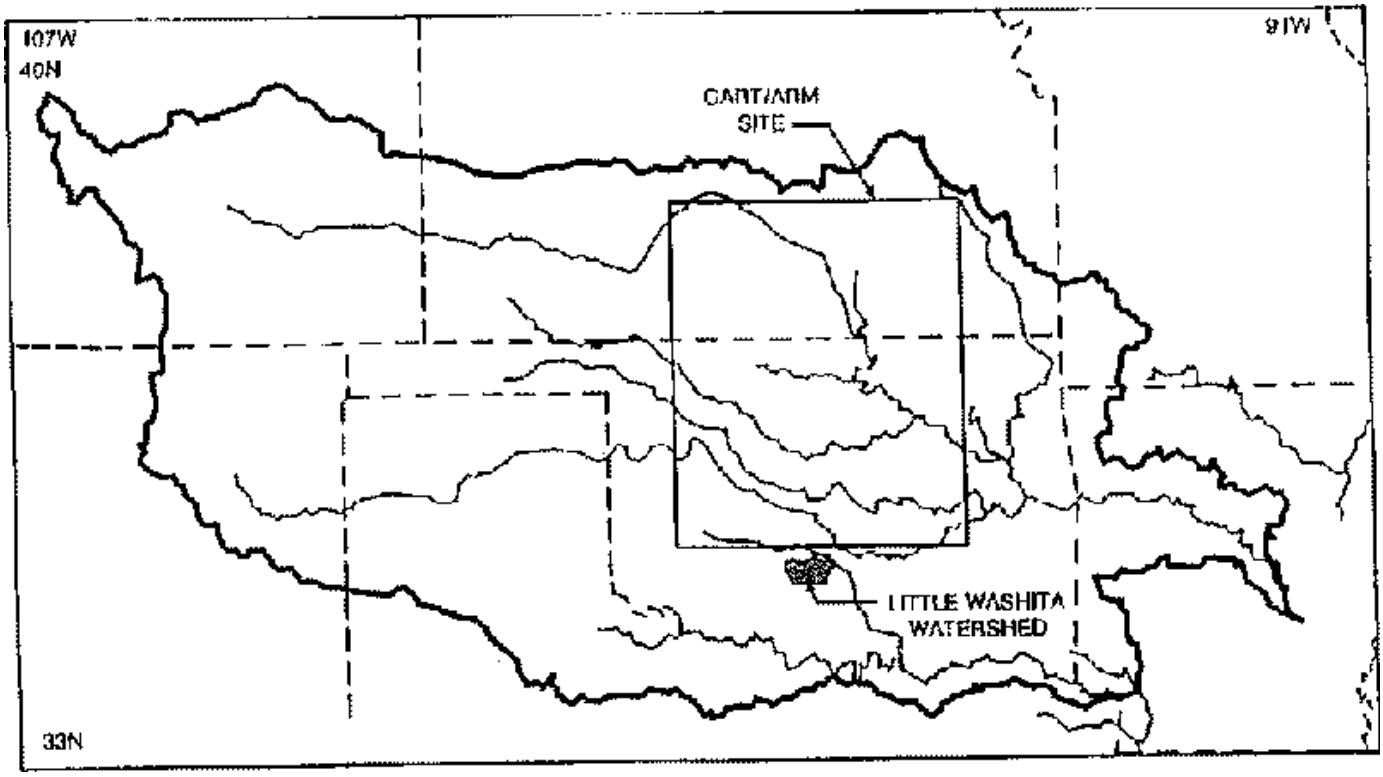
GLOBAL ENERGY AND WATER CYCLE EXPERIMENT

WORLD CLIMATE RESEARCH PROGRAMME (WCRP) INTERNATIONAL GEWEX PROJECT OFFICE (IGPO)

TACTICAL DATA COLLECTION AND MANAGEMENT REPORT for the GCIP INTEGRATED SYSTEMS TEST (GIST)



GIST - 1 April - 31 August 1994

October 1996

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No. 20

TACTICAL DATA COLLECTION AND MANAGEMENT REPORT for the GCIP INTEGRATED SYSTEMS TEST (GIST)

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PREFACE

The science plan for the Global Energy and Water Cycle Experiment (GEWEX) Continental-scale International Project (GCIP) noted in its Preface that ..."GCIP will make full use of and in fact, depend upon, the deployment of considerably advanced new ground-based observing systems as part of the United States' ongoing modernization of its operational meteorological observing network." From the start, the guiding principle is that GCIP will, to the extent possible, rely upon existing or planned operational observing programs over the continental U.S.A., including space-based observations.

It was recognized early that GCIP needed to complete a data systems test prior to the start of the five-year Enhanced Observing Period. The GCIP Integrated Systems Test (GIST) brought together the science and data management aspects of GCIP in the Arkansas-Red River basins which is both a data-rich area as well as providing a number of watershed areas that are very useful for the hydrologic focused studies needed by GCIP as a precursor to developing a coupled land surface/atmospheric model. Enhancements to the routine operational networks are also available in this region. GCIP is particularly grateful to the Department of Energy for making the data from the Atmospheric Radiation Measurement (ARM) Program available to GCIP through the Southern Great Plains Cloud and Radiation Testbed (CART) facility. GCIP also acknowledges the contribution from the Oklahoma Climate Survey of the data from the 111 station locations in the Oklahoma Mesonet which were installed just prior to the GIST.

The GCIP Data Collection and Management (DACOM) committee set three principal objectives for GIST:

(i) To perform an early end-to-end test of an on-line demonstration system as an early prototype of a data management and service system for the GCIP research community.

(ii) To evaluate the utility of the data archive systems for new and/or modernized data sources in both data and information content as well as accessibility; and,

(iii) To formalize the formats and procedures for compiling GCIP data sets during the five-year Enhanced Observing Period.

The contributions from all the members of DACOM in successfully completing all three objectives are gratefully acknowledged.

Special acknowledgments are due to Steve Williams and Scot Loehrer from the University Corporation for Atmospheric Research (UCAR) for their outstanding work in bringing together the many and diverse sources of information about the data collected during the GIST. Their thorough and complete job in this initial GCIP data report has set a high standard for the GCIP data reports to be produced during the five-year Enhanced Observing Period.

John A. Leese, Chairman
DACOM
15 June 1996

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1. INTRODUCTION

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

1.1 The GCIP Project

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

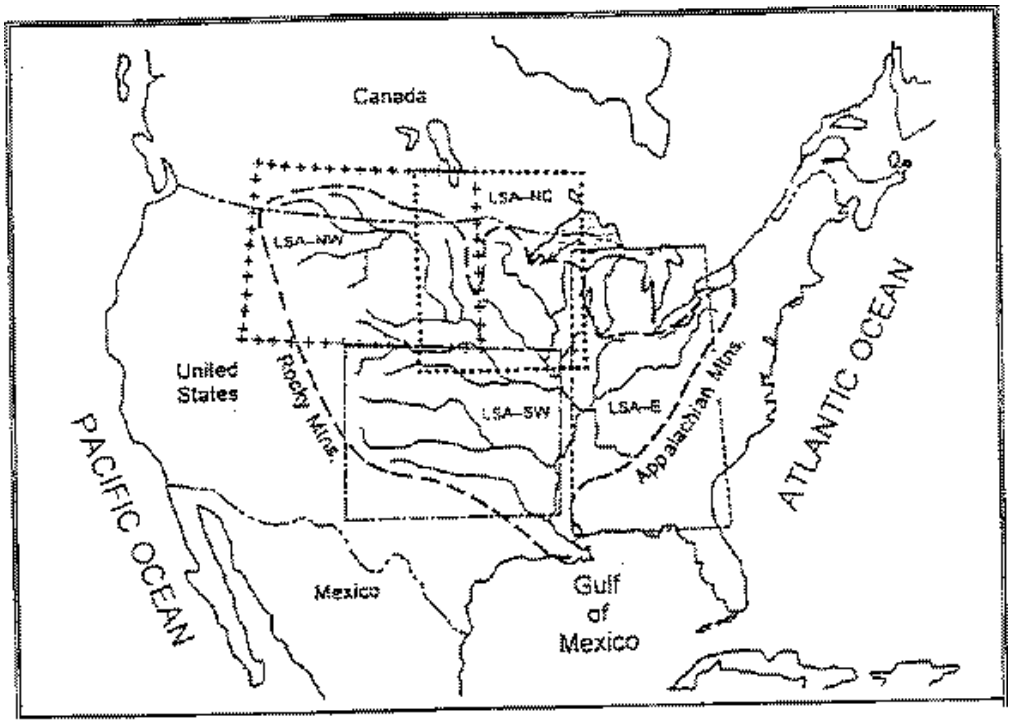
The GCIP Science Plan [World Meteorological Organization (WMO), 1992] poses science questions that need to be addressed to advance knowledge of the hydrological and energy cycles involved in the complex land-atmosphere-ocean interactions for a major river basin. The GCIP research involves a systematic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

Continental-scale area (CSA) activities span the entire domain of the Mississippi River basin (3.2 x 10^6 km^2). These activities will evolve and increase 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 Observing Periods (IOPs) over concentrated regions to study a focused set of issues.



TIME PHASING OF GCIP RESEARCH EMPHASIS

Multi-Scale Framework	1994 GIST	1995 ESOP	1996	1997	1998	1999	2000
			FISCAL OR WATER YEAR				
			ENHANCED		OBSERVING		PERIOD
Continental Scale Area	*	*	***	***	***	***	***
Large Scale Areas (LSAs)							
LSA-SW ——>	***	***	***	***	**	**	**
LSA-NC ——>	*	*	*	***	***	*	*
LSA-E ——>	*	*	*	*	***	***	*
LSA-NW ——>	*	*	*	*	*	***	***

*** High
** Moderate
* Low

Figure 1-1 Boundaries for the GCIP LSAs (top) and the temporal emphasis for each LSA (bottom).

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

1.2 GCIP Initial Datasets

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

basin. GIDS-2 is planned to consist of two abnormal climate events in the Mississippi River basin, i.e. the 1988 drought and the 1993 floods. GIDS-3 consists of data collected during the GCIP Integrated Systems Test (GIST) which took place from 1 April to 31 August 1994, with a concentrated effort during the summer season of June, July, and August. The GIST took place in the LSA-SW (see Figure 1-1) and it is the subject of this document. A GCIP Reference Dataset (GREDS) was completed in early 1995. The 17 different geographic 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 1995, 1996 and Outlook for 1997 (IGPO, 1994). 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 The GCIP Integrated Systems Test (GIST)

The GIST was conducted 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 (Figure 1-1) and it was essentially a GCIP pilot study to test data collection and management procedures and allow investigators to conduct some initial analysis efforts, including diagnostic, evaluation, and modeling studies. The LSA-SW has four environmental features that are significant to GCIP: A large east-west variation in climate, a large water vapor transfer via a low level jet, a large portion of the precipitation is due to convective activity, and there is a large diurnal variability in the summer season for hydrologic components such as water vapor transport and convective regimes. The scientific objectives for these studies are described in the Implementation Plan for the GEWEX Continental-scale International Project (GCIP)(IGPO, 1993).

The GCIP LSA-SW domain is shown in Figure 1-2. The LSA-SW was chosen because it was the best instrumented river basin within the Mississippi River basin and there were other special data collection efforts underway. The geographical area of responsibility for the National Oceanic and Atmospheric Administration (NOAA)-National Weather Service (NWS) Arkansas-Red Basin River Forecast Center (ABRFC) in Tulsa, Oklahoma, was used to define the areas of the Arkansas-Red River basins as the irregular shaped polygon in Figure 1-2. For atmospheric modeling and other applications a more regular-shaped area was defined by the boundaries of 33° to 40° N latitude and 91° to 107° W longitude, and these were used as the latitude-longitude boundaries for the LSA-SW. The meteorological and hydrological networks covering the Mississippi River basin were being enhanced by new Weather Surveillance Radar - 1988 Doppler (WSR-88D) radars, wind profilers, and automatic weather stations. Most of these systems were already operating in the LSA-SW during the GIST period. Enhancements to these observing networks were also available in the form of mesoscale networks, the Department of Energy (DOE) Atmospheric Radiation Measurements (ARM) Program at the southern Great Plains Cloud and Radiation Testbed (CART) facility, the United States Department of Agriculture (USDA)/Agricultural Research Service (ARS) Little Washita experimental watershed, and the Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX). The linkages between GIST, ARM/CART, and VORTEX are discussed in section 2.

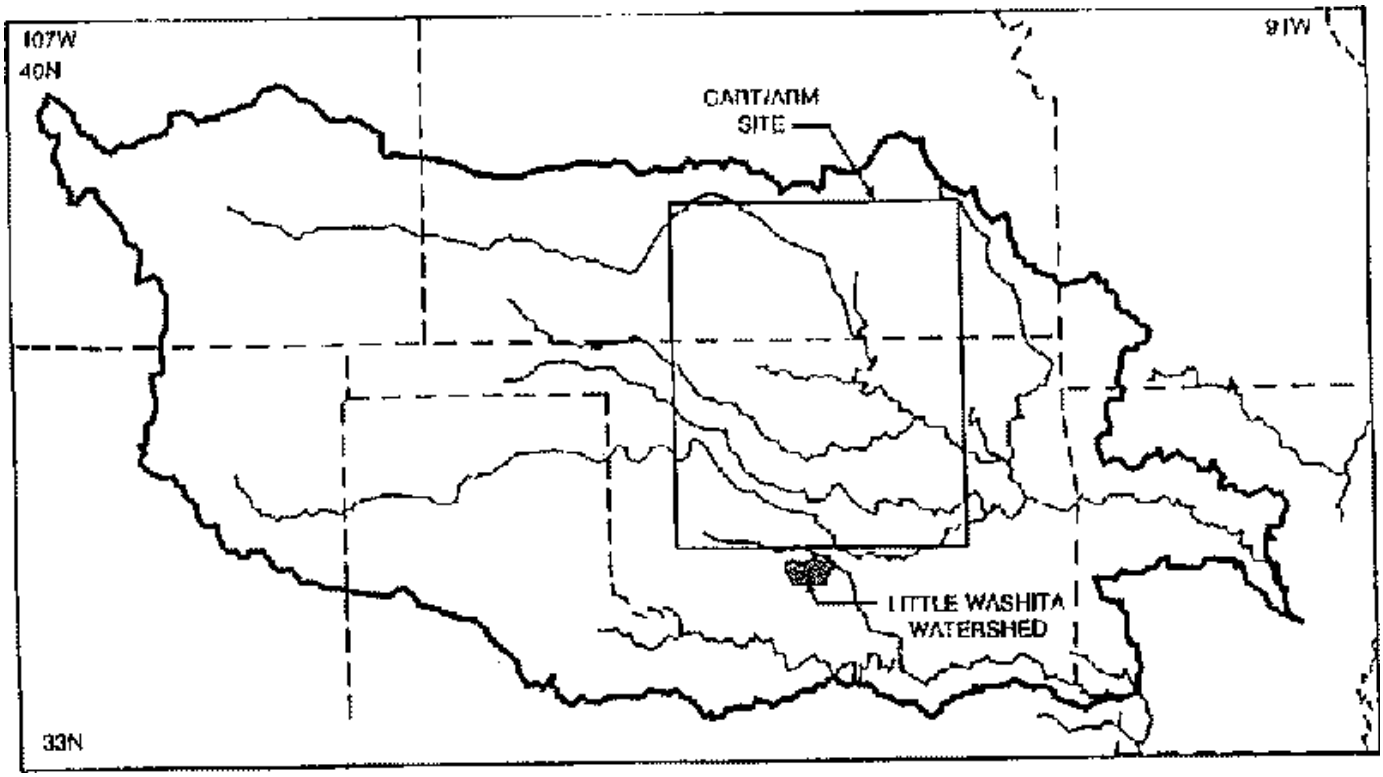


Figure 1-2 Latitude-longitude boundaries for the LSA-SW. The thick line represents the area of responsibility for the ABRFC. Also shown are the ARM/CART domain and Little Washita watershed.

1.4 Purposes of Document

This document is entitled the Tactical Data Collection and Management Report for GIST and is intended to serve a dual purpose:

(i) A summary of the data collection efforts that occurred during the period of 1 April through 31 August 1994. Some of the specialized efforts for enhanced observations (i.e. ARM/CART and VORTEX; described in section 2) have operations plans which were prepared by the persons contributing those enhanced observations to the GIST.

(ii) The data that were collected during GIST provided the basis for the third initial dataset (GIDS-3).

The approach to GIST, a description of the data collected, and how it is being disseminated are described in the remainder of this document.

2. OBJECTIVES AND APPROACH

The purpose of compiling the GIST dataset was to create a prototype dataset over one of the GCIP LSAs that was similar to the future datasets collected during the GCIP EOP that began October 1995. In particular, the objective was to formalize the formats and procedures for compiling, archiving, and disseminating the GCIP EOP datasets. The approach taken by the GCIP was to rely on existing operational observing programs over the continental United States while taking advantage of special collection of higher resolution data. Also, as additional improvements were made to the operational observing systems [i.e. ASOS (Automated Surface Observing System) and WSR 88-D] they were incorporated. These operational networks include the traditional meteorological and hydrological networks in addition to WSR-88D radars, wind profilers, ASOS, satellites, and operational model output. The LSA-SW was selected in part because many of these additional systems were already available. Also, within the LSA-SW, there were the enhanced special observational networks associated with the ARM/CART and VORTEX projects.

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

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

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

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

Single-Column Model (SCM) IOPs were conducted in April and July 1994. An SCM is a physical parameterization package extracted from a GCM. The primary purpose of the SCM IOPs was to test the current understanding of clouds and radiative transfer. These SCM IOPs provide, as boundary conditions, the advective tendencies and vertical velocities that are the dynamic forcing normally calculated with a GCM. The balloon-borne sounding system is the only technology able to provide the necessary

observations to estimate these boundary conditions. Thus, these IOPs included an enhanced frequency of vertical soundings of temperature, water vapor and winds, as well as other observations. The sounding frequency was increased to eight per day at the central and boundary facilities (see Figure 3-5). These SCM IOPs also served as useful background data collection efforts for simultaneous IOPs.

During the April SCM IOP the ARM Unmanned Aerospace Vehicle (UAV) IOP also took place. The primary purpose of the ARM UAV IOP was to collect measurements of clear-sky flux profiles using a UAV (the General Atomics Gnat 750) and surface support data to understand clear-sky heating rates and the ability of models to reproduce the observations.

During April and May 1994 the Remote Cloud Sensing Field Evaluation IOP occurred. The primary purpose was to conduct a field evaluation and calibration of several remote sensing cloud-observing instruments. Included among the remote sensors operational during this IOP were Raman lidars [National Aeronautics and Space Administration (NASA)/ Goddard Space Flight Center (GSFC) and Sandia National Laboratories], 95 GHz radar and Polarization Diversity Lidar (University of Utah), a Doppler lidar (NOAA/Environmental Technology Laboratory), an infrared radiometer [Commonwealth Scientific and Industrial Research Organization (CSIRO)], a combined 35/95 GHz and another 95 GHz mm-wave radar (University of Massachusetts), a 95 GHz radar [Pennsylvania State University (PSU)], a combined narrow-field-of-view/hemispherical-field-of-view infrared radiometer (NASA/Ames Research Center), and a sky-scanning spectrophotometer (NASA/GSFC). Additional already tested and operational sensors included the Atmospherically Emitted Radiance Interferometer (AERI) (University of Wisconsin), SORTI (Solar Radiance Transmission Interferometer) (University of Denver), and the Micropulse Lidar (NASA/GSFC). Flight operations were conducted by the University of North Dakota Citation aircraft.

During May 1994 two additional IOPs took place. The WB-57 Overflight for the Measurement of Atmospheric Water Vapor at High Altitude IOP was an attempt to infer the vertical distribution of water vapor at high altitudes from solar transmission spectra. The other IOP was the VORTEX IOP, for which special rawinsonde releases were made. Further information on VORTEX appears later in this section.

Finally, during August 1994 the ARM/GCIP/IOP took place. This IOP was part of a collaboration between GCIP and ARM during which ARM conducted special rawinsonde releases in support of GIST. This was part of the general effort to improve climate models by improving the parameterizations of the hydrologic and energy cycles.

The GIST was coordinated with the VORTEX project which was conducted from 1 April through 15 June 1994 in the Arkansas-Red River Basin area (Figure 1-2). The broad objectives of VORTEX were to gain understanding of tornado-genesis processes, the roles of the environment in producing and modulating tornadic storms, and tornado kinematics and dynamics. Many of the same observations required to support VORTEX objectives were also useful for GCIP thus providing a natural collaboration of the projects. In fact, by combining the data collection from VORTEX and GIST, researchers are provided with access to both routine operational as well as high-resolution augmented research network data.

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

3. DATA SOURCES AND DATA COLLECTION

The GIST data can be divided into three major data categories: In situ, satellite, and model. Although most of the data sources were operational in nature, special arrangements were made to obtain these data in the highest resolution possible. Table 3-1 summarizes the individual datasets comprising the GIST. 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 as well as in Appendix B. Information on dataset dissemination is provided in section 5.

TABLE 3-1 Datasets Comprising the GIST

IN-SITU DATA

Surface Data

Automated Surface Observing System (ASOS) Data
FAA Automated Weather Observing System (AWOS) Data
Surface Airways Observations (SAO) Hourly Data

SAO Special Observation Data
High Plains Climate Network (HPCN) Data
Oklahoma Mesonet Data
NOAA Wind Profiler Demonstration Network (WPDN) Surface Observations
DOE ARM/CART Surface Data
NWS Cooperative Observer Daily Observations
NWS Cooperative Observer Precipitation Data
Arkansas-Red Basin River Forecast Center (ABRFC) Precipitation Data
US Army Corps of Engineer (USACE) Precipitation and Streamflow Data
USGS Streamflow Data
USGS Reservoir Data
USDA/Soil Conservation Service (SCS) Soil Moisture Data
GIST Hourly Surface Composite
GIST 5-minute Surface Composite
GIST Hourly Precipitation Composite
GIST 15-minute Precipitation Composite
GIST Daily Precipitation Composite

Upper Air Data

NWS Upper Air Rawinsonde Data (6-second vertical levels)
NWS Upper Air Rawinsonde Data (mandatory/significant levels)
DOE ARM/CART Site Upper Air Data NOAA Wind Profiler Demonstration Network (WPDN) Data
VORTEX Fixed and Mobile Site Upper Air Data

Radar Data

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

Land Characterization Data

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

SATELLITE DATA

GOES-7 Satellite Imagery (Infrared, Visible, and Water Vapor)
GOES-7 VAS Data/Derived Products
NOAA Polar Orbiting Environmental Satellite (POES) AVHRR Imagery
NOAA POES TOVS Data
Defense Meteorological Satellite Program (DMSP) SSM/I Data/Imagery
NOAA Weekly Northern Hemisphere Snow Cover Analysis
CLAVR Clouds
EDC Bi-Weekly Vegetation Index Data
CAGEX Products
SAR Data for the Little Washita Watershed

MODEL OUTPUT

Atmospheric Model Output

NOAA/NMC Eta Model Output
NOAA/NMC Eta Model 12 UTC Initial Analysis Daily GIFs
NOAA/NMC Eta MOLTS Output
NOAA/NMC Eta MOLTS Derived Sounding Output
AES/CMC RFE Model Output
Model Output Reduced Dataset (MORDS) Output
NOAA/FSL MAPS Model Output
NOAA/FSL LAPS Model Output

Hydrological Model Output

3.1 IN-SITU DATA

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

3.1.1 Surface Data

Automated Surface Observing System (ASOS) Data - These data include 5-minute observations of temperature, dew point, station pressure, precipitation type (rain, snow, and freezing rain), precipitation amount, wind speed, wind direction, visibility to 10 miles, and sky condition to 12,000 feet. These data were available at 51 uncommissioned and 15 commissioned sites within the LSA-SW (Figure 3-1). The high resolution ASOS data were routinely downloaded over telephone modem on a daily basis by OFPS. Data were then merged, quality controlled, and archived at the OFPS. Commissioning means that the ASOS station has passed all operational and quality assurance specifications and replaces the manual observations with 24-hour automated observations at that station. NOTE - Caution should be exercised by the researcher when using uncommissioned ASOS data.

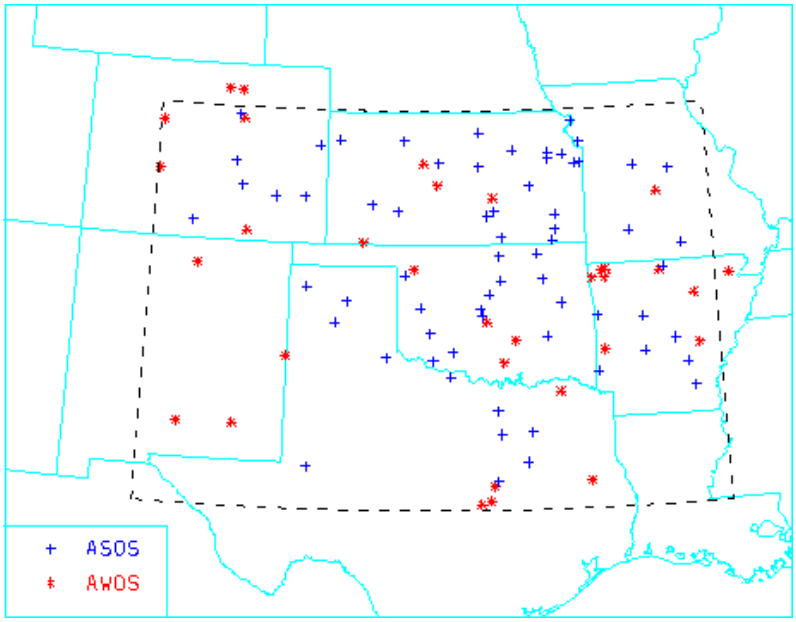


Figure 3-1 ASOS and AWOS station locations within the LSA-SW.

FAA Automated Weather Observing System (AWOS) Data - These Federal Aviation Administration (FAA) AWOS data include 20-minute (except one site in Norman, OK which has 5-minute) observations of temperature, dew point, station pressure, precipitation type (rain, snow, and freezing rain), precipitation amount, wind speed, wind direction, visibility to 10 miles, and sky condition to 12,000 feet. These data were available at 33 sites within the LSA-SW (Figure 3-1). The high resolution AWOS data were routinely downloaded over telephone modem on a daily basis by OFPS. Data were then merged, quality controlled, and archived at the OFPS.

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 were routinely recorded at 96 sites within the LSA-SW (Figure 3-2) and were processed and archived at National Climatic Data Center (NCDC). Data for the GIST period were extracted and forwarded to the OFPS.

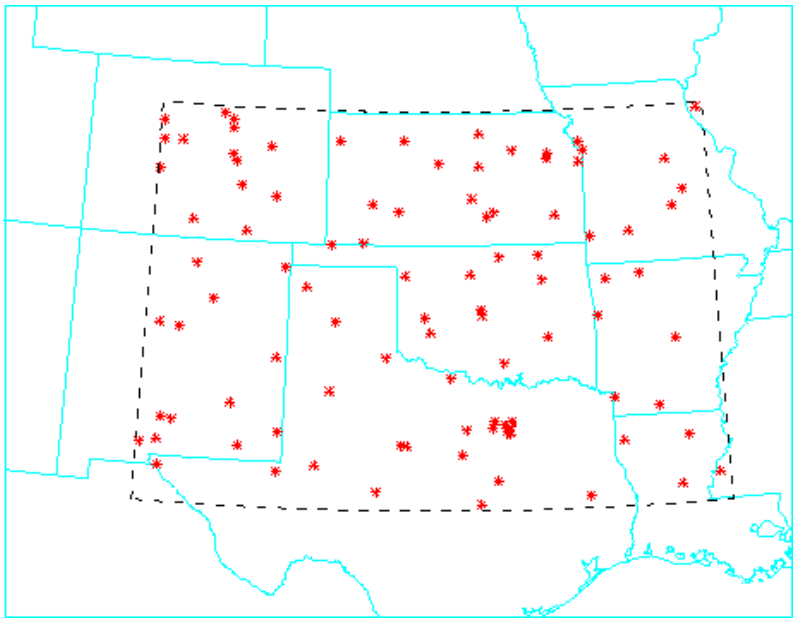


Figure 3-2 SAO station locations within the LSA-SW.

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 were routinely recorded at 96 sites within the LSA-SW (Figure 3-2) and were processed and archived at NCDC. Data for the GIST period were extracted and forwarded to the OFPS.

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

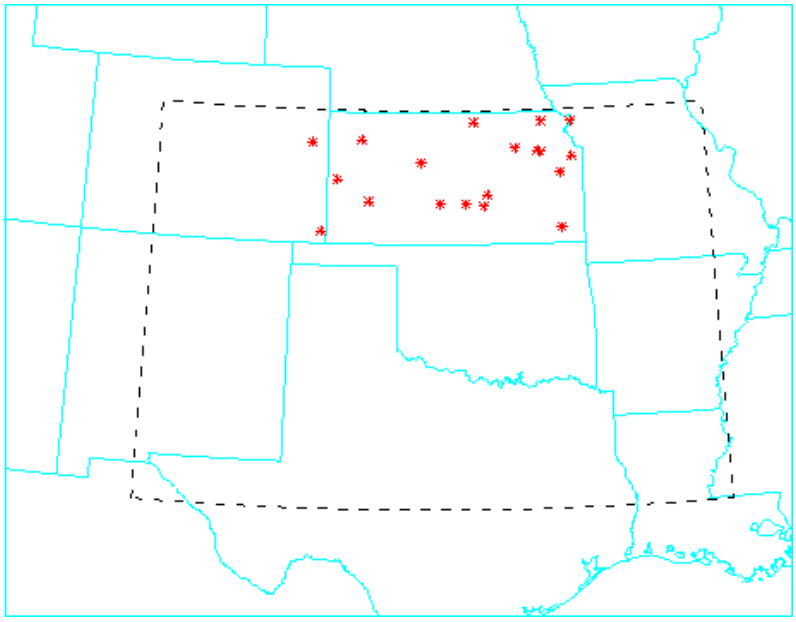


Figure 3-3 HPCN station locations within the LSA-SW.

Oklahoma Mesonet Data - The Oklahoma Mesonet sites routinely collected and archived 5- minute observations of temperature (2 levels), relative humidity, station pressure, precipitation amount, wind speed (2 levels), wind direction, solar radiation, leaf wetness

(selected sites), and soil temperature/moisture (selected sites). These data were available from 111 sites (at least one per Oklahoma county) in the LSA-SW (Figure 3-4). The data were collected, processed, and archived by the Oklahoma Climate Survey at the University of Oklahoma. Data for the GIST period were extracted and forwarded to the OFPS.

Figure 3-4 Oklahoma Mesonet station locations.

NOAA Wind Profiler Demonstration Network (WPDN) Surface Observations - The NOAA WPDN routinely recorded hourly and 6-minute surface observations of temperature, dew point, station pressure, precipitation amount, wind speed, and wind direction at 13 of its 16 profiler sites in the LSA-SW (see Figure 3-12). The data were routinely collected and processed by NOAA/Forecast Systems Laboratory (FSL) and archived at NOAA/NCDC. Data for the GIST period were extracted and forwarded to the OFPS.

DOE ARM/CART Surface Data- The DOE ARM Program routinely obtained 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 a central site and 4 extended facilities in the LSA-SW (Figure 3-5). The data were collected and processed by the DOE ARM Program and archived at DOE Oak Ridge National Laboratory (ORNL). Data for the GIST period were extracted and forwarded to the OFPS.

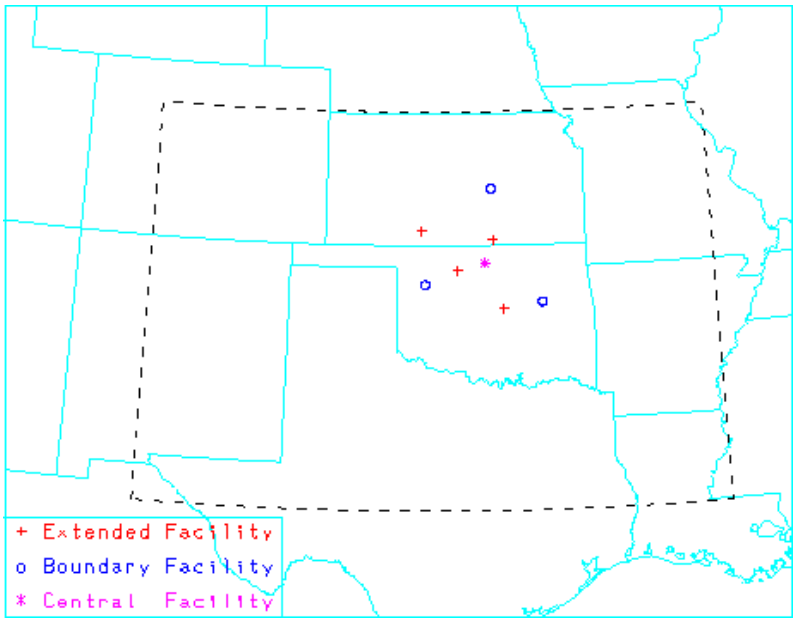


Figure 3-5 DOE ARM/CART facility locations.

NWS Cooperative Observer Daily Observations - Data were routinely collected at approximately 2700 sites operated by cooperative observers over the conterminous United States and were processed and archived by NOAA/NCDC. This network recorded 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 were available at approximately 200 km spacing and daily observations of soil temperature were available at about 500 km spacing. Data for the 1389 stations within the LSA-SW (Figure 3-6) were extracted and forwarded to the OFPS.

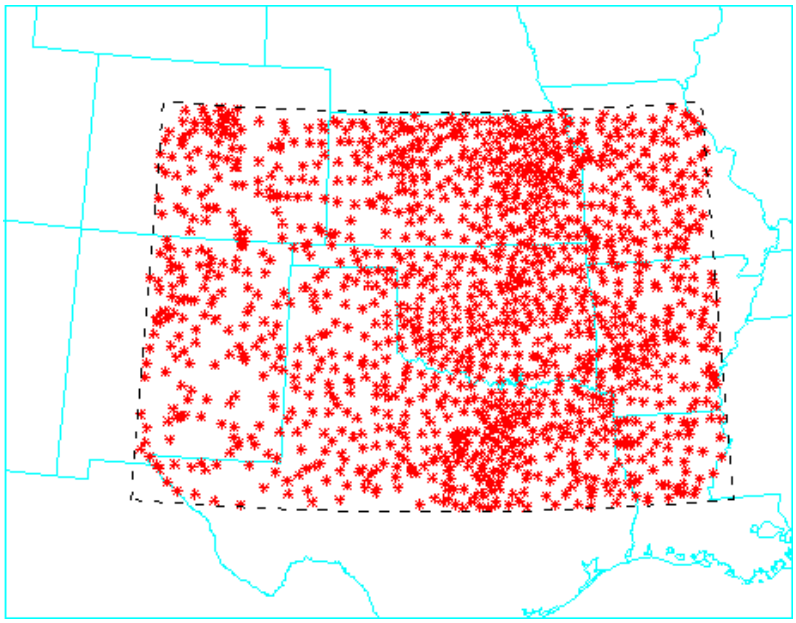


Figure 3-6 NWS cooperative observer daily observation locations within the LSA-SW.

NWS Cooperative Observer Precipitation Data - Data were routinely collected at approximately 2700 sites operated by cooperative observers over the conterminous United States and were processed and archived by NOAA/NCDC. For the LSA-SW these data included 15-minute (431 sites) or hourly (27 sites) observations of precipitation from Fisher- Porter and Universal rain gages operated by cooperative observers (Figure 3-7). Data for the GIST period were extracted and forwarded to the OFPS.

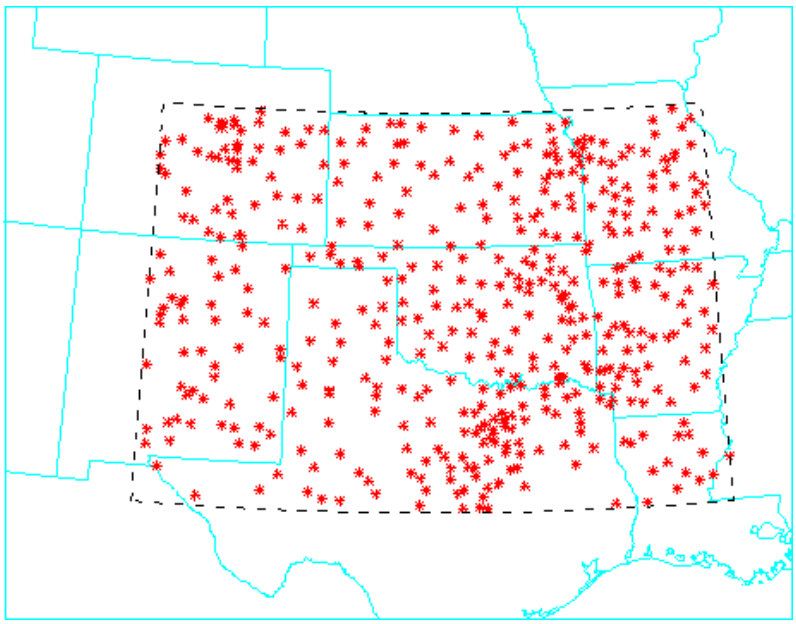


Figure 3-7 NWS cooperative 15-min and hourly precipitation observation locations within the LSA-SW.

Arkansas-Red Basin River Forecast Center (ABRFC) Precipitation Data - These data include precipitation observations from 949 ABRFC stations. The frequency of the observations varied from 15 min (185 stations) to hourly (257 stations) to stations that collect data with no set schedule (507 stations). A map of the ABRFC precipitation stations is shown in Figure 3-8. These data were

archived by the NOAA/Office of Hydrology (OH) in Silver Spring, MD. Data for the GIST period were extracted and forwarded to the OFPS.

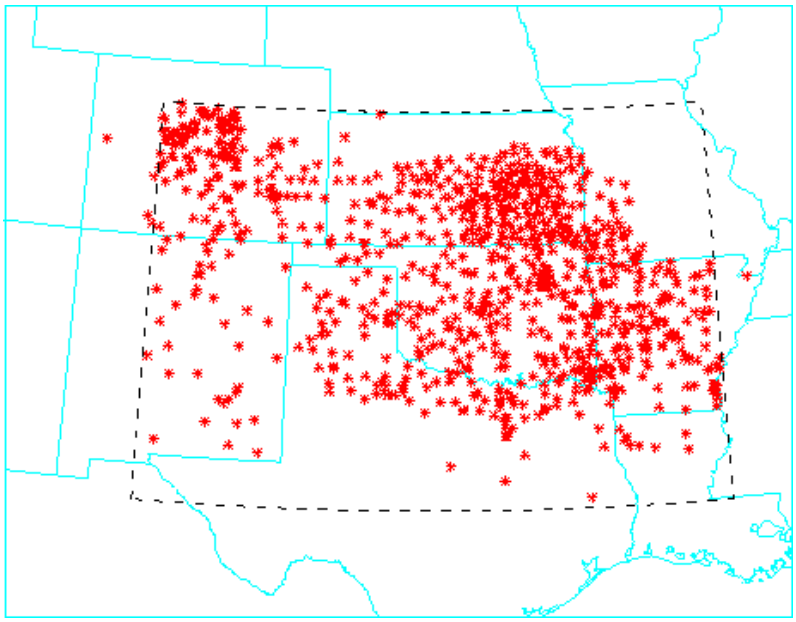


Figure 3-8 ABRFC precipitation observation locations within the LSA-SW.

US Army Corps of Engineer (USACE) Precipitation and Streamflow Data - These data include hourly observations of precipitation and daily observations of streamflow from USACE operational gages. Approximately 50 stations were located within the LSA-SW. Data for the GIST period were extracted and forwarded to the OFPS.

USGS Streamflow Data - These data include daily observations of streamflow from United States Geological Survey (USGS) gages. A total of 759 streamflow stations (Figure 3-9) were located within the LSA-SW and all data are available through the USGS National Water Data Exchange (NAWDEX) Office in Reston, VA as well as the district (state) offices. Data for the GIST period were extracted and forwarded to the OFPS. NOTE - The streamflow data were generally not adjusted for diversions or reservoir storage.

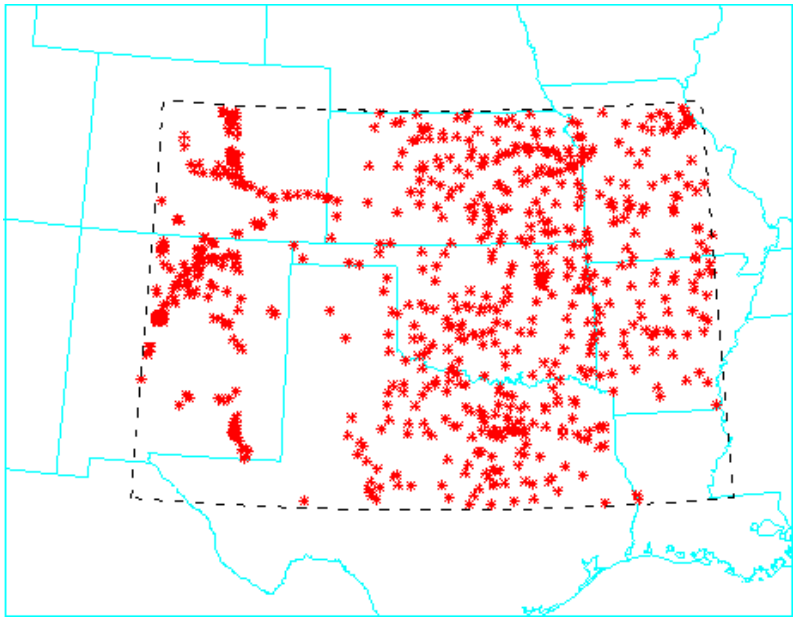


Figure 3-9 USGS streamflow observation locations within the LSA-SW.

USGS Reservoir Data - These data include daily observations of reservoir contents or water level for 103 reservoirs within the LSA-SW (Figure 3-10). All data are available through the USGS NAWDEX Office in Reston, VA as well as the USGS and USACE

district offices. Data for the GIST period were extracted and forwarded to the OFPS.

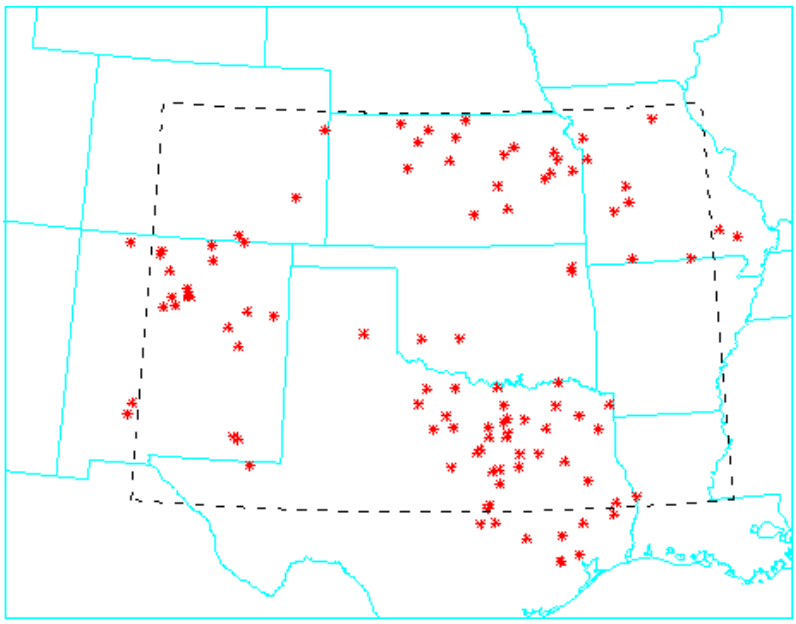


Figure 3-10 USGS reservoir observation locations within the LSA-SW.

USDA/Soil Conservation Service (SCS) Soil Moisture Data - Limited soil moisture data was available for the LSA-SW from the USDA/SCS, presently the USDA/Natural Resources Conservation Service (NRCS). Most soil moisture measurements were manually performed and were not routinely scheduled until the spring planting season (i.e. April and May). These data were collected, processed, and archived by the SCS in Portland, OR. Data for the GIST are available through the USDA/SCS.

GIST Hourly Surface Composite - This composite contains surface and sea level pressure, temperature, dew point, wind speed and direction, and precipitation hourly observations from surface observing sites in the LSA-SW as well as visibility, present weather, ceiling and cloud type heights and amounts for those stations that report them (generally SAO and ASOS). This composite does not contain the precipitation data from those sites that collected only precipitation data (i.e. the site must also have collected meteorological observations to have been included). The precipitation only sites were included within the precipitation composites which are described below. The composite was produced by the OFPS and contains hourly data from the following networks: ASOS, AWOS, SAO's, HPCN, Oklahoma Mesonet, DOE ARM/CART, and NOAA WPDN surface observations. These data were quality controlled by OFPS (see section 4.1.1).

GIST 5-minute Surface Composite - Similar to the GIST hourly surface composite (above) but only the 5-min data from ASOS, Oklahoma Mesonet, the Norman, OK AWOS, and DOE ARM/CART surface stations were merged and quality controlled (see section 4.1.1) to form this composite.

GIST Hourly Precipitation Composite - The hourly precipitation composite contains precipitation data from all real-time and recording gages in the LSA-SW. The composite was produced by the OFPS and contains hourly totals from gages in the following networks: ASOS, AWOS, SAO's, HPCN, Oklahoma Mesonet, DOE ARM/CART, NWS Cooperative Observer, and ABRFC. These data were quality controlled by OFPS (see section 4.1.2).

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

GIST Daily Precipitation Composite - The daily precipitation composite contains precipitation data from all real-time and recording gages in the LSA-SW. The composite was produced by the OFPS and contains daily totals from gages in the following networks: ASOS, AWOS, SAO's, HPCN, Oklahoma Mesonet, DOE ARM/CART, NWS Cooperative Observer, ABRFC, USGS, and USACE. These data were quality controlled by OFPS (see section 4.1.2).

3.1.2 Upper Air Data

NWS Upper Air Rawinsonde Data (6-second vertical levels) - This dataset contains 12-hourly (occasionally more frequent at the request of VORTEX or 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 were obtained from 12 NWS sites in the LSA-SW (Figure 3-11) and processed by the OFPS.

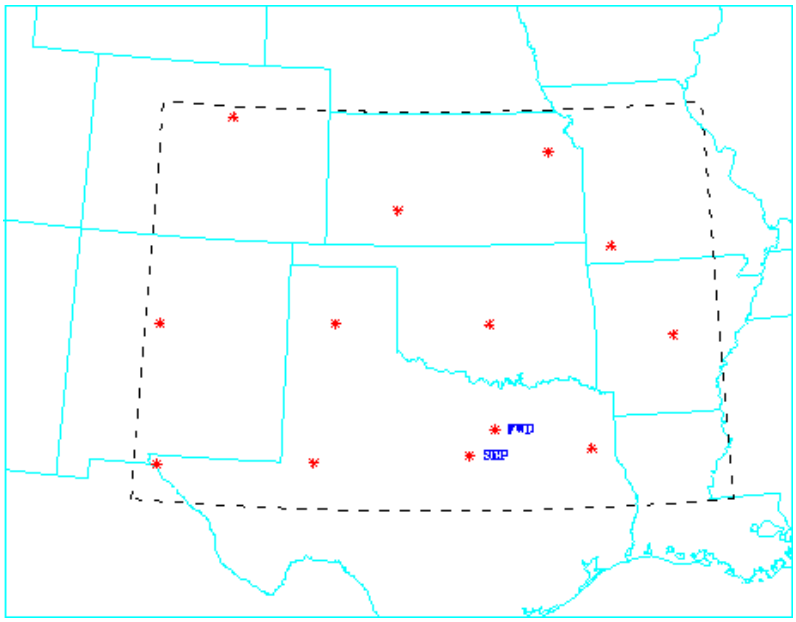


Figure 3-11 NWS rawinsonde release locations within the LSA-SW. The station labeled SEP moved to the station named FWD on 9 July 1994.

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 were routinely collected at 72 sites (approximately 400 km spacing) over all of the conterminous United States and archived at NOAA/NCDC. Data for the LSA-SW (see Figure 3-11) were archived and available at NCDC.

DOE ARM/CART Site Upper Air Data - The DOE ARM Program routinely obtained upper air observations, at 2-sec vertical resolution, at the Southern Great Plains CART site in Kansas and Oklahoma. These measurements include up to 3-hourly soundings of pressure, temperature, humidity, and wind at a central site and 3 boundary facilities in the LSA-SW (see Figure 3-5). These data were collected and processed by the DOE ARM Program and archived at the DOE/ORNL. Data for the GIST period were extracted and forwarded to the OFPS.

NOAA Wind Profiler Demonstration Network (WPDN) Data - The NOAA WPDN routinely collected vertical profiles of hourly component winds (u, v, and w) and six-minute radar return spectral moments both with 250 meter resolution. These data were taken at about 200 km spacing over Oklahoma and Kansas and about 450 km spacing over the central U.S. for a total of 28 sites. The data were routinely collected and processed by NOAA/FSL and archived at NOAA/NCDC. Data for the LSA-SW (Figure 3-12) were extracted and forwarded to the OFPS.

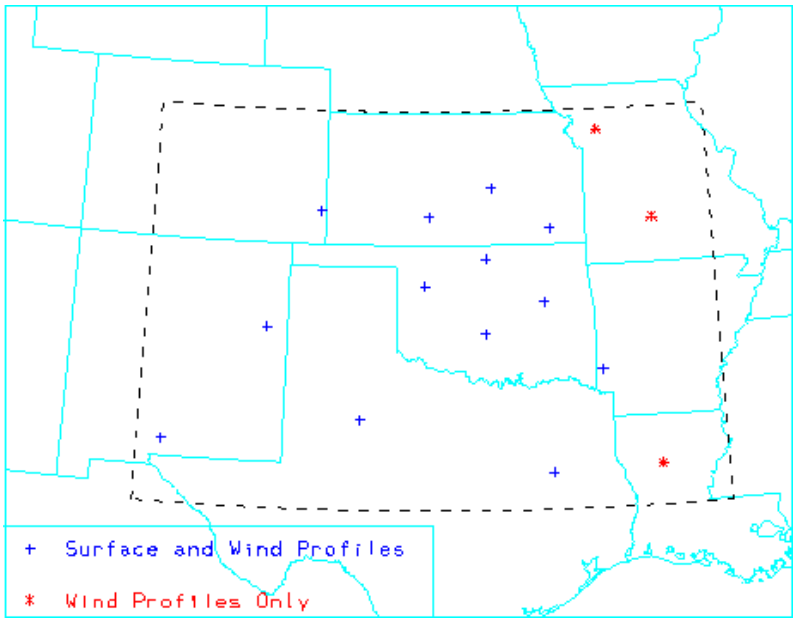


Figure 3-12 NOAA WPDN locations within the LSA-SW.

VORTEX Fixed and Mobile Site Upper Air Data - During the VORTEX-94 period (1 April to 15 June 1994) 10-sec vertical resolution upper air observations were obtained at up to two fixed sites (Ardmore, Oklahoma and Lubbock, Texas) and five mobile platforms [four National Severe Storms Laboratory (NSSL) and one National Center for Atmospheric Research (NCAR) platform(s)]. Data were collected only on selected days and at no specified schedule. The data were processed and archived both at NCAR/Surface and Sounding Systems Facility and OFPS.

3.1.3 Radar Data

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

WSI Reflectivity Composite Imagery - The Weather Services International (WSI) routinely produced and distributed a mosaic of reflectivity from all NWS radars in the conterminous United States. The product, called NOWRAD, was available at a variety of resolutions and coverages in real time. For GIST, 2 km data were recorded at 15 minute intervals in a fixed sector overlaying the LSA-SW. From this dataset a representative daily image was selected at 12 UTC, or the closest available time, to coincide with the NOAA/National Meteorological Center [NMC; presently the National Centers for Environmental Prediction (NCEP)] Eta model daily weather map imagery and the GOES-7 infrared image. The selected daily images were translated to GIF (Graphical Interchange Format). These are available online for browsing purposes. The full 15-min dataset in its original format is available directly from OFPS. These images were obtained at the OFPS from the NOAA/National Severe Storms Forecast Center (NSSFC; presently the Storm Prediction Center) in Kansas City, MO.

ABRFC Stage III WSR-88D Data - The ABRFC routinely produced an hourly composite derived precipitation product from all the WSR-88D radars covering the Arkansas-Red River basins. These data are on a 4 km by 4 km grid and are in GRIB (GRId point values expressed in Binary format). These data were archived by NOAA/OH together with the Digital Precipitation Array and the Supplemental Precipitation Product (Stage I) and the Stage II hourly Precipitation Processing System products. Data for the GIST period were extracted and forwarded to OFPS. The OFPS provides daily 24-hr total precipitation estimate GIF imagery for online browse purposes.

NASA/MSFC National Radar-derived Precipitation Rate Composite - The NASA/Marshall Space Flight Center (MSFC) produced precipitation rate imagery by converting WSI composite radar data to rainfall rates using the Z-R relation that is the default equation used by the NWS WSR-88D radars to generate a rainfall product. These are available from NASA/MSFC/Global

Hydrology and Climate Center (GHCC) Distributed Active Archive Center (DAAC) with 8 km resolution in either GIF or HDF (Hierarchical Data Format). These files were translated to GIF and provided to OFPS. OFPS selected representative daily imagery at 1200 UTC (or the closest available time) and they are available for online browse purposes.

3.1.4 Land Characterization Data

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

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

3.2 SATELLITE DATA

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

GOES-7 Satellite Imagery (IR, VIS, 6.7 micron) - Most of the satellite data for GIST were obtained from the geosynchronous Geostationary Operational Environmental Satellite (GOES-7) positioned near 112° longitude. The primary instrumentation on GOES-7 was the Visible (VIS) and Infrared (IR) Spin-Scan Radiometer (VISSR) which produced both day and night IR (10.5 to 12.5 micrometers) and day VIS (0.5 to 0.7 micrometers) radiometric images of the full disk at 30-min intervals. In addition, the VISSR Atmospheric Sounder (VAS) sensor had four IR detectors and 12 narrow band filters that produced multi-spectral data [from 14.73 to 3.95 micrometers]. During GIST, image frequency was occasionally increased by placing the satellites into Rapid Interval Scan Operations Plan (RISOP) mode or "Rapid Scan". Under RISOP, up to 12 VIS/IR images per hour could be obtained depending on location of interest. Note that during RISOP, normal, scheduled VAS operations could have been suspended or changed. These data were 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 LSA-SW, OFPS collected visible and infrared imagery every 30-min and water vapor (6.7 micrometers) imagery every hour from the NOAA/NSSFC.

GOES-7 VAS Data/Derived Products - The GOES-7 VISSR Atmospheric Sensor (VAS) provided IR radiance observations at 12 wavelengths between 3.9 and 14.7 micrometers as well as two imaging modes (6.9 to 13.8 km resolution) and a sounding mode (13.8 km resolution). Meteorological parameters derived from VAS (for clear and partly cloudy areas) include: cloud cover, earth/cloud temperatures, cloud type, cloud motion derived winds, stereo derived cloud-top heights, water vapor fields, temperature fields, improved surface temperatures, and temperature and moisture profiles (dwell soundings). The interval and number of dwell soundings and derived products depended upon whether the satellites are in normal operation or RISOP mode. VAS data were routinely archived by NOAA/NESDIS/ NCDC at the University of Wisconsin's SSEC.

NOAA Polar Orbiting Environmental Satellite (POES) AVHRR Imagery - Two NOAA series Polar Orbiting Environmental Satellites (POES; NOAA-11 and NOAA-12) carried 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 were routinely collected, processed, and archived at NOAA/NESDIS/NCDC.

NOAA POES TOVS Data - Two NOAA series polar orbiting satellites (NOAA-11 and NOAA-12) carried 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 were collected (1600 km swath) during subsequent sun-synchronous morning/evening ascending and descending passes (up to 4 passes daily). TOVS data were 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 three near polar orbiting satellites (F8, F10, and F11) that provide global microwave data from the Special Sensor Microwave Imager (SSM/I). The SSM/I sensor provides water vapor measurements (1400 km swath) at three

frequencies (19.35, 37.0, and 85.5 GHz). The satellites operate in pairs to provide sun-synchronous SSM/I data primarily during dawn/dusk and noon/midnight ascending and descending passes (up to 4 passes total daily). NOTE - that no 85.5 GHz data are available from F8. DMSP data were 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 were created on a hemispheric map and faxed to the NCDC from the NESDIS Synoptic Analysis Branch. The analysis was done over a 7-day period and extends from 35° to 67° N latitude. Because of the use of satellite techniques, the analysis was not done beyond 67° N latitude since there were mostly dark hours. The categories in the analysis were 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, GMS (Geostationary Meteorological Satellite), and METEOSAT (Meteorological Satellite). These analyses were archived at NCDC and are available via FAX subscription.

CLAVR Clouds - The CLouds from AVhRr (CLAVR) products were undergoing improvement during the GIST period. Prototype datasets were being generated. Please contact the GCIP Satellite Data Source Module (SDSM) for access information.

EDC Bi-Weekly Vegetation Index Data - Satellite-derived values of vegetation index were 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 were produced bi-weekly from 1 km resolution AVHRR and translated to GIF by the USGS EDC. The full land characteristics database is available on CD-ROM from EDC. GIF imagery data for the GIST period were extracted and forwarded to the OFPS from the EDC.

CAGEX Products - The CERES (Clouds and the Earth's Radiant Energy System)/ARM/ GEWEX Experiment (CAGEX) is intended to foster the development of algorithms for the retrieval of vertical profiles of broadband radiative fluxes with satellite data. CAGEX provides satellite-based cloud properties, atmospheric sounding data, and other necessary input parameters that are sufficient for broadband radiative transfer calculations. Version 1 of CAGEX occurred in April 1994. The geographical areal extent was a 3 by 3 0.3° grid centered over the ARM central facility (Figure 3-13). The temporal resolution was half- hourly time steps during daytime hours (1409-2239 UTC). There were no nighttime data. The vertical resolution was variable, with 45-50 levels depending on the surface pressure. From the surface to 40 mb above the surface the levels were at 10 mb increments, from 40- 100 mb above the surface the levels were at 20 mb increments. Then from 100 mb above the surface to 700 mb the levels were at 25 mb increments. Then from 700-100 mb the levels were at 25 mb intervals (i.e. start constant pressure level data). Above 100 mb there were eight variously spaced levels. Satellite products include cloud retrievals from the layered bi- spectral thresholding method applied to GOES-7 VIS and IR images (Minnis et al. 1995). These include low, middle, high, and total values for cloud fraction, cloud center and top temperature and height, cloud thickness, VIS and IR optical depths, cloud reflectance, cloud albedo, and cloud IR emissivity. These data were archived at NASA/Langley Research Center. Further information and data are available via the following URL:

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

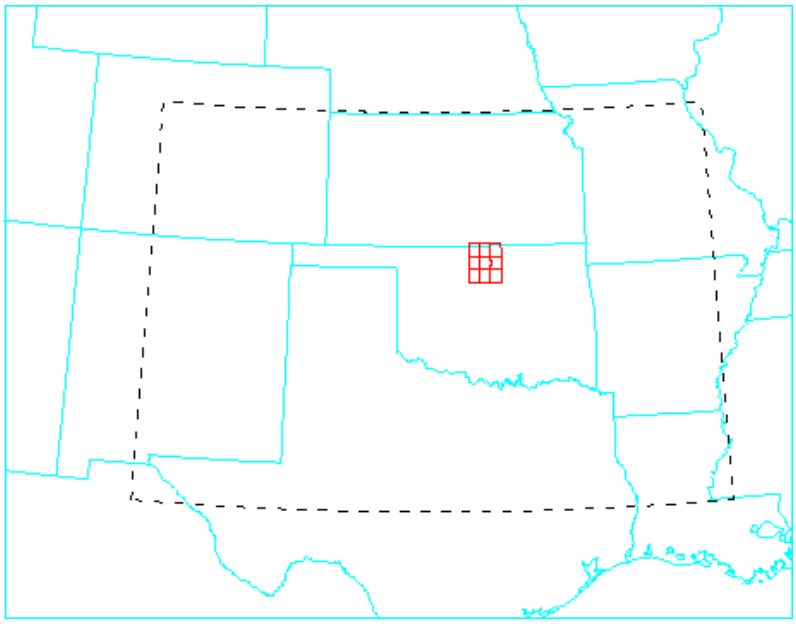


Figure 3-13 CAGEX domain (denoted by the solid line grid).

Synthetic Aperture Radar (SAR) Data for the Little Washita Watershed - Data for the spring and fall 1994 field exercises were collected by the NASA, USDA/ARS, and Princeton University scientists involved. A dataset was later compiled on CD-ROM and has been distributed through the NASA/GSFC Hydrological Sciences Branch. The Satellite Data Source Module (SDSM) has taken that CD and put the data online via the GCIP SDSM home page. The duration of the data online via the home page is uncertain. However, the satellite module will maintain a copy of the CD should users require the data. Please see the online WWW home pages for further information or contact the SDSM.

3.3 MODEL OUTPUT

3.3.1 Atmospheric model output

The following atmospheric model output are 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 GIST was on the regional mesoscale models with output from the following four models:

(i) NOAA/NMC Eta Model
(ii) Atmospheric Environment Service/Canadian Meteorological Centre (AES/CMC) Regional Finite Element (RFE) Model
(iii) NOAA/FSL Mesoscale Analysis and Prediction System (MAPS) Model
(iv) NOAA/FSL Local Analysis and Prediction System (LAPS) 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 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 Dataset (MORDS).
(3) Gridded three-dimensional atmospheric fields containing all of the atmospheric variables produced by the models.

NOAA/NMC Eta Model Output - The NOAA/NMC provided operational output from its regional Eta model including output from the Eta Data Assimilation System (EDAS). The Eta operated in analysis and forecast cycles at 6-hr intervals with forecasts provided up to 24 hours. The EDAS was also run at the intermediate 3-hrly intervals to produce eight analyses per day. The horizontal resolution of the Eta model output provided to GCIP was constant at a 40 km resolution independent of the resolution of the operational model. The vertical resolution of the 3-D atmospheric fields provided to GCIP was constant (25-mb intervals from 1000 to 50 mb) independent of the resolution of the operational model. These data were archived by NCAR/SCD.

NOAA/NMC Eta Initial Analysis Daily GIFs - The NSSL routinely collected NOAA/NMC Eta model initial analyses. The OFPS received these analysis plots and converted them to GIF imagery. The Eta model analysis covers most of North America, and images are available for the 12 UTC Eta model run at 1000, 850, and 500 mb. GIF imagery for the GIST period are available for the purpose of summarizing the surface and upper-air conditions during GIST. These output were archived by OFPS.

NOAA/NMC Eta Model Location Time Series (MOLTS) - The NOAA/NMC Eta model provided vertical and hourly time series of model output (MOLTS) at selected locations. The output variables of the Eta MOLTS during the GIST period are shown in Table 3-2. The Eta MOLTS output were available from 257 locations over North America. Within the LSA-SW there were 67 locations (Figure 3-14). Depending on the surface pressure, there were up to 38 vertical levels. Output were provided from the 00 and 12 UTC model runs from the initial analysis time out to the 48 hour forecast. These output were available only for the period from 16 July to 31 August 1994 and were archived in BUFR (Binary Universal Form for Data Representation) format at NCAR/SCD.

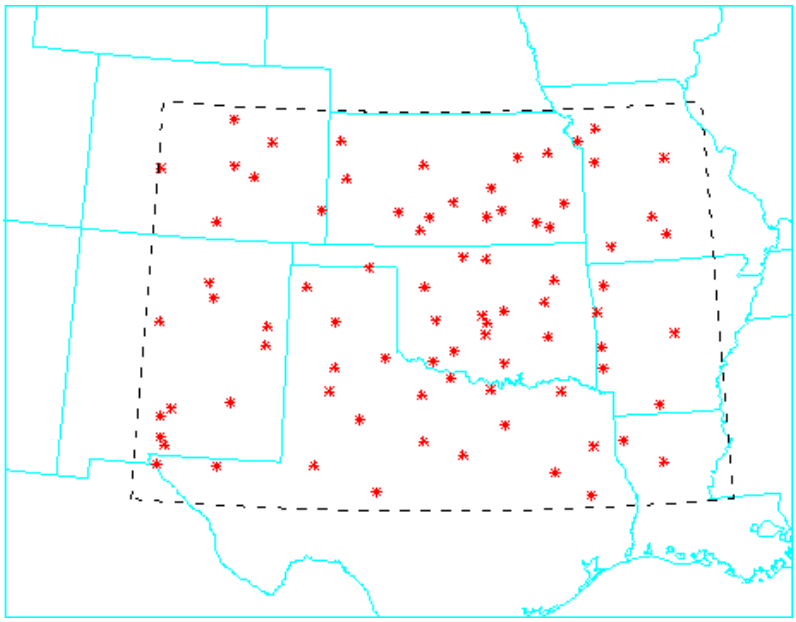


Figure 3-14 NOAA/NMC Eta MOLTS locations within the LSA-SW.

TABLE 3-2 Output Variables for the Eta Model MOLTS

1) Identifiers

Location identifiers
Valid date/time
Latitude/Longitude/Elevation

2) Surface Parameters

Mean sea level pressure
Surface pressure
Skin temperature
Minimum temperature over hour
Maximum temperature over hour
Surface moisture availability
Total precipitation in last hour
Convective precipitation in last hour
Snow precipitation type
Ice pellet precipitation type
Freezing rain precipitation type
Rain precipitation type
Latent heat flux
Potential flux of latent heat
Sub-surface heat flux
Sensible heat flux
Snow phase-change heat flux
Short-wave radiation flux downward
Short-wave radiation flux upward
Long-wave radiation flux downward
Long-wave radiation flux 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
Bottom soil temperature
Roughness length

3) Atmospheric Variables at Each Model Vertical Level

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

Eta MOLTS Derived Sounding Output - OFPS extracted the MOLTS output from the locations within the LSA-SW for the Eta model (see Figure 3-14). These output were then processed and converted to a format similar to that used by OFPS for the actual atmospheric sounding data (i.e. NWS, VORTEX, and ARM/CART). This was done by stripping out the state parameters at the surface and each model level. Only the 00 hour initial analysis time was processed. Output are available for each model analysis time (00 and 12 UTC). These output are provided to allow intercomparison studies. These output were available only from 16 July to 31 August 1994 and were archived at OFPS.

AES/CMC RFE Model Output - The AES/CMC provided operational output from the RFE model including output from its data assimilation system. The RFE operated in analysis and forecast cycles at 6-hr intervals with forecasts up to 24 hours. The horizontal resolution of the model was 50 km over the LSA-SW. The vertical resolution was 23 levels at a variable spacing. Model output were archived by the AES/CMC.

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) was 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 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 3-3. The output from the three models may not include all of the variables listed in Table 3-3, and this fact will be a part of the metadata provided with the specific model output. For the GIST period only the Eta and RFE models provided MORDS output. For information on the Eta output contact the NCAR/SCD. The RFE MORDS output were archived by AES/CMC.

TABLE 3-3 MORDS Output Variables

Near-Surface Fields

Mean sea level pressure
Surface pressure at 2 m

Temperature at 2 m
Specific humidity at 2 m
U component of the wind at 10 m
V component of the wind at 10 m
Surface latent heat flux (time average)
Surface sensible heat flux (time average)
Ground heat flux (time average)
Snow phase change heat flux (time average)
Surface momentum flux (time average)
Vertically integrated moisture convergence (time average)
Vertically integrated energy convergence (time average)
Total precipitation (time accumulated)
Convective precipitation (time accumulated)
Surface runoff (time accumulated)
Subsurface runoff (time accumulalted)
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

NOAA/FSL MAPS Model Output - The NOAA/FSL ran the MAPS model every 6 hours (00, 06, 12, and 18 UTC) with up to 6 hour forecasts at a standard resolution of 60 km over the LSA-SW during the VORTEX project. Standard fields were available at 25 levels from the surface to 100 mb. The data cutoff for model runs was approximately 1 hour, and the output format was GRIB. Since this model was run to support VORTEX, output for the LSA-SW are available for 1 April through 15 June only. These output are available from the OFPS.

NOAA/FSL LAPS Model (10 km and 2 km) Output - The NOAA/FSL ran the LAPS model every 6 hours (00, 06, 12, and 18 UTC) with up to 6 hour forecasts at a resolution of 10 km and a subset area of 2 km over the LSA-SW during the VORTEX experiment. Standard fields were available at 25 levels from the surface to 100 mb. The data cutoff for model runs was approximately 1 hour, and the output format was GRIB. Since this model was run to support VORTEX, output for the LSA-SW are available for 1 April through 15 June only. These output are available from the OFPS.

3.3.2 Hydrologic model output

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

The NWSRFS Sacramento model output includes values every six hours of all of the available elements of the daily water budget: precipitation, runoff (surface runoff and baseflow), evaporation and soil moisture storage for individual soil moisture accounting (SMA) areas and the downstream routed streamflows. These output sets enable surface water budgets to be made over large areas for verification of atmospheric and coupled atmospheric- hydrological models. Table 3-4 lists the RFC model outputs proposed by the NOAA/OH.

TABLE 3-4 RFC Hydrological Six-hour Sacramento Model Outputs Proposed by NOAA/OH for GCIP

Mean Areal Precipitation
Mean Areal Air Temperature
Mean Areal Snow Water Equivalent1
Percent of Areal Extent of Snow Cover
Heat Deficit in the Snow Pack
Mean Areal Rain Plus Melt from Snowmelt Model
Mean Areal Potential Evaporation2
Upper Zone Tension Water Storage
Upper Zone Free Water Storage (UZFW)
Lower Zone Tension Water Storage
Lower Zone Primary Free Water Storage
Lower Zone Secondary Free Water Storage
Additional Impervious Area (fraction of basin area)
Impervious runoff from permanent impervious areas and direct runoff from temporary impervious areas
Surface runoff when UZFW is full and precipitation intensity exceeds the rate of percolation and interflow
Interflow resulting from the lateral drainage of the UZFW
Supplementary Baseflow
Primary Baseflow
Subsurface Outflow
Total Runoff
Streamflow from SMA at outlet
Routed Streamflow from Areas Above SMA
Forecast Streamflow After Blending with Observed Streamflow
Computed SMA Daily Evaporation for Model Water Balance3

1Snow water equivalents and snowmelt may be calculated for several contour increments within an SMA in mountainous areas.
2Mean areal potential evaporation is computed on a daily basis and the six-hour values are simply 1/4 of the daily total.

3Because the potential evaporation forcing is a daily average, the six-hour evaporation amounts do not include diurnal variability and a daily sum is given.

4. SPECIAL PROCESSING

This section includes summaries of some of the special processing that occurred relative to data collected during GIST.

4.1 In-Situ

The quality control (QC) of the surface and precipitation composites created for GIST is discussed in this section. Detailed descriptions of the components of the composite datasets were provided in section 3. Uniform QC procedures were applied during the compositing process. A brief description of the QC procedures for the Surface Composites and Precipitation composites is given in the remainder of this section.

4.1.1 QC of GIST Surface Composites

The GIST 5-min and hourly surface composites were formed by an aggregation of datasets from several surface meteorological networks (Figure 4-1). This figure is for the hourly surface composite, the 5-min composite was similar except only the ASOS, ARM surface, and Oklahoma Mesonet data were used. Each dataset was quality controlled by comparing the station observations with the MAPS hourly gridded surface analyses (Scully and McGuirk 1993). A copy of this paper is included in Appendix A.

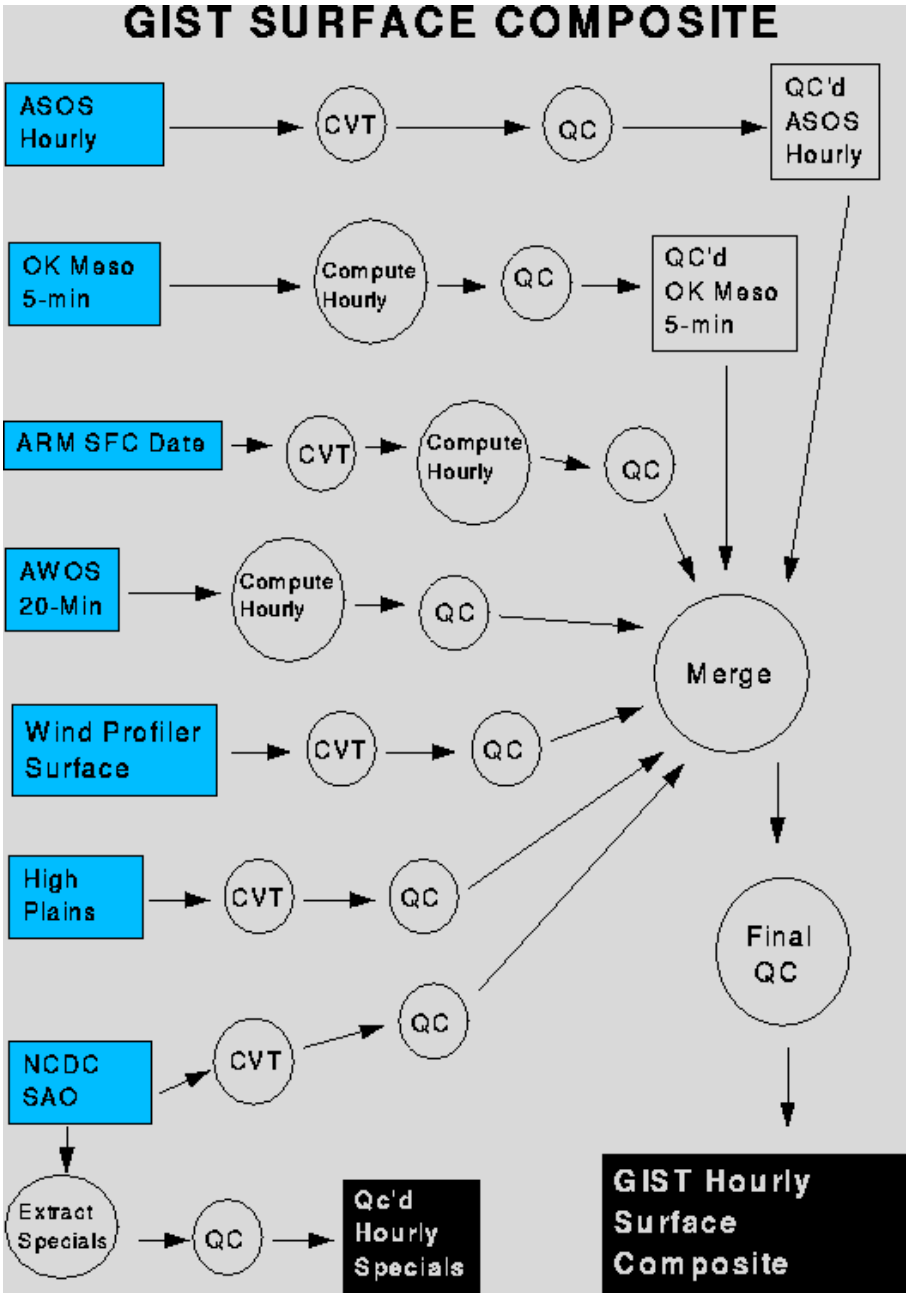


Figure 4-1 Schematic diagram of the compositing and quality control procedures conducted for the GIST hourly surface composite.

Hourly MAPS gridded values were interpolated to a station's latitude, longitude, elevation, and observation time. These interpolated MAPS analysis values were then compared to the observed values. This procedure was conducted only for the station pressure, sea level pressure, temperature, dew point, wind speed, and wind direction. Based on these comparisons the observed values were flagged as "good", "questionable", or "unlikely". Data were not changed by this procedure, only flagged. Table 4-1 shows the allowed variances from the MAPS values for each parameter. The calculated sea level pressure was not quality controlled on its own unless the station pressure was missing. If the station pressure was not missing, the flag applied to it was also applied to the calculated sea level pressure.

Some additional general consistency checks were applied to the dry bulb temperature, wind direction, and the relationship between precipitation and cloud amount/cover. If the dew point temperature was greater than the dry bulb temperature, both values were flagged as "questionable". Also, the wind direction for observed "calm" winds was given the same flag as the wind speed. If precipitation was reported, but the cloud amount was "none" or "clear", then both the cloud amount and precipitation values were flagged as "questionable". Also, several impossible values were checked. Negative wind speeds and wind directions less than 0° or greater than 360° were flagged as "unlikely".

TABLE 4-1 Allowable Variance from MAPS Analysis Parameter Values

Parameter	Good	Questionable	Unlikely
Station Pressure	< 2 mb	2–5 mb	>= 5 mb
Sea Level Pressure	< 2 mb	2–5 mb	>= 5 mb
Calculated Sea Level Pressure	< 4 mb	4–10 mb	>= 10 mb
Dry Bulb Temperature	< 2.5°C	2.5–5°C	>= 5°C
Dew Point Temperature	< 2.5°C	2.5–5°C	>= 5°C
Wind Speed	< 5 ms-1	5–10 ms-1	>= 10 ms-1
Wind Direction (wind speed < 10 ms-1)	< 90°	90–180°	>=180°
Wind Direction (wind speed > 10 ms-1)	< 50°	50–90°	>= 90°

4.1.2 QC of GIST Precipitation Composites

The GIST 15-min, hourly, and daily precipitation composites were 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 were produced in a similar fashion except that they used other segments of the data as described in section 3.1.1. Each dataset was quality controlled by the use of a series of global limit checks.

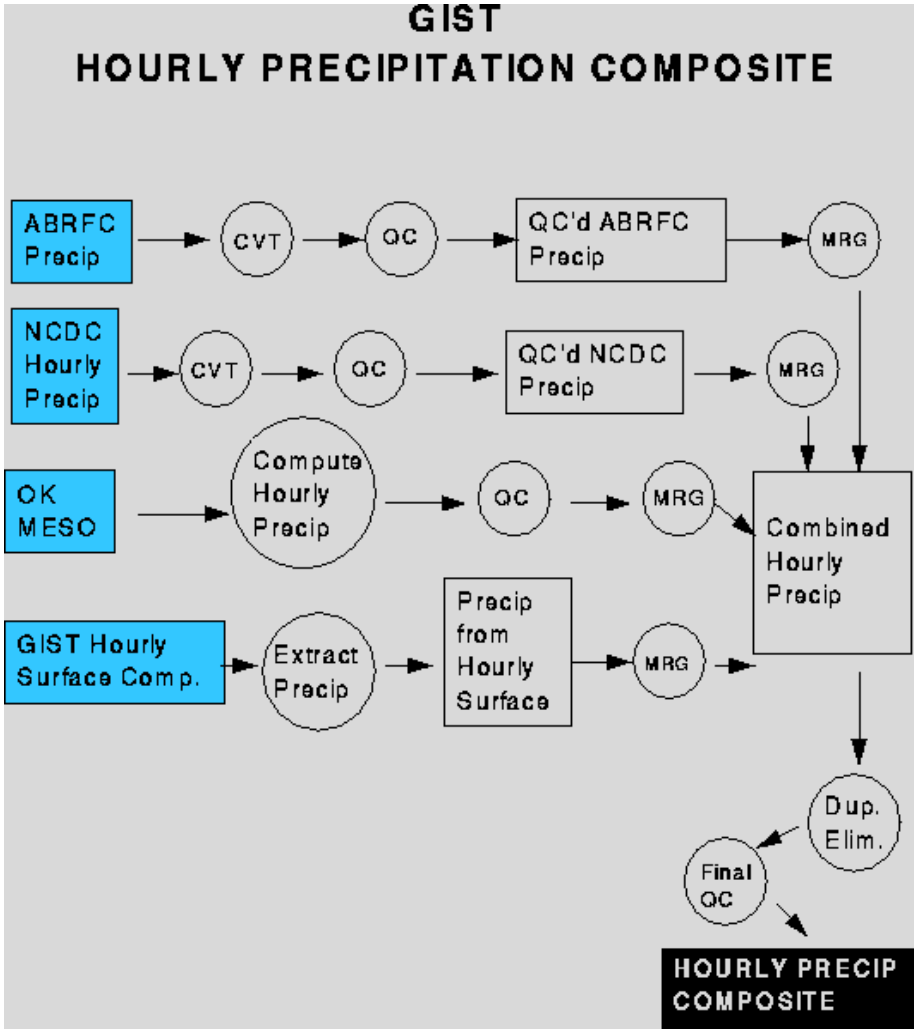


Figure 4-2 Schematic diagram of the compositing and quality control procedures conducted for the GIST hourly precipitation composite.

Gross limit checks were used to determine the quality of the precipitation values (Table 4-2). Several of the "questionable" and "unlikely" data were also manually inspected. After inspecting, the QC flag could have been manually modified to better reflect the physical reasonableness of the data. Again, data were never modified, only flagged. Also, negative precipitation values were flagged as "unlikely".

TABLE 4-2 QC Limits Applied to Precipitation Values for GIST Precipitation Composites

Parameter	Good	Questionable	Unlikely
5-minute Precipitation	< 10 mm	10-25 mm	>= 25 mm
Hourly Precipitation	< 25 mm	25-75 mm	>= 75 mm
Daily Precipitation	< 101.6 mm	101.6-127 mm	>=127 mm

5. DATA DISSEMINATION

Data for the GIST are 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 GIST On-line Data Access

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

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

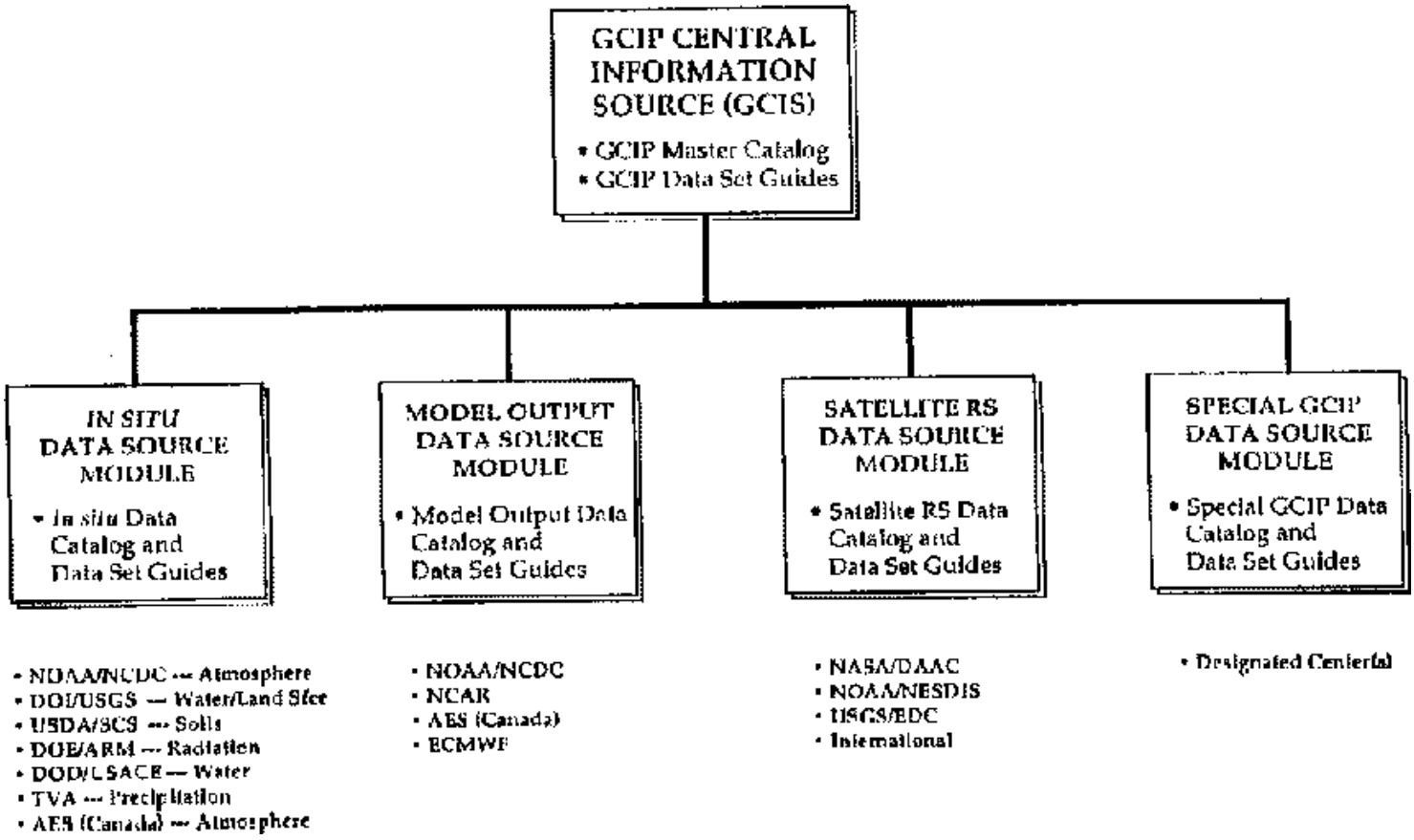


Figure 5-1 Organization of the GCIP DMSS.

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 has not yet been implemented.

5.1.1 The In-situ Data Source Module

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

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

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

CODIAC System Access via the WWW

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

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

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

5.1.2 The Satellite Remote Sensing Data Source Module

The GCIP Satellite Remote Sensing Data Source Module (SDSM) was identified to be the NASA/Marshall Space Flight Center Distributed Active Archive Center (MSFC-DAAC). Activities will be transferred from the DAAC in the first quarter of 1997. The GCIP SDSM coordinates and identifies datasets relevant to GCIP efforts such as the GIST. Additionally, GIST 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://wwwdaac.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, Data Support Section. This module is the primary point of contact for the Eta model output. This module does not currently have a WWW home page, but one has been proposed. The Data Support Section has a home page on the WWW at the following URL:

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

The NCEP has a GCIP home page that provides detailed information on the various Eta model output including the 3-D and 2-D 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 GIST CD-ROM

A subset of the datasets that are available through CODIAC have been published on a CD-ROM. Table 5-1 provides a summary of these datasets. Detailed descriptions of the datasets were provided in Section 3.0. Companion software tools are available to browse and display the data (i.e., areal plots, time series plots, altitude plots, image displays). These tools are 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 is 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 GIST CD-ROM Dataset Contents

Surface

GIST Hourly Surface Land Composite Data
GIST 15-min Precipitation Composite Data
GIST Hourly Precipitation Composite Data
GIST Daily Precipitation Composite Data
NCDC Cooperative Observer Network Data (Summary of the Day)
USGS Streamflow Data
USGS Reservoir Data
ABRFC Precipitation Data
NCDC SAO "Specials" Data

Upper Air

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

Imagery

ABRFC Stage III Daily Accumulated Precipitation Estimate Composites
Daily 1200 UTC GOES-7 at 4-km resolution Infrared Satellite Image
Daily 2100 UTC GOES-7 at 2-km resolution Visible Satellite Image
Daily 1200 UTC GOES-7 at 8-km resolution 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 Precipitation Rate Composite
WSI 1200 UTC NOWRAD Composites

Documentation

File Descriptions
Station Lists

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* Datasets are published in compressed format.

TABLE 5-2 Contents of USGS Geographic Reference Dataset (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

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IGPO (International GEWEX Project Office), 1994b: *Implementation Plan for the GEWEX Continental-Scale International Project (GCIP) - Volume III - Strategic Plan for Data Management*. IGPO Publication Series *No. 8*, IGPO, Washington, D.C.

IGPO (International GEWEX Project Office), 1994: *Major Activities Plan for 1995, 1996 and Outlook for 1997*. IGPO Publication Series *No. X*, IGPO, Washington, D.C.

Minnis, P., W. L. Smith Jr., D. P. Garber, K. Ayers, and D. P. Doelling, 1995: Cloud Properties Derived From GOES-7 for Spring 1994 ARM Intensive Observing Period Using Version 1.0.0 of ARM Satellite Data Analysis Program. NASA Reference Publication 1366.

Scully, K. W., and D. E. McGuirk, 1993: The use of MAPS analyses for quality control of surface observations from STORM-FEST. Preprints, *Eighth Symposium on Meteorological Observations and Instrumentation*, Anaheim, California, Amer. Meteor. Soc., 17-22.

US Department of Commerce, 1988: Federal Meteorological Handbook No. 1, Surface Observations. FCM-H1-1988, Office of the Federal Coordinator for Meteorological Services and Supporting Research, Washington, D. C.

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APPENDIX A

THE USE OF MAPS ANALYSES FOR QUALITY CONTROL OF SURFACE OBSERVATIONS FROM STORM-FEST

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1. INTRODUCTION

The STORM-FEST (STormscale Operational and Research Meteorology - Fronts Experiment Systems Test) field program was held in the central United States February 1 through March 15, 1992. As part of the experiment, surface observations were collected from a variety of national, regional, state and research networks. These observations were converted to a common format and combined into two composite datasets: one contains hourly data, the other 5-minute data.

Over 10 million observed values of 6 common parameters have been incorporated into the composite datasets. Because of the large number of observations collected and the desire to provide this data to the research community as quickly as possible, it was necessary to automate the quality control function as much as possible and to do so in a way that did not require extensive software development. As a result, we chose to quality control these datasets by comparing the observations with the MAPS (Mesoscale Analysis and Prediction System) hourly gridded surface analyses.

2. QUALITY CONTROL PROCEDURE

The MAPS analyses are created hourly with data ingested in near real time. Much of these data are included in the STORM-FEST composites but the STORM-FEST sets also include data from several observation platforms that are not included in the MAPS analyses. The MAPS system pre-processes the data applying its own quality control checks which includes sophisticated checks for horizontal consistency ("buddy checks"). The observations are then interpolated to a 60 km grid.

We obtained the MAPS surface analyses for the STORM-FEST time period and compared them to STORM-FEST observations. For each station the adjacent MAPS gridded values were interpolated to the station latitude, longitude, elevation and observation time and were then compared to the observed values. Observations were flagged as "good", "questionable" or "unlikely" based on this comparison with MAPS. Maximum variance levels were defined for each parameter and were used to determine the appropriate quality control codes. Station pressure, sea level pressure, temperature, dew point, wind speed and wind direction were checked in this way. Table 1 lists the variance levels we used in the comparison.

TABLE 1
Allowed variance from MAPS values

Parameter	Unlikely	Questionable
Station Pres	10.00 mb	3.00 mb
Sea Level Pres	10.00 mb	3.00 mb
Dry Bulb Temp	8.00 C	5.00 C
Dew Point Temp	8.00 C	5.00 C
Wind Speed	20.00 m/s	5.00 m/s
Wind Direction	----	90.00 deg

3. RESULTS

99.5 % of these 6 parameters were checked. The remaining .5% could not be checked because of gaps in the MAPS data. Tables 2 and 3 provide some summaries of quality control results by parameter and by observational platform.

TABLE 2
Results by parameter for hourly data (% of total obs)

"G" = "Good"
"U" = "Unlikely"
"Q" = "Questionable"

Parameter	"G"	"U"	"Q"
Station Pressure	99.0	0.2	0.9
Sea Level Pres	98.9	0.4	0.7
Dry Bulb Temp	96.2	2.2	1.7
Dew Point Temp	96.8	0.9	2.3
Wind Speed	98.0	<0.1	1.9
Wind Direction	95.1	<0.1	4.9

TABLE 3
Results by platform for hourly data (% of total obs)

"G" = "Good"
"U" = "Unlikely"
"Q" = "Questionable"

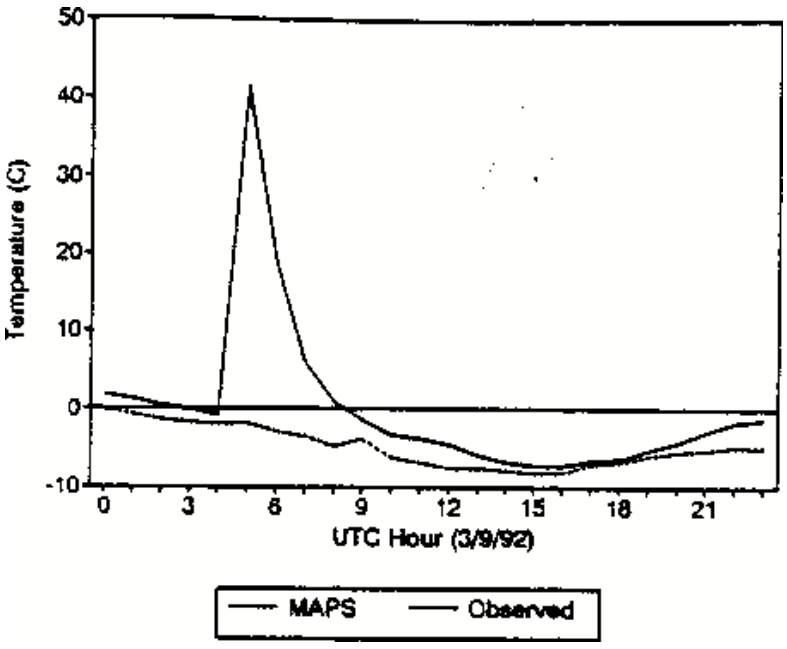
Parameter	"G"	"U"	"Q"
ASOS	97.0	0.8	2.2
AWOS (Qualimetrics)	98.8	0.1	1.2
AWOS (Handar)	>99.9	<.1	<0.1
NCAR PAM	96.3	0.4	3.3
Nebraska High Plains	94.7	2.2	3.2
Illinois Water Survey	99.1	<.1	0.9
PROFS	86.4	1.4	12.2
Wind Profiler	97.8	<.1	2.1
NCDC SAO's	98.8	0.3	0.9
All platforms	97.6	0.5	1.9

4. CASE STUDIES

Six case studies are presented to demonstrate the effectiveness of this method under different meteorological situations.

4.1 Random data spikes

The first case shows sharp spikes in the temperature observations at the Gudmundsen station in the Nebraska High Plains network. Hours 6-8 were flagged unlikely and hour 9 as questionable. These spikes were very large and fell outside the variance limits. Smaller spikes would not have been caught as they would fall within the established temperature variance limits.

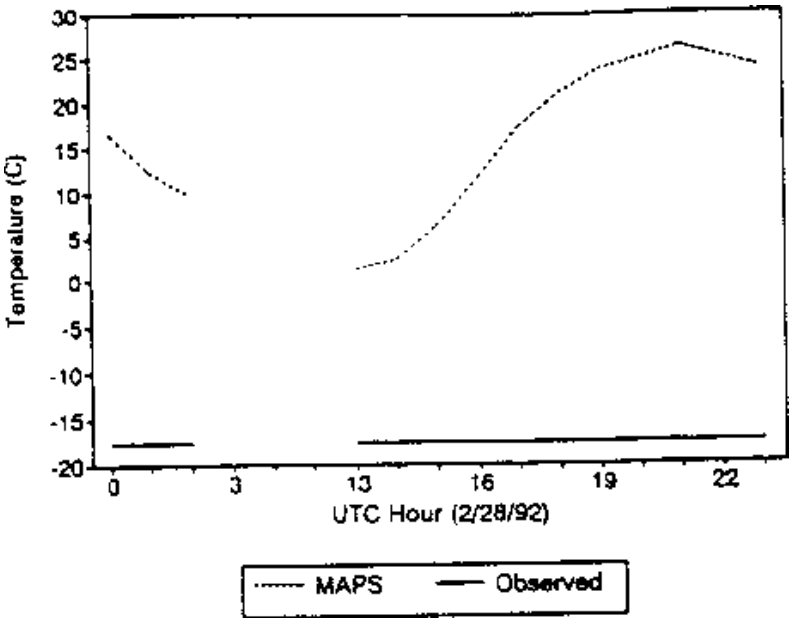


Case 1. Temperature spike at Gudmundsen, NE on March 9, 1992.

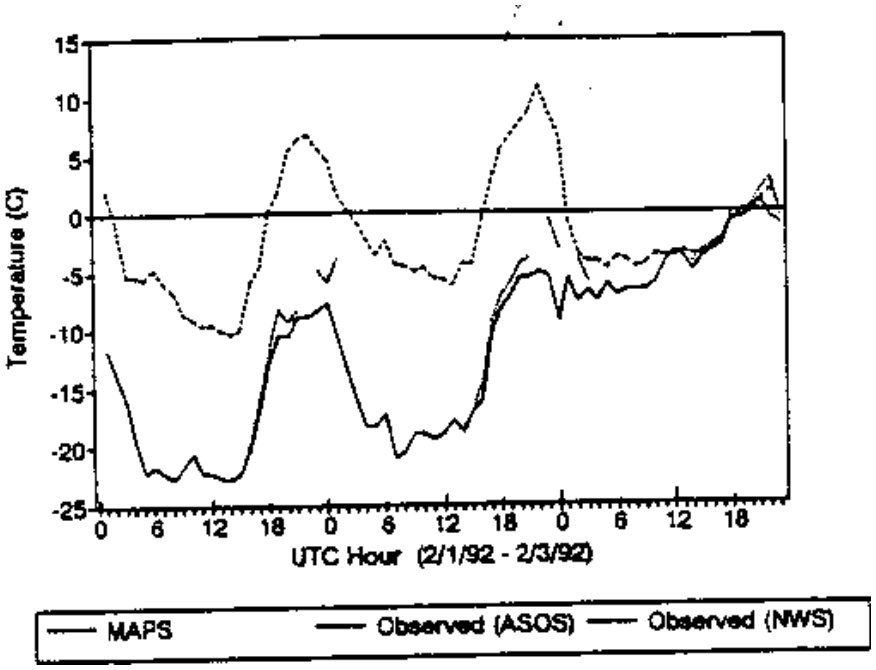
4.2 Faulty gauges

Cases 2 and 3 show situations where a gauge was stuck. In case 2 the temperature gauge at the Clinton-Sherman station in Oklahoma read -17.75 (C) (or 0 F) for every observation reported for the entire 6 weeks of the STORM-FEST program. This was significantly colder than anything contained in the MAPS analyses for the length of the program so all of these values were correctly flagged as unlikely.

Case 3 illustrates a pressure gauge that was stuck at a value of 1012.99 mb for the entire field program at the Pt. Piedras Blancas station in California. The pressures in the MAPS analyses oscillated higher and lower around this value over the 6 week period. When MAPS was significantly above or below this value the observation was correctly flagged as unlikely. However, as the pressure at this station approached and passed through the 1012.99 mb level it compared well with the MAPS analyses value and was incorrectly flagged as good. The observations were also incorrectly flagged questionable for moderately discrepant comparisons.



Case 2. Stuck temperature guage at the Clinton-Sherman, OK station on February 2, 1992.

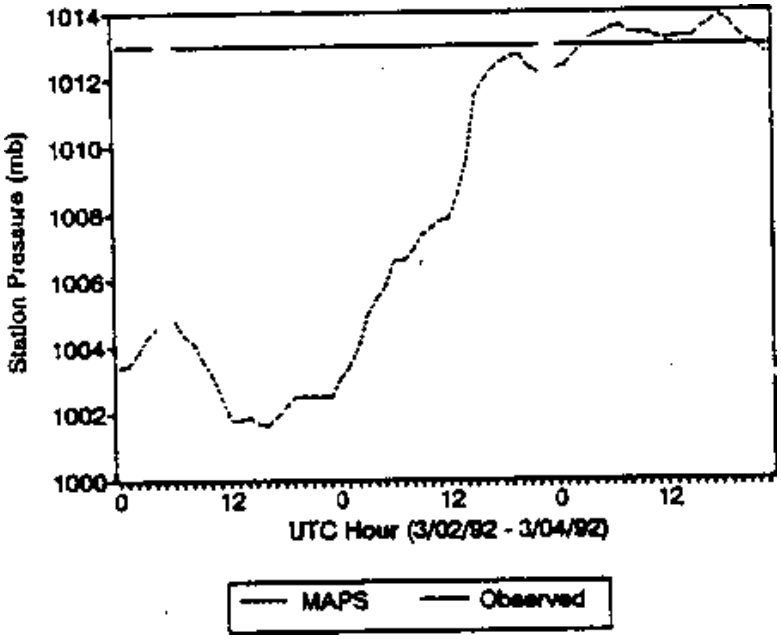


Case 3. Stuck pressure guage at the Pt. Piedras Blancas, CA station on March 2, 1992.

4.3 Sub-grid-scale effects

In case 4 the temperatures at the Alamosa, Colorado ASOS station (elevation 2299m) were compared with the MAPS analyses. Temperature observations differed greatly (as much as 17 degrees C) from the MAPS values the first two days of February but were in relatively close agreement beginning the third day. As a result, the first two days were flagged as unlikely. However, by comparing ASOS to the temperatures recorded at an NWS site also located in Alamosa, the ASOS station temperatures can be shown to be correct and MAPS incorrect. The ASOS and NWS sites were in closer agreement with each other than with MAPS.

Alamosa is set in a high mountain valley and falls approximately mid-way between the nearest MAPS grid points. When cold air pools in Alamosa, it is significantly colder than surrounding areas. Since the 60 km MAPS gridscale can not provide an accurate representation of the local topography, MAPS is not able to reflect these topographically- induced values.

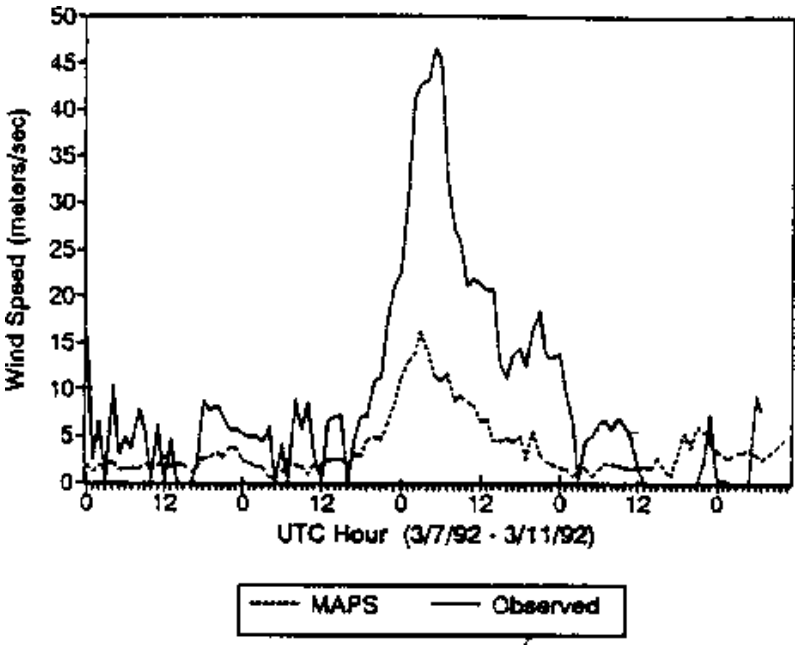


Case 4. The temperature at the Alamosa, CO ASOS station was significantly colder than the MAPS analyses on February 1-2, 1992. On February 3 the Alamosa station agrees with MAPS.

4.4 Frontal timing

Case 5 presents a situation where MAPS correctly represented frontal passage but shows the front moving through the area too soon. The example shows a major winter storm in the midwest that occurred on March 9th as it approached the St. Charles state water survey station in Illinois. MAPS shows the front, as indicated by a large temperature drop, passing through St. Charles beginning around 20 Z. The station recorded the front passing about an hour later. Also, since MAPS provides hourly analyses, it shows a gradual temperature drop. As a result, 5 minute observations in hours 21-22 Z were incorrectly flagged questionable because the front hadn't arrived yet.

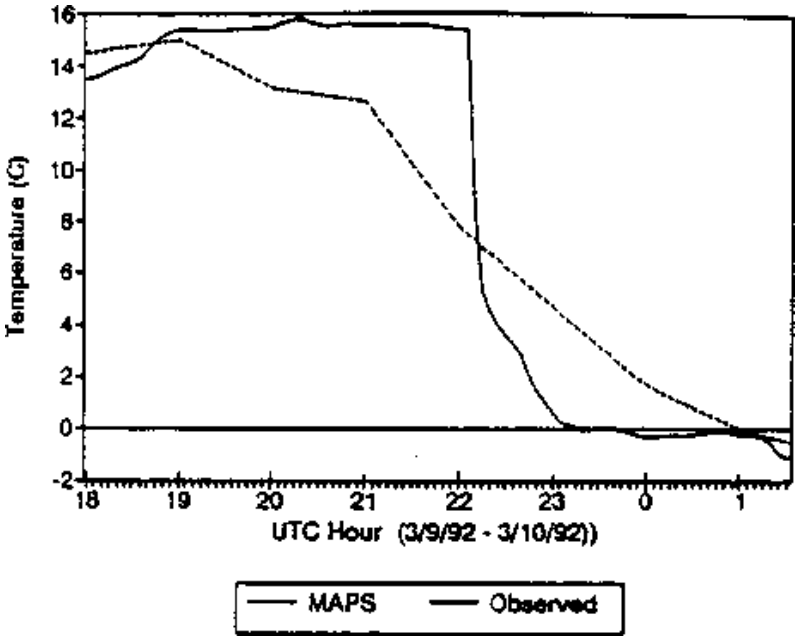
The change in temperature in the observations during the 22 Z hour also demonstrates how the temperature can drop more suddenly than hourly analyses can predict.



Case 5. The MAPS analyses represented the front moving through St. Charles, IL on March 9, 1992 about an hour ahead of what was recorded at the St. Charles State Water Survey station.

4.5 High Winds

In the previous examples we were able to tell whether the comparison to MAPS produced correct or incorrect flags by studying the details of each case. This is not possible in case 6. On March 9th, during the height of a major winter storm, the Nunn, Colorado station in the PROFS network showed some unusually high (hurricane level) wind speeds at hours 0 Z - 6 Z. Observations from 19 Z, Feb 8 to 1 Z Feb 10 were all flagged questionable. These observations were higher than those of surrounding stations and more than 20 mps higher than the MAPS analyses. However, there is no indication of instrument failure and the readings were in agreement with MAPS before and after the storm. Furthermore, this station sits near the base of the Rocky Mountains in Colorado where higher winds are not unlikely and the winds were recorded in the midst of the worst part of the storm. Further investigation will be necessary to determine the accuracy of these measurements.



Case 6. Hurricane force winds were recorded at the Nunn, CO PROFS station during a storm on March 9, 1992. Before and after the storm show MAPS and the observed values in agreement.

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5. CONCLUSIONS

Advantages:

- Quality control by comparison with MAPS analyses provided a simple means to check the quality of surface data from a variety of observation networks. Due to the large number of observations it is usually impossible to check the quality of each observation manually. This automated procedure provides a method that gives a satisfactory "first cut" check. Kickouts which need further investigation and deserve manual checking constitute less than 3% of the total.
- This qc method provides an internal check on conversion of data from platform specific formats to a common distribution format.
- For sparsely located observation points this method provides values for comparison.

Disadvantages:

- The MAPS analyses contain 9 parameters. While most of these correspond to parameters in the STORM- FEST surface composites there are many parameters in the composites that can not be checked by this method. Most of these parameters either remained unchecked or have been checked in an elementary manner (min/max values, impossible values, etc.).
- The MAPS surface analyses are hourly files which work well with the STORM- FEST hourly composite, however, the 5-minute surface composite requires an interpolation in time to determine appropriate values for comparison.
- MAPS ingests its data in real-time for use as a forecasting tool and is not primarily intended to be a data archival system. Because of this real time focus, there are occasional gaps in the MAPS data. We used an algorithm to adjust for gaps up to three hours, but where longer gaps exist the STORM-FEST data could not be checked.
- Double interpolation introduces additional uncertainties. MAPS interpolates observational data points to gridded values and we interpolated gridded values back to the observational points.
- MAPS analyses are based on a 60km grid. Local effects can be missed when a station falls between grid points.
- It is very difficult to set variance levels. Levels must be wide enough to assure that not too many "good" values are flagged incorrectly "bad", but narrow enough to capture those observations that are genuinely questionable.
- Most data flagged as "unlikely" or "questionable" were in reality "good". This can only be corrected by manually checking all of these values.
- Researchers using data checked this way must understand the qc flags as meaning "relative to MAPS analyses". That is, an observation is "unlikely", "questionable" or "good" only as compared to MAPS. The investigator must still make his own determination as to an observations true accuracy.

6. REFERENCES

Miller, P.L. and Benjamin S.G., 1992: A System for the Hourly Assimilation of Surface Observations in Mountainous and Flat Terrain.

Miller, P.L. and Benjamin S.G., 1991: Horizontal Quality Control for a Real-time 3-H Assimilation System Configured in Isentropic Coordinates.

APPENDIX B

ACRONYMS

ABRFC
: Arkansas-Red Basin River Forecast Center

AERI
: Atmospherically Emitted Radiance Interferometer

AES
: Atmospheric Environment Service (Canada)

ARM
: Atmospheric Radiation Measurements (DOE)

ARS
: Agricultural Research Service (USDA)

ASOS
: Automated Surface Observing System

AVHRR
: Advanced Very High Resolution Radiometer

AWOS
: Automated Weather Observing System

BUFR
: Binary Universal Form for Data Representation

CAGEX
: CERES/ARM/GEWEX Experiment

CART
: Clouds and Radiation Testbed (DOE/ARM)

CD
: Compact Disk

CERES
: Clouds and the Earth's Radiant Energy System

CLAVR
: Clouds from AVhRr

CMC
: Canadian Meteorological Centre

CSA
: Continental Scale Area

CSIRO
: Commonwealth Scientific and Industrial Research Organisation

DAAC
: Distributed Active Archive Center

DEM
: Digital Elevation Model

DMSP
: Defense Meteorological Satellite Program

DMSS
: Data Management and Service System

DOE
: Department of Energy

EDAS
: Eta Data Assimilation System

EDC
: EROS Data Center (USGS)

EOP

Enhanced Observing Period

EPA
: Environmental Protection Agency

EROS
: Earth Resources Observation Systems (USGS)

FAA
: Federal Aviation Administration

FAX
: Facsimile

FEST
: Fronts Experiment Systems Test (STORM)

FSL
: Forecast Systems Laboratory (NOAA)

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/MSFC)

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

GSFC
: Goddard Space Flight Center (NASA)

HDF
: Hierarchical Data Format

HIRS
: High Resolution Infrared Radiation Sounder

HPCN
: High Plains Climate Network

HRPT
: High Resolution Picture Transmission

IGPO
: International GEWEX Project Office

IOP
: Intensive Observation Period

IR
: Infrared

ISA
: Intermediate-Scale Area

ISLSCP
: International Satellite Land-Surface Climatology Project

JICP/PO
: Joint International Climate Projects/Planning Office (UCAR)

JOSS
: Joint Office for Science Support (UCAR)

LAC
: Local Area Coverage
LAPS
: Local Analysis and Prediction System
LSA
: Large-Scale Area

MAPS
: Mesoscale Analysis and Prediction System
METEOSAT
: METEOrological SATellite (Europe)
MOLTS
: Model Location Time Series
MORDS
: Model Output Reduced Dataset
MSFC
: Marshall Space Flight Center (NASA)
MSU
: Microwave Sounding Unit

NASA
: National Aeronautics and Space Administration
NAWDEX
: NAtional Water Data EXchange
NCAR
: National Center for Atmospheric Research
NCDC
: National Climatic Data Center
NCEP
: National Centers for Environmental Prediction (NOAA) (formerly NMC)
NESDIS
: National Environmental Satellite, Data and Information Service (NOAA)
NEXRAD
: NEXt generation RADar (now called WSR-88D)
NMC
: National Meteorological Center (NOAA) (now NCEP)
NOAA
: National Oceanic and Atmospheric Administration
NRCS
: Natural Resources Conservation Service (USDA)
NSIDC
: National Snow and Ice Data Center
NSSFC
: National Severe Storms Forecast Center (NOAA)
NSSL
: National Severe Storms Laboratory (NOAA)
NWS
: National Weather Service (NOAA)
NWSRFS
: National Weather Service River Forecast System

OFPS
: Office of Field Project Support (UCAR)
OH
: Office of Hydrology (NOAA)
ORNL
: Oak Ridge National Laboratory (DOE)

PAM
: Portable Automated Mesonetwork (NCAR)
POES

Polar Orbiting Environmental Satellite

PROFS
Program for Regional Observing and Forecasting Services (NOAA)

PSU
Pennsylvania State University

QC
Quality Control

RFC
River Forecast Center

RFE
Regional Finite Element

RISOP
Rapid Interval Scan Operations Plan

ROM
Read Only Memory

SAO
Surface Airways Observation

SAR
Synthetic Aperture Radar

SBUV
Solar Backscattered Ultra Violet System

SCD
Scientific Computing Division (NCAR)

SCM
Single Column Model

SCS
Soil Conservation Service (USDA)

SDSM
Satellite Data Source Module (GCIP)

SMA
Soil Moisture Accounting

SMOS
Surface Meteorological Observation Station (DOE/ARM)

SORTI
Solar Radiance Transmission Interferometer (DOE/ARM)

SSA
Small-Scale Area

SSEC
Space Science and Engineering Center (University of Wisconsin-Madison)

SSM/I
Special Sensor Microwave Imager

SSU
Stratospheric Sounding Unit

STATSGO
State Soil Geographic Database (USDA)

STORM
STorm-scale Operational and Research Meteorology

SW
South West

TIROS
Television and Infrared Observation Satellite

TOVS
TIROS Operational Vertical Sounder

UAV
Unmanned Aerospace Vehicle

UCAR
University Corporation for Atmospheric Research

URL
Uniform Resource Locator

USACE
: United States Army Corps of Engineers

USAF
: United States Air Force

USDA
: United States Department of Agriculture

USGS
: United States Geological Survey

UTC
: Universal Time Coordinated

UZFW
: Upper Zone Free Water

VAS
: VISSR Atmospheric Sounder

VIS
: Visible

VISSR
: Visible and Infrared Spin-Scan Radiometer

VORTEX
: Verifications of the Origins of Rotation in Tornadoes EXperiment

WCRP
: World Climate Research Programme

WMO
: World Meteorological Organization

WPDN
: Wind Profiler Demonstration Network

WSI
: Weather Services International

WSR-88D
: Weather Surveillance Radar - 1988 Doppler (formerly NEXRAD)

WWW
: World Wide Web