the three regional models being used by GCIP to provide model output data for budget studies and other applications was reviewed with emphasis on the capability to produce the model output needed during the Water Years 1998 and 1999.

The three regional models producing output for GCIP are archived on a 40 km resolution grid using a Lambert Conformal Map projection true at 100W longitude. However, the "native" grid system resolution varies among the three models. These variations provide an opportunity to investigate the extent to which each of the three regional model grid and coordinate systems are adequate to model the effect of orography on precipitation and the effect of heterogeneous vegetation in the LSA-E.

However, these evaluations should include comparisons with higher resolution grids. The Eta model produced model output at 10 km resolution over a portion of the LSA-E during the period of the 1996 Olympics in Atlanta, GA. A model output data set such as this is well suited for comparative evaluation on the effects of grid resolution in capturing orographic effects on precipitation and the effect of heterogeneous vegetation.

B.3.2 Model Initiation

The Work Session considered there is little data available in LSA-E for coupled hydrologic/atmospheric modeling in both the operational and the research mode. It was recommended that sensitivity studies be conducted on the effects of improved initiation of coupled mesoscale models in very complex regions (such as the LSA-E) with special attention to orography, vegetation, groundwater, and heavily managed runoff.

It was suggested that a coupling between the Land Data Assimilation System (LDAS) and hydrological models and applied in the Ohio and Tennessee river basins could be a test bed for some of these sensitivity studies.

B.3.3 Modeling Clouds

The Work Session recognized that all aspects of cloud parameterization in atmospheric models could be improved. However, it was recommended that some emphasis should be placed on the problem of representing low-level cumulus clouds. The feedback on the surface energy balance needs to be included in coupled mesoscale models and the parameterization of such clouds evaluated using detailed, satellite based estimates of cloud cover.

B.3.4 Compatibility of Regional and Global Models

It was considered that the relative value of output from regional and global models is largely an open question in the case of LSA-E, and that this may have seasonal characteristics. The Work Session recommended that some priority be given to the evaluation of global model output using regional data sets from the LSA-E. In this regard, it was recommended that GCIP give consideration to the following questions.

(a) Should global model output products be a formal part of the GCIP data base?
(b) Should the model physics be consistent between the regional and global models used at NCEP to produce operational output products?
(c) Is the soil moisture initiation in regional and global models adequate?

B.4 Diagnostic Studies/Energy and Water Budgets Work Session Determining the time and space variations of the energy and water budgets from daily to seasonal and interannual periods for the continental scale is one of the scientific objectives for GCIP. This Work Session was asked to consider the types of energy and water budget studies that could best be done in the LSA-E that could contribute to the successful achievement of this scientific objective for GCIP. This Work Session was also asked to identify the data requirements needed to conduct energy and water budget studies; to consider how the existing facilities could contribute to these budget studies; and to recommend enhancements to the existing facilities which the GCIP Project should make during the two-year data collection period of Water Years 1998 and 1999.

The Work Session was focused on energy and water budgets and their variations on seasonal to interannual time scales. The primary questions it addressed were:

What types of energy and water budgets are required over the LSA-East?
What are the data requirements to support these studies?
How can existing facilities contribute to meet these data requirements?

The Working Group was asked to make specific recommendations with respect to:

(i) Candidate list of small-scale area basins(SSAs)within the LSA-East,
(ii) Candidate intermediate scale area basins(ISAs) within the LSA-East,
(iii) Identification of existing sources to meet data requirements in the LSA-East, and
(iv) Data collection enhancements to existing facilities for the 1998 and 1999 Water Years.

The Group in the Work Session noted that given the overall complexity and heterogeneity of the LSA-E it would be exceedingly difficult to design an observational program that could sample data representative of each micro-climate and ecosystem niche. Thus the group suggested that it would be prudent to suggest the minimum number of SSAs that would sample two major ecosystem types, forests versus cultivated land areas, and regions with distinctive climates, northern versus a southern areas. A survey of existing instrumented sites resulted in recommending that the following sites be considered as candidates for SSA sites:

(1) Goodwin Creek Watershed; Oxford, MS USDA/ARS/NSL
(2) Walker Branch Experimental Watershed; Oak Ridge, TN
(3) North Appalachian Experimental Watershed;Coshocton, OH USDA/ARS
(4) Alabama A&M Experiment Station and Remote Sensing Center; Huntsville, AL/
(5) Redstone Arsenal; Huntsville, AL U.S. Army
(6) Panola experimental watershed near Atlanta, GA USGS and NOAA/ERL

The Working Group recommended augmenting or changing locations for the current MOLTS array produced by the coupled mesoscale models to include the candidate SSA sites listed above.

As in all GCIP study areas, precipitation was identified as the most critical variable. It was recommended that the current GCIP mosaic precipitation data set be checked to insure that it was obtaining all of the precipitation networks within the LSA-E. Given the complex terrain and potentially large amounts of data it was suggested that the WSR-88D estimated rainfall would be most useful in conjunction with SSA and ISA study areas.

B.5 Hydrometeorological Prediction and Water Resources Management

The water resources working group focused on how GCIP LSA-E activities could contribute to GCIP's evolving goals with respect to water resources. The group started by identifying some of the most important characteristics of LSA-E with respect to water resources:

1) For water resources purposes, LSA-E consists of the Tennessee-Cumberland and Ohio River systems. The two systems have hydroclimatological similarities, but from a water resource systems standpoint they are much different. The Tennessee River system is highly regulated, via the TVA reservoir system, whereas the Ohio system is largely unregulated. From an institutional standpoint, TVA is a focal point for Tennessee (and, to some extent, Cumberland) system operations and planning issues. For the Ohio River, no one agency has comparable responsibility, although the U.S. Army Corps of Engineers (USACE) does have system-wide responsibility primarily as a result of its ownership of navigation works.

2) For the Tennessee River system, TVA operations and planning models such as PRYSM define a clear modeling framework and corresponding boundary conditions/forcings which could be provided by GCIP products. Essentially this information includes future reservoir inflows over a wide range of future time scales, ranging from a few days to months and seasons. Also, temperature forecasts would be important to the operation of the energy systems.

3) Opportunities to support water management in the Ohio River appear to include navigation interests on the main stem and a variety of reservoir operations on some of the tributaries. These opportunities need to be explored in more detail. Benefits to navigation of improved forecast information appear to exist for forecast periods up to about two weeks.

B.5.1 Relationship to Ongoing NWS Activities

Present operational hydrologic forecast models in use at the two NWS RFCs in LSA-E and by water management agencies do not include new representations of vegetation that have been developed by the land surface community, do not model the surface energy budget, and generally make limited use of available soils, land use and remote sensing information. On the other hand the land surface models are beginning to include hydrologic components that account for infiltration, surface runoff, and subsurface runoff and water storage. As GCIP begins to focus on the LSA-E, subsurface storage and runoff processes will need to be represented well in the land surface models. This will be required for these models to represent the surface moisture conditions that actually exist in the LSA-E and that are important for surface forcing of the atmosphere in climate models as well as weather prediction models. On the other hand, operational hydrologic prediction models would be significantly improved if they included better and more physically based representations being developed by GCIP for application in atmospheric models and for use in LDAS to provide initial soil moisture and temperature information for NWP models.

NWS is developing an ensemble precipitation forecasting capability. This will use ensemble forecasts from regional and global numerical prediction models, but it will include a range of statistical approaches to processing model output information, for simulating fine scale space-time characteristics of precipitation not represented in model output, and for accounting for short-term forecast uncertainty that may not be included in NWP ensemble products. This also includes development of a precipitation snalysis system to be used at RFCs that will include various statistical tools for combining all of the information from different sources and for producing the final precipitation ensembles for the hydrologic models.

B.5.2 Relevance of GCIP Plans to Water Resources Operations in LSA-E

TVA has an interest in streamflow forecasts with two lead times: a) for operational purposes (up to about a week); and b) for planning purposes (months to seasonal). At present, TVA uses probabilistic (10, 50, 90 percentile) forecasts derived from NCEP products; these are used as forcings in the Lettenmaier/Grygier/Stedinger model streamflows (Sacramento model for five index catchments disaggregated stochastically to 42 inflow nodes). For planning purposes, an analogue approach is used, wherein historical observed streamflows for selected years are routed through a reservoir system model. In addition to inflows to the reservoir system, TVA has an interest in forecasts of surface air temperature, which affect both water temperature, which is a key operating constraint, and power demand.

The PRSYM model was implemented by a research group, and is not currently used operationally by TVA. The ESP approach is not used operationally at present in LSA-E, either by the NWS River Forecast Centers, or by TVA. There is a potential TVA interest in ESP-type forecasts over a range of time scales from several days (for power operations purposes) through seasonal (for power planning).

The NWS scheme(s) for producing QPF are evolving. For short lead times (out to about two days), forecasts will be produced from Eta model output. Because the source of forecast uncertainty is not entirely clear at short lead times (probably a combination of uncertainty in model initialization, parameter error, and residual error due to subgrid effects) it will be necessary to develop schemes to represent, possibly via rescaling, forecast error probability density functions. At longer time scales (up to two weeks), ensemble forecasts will be produced using the NCEP's global model. At these lead times, ensemble predictions are expected to represent more realistically the range of likely forecast errors. Finally, at seasonal time scales, ensemble forecasts will be developed from NCEP's coupled ocean-atmosphere model.

B.5.3 Recommendations

Improvements in short and long-range weather forecasting represent the strongest tie between the GCIP research community and water resources operations, both generally and for LSA-E in particular. As a means to direct the LSA-E water resources activity in this direction, the feasibility of developing an experimental water resources forecast capability for part or all of LSA-E was recommended, as follows:

1) GCIP should develop an experimental streamflow forecast capability for the two major river systems within LSA-E: The Tennessee-Cumberland, and the Ohio River systems. It is important that this activity be implemented with parallel research and operational pathways, the latter of which would incorporate the involvement of the two RFCs that operate in LSA-E. This capability may well encompass multiple modeling systems, but should have the following general attributes:

   a) For the Tennessee-Cumberland River systems, produce streamflow at inflow points to existing TVA reservoir systems models, such as the PRSYM system developed collaboratively between TVA, USGS, and other cooperators;

b) For the Ohio River System, forecast points should be selected to match those used by NWS/OHRFC;

c) The system should have the capability of using off-line (e.g., observational) forcings, as well as forecast products produced by the NCEP models.

d) Hydrologic developments should be undertaken as a cooperative effort with the two NWS River Forecast Centers, as well as the key operating agencies (TVA in the case of the Tennessee-Cumberland system; USACE in the case of the Ohio);

2) An ensemble approach to hydrologic forecasting is needed for several reasons. First, PRYSM-type water resources systems models are designed to process ensembles of events to evaluate the implications of alternative operating decisions when the future reservoir inflows are not known exactly. In other words, PRYSM-type models need ensemble forecasts of reservoir inflows. In addition, ensemble prediction methods allow uncertainty in future precipitation patterns throughout a river basin to be analyzed in a way that is statistically consistent for all forecast points in the basin. The TVA system could provide an excellent test site for evaluation of ensemble hydrologic forecasts derived from coupled land-atmosphere models. In this context, analysis of precipitation climatologies should be undertaken to support verification and testing of precipitation forecasts, including ensemble precipitation forecasts. In addition, hydrologically relevant verification methods are needed to assess precipitation forecasts. This includes techniques to assure that the climatology of precipitation forecasts (including ensemble forecasts) matches climatology (i.e. the forecasts are statistically unbiased). Also, hydrologically relevant approaches are needed to measure the skill in these forecasts over a range of space and time scales.

3) Opportunities for diagnosis of NWP models' soil moisture should be exploited using the parallel simulations produced using observed forcings. The potential for updating for NWP model soil moisture using streamflow prediction errors should be evaluated as well.

4) Consideration should be given to broadening the scope of the proposed GCIP/Tennessee River workshop to include some aspects of the Ohio River as well, especially synergisms in the operation of these two systems with respect to effects on the Lower Mississippi River.

5) Attention should be given to the role of biases in both meteorological forecasts (forcings to hydrologic forecast models) and in the hydrologic models themselves. Every hydrologic model includes at least some seasonal bias in the statistical properties (e.g., means and variances) of model outputs when the models are operated in a simulation mode using historical observations. Some method of correcting for these biases is essential for water resource applications of the forecasts. The required corrections usually must be accomplished through post processing of model outputs. Experiments are needed to demonstrate that the climatology of hydrologic forecasts agree with the climatology of historical streamflow events. In addition, useful methods to measure the skill in these forecasts need to be demonstrated to develop the appropriate level of confidence among water resource managers.

B.6 Research Issues Work Session

This Work Session used the results from the first set of Work Sessions to develop an overall listing of the research topics which GCIP should concentrate on during the period of 1997 and 1998 for focused studies on cold season/region hydrometeorology in the LSA-NC. It was agreed that:

1) LSA-E has a wide array of precipitation regimes influenced by orography, soil moisture, and land use.

2) A large question for coupled modeling within the LSA -E is how can models be applied to such things as areal averaging across the region.

3) The LSA-E has high temporal variability in precipitation as well as the highest precipitation within the GCIP region as a whole. Additionally, the LSA-E has systemic wet and dry periods that have a

pronounced effect on hydrometeorology.

4) Surface energy balance/radiation data are sparse across the LSA-E, but could be very useful for coupled modeling if the existing sites are augmented.

The following items were recommended:

- Augment surface flux capabilities within the LSA-E at specific sites selected for focus studies.
- Investigate the availability of aircraft measurements within the LSA-E.
- Develop an action plan for evaluating and improving WSR- 88D and gauge precipitation data sets for model prediction (e.g., topography, snow cover)

One other aspect that needs to be undertaken is to evaluate and improve GOES and polar orbiting data for surface radiation budgets, radiative flux estimates, and to develop data sets for flux profiling of surface fluxes. It was suggested there be development of the LDAS concept, both for operational and research uses, and, to develop a strategy to validate with streamflow gauging with emphasis on focus study areas.

It was recommended that GCIP/DACOM include the following sites in their inventory of data available in the LSA-E.

1. Walker Branch Watershed at Oak Ridge
2. Bondville, IL SURFRAD site/Reifsteck farm in situ site
3. USDA-ARS Hydrologic Experiment Station at Coshocton, OH
4. Alabama A&M University research farm and U.S. Army Redstone Arsenal Meteorological station, Huntsville, AL
5. Panola experimental watershed near Atlanta, GA
6. Giles County, TN -- TVA Land Between the Lakes site
7. Coweta Experimental Watershed, Otto, NC

Additionally, land-grant universities within the LSA-E (i.e., agricultural schools) should be contacted to find out if they monitor any flux tower sites and instrumented watersheds within the LSA-E. Potential schools are: University of Tennessee, Knoxville; University of Kentucky; University of Georgia; Auburn University; Mississippi State University; Ohio State University; West Virginia University; Virginia Tech as well as possibly others.

B.7 Data Issues Work Session

This Work Session used the results from the first set of Work Sessions to develop a consolidated list of data requirements for the LSA-E. The Work Session started with the strawman"list of data requirements which had been developed prior to the workshop. Several possible additions of data from states within and just outside the LSA-E were discussed. This included the Georgia Forestry Commission (28 meteorological stations), the Alabama Weather Observing Network (several automatic meteorological stations) and Alabama Redstone (18 meteorological stations), the North Carolina State Network (14 meteorological stations). Possible additions to upper-air data include profiler data from Redstone Arsenal, University of Alabama-Huntsville (UAH) and Oak Ridge, Tennessee. The consolidated list which resulted from a discussion in a Plenary Session at the Workshop was given in Section 12 of this report.

The group recommended the following actions for GCIP in preparation for research activities in the LSA-E:

- Perform a survey to find out what data products are available and what instrumentation is available within the LSA-E. Focus on existing data sources and data sets within the LSA-E.
- Produce a detailed survey of in situ data availability within the LSA-E
- Identify researcher requirements for WSR-88D data (i.e., volumes, cost, browse availability).

The group raised a number of questions pertaining to the availability and use of satellite remote sensing data in the LSA-E.

What is the future of the satellite data source module as part of the Data Management and Service System?
What happens to data availability after the MSFC DAAC closes?
What are the satellite data requirements for GCIP researchers?
What is the quantity of data available? (How accessible are these data and at what cost?)
Is there a need for a satellite data source module and what role should it play in LSA-E research? (e.g., as a provider/pointer?)

The Session was informed that the MSFC/DAAC as the current satellite remote sensing data source module Work is developing a detailed survey of data availability through remote sensing satellites affecting the LSA-E.

APPENDIX C

ACRONYM LIST

2-D
  Two-Dimensional
3-D
  Three-Dimensional
4-D
  Four-Dimensional
4DDA
  Four-Dimensional Data Assimilation
ABRFC
  Arkansas-Red Basin River Forecast Center
ACARS
  Aircraft Communication and Recording System
AERI
  Atmospherically emitted Radiance Interferometer
AES
  Atmospheric Environmental Service
AFGWC
  Air Force Global Weather Central
AIRS
  Advanced Infrared Studies AIRS
AM1
  Designation for first polar platform in Mission to Planet Earth
AMIP
  Atmospheric Modeling Comparison Project
AQP
  Avionics Qualification Policy
ARESE
  ARM Enhanced Shortwave Experiment
ARL
  Air Resource Laboratory
ARM
  Atmospheric Radiation Measurement
ARS
  Agriculture Research Service
ASCII
  American National Standard Code for Information Exchange
ASTER
  Atmosphere Surface Turbulent Exchange Research facility
ASOS
  Automated Surface Observing System
ATDL
  Advanced Technology Development Laboratory
ATSR
  Along-Track Scanning Radiometer
AVHRR
  Advanced Very High Resolution Radiometer
AVIRIS

Airborne Visible Infrared Imaging Spectrometer

AWDN
: Automated Weather Data Network

AWIPS
: Advanced Weather Interactive Processing System

AWON
: Agricultural Weather Observation Network

AWOS
: Automated Weather Observing System

BALTEX
: Baltic Sea Experiment

BATS
: Biosphere-Atmosphere Transfer Scheme

BOREAS
: Boreal Ecosystem Atmosphere Study

BRDF
: Bidirectional Reflectance Distribution Function

BSRN
: Baseline Surface Radiation Network

BUFR
: Binary Universal Form for Representation of meteorological data

CAC
: Climate Analysis Center

CAGEX
: CERES-ARM-GEWEX Experiment

CAPE
: Convective Available Potential Energy

CART
: Clouds and Radiation Testbed

CASES
: Cooperative Atmosphere-Surface Exchange Study

CASH
: Commercial Aviation Sensing Humidity

CAWS
: Commercial Agriculture Weather Station

CCA
: Canonical Correlation Analysis

CD-ROM
: Compact Disk, Read-Only Memory

CDAS
: Climate Data Assimilation System

CERES
: Clouds and the Earth's Radiant Energy System

CLAVR
: Clouds from the Advanced Very High Resolution Radiometer

CLIVAR
: Climate Variations

CMC
: Canadian Meteorological Centre

CODIAC
: Cooperative Distributed Interactive Atmospheric Catalog

COE
: Corps of Engineer

CONUS

Continental United States
CSA
Continental-Scale Area
CSIRO
Commonwealth Scientific and Industrial Research Organization
DAAS
Data Acquisition and Archive Center
DACOM
Data Collection and Management
DEM
Digital Elevation Model
DIAL
Differential Absorption Lidar
DLG
Digital Line Graph
DLR
Downward Longwave Radiation
DMA
Defense Mapping Agency
DMSP
Defense Meteorological Satellite Program
DMSS
Data Management and Service System
DNR
Department of Natural Resources
DOD
Department of Defense
DOE
Department of Energy
DOI
Department of Interior
DOT
Department of Transportation
DPI
Derived Product Imagery
DRADAP
Digital Radar Precipitation
EBBR
Energy Balance Bowen Ratio
ECMWF
European Centre for Medium-Range Weather Forecasting
ECOR
Eddy Correlation
EDA
Eta Data Assimilation
EDAS
Eta Model Data Assimilation System
EDC
EROS Data Center
EMC
Environmental Modeling Center in NCEP
EMEX
Equatorial Mesoscale Experiment
EOP

Enhanced Observational Period

EOS
: Earth Observing System

EOSDIS
: EOS Data and Information System

EPA
: Environmental Protection Agency

EROS
: Earth Resources Observation Satellite

ERL
: Environmental Research Laboratory

ERS
: Earth Resources Satellite

ESA
: European Space Agency

ESDIM
: Environmental Services Data and Information Management

ESOP
: Enhanced Seasonal Observing Period

ESOP95
: Enhanced Seasonal Observing Period of 1995

ESOP96
: Enhanced Seasonal Observing Period of 1996

ESOP97
: Enhanced Seasonal Observing Period of 1997

ESP
: Extended Streamflow Prediction

ESTAR
: Electronically Scanned Thinned Array Radiometer

Eta
: (Traditional name of an NMC model using Greek letter for the vertical coordinate)

ETL
: Environmental Technology Laboratory

4-D VAR
: 4-Dimensional Variational Assimilation System

FAA
: Federal Aviation Administration

FIFE
: First ISLSCP Field Experiment

FNOC
: Fleet Numerical Oceanographic Center

FPAR
: Fractional of Absorbed Photosynthetically Active Radiation

FSL
: Forecast Systems Laboratory

GAC
: Global Average Coverage

GARP
: Global Atmospheric Research Program

GATE
: GARP Atlantic Tropical Experiment

GCDIS
: Global Change Data and Information System

GCIP

GEWEX Continental-Scale International Project

GCIS
: GCIP Central Information Source

GCM
: General Circulation Model

GCMD
: Global Change Master Directory

GCSS
: GEWEX Cloud Systems Study

GCTP
: Global Coordinate Transformation Package

GEF
: Global Finite Element

GEOS
: Goddard Earth-Observing System

GEWEX
: Global Energy and Water Cycle Experiment

GFDL
: Geophysical Fluid Dynamics Laboratory

GHCC
: Global Hydrology Climate Center

GHP
: GEWEX Hydrometeorology Panel

GIDS
: GCIP Initial Data Sets

GIS
: Geographic Information Systems

GIST
: GCIP Integrated Systems Test

GMT
: Greenwich Meridian Time

GNEG
: GEWEX Numerical Experimental Group

GNEP
: GEWEX Numerical Experimentation Panel

GOALS
: Global Ocean Atmosphere Land Surface

GOES
: Geostationary Operational Environmental Satellite

GPCP
: Global Precipitation Climatology Project

GPS
: Global Positioning System

GRDC
: Global Runoff Data Centre

GREDS
: GCIP Reference Data Set

GRIB
: Grid point values expressed in Binary form

GSFC
: Goddard Space Flight Center

GVI
: Global Vegetation Index

GVaP

GEWEX Water Vapor Project

GVAR
: GOES Variable Record

HAPEX
: Hydrological-Atmospheric Pilot Experiment

HCDN
: Hydrology Climate Data Network

HH
: Horizontal Send Horizontal Receive

HIRS
: High-Resolution Infrared Sounder

HPC
: Hydrometeorology Prediction Center of NCEP

HPCN
: High Plains Climate Network

HSCaRS
: Hydrology, Soil Climatology, and Remote Sensing

IAV
: Interannual Variability

ICN
: Illinois Climate Network

IDEM
: Indiana Department of Environmental Management

IFC
: Intensive Field Campaign

IGBP
: International Geosphere Biosphere Project

IGPO
: International GEWEX Project Office

IOP
: Intensive Observing Period

IRC
: International Radiation Commission

IR
: Infrared

IRI
: Interdisciplinary Research Initiative

ISA
: Intermediate-Scale Area

ISLSCP
: International Satellite Land Surface Climatology Project

ISCCP
: International Satellite Cloud Climatology Project

ISWS
: Illinois State Water Survey

JERS
: Japanese Earth Resources Satellites

JPL
: Jet Propulsion Laboratory

LAI
: Leaf Area Index

Lake-ICE
: Lake Induced Convection and Evaporation

LAMBADA

Large-Scale Atmospheric Moisture Balance of Amazonia Using Data Assimilation
LANDSAT
Land (Remote Sensing) Satellite
LAPS
Local Analysis Prediction System
LC
Longwave Cooling
LDAS
Land Data Assimilation System
LEAF
Land-Ecosystem-Atmosphere Feedback
LFM
Limited Fine Mesh
LLJ
Low-Level Jet
LSA
Large-Scale Area
LSA-E
Large-Scale Area-East
LSA-NC
Large-Scale Area-Northcentral
LSA-SW
Large-Scale Area-Southwest
LSP
Land Surface Parameterization
LTER
Long Term Ecological Research
LW
Long Wave
LWW
Little Washita Watershed
MAC
Multi-Sensor Aircraft Campaign
MAGS
Mackenzie GEWEX Study
MAPS
Mesoscale Analysis and Prediction System
MCC
Mesoscale Convective Complex
MCS
Mesoscale Convective Systems
MFRSR
Multi-Filter Rotating Shawdowband Radiometers
MIRBEX
Mississippi River Basin Experiment
MISR
Multi-angle Imaging Spectro-Radiometer
MIT
Massachusetts Institute of Technology
MKE
Mesoscale Kinetic Energy
MM4
Mesoscale Model (NCAR)
MM5

Mesoscale Model (NCAR)

MODIS
: Moderate Resolution Imaging Spectrometer

MOLTS
: Model Location Time Series

MORDS
: Model Output Reduced Data Set

MOS
: Model Output Statistics

MPCA
: Minnesota Pollution Control Agency

MRF
: Medium-Range Forecast

MSEA
: Management Systems Evaluation Areas

MSFC
: Marshall Space Flight Center

MSP
: Minneapolis, MN

MSS
: Multi-Spectral Scanner

MTPE
: Mission to Planet Earth (NASA)

NASA
: National Aeronautics and Space Administration

NASDA
: National Space Development Agency

NASS
: National Agricultural Statistics Service

NATSGO
: National Soil Geographic Database

NCAR
: National Center for Atmospheric Research

NCDC
: National Climate Data Center

NCEP
: National Centers for Environmental Prediction

NCGIA
: National Center for Geographic Information and Analysis

NCRFC
: North Central River Forecast Center

NCSS
: National Cooperative Soil Survey

NDVI
: Normalized Difference Vegetation Index

NESDIS
: National Environmental Satellite Data and Information Service

NESOB
: Near Surface Observation

NetCDF
: Network Common Data Format

NEXRAD
: Next Generation Radar

NFS

Forecast System for the Nile River

NGM
: Nested Grid Model

NIC
: National Ice Center

NIP
: Normal Incident Pyrheliometer

NIR
: Near Infrared

NMC
: National Meteorological Center (recently changed to NCEP)

NOAA
: National Oceanic and Atmospheric Administration

NOHRSC
: National Operational Hydrologic Remote Sensing Center

NPA
: National Precipitation Analysis

NPN
: NOAA Profiler Network

NRC
: National Research Council

NRCS
: National Resource Conservation Service

NSF
: National Science Foundation

NSL
: National Sedimentation Laboratory

NWIS
: National Water Information System

NWP
: Numerical Weather Prediction

NWS
: National Weather Service

NWSRFS
: National Weather Service River Forecast System

OFPS
: Office of Field Project Support

OH
: Office of Hydrology

OLAPS
: Oklahoma Local Analysis and Prediction System

OLDS
: On-Line Demonstration System

OLR
: Outgoing Longwave Radiation

ORFC
: Ohio River Forecast Center

ORNL
: Oak Ridge National Laboratory

OSU
: Oregon State University

PACS
: Pan American Climate Studies

PAR

Photosynthetically Active Radiation

PBL
: Planetary Boundary Layer

PILPS
: Project for Intercomparison of Land Surface Parameterization Schemes

POES
: Polar Orbiting Environmental Satellite

PNE
: Prototype Numerical Experiments

PPS
: Precipitation Processing System

PPT
: Precipitation

PRA
: Principal Research Area

PRAC
: Principal Research Area Coordinator

PRE-STORM
: Preliminary Regional Experiment for Storm-Central

PRISM
: Precipitation-development Regressions on Independent Slopes Model

PRYSM
: Power and Reservoir Model

QPF
: Quantitative Precipitation Forecast

RADARSAT
: Radar Satellite

RAMAN
: Regional Atmospheric Monitoring and Analytical Network

RAMS
: CSU Regional Area Modeling System

RASS
: Radio Acoustic Sounding System

RFC
: River Forecast Centers

RFE
: Regional Finite Element

RPCA
: Rotated Principal Components Analysis

RPN
: Recherche en Prevision Numerique

SAO
: Surface Aviation Observations

SAR
: Synthetic Aperture Radar

SARB
: Satellite Radiation Budget

SAST
: Scientific Assessment and Strategy Team

ScaRab
: French-Russian Scanner for Earth Radiation Budget

SCAT
: Scatterometer

SEUS

Snow Water Estimations and Updating System
SGP
Southern Great Plains
SiB
Simple Biosphere
SiB2
Simple Biosphere Model 2
SIR
Shuttle Imaging Radar
SMA
Soil Moisture Accounting
SM/ST
Soil Moisture/Soil Temperature Project
SNOTEL
SNOpack TELemetry
SNR
Signal-to-Noise Ratio
SOLRAD
Solar Radiation
SPOT
Syst`eme Pour l'Observation de la Terre
SRB
Surface Radiation Budget
SSA
Small-Scale Area
SSG
Scientific Steering Group
SSM/I
Special Sensor Microwave Imager
SSTA
Space Science and Technology Alliance
SSURGO
Soil Survey Geographic Database
STATSGO
State Soil Geographic Database
STC
Supplement Type Certificate
STORM
Storm-Scale Operational and Research Meteorology
SVAT
Soil Vegetation Atmosphere Transfer
SWATS
Soil Water and Temperature Systems
SWE
Snow Water Equivalent
FEST
Fronts Expemiment Systems Test
SURFRAD
Surface Radiation Monitoring Network
TBD
To Be Determined
TBRG
Tipping Bucket Raingauge
TDR

Time Delay Reflectometry
TIGER
Terrestrial Initiative in Global Environment Reseach
TIMS
Thermal Infrared Multispectral Scanner
TM
Thematic Mapper
TOA
Top-of-the-Atmosphere
TOGA-COARE
Tropical Ocean Global Atmosphere Coupled Ocean Atmosphere Response Experiment
TOP
Topography-Based
TOVS
TIROS Operational Vertical Sounder
TRFC
Tulsa River Forecast Center
TRMM
Tropical Rainfall Measuring Mission
TVA
Tennessee Valley Authority
UAH
University of Alabama, Huntsville
UAV
Unmanned Aerospace Vehicles
UCAR
University Corporation for Atmospheric Research
UK
United Kingdom
UM
University of Minnesota
UPS
United Parcel Service
U.S.
United States
USACE
U.S. Army Corps of Engineers
USDA
U.S. Department of Agriculture
USGCRP
United States Global Change Research Program
USGS
U.S. Geological Survey
USRA
Universities Space Research Association
USWRP
U.S. Weather Research Program
UW
University of Wisconsin
VAD
Velocity Azimuth Display
VAS
VISSR Atmospheric Sounder
VIL

Vertically Integrated Liquid

VV
: Vertical Send Vertical Receive

WARFS
: Water Resources Forecasting System

WARM
: Illinois Water and Atmospheric Resources Monitoring Network

WAVE
: Weather Analysis and Verfication Experiment

WBW
: Walker Branch Watershed

WCP
: World Climate Programme

WCRP
: World Climate Research Programme

WDT
: Wisconsin Dense Till Project

WFOV
: Wide Field of View

WMO
: World Meteorological Organization

WPMM
: Window Probability Matching Method

WRD
: Water Resources Division

WSI
: Weather Services International

WSR-88D
: Weather Service Radar 88-Doppler

WVSS
: Water Vapor Sensing System

WY
: Water Year

APPENDIX D

Summary of GCIP Initial Data Sets Compiled

A number of GCIP initial data sets (GIDS) were prepared to provide the data services support during the build-up period before the EOP. The GCIP researchers considered the availability of existing data sets from special experiments and/or reanalysis periods in selecting time periods for these initial data sets.

Preparation of the GIDS started in 1993, and the data sets were compiled for on-line access by GCIP investigators to the extent that is technically feasible. They were also packaged in a manner (e.g., use of CD-ROM) for wide distribution especially to international persons interested in performing initial diagnostic, evaluation, and modeling studies on GCIP-related topics.

D.1. GIDS-1 Winter-Early Spring Season

The first GCIP data set served as both a scientific data set and a GCIP static data system test that made use of existing experimental and operational capability to provide a composite observing and model output data set derived from the new observation and assimilation schemes. The period for this data set is from 1 February to 30 April 1992. This data set includes data from STORM-FEST, conducted from 1 February to 15 March 1992, and was augmented by hydrological, geographical, and vegetation data for the Mississippi River basin. An additional six weeks of atmospheric, hydrological, and land surface data were added from existing data centers.

The GIDS-1 data set became available online through the CODIAC system operated by the UCAR/OFPS in April 1994. A CD-ROM containing a selected portion of GIDS-1 data was distributed in August 1994. A summary report for this data set was completed in September 1996.

D.2. GIDS-2 Abnormal Climate Events

The compilation of this data set was postponed due to lack of resources.

D.3. GIDS-3 Initial Warm Season

The observations and model output data collected during a GCIP Integrated Systems Test (GIST), provided the third of the initial data sets. Such a data set was completed in June 1995 and is available on line through the CODIAC system operated by the UCAR/OFPS. A CD-ROM containing a selected portion of the GIDS-3 data was distributed in October 1995. The data summary report was completed in September 1996.

The GIST data collection period extended from 1 April 1994 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 which was shown in Figure 7-1. A listing of the data types to be included in the GIDS-3 data set is given in Table D-1.

Table D-1. Data Sets Collected During GIST

DATA SET
Surface Data
GIST Hourly Surface Composite *
GIST Hourly Precipitation Composite *
GIST Daily Precipitation Composite *
NWS ASOS Data
FAA AWOS Data
NCDC Surface Aviation Observations (SAO) Data
High Plains Climate Network (HPCN) Data
Oklahoma Mesonet Data
DOE/ARM CART Surface Data
NWS Cooperative Observer Data
Tulsa River Forecast Center (TRFC) Precipitation Data
U.S. Army Corps of Engineer Precipitation and Streamflow Data
USGS Precipitation and Streamflow Data
USDA/ARS Precipitation Data

```
USDA/Natural Resources Conservation Service Soil Moisture Data
--------------------------------------------------------------
                        Upper Air Data
--------------------------------------------------------------
NWS Upper Air Rawinsonde Data (Micro-ART 6-sec diskettes)
NWS Upper Air Rawinsonde Data (Mandatory/Significant Levels)
DOE/ARM CART Site Upper Air Data
NOAA Demonstration Network Profiler Data
--------------------------------------------------------------
                        Satellite Data
--------------------------------------------------------------
GOES-7 Satellite Imagery (IR, Visible 6.7pm)
GOES-8 Satellite Imagery (preliminary)
NOAA POES AVHRR Imagery
NOAA POES TOVS Data
DMSP OLS Imagery
MDPS SSM/I Data
--------------------------------------------------------------
                         Radar Data
--------------------------------------------------------------
WSR-88D LEVEL II Data
WSI Reflectivity Composite Imagery
--------------------------------------------------------------
                         Model Data
--------------------------------------------------------------
AES/CMC RFE Model
NOAA/NMC Eta Model
NOAA MAPS Model
Oklahoma Local Analysis and Prediction System (OLAPS) Model
   GCIP can access global model output produced by AES/CMC,
   ECMWF, and NOAA/NMC and hydrology model output produced
   by NOAA and shown in Table 1.
--------------
*  Contains data from ASOS, AWOS, NCDC SAOs, HPCN, Okalhoma
   Mesonet, DOE/ARM CART, NWS Cooperative Observer, TRFC,
   USGS, USACE, and USDA.
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D.4. GIDS-4 Second Warm Season

The Enhanced Seasonal Observing Period (ESOP) of 1995 (ESOP-95) was conducted from 1 April 1995 to 30 September 1995 to initiate the ongoing program of observations in support of the LSA-SW focus and to concentrate the buildup in the six months prior to the start of the EOP. The ESOP-95 data collection was done in cooperation with the VORTEX II and a US Weather Research Program campaign labeled Weather Analysis and Verification Experiment (WAVE) conducted in the first three months of the ESOP-95 period.

The ESOP-95 provided the basis for the fourth initial data set (GIDS-4). The GIDS-4 contains many of the same data types as was collected during GIST in 1994. The data set was completed in Sepatember 1996 and the data summary report is in preparation.

A listing ot the data types to be included in the GIDS-4 data set is given in Table D-2.

Table D-2. Data Sets Contained in the GIDS-4 Database

```
______________________________________________________________________
                  IN-SITU DATA
----------------------------------------------------------------------
Surface
----------------------------------------------------------------------
GIDS-4 Hourly Surface Composite
GIDS-4 Hourly Precipitation Composite
GIDS-4 Daily Precipitation Composite
NWS Automated Surface Observing System (ASOS) Data
FAA Automated Weather Observing System (AWOS) Data
NCDC Surface Aviation Observations (SAO) Data
High Plains Climate Network (HPCN) Data
Oklahoma Mesonet Data
DOE/ARM CART Surface Data
NWS Cooperative Observer Data
Arkansas-Red River Basin Forecast Center (ABRFC) Precipitation Data
U.S. Army Corps of Engineer (USACE) Precipitation and Streamflow Data
```

USGS Precipitation and Streamflow Data
USDA/Agricultural Research Service (ARS) Surface and Soil Moisture Data
USGS Reservoir Data

Upper Air Data

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

Radar Data

WSR-88D Level II Data
WSI Reflectivity Composite Imagery
ABRFC Stage III WSR-88D Data (including daily GIF imagery)

Land Characterization Data

Vegetation/Data Products

SATELLITE DATA

GOES-8 Satellite Imagery (IR, Visible 6.7 micron)
NOAA POES AVHRR Imagery
NOAA POES TOVS Data
DMSP OLS Imagery
DMSP SSM/I Data
NOAA Weekly Northern Hemisphere Snow Cover Analysis
ASOS Cloud Observations
CLAVR Clouds
Satellite Radiation Datasets
Vegetation Index
Little Washita River Basin Soils and Land Cover

Model Data

CMC RFE Model Data
Eta Model Data (3 hourly)
Eta Model Initialization Analyses GIF Imagery (daily: 12 UTC)
Eta Enhanced Model Output Profiles
NOAA/FSL MAPS Model Data (hourly)

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* Contains data from ASOS, AWOS, NCDC SAOs, HPCN, Okalhoma Mesonet, DOE/ARM CART, NWS Cooperative Observer, ABRFC, USGS, USACE, and USDA/ARS.

GCIP Reference Data Set

The USGS supported the preparation of a CD-ROM containing a number of different data sets which is expected to have wide use among GCIP investigators. One of the major criteria for including a specific type of data on the CD-ROM was that the data are expected to change little if any during the next two to three years. A CD-ROM containing the GCIP Reference Data Set (GREDS) was published in August 1995. A description of the data sets on this CD-ROM is included as part of the documentation for each CD-ROM. The list of data sets for the GCIP Reference Data Sets CD-ROM is given in Table D-3.

Table D-3   GCIP Reference Data Sets CD-ROM

1. Two ASCII files of USGS, reservoir and NOAA meteorological sites plus Canadian hydrometric and meteorological stations for the Mississippi River basin.

2. An ASCII file inventory of daily values for the USGS sites.

3. A 500-m Digital Elevation Model.

4. Geology of the conterminous United States, from 1:2,500,000-scale King and Beikman map.

5. Land use from 1:7,500,000-scale map of conterminous US.

6. River-Reach File, Version 1 (RF1). Data set derived from original EPA files, with attributes, for the

conterminous US.

7. Large Reservoirs of the US. (Hitt, 1990). Locations and selected characteristics of approximately 2,700 reservoirs and controlled natural lakes that have normal capacities of at least 5,000 acre-feet or maximum capacities of at least 25,000 acre-feet and that were completed as of January 1, 1988.

8. Average Annual Runoff. (Gebert et al., 1987). This is an isoline map of average annual runoff in the conterminous United States, 1951-1980, base scale 1:7,500,000.

9. Climatography of the US, No. 81 -- Supplement No. 3: Contour maps of Annual 1961-90 Normal Temperature, Precipitation, and Degree Days, from NCDC.

10. LANDSAT nominal row and path boundaries and center points. An index to LANDSAT scenes.

11. Grid node locations and complete descriptions of model parameters for the ETA model. Projected to Lambert Azimuthal Equal Area, to match with the other data sets.

12. State and county boundaries from the 1:2,000,000 Digital Line Graph format.

13. Quadrangle index maps for USGS 1:250,000-, 1:100,000-, and 1:24,000-scale quadrangle map series. Including quad name, states, index numbers needed for ordering quad maps from USGS. Useful for determining list of quads needed for a particular study area.

14. Hydrological units of the conterminous United States. Boundaries for the 8-digit hydrological unit codes, digitized from 1:250,000-scale base map.

15. An ASCII listing of sites identified as having long-term records useful for climate studies, including the USGS hydro-climatic data network (Slack and Landwehr, 1993).

16. Graphic interface format images of the above data sets for browsing. Each image is 1024 x 768 pixels.

17. Software -- PC executable and C source code for Lambert Azimuthal Equal Area projection to Latitude/Longitude, and vice versa. FORTRAN source distribution (USGS version) for entire Global Coordinate Transformation Package (GCTP).