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GLOBAL ENERGY AND WATER CYCLE EXPERIMENT (GEWEX)

CONTINENTAL-SCALE INTERNATIONAL PROJECT (GCIP)

TACTICAL DATA COLLECTION AND MANAGEMENT PLAN for the 1997 ENHANCED SEASONAL OBSERVING PERIOD (ESOP-97)

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

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

1.1 The GCIP Project

The overall objectives of the GCIP are to improve scientific understanding of, and to model on a continental scale, the coupling between the atmosphere and the land surface for climate prediction purposes. This includes the determination of the temporal and spatial variability of the hydrological and energy budgets on the continental scale as well as the development and validation of macroscale hydrological models, related high

resolution atmospheric models, and coupled hydrologic and atmospheric models. The operational or Enhanced Observing Period (EOP) of GCIP commenced in October 1995 and will run for approximately five years.

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

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

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

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

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

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

1.2 GCIP Datasets

A number of GCIP Initial Datasets (GIDS) were prepared to provide data services support during the 2-yr buildup period prior to the start of the 5-yr EOP in October 1995. GIDS-1 covered the period from 1 February to 30 April 1992 and included data from the STorm-scale Operational and Research Meteorology (STORM)-Fronts Experiment Systems Test (FEST) augmented by an additional six weeks of atmospheric, hydrological, and land surface data from existing data centers for the central Mississippi River basin. GIDS-2 is planned to consist of two abnormal climate events in the Mississippi River basin, i.e. the 1988 drought and the 1993 floods. GIDS-3 consists of data collected during the GCIP Integrated Systems Test (GIST) which took place from 1 April to 31 August 1994, with a concentrated effort during the summer season of June, July, and August. The GIST took place in the LSA-SW (see Figure 1-1). GIDS-4 consists of data collected during the GCIP 1995 Enhanced Seasonal Observing Period (ESOP-95) which was also conducted in the LSA- SW (1 April - 30 September 1995). The GIDS-4 CD-ROM is scheduled to be completed by approximately November 1996. A GCIP Reference Dataset (GREDS) was completed in early 1995. The 17 different datasets on this CD-ROM contain data that are expected to change little if any during the next two to three years. A summary of the contents of each of the above datasets is given in the GCIP Major Activities Plan for 1996, 1997 and Outlook for 1998 (IGPO 1995).

The first dataset collected during the 5-yr EOP was the ESOP-96 which took place from 1 April to 30 September 1996 in the LSA-SW. The ESOP-96 CD-ROM is scheduled to be completed by approximately July 1997.

Specific information about each dataset is available on the Internet World Wide Web (WWW) via the GCIP home page at the following URL (Uniform Resource Locator):

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

1.3 1997 Enhanced Seasonal Observing Period (ESOP-97)

The ESOP-97 will be conducted from 1 October 1996 to 31 May 1997 and will begin the observations in support of the LSA-NC focus as shown in Figure 1-1. A major objective for ESOP-97 is to contribute to a comprehensive dataset for diagnostic, evaluation, and modeling studies and it is the first GCIP dataset to have its focus outside of the LSA-SW.

The LSA-NC has three environmental features that are significant to GCIP: Winter snow accumulation and spring snowmelt and their roles in the annual water budget, large natural inertia in the water runoff system due to lakes, and minimal orographic effects for precipitation. The scientific objectives and approach for these studies are described in the GCIP Major Activities Plan for 1996, 1997 and Outlook for 1998 (IGPO 1995).

The GCIP LSA-NC domain is shown in Figure 1-2. The geographical area extent of the Upper Mississippi River basin is defined as the irregular shaped polygon in Figure 1-2. For atmospheric modeling and other applications a more regular-shaped area is defined by the boundaries of 37° to 50° N latitude and 85° to 99° W longitude, and this is used as the latitude-longitude boundaries for the LSA-NC. The meteorological and hydrological networks covering the Mississippi River basin are currently being enhanced by new Weather Surveillance Radar - 1988 Doppler (WSR-88D) radars, wind profilers, and automatic weather stations. Most of these systems are now operating in the LSA-NC. In addition, mesoscale networks including the Illinois State Water Survey (ISWS) Illinois Climate Network (ICN) and the state Department of Transportation (DOT) Automated Weather Observing System (AWOS) networks in Minnesota and Iowa are contained within the LSA-NC domain.

1.4 Purposes of Document

This document is entitled the Tactical Data Collection and Management Plan for ESOP-97 and is intended to serve two purposes:

(i) A summary of the approach to the data collection efforts during the period of 1 October 1996 through 31 May 1997 in lieu of an operations plan covering this period.

(ii) The data collected during ESOP-97 will provide the basis for the second ESOP dataset from the 5-yr GCIP EOP and is the first GCIP dataset located outside of the LSA-SW region. The ESOP-97 will contain all of the same data types as were collected for ESOP-96 in 1996. Enhancements such as airborne gamma snow surveys will also be available for ESOP-97.

The approach to ESOP-97, a description of the data collected, and how it will be disseminated are described in the remainder of this document.

2. OBJECTIVES AND APPROACH

The research objectives to be achieved from the ESOP-97 datasets are described in the GCIP Major Activities Plan (IGPO, 1995). The purpose of compiling the ESOP-97 dataset is to create the second GCIP ESOP dataset during the GCIP 5-yr EOP which began in October 1995 and it will enable GCIP investigators to conduct focused studies (i.e. coupled model and diagnostic) unique to the LSA-NC during the late fall, winter, and early spring seasons. The approach taken by the GCIP is to take the maximum advantage of the existing operational observing programs over the continental United States while taking advantage of special collection of higher

resolution data. Also, as additional improvements are made to the operational observing systems [i.e. Automated Surface Observing System (ASOS) and WSR 88-D] they are incorporated. These operational networks include the traditional meteorological and hydrological networks in addition to WSR-88D radars, wind profilers, ASOS, satellites, and operational model output.

The LSA-NC offers several areas suitable for LSA, ISA, and SSA studies. On the LSA and ISA scales there is the Des Moines River basin extending from southwest Minnesota to southeast Iowa, the Minnesota River basin over southwestern and southcentral Minnesota, and the state of Illinois with the Illinois Climate Network (ICN). On the ISA to SSA scale there are opportunities in some of the focused study areas within the LSA-NC. The University of Minnesota Experiment Station in Rosemount, Minnesota presently measures nearly all those parameters identified as needed for model intercomparison studies. There is also the highly instrumented area around Bondville, Illinois which includes an ICN site (with soil moisture measurements, a SURFace RADiation (SURFRAD) measurement site, and it is part of the Environmental Protection Agency wet/dry deposition network. The Walnut Creek watershed, within the Des Moines River basin (Figure 2-1), has been extensively instrumented by the National Soil Tilth Laboratory (NSTL). Also, there is the Shingobee River watershed in north-central Minnesota which includes the United States Geological Survey (USGS) Interdisciplinary Research Initiative (IRI) site. This site is the only one of the above that is mostly forested.

The scientific issues to be focused on during the ESOP-97 include land surface model physics, land surface modeling of subgrid-scale heterogeneity effects and monitoring of the land-surface state. The land surface model physics 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 scale snow patchiness. The land surface modeling of subgrid- scale heterogeneity effects are most relevant during snowmelt when the change in albedo can exert a profound influence on the surface-atmosphere energy exchange. The monitoring of the land-surface state includes studies of the water and energy budgets during the cold season in the LSA-NC.

During ESOP-97 there will be three research projects occurring within the LSA-NC, the Lake-Induced Convection Experiment (Lake-ICE), the Chicago Deicing Experiment, and the Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Program at the southern Great Plains Cloud and Radiation Testbed (CART).

The Lake-ICE is a field project designed to examine the processes, on multiple size scales, by which the atmosphere is modified by low-level sources of heat, moisture, and particles. The objectives of Lake-ICE include measuring the spatial and temporal extents to which the Great Lakes impact wintertime pressure, temperature, wind, humidity, cloud, and precipitation fields, to document the growth of the boundary layer, to document the development and evolution of mesoscale convective structures as the boundary grows and atmospheric conditions are modified by this growth, determine the factors that govern turbulence development and subsequent vertical transports through the boundary layer, and to determine the relationships between cloud condensation nuclei populations and glaciation. Lake-ICE is proposed to take place over Lake Michigan during December 1996 and January 1997.

The Chicago Deicing Experiment is an onsite test and demonstration of new forecasting tools designed to improve winter aviation safety. This project is conducted by the National Center for Atmospheric Research (NCAR) at Chicago's O'Hare International Airport. This project includes a four station mesonet as well as five snow-weighing gages. The project will take place from December 1996 through March 1997.

The primary objective of the ARM program is to characterize the radiative processes in the earth's atmosphere with improved accuracy and resolution. The strategy is to deploy, for at least a decade, a sufficiently complete set of observing systems that, when combined with other operational or experimental systems, will obtain a continuous representation of the radiative and meteorological fields over a volume of space equivalent to the minimum spatial resolution of a typical global climate model (GCM). The goal of CART is to generate a dataset that is sufficiently complete to enable diagnosis of the performance of GCM subgrid scale paramiterization schemes that are important to representing cloud and radiation properties in these models. The sensor systems and measurements at the ARM/CART site were described in Volume I of the GCIP Implementation Plan (IGPO, 1993).

In summary, ESOP-97 will provide a dataset that: (1) includes atmospheric and hydrological data obtained in a major river basin; (2) includes a hydrologically important time of year (i.e. winter); (3) includes routine operational data as well as special research observing platforms combined for a six month period; and (4) provides quality controlled surface and upper air composite datasets as required by the GCIP EOP.

3. DATA SOURCES AND DATA COLLECTION

The ESOP-97 data can be divided into three major data categories: In situ, satellite, and model. The responsibility in data collection will fall under each module of the GCIP Data Management and Service System (DMSS). Although most of the data sources are operational in nature, special arrangements will be made to obtain these data in the highest resolution possible. Table 3-1 summarizes the individual potential datasets comprising the ESOP-97. A brief description of each dataset is then provided in the following subsections with information regarding data collection, processing, and final archival. Acronyms within the table are defined within each dataset summary section and in Appendix A. For reference the page numbers of the dataset descriptions are included within Table 3-1. Information on dataset dissemination is provided in section 5. As this is a planning document, not all datasets described herein may be collected. Conversely, additional datasets may be discovered at a later date and added. Information on the final ESOP-97 datasets will be provided in the ESOP-97 Tactical Data Collection and Management Report to be published after the data collection phase of ESOP-97 is complete.

TABLE 3-1 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
- US Army Corps of Engineer (USACE) Precipitation and Streamflow Data
- USGS Streamflow Data
- 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
- 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 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)
NPN 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

3.1 IN-SITU DATA

The following in-situ datasets will be collected, processed, quality assured, archived, and disseminated at the In-Situ Data Module [University Corporation for Atmospheric Research (UCAR)/Joint Office for Science Support (JOSS; formerly the Office for Field Project Support)]. Dataset details are provided in the following subsections. Information on data and metadata retrieval is provided in Section 5.

3.1.1 Surface Data

Automated Surface Observing System (ASOS) Data - These data include hourly observations of temperature, dew point, station pressure, precipitation type (rain, snow, and freezing rain), precipitation amount, wind speed, wind direction, visibility to 10 miles, and sky condition to 12,000 feet. These data are available at 130 sites (including both commissioned and uncommissioned sites) within the LSA-NC (Figure 3-1). Data will be merged, quality controlled, and archived at the JOSS. Commissioning means that the ASOS station has passed all operational and quality assurance specifications and replaces the manual observations with 24-hour automated observations at that station. NOTE - Caution should be exercised by the researcher when using uncommissioned ASOS data.

Automated Weather Observing System (AWOS) Data - This includes data from the Federal Aviation Administration (FAA) AWOS stations as well as the networks operated by the states of Minnesota and Iowa. These data include 20-minute (except for the Iowa stations which provide 1-min) observations of temperature, dew point, station pressure, precipitation type (rain, snow, and freezing rain), precipitation amount, wind speed, wind direction, visibility to 10 miles, and sky condition to 12,000 feet. These data are available at 117 sites within the LSA-NC (Figure 3-2). Data will be merged, quality controlled, and archived at the JOSS.

Surface Airways Observations (SAO) Hourly Data - These data include hourly SAOs of temperature, dew point, station and sea level pressure, altimeter setting, precipitation type and amount, wind speed, wind direction, visibility, ceiling, and cloud type, height, and amount, and remarks. Data are routinely recorded at 96 sites within the LSA-NC (Figure 3-3) and will be processed and archived at National Climatic Data Center (NCDC). Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

SAO Special Observation Data - These data include the "special" SAOs. These are SAOs that are reported at off-hour times and report significant changes in conditions from the previous hourly reports. These reports can include all of the information shown above for the hourly SAOs, but more typically, report only portions of the data. A complete listing of the requirements to issue a "special SAO" are included in the Federal Meteorological Handbook No. 1 (1988). Data are routinely recorded at 96 sites within the LSA-SW (Figure 3-3) and will be processed and archived at NCDC. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

High Plains Climate Network (HPCN) Data - The HPCN mesonet routinely collects and archives hourly observations of temperature, dew point, precipitation amount (warm season only), wind speed, and wind direction to support agricultural operations on the high plains. These data are available from 69 sites in the LSA-NC (Figure 3-4). Soil moisture measurements are also available from 10 of the sites within the LSA-NC region (see Figure 3-4) at either weekly or biweekly intervals. The data are collected, processed, and archived by the High Plains Regional Climate Center at the University of Nebraska/Lincoln. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

DOE ARM/CART Surface Meteorological Data - The DOE ARM Program routinely obtains surface measurements from its Surface Meteorological Observation Stations (SMOS) at the Southern Great Plains CART site in Kansas and Oklahoma. These measurements include radiometric, wind, temperature, humidity, clouds, and surface flux at eight extended facilities in the LSA-NC (Figure 3-5). The data are collected and processed by

the DOE ARM Program and archived at DOE Oak Ridge National Laboratory (ORNL). Data for the ESOP- 97 period will be extracted and forwarded to the JOSS.

NOAA (National Oceanic and Atmospheric Administration) Profiler Network (NPN) Surface Observations - The NPN routinely record hourly and 6-minute surface observations of temperature, dew point, station pressure, precipitation amount, wind speed, and wind direction at two of its 10 405 MHz profiler sites in the LSA-NC (Figure 3-6). The data are routinely collected and processed by NOAA/Forecast Systems Laboratory (FSL) and archived at NOAA/NCDC. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

Missouri Commercial Agriculture Weather Station (CAWS) Network Data - The University of Missouri Extension Service operates the CAWS network of 16 automated stations over the northern and southeastern sections of Missouri (Figure 3-7). They routinely archive hourly observations of temperature, relative humidity, bare soil temperature at 2 inches, wind speed, wind direction, incoming solar radiation, and precipitation. Data for the ESOP-97 period will be extracted by the Department of Soil and Atmospheric Science at the University of Missouri and forwarded to the JOSS.

Missouri Department of Conservation (DOC) Fire Weather Network (FWN) Data - The Missouri DOC operates a network of eight (they also collect data from three stations operated by the US Forest Service (USFS) and the US Park Service) automated Forest Technology Systems (FTS), Incorporated stations over the southern sections of Missouri (Figure 3-8). They archive hourly observations of temperature, relative humidity, wind speed, wind direction, and precipitation. Data for the ESOP-97 period will be extracted and forwarded to JOSS.

Missouri Air Pollution Control Program Network Meteorological Data - The Missouri Air Pollution Control Program is a section of the Missouri Department of Natural Resources (DNR). They operate a network of air quality and meteorological stations throughout the state. The meteorological data collected includes wind speed, wind direction, temperature, pressure, and solar radiation. Not all stations collect all parameters.

Minnesota DNR FWN Data - The Minnesota DNR operates a network of 17 automated FTS weather stations (Figure 3-9). Twelve of the stations are funded by the Minnesota DNR, two by the US Forest Service (USFS), two by the US Fish and Wildlife Service (USFWS), and one by the National Parks. The observations are hourly and represent an instantaneous value. The observed parameters include temperature, relative humidity, wind speed and direction, and precipitation. These stations (except for Baudette in north central Minnesota) do not have heated rain gages and thus are not operational from middle November to early April. The data for the ESOP-97 period will be extracted by the Minnesota DNR and forwarded to the JOSS.

Minnesota Road Research Project (Mn/ROAD) Data - The Minnesota Road Research Project (Mn/ROAD) project operates in Otsego, MN which is located about 40 miles northwest of Minneapolis. There are two stations operated on the site. First is the Vaisala Automated Weather Station located on the east end of the site. This station provides measurements of air temperature, wind speed, wind direction, relative humidity, precipitation, barometric pressure, and incoming and reflected solar radiation. Also operating at the site is a US Army Corps of Engineers (USACE) Cold Regions Research and Engineering Laboratory (CRREL) weather station. This station is monitored by USACE and provides measurements of air temperature, wind speed, wind direction, relative humidity, precipitation, barometric pressure, snow depth, and incoming solar and long wave radiation. These data are at 15 minute intervals. These data are archived by the Mn/ROAD project and those for the ESOP-97 period will be extracted and forwarded to JOSS.

University of Minnesota (UM) Extension Climatology Network Data - Mark Seeley the UM Extension Climatologist operates a network of 16 stations (Figure 3-10) which collect hourly average values of air temperature, precipitation, wind speed, wind direction, solar radiation, relative humidity, and soil temperature at 10 and 20 cm. It is mostly located in non-forested agricultural regions.

Grand Forks Air Force Base Network Data - A network of 15 automated weather observing stations is operated by an as yet unknown agency (United States Air Force?). These data are processed, stored, and analyzed at the University of North Dakota's (UND) Regional Weather Information Center (RWIC).

University of Wisconsin (UW) Agricultural Weather Observation Network (AWON) Data - The UW Soils Science Department operates a network of 18 stations throughout the state at UW Experiment Stations (Figure 3-11). The stations provide measurements of air temperature, relative humidity, wind speed, wind direction, solar radiation, and soil temperature at 2, 4, 20, and 40 in. Not all stations measure the relative humidity and some also do not measure the soil temperature at all levels. These data are hourly average values. Hourly total precipitation and peak 5 sec and 1 min wind gusts are also recorded. Two stations (Cranmoor and Manitowish Waters) are located over cranberry bogs for low temperature forecast verification. These two sites have a 10 m tower set up with the following measurements: 1.5 m temperature and relative humidity, 2 m pyranometer, 3 m wind speed and direction, and 10 m temperature, relative humidity, and wind speed and direction. They also have a tipping bucket gage for precipitation. These data are archived by the UW Soils Science Department and data for the ESOP-97 will be extracted by JOSS.

Wisconsin DOT Network Data - The Wisconsin DOT, in conjunction with Surface Systems, Inc. (SSI), operates a network of 51 roadside pavement sensors throughout the state (no map available). The parameters observed include temperature, dew point, relative humidity, wind speed, wind direction, and yes/no precipitation. These data are hourly instantaneous values. Four sites have optical weather indicators that provide estimated precipitation rate and accumulation. These sites do not have latitude/longitude information. They are typically about 10-30 feet from roadways and are over mowed grassland.

Wisconsin DNR FWN Data - The Wisconsin DNR operates a network of 20 automated FTS weather observation stations (they also collect data from six others operated by the USFS and the USFWS) located primarily over the northern sections of the state. The observations are hourly and represent an instantaneous value. The observed parameters include temperature, relative humidity, wind speed and direction, and precipitation. These stations do not have heated rain gages and thus are not operational from middle November to early April.

Wisconsin DNR Air Quality Network Data - The Wisconsin DNR operates a network of 29 automated weather observing stations concentrated mostly in the eastern part of the state (Figure 3-12). Only 14 of the stations operate year round. Measurement taken include temperature, dew point, wind speed, wind direction, solar radiation, and barometric pressure. All sites collect wind speed and direction data, only 11 collect temperature, seven collect dew point, five collect solar radiation, and four collect barometric pressure. These data are hourly averages. The data for the ESOP-97 period will be extracted and forwarded to the JOSS.

Illinois DOT Network Data - The Illinois DOT, in conjunction with Surface Systems, Inc. (SSI), operates a network of 31 stations over the state of Illinois. The stations record precipitation, visibility, air temperature, wind speed, wind direction, road temperature, and road surface conditions data at hourly intervals.

Chicago Deicing Project Mesonet Data - In conjunction with the NCAR ground de-icing research being conducted at Chicago's O'Hare International Airport, a network of four stations, all within 12 miles of the Airport, has been established that will be operational during the ESOP-97 period. These stations provide at least hourly measurements of temperature, precipitation rate, relative humidity, wind speed, and total precipitation.

Illinois Climate Network (ICN) Data - The Illinois State Water Survey (ISWS) operates a network of 19 automated weather stations located throughout the state (Figure 3-13). The data are sampled at 10 sec intervals with hourly averages archived. Each station collects measurements of barometric pressure, air temperature, relative humidity, wind speed, wind direction, solar radiation, and soil temperature at 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 cm.

Michigan State University Automated Weather Station Network Data - The Michigan State University Agricultural Weather Office in conjunction with the Michigan Department of Agriculture and the State Climatologist Office operates a network of seven stations located throughout the state (Figure 3-14). These stations provide hourly averages of air temperature, relative humidity, wind speed, wind direction, solar radiation, and soil temperature at 4 in. Also, hourly leaf wetness and total precipitation are measured. The relative humidity, leaf wetness, and total precipitation measurements may not be available or reliable from 1 November to 28 February.

Indiana Department of Environmental Management (IDEM) Air Quality Network Data - The IDEM operates a network of eight air quality monitoring stations near urban areas and also collects data from a total of 46 stations (25 with some meteorological data) operated by 13 industrial organizations (Figure 3-15). The meteorological data collected varies significantly by station. All stations with meteorological data collect wind speed and wind direction. Some stations also collect, in descending order of frequency, temperature, pressure, dew point, solar radiation, and precipitation. Several of the industrial sites have masts set up collecting data at up to three different levels (up to either 60 or 91 m).

Walnut Creek Watershed Meteorological Data - The National Soil Tilth Laboratory (NSTL) conducts a variety of research on the Walnut Creek watershed in central Iowa (see Figure 2-1). NSTL operates two meteorological stations on the watershed (Figure 3-16 stations 701 and 702). One of the stations is on a lawn on a farmstead, the other is in a pasture. Each station measures hourly averages of wind speed, wind direction, air temperature, soil temperature, panel temperature, actual and saturated vapor pressure, total radiation, and rainfall (the pasture station also measures barometric pressure). These data are archived by NSTL.

Great Lakes Meteorological Data - There are three CMAN stations operating on Lake Superior (Figure 3-17) which measure air temperature, dew point, wind speed, wind direction, and station pressure at hourly intervals. There are also three buoys on Lake Superior and two on Lake Michigan which measure air temperature, wind speed, wind direction, wind gust, station pressure, water temperature, wave height, and wave period at hourly intervals. There is also occasional voluntary ship data reported on these lakes which typically include air temperature, wind speed, wind direction, station pressure, cloud cover, water temperature, wave height, and wave period some also report dew point. The US Coast Guard operates nine stations along the shore regions of Lake Michigan and three along Lake Superior which record hourly air temperature, wind speed, wind direction, cloud cover, water temperature, and wave height.

University of Minnesota (UM) Watershed Assessment of Chemical Agriculture Project Data - This project includes the instrumentation of three small watersheds in southeastern Minnesota near St. Charles. Each watershed covers about 7-10 acres and has a flow monitoring device. Most of the flow is spring flow. The watersheds are located at the base of a hill below a corn field, at the base of a hill below an organic field, and the other is in a more forested area also near corn fields. Precipitation is measured at each site except the forested site. There is one weather station on the hill above the organic field that provides hourly measurements of temperature, relative humidity, wind speed, wind direction, solar radiation, and precipitation.

The same group operates another site in south central Minnesota near Easton. At this site there are measurements of soil moisture and snowfall as well as a weather station similar to that at the St. Charles site.

Minnesota Pollution Control Agency (MPCA) Watershed Project Data - The MPCA also operates watershed sites near St. Charles Minnesota. They have flow measurement devices within two 70-80 acre watersheds. Additional measurements have yet to be finalized (although soil moisture is a possibility, a weather station is unlikely) as this project is still in development.

Long-Term Ecological Research (LTER) Site Data - The LTER project was developed by the National Science Foundation (NSF) and consists of 15 sites in the US. Much of the data collected at these sites is unrelated to GCIP (i.e. chemical, flora, fauna, etc), but each site has some data of interest.

NTL LTER Data - The North Temperate Lakes (NTL) LTER is operated by the UW and has two study regions, the Trout Lake Region of north-central Wisconsin and the Madison Lakes region around Madison, Wisconsin. The data being collected at this site includes an automated weather station at Noble F. Lee Municipal Airport, north of Minocqua, WI in the north-central portion of the state. It provides 1-min observations which are archived as hourly and daily averages of air temperature, relative humidity, wind speed, wind direction, total long- and short-wave radiation, photosynthetically active radiation (PAR), soil temperature at 5, 10, and 50 cm depths, and total precipitation.

KBS LTER Data - The W. K. Kellogg Biological Station (KBS) LTER is operated by Michigan State University in southwestern Michigan 50 km to the east of Lake Michigan. There are two automated weather stations located

on the site. The LTER site weather station collects hourly measurements of air temperature, relative humidity, solar radiation, precipitation, PAR, wind speed, and wind direction. It also houses an in-ground weighing lysimeter used to measure evapotranspiration and deep percolation. There is also the Pond Lab automated weather station located 0.3 km north-northwest of the LTER station which collects hourly measurements of air temperature, relative humidity, solar radiation, precipitation, PAR, wind speed, wind direction, and soil temperature

Cedar Creek Natural History Area LTER Data - The Cedar Creek Natural History Area LTER is operated by the University of Minnesota about 50 km north of Minneapolis in Bethel Minnesota. There is one automated weather station at this site and it is a part of the Minnesota Extension Climatology Network.

Konza Prairie Research History Area LTER Data - The Konza Prairie Research History Area LTER is operated by Kansas State University near Manhatten, KS. The data collected at this site includes precipitation at 12 sites, including daily data from four sites and 15-min data from eight sites. Only one of each collects data year round, the others are limited to 1 April to 1 November. Also, an automated meteorological station collects hourly averages of temperature, relative humidity, wind speed, and wind direction as well as hourly total precipitation and solar radiation. Also at the same location as the meteorological station, hourly average soil temperatures are collected at depths of 2, 10, and 25 cm from mid-April to 1 November. Soil moisture is measured at six sites at depths of 25, 50, 75, 100, 125, 150, 175, and 200 cm in deep soils for watersheds burned at one and four year intervals and unburned watersheds. Measurements are via neutron probe and are conducted every two weeks from 1 April to 1 November and monthly from November to March when the temperature is > 20°F and there is no snow cover.

Management Systems Evaluation Areas (MSEA) Project Data - MSEA is a multi-agency program looking at agricultural chemicals and water quality. There are eight MSEA research locations within the LSA-NC (Figure 3-18). Only the original five locations have an automated weather station on site. These stations provide hourly averages of temperature, relative humidity, wind speed, and wind direction. Also hourly precipitation is recorded via a tipping bucket raingage and soil temperatures are recorded down to 1 m. Some of the sites may be collecting soil moisture measurements.

University of Minnesota (UM) Rosemount Experiment Station Data - The UM operates an experiment station in Rosemount, Minnesota. Rosemount is about 30 miles south of Minneapolis. The site is about 3000 acres. The site has a relatively level field with ponding occurring in low areas during snowmelt. The depression has automated Time Domain Reflectometry (TDR) soil moisture measurements. Measurements include incoming and reflected solar radiation, incoming and outgoing longwave radiation, net radiation, wind speed at four heights, air temperature, and humidity, soil temperature and soil moisture profiles measured using thermistors at 10 depths, snow depth, precipitation, and latent and sensible heat fluxes. All data are at 30 minute intervals. Also on-site is one of the UM Extension Climatology weather stations. All data are quality controlled and assured by John Baker's group at UM Department of Soils, Water, and Climate. Data are archived at the UM and are currently being placed in an object oriented database. There are about 7-8 years of data from this site.

Other UM Experiment Station Data -

Waseca - This experiment station is located in south central MN at Waseca. There is a UM Extension Climatology weather station at the site. Also soil moisture is measured at three locations on the landscape, in a depression, at mid-slope, and at the top of the slope. The soil moisture measurements are done weekly and are not automated. This site is included in a proposal that looks to improve the meteorological and soil moisture data that is collected. This site is in the drainage of the Minnesota River Valley.

Lamberton - This experiment station is located in southwest MN at Lamberton. There is a UM Extension Climatology weather station at the site. Also, there has been long term (30 years) of soil moisture data collected at this site from the spring thaw to fall freeze-up. The soil moisture is measured using a neutron probe to depths of 2 m. This site has also been included in the Waseca proposal. This site is in the drainage of the Cottonwood River.

Anoka - There is a cooperative study being conducted over the Anoka sand plain near Anoka MN which is in east central MN north of Minneapolis. Along with an Extension Climatology station there is an automated TDR system present at the site collecting soil moisture data. This and other sites at Becker (in east central MN northwest of Minneapolis) and Crookston (in northwest MN) are small plot sites that are not conducive to micrometeorological and flux measurements.

Morris - This experiment station is located in west central MN at Morris. In addition to the UM Extension Climatology weather station at the site, where are also soil moisture measurements taken.

Wisconsin Tower Flux Measurement Data - Ken Davis of the UM Soil, Water, and Climate Department operates a NOAA and DOE funded 450 m tower in north central WI about 15 km to the east of Park Falls. This site collects eddy correlation fluxes at three levels (30, 122, and 396 m). The measurements taken allow the calculation of hourly fluxes of momentum, heat, water vapor, and carbon dioxide. Standard meteorological measurements as well as soil moisture and soil temperature measurements are also collected nearby. Future plans at the site include the possibility of adding measurements of snow depth, boundary layer profiling, and enhanced radiation and precipitation measurements. The site is located in a heavily forested location with mixed hardwood and conifers.

USGS IRI Site Data - The USGS operates the Interdisciplinary Research Initiative (IRI) site in the upper reach of the Shingobee River watershed in north-central Minnesota. There are two primary lakes in the IRI site, Williams Lake is near the head of the Shingobee River watershed and is 5 km to the south-southeast of Shingobee Lake. The watersheds of both lakes are generally forested. Data collected include climatic data from rafts located on both lakes during the open-water season as well as from a land-based station near Shingobee Lake. The stage of the lakes and discharge of the Shingobee River upstream and downstream from Shingobee Lake are monitored continuously. Water levels in about 70 ground-water wells are measured biweekly to monthly, however at select sites daily water level data are collected. There are also plans for the GCIP, through funds provided by the Department of Interior and NOAA, to provide a soil moisture measurement site within the IRI as part of a north-south transect of soil moisture measurement sites. The transect is planned to run from the IRI site south to Prairie View Texas.

Canadian Surface Observations - Any available Canadian surface observations will be included within the ESOP-97 dataset.

National Weather Service (NWS) Cooperative Observer Daily Observations - Data are routinely collected at approximately 2700 sites operated by cooperative observers over the conterminous United States and are processed and archived by NOAA/NCDC. This network records daily observations of maximum and minimum temperature, precipitation, snowfall, and snow depth at approximately 100 km spacing over the conterminous United States. Daily observations of evaporation are available at approximately 200 km spacing and daily observations of soil temperature are available at about 500 km spacing. Data for the 1875 stations within the LSA-NC (Figure 3-19) will be extracted and forwarded to the JOSS.

NWS Cooperative Observer Precipitation Data - Data are routinely collected at approximately 2700 sites operated by cooperative observers over the conterminous United States and are processed and archived by NOAA/NCDC. For the LSA-NC there are 817 total stations and these data include 15-minute or hourly observations of precipitation from Fisher-Porter and Universal rain gages operated by Cooperative Observers (Figure 3-20). Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

North Central River Forecast Center (NCRFC) Precipitation Data - These data include precipitation observations from various stations. The frequency of the observations varies from 15 min to hourly to stations that collect data with no set schedule. No map yet available. These data will be archived by the NWS Office of Hydrology (OH) in Silver Spring, MD. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

Cook County Precipitation Network Data - This network of 25 precipitation gages is located on an 8 by 8 km grid over Cook County, Illinois (Figure 3-21) and is operated by USACE. These are weighing bucket data

recorded on strip charts. Hourly and daily accumulations are archived by ISWS.

Imperial Valley Water Authority Precipitation Network Data - This network of 25 precipitation gages is located on an 8 by 8 km grid in west-central Illinois (Figure 3-21) and is operated by the Imperial Valley Water Authority. These are weighing bucket data recorded on strip charts. Hourly and daily accumulations are archived by ISWS.

Walnut Creek Watershed Precipitation Observation Data - The NSTL operates a network of 20 rain gages in the Walnut Creek watershed (Figure 3-22). The stations are on an approximate 1 mile by 1 mile grid. All stations measure rainfall rates using tipping buckets which measure rainfall at 5-min intervals and total rainfall per day. Also, the sites labeled 703-722 in Figure 3-22 measure air temperature at 1-min intervals. The data are archived at NSTL, it appears that only the maximum and minimum temperatures and daily rainfall are archived.

North Dakota Atmospheric Resources Board (NDARB) Cooperative Raingage Network Data - This is a network of 900 volunteer observers (Figure 3-23) led by the NDARB. The NDARB is a division of the State Water Commission and its primary function is to protect the rights of the public concerning cloud seeding operations. The network is only operational during the growing season of April through September. The number within the LSA-NC region is unknown. These data are processed, stored, and analyzed at the UND RWIC.

Minnesota Precipitation Network Data - This is a network of over 1500 stations throughout the state that is administered by the State Climatology Office. Most of these operate only during the warm season. The observational frequency is daily.

Davenport Iowa ALERT Network Data - The City of Davenport Iowa in conjunction with the Davenport NWS office is in the process of setting up an ALERT (Automated Local Evaluation in Real Time) system. The network will include two river gages and five rain gages. The system is planned to be operational by early January 1997.

Papio Basin ALERT Network Data - The Papio-Missouri River Natural Resources District operates a network of 17 river gages and two precipitation gages located in the area around Omaha Nebraska. The system is operational only during the warm season from April to September.

Overland Park Kansas ALERT Network Data - The city of Overland Park Kansas operates a network that includes two automated weather stations providing 15-min air temperature, relative humidity, wind direction, wind run, barometric pressure, and precipitation. Also, there are eight streamflow gages and 17 precipitation gages providing 15-min values.

US Army Corps of Engineer (USACE) Precipitation and Streamflow Data - These data include hourly observations of precipitation and daily observation of streamflow from USACE operational gages. The number of stations located within the LSA-NC is not yet known. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

USGS Streamflow Data - These data include daily observations of streamflow from USGS gages. A total of 1843 streamflow stations (Figure 3-24) are located within the LSA-NC and all data are available through the USGS NAWDEX (National Water Data Exchange) Office in Reston, VA as well as the district (state) offices. Provisional (preliminary) data may be received monthly at the JOSS from all districts in the ESOP-97 domain. These preliminary data will be replaced by final quality assured data by the USGS nine months after the completion of the water year which ends on 30 September 1997. Data for the ESOP-97 period will be extracted and forwarded to the JOSS. *NOTE* - The streamflow data generally represent actual observed flows; they generally are not adjusted ("naturalized") to remove effects of diversions or reservoir storage. **CAUTION** - The preliminary streamflow data are subject to reprocessing and substantial revision until they are formalized and published about nine months after the end of the water year (1 October - 30 September). The preliminary data are furnished in the interest of free and timely information exchange, but it must be remembered that they represent work in progress. Substantial revisions may be required because of malfunctions of sensing and recording equipment or because of physical changes in the relation between measured water level (stage) and discharge.

These changes may be caused by accumulation or break-up of debris jams or winter ice, by growth or decay of aquatic vegetation, or by erosion or deposition of sediments in the stream channel. Preliminary streamflow data for periods of severe ice effects may bear little relation to actual flows. Data users are cautioned to consider carefully the provisional nature of the information before using it for decisions that concern personal or public safety or the conduct of business that involves substantial monetary or operational consequences.

NCRFC Winter Graphical Products and Data - During the winter months the NCRFC routinely produces maps of snow depth, snow water equivalent, new snow, and frost depth. These maps are updated at least weekly, but may be updated based on snowfall events. These maps are produced using GRASS software. These will be converted to GIF (Graphical Interchange Format) imagery and made available to JOSS. The underlying data will also be made available to JOSS.

ISWS Soil Moisture Monitoring Network Data - The ISWS operates a network of 18 soil moisture monitoring sites throughout the state (see Figure 3-13). Most of the sites are collocated with ICN sites. The measurements are conducted by a neutron depth probe and neutron surface moisture gage. The observations are collected once per month during each of the ESOP-97 months except March, April, and May 1997 when observations will be twice per month. The sampling depth is 2 m.

DOE ARM/CART Soil Water and Temperature System (SWATS) Data - The DOE ARM/CART program operates a network of eight SWATS sites located at three of the extended facilities in the LSA-NC (Figure 3-25). The Campbell Scientific Heat Dissipation Soil Moisture Sensor is used to provide soil moisture and temperature measurements at eight depths: 5, 15, 25, 35, 60, 85, 125, and 175 cm. Each site will have two profiles located one meter apart. The data are collected and processed by the DOE ARM program and archived at DOE ORNL.

Iowa State University (ISU) Soil Moisture Survey Data - The ISU Extension Service conducts a twice yearly gravimetric survey of soil moisture across the state of Iowa. The measurements are typically conducted around early November and early April coinciding with the beginning and ending of the ESOP-97 period. Measurements are taken from about 50 locations using core samples taken via a 5 foot tube. Measurements are taken at six inch intervals down to five feet. During the remainder of the year they model soil moisture through the use of the Shaw model (Shaw 1983). Both the observed and simulated soil moisture are archived at ISU. Observed data have only been digitized through 1985.

USDA/Natural Resource Conservation Service (NRCS) Soil Moisture Data - Limited soil moisture data is available for the LSA-NC from the United States Department of Agriculture (USDA)/NRCS. Most soil moisture measurements are manually performed and are not routinely scheduled until the spring planting season (i.e. April and May). These data are collected, processed, and archived by the NRCS in Portland, OR. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

USDA/NRCS SM/ST Data - The NRCS operates a Soil Moisture/Soil Temperature Pilot Project (SM/ST) as a preliminary effort to set up a network of soil climate sites throughout the US and consists of 21 sites. Six of these are within the LSA-NC (Figure 3-26). Measurements at each site include soil moisture and soil temperature at six depths (2, 4, 8, 20, 40, and 80 inches). Also, air temperature, relative humidity, wind speed, wind direction, solar radiation, and precipitation are measured at each site. The soil moisture is measured via two types of electrical resistance blocks at each depth. The soil at each site has been sampled and characterized, including soil bulk density and soil water retention curves for each horizon. Measurements are usually recorded every six hours, although other intervals have also been used. Data are archived by NRCS in Portland, OR. The data are uncalibrated, uncorrected, largely unchecked, and used primarily to work on the system. The data are available via the Internet, although logins and passwords are required.

USDA/NRCS WDT Data - The NRCS operates the Wisconsin Dense Till Project (WDT) which consists of 28 sites in northern and central Wisconsin (Figure 3-27; each mark represents a county where several sites are located). Soil moisture sensors (Fiberglass electrical resistance blocks) are at 12 depths (10, 25, 40, 50, 70, 85, 100, 120, 140, 160, 180, and 200 cm) at each site. Soil temperature is measured at three depths (25, 50, and 200 cm) at all sites except those in Taylor and Clark Counties which measures it at each of the 12 depths. The Forest, Vilas, and Lincoln County sites are in mixed forest vegetation. The Barron County sites includes both forested

and cultivated conditions. Some of the locations in Clark and Taylor Counties are cultivated. Some of the non-forested locations include both fields and adjacent non-cultivated field edges for comparison. Measurements are made bi- weekly during the summer and monthly during the winter. Dataloggers were installed at the Clark, Taylor, and Forest County locations allowing hourly readings to be made. Data are archived at the NRCS National Soil Survey Center (NSSC) in Lincoln, Nebraska.

Wisconsin and Illinois Gravediggers Network - As a part of their wintertime duties, the Wisconsin and Illinois gravediggers report frost depth. Further information is being dug up.

Walnut Creek Watershed Surface and Ground Water Data - The USGS operates a network of five water quality monitoring and stream gaging stations in the Walnut Creek watershed (Figure 3-28). The network design allows for isolated study of surface water flow from three subwatersheds (13-20 km^2) and the entire watershed (approximately 47 km^2). Stage measurements are recorded every 5-min as are automatic stream temperature measurements.

The NSTL operates a network of three surface water runoff and water quality monitoring stations in the Walnut Creek watershed (Figure 3-29). Stage values are measured every min with 5-min averages recorded. Runoff samples are collected automatically during major runoff events.

The NSTL operates a network of two field and three county drainage district tiles in the Walnut Creek watershed (Figure 3-30). At each site the flow is monitored continuously. There is no surface water component to the flow in the field tiles due to the lack of surface inlets. The three county drainage tiles correspond to the terminal end of three subbasins.

The USGS monitors 38 groundwater well nests with 106 total wells (Figure 3-31). The wells are used to monitor groundwater elevations and water quality and to determine aquifer hydraulic characteristics. Well sites were selected topographically downgradient and upgradient from fields with specific crop and soil management systems. Groundwater elevations in upgradient and downgradient wells are used to determine groundwater flow gradient and direction. Wells installed in the watershed are nested, with each nest consisting of two or more wells. Wells in each nest were installed at different depths in close proximity. Water levels are measured by NSTL twice per month for the wells on the Walnut Creek watershed.

USGS Reservoir Data - These data include daily observations of reservoir contents or water level for 523 reservoirs within the LSA-NC (Figure 3-32). All data are available through the USGS NAWDEX Office in Reston, VA as well as the USGS and USACE district offices. Data for ESOP-97 period will be extracted and forwarded to the JOSS.

ISWS Shallow and Deep Ground-Water Observation Wells - The ISWS collects observations from 17 shallow (Figure 3-33) and approximately 170 deep (Figure 3-34) ground-water observation wells over the state.

SURFRAD Data - The NOAA Air Resources Laboratory (ARL) operates the Surface Radiation Budget Network (SURFRAD) which has four locations over the US. Within the LSA-NC there is one station at Bondville in east central Illinois. Bondville is in a flat agricultural region and is collocated with several ISWS instruments (i.e. ICN and soil moisture). Measurements include direct solar radiation via a normal incidence pyrheliometer, downwelling global solar radiation via an upward-viewing broadband pyranometer, solar radiation reflected from the surface via a downward-viewing broadband pyranometer, thermal IR emitted downward via an upward-viewing pyrgeometer, upwelling thermal radiation from the surface via a downward-viewing pyrgeometer, ultraviolet radiation at the surface via a UVB radiometer, and global and diffuse solar radiation in one broadband channel and six narrow bands of the solar spectrum via a Multi-Filter Rotating Shadowband Radiometer (MFRSR). Also on site are instruments to measure wind speed, wind direction, air temperature, relative humidity, and station pressure at the top of a 10 m tower.

DOE ARM/CART Radiation Data - The DOE ARM Program has a variety of radiation instrumentation located at the Southern Great Plains CART site in Kansas and Oklahoma. Within the LSA-NC there is only the Solar and Infrared Radiation Observing System (SIROS) which provides measurements of up and down-welling

hemispherical solar irradiances, direct- beam solar irradiance, diffuse hemispherical solar irradiance from the sky and up- and down- welling hemispherical infrared irradiances via its collection of instruments including the MFRSR, pyranometer, pyrheliometer, and pyrgeometer at 10 of the ARM extended facilities, including the central facility (see Figure 3-5). The data are collected and processed by the DOE ARM Program and archived at DOE ORNL. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

DOE ARM/CART EBBR and ECOR Data - The DOE ARM/CART program operates a network of Eddy Correlation (ECOR) systems that provide measurements of the surface momentum and latent and sensible heat fluxes. ECOR systems are planned to be operational at five of the ARM extended facilities in the LSA-NC (see Figure 3-24) located over wheat and other crops. The ARM/CART program also operates a network of Energy Balance Bowen Ratio (EBBR) systems that provide measurements of sensible and latent heat fluxes. EBBR systems are planned to be operational at four of the extended facilities (all are located at the extended facilities which do not have the ECOR system) located over pasture and rangeland. Ten of the EBBR stations are also equipped to provide soil moisture and temperature profiles in the 3 to 5 cm range at five points around each station. The EBBR soil moisture profiles provide information for correcting the thermal conductivity of the soil so the soil heat fluxes can be determined. The accuracy of these measurements may not be sufficient for some model evaluation purposes. The data are collected and processed by the DOE ARM Program and archived at DOE ORNL.

Walnut Creek Watershed Energy Balance and Evapotranspiration Monitoring Network Data - The NSTL has the capability to operate a network of 20 Bowen ratio energy balance stations in the Walnut Creek watershed. From the time of planting to harvest (i.e. summer) these provide estimates of latent and sensible heat fluxes via direct measurements of the net radiation; temperature, vapor pressure, and wind speed at two levels; and soil heat flux. These fluxes are used to compute the evapotranspiration of the field crops. The sampling frequency is 60 sec with average/total values every 30 min. During the time from harvest to planting (i.e. winter) the stations provide net radiation, soil heat flux, and soil temperature similar to the summer mode. The temperature, relative humidity, and wind speed are collected from only a single height. Data are still sampled every 60 sec for 30 min averages/totals. These stations are set up to examine specific research questions, thus the potential exists for the movement of these systems. For example, in 1995 measurements were spread across eight fields while in 1996 they were mostly focused in one field. The focus over the next 3-4 years will be southwest of site 223 (see Figure 3-28) and thus some of the systems may be moved there.

The NSTL also operates two eddy correlation stations collocated with two of the Bowen ratio stations. Each site includes a sonic anemometer, thermocouple, and krypton hygrometer to directly measure the sensible and latent heat flux. Due to the sensitivity of the sonic anemometer to water, measurements are only made during periods in which there is no possibility of precipitation. Data are 30 min averages and are archived by NSTL.

USGS SAST Data - The USGS developed the Scientific Assessment and Strategy Team (SAST) to develop an environmental information system for the Upper Mississippi and Lower Missouri River basins in response to the 1993 floods in these basins. Datasets available include boundary data (i.e. state, county, USGS quadrangle, USGS hydrologic unit, etc), infrastructure data (i.e. roads, bridges, etc), hydrography data (i.e. lakes, rivers, reservoirs, etc), ecological data [i.e. land use, land cover, STATSGO (State Soil Geographic Database), forestry data, etc], hydrology and flood data (i.e. flood probability, levees, streamflow, etc), and raster data [i.e. Digital Elevation Model (DEM), Advanced Very High Resolution Radiometer (AVHRR), Landsat, SPOT, and ERS-1 flood images; not available on-line]. All data are in ARC/INFO Export format and/or Spatial Data Transfer Standard (SDTS) format. Sample GIF (Graphical Interchange Format) imagery is also available for some datasets. All data are available on-line via:

http://edcwww2.cr.usgs.gov/sast-home.html

National Ice Center (NIC) Great Lakes Ice Data - The National Ice Center is a cooperative operational center including the US Navy, NOAA, and the US Coast Guard. Every Monday, Wednesday, and Friday during the Great Lakes ice season NIC produces Great Lakes ice analysis maps using information from a variety of sources including reconnaissance, ship reports, shore reports, visible and infrared satellite imagery, and radar. The sources used vary from analysis to analysis. The maps use WMO sea ice symbology ("Egg Code") and include

information on total concentration, partial concentration (from the thickest to the thinnest ice), stage of development (from thickest to thinnest), and forms of ice indicating the floe size corresponding to the stages. These maps are archived by NIC and are available in GIF format. Data for the ESOP-97 period will be extracted by JOSS.

ESOP-97 Hourly Surface Composite - This composite will contain surface and sea level pressure, temperature, dew point, wind speed and direction, and precipitation hourly observations from surface observing sites in the LSA-NC as well as visibility, present weather, ceiling and cloud type heights and amounts for those stations that report them (generally SAO and ASOS). This composite will not contain the precipitation data from those sites that collect only precipitation data (i.e. the site must also collect meteorological observations to be included). The precipitation only sites will be contained within the precipitation composites which are described below. The composite will be produced by the JOSS and contain hourly data from the following networks: ASOS, AWOS, SAO's, HPCN, CAWS, NPN surface observations, and others (see Figure 4-1). These data will be quality controlled by JOSS (see section 4.1.1).

ESOP-97 Hourly Precipitation Composite - The hourly precipitation composite will contain precipitation data from all real-time and recording gages in the LSA-NC. The composite will be produced by the JOSS and contain hourly totals from gages in the following networks: ASOS, AWOS, SAO's, HPCN, CAWS, NWS Cooperative Observer, and others. These data will be quality controlled by JOSS (see section 4.1.2).

ESOP-97 Daily Precipitation Composite - The daily precipitation composite will contain precipitation data from all real-time and recording gages in the LSA-NC. The composite will be produced by the JOSS and contain daily totals from gages in the following networks: ASOS, AWOS, SAO's, HPCN, CAWS, NWS Cooperative Observer, USGS, USACE, and others These data will be quality controlled by JOSS (see section 4.1.2).

3.1.2 Upper Air Data

NWS Upper Air Rawinsonde Data (6-sec vertical levels) - These data will contain 12-hourly (occasionally more frequent at the request of the NWS) vertical profiles of time, pressure, temperature, altitude, relative humidity, wind speed and direction, complete with quality flags, at 6-sec intervals from the surface to the top of each sounding, usually about 25 mb. These high resolution data will be obtained from nine NWS sites in the LSA-NC (Figure 3-35). All data will be processed by the JOSS.

NWS Upper Air Rawinsonde Data (mandatory/significant levels) - These data include 12- hourly vertical profiles of pressure, altitude, temperature, dew point, and wind speed and direction at all mandatory and significant levels. Data are routinely collected at 72 sites (approximately 400 km spacing) over all of the conterminous United States and archived at NOAA/NCDC. Data for the LSA-NC (see Figure 3-35) will be archived and available at NCDC.

DOE ARM/CART Site Upper Air Data - The DOE ARM Program routinely obtains upper air observations, at 2-sec vertical resolution, at the Southern Great Plains CART site in Kansas and Oklahoma. These measurements include up to 3-hourly soundings of pressure, temperature, humidity, and wind at the one boundary facilities in the LSA-NC (see Figure 3-5). The data are collected and processed by the DOE ARM Program and archived at the DOE/ORNL. Data for the ESOP-97 period will be extracted and forwarded to the JOSS.

Canadian Upper Air Rawinsonde Data (10-sec vertical levels) - These data will contain 12- hourly vertical profiles of time, pressure, temperature, altitude, relative humidity, wind speed and direction, complete with quality flags, at 10-sec intervals. If available, these high resolution data will be obtained from one station within the LSA-NC and possibly three others near the LSA-NC (see Figure 3-35).

Canadian Upper Air Rawinsonde Data (mandatory/significant levels) - These data include 12- hourly vertical profiles of pressure, altitude, temperature, dew point, and wind speed and direction at all mandatory and significant levels. Data are routinely collected at sites throughout Canada and archived at NOAA/NCDC. Data for the LSA-NC (see Figure 3-35) will be archived and available at NCDC.

NOAA Profiler Network (NPN) Data - The NPN routinely collects vertical profiles of hourly component winds (u, v, and w) and six-minute radar return spectral moments, both with 250 meter resolution. These data are available from 10 405 MHz profiler sites within the LSA- NC (see Figure 3-6). No sites within the LSA-NC have collocated Radio Acoustic Sounding Systems (RASS). The data are routinely collected and processed by NOAA/FSL and archived at NOAA/NCDC. Data for the LSA-NC period will be extracted and forwarded to the JOSS.

Boundary Layer Prolifer Data - The University of Nebraska-Lincoln operates a boundary layer profiler near Lincoln, Nebraska. This is a Ultra-High Frequency (UHF) Doppler radar. The minimum range is about 100 m above ground level. The range resolutions are selectable from 60m to 400 m. Depending on the configuration they are capable of measuring the wind up to about 3 km. The frequency of observation is unknown, but can vary from 10 min to hourly. NOAA/FSL acquires the data from this profiler and processes it into hourly, quality controlled products, and archives the data.

3.1.3 Radar Data

WSR-88D Data - There are 24 WSR-88D radars within the LSA-NC (Figure 3-36). Data from the WSR-88D network are divided into a number of archive levels depending upon the level of processing performed. Archive I is the raw engineering data; Archive II contains reflectivity and radial velocity information at the highest resolution and over each full volume scan of the radar; and Archive III contains operational products as graphics meta files from commissioned radars. Archive II provides the basis for all high level products while Archive III includes a variety of products including base level reflectivity and velocity data at 1 km by 1o resolution and hourly precipitation at 4 km by 4 km. Since Archive III data are stored as graphics meta files, they are extremely difficult to work with digitally and are best used as hardcopy browse products. Included in the Archive III are some digital products, in particular the Digital Precipitation Array of hourly data on a 4 km by 4 km grid and the Supplemental Precipitation Product giving information on the performance of the precipitation algorithms and coarser resolution precipitation data. Archive II and III data are routinely archived and available at the NOAA/NCDC.

WSR-88D NIDS Data - The NEXRAD (now WSR-88D) Information Dissemination Service (NIDS) will be provided to JOSS from Weather Services International (WSI) through the Cooperative program for Operational Meteorology, Education, and Training (COMET). NIDS products consist of selected information from the Level III database from each WSR-88D site (Table 3-2). Data for selected radars during the ESOP-97 period (Figure 3-36) will be extracted and forwarded to JOSS for archival.

WSI Reflectivity Composite Imagery - The WSI routinely produces and distributes a mosaic of reflectivity from all NWS radars in the conterminous United States. The product, called NOWRAD, is available at a variety of resolutions and coverages in real time. For ESOP-97, 2 km data will be recorded at 15 minute intervals in a fixed sector overlaying the LSA-NC. From this dataset a representative daily image will be selected at 12 UTC, or the closest available time, to coincide with the NOAA/National Centers for Environmental Prediction (NCEP) Eta model daily weather map imagery and the GOES-8 infrared image. The selected daily images will be translated to GIF. These will be available online for browsing purposes. The full 15-min dataset in its original format will be available directly from JOSS. These images will be obtained by the JOSS from the NIDS data stream (U.S. contiguous composite).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

NCRFC Stage III WSR-88D Data - The NCRFC routinely produces an hourly composite derived precipitation product from all the WSR-88D radars covering the Upper Mississippi River region. These data are on a 4 km by 4 km grid and are in GRIB (GRId point values expressed in Binary format). These data are archived by NOAA/Office of Hydrology (OH) together with the Digital Precipitation Array and the Supplemental Precipitation Product (Stage I) and the Stage II hourly Precipitation Processing System products. Data for ESOP-97 period will be extracted and forwarded to JOSS. The JOSS will provide daily 24-hr total precipitation estimate GIF imagery for online browse purposes. Measurement of solid precipitation is difficult with radar. Algorithms to improve this product are currently under development. The NEXRAD Precipitation Processing System Stage III data which encompasses snow will be flagged and should be used with caution as to the quantitative precipitation values provided.

3.1.4 Land Characterization Data

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

Walnut Creek Watershed Soil Characterization Data - The NSTL has selected 14 locations within the no-till field for soil characterization studies (no map yet available). Soil cores were taken in fall 1993 at each site for detailed soil descriptions. Soil morphologic characteristics such as horizonization, color, structure, drainage class, and other features were determined by an NSTL scientist for each core and recorded on data sheets. Soil parameter size analysis will be determined for each major horizon in each core collected at each site. Soil cores are used to determine soil hydraulic properties and bulk density. Saturated hydraulic conductivity was also determined.

3.2 SATELLITE DATA

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

GOES-8/9 Satellite Imagery and Derived Products - Most of the satellite data for ESOP-97 will be obtained from the two geosynchronous Geostationary Operational Environmental Satellites (GOES-8/9) positioned near 75°W and 135°W longitude. These two new satellites provide increased imaging and sounding capabilities over their predecessors with separate imagers and sounders, increased spatial resolution, and better radiometric performance. The Imager is a five channel scanner having one visible (VIS) and four infrared (IR) channels (3.9, 6.7, 10.8, and 12.0 micrometers). The VIS channel senses reflected radiation from the surface and cloud features at about 1 km resolution while the IR channels sense upwelling energy from the surface, clouds, and atmospheric water vapor at 4 km resolution (8 km for the 6.7 micrometer channel). The duty cycle of the instrument is such that data is available over the continental US every seven minutes throughout the day. More rapid data collection has been tested but may not be available during the ESOP-97. The GOES-8/9 Sounder provides increased capabilities over the previous GOES 7/VIS and IR Spin-Scan Radiometer (VISSR) Atmospheric Sounder (VAS) by adding more channels and greater spatial resolution. The Sounder is a 19 channel scanner with channels similar to the High Resolution Infrared Radiation Sounder (HIRS) instrument on the NOAA polar orbiting satellites. In addition to a single VIS channel, the Sounder has 18 channels which span the carbon dioxide and water vapor absorption regions from 3.7 to 14.7 micrometers. This is an increase of three temperature and two water vapor channels over that of VAS. Operational scan scenarios provide continental US coverage every hour in all sounding channels and 15 minute sounding data may be available in severe weather situations. Details of the new GOES-8/9 satellites can be found in Menzel and Purdom (1994). These data are routinely archived by NOAA/National Environmental Satellite, Data and Information Service (NESDIS)/NCDC at the University of Wisconsin's Space Science Engineering Center (SSEC). For the ESOP-97 period, JOSS will collect VIS (4 km) and IR (8 km) imagery over the conterminous US and 1 km resolution sector imagery over the LSA-NC domain.

A large number of derived products from the GOES-8/9 Imager and Sounder are produced by NOAA as part of their operational support for the NWS and the NCEP. The product list is more encompassing than that from GOES VAS because of the increased capabilities and performance of the sensors. Sounding products include temperature and moisture profiles, mean layer temperature and precipitable water values, lifted indices, and thermal wind profiles. Additionally, geopotential height fields and a cloud depiction product to supplement the ASOS system are derived from the Sounder (Menzel and Purdom 1994; and Hayden and Schmidt 1991). Imagery products consist of cloud and water vapor drift winds, stability products, total precipitable water, and heavy precipitation estimates. The Imager data is also used by a number of research groups to derive additional

products such as areas of aircraft icing, fog and stratus detection, land surface and sea surface temperatures, and other experimental parameters (Menzel and Purdom 1994; and Hayden et al. 1996).

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

NOAA POES TOVS Data - Two NOAA series polar orbiting satellites (NOAA-12 and NOAA-14) carry the microwave Television and Infrared Observation Satellite (TIROS) Operational Vertical Sounder (TOVS). The TOVS system consists of four separate sensors: (1) High Resolution Infrared Radiation Sounder (HIRS/2), which measures incident radiation primarily in the infrared; (2) Microwave Sounding Unit (MSU), a passive scanning microwave spectrometer with 4 channels (5.5 micrometer region); (3) Stratospheric Sounding Unit (SSU), a step-scanned far-infrared spectrometer with three channels (15 micrometer region); and (4) Solar Backscattered Ultraviolet system (SBUV/2), which maps total ozone concentrations and vertical ozone distributions. Data are collected (1600 km swath) during subsequent sun-synchronous morning/evening ascending and descending passes (up to 4 passes daily). TOVS data are routinely collected, processed, and archived at NOAA/NESDIS/NCDC.

DMSP SSM/I Data/Imagery - The United States Air Force (USAF) operates the Defense Meteorological Satellite Program (DMSP) which is a system of near polar orbiting satellites (F10 and F13) that provide global microwave data from the Special Sensor Microwave Imager (SSM/I). The SSM/I sensor provides water vapor measurements (1400 km swath) at four frequencies (19.35, 22.235, 37.0, and 85.5 GHz). DMSP data are routinely archived at the National Snow and Ice Data Center (NSIDC) at Boulder, CO.

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

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

Extraction of cloud height and amount is accomplished by means of the "CO2 slicing" technique which calculates the cloud information from radiative transfer equations. The technique uses multi-spectral IR data in the CO2 and longwave window channels, as well as ancillary surface and numerical forecast temperature and moisture profiles. Solution of the radiative transfer equations results in the determination of cloud top pressure and effective cloud amount. Application of empirical decision trees results in a composite cloud height and

amount for a 40 by 40 km area centered on a particular ASOS station. These data are being produced at NOAA/NESDIS routinely in real-time. They can be accessed via the Satellite Data Source Module (SDSM) home page (see Section 5.1.2). These data are also available in McIDAS area format, please contact the SDSM for data access.

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

Satellite Radiation Datasets - These products use five channels of GOES-8 data, Eta model forecasts, and USAF snow cover analyses to create gridded half degree resolution products in the domain from 25°N to 50°N and 65°W to 125°W. These images are available hourly in GIF and binary formats and are online via the GCIP SDSM home page. The products will continue to be reviewed and validated during the ESOP-97 period. A list of the available products is in Table 3-3.

EDC Bi-Weekly Vegetation Index - Satellite-derived values of vegetation index are routinely produced at NOAA/NESDIS and the Earth Resources Observation Systems (EROS) Data Center (EDC) at Sioux Falls, SD. One set of data at 1 km resolution is available bi-weekly from the EDC while another set at 15 km resolution is available weekly from the NOAA/NESDIS in Washington, D.C. The land cover imagery will be produced bi-weekly from 1 km resolution AVHRR and translated to GIF by the USGS EDC. The full land characteristics database will be available on CD-ROM from EDC. GIF imagery data for ESOP-97 will be extracted and forwarded to the JOSS from the EDC.

TABLE 3-3 Satellite Radiation Datasets

Mean radiance (channel 1)
Mean radiance (channel 2)
Mean radiance (channel 3)
Mean radiance (channel 4)
Mean radiance (channel 5)
Clear sky composite radiance
Number of clear pixels
Number of cloudy pixels
Snowcover
Standard deviation of channel 1
Standard deviation of channel 4
Precipitable water
Temperature at first level above surface
Surface pressure
Surface downward flux (clear + cloudy)
Surface upward flux (clear + cloudy)
Top of atmosphere downward flux (clear + cloudy)
Top of atmosphere upward flux (clear)
Surface downward flux (clear)
Surface downward flux (cloudy)

NOAA Airborne Gamma Snow Surveys - The NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) operates the Airborne Gamma Snow Survey Program. Radiation detection systems on-board low-flying aircraft are used to measure the gamma radiation emitted from trace elements of potassium, uranium, and thorium radioisotopes in the upper 20 cm of the soil. The water mass in the snow attenuates the terrestrial radiation signal. Thus, the difference between the radiation measurements over bare ground and snow- covered

ground is used to derive a mean areal snow water equivalent (SWE). Soil moisture surveys are often conducted in the late fall so that an accurate soil moisture value is available to derive the SWE during the winter. The typical survey operations are conducted from January through April using two aircraft simultaneously. Each flight line is typically 16 km long and 300 m wide, or an area of approximately 5 km2. As such, each SWE measurement is a mean areal measure integrated over the 5 km2 area of the flight line. These SWE and upper 20 cm soil moisture data are available in GIF, GRASS, ARC/INFO, and ASCII text formats with a resolution of 30 arc seconds and at a variable frequency. Also available are the SWE and soil moisture line and sub-line data for research use. There may be special observations made during ESOP-97, but this has yet to be defined.

NOHRSC Satellite-Derived Snow Cover Extent Data - The NOAA/NOHRSC routinely produces areal extent of snow cover data derived from the GOES and AVHRR imagery. These data have a resolution of 30 arc seconds and are available daily. They are available in GIF, GRASS, and ARC/INFO formats. Also, NOHRSC produces SSM/I-derived snow cover imagery. They use five SSM/I channels, which measure emitted radiation at 19, 22, 37, and 85 Ghz. The 19 Ghz data are horizontally and vertically polarized (accounting for two channels used at this frequency) while the remaining channels are vertically polarized. The higher frequency channels undergo more scattering which lowers the temperature sensed by the satellite instrument. The scattering increases as a function of the snow depth. The algorithm takes advantage of the differential scattering of surface microwave radiation by the snow pack and isolates snow from other scattering surfaces such as deserts, precipitation, and frozen ground. NOHRSC uses the SSM/I snow cover algorithm to detect the areal extent of snow in the presence of non- precipitating clouds when the GOES and AVHRR are rendered unusable by cloud cover. This technique has proven to be quite useful during the winter snow season when various parts of North America can be covered by clouds for extended periods of time.

3.3 MODEL OUTPUT

3.3.1 Atmospheric model output

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

The emphasis for model output during ESOP-97 is on the regional mesoscale models with output from the following three models:

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

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

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

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

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

NOAA/FSL MAPS Model Output - The NOAA/FSL will run the MAPS model every 3 hours with up to 6 hour forecasts during the ESOP-97. Characteristics of the model are provided in Table 3-4. The data cutoff for model runs is approximately 1 hour, and the output format is GRIB. These data will be archived by NCAR/SCD.

TABLE 3-4 Regional Model Characteristics

Model	Analysis Cycles	Forecast Cycles	Forecast Length (h)	Resolution (km)	Vertical Levels	MOLTS in LSA-NC	MOLTS parameters Upper Air/Surface
Eta	3 hrly	6 hrly	48	40	38	59	12/40
RFE	6 hrly	12 hrly	24	35	28	61	27/28
MAPS	3 hrly	3 hrly	6	40	40	59	16/30

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

TABLE 3-5 Fundamental Output Variables for the MOLTS

1) Identifiers

Location identifier
Valid date/time
Latitude/Longitude/Elevation

2) Surface Parameters

Mean sea level pressure
Surface pressure
Skin temperature
Total precipitation in last hour
Convective precipitation in last hour
Latent heat flux
Sensible heat flux
Snow phase-change heat flux

Short-wave radiation flux downward and upward
Long-wave radiation flux downward and upward
Net long-wave radiative flux at top of atmosphere
Net short-wave radiative flux at top of atmosphere
Soil temperature
Soil moisture
Snow water equivalent
Snow melt
Surface runoff
Baseflow-groundwater runoff
U-wind and V-wind components at 10 m
Temperature at 2 m
Specific humidity at 2 m

3) Atmospheric Variables at Each Model Vertical Level

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

The NOAA/NCEP Eta model MOLTS output will be available from 299 locations over North America. Within the LSA-NC there will be 59 locations (Figure 3-37). These output will contain 40 surface state and flux parameters and 12 parameters at each of the 38 vertical levels. Output will be provided from the 00 and 12 UTC runs from the initial analysis time out to 48 hours.

The AES/CMC RFE model MOLTS output will be available from 217 locations over North America. Within the LSA-NC there will be 61 locations (Figure 3-37). These output will contain 28 surface parameters and 27 parameters at each of the 28 vertical levels. Output will be provided from the 00 and 12 UTC runs from the initial analysis time out to 36 hours.

The NOAA/FSL MAPS model MOLTS output will be available from 270 locations over North America. Within the LSA-NC there will be the same 59 locations as the NOAA/NCEP Eta model (Figure 3-37). These output will contain 30 surface parameters and 16 parameters at each of the 40 vertical levels. Output will be provided from each 3-hourly MAPS run from the initial analysis time out to 6 hours.

MOLTS Derived Sounding Output - JOSS will extract from the MOLTS output from the locations within the LSA-NC for each of the three models described above (see Figure 3-37). These output will then be processed and converted to a format similar to that used for the actual atmospheric sounding data (i.e. NWS). This will be done by stripping out the state parameters at the surface and each model level. Only the 00 hour initial analysis time will be processed. Output will be available from each model analysis time. This output is provided to allow intercomparison studies. These output will be archived at JOSS.

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

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

The specific model output variables in each of the four components are listed in Table 3-6. The output from the three models may not include all of the variables listed in Table 3-6, and this fact will be a part of the metadata provided with the specific model output. The output from each of the three models will be provided on a standard AWIPS (Advanced Weather Interactive Processing System) 212 grid (Figure 3-38) in GRIB format.

TABLE 3-6 MORDS Output Variables

Near-Surface Fields

Mean sea level pressure
Surface pressure at 2 m
Temperature at 2 m
Specific humidity at 2 m
U component of the wind at 10 m
V component of the wind at 10 m
Surface latent heat flux (time average)
Surface sensible heat flux (time average)
Ground heat flux (time average)
Snow phase change heat flux (time average)
Surface momentum flux (time average)
Vertically integrated moisture convergence (time average)
Vertically integrated energy convergence (time average)
Total precipitation (time accumulated)
Convective precipitation (time accumulated)
Surface runoff (time accumulated)
Subsurface runoff (time accumulated)
Snow melt (time accumulated)
Snow depth (water equivalent)
Total soil moisture (within total active soil column)
Canopy water content (if part of surface physics)
Surface skin temperature
Soil temperature in top soil layer

Surface downward shortwave radiation (time average)
Surface upward shortwave radiation (time average)
Surface downward longwave radiation (time average)
Surface upward longwave radiation (time average)
Total cloud fraction (time average)
Total column water vapor
Convective Available Potential Energy

Lowest-Level Atmospheric Fields

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

Upper Atmospheric Fields

1000 hPa height
700 hPa vertical motion
850 hPa height
850 hPa temperature
850 hPa specific humidity
850 hPa U component of the wind
850 hPa V component of the wind
500 hPa height
500 hPa absolute vorticity
250 hPa height
250 hPa U component of the wind
250 hPa V component of the wind
Tropopause height (or pressure)
Top-of-the-atmosphere net longwave radiation (time average)
Top-of-the-atmosphere net shortwave radiation (time average)

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

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

3.3.2 Hydrologic model output

The NOAA/OH will provide operational model output from the National Weather Service River Forecast System (NWSRFS) from the River Forecast Centers (RFC) in the Mississippi River basin. The NWSRFS is a system which integrates a variety of hydrologic models into a comprehensive river forecast system. It includes models

of runoff-generating processes, including the accumulation and ablation of snow, and runoff and streamflow routing. For ESOP-97, model output from the NCRFC will be archived and provided by NOAA/OH on a file server linked to the DMSS Model Output Source Module. Table 3-7 lists the RFC model outputs proposed by NOAA/OH.

The snow accumulation and ablation model is a conceptual model in which each of the significant physical processes affecting snow accumulation and snowmelt is mathematically represented. Air temperature is used as an index for computing snowmelt as it is readily available from climatological and operational hydrometeorological networks and has been shown to be the best single index of snow cover energy exchange across the snow- air interface. The model calculates the mean areal snow water equivalent and routes the melt through the snow pack to provide the snow cover outflow to be added to rain on bare ground. The areal extent of snow cover is computed and is further used in runoff calculations. Full details of the model are given in Anderson (1973).

TABLE 3-7 RFC Hydrologic Six-Hourly Model Outputs Proposed by NOAA/OH for GCIP

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1. Mean Areal Precipitation
2. Mean Areal Air Temperature
3. Mean Areal Snow Water Equivalent**1**
4. Percent Areal Extent of Snow Cover
5. Heat Deficit in the Snow Pack
6. Mean Areal Rain Plus Melt from Snowmelt Model
7. Mean Areal Potential Evaporation**2**
8. Upper Zone Tension Water Storage
9. Upper Zone Free Water Storage (UZFW)
10. Lower Zone Tension Water Storage
11. Lower Zone Primary Free Water Storage
12. Lower Zone Secondary Free Water Storage
13. Additional Impervious Area (fraction of basin area)
14. Impervious runoff from permanent impervious areas and direct runoff from temporary impervious areas
15. Surface runoff when UZFW is full and precipitation intensity exceeds the rate of percolation and interflow
16. Interflow resulting from the lateral drainage of the UZFW
17. Supplementary Baseflow
18. Primary Baseflow
19. Subsurface Outflow
20. Total Runoff
21. Streamflow from SMA at outlet
22. Routed Streamflow from Areas Above SMA
23. Forecast Streamflow After Blending with Observed Streamflow
24. Computed SMA Daily Evaporation for Model Water Balance**3**

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

NOTE: Items 7-20 are available for basins which have been calibrated for the Sacramento Model which is being progressively applied to the 725 SMAs in the NCRFC area. The 43 SMAs of the Des Moines River above St. Francisville, IA have been calibrated and the Sacramento Model is running on the 23 SMAs on the Minnesota River above Jordan. Elsewhere the API (Antecedent Precipitation Index) Model is in use from which the

parameters of API, week of year, storm precipitation, surface runoff, baseflow, and total runoff are available to compute items 21-24.

The principal soil moisture accounting (SMA) model used within NWSRFS is a conceptual model that provides a complete accounting of the exchange of water at the soil surface by accounting for initial abstractions, evapotranspiration and infiltration, as well as the movement of water over and through the soil and into groundwater storage. The Sacramento model separately models tension water, or water that can only be removed by evaporation or evapotranspiration, and free water which drains from the soil. Upper and Lower Zone Storages are used to model direct and impervious runoff, surface runoff and interflow, and baseflow and subsurface outflow respectively. The movement of water between the two Upper Zone and three Lower Zone Storages represents infiltration at the surface and percolation in the soil. Full details of the model are given in Burnash et al. (1973).

Runoff volume from the runoff generating model is converted to instantaneous discharge at a gage or SMA outflow point using a unit hydrograph. This is a simple but effective method of distributing runoff. It is a linear and time invariant system which takes into account channel storage effects above a flow point and the travel time or areal distribution of runoff.

The movement of water along a channel, e.g. from inflow from a SMA upstream through a SMA and/or reservoir or lake, is modelled using a variety of channel system models. These take account of the reduction and attenuation of the hydrograph between upstream and downstream flow points. The Lag and Route, Muskingum, and Layered Muskingum or Layered Coefficient Routing models are the most frequently used.

The NWSRFS model output to be provided include values every six hours of all of the available elements of the daily water budget: precipitation (including snow and snowmelt), runoff (direct, surface runoff, interflow, and baseflow), evaporation and soil moisture storage for individual SMA areas (the NCRFC covers an area of about 843,320 km2 and consists of 725 SMA areas), streamflow from the SMA at the outlet, routed streamflow from areas above the SMA, and forecast and observed streamflow. (Note that not all areas in the Mississippi River basin have been calibrated to this model and the level of calibration varies considerably. During GCIP there will be a major effort to calibrate and operate the model in the upper and middle areas of the Mississippi River basin. The evaporation component of the water balance is not comprehensively modeled. However, the soil moisture estimates and the other soil wetness indices, e.g. various modified antecedent precipitation indices, should prove useful in studying the spatial and temporal variability of these values in comparison to the outputs from the upgraded hydrologic and atmospheric models. Additional information will be provided on the location of the SMA areas and values of the parameters associated with each area.

Outputs of the model state variables for these processes are essential to the development of surface water budgets over large areas. They also will be used in the development, validation, and parameterization of the hydrologic components of the Eta model upgrade and associated off-line assimilation system.

NOAA will collect the values of the SMA state variables, as well as computed values for mean areal precipitation, runoff, and streamflow for the current operational models. These data, along with the metadata describing time and space attributes and model parameters, will be captured in the operational processing environment used by each RFC. It will be transported to and archived in the NOAA Hydrologic Data System. Once captured and archived, the data will be subject to quality assurance procedures and will be aggregated into datasets that are useful to the GCIP research community.

4. SPECIAL PROCESSING

This section includes summaries of some of the special processing that will occur relative to data to be collected during ESOP-97.

4.1 In-Situ

This section discusses the quality control (QC) of the surface and precipitation composites to be created for ESOP-97. Detailed descriptions of the components of the composite datasets are provided in Section 3. Uniform QC procedures will be applied during the compositing process. Brief descriptions of the QC processes follow.

4.1.1 QC of ESOP-97 Surface Composites

The ESOP-97 hourly surface composite will be formed by an aggregation of datasets from several surface meteorological networks (Figure 4-1). Selected parameters from each dataset will be quality controlled by the use of horizontal quality control procedures.

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

Where [...] represents the summation over all stations within the ROI that have valid observations of the parameter at the time in question, *X_e* is the "expected value" of the parameter at the site in question, *w_i* is the weighting factor for site *i* (here the inverse of the distance between site *i* and the station being quality controlled), and *X_o* is the observed value of the parameter at site *i*.

To determine an observation's HQC flag setting, the difference between the actual observation and its "expected value" will be compared to that parameter's normalized standard deviation. Normalizing factors (also called the sensitivity coefficients) were chosen to control the "good", "questionable", and "unlikely" flag limits for each parameter. See Table 4-1 for ESOP-97 (the same as were used for ESOP-95) normalizing factors. Table 4-2 contains the HQC flag limit ranges derived from the normalizing factors given in Table 4-1 and estimated standard deviations for each parameter so that 95% of the QC limits applied to the ESOP-95 data fell within these ranges. For example, 95% of the observed station pressure values that were flagged as "good" were within 1.5 mb of the expected value. Values for ESOP-97 are expected to be similar. The significant overlap of the ranges seen in Table 4-2 is partially due to seasonal and station differences in standard deviations. The actual HQC limits applied at any particular time depend upon the dynamic nature of the particular station's parameter values over time.

Data will never be changed, only flagged.

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

Table 4-1 Normalizing factors used for ESOP-97 Surface Composites

Parameter	Good	Questionable	Unlikely
Station Pressure	0.2	0.2	0.5
Sea Level Pressure (SLP)	0.2	0.2	0.5

Calculated SLP	0.4	0.4	1.0
Dry Bulb Temperature	0.5	0.5	1.0
Dew Point Temperature	0.5	0.5	1.0
Wind Speed	2.25	2.25	4.0
Wind Direction	1.22	1.22	2.2

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

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

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

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

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

4.1.2 QC of ESOP-97 Precipitation Composites

The ESOP-97 15-min, hourly, and daily precipitation composites will be formed from an aggregation of datasets from several surface precipitation networks (Figure 4-2). The schematic shows the processing steps involved in the preparation of the hourly precipitation composite. The 15-min and daily composites are produced in a similar fashion except that they use other segments of the data as described in section 3.1.1. Each dataset will be quality controlled by the use of a series of global limit checks.

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

TABLE 4-3 QC limits to be applied to precipitation values for ESOP-97 precipitation composites

Parameter	Good	Questionable	Unlikely
5-minute Precipitation	< 3 mm	3-6 mm	>= 6 mm
15-minute Precipitation	< 8 mm	8-18 mm	>= 18 mm
Hourly Precipitation	< 20 mm	20-50 mm	>= 50 mm
Daily Precipitation	< 100 mm	100-125 mm	>= 125 mm

5. DATA DISSEMINATION

Data for the ESOP-97 will be primarily distributed to the GCIP community in two ways: (1) through on-line access, providing on-line transfer and off-line media; and (2) CD- ROM. Further details are provided in the following subsections.

5.1 ESOP-97 On-line Data Access

The ESOP-97 data will be available on-line from the GCIP Data Management and Service System (DMSS). The DMSS provides a central information source for GCIP. It provides overviews and up-to-date information regarding GCIP and the DMSS. Also provided are links to the four GCIP data source modules that specialize the GCIP datasets by type. The modules include the in-situ data, model output, satellite remote sensing, and special GCIP dataset source modules. Figure 5-1 depicts the DMSS structure. The World Wide Web (WWW) home page for GCIP and the DMSS resides at NOAA/NCDC at the following URL:

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

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

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

The ESOP-97 In-situ data will be available through the UCAR/JOSS Distributed Data Management System also known as CODIAC. CODIAC is an on-line, interactive data management system that consists of a data catalog, data inventories, station descriptions, and an order entry system. CODIAC is a distributed system that allows the user to link to other centers with on-line data systems (e.g. NCDC) for further information on datasets and data delivery. CODIAC provides information about each field projects' datasets by title, abstract, time, location, and frequency of observations. Detailed information on stations and observing platforms include station name and location as well as observed parameters.

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

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

CODIAC System Access via the WWW

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

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

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

5.1.2 The Satellite Remote Sensing Data Source Module

The GCIP Satellite Remote Sensing Data Source Module (SDSM) was identified to be the NASA/Marshall Space Flight Center Distributed Active Archive Center (MSFC-DAAC). The DAAC concentrates its data holdings in the discipline of the hydrologic cycle and currently contains mostly satellite-derived datasets. The GCIP SDSM at the DAAC coordinates and identifies datasets relevant to GCIP efforts such as the ESOP-97. Additionally, ESOP-97 users and data producers may contact the module with inquiries or additional requirements. The SDSM home page builds upon the available data and coordinating efforts. The SDSM home page is currently linked to the GCIP home page and the In-situ and Modeling Modules. The SDSM URL is:

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

5.1.3 The Model Output Source Module

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

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

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

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

5.2 ESOP-97 CD-ROM

A subset of the datasets that will be available through CODIAC will be published on a CD-ROM. Table 5-1 provides a summary of these proposed datasets. This list may change depending upon the requirements of the GCIP Scientific Community, Science Panels, GCIP Project Office, and the GCIP Data Management Committee. Detailed descriptions of the datasets are provided in Section 3.0. Companion software tools will be available to browse and display the data (i.e., areal plots, time series plots, altitude plots, image displays). These tools will be available for DOS, MacIntosh, and UNIX based systems.

A companion CD-ROM to GCIP has been produced by the USGS. This CD-ROM contains geographic information for the entire GCIP domain. Datasets contained on this CD- ROM are summarized in Table 5-2. Software to extract and view data have been included. Much of this information is also available via the GREDS WWW page at:

http://nsdi.usgs.gov/nsdi/wais/water/gcip.HTML

TABLE 5-1 PROPOSED ESOP-97 CD-ROM DATASET CONTENTS

Surface

ESOP-97 Hourly Surface Land Composite Data
ESOP-97 Hourly Precipitation Composite Data
ESOP-97 Daily Precipitation Composite Data
NCDC Cooperative Observer Network Data (Summary of the Day)
USGS Streamflow Data
USGS Reservoir Data
NCDC SAO "Specials" Data

Upper Air

NWS high resolution (6-sec) soundings
NOAA Profiler Network Hourly Data (405 MHZ)

Imagery

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

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

Meteorological and Hydrological Station Locations

Digital Elevation Model (DEM) at 500-m resolution

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

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

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

Locations of Large Reservoirs of the United States

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

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

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

Eta Model Grid Node Locations and description of Parameters

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

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

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

Listing of Long Term Climatological Stations

GIF Imagery of above Datasets (Browse purposes)

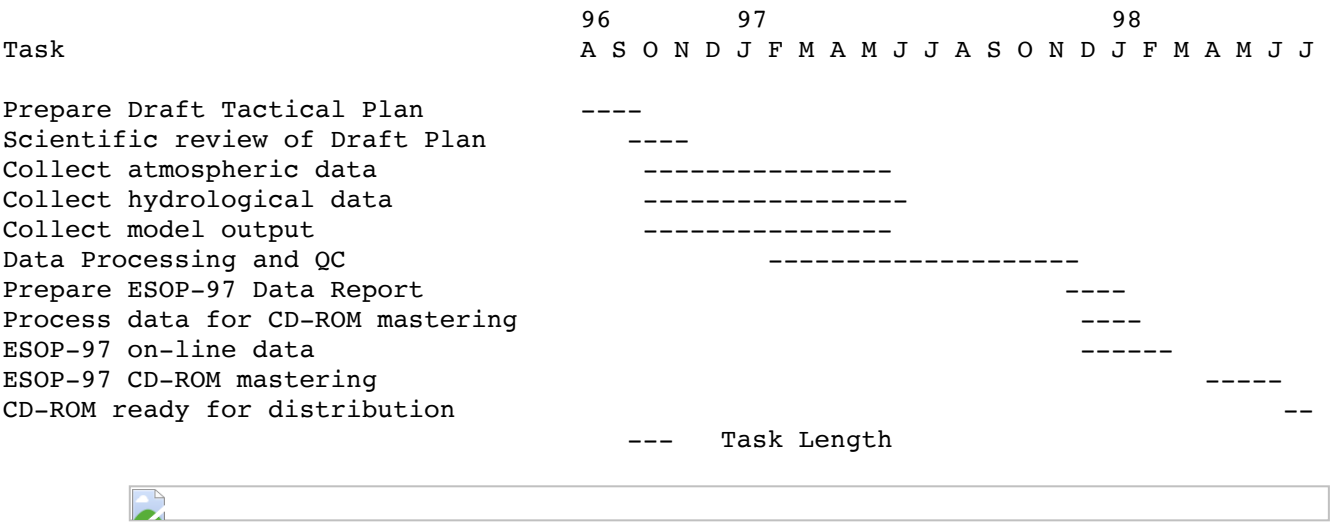
Miscellaneous Documentation of above Datasets

Software and Source Code for Dataset Projection Translation

6. IMPLEMENTATION AND SCHEDULE

Since GCIP, and therefore ESOP-97, aims to make maximum use of existing data sources, the first step in the planning and development effort must be identification of potential sources of data pertinent to the program. The JOSS has conducted an investigation of potential datasets and the results are summarized in this document. The JOSS then conducted an extensive investigation of potential datasets and sources of in-situ data and, in conjunction with the GCIP Data Collection and Management Committee (DACOM), developed the list of ESOP-97 datasets. For each data source, the JOSS will then: determine the quality, limitations, and problems with the data; assess the level of functionality possible at the responsible center; and determine the most cost-effective data access mechanism. The comments on the draft Tactical Data Collection and Management Plan from DACOM, the GCIP science sub panels and community, will be used to develop the Final ESOP-97 Tactical Data Collection and Management Plan. Following the data collection period, an ESOP-97 Tactical Data Collection and Management Report will be developed identifying that data which was included within the ESOP-97 dataset.

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



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APPENDIX A

ACRONYMS

AES
: Atmospheric Environment Service (Canada)

AFOS
: Automated Field Operations and Services

ALERT
: Automated Local Evaluation in Real Time

API
: Antecedent Precipitation Index

ARL
: Air Resources Laboratory (NOAA)

ARM
: Atmospheric Radiation Measurement (DOE)

ARS
: Agricultural Research Service (USDA)

ASOS
: Automated Surface Observing System

AVHRR
: Advanced Very High Resolution Radiometer

AWIPS
: Advanced Weather Interactive Processing System (NOAA)

AWON
: Agricultural Weather Observation Network (UW)

AWOS
: Automated Weather Observing System

BUFR
: Binary Universal Form for Data Representation

CART
: Clouds and Radiation Testbed (DOE/ARM)

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

CD
: Compact Disk

CLAVR
: Clouds from AVhRr

CMC
: Canadian Meteorological Centre

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

CRREL
: Cold Regions Research and Engineering Laboratory (USACE)

CSA
: Continental Scale Area

DAAC
: Distributed Active Archive Center (NASA)

DACOM
: Data Collection and Management Committee (GCIP)

DEM
: Digital Elevation Model

DMSP
: Defense Meteorological Satellite Program

DMSS
: Data Management and Service System (GCIP)

DNR
: Department of Natural Resources

DOC
: Department of Conservation

DOE
: Department of Energy

DOT
: Department of Transportation

EBBR
: Energy Balance Bowen Ratio

ECOR
: Eddy Correlation

EDAS
: Eta Data Assimilation System

EDC
: EROS Data Center (USGS)

EOP
: Enhanced Observing Period

EPA
: Environmental Protection Agency

EROS
: Earth Resources Observation Systems

ESOP
: Enhanced Seasonal Observing Period

FAA
: Federal Aviation Administration

FAX
: Facsimile

FEST
: Fronts Experiment Systems Test (STORM)

FOS
: Family of Services

FSL
: Forecast Systems Laboratory (NOAA)

FTS
: Forest Technology Systems, Incorporated

FWN
: Fire Weather Network

GAC
: Global Area Coverage

GCIP
: GEWEX Continental-scale International Project

GCM
: Global Climate Model

GEWEX
: Global Energy and Water Cycle Experiment

GHCC

Global Hydrology and Climate Center (NASA)

GIDS
: GCIP Initial Data Sets

GIF
: Graphic Image Format

GIST
: GCIP Integrated Systems Test

GMS
: Geostationary Meteorological Satellite (Japan)

GOES
: Geostationary Operational Environmental Satellite

GREDS
: Geographic Reference Data Set (USGS)

GRIB
: GRId point values expressed in Binary form

HDF
: Hierarchical Data Format

HIRS
: High Resolution Infrared Radiation Sounder

HPCN
: High Plains Climate Network

HQC
: Horizontal QC

HRPT
: High Resolution Picture Transmission

IBM
: International Business Machines

ICN
: Illinois Climate Network

IDEM
: Indiana Department of Environmental Management

IGPO
: International GEWEX Project Office

IOP
: Intensive Observation Period

IR
: InfraRed

IRI
: Interdisciplinary Research Initiative (USGS)

ISA
: Intermediate-Scale Area

ISU
: Iowa State University

ISWS
: Illinois State Water Survey

JOSS
: Joint Office for Science Support (formerly OFPS)

KBS
: Kellogg Biological Station (LTER)

LAC

Local Area Coverage

Lake-ICE
: Lake-Induced Convection Experiment

LSA
: Large-Scale Area

LTER
: Long-Term Ecological Research (NSF)

MAPS
: Mesoscale Analysis and Prediction System

METEOSAT
: METEOrological SATellite (Europe)

MFRSR
: Multi-Filter Rotating Shadowband Radiometer

MN
: Minnesota

Mn/ROAD
: Minnesota Road Research Project (Minnesota DOT)

MO
: Missouri

MOLTS
: Model Location Time Series

MORDS
: Model Output Reduced Dataset

MPCA
: Minnesota Pollution Control Agency

MSEA
: Management Systems Evaluation Areas

MSFC
: Marshall Space Flight Center (NASA)

MSU
: Microwave Sounding Unit

NASA
: National Aeronautics and Space Administration

NAWDEX
: NAtional Water Data EXchange (USGS)

NC
: North Central

NCAR
: National Center for Atmospheric Research

NCDC
: National Climatic Data Center (NOAA)

NCEP
: National Centers for Environmental Prediction (NOAA)

NCRFC
: North Central River Forecast Center

NDARB
: North Dakota Atmospheric Resource Board

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

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

NIC

National Ice Center (DOD, NOAA, and DOT)

NIDS
: NEXRAD Information Dissemination Service

NOAA
: National Oceanic and Atmospheric Administration

NOHRSC
: National Operational Hydrologic Remote Sensing Center (NOAA)

NPN
: NOAA Profiler Network

NRCS
: Natural Resource Conservation Service (USDA)

NSF
: National Science Foundation

NSIDC
: National Snow and Ice Data Center

NSSC
: National Soil Survey Center (USDA/NRCS)

NSTL
: National Soil Tilth Laboratory

NTL
: North Temperate Lakes (LTER)

NWS
: National Weather Service

NWSRFS
: NWS River Forecast System

OFPS
: Office of Field Project Support (currently JOSS)

OH
: Office of Hydrology (NOAA)

ORNL
: Oak Ridge National Laboratory (DOE)

PAR
: Photosynthetically Active Radiation

POES
: Polar Orbiting Environmental Satellite

PSU
: Pennsylvania State University

QC
: Quality Control

RASS
: Radio Acoustic Sounding System

RFC
: River Forecast Center

RFE
: Regional Finite Element

RISOP
: Rapid Interval Scan Operations Plan

ROI
: Radius Of Influence

ROM

Read Only Memory

RWIC
Regional Weather Information Center (UND)

SAO
Surface Airways Observation

SAST
Scientific Assessment and Strategy Team (USGS)

SBUV
Solar Backscattered Ultra Violet System

SCD
Scientific Computing Division (NCAR)

SDSM
Satellite Data Source Module (GCIP)

SDTS
Spatial Data Transfer Standard

SIROS
Solar and Infrared Radiation Observing System

SLP
Sea Level Pressure

SMA
Soil Moisture Accounting

SMOS
Surface Meteorological Observation System

SM/ST
Soil Moisture/Soil Temperature (USDA/NRCS)

SSA
Small-Scale Area

SSEC
Space Science and Engineering Center (UW)

SSI
Surface Systems, Incorporated

SSM/I
Special Sensor Microwave Imager

SSU
Stratospheric Sounding Unit

STATSGO
State Soil Geographic Database (USDA)

STORM
STorm-scale Operational and Research Meteorology

SURFRAD
SURFace RADiation budget network (NOAA/ARL)

SW
South West

SWATS
Soil Water and Temperature System

SWE
Snow Water Equivalent

TDR
Time Domain Reflectometry

TIROS
Television and Infrared Observation Satellite

TOVS

TIROS Operational Vertical Sounder

UCAR
University Corporation for Atmospheric Research
UHF
Ultra-High Frequency
UM
University of Minnesota
UND
University of North Dakota
URL
Uniform Resource Locator
US
United States
USACE
United States Army Corps of Engineers
USAF
United States Air Force
USDA
United States Department of Agriculture
USFS
United States Forest Service
USFWS
United States Fish and Wildlife Service
USGS
United States Geological Survey
UTC
Universal Time Coordinated
UW
University of Wisconsin
UZFW
Upper Zone Free Water

VAS
VISSR Atmospheric Sounder
VIS
Visible
VISSR
Visible and Infrared Spin-Scan Radiometer

WCRP
World Climate Research Programme
WDT
Wisconsin Dense Till (USDA/NRCS)
WI
Wisconsin
WMO
World Meteorological Organization
WSI
Weather Services International
WSR-88
Weather Surveillance Radar - 1988 Doppler
WWW
World Wide Web