AD-A265 957

DTIC
ELECTE
JUN 1 4 1993
S
C
D

PL-TR-92-2327

THE AIR FORCE INTERACTIVE METEOROLOGICAL SYSTEM: A RESEARCH TOOL FOR SATELLITE METEOROLOGY

Charles F. Ivaldi Jr.
Gary B. Gustafson
Joseph Doherty

Atmospheric and Environmental Research, Inc.
840 Memorial Drive
Cambridge, MA 02139

2 December 1992

Scientific Report No. 2

Approved for public release; distribution unlimited

PHILLIPS LABORATORY
Directorate of Geophysics
AIR FORCE MATERIEL COMMAND
HANSCOM AIR FORCE BASE, MA 01731-5000

93-13147

93 6 11 040

This technical report has been reviewed and is approved for publication.

ALLAN J. BUSSEY
Contract Manager

JOSEPH W. SNOW
Chief, Satellite Meteorology Branch
Atmospheric Sciences Division

ROBERT A. McCLATCHEY
Director, Atmospheric Sciences Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 2 December 1992	3. REPORT TYPE AND DATES COVERED Scientific No. 2

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
The Air Force Interactive Meteorological System: A Research Tool for Satellite Meteorology	PE 62101F PR 6670
6. AUTHOR(S) Charles F. Ivaldi, Jr., Gary B. Gustafson and Joseph Doherty	TA 17 WU CA Contract F19628-91-C-0011

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBERS
Atmospheric and Environmental Research, Inc. 840 Memorial Drive Cambridge, MA 02139	

9. SPONSORING / MONITORING AGENCY NAMES(S) AND ADDRESS(ES)	10. SPONSORING / MONITORING AGENCY REPORT NUMBER
Phillips Laboratory 29 Randolph Road Hanscom AFB, MA 01731-3010 Contract Manager: Allan Bussey/GPA	PL-TR-92-2327

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution unlimited	

13 ABSTRACT (Maximum 200 words)

This report summarizes work that was performed under a research contract with the Satellite Meteorology Branch of the Phillips Laboratory (Geophysics Directorate) Atmospheric Sciences Division. The topic addressed is the use of the Air Force Interactive Meteorological System (AIMS) as a research tool for the acquisition, processing, display and management of large sets of satellite data obtained from different platforms and sensors. Of particular importance is the foundation that AIMS provides for establishing an optimal satellite data processing system based on a systematic and integrated approach to data handling and manipulation. This foundation is composed of four functional areas: 1) access to meteorological data sources including: direct broadcast NOAA, DMSP, and GOES satellite data; global surface and upper air reports from the NWS Family of Services; and lightning data from the SUNY-Albany lightning detection network, 2) data visualization and processing that employs both 8-bit and 24-bit full color imaging workstations, and 3) interactive development, data analysis, and batch processing capabilities supported by mid-range performance minicomputers. This report includes a historical perspective of AIMS, its current configuration, a review of scientific applications supported by AIMS, ongoing work to provide an integrated approach to data management, analysis and processing, and a discussion of current short term needs and long range planning issues.

14. SUBJECT TERMS		15. NUMBER OF PAGES
satellite meteorology	algorithm development	92
interactive data analysis	visualization	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

TABLE OF CONTENTS

DTIC QUALITY INSPECTED 2

LIST OF FIGURES

LIST OF TABLES

1. Introduction

For over six years scientists in the Satellite Meteorology Branch of the Atmospheric Sciences Division of the Geophysics Directorate of the Phillips Laboratory have been utilizing a computer system known as AIMS in support of their research. During that time both branch and divisional requirements have increased significantly for computing to support research in the atmospheric sciences, resulting in concomitant growth in AIMS hardware and software resources and the number of users supported. Aggregate CPU processing capability has risen by 1700% over the past six years and fixed-disk mass storage has increased by 400%. A relatively new removable mass storage media based on magneto-optical technology is now used extensively in cloud analysis studies to store high-volume polar-orbiting and geostationary satellite data and ancillary datasets such as fine resolution (6 km) topographic data. In total, the use of this media alone approaches 20 gigabytes. In parallel with the physical growth of AIMS the number of user accounts have tripled since 1986. Today, AIMS supports 50 user accounts cf which approximately half use the system on a regular basis.

Part of the system growth has been attributable to the expanding need to handle large sets of satellite data from a number of different platforms and sensors, a requirement that has been and continues to be a focus for continued development. More recently, new applications are being supported by AIMS that extend beyond traditional requirements in satellite meteorology to other areas of study within the Atmospheric Sciences Division. Examples include application of mesoscale forecast models through data assimilation (Lipton, 1990; Hamill, 1991), application of artificial intelligence techniques for quality control of acquired conventional meteorological data (O'Donnell, 1990) and support to real-time radar data collection for polarimetric studies (Metcalf, 1992). Application-related support functions are also being performed on AIMS such as collection of real-time and archived satellite and conventional meteorological data, data reformatting and data staging. The popularity and availability of desktop software has also made it possible for scientists using AIMS to prepare publication-quality scientific reports and articles. Finally, AIMS has expanded to support functions (through assuming additional responsibilities) that may appear unconnected with the applications-oriented environment of the system but nevertheless contribute to AIMS as a system. For example, AIMS is now an important hub for the exchange of information both within the laboratory and with institutions and organizations outside the laboratory through the use of applications such as electronic mail

and remote file transfer capabilities. AIMS also functions as a server, providing file and print services to a number of personal computers throughout the division.

AIMS has evolved over the last six years into a system that reflects the initial motivation behind its development as well as new ad hoc requirements from an increased community of users. This paper details the evolution of AIMS, its role in support of atmospheric research projects within GPA, the consequences of that evolution, and some guidelines and recommendations for the future.

2. History

AIMS has its roots in the Man Computer Interactive Data Access System (McIDAS) developed by the University of Wisconsin to provide an interactive capability for analysis and display of conventional and remotely sensed meteorological data. The Geophysics Directorate (then known as the Air Force Geophysics Laboratory (AFGL)) purchased a McIDAS in the mid 1970's to support ongoing and proposed research in satellite meteorology and numerical weather prediction within the Atmospheric Sciences Division (Fournier, 1982). The AFGL McIDAS included a real-time GOES ground station capability, a connection to the WB604 line for access to conventional meteorological data and a dialup capability to acquire Weather Bureau Remote Radar (WBRR) data. Based on a Harris 6024/5 minicomputer, the system boasted 64K of core memory, a single 80 MB removable disk and two interactive 6-bit image workstations tied to a custom digital video storage system. By the early 1980s an increasingly large number of projects encompassing a range of atmospheric research topics were using the AFGL McIDAS for computer support. These included studies to improve the satellite portion of the AFGWC real-time nephanalysis program, processing and quantitative evaluation of multispectral data from the GOES VISSR Atmospheric Sounder (VAS) and an assessment of the use of interactive graphics in short-range weather forecasting. By 1983 these and other applications were severely taxing the capabilities of the AFGL McIDAS, prompting the need for an upgrade plan to address user and application needs for the next 10 years.

In 1983 users of the AFGL McIDAS formulated a plan to develop a new interactive computer system based on the following requirements:

1. expandable to accommodate increasing amounts of satellite and other types of data from different platforms and sensors;
2. facilitate integration of new data sources;

2

3. maximize data visibility and minimize user impact;
4. facilitate resource (CPU, peripherals) expansion;
5. emphasize satellite data handling and display; and
6. provide a user-friendly human interface that supports varying skill levels.

The system specifications drawn from these requirements called for a distributed system of processors, each functionally unique and connected by a local-area network. Three areas of functional use were identified: 1) data ingest for both real-time and archived satellite, radar and conventional meteorological data; 2) interactive satellite image processing, graphical analysis and data visualization; and 3) batch processing to support non-interactive compute-intensive applications. For real-time GOES ingest, a Gould SEL (now Encore) minicomputer was chosen for its real-time performance capabilities to handle the increased bandwidth of VAS data. Digital Equipment Corporation (DEC) MicroVAX II minicomputers were specified to host ADAGE 32-bit imaging subsystems for interactive display and processing of multispectral satellite data. For application development and batch processing, a VAX 11/750 was employed to exploit its user-friendly development environment and processing capabilities. Although off the shelf hardware and software were used wherever possible to minimize development time and complexity, the AIMS multi-platform configuration posed problems for commercially available networking solutions of the time. The AIMS specification for data access within the local-area network called for a distributed file system that would accommodate different hardware platforms. Unfortunately, such a capability was not commercially available at the time. Consequently, AIMS evolved into two networks utilizing the DECnet protocol suite: a point-to-point network connecting the Gould with a "gateway" DEC computer and a multipoint network of DEC computers.

The growth and development of AIMS continued throughout the mid 1980s. Gustafson *et al.* (1987) described the physical and functional configuration of AIMS while a companion report by Kleespies *et al.* (1987) provided an overview of applications utilizing the new system at that time. Since that time AIMS has continued to grow steadily through the addition of new processors for interactive development, the introduction of workstations, mass storage and memory expansions, additional real-time data acquisition systems and various peripheral devices. The number of applications supported on AIMS has also grown and presently covers the range from investigations into the use of numerical weather prediction models for mesoscale forecasting to applied research directed toward nephanalysis algorithm development for global and regional cloud analysis models, characterization of tropical cyclones using microwave data and technique development for

retrieval of low-level water vapor and precipitable water amounts from multispectral infrared sensor data.

3. Current Configuration

The current configuration of AIMS is summarized in Table 1 and illustrated by the schematic in Figure 1. AIMS consists of second-, third- and fourth-generation DEC MicroVAX minicomputers and workstations, three imaging workstations built around Adage image processing systems, a GOES mode AAA ground station interfaced to an Encore 32/67 minicomputer, and NOAA/TIROS and DMSP ground stations interfaced to Sun workstations. It is apparent from Table 1 that system expansion has favored the DEC architecture, namely VAX/VMS. The reason for this has been the ability of the VAX/VMS architecture to consistently meet the majority of the requirements developed in the original upgrade plan and subsequently as new requirements evolved. The reasons for this are threefold. First, regardless of changes at the hardware level, the VMS operating system has remained unchanged across VAX platforms from both the user and systems perspective. Thus AIMS, for the most part, has developed into a homogeneous network that provides a consistent interface to the user. Second, advances in networking in the late

Qty	System	O.S.	Memory (MB)	Disk (MB)	Tape	Description
1	Encore 32/67	MPX	1	680	9-track	GOES realtime ingest
1	Sun Sparc II	UNIX	64	1903	4mm	NOAA realtime ingest
1	Sun Sparc II	UNIX	64	2424	4mm	DMSP realtime ingest
3	Adage 3000		4-16			Image processing/display
3	VAXstation 3600	VMS	16	70	TK50	Adage host, 8-bit display
5	VAXstation 3100	VMS	16	200		8-bit image display
2	VAXstation 2000	VMS	16	70		8-bit image display
1	VAXstation 2000	VMS	16	70		Lightning realtime ingest
1	MicroVAX 3600	VMS	32	300	8mm	FAA WB604 realtime ingest
				900	9-track	Interactive development
1	VAX 4000-200	VMS	16			Interactive development
1	MicroVAX 3800	VMS	24	2420	9-track	Batch processing
				600		Removable optical media
1	MicroVAX II	VMS	9	835		GOES gateway, database
1	VAXserver 3800	VMS	16	1050	8mm, 9-track	LAVC boot member
				600		Removable optical media

Table 1. Physical and Functional Overview of AIMS.

4
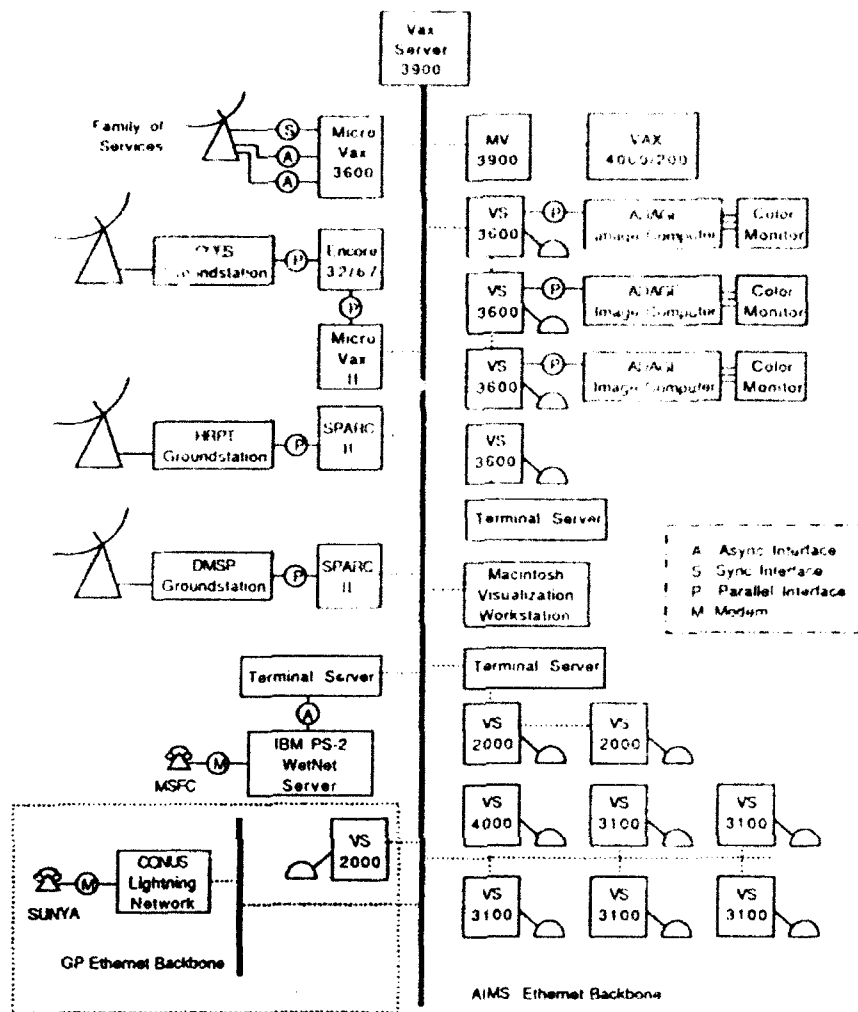
Figure 1. AIMS Hardware and Network Configuration.

1980s made it possible to more tightly couple VAX-based networks using intelligent mass storage devices and highly-optimized protocols. A networking architecture known as clustering was adopted by AIMS in 1988 to provide a system-level link among nodes (computers) on the network and a distributed file system in which disks (and now tape drives) attached to any network node can be accessed transparently from any other node. Clustering immediately satisfied three of the requirements in the upgrade plan. First transparent access to disks located anywhere within the network meant that the visibility (availability) of satellite data was immediate regardless of where it was located. Second, AIMS could easily accommodate increased amounts of satellite data simply by adding additional disks within the network and configuring them for cluster access. Third, AIMS

5

could expand easily if requirements warranted additional processing resources by utilizing an additional feature of cluster software that allows nodes to be added to the network without incurring the overhead of having to manage it as a separate system.

Finally, the popularity of the VMS operating system among AIMS users has been consistent over the past ten years. VMS has a highly intuitive command-level language with extensive help facilities. Coupled with powerful features that allow easy customization of the user environment, VMS easily accommodates the novice user as well as the expert.

3.1 Network Access

The physical configuration of AIMS is centered around an Ethernet backbone that provides a high-speed, functionally robust network for DEC systems (refer to Figure 1). Coupled with cluster software, the configuration is referred to as a Local Area VAX Cluster (LAVC). Third party software extends DECnet functionality over the AIMS Ethernet to the SUN NOAA and DMSP ground station computers while a separate third party hardware/software package extends the same functionality to the Encore GOES ground station computer via a high-speed parallel link.

In addition to the access within the LAVC, AIMS has historically required access to other resources both within and outside the laboratory. Early in its existence, however, AIMS experienced chronic problems attempting to communicate at terminal speeds over the GP network, a broadband-based net that links nearly all computer systems within GP, including a central computing facility. In 1988 these problems were mitigated when GP installed a facility wide Ethernet backbone, a decision that was greatly influenced by requirements of the Atmospheric Sciences Division for reliable, high speed transfer of satellite data to NSI (then known as SPAN) as well as improved connectivity to the central computing facility. Today AIMS is a subnet bridged to the GP Ethernet backbone. The GP network, in turn, provides access to the NSI network and the New England Academic Regional Network (NEARnet). Finally, NEARnet itself is a subnet to the global computer network INTERNET that links nearly all U.S. government research facilities and universities along with many private organizations and overseas institutions. The GP network also serves general user computing requirements by providing access to VAX 9000 and CONVEX mainframe computers and (through a direct T1 satellite link) a CRAY-2 super computer located in Albuquerque, NM. Figure 2 shows the network configuration of AIMS with respect to the GP Ethernet network and outside networks.

3.2 Data Sources

A description of AIMS is best accomplished by examining the functional components of the system, beginning with data ingest. Figure 3 shows the configuration of the direct-readout GOES ground station for the real-time acquisition of VAS data utilized by studies in environmental parameter retrieval and mesoscale analysis. It consists of an 8m antenna and associated downlink electronics, demodulator, variable-rate bit sync and frame sync. A downlink interface converts the serial stream to 32-bit parallel and provides handshaking to the host computer, an Encore 32/67 minicomputer. The 32/67 is characterized by a high speed backplane (~26 Mbytes/sec) and interface to the ground station (3.2 Mbytes/sec) as well as the MPX-32 operating system that is well suited to real-time data acquisition. Two disk drives store subsets of the visible and infrared earth disk image every half-hour. Figure 4 depicts the geographical coverage as currently seen by GOES-7 as well as a subsection that represents the coverage of data ingested by AIMS. Visible data at 1 km nominal resolution are stored as brightness counts. Infrared data
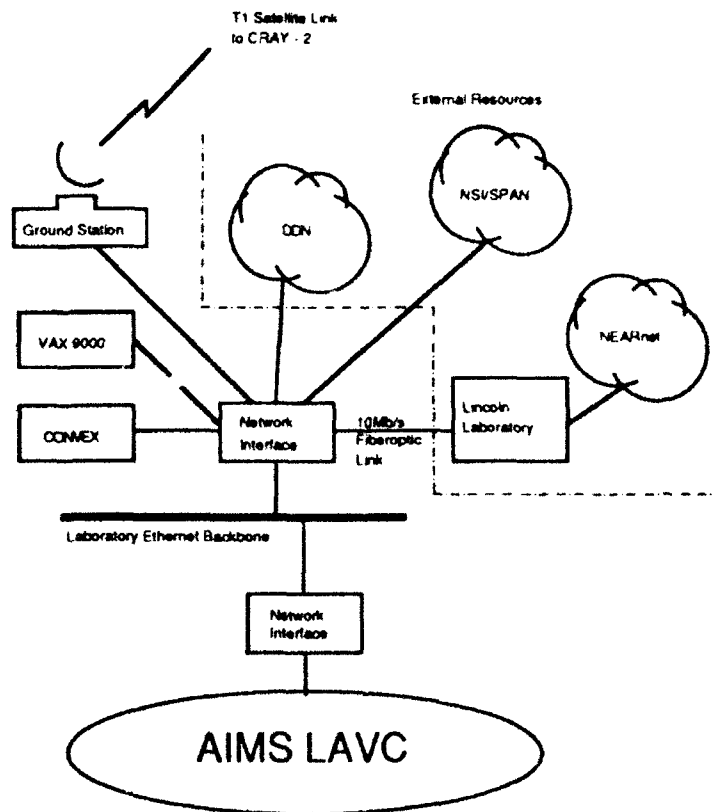
Figure 2. AIMS/GP Network Configuration.

7
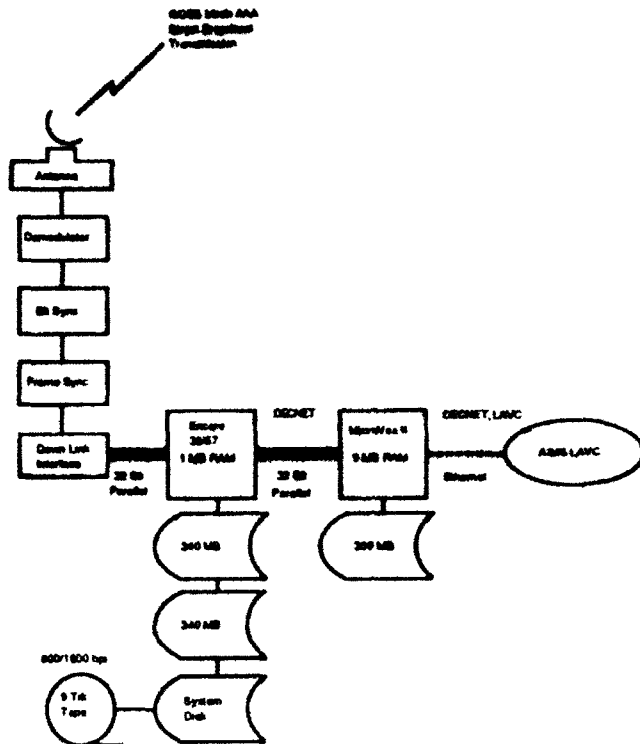
Figure 3. GOES Groundstation Configuration.
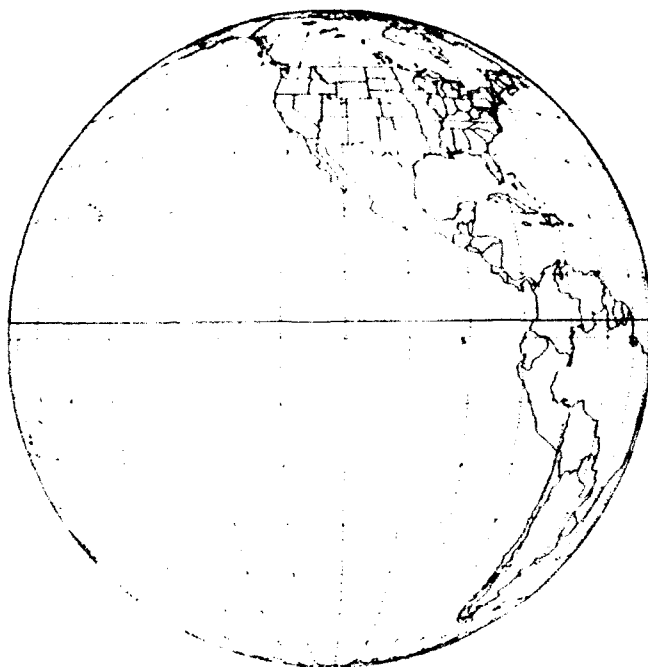
Figure 4.   Geographical Coverage of the Earth as Currently Seen by GOES-7 (Subpoint Longitude 112.4°W). The Area Above the Darkened Line is the Coverage of Data Ingested by AIMS.

8

always include the 11μm thermal infrared channel with nominal 7 km resolution plus two additional channels at 14 km resolution (typically 3.7, 6.7 or 12 μm). Infrared data are stored on the Encore as raw 10-bit counts related to radiance. VAS instrument characteristics are described in Table 2.

For GOES data to be generally accessible by AIMS users it must be moved from the Encore to a node that is part of the AIMS LAVC. As shown in Figure 3, this "gateway" computer is a MicroVAX II with storage for user-defined subsets of GOES data. The MicroVAX and Encore computers are connected via a point-to-point link using third-party hardware and software that provide high-speed parallel communications between DEC and Encore computers. The system is known as Q-LINK and provides peripheral sharing, automatic file transfer/translation, remote log-on, and a DECnet capability known as Q-NET. At preset time intervals that coincide with the completion of real-time ingest on the Encore, software executing on the MicroVAX utilizes Q-LINK to extract and copy user-defined subsets to local storage. Within the extraction process, infrared data are converted to 8-bit greyshade values (related to brightness temperature) to facilitate display processing. Four times daily navigational elements are copied to the AIMS LAVC. These elements are required input to a generalized mathematical solution to the satellite/earth coordinate transform used for earth location of GOES sensor data.

A direct-readout capability for NOAA polar-orbiting satellites exists on AIMS to provide timely visible and infrared multispectral data primarily for use in the development of improved cloud algorithms for nephanalysis applications such as the Air Force tactical nephanalysis (TACNEPH) program. As illustrated in Figure 5, the configuration is a High Resolution Picture Transmission (HRPT) ground station developed by SeaSpace. It consists of a 1.2 m tracking antenna, antenna control unit and positioner, downconverter, receiver, bit sync and frame sync. The acquisition system is hosted by a Sun Sparc station II running the UNIX operating system. Supporting hardware includes storage for a rotating on-line archive to store the most recent four passes, a 4 mm DAT drive for off-line storage and a user disk for storing user data sets and generated products. The HRPT broadcast stream provides sensor data from the five-channel Advanced Very-High Resolution Radiometer (AVHRR) and the three-instrument TIROS Operational Vertical Sounder (TOVS). The AVHRR provides visible and near IR channels at 0.62 and 0.86 μm and three infrared channels at 3.7, 10.7 and 11.8 μm (Table 2). Spatial resolution is nominally 1 km. TOVS provides data from two infrared instruments and one microwave instrument: the High-Resolution Infrared Radiation Sounder (HIRS), Stratospheric

9

Satellite/ Channel	Instrument Wavelength or Frequency		Resolution at Nadir
	(μm)	(GHz)	(km)
DMSP OLS			
Visible	0.4 - 1.1 μm		0.6
Longwave IR	10.5 - 12.6 μm		2.8
DMSP SSM/I[1]			
1		19.35 GHz V/H	25
2		22.235 GHz V	25
3		37.0 GHz V/H	25
4		85.5 GHz V/H	12.5
DMSP SSM/T2			
1 (Window)		91.5 GHz	90
2 (H_2O)[2]		150 GHz	64
3 (H_2O)		183 +/- 1 GHz	50
4 (H_2O)		183 +/- 3 GHz	50
5 (H_2O)		183 +/- 7 GHz	50
NOAA AVHRR			
Visible/Near IR	0.58 - 0.68 μm		1.1, 4[3]
Visible/Near IR	0.725 - 1.1 μm		1.1, 4[3]
Shortwave IR	3.55 - 3.93 μm		1.1, 4[3]
Longwave IR	10.3 - 11.3 μm		1.1, 4[3]
Longwave IR	11.5 - 12.5 μm		1.1, 4[3]
NOAA HIRS			
1 - 7 (CO_2)	13.3, 13.6, 13.9, 14.2, 14.4, 14.7, 14.9 μm		42
8 (Window)	11.11 μm		42
9 (O_3)	9.71 μm		42
10 - 12 (H_2O)	6.72, 7.33, 8.22 μm		42
13 - 17 (N_2O/CO_2)	4.23, 4.40, 4.46, 4.52, 4.57 μm		42
18 - 19 (Window)	3.76, 4.00 μm		42
20 (Window)	0.69 μm		42
NOAA MSU			
1 (Window)		50.31 GHz	168
2 (O_2)		53.74 GHz	168
3 (O_2)		54.96 GHz	168
4 (O_2)		57.95 GHz	168
NOAA SSU			
1 (CO_2)	15.0 μm		62
2 (CO_2)	15.0 μm		62
3 (CO_2)	15.0 μm		62
GOES VAS[4]			
Visible	0.55 - 0.75 μm		1
1 - 6, 11 (CO_2)	4.44, 4.52, 13.31, 13.99, 14.23, 14.45, 14.71 μm		7, 14
7 (H_2O)	12.66 μm		7, 14
8 (Window)	11.17 μm		7, 14
9 - 10 (H_2O)	6.725, 7.25 μm		7, 14
12 (Window)	3.94 μm		14

[1]Channel data are dual polarized except 22.235 GHz which are only vertically polarized.
[2]Principal absorbing constituents for sounding channels.
[3]Nominal resolution for all channels is 1.1 km. GAC data are available at 4 km reduced resolution.
[4]Data from channels 3-6 and 7-11 are available at either 7 or 14 km.

Table 2. Characteristics of Satellite Sensor Data Used on AIMS.
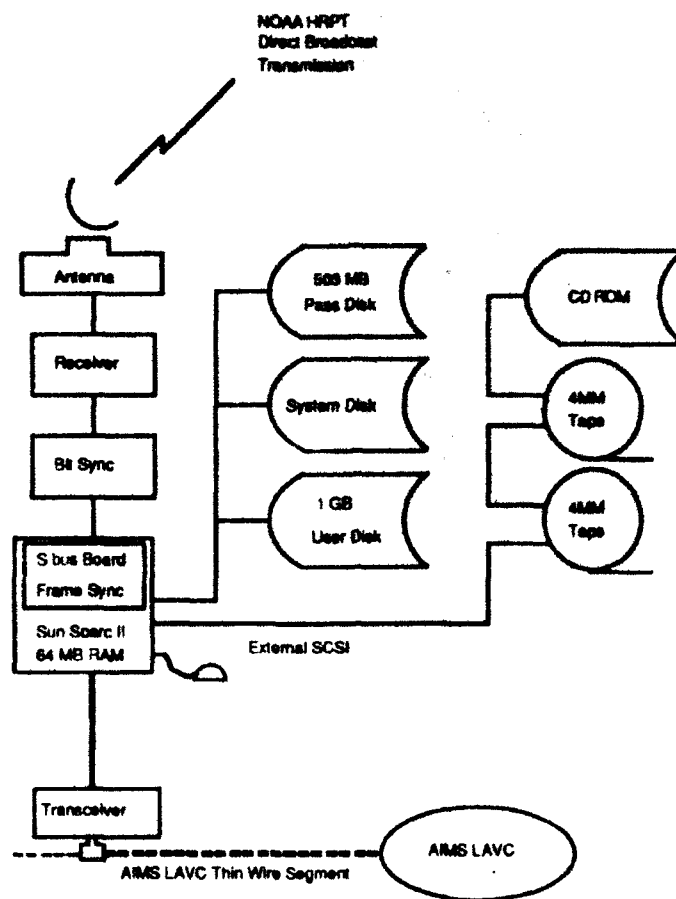
Figure 5. NOAA Groundstation Configuration.

Sounding Unit (SSU) and Microwave Sounding Unit (MSU) (Table 2). Together the three instruments provide 27 spectral channels that are used to obtain vertical profiles of atmospheric temperature and water vapor. A comprehensive software package is provided with the system to extract, format, calibrate and earth-locate subsets of the HRPT telemetry data. X-based software is also provided for interactive image display and processing of the data.

A companion system to the HRPT ground station provides satellite data from the Defense Meteorological Satellite Program (DMSP) including visible, infrared, microwave imagery and sounding sensor data (Table 2). As shown in Figure 6, the configuration is a Real Time Data (RTD) ground station, also developed by SeaSpace. The broadcast data stream provides sensor data from the Operation Line Scanner (OLS), a two channel radiometer with a visible channel at 0.75μm and an infrared channel at 11.55μm. Sensor resolution is 0.6 km for the visible and 2.8 km for the infrared. In addition to OLS sensor

11
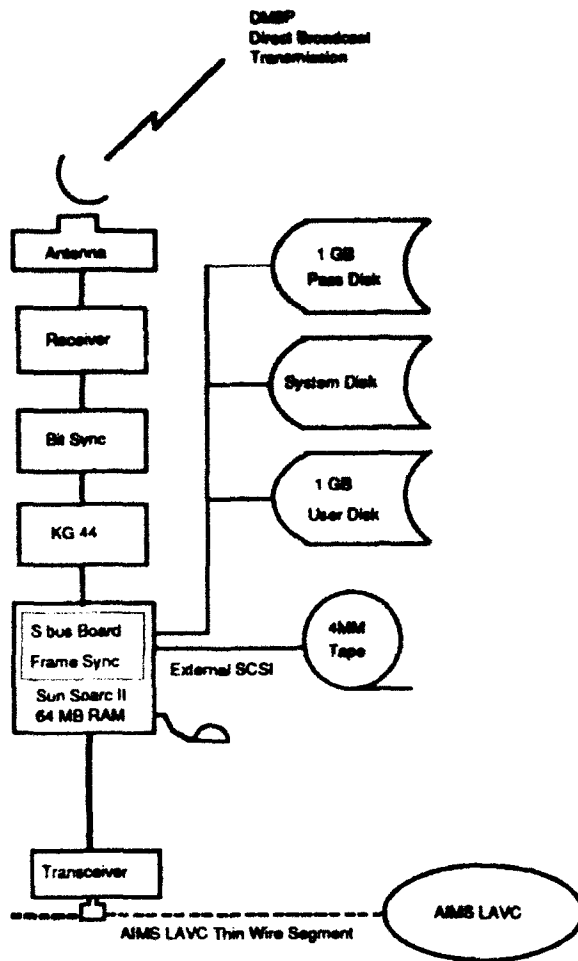
Figure 6. DMSP Groundstation Configuration.

data, the ground station also supports two sensors from the special sensor suite. The first is the Special Sensor Microwave Imager (SSM/I), a seven-channel, four-frequency microwave radiometer used primarily to estimate geophysical parameters of the earth and atmosphere. These include ocean surface wind speed, ice coverage and age, precipitation rates, cloud water content, total integrated water vapor, soil moisture, land surface temperature, surface type and cloud amount. The second special sensor supported is the Special Sensor Temperature (SSM/T) Sounder, a seven-channel microwave radiometer that measures upwelling radiation between 50 and 60 GHz. Channel data from the SSM/T Sounder are input to applied inversion techniques to estimate temperature profiles of the atmosphere. Characteristics of both special sensors are summarized in Table 2.

Unlike the GOES ground station computer, the Sun hosts to the HRPT and RTD ground stations are connected directly to the AIMS Ethernet network (Figures 5 and 6).

12

Although it cannot participate directly as a clustered node, third-party software known as TSSnet allows the HRPT system to participate as a DECnet end node providing the capabilities for file transfer, remote log-on, remote job activation and X interoperability within AIMS. The Network File System (NFS), a network architecture developed by SUN Microsystems and similar in function to Digital's clustering, extends the HRPT systems access to data located on the RTD ground station, such that DMSP data can be transferred within the AIMS LAVC without the need for the host workstation to participate directly as a DECnet node. Projects such as TACNEPH use TSSnet to transfer AVHRR and OLS satellite data to a database on the AIMS LAVC to take advantage of existing processing software.

Conventional meteorological data are used extensively on AIMS to support a wide range of applications. These data are generally made available via connections to two components of the National Weather Service (NWS) Family of Services (FOS). The first component, known as the Domestic Data Service (DDS), provides coded observations, reports, forecasts and analyses for the U.S., Canada and the Caribbean. The DDS is broadcast as a serial, asynchronous data stream at 4800 baud. The second component is known as the International Data Service (IDS) and provides worldwide coded observations, reports and forecasts. The IDS is broadcast as a serial, asynchronous data stream at 1200 baud. Figure 7 depicts the configuration for real-time acquisition from this data source. The DDS and IDS lines connect to serial ports on a MicroVAX III with dedicated on-line storage for processed conventional reports. The computing requirements imposed by this data source are quite modest compared to satellite-based acquisition requirements. This means that a number of AIMS LAVC nodes that have two serial ports and adequate disk capacity can perform this function should the designated node fail, a capability that reflects the distributed design of AIMS.

The FOS multiplexes data originating from different sources, producing a data stream of point, gridded and tabular data with varied formats. AIMS recognizes, decodes and reformats a subset of data sources that includes Service A, synoptic, ship and buoy, METAR, upper-air, manually digitized radar (MDR) and NMC model guidance. Table 3 describes the conventional meteorological data sources available on AIMS while Table 4 lists the data types associated with each source. All data have been archived to 8 mm tape since September of 1989. Unprocessed conventional meteorological data are characteristically high in volume and low in information content. Substantial development over the last six years has produced generalized applications and programming utilities that

13
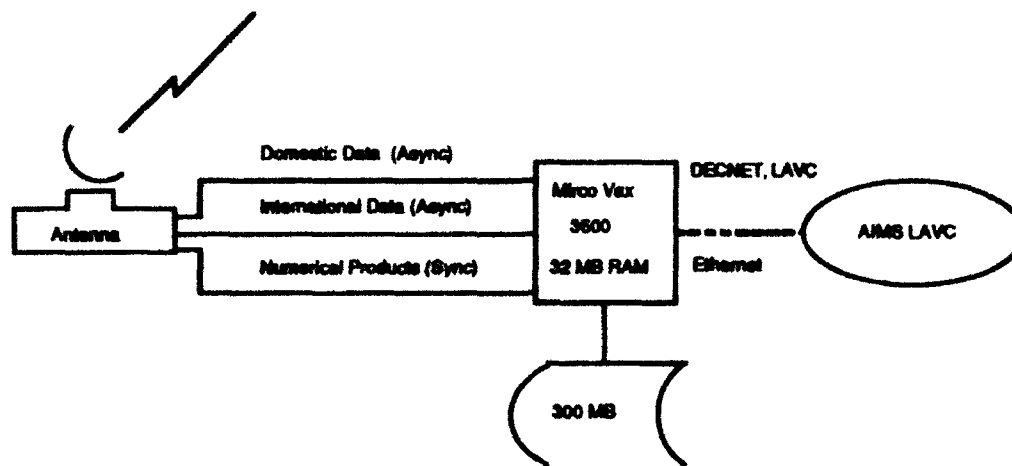
Figure 7. NWS Family of Services Data Ingest Configuration.

Source	Type	Coverage	Frequency	Data Characteristics[1]
Service A	Point	US, Canada	Hourly	Surface observations
Synoptic	Point	Global	4/8 times daily	Surface observations
METAR	Point	Global	8 times daily	Surface observations
Ships/Buoys	Point	Global	4/8 times daily	Platform observations
Upper Air	Point	Global	Twice daily	Radiosonde, rawinsonde measurements
Forecast Guidance	Point	US	Twice daily	LFM and NGM model output. Forecasts for 6 hour intervals out to 48 hours
Forecast Model Output Statistics (MOS)	Point	US	Twice daily	Statistically-based forecasts derived from the LFM. Forecasts for 6 hour intervals out to 48 hours
Trajectory Forecasts	Point	US	Twice daily	Statistically-based forecasts derived from the LFM. Includes parcel trajectories for 6 hour intervals out to 24 hours
Lightning	Point	US	Every minute	Location of cloud to ground lightning strokes
Manually Digitized Radar (MDR)	Gridded	US	Hourly (on the half-hour)	Maximum reflectivity reported for grid box. Also some cell characteristics.

[1] See Table 4 for a complete listing of source data types.

Table 3. Conventional Meteorological Data Sources Available on AIMS.

Type	Guidance	MOS	Trajectory	Upper Air	Service A	Synoptic	Metar	MDR	Lightning	SID
Raw Report	X	X	X	X	X	X	X	X	X	X
Day	X	X	X	X	X	X	X			
Hour	X	X	X	X	X	X	X			
Seconds									X	
Temperature	X	X	X	X	X	X	X			
Dew Point	X	X	X	X	X	X	X			
Pressure	X	X	X	Y	X	X	Y			
Wind Direction	X	X		X	X	X	X			
Wind Speed	X	X		X	X	Y	X			
Precip (3 hour)					X	X				
Precip (6 hour)	X				X	X				
Precip (24 hour)	Y				X	X				
Altimeter				Y	X	Y	X			
Station Pressure				X	Y	X	Y			
Pressure Tendency					X	X				
Cloud Amount (Octas)					X	X	X			
Cloud Amount					X	X	X			
Cloud Type						X	X			
Cloud Base					X	X	X			
Total Cloud Amt						X				
Visibility					X	X	X			
Gust					X	X	X			
Weather					X	X	X			
Sea Sfc Temperature						X				
Wave Period						X				
Wave Height						X				
Eq Water Snow Depth					X	X				
Snow Depth					X	X				
Snow Accumulation					X	X				
Freezing Level				Y	X					
R1	X									
R2	X									
R3	X									
Vertical Velocity	X									
Precip Prob (6 hour)		X								
Precip Prob (12 hour)		X								
Precip Amt (6 hour)		X								
Precip Amt (12 hour)		X								
Tstorm Prob		X								
Max Temp		X			X	X				
Min Temp		X			X	X				
Prob Cld Amt		X								
Prob Ceiling Hgt		X								
Prob Visibility		X								
Best Ceiling/Vis		X								
Prob Obstruct Vision		X								
Geo Pot Hgt	Y			X						
MDR Grid								X		
MDR Remarks								X		
Latitude						X		X	X	
Longitude						X		X	X	
Signal Strength									X	
Multiplicity									X	
Station ID										X
Station Height										X
Station Class										X
Station Location										X
Station Latitude										X
Station Longitude										X
Stability	X		X	Y						
Thickness	X			Y						
Wind Chill Temp		Y			Y	Y				
Mixing Ratio				Y	Y	Y	Y			
Relative Humidity	X	Y		Y	Y	Y	Y			
Specific Humidity				Y	Y	Y	Y			
Potential Temp				Y	Y	Y	Y			
Virtual Temp				Y	Y	Y	Y			
Wet Bulb Temp				Y	Y	Y	Y			
Equivalent Temp				Y	Y	Y	Y			
Equivalent Pot Temp				Y	Y	Y	Y			
Vapor Pressure		Y		Y	Y	Y	Y			
Sat Vapor Pressure		Y		Y	Y	Y	Y			
LCL				Y	Y	Y	Y			
LCL Temperature				Y	Y	Y	Y			
Lifted Index				Y	Y	Y	Y			

X -- type in data base
Y -- type not in data base but easily derivable from known quantities.

Table 4. *Data Source/Type Matrix for the AIMS Conventional Meteorological Database.*

15

present data that is low in volume and high in information content. These applications are described in section 3.6.

Lightning data are the most recent addition to acquired sources of conventional data (Tables 3 and 4) and have already been utilized to support the acquisition of radar data for polarimetric studies. As shown in Figure 8, the physical configuration developed to acquire lightning data into AIMS is unique since the ingest hardware is maintained separately at a remote location within GP. The GP broadband Ethernet network is used to provide transparent connectivity from the lightning ingest facility to AIMS. Lightning data are received in real-time from the SUNY-Albany lightning detection network and automatically ingested by a PC-based turnkey system operated by the Atmospheric Structures Branch. A serial connection on the PC provides a 9600 baud output stream for lightning data that is connected to a port on a local terminal server which in turn is connected to the GP broad band Ethernet network. By employing existing Local Area Transport (LAT) software on both AIMS and the terminal server, the port on the terminal server appears local to the AIMS LAVC node that requests it using a LAT software configuration utility. Ultimately, ingest software running on the designated AIMS node assigns a connection to the port as if it were physically attached to that node. As shown in Figure 8, the lightning ingest computer is a VAX station 2000 with a 70 MB disk available for lightning data storage. Although dependent on a number of components, this configuration for the acquisition of lightning data provides excellent fail-over capabilities to any node in the AIMS LAVC. This is accomplished by simply moving the executable software to the new node and configuring the port connection through software.

3.3 Data Visualization and Processing

Interactive display and processing of single and multispectral satellite data are performed on three VAX station 3600 workstations configured with Adage 3000 image display subsystems (refer to Figure 9). Each Adage is configured with a minimum of 4 MB of image refresh memory, a 32-bit programmable bit-slice processor, four 8-bit lookup tables for 8-bit pseudo or 24-bit full color display, an 8-bit overlay channel and a crossbar switch that allows the user to select any combination of memory planes for subsequent output. The bit-slice processor is programmable from the host either directly in micro code or by using a higher-level language cross-compiler. This allows basic image processing functions such as histogram creation or imaging filters to execute at screen refresh rates (e.g., 1/30 sec). Supporting the Adage and VAX station computer, each image processing workstation has two monitors, one for full color display from the Adage frame buffers and
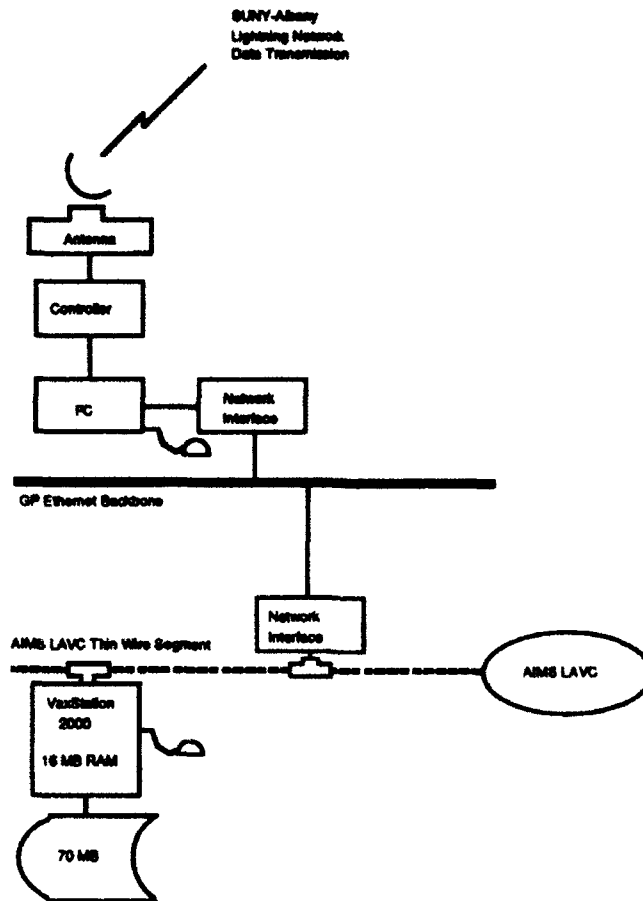
16

Figure 8. Lightning Data Ingest Configuration.
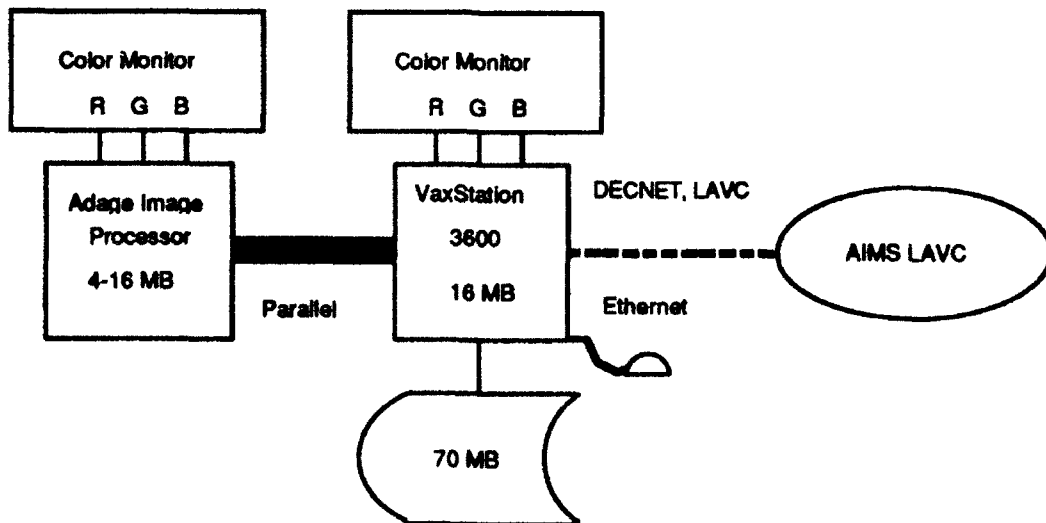
Figure 9. Adage-Based Workstation Configuration.

17

the second for 8-bit color image display and graphics from the VAX station. The VAX station provides an Ethernet interface to the AIMS LAVC plus keyboard entry, menu display and a mouse for cursor control. The VAX station supports the Graphics Kernel System (GKS) and the X windowing system standards.

Visualization of satellite imagery and analysis results is one of the most widely used capabilities on AIMS. The Adage systems combined with the VAX stations are well suited for this application. The 24-bit full color capability is routinely used to display both single channel and multispectral sensor data from systems such as the AVHRR, OLS, VAS and SSM/I. The overlay channel is used to provide additional information on top of the imagery (e.g., annotation, geopolitical boundaries, contour plots, display of model analysis results). The large frame buffers combined with multiple hardware lookup tables and crossbar switch allow for rapid toggling (at frame refresh rates) between data stored in separate areas of frame buffer memory. This is useful for visualizing different sensor channels, analysis images, overlay configurations, enhancement functions or any other data combination appropriate for a given application. The graphics capabilities of the VAX stations are used to display descriptive or quantitative information about the imagery on the Adage monitor. This type of information includes frequency distribution histograms, enhancement functions or tabulated brightness temperature and albedo values. Several applications have been developed that use the function keys on the VAX station keyboard to drive specific channel and enhancement combinations on the Adage. Function keys can be programmed so that the display configuration can be selected and changed virtually instantaneously with the push of a key. Thus the separate capabilities of the Adage and VAX station systems complement each other to provide a full functioned, customizable environment well suited to interactive investigations.

Less powerful but more numerous 8-bit image display workstations provide complementary capabilities for data visualization. They include three VAX station 2000 workstations and five VAX station 3100 workstations each configured with 16 MB of host memory, local disk storage for application software and data files, color monitor and mouse. The X windowing system has been adopted on all workstations as the default windowing interface for file management and virtual terminal capability in addition to graphics and imaging functions. DEC based workstations use the DEC implementation known as DEC windows and the SUN workstations (NOAA and DMSP ground station computers) incorporate SUN Microsystems Open Windows. X was chosen for its flexible client/server architecture coupled with a network-based design and its availability on different vendor platforms. The client/server model provides a means for dividing an

18

application into two components, the non-display portion that generally represents the bulk of the application (client) and the display portion (server). By dividing the application program, performance can be improved through overlapping execution of client and server functions. The network aspect of X extends the client/server model by allowing the user to choose which computer in the network is best suited to perform each of the application components (e.g., choosing a high-end computer for a CPU-intensive client). Thus a single X program may actually be running on different (and potentially widely separated) machines. On AIMS, X windows has been used to provide low-end workstation users with transparent access to higher performance processors to execute the CPU intensive portion of an application, leaving the workstation only to display the resultant output. Since X is a universally accepted *de facto* standard, it has already facilitated the use of existing graphics and imaging applications on different hardware platforms that adhere to the standard. In addition to the VAX stations, an NCD X-terminal provides imaging and graphics capabilities similar to the workstations but with maintenance characteristics more typical of a character-cell terminal. This is because the X-terminal depends on a remote host for CPU processing; only the X server program runs locally.

3.4   Interactive Development and Batch Processing

Three multi-user MicroVAX computers provide interactive access for the majority of AIMS users for application development, debug, test and access to existing generalized applications. Illustrated in Figure 10, they consist of a MicroVAX 3600 with mass storage for user space, 9-track tape drive, 8 mm helical-scan tape drive and 1200 baud modem for remote access; a MicroVAX 3900 with mass storage for satellite data and user space and a dual-density 9-track tape drive; and a VAX 4000-200. Access to these systems is primarily through one of four 8-port terminal servers that connect directly to the AIMS Ethernet network. In addition to disk storage associated with these systems, seven magneto-optical disk drives have been added within the past two years to meet the increasing demand for on-line storage of high volume satellite and associated ancillary data. Magneto-optical media are removable dual-sided cartridges with a capacity of 300 MB per side. On AIMS, these drives are configurable as ordinary disk drives and thus can be mounted from anywhere within the AIMS LAVC as private volumes. Magneto-optical drives compare favorably with Winchester-technology disk drives for disk reads; however disk writes are approximately 40% slower. Three additional drives were recently purchased to support additional satellite storage requirements for data intensive programs such as TACNEPH and calibration/validation of the SSMT2 millimeter-wave sounder.

19
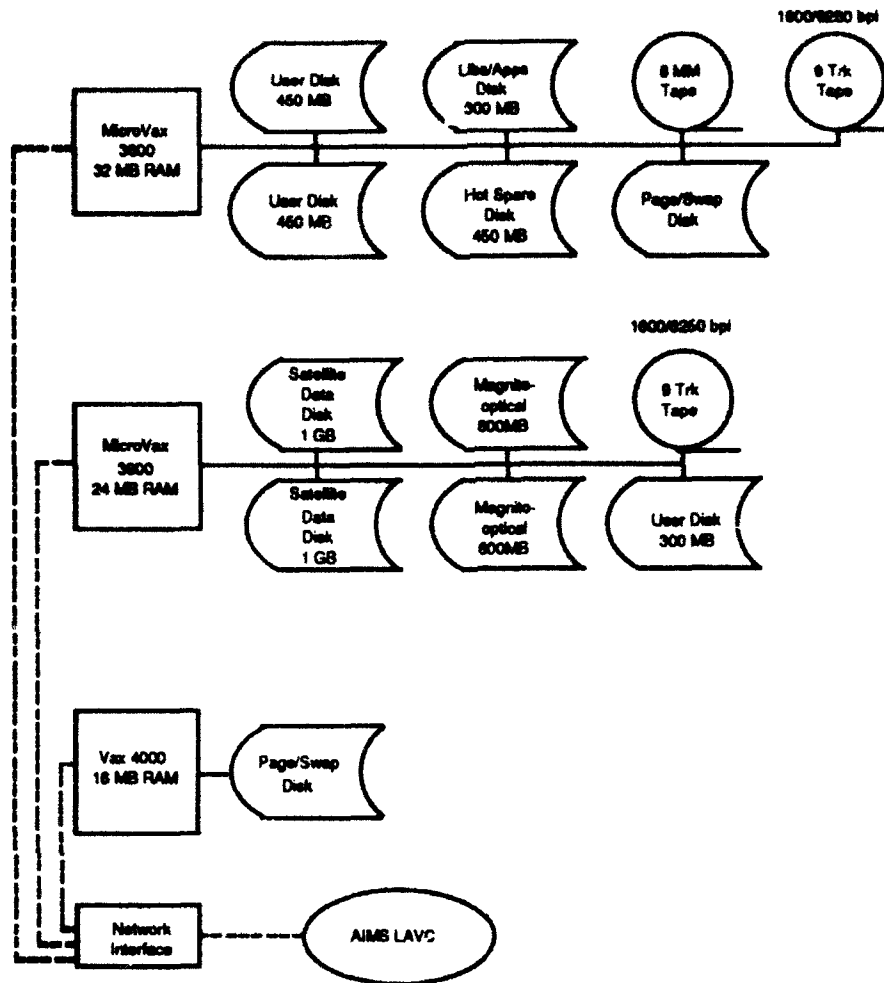
Figure 10. Interactive Development and Batch Processing Configuration.

AIMS has a limited capability for batch processing to handle CPU intensive applications such as mesoscale numerical models and radiative transfer models (e.g. FASCODE). While all AIMS LAVC nodes have batch capabilities, system wide batch queues have been established which attempt to optimally match program resource requirements with processor capabilities. For example, the multi-user MicroVAX 3900 is generally used for moderately CPU-intensive applications because overall its resources provide the best match with "typical" program requirements. Processing capabilities of the batch node are approximately three times that of the previous batch system, a VAX 11/750 minicomputer. Beyond the MicroVAX 3900, the laboratory's main computing center supports greater CPU-demand computing. A VAX 9000 and CONVEX mainframe provide five to ten times the processing capability of AIMS batch nodes.

3.5 Functional Use

The functional components of AIMS (data sources, data visualization and processing, interactive development and batch processing) together provide a flexible and full featured environment for the interactive display and processing of remotely sensed meteorological data. Realtime satellite data sources including GOES, NOAA/TIROS and DMSP provide timely high-quality imagery suitable for cloud analysis and studies related to environmental parameter retrievals. Once transferred to the LAVC side of AIMS through their respective DECnet links, these data are immediately available to Adage, VAX and SUN based workstations for interactive display and image processing. Additionally, computationally intensive processing of satellite data (e.g., RTNEPH satellite processor) not suitable for processing on the workstations due to high CPU and memory requirements, can take advantage of the AIMS batch node which also affords immediate and transparent access to the data. Typically, the results from batch processing are displayable cloud analyses or synthetic imagery that, in turn, are immediately available for visualizing on AIMS workstations.

The common thread that binds these functional components together is the system functionality of the LAVC. The AIMS Ethernet network provides a high bandwidth, system-extensible environment to accommodate meteorological data sources. Clustering tightly couples the ..etwork so that system resources and data are readily accessible from all workstation and multi-user nodes on the network. This provides an excellent solution to the acquisition, preprocessing and visualization procedural approach used by many research projects within the division. The disk-sharing characteristics of clustering mean that increased demand for data can be met by simply adding mass storage devices, such as magneto-optical, to the network. Finally, the VMS operating system, that runs on all AIMS LAVC nodes, provides a user-friendly interactive environment for application development. Program development, debugging, testing and performance measurement tools designed for the VMS environment are also available on virtually all AIMS LAVC systems to maximize availability of use.

3.6 AIMS Applications and the Development Environment

The growth and development of AIMS as an analysis tool for research in the atmospheric sciences is tightly bound to applications, both developed and acquired, that exploit the functional components of AIMS to facilitate its use. The VMS development environment was adopted early on as the foundation for AIMS applications because of its

inherent user-friendly interface and the wealth of tools available for program development. Adopting the VMS environment also meant that users would have a single, consistent view of the system in which user-developed applications would take on the same command structure already familiar to the AIMS user. The VMS command language is known as the Digital Command Language (DCL), a pseudo-natural language characterized by verbs that form the basis of the command and qualifiers and parameters that serve to further define or modify a verb's action. DCL can facilitate the production of long verbose commands and the development environment provides abbreviation to reduce command length. An alternative to abbreviation is the use of symbols. A symbol is a name that represents a numeric, character, or logical value. When used in a DCL command line, DCL replaces the symbol with its value. Symbols have a number of applications, one of which is using them as synonyms. Defining a symbol as a command line (or a portion of the command line) facilitates execution of the command because only the symbol name needs to be typed. As an example consider the command a user would have to type on AIMS to print a file (called Output.Txt) to one of its printers without the benefit of symbols:

$ Print/Notify/Queue=LYS_Laser/Setup=LN03_80 Output.Txt

By defining a symbol that equates to the command line (excluding file name):

$ P = Print/Notify/Queue=LYS_Laser/Setup=LN03_80

the user can use the symbol as a synonym for the command line, thus reducing the amount of typing required to execute the print command. The command line with symbol replacement would look like:

$ P Output.Txt   or in general,

$ P *<Filename>*

Synonym use of symbols is typically used to customize the user environment, reducing lengthy commands to short familiar symbols that will be used on a regular basis. In fact symbols can be used to emulate other operating system command languages such as the UNIX Bourne shell. VMS also supports a feature known as logicals. Logicals allow the user to dynamically map a physical expression (e.g., file pathname) to a logical name. By referring to the logical name (rather than the physical expression) within an applications program, reassignment of the physical expression can take place without having to make code changes. Logicals are used extensively by AIMS applications as an effective way to

address the location of data that potentially may move from one physical location to another (e.g., because of a hardware failure or reconfiguration). For example on AIMS all conventional meteorological data are stored in and accessed from the physical location:

ARCUNO$DUC0:[FAA.Data]

where ARCUNO is the node, DUC0 is the disk and FAA.Data is the directory location. Software programs that make use of conventional data could access the data by referring directly to this physical location. However the disadvantage of using the physical location is that if the data had to be moved to a new physical location, software programs (possibly many) would require code changes. Alternatively, the physical location is mapped to a logical name. In this example, the logical name FAA_Data is used to define the location of conventional meteorological data. To effect the logical to physical mapping one would execute the command:

$ Define FAA_Data ARCUNO$DUC0:[FAA.Data]

If, at some later time, the physical location changes and the database administrator updates the logical name to:

$ Define FAA_Data ARCDEV$DUA0:[FAA.Data]

then programs that refer to the logical FAA_Data would not require code changes. This is because the mapping is dynamic, that is, references to the logical name will always map to the most recent physical definition.

The AIMS development environment provides a diverse set of software tools described in Table 5. Software exists for code development in high-level languages, interactive debugging and a tool to measure program performance. GKS is used for basic graphics and NCAR graphics, based on GKS, provides scientists with higher-level functions geared towards applications in the atmospheric sciences such as objective analysis for contour programs and specialized graph generation. The following sections describe some of the more generalized applications developed to provide the AIMS user community with useful tools for the research environment.

Applications centered around processing and display of satellite data have been developed primarily for the Adage workstations although recent efforts have ported some

23

Product	Function
VAX Fortran	Scientific Programming
VAX C	Scientific/System Programming
VAX Debugger	Application Debugging
VAX Performance and Coverage Analyzer	Application Performance Analysis
DEC Graphics Kernel System (GKS)	2-D Graphics
NCAR Graphics	Scientific Graphics Based on GKS
Motif/DECWindows	X Window Interface
DECWrite	Document Preparation
DECWrite CDA	Document Conversion/Incorporation
Quantum I/O	Programming Interface to File System

Table 5. Software Tools Available on AIMS.

of these applications to low-end workstations and X-terminals. Utilities exist to manipulate registers and perform standard functions on the Adage. Standard functions revolve around manipulation of channels, frames, window and viewport, cursor control, overlay color, erase and zoom/pan. Adage color lookup tables can be manipulated interactively as well. Supported assignments include linear, bilinear, histogram equalization, histogram matching, multiple lookup tables and the ability to save and restore lookup tables. Image loading transfers an image or image subset from a disk file to Adage frame buffer memory. Conversely, the image save function saves an image or image subset from Adage frame buffer memory to a disk file. Another interactive utility allows the user to toggle among channels and frames on the Adage and provides cursor control to move and monitor cursor position. For applications development, a library of image processing functions has been developed to perform functions such as high/low pass filtering, gradient filtering and other convolution techniques; image addition and subtraction; geometric and gray scale transformations; thresholding; and histogram generation.

Application development for conventional meteorological data began at the programming level to provide a single programming point-of-access to all data sources and data types that comprise the conventional meteorological database (Table 4). Known as the AIMS DataBase (ADB) utility (Thomason and Ivaldi, 1990), the utility consists of a programming interface and data "drivers," modules that extract data elements for a particular data source. ADB supports geographic-based requests for conventional meteorological data using station number, station ID, state, country, latitude-longitude box or sectional area as location specifiers. It also supports time-series-based requests using a

24

start and stop time and time increment for a single station. ADB supports integer, real and character string output formats that are programmer-definable and imposes no restrictions on the amount of information returned to the calling program.

Additional support modules complement the application environment for conventional data. Like ADB they provide a single calling interface for applications programming and adhere to the VAX calling standards. These modules are summarized below.

1. The Station ID module provides access to the conventional meteorological station database. This software accepts a station attribute and returns the remaining attributes for a single station or group of stations. Queries can confine the station list to a single reporting class or only those stations that report observations on a "regular" basis.

2. The AIMS Map Library converts a coordinate or array of coordinates from one projection to another. Supported projections include latitude-longitude, Mercator, polar stereographic, Lambert conformal and spin-stabilized GOES. The capability also exists to convert absolute coordinates to relative coordinates for transformations associated with gridded fields.

3. Spatial objective analysis software provides a means of determining a uniform gridded representation of a data field from randomly spaced data points. Analysis methods are based primarily on empirical techniques including weighted interpolation and spline fit. The analysis includes a first-guess stage to initialize grid points; supported methods are simple zeroing, arithmetic mean, area-weighted mean, planar, and median filter. Empirical interpolation methods are based on either Barnes (1964) or Cressman (1959) techniques.

4. Support libraries include the AIMS Library Utility, a collection of software modules that compute derived meteorological data types, and a clock library that provides routines for computing date and time information in character string, binary, integer binary and integer julian formats.

Appendices A through D contain functional descriptions of the most commonly used routines including ADB, Station ID, Map Transform and the clock library.

The completion of ADB and associated modules and libraries facilitated development of generic and flexible list, plot, and analysis applications. Appendix E provides a

25

synopsis of each application along with example output produced by its execution. All applications utilize the DCL calling interface for activation to comply with the interactive environment already familiar to the user. Graphics-oriented plot and analysis applications are based on GKS, which supports many output devices on AIMS including LN03 laser printers, POSTSCRIPT, an ink-jet printer, graphics terminals and X devices. An extension to the development environment is the use of the VMS help facility to document command-level use of developed applications. The help facility is also used to provide first-time users with information about AIMS and a description of its resources including archive storage, disk storage, printers, the batch environment and backup procedures.

3.7 System Integrity and Reliability

System integrity and reliability of hardware, software and data are primary concerns of AIMS users. Several measures have been taken to minimize down time and reduce data loss. First, critical hardware is covered by a third-party maintenance contract that requires response within 24 hours of notification. Spare equipment is on hand to provide interim solutions to the 24 hour response window of the maintenance contract. They include a disk to shadow one of the two major user disks of the system and redundant 9-track tape drives for 1600 bpi use. Second, custom components not covered by maintenance generally have spares available to protect against equipment failure. They include the GOES ground station receiver and DLI and QLINK interfaces. In general, AIMS peripherals are multiply configured not only to meet increased user demand but also to provide a minimum configuration should one or more components fail. Multiple components include laser printers, dual-density 9-track tape drives, 8 mm tape drives and magneto-optical disk drives. Finally, Uninterruptible Power Supplies (UPS) for all AIMS nodes have been installed to protect AIMS from potential damage caused by blackouts, brownouts, lightning and line surge. One of the features of the UPS systems is a computer communications port that facilitates the orderly shutdown of computer systems during prolonged power loss. This is an important feature for systems such as AIMS that have a distributed file system.

The day-to-day computer operations of AIMS are comprised of various tasks, some of which address data integrity. Full backup of user data occurs weekly utilizing a systematic rotation procedure that employs three sets of archive tapes. Data loss is limited to one week at worse while data recovery extends to the previous three months. System files are backed up every few months. GOES data are not archived on a regular basis primarily because of the volatility and enormous volume of data available. Rather, GOES

data are archived on an as-needed basis for regions of interest that satisfy a particular need. Conventional meteorological data, including lightning data, are archived bi-weekly and then purged from the system to minimize storage requirements. Polar-orbiting satellite data from selected passes of NOAA-11 and 12 and DMSP F10 and F11 satellites are automatically archived to 4 mm DAT tape daily. From a software perspective, maintenance and upgrade releases of the operating system and layered products are typically installed after careful review to assess the benefit/impact of performing the upgrade. Maintenance releases are provided solely for bug fixes while upgrades (major and minor) usually add functionality to existing software.

4. AIMS Support to Atmospheric Research

The design philosophy for AIMS emphasizes user needs and requirements over systems engineering considerations. This design philosophy is reflected in many of the system components including the choice of operating system, the large number of individual workstations, the emphasis on interactive capabilities and most significantly, in the distributed nature of the system. In order to understand AIMS it is necessary to understand the types of applications it was developed for. In the six plus years since its inception, the system has been used to support a large number of different applications. While scientifically distinct, many of these have shared a common requirement for processing large amounts of satellite sensor data in an interactive environment. The volume and unique processing requirements imposed by the data drove many of the system design considerations. The interactive aspect is one that has served the research needs of the users especially well. It is ideally suited to the iterative, trial-and-error approach that is common to many research problems. In this section we review the scientific applications that have been supported by AIMS.

4.1 Image Processing for Data Visualization and Interaction

An early project on AIMS investigated the usefulness of interactive image processing as a diagnostic and analytical tool for interpretation of satellite imagery. As a result of this investigation many of the current image processing and display capabilities available on AIMS were developed. For effective acquisition and processing of multispectral imagery from the DMSP OLS and SSM/I, NOAA AVHRR, and GOES VAS sensors, and to more fully exploit these data sources for cloud analysis and other meteorological applications, an optimal satellite data processing capability was developed to provide a systematic and integrated approach to manipulation of the data. This approach was also successfully

27

applied to products derived from objective analysis and interpretation of digital satellite and other meteorological data (e.g., gridded cloud amount and altitude, sounding profiles). Interactive image processing has been used extensively to maintain a qualitative control of analyses accuracy and data quality through manual examination of synthetic imagery produced from derived products. Discontinuities or anomalous values are quickly and easily detected in the imagery data and visual comparisons between initial data fields and analysis products are useful for characterizing algorithm performance. Aspects of the integrated processing and analysis approach include graphical display, image processing, interactive analysis and database management.

As described in section 3.3, fundamental image processing and display functions such as contrast enhancements, convolution filtering, and pseudo/full color displays are available on the image processing workstations. However, new and upgraded techniques that exploit the advanced capabilities of single-user workstations now available on AIMS are being developed in response to specific research requirements. For example recent work using full color imaging for display and interpretation of multispectral imagery has shown considerable promise both as an interactive image interpretation tool and for qualitative evaluation of potential new nephanalysis algorithms. Synthetic imagery derived from either manual or automated analysis techniques offer potential as ground truth for nephanalysis. In general, graphical display capabilities are varied and non-standardized; however, on AIMS the need for graphical display as a visualization tool is universal. Typical meteorological applications include optimum interpolation and objective analysis, linear cross-section analysis, atmospheric (vertical) profile representation, data plotting on standard map or satellite projections, regression analysis, and curve fitting. Ongoing development of advanced image processing and display capabilities complements virtually all aspects of satellite cloud and precipitation research being performed within the Satellite Meteorology Branch.

4.2 Objective Nephanalysis

While many applications are supported on AIMS, the most significant in terms of resource allocation (e.g., CPU time, mass storage, memory, image display and graphics) is cloud analysis. Nephanalysis work within the Satellite Meteorology Branch predates AIMS (see for example Valovcin, 1978; Bunting and Fournier, 1980; d'Entremont et al., 1982; Bunting et al., 1983) and was one of the principal drivers for the original system specifications. Traditionally cloud research has concentrated on global nephanalysis from visible, infrared, and multispectral satellite sensor data, generally in support of the Air Force

RTNEPH operational model (d'Entremont, 1986; d'Entremont *et al.*, 1989a; d'Entremont *et al.*, 1989b; Griffin and Thomason, 1990; Barker Schaaf *et al.*, 1990; d'Entremont *et al.*, 1990 and Ward *et al.*, 1992). More recently this has been expanded to include the effect of retrieved temperature and moisture profiles and other environmental parameters from microwave imager channels. In the past few years nephanalysis work has focused on development of a new, regional or theater-scale cloud model for use in tactical applications (Isaacs and Gustafson, 1991; Gustafson and d'Entremont, 1992). Nephanalysis techniques under investigation rely on both the spatial and spectral characteristics of multispectral satellite sensor data. Cloud detection is performed through interpretation of spectral characteristics of cloud surfaces relative to background or atmospheric contributions. Cloud layer analyses are performed through segregation of the spatial characteristics of cloud layers. AIMS capabilities for data acquisition, data handling and manipulation, batch processing, and image processing and display are used extensively for nephanalysis work.

In addition to cloud detection work, AIMS is also used to support development of an innovative technique for determining cloud microphysical properties using daytime near-infrared middle-wavelength (MWIR) infrared radiances from geosynchronous satellites. Since at MWIR wavelengths upwelling radiances from water clouds are a combination of emitted thermal and reflected solar components, a simple method is used to first remove the thermal effects. The remaining scattered solar radiances can be used to determine the mode radius of the cloud particles. The method is presently being tested using GOES VAS data that are received in real-time on AIMS. In conjunction with the GOES investigation, a theoretical study was also performed which determined that if an interferometer were available on a geosynchronous satellite, both the mode radius and the optical depth could be determined. The theoretical studies make use of a polydispersion Mie code described by Longtin and Shettle (in press) and a discrete ordinate radiative transfer model described by Stamnes *et al.* (1989).

4.3 Composite Satellite Image Display

A technique known as Composite Image Display (CID) was developed on AIMS to simulate a full color (24-bit) multispectral image display on 8-bit color systems. CID combines the spectral information from two or three channels of data into a single image product in which colors are used to highlight areas of primary meteorological interest to users such as operational forecasters. Full color techniques were originally applied at PL using the 32-bit Adage image processing systems. These techniques have been commonly

29

used on AIMS to interpret data from multispectral instruments like the AVHRR for applications such as detection of low clouds and fogs at night and identification of thin cirrus and contrails. Daytime detection of clouds is also enhanced. With CID it is possible to combine multispectral data and display results comparable to high-end 24-bit display systems on relatively inexpensive and commonly available 8-bit workstation computers. CID technology has been used by researchers and operational meteorologists at the Air Force Global Weather Central; European Forecast Unit, Detachment 13, 2nd Weather Wing at Traben-Trarbach, Germany; and DoD contractors such as Harris Corporation, Aerospace Corporation, and Lockheed. It is currently in operational use at the German Military Geophysical Office in Traben-Trarbach. For details on the CID composite simulation technique, see Thomason and d'Entremont (1992).

4.4 Passive Microwave Remote Sensing

Microwave imagery data from the DMSP Special Sensor Microwave/Imager (SSM/I) are being used to study the characteristics of tropical cyclones occurring in the western North Pacific. The SSM/I is of particular value in obtaining information on cloud, precipitation, and wind speed distributions in these storm systems. Analysis of derived brightness temperature data is being used to develop algorithms for identifying storm features such as the distribution and extent of most intense convective activity, location of storm center (eye), and estimates of storm dimension and intensity. SSM/I data are received in real-time at the AIMS DMSP ground station and on tape from the U.S. Navy for locations in the Pacific.

In late 1991 the SSM/T-2 moisture sounding instrument was first launched on board the DMSP F-11 satellite. PL/GPAS is conducting the instrument calibration effort as part of the Air Force calibration/validation study that is being performed prior to designating the new sensor as operational. All data storage, handling and analysis for this program is being performed on AIMS. The initial phase of the program is to verify the instrument calibration with the ultimate goal to determine how accurately estimates of the vertical distribution of atmospheric water vapor can be retrieved from the sensor data. Diverse databases, such as the satellite sensor data, radiosonde and surface observations, and NASA aircraft measurements, are being collected, merged and collocated. Radiative transfer models are being used to calculate expected instrument brightness temperatures from radiosonde and surface observations. PL/GPAS also participated in the calibration study for the SSM/I instrument following its initial launch on the F-8 satellite in 1987 (Hollinger, 1991; Gustafson and Felde, 1989).

30

To achieve global coverage from microwave sounding instruments, one proposal has been to increase the scanning angle on future sensors. However, resulting large incidence angles could impact the accuracy of geophysical parameter retrieval algorithms. The gross effect of high angle measurements is an increase in the atmospheric path sampled due to the cosine dependence of the optical thickness on air mass factor. Generally, an increase in the atmospheric path will enhance sensitivity to atmospheric parameters (e.g., water vapor and cloud liquid water) at the expense of retrieved surface parameters (e.g., surface emissivity and sea surface wind speed). A study is currently underway to investigate the physics involved with viewing the atmosphere and geophysical surfaces at large incidence angles with passive microwave sensors. The investigation consists of three parts: (1) development of appropriate simulation tools, (2) assessment of the impact of large viewing angles through geophysical parameter retrievals using simulated data at large viewing angles, and (3) extending existing capabilities for modeling microwave surface emissivity properties to large angles and higher frequencies. Data simulations will require extensions to the RADTRAN radiative transfer model previously developed at the Phillips Lab. AIMS is being used for all phases of the project including software development and testing as well as the actual model runs.

4.5 Satellite/Model Coupled Mesoscale Analysis

AIMS has been employed to run a mesoscale weather analysis system in which numerical interpretation of satellite data is coupled with integration of a numerical model (Lipton and Vonder Haar, 1990). The satellite provides input data for the model and the model provides initial-guess data for retrieving meteorological information from satellite radiances. The direct product of the system is a four-dimensional mesoscale analysis. Experiments have focused on understanding regionalization of convective cloud development, and have incorporated satellite data on water vapor concentrations, ground surface temperatures, and radiative characteristics of clouds (Lipton, 1990).

5. Future of AIMS

Short to intermediate term needs for AIMS are usually planned on a yearly basis and address general as well as project-specific requirements for hardware, software and service improvements and additions. Current needs are discussed below. Long-range planning for AIMS has not been adequately addressed since the time of its inception. Subsequent sections describe some of the factors that have shaped the current AIMS

31

configuration and where AIMS is headed, and suggest guidelines and recommendations for future planning.

5.1 Short Term Needs - Systems and Services

Short term needs of the system need to be addressed to insure the continued use of AIMS as a system designed to support the atmospheric research community through acquisition, processing and display of remotely sensed meteorological data. The Adage-based workstations that provide AIMS with high-end image processing capabilities are in need of upgrading. The hardware is close to 10 years old, maintenance is not available and spare parts are difficult if not impossible to obtain. From a software perspective, applications developed over the past six years to provide users an interactive interface to Adage capabilities have been driven primarily by project-specific needs, resulting in multiple and somewhat redundant utilities. Consequently a generic interactive interface to the Adage based on a set of user-defined core requirements has never emerged. Addition-ally the Adage is the only workstation architecture on AIMS that does not support the X windowing system. This is a distinct disadvantage for the Adage because X-based applica-tions for high-end imaging are now available on the commercial market. It is also a dis-advantage for AIMS because it creates an undesirable dual workstation environment. The selection of a successor to the Adage must obviously meet the minimum requirements that the Adage now provides in hardware and that the base of developed applications provides in functionality. Support for a standard such as X will provide users a single consistent workstation environment across operating systems and hardware platforms. X would also facilitate the development of a generic display and processing environment in which lower-end workstations would share a subset of the capabilities of high-end workstations.

There is also a need to provide high quality black-and-white and color hard copy output for the Adage workstations. From an evaluation of current print technologies, thermal-dye sublimation appears superior in image reproduction and color fidelity. Unfortunately, these printers are still relatively new to the market as reflected by the lack of integrated solutions for various computer platforms and limited support for POSTSCRIPT. When a viable solution for AIMS is available this capability will complete the general upgrade requirement for image processing and display.

Finally, the need for a system on AIMS that can serve computationally intensive tasks has been discussed and debated for some time. Existing applications that tend to be

32

computationally intensive include automated cloud analysis, radiative transfer calculations and limited numerical modeling although actual use has been infrequent. Traditionally these types of applications have been run on higher-end systems located at the central computing facility but this has created problems in making the datasets that normally reside on AIMS available to these systems. One short-term solution that would facilitate use of mainframe systems in the lab is a capability that already exists within the lab but has not been exploited. It is a DEC product known as Distributed File System (DFS) and it provides a subset of clustering capabilities for DECnet networks. DFS could be used to extend the existing GP Ethernet backbone to provide a tightly coupled network configuration between a dedicated AIMS disk containing the required datasets and a mainframe machine, such as the VAX 9000, to run the program.

5.2 Short Term Needs - Software and Applications

The need for a comprehensive graphics software package that can satisfy the spectrum of needs from simple interactive plotting of spreadsheet data to support for sophisticated program-based objective analysis applications has been universal among AIMS users but difficult to fulfill. GKS-based products from DEC and NCAR partially satisfy the need, but even these products have problems such as poor documentation and inadequate support for problem resolution and bug fixes. Other interactive solutions are currently being used in a limited capacity. PV-WAVE from Precision Visuals is an interactive software system used for analysis of scientific data. PV-WAVE installs on existing VAX stations running X windows and provides a fourth-generation programming language and a plotting/image display package. PV-WAVE is currently being used to support numerical model assimilation studies using radar data. On personal computers, products such as Quattro Pro and Harvard Graphics are used to interactively produce simple line plots of scientific data in spreadsheet format. The benefit of these types of packages is the relative ease in producing both complex and simple plot displays interactively, thus avoiding the often tedious procedure of developing a software program to provide the same capability.

Commercial hardware and software solutions for integrating data sources into the AIMS environment are often incomplete and require development effort to facilitate its use and provide a cohesive system. In the case of GOES data, current capabilities are limited to a 24-hour rotating archive of visible and multispectral infrared imagery that are transferred to the LAVC side of AIMS following ingest. User-defined image subsets are fixed with respect to geographic extent and data files must be managed manually, typically by storing

33

files in different directory structures. Improvements to handling and managing GOES data are currently underway. Software is being developed to provide the AIMS LAVC an interactive capability to schedule the real-time GOES ingest as well as request data from a database system that manages data automatically on both the ingest computer and the LAVC gateway node. A formal database for GOES data will also provide the capability to interactively query data based on data characteristics rather than depending on file names to describe file contents.

The lower-end 8-bit workstations on AIMS total nine at present and are somewhat under utilized due to the lack of available software to exploit the satellite and conventional data processing capabilities of AIMS. Software that is available generally takes the form of a menu or screen-based utility that must be terminated in order for the user to perform any other interactive functions. Thus it is the utility that is interactive and not the workstation environment. An interactive workstation environment must provide a software framework, preferably based on X, that can manage the asynchronous execution of multiple concurrent applications that share workstation resources. Such an interactive environment (although not workstation-oriented) has been implemented on the Encore GOES ground station computer and more recently a limited capability has been demonstrated on AIMS 8-bit workstations.

In addition to the domestic and international data services under the FOS, the Numerical Product Services (NPS) is also available, containing analyses and forecasts derived from NMC LFM, NGM and global spectral models. The data are binary and are formatted in WMO GRIdded Binary (GRIB) format prior to transmission. Data are transmitted in synchronous mode (as opposed to asynchronous mode used by all other data services) using the X.25 protocol standard and thus will require a synchronous port connection on AIMS. The availability of software to handle X.25 transmission and the GRIB format will require further investigation; however, plans to incorporate this data into the AIMS conventional database for interactive and programming access have already been outlined. The plan calls for the integration and management of gridded data from this service (as well as the current capability to produce gridded fields from raw data) through development of a grid-point database and management utility.

5.3 Long-Range Plans and Goals

From a systems perspective, AIMS has been shaped not only by the original requirements developed for the acquisition and processing of meteorological data but also

34

by additional ad-hoc requirements, both well- and ill-defined with respect to matching needs to AIMS and its resources. AIMS has become increasingly popular as a system that supports a wide range of needs and is convenient to use. This can be attributed, in part, to the marked improvement of computer connectivity made possible by off-the-shelf computer networking hardware and software that emerged in the late 1980s. It is also a reflection of the flexible and extensible nature of AIMS that has permitted, if not encouraged, the expansion of the system into the diverse areas that it now supports. To understand where AIMS is headed it is important to understand how AIMS is currently used.

In addition to the primary research-driven functions, AIMS also performs functions characteristic of a general-purpose computing system. It is an important hub for the exchange of information, primarily through the use of electronic mail, both within the laboratory and to outside networks. It is used for computer training, data entry, word processing, desktop publishing and supports a generic account that provides a simple interface to AIMS general purpose meteorological applications that is geared to the novice user. AIMS provides disk and print services to a growing base of PC users that are beginning to perform many of the data processing and display functions normally associated with AIMS workstations. AIMS is also starting to expand beyond the long-held DEC computer architecture to support other platforms such as SUN, IBM and Apple, each requiring individual administration that is complicated by the need to integrate these platforms into the existing LAVC environment.

From a physical standpoint, AIMS has grown dramatically from its modest beginnings and this has introduced logistical issues for system administration and management that did not exist six years ago. These issues need to be addressed as part of long range planning, particularly in light of recent trends toward heterogeneous networking (i.e., a network with a significant mix of computers from different vendors), individualized computing on the desktop and general-purpose computing. The expansion of these three areas without formal planning could endanger the effective use of AIMS and render the system unmanageable. The following guidelines are presented as a basis for long range planning for AIMS:

1. Goals must be clearly defined before long range planning can proceed. If current trends and use of the system reflect new or different goals they should be formally identified.

35

2. There needs to be a balance between what AIMS can do and what can be supported based on current staffing. Additional staffing may be necessary based on current growth trends.

3. There needs to be improved analysis of matching project requirements to laboratory resources before the start of the project.

4. Criteria for establishing system needs must be formulated (e.g., capabilities should be added with the overall community of users and system goals in mind; capabilities should be added on a per-project basis, independent of others).

Historically AIMS has been primarily a homogeneous system composed of DEC computers that form a tightly coupled network with LAVC software. However platforms from other vendors, particularly in the UNIX workstation market, are now being considered for CPU processing capabilities and hardware/software solutions for image processing. Careful thought about system integration issues must be given if AIMS is to move closer to a heterogeneous network. One way to address these issues is through the use of *de facto* and ANSI/IEEE standards. X-Terminals provide a viable alternative to workstations for low-end image and graphics processing. Because they implement X directly and support multiple networking protocols (e.g. DECnet and TCP/IP), they can be hosted by any number of platforms that support X (e.g. DEC, SUN, Hewlett Packard). Additionally, their terminal characteristics simplify systems administration. X as a windowing interface currently cannot totally hide the specifics of the underlying operating system but nevertheless facilitates the use of systems in a multivendor environment. A more important issue for systems integration will be the file system, a critical part of AIMS that has bridged almost all functional components through incorporation of LAVC software. Distributed file systems are well developed for homogeneous networks like LAVC and SUN's Networked File System (NFS) but solutions for heterogeneous networks do not have the benefit of a standard that could be adopted by vendors. AIMS may have to depend on third-party solutions to maintain a possibly degraded distributed file system.

6. **Summary**

In 1986 an interactive computer system known as AIMS was developed by the Satellite Meteorology Branch at the then Air Force Geophysics Laboratory (now the Geophysics Directorate of the Phillips Laboratory) to replace an aging and overburdened

McIDAS. The requirements for the system specified a network of distributed processors, each functionally unique and linked by a local area network. The emphasis on providing a flexible and extensible system for research users has been maintained throughout the lifetime of the system, largely because many of the research users were responsible for the selection, acquisition and development of new hardware and software. Because AIMS was designed specifically as a research tool for scientists, a decision was made to select a hardware and software architecture for the system that favored simplicity of operation and easy expansion over one that emphasized brute calculating power. Thus the VAX/VMS architecture from Digital Equipment Corporation was chosen for the processing environment and the DECnet networking protocol, later supplemented by the Local Area VAX Cluster protocol, for network communications. In spite of the overall success of the DEC configuration, certain specific operations were not easily implemented in this environment. Consequently, two special purpose computers were also integrated into AIMS; they include a Gould (now Encore) minicomputer along with necessary receiver, bit and frame synchronizer hardware to handle real-time ingest of GOES satellite data, three Adage imaging subsystems for image processing and display operations and most recently two SUN Sparc stations with satellite receiving antenna subsystems for real-time acquisition of NOAA/TIROS and DMSP polar orbiting data.

AIMS in its current configuration satisfies the needs of some thirty active users through four functional capabilities: network access, real-time and archived data sources, data visualization and image processing, and interactive and batch processing. Ethernet hardware provides the network backbone for AIMS, all systems are either tied directly to the AIMS Ethernet or are reachable through a network gateway computer. Imaging systems are hosted on dedicated VAXstations that are members of the cluster. LAVC software provides transparent file access among all DEC systems on the network. The GP broad band network links the AIMS LAVC to numerous outside networks via an Ethernet bridge. Outside networks including NSI, DDN, and NEARnet (DDN and NEARnet are both members of Internet) provide access to laboratories, government facilities, and private companies worldwide. AIMS also has access to a direct T1 satellite link between the Geo-physics Directorate at Hanscom AFB and a Cray-2 supercomputer at Kirtland AFB, NM.

Meteorological and supporting data flow into AIMS through several possible routes: 1) real-time direct broadcast satellite transmissions, 2) network file transfers (e.g., FTP), 3) direct serial links, 4) 9 track, 8 mm, or 4 mm DAT magnetic tape, or 5) CD ROM optical disks. Satellite transmissions are received directly at one of three satellite ground

37

stations configured to receive GOES, HRPT and DMSP broadcasts. These subsystems are based around non-DEC computers and require third-party software to communicate with the AIMS LAVC. Most network file transfers from outside the laboratory enter the system via a separate gateway computer maintained by the Geophysics Directorate's main computing center. This gateway computer is a node on the GP broadband network and communicates with AIMS using DECnet protocols. The gateway computer is needed to translate incoming data packets from the Internet standard TCP/IP protocol to DECnet since AIMS currently does not support TCP/IP. Plans to install TCP/IP software on AIMS are forthcoming. At present, the only data coming into AIMS through serial links are lightning data received indirectly from the SUNY-Albany lightning detection network. The existing connection to the FAA WB604 line for reception of conventional meteorological data was recently upgraded to the NWS Family of Services received from a communications satellite through a preexisting receiving system. Data on magnetic tape are received from numerous outside agencies including AFGWC, ETAC, NOAA/NESDIS, NASA, NCAR, ASL and GMGO. Historically, tapes have been the preferred method for transferring data from outside the organization; however, this is rapidly being replaced by direct file transfers via Internet. Recently the Defense Mapping Agency began distributing large volume geographic data sets on CD ROM. CD ROM is also becoming the preferred medium for software vendors to distribute new and revised software packages to customers.

Visualization of data and experiment results is probably the single most important capability on AIMS. Virtually every scientific project that uses AIMS exploits this capability, at least for quality control of the input data and validation of algorithm results. There are basically two types of display systems on AIMS. The first are image processing workstations that consist of VAX station 3600 single user systems linked to Adage 3000 imaging subsystems. Each workstation configuration consists of two monitors; one each for the VAX station and the Adage; large frame buffers; high speed bit-slice processors for processing raster data; multiple 8-bit look up tables; and keyboard and mouse for user input. These systems are capable of performing standard image processing and display functions on large multispectral data sets at interactive speeds. The VAX station and Adage subsystems complement each other functionally with the VAX station providing network communications, a standardized user interface, and high level graphical display capabilities while the Adage provides high speed display and image manipulation functions. The second type of display system available on AIMS are stand-alone single-user VAX workstations. These systems are characterized by 8-bit color graphics, ample system memory, local storage disks, and membership on the AIMS LAVC. They provide an X window

based interface to AIMS, generally reside within individual offices and are used for a variety of applications including software development, analysis and display of meteorological data, word processing, network communications, and other general purpose computing. X windows is becoming the *de facto* interface standard for all AIMS workstations due to its functionality and nearly universal acceptance across hardware platforms.

Although AIMS was primarily developed to support interactive computing there has been a consistent secondary need to support relatively compute-intensive jobs through batch processing. All VMS systems have batch queues as an integral part of the operating system, however, on AIMS a select number of systems have been tailored to handle relatively large batch type operations. To satisfy the requirement for batch capabilities in an efficient manner, several system-wide batch queues have been developed. Each queue is matched to a particular type of application depending on the requirements for memory, mass storage, CPU, and wall clock time. Each queue is backed by system resources designed to provide optimal performance for its particular type of application with minimal impact on the rest of the cluster. Also, in addition to the capabilities on AIMS, users have direct access to a VAX 9000 mini super computer and a Convex mainframe maintained at the GP main computing center.

Over the six plus years since its inception, AIMS has grown steadily through an evolutionary process. When shared access to distributed mass storage and processing units became possible through incorporation of LAVC software, AIMS enhanced its networking base to include clustering in addition to DECnet. Similarly in the late 1980s a new generation of VAX systems based on microprocessor technology brought about a quantum increase in processing power over previously available minicomputers. At the same time the size, complexity, and cost of these systems were reduced to a level where small organizations such as GPAS could now realistically afford to build large, high powered distributed systems through incremental growth. Later, the idea of low cost, fast microprocessor-based systems was extended to the workstation. Once again, because of its distributed nature, AIMS was able to exploit this development to put not only here-to-fore unavailable processing power on a scientist's desk but to also provide graphics and imaging capabilities as well. Thus the development of the microprocessor and workstation resulted in a quantum increase in both the power and size of AIMS. Unfortunately this growth did not come without a price. As the system grew it was accompanied by a dramatic increase in the complexity of system management and planning. Originally AIMS was run by a somewhat haphazard coalition of scientific end users and programmers. This

39

arrangement was quickly replaced by a single designated system manager and now has grown to two full time administrators and a hardware technician. In general AIMS has been sensitive to the changing short term needs of its users and its expansion into a division wide resource has reemphasized long term planning issues. Recently, a coalition known as the AIMS User Group (AUG) was formed to 1) discuss user and system requirements related to growth, policy changes or software development, 2) provide an outlet for the technical exchange of AIMS related information and presentation of applications of general interest, 3) provide system announcements such as scheduled downtime for system upgrades, and 4) discuss long range plans for AIMS.

7. References

Barker Schaaf, C.L., J.M. Ward, G.B. Gustafson, R.P. d'Entremont, M.K. Griffin, P.L. Novak, and J.T. Bunting, 1990: Effects of terrain elevations on the RTNEPH IR satellite processor. Preprints, Fifth Conf. on Mountain Meteor., Boulder, CO, 25-29 June, Amer. Meteor. Soc., Boston, 160-163.

Barnes, S.L., 1964: A technique for maximizing details in numerical weather map analysis. J. Appl. Meteor., 3, 396-409.

Bunting, J.T. and R.F. Fournier, 1980: Tests of spectral cloud classification using DMSP fine mode satellite data. AFGL-TR-80-0181, ADA094119.

Bunting, J.T., R.S. Hawkins, R.P. d'Entremont, and G.B. Gustafson, 1983: R&D neph-analysis at the Air Force Geophysics Laboratory. Preprints, Fifth Conf. on Atmos. Radiation, Baltimore, MD, 31 Oct-4 Nov, Amer. Meteor. Soc., Boston, 272-275.

Cressman, G.P., 1959: An operational objective analysis system. MWR, 87, 367-371.

d'Entremont, R.P. 1986: Low- and midlevel cloud analysis using nighttime multispectral imagery. J. Climate Appl. Meteor., 25, 1853-1869.

d'Entremont, R.P., R.S. Hawkins, and J.T. Bunting, 1982: Evaluation of automated imagery analysis algorithms for use in the three-dimensional nephanalysis model at AFGWC. AFGL-TR-82-0397, ADA131986.

d'Entremont, R.P., J-L. Moncet, T.R. Miller, M.K. Griffin, L.W. Thomason, J.T. Bunting, and C. Barker Schaaf, 1989a: An outline for the RTNEPH infrared atmospheric water vapor attenuation study. GL-TR-89-0344, ADA221753.

d'Entremont, R.P., G.B. Gustafson, J.T. Bunting, M.K. Griffin, C. Barker Schaaf, P.L. Nowak, J.M. Ward, and R.S. Hawkins, 1989b: Comparisons between the RTNEPH and AFGL cloud layer analysis algorithms. GL-TR-89-0175, ADA216637.

d'Entremont, R.P., M.K. Griffin, and J.T. Bunting, 1990: Retrieval of cirrus radiative pro-perties and altitudes using multichannel infrared data. Preprints, Fifth Conf. on Satellite Meteor. and Ocean., London, 3-7 Sept., Amer. Meteor. Soc., Boston, 4-9.

Fournier, R.F., 1982: "The AFGL McIDAS: a real-time interactive meteorological display system", Preprints, First Conference on Interactive Meteorological Processing, 1982.

Griffin, M.K. and L.W. Thomason, 1990: The determination of the clear atmosphere con-tribution to satellite-measured radiances in window channels. Preprints, Fifth Conf. on Satellite Meteor. and Ocean., London, 3-7 Sept., Amer. Meteor. Soc., Boston, 156-161.

Gustafson, G.B. and G.R. Felde, 1989: Validation of Automated Cloud Detection from Micro-wave Imagery. Preprints, AMS 5th Conference on Interactive Information and Processing Systems, Anaheim, CA, 30 Jan. - 3 Feb., Amer. Meteor. Soc., Boston, 379-386.

Gustafson, G.B. and R.P. d'Entremont, 1992: Single channel and multispectral cloud algorithm development for TACNEPH. Preprints, Sixth Conf. on Satellite Meteor. and Ocean., 5-10 Jan, Amer. Meteor. Soc., Boston, 13-16.

Gustafson, G.B., D.K. Roberts, C.F. Ivaldi, R. Schechter, T.J. Kleespies, K. Hardy, R.P. d'Entremont, G.R. Felde and R. Lynch, 1987: The AFGL interactive meteorological system. Preprints, Third Conference on Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology, AMS, Boston, MA.

Hamill, T.M., 1991: Prediction of thunderstorm initiation through 4-dimensional data assimilation of doppler radar data., Scientific Report No. 1, Contract F19628-91-C-0011, Atmospheric and Environmental Research Inc., 84pp, PL-TR-92-2029, ADA251243.

Hollinger, J.P. (ed), 1991: DMSP special sensor microwave/imager calibration/validation. Final Report, Naval Research Laboratory, Washington, DC.

Isaacs, R.G. and G.B. Gustafson, 1991: Tactical nephanalysis (TACNEPH) program overview. Reprints, Conference on Cloud Impacts on DoD Operations and Systems, Los Angeles, CA, 9-12 July.

Keeespies, T.J., R.P. d'Entremont, G.R. Felde, K. Hardy, L.W. Thomason, G.B. Gustafson and C.F. Ivaldi, 1987: Application of the AFGL interactive meteorological system to atmospheric research. Preprints, Third Conference on Interactive Processing Systems for Meteorology, Oceanography and Hydrology, AMS, Boston, MA.

Lipton, A. E., 1990: Retrieval of the shading effects of clouds in a satellite/model coupled mesoscale analysis system. Preprints, Fifth Conf. on Satellite Meteor. and Ocean., London, 3-7 Sept., Amer. Meteor. Soc., Boston, 339-344.

Lipton, A. E. and T. H. Vonder Haar, 1990: Mesoscale analysis by numerical modeling coupled with sounding retrieval from satellites. MWR, 118, 1308-1329.

Longtin, D.R., and E. P. Shettle, in press: Users Guide to the Mie Scattering Codes at AFGL.

Metcalf, J., 1992: Radar observations of the effects of changing electric fields on the orientation of hydrometeors. Environmental Research Papers No.1100, PL-TR-92-2122, ADA256712.

O'Donnell, R., 1990: MOM: a meteorological data checking expert system in CLIPS", Preprints, First CLIPS Conference, NASA-Lyndon B. Johnson Space Center, Houston, TX. NASA Conference Publication No. 10049.

Stamnes K., Tsay S., Wiscombe W., Jayaweera K., 1989: Numerically stable algorithm for discrete-ordinate-method radiative transfer in multiple scattering and emitting layered media. Appl Optics 27:2502-2509.

Thomason, L.W. and C.F. Ivaldi, 1990: A unified treatment of conventional meteorological data. Preprints, Sixth Conference on Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology, AMS, Boston, MA.

Thomason, L.W. and R.P. d'Entremont, 1992: Full color composite imagery for 8 -bit display devices. Submitted to Int. J. Remote Sensing.

Valovcin, F.R., 1978: Spectral Radiance of Snow and Clouds in the Near Infrared Spectral Region. AFGL-TR-78-0289, ADA063761.

Ward, J.M., H.S. Muench, M.K. Griffin, G.B. Gustafson, C. L. Barker Schaaf, and R.P. d'Entremont, 1992: Development of 6 km global terrain elevation data for satellite-based cloud analysis models. Preprints, Sixth Conf. on Satellite Meteor. and Ocean., 5-10 Jan, Amer. Meteor. Soc., Boston, 25-27.

ADB_ACQUIRE

ADB_Acquire is an Integer*4 function used to access the conventional meteorological data base.

Format   Istatus = ADB_Acquire(Source, Key_List, Data_List)

Returns   Status return values are listed under Condition Values Returned.

Arguments:

Source is a **Character*12** that specifies the data source of interest. Currently supported sources include:

Data Source	Source Specifier
LFM Guidance	GUIDANCE
LFM MOS	MOS
LFM Trajectory	TRAJECTORY
NGM Guidance	NGM_GUIDANCE
Service A	SERVICE_A
Synoptic	SYNOPTIC
Ships and Buoys	SHIPS_BUOYS
METAR	METAR
Upper Air	UPPER_AIR
Station Information	SID
Radar	MDR

Key_List is a structure defined in AIMS_Includes:ADBDef.For with the structure name ADB_Key_List. **Key_List** is used to define how the data is to be retrieved based on time and geographic location or based on a time series data for a single station. The elements of this structure are described below.

> **Time** is an **Integer*4** that specifies the time for which data is requested. For a time series request **Time** is the start time of the series. Time is expressed in the form YYJJJHHMM.
>
> **Access Value** is a multiply mapped element composed of several different data types. It specifies the geographic location, either a point or area, for which data are requested. Only one mapped element can be chosen for a single invocation of ADB_Acquire. The data types and their definitions are listed below.
>
>> **Station_ID** is a **Character*4** that specifies a single station using a three or four letter station identifier.

Station_No is a **Character*6** that specifies a single station using a station number.

State is a **Character*2** that specifies all stations within a state or province.

Country is a **Character*2** that specifies all stations within a country.

Access_C is a **Character*8** that specifies all stations within predefined latitude-longitude bounds (e.g., New England).

N_Lat, S_Lat, E_Lon, and W_Lon are **Integer*2's** that specify the north latitude, south latitude, east longitude and west longitude of a latitude-longitude box. Units are degrees*100. Latitudes range from 9000 to -9000, positive north. Longitudes range from 18000 to -18000, positive east.

SID_Flags is an Integer*2 used a bit mask to control aspects of the collection of station information for the data request. Bits 0 through 3 are used to inform the station data base utility SID_Acquire how to organize the collection of stations. The modifiers used for these bits include:

Access Organization	Modifier
Station identifier	SID_ID
Station number	SID_Number
State	SID_State
Country	SID_Country
Lat-Lon Box	SID_LatLon

The next bit, bit 4, is known as the "ADB only" bit. This bit is used to inform SID_Acquire to use a type specific station data base file to retrieve station information rather than the master station data base file, thereby reducing I/O overhead. If SID_Acquire determines that a type specific station data base file does not exist, it will use the master file. The modifier that activates this bit is SID_ADB_Only.

Bits 5 through 15 are used to inform SID_Acquire the type of station(s) for which information is being retrieved. The modifiers used for these bits include:

SID_Synoptic
SID_MOS
SID_Guidance
SID_Trajectory
SID_RAOB
SID_Radar
SID_METAR
SID_Service_A
SID_NGM_Guidance

Time_Interval is an unsigned Byte that specifies the length of the time interval for a time series request. Values range from 1 to 255 hours.

44

Time_Increment is a **Byte** that specifies a time increment for a time series request. Values range from 1 to 63. Units are specified by the use of a modifier. They include:

    ADB_M_Seconds
    ADB_M_Minutes
    ADB_M_Hours
    ADB_M_Days

Reserved is an **Integer*4** reserved for future use.

Data_List is an item list defined by the structure in AIMS_Includes:ADBDef.For with the structure name ADB_Data_List. The elements of this structure are defined as follows:

Data_Type is an **Integer*4** that specifies the data type of interest. Data types are source dependent; refer to the attached table that lists valid data types for all supported data sources. The following is a list of symbolic constants to use to specify **Data Type**.

    ADB__Temperature
    ADB__Dewpoint
    ADB__Pressure
    ADB__R1
    ADB__R2
    ADB__R3
    ADB__Vertical_Velocity
    ADB__Stability
    ADB__Wind_Direction
    ADB__Wind_Speed
    ADB__Precip_3
    ADB__Precip_6
    ADB__Precip_12
    ADB__Precip_24
    ADB__POP06
    ADB__POP12
    ADB__QPF06
    ADB__QPF12
    ADB__TStorm_Prob
    ADB__Min_Temperature
    ADB__Max_Temperature
    ADB__Cloud_Amt_Prob
    ADB__Ceiling_Hgt_Prob
    ADB__Visibility_Prob
    ADB__Best_C_V
    ADB__Obstruction_Prob
    ADB__Geopotential_Height
    ADB__Altimeter
    ADB__Station_Pressure
    ADB__Pressure_Tendency
    ADB__Cloud_Amt_Oktas
    ADB__Cloud_Amt
    ADB__Total_Cloud_Amt
    ADB__Cloud_Type
    ADB__Cloud_Height

45

```
ADB__Gust
ADB__Snow_Depth
ADB__Snow_Accumulation
ADB__Freezing_Level
ADB__Wave_Period
ADB__Wave_Height
ADB__Station_ID
ADB__Station_Number
ADB__Station_Lat
ADB__Station_Lon
ADB__Station_Height
ADB__Station_Location
ADB__I
ADB__J
ADB__Thickness
ADB__Mixing_Ratio
ADB__Specific_Humidity
ADB__RH
ADB__Potential_Temp
ADB__Virtual_Temp
ADB__Vapor_Pressure
ADB__Sat_Vapor_Pressure
ADB__Eq_Temperature
ADB__Wet_Bulb
ADB__LCL
ADB__Lifted_Index
ADB__Eq_Potential_Temp
ADB__Latitude
ADB__Longitude
ADB__MDR_Grid
ADB__Cell_Top
ADB__Cell_Direction
ADB__Cell_Speed
ADB__Sea_SFC_Temp
ADB__DDFF
ADB__DDFFF
ADB__Wind_Flags
ADB__Wind_Vectors
ADB__Streamlines
ADB__Day
ADB__Hour
ADB__Parcel_Trajectory
ADB__Wind_Chill_Temp
ADB__Signal_Strength
ADB__Multiplicity
ADB__Seconds
ADB__T1
ADB__T3
ADB__T5
ADB__Structure*
```

* The data type ADB__Structure is used to retrieve the raw record(s) from a particular data source. No formatting or unit conversion is performed.

There are also numerous modifiers associated with **Data Type** that are valid for certain data source/type combinations. The use and meaning of these modifiers is described below. *Note - parameters are combined with one or more modifiers through logical 'or'ing.*

For METAR and Synoptic data there are modifiers to limit the retrieval of cloud information to certain layers or to gather data from all layers:

> ADB_M_Layer_1
> ADB_M_Layer_2
> ADB_M_Layer_3
> ADB_M_Layer_4
> ADB_M_All_Layers

For Upper Air data there are modifiers to specify data for a particular mandatory level:

> ADB_M_Surface
> ADB_M_1000mb
> ADB_M_850mb
> ADB_M_700mb
> ADB_M_500mb
> ADB_M_400mb
> ADB_M_300mb
> ADB_M_250mb
> ADB_M_200mb
> ADB_M_150mb
> ADB_M_100mb

and the tropopause level and level of maximum winds:

> ADB_M_Tropopause
> ADB_M_Max_Winds

as well as a sorted retrieval of mandatory and significant level pressure data:

> ADB_M_All_Sorted

When used in conjunction with ADB__Structure, the following modifiers define the type of raw data to retrieve.

ADB_M_TTAA	Mandatory level temperature data
ADB_M_TTBB	Significant level temperature data
ADB_M_PPBB	Significant level wind data
ADB_M_Hourly	Service A hourly data
ADB_M_Remarks	Service A remarks
ADB_M_MDR_Grid	MDR grid
ADB_M_MDR_Cells	MDR cell information

Data_Buffer_Adr is an **Integer*4** that specifies the starting address of a buffer that will be used to receive the data.

47

Data_Buffer_Len is an Integer*4 that specifies the size of the buffer in bytes.

Data Format is a Byte that specifies the output format of the data. Modifiers are used to indicate the format.

ADB_M_Integer	for integer format
ADB_M_Real	for floating point format
ADB_M_Character*	for character format (63-character maximum)

* For character format, the receive buffer character string length must be logically 'or'ed with the
parameter.

Example: Character*4 Station_ID(10)
Data_List(1).Data_Format = ADB_M_Character .or. 4

Valid Time is a Byte that specifies a forecast valid time when used with LFM or NGM guidance, MOS, or trajectory data sources.

Missing data:

Missing data is flagged with parameters based on data format:

Parameter	Format	Value
ADB_Missing_I	integer	2^{24}
ADB_Missing_R	real	2^{24} (16777216.0)
ADB_Missing_C	character	77 (the letter M)

For entire reports missing (with the use of ADB__Structure):

ADB_Missing_Report_I	integer	2^{25}
ADB_Missing_Report_R	real	2^{25} (33554432.0)
ADB_Missing_Report_C	character	42 (asterisk)

Description:

ADB_Acquire is a single point-of-access programming interface to the conventional meteorological data base. For a specified data source, ADB_Acquire can retrieve one or more data types for a point source (i.e., station) or a geographic area (e.g., state, latitude-longitude box). For a time series request, the function will retrieve one or more data types for a single station over the time period defined by the series. There are no artificial restrictions placed on the number of data types that can be retrieved per invocation. This is because ADB_Acquire makes use of the VMS item list to string together data type requests. The physical limitation is governed by the number of valid data types that exist for a particular data source. ADB_Acquire makes use of the VAX/VMS item list. Programmers unfamiliar with the item list should reference the appropriate VMS documentation beforehand. Also the programmer is expected to know approximately how much data will be returned for any given call, allocating a buffer or buffers large enough to accommodate the request.

An interactive implementation of ADB_Acquire is available through the AIMS DCL command ADB (see the AIMS applications documentation or on-line Help for the use of ADB).

Example Code Stub:

```
      Program ADB_Example
C
C ADB includes needed for constructing the key and data lists
C
      Include 'AIMS_Includes:ADBDef.For'
      Include 'AIMS_Includes:SIDDef.For'
C
      Record /ADB_Key_List/ Key_List
      Record /ADB_Data_List/ Data_List(3)
      Character*12 Source /SERVICE_A  '/
      Integer*4 ADB_Acquire, N_Points, Iret
      Real*4 Temp(100)
      Character*4 Station_ID(100)
C
C Application-specific code
C
                  .
                  .
                  .


C
C Begin ADB call setup
C Access is by state, using Service A stations only.
C The SID parameters (SID__...) are defined in SIDDef.For
C
      Key_List.State = 'CA'         ! California
      Key_List.Sid_Flags = SID__State .or. SID__Service_A .or. SID_ADB_Only
C
C Time is given in YYJJJHHMM
C
      Key_List.Time = 892790000 ! 6-Oct-1989, 0Z
C
C The item list entry for temperature.  Note that %loc() returns the address of a variable.
C The buffer length is always given in bytes.  Parameters ADB__ ... or ADB_M_... are
C defined in ADBDef.For
C
      Data_List(1).Data_Type = ADB__Temperature
      Data_List(1).Data_Buffer_Adr = %loc(Temp)
      Data_List(1).Data_Buffer_Len = 400
      Data_List(1).Data_Format = ADB_M_Real
C
C The item list entry for station ids
C
      Data_List(2).Data_Type = ADB__Station_ID
      Data_List(2).Data_Buffer_Adr = %loc(Station_ID)
      Data_List(2).Data_Buffer_Len = 400
      Data_List(2).Data_Format = ADB_M_Character .or. 4
C
C The item list terminator.  Parameter ADB__End is 0
C
      Data_List(3).Data_Type = ADB__End
C
C Call the data base interface
```

49

```
C
        Iret = ADB_Acquire(Source, Key_List, Data_List)
C
C  Determine the number of data points found
C
        N_Points = (400 - Data_List(1).Data_Buffer_Len) / 4
C
C  Continue application
C
             .
             .
             .
```

Condition Values Returned:

ADB_Normal -- Normal completion status value.

ADB_Buffer_Full -- The user supplied buffer was filled before data collection had completed. Increase the size of the buffer and try again.

ADB_Invalid_Format -- An invalid data format was specified.

ADB_Illegal_Access -- A time series request was made for geographic access other than a single station.

ADB_Illegal_Time_Units -- The units of the time interval for a time series request was invalid.

ADB_Illegal_Time_Increment -- An invalid time increment was specified (Value was outside of range 1 to 63).

ADB_UnkSource -- An unknown data source was specified.

ADB_Non_Existent_Record -- No data for the time and location specified was available.

ADB_Read_Error -- This is an I/O error produced by FORTRAN for a status return that is something other than ADB_Non_Existent_Record. Notify the AIMS System Manager.

ADB_Open_Failure -- This is an I/O error produced by a non-zero status return from FORTRAN OPEN. Notify the AIMS System Manager.

ADB_Missing_Data -- Some or all of the requested data is missing.

ADB_Buffer_Too_Small -- The specified user buffer was too small for the data record. Valid for data type ADB__Structure only.

ADB_Invalid_Data_Type -- The data type specified is not valid for the requested data source.

ADB_Invalid_Valid_Time -- The forecast verification time specified is not valid for the requested data source.

ADB_Invalid_Data_Modifier -- The data type modifier specified is not valid for the data source and type requested.

ADB_Non_Existent_Hourly -- Same as ADB_Non_Existent_Record but for surface hourlies only (i.e., Service A, Synoptic and Ship/Buoy data sources).

ADB_Non_Existent_Remarks -- Same as ADB_Non_Existent_Hourly but for surface hourly remarks.

ADB_UnkAccess -- An unknown access type was specified in the key list.

ADB_UnkModifier -- An unknown data type modifier was specified.

ADB_String_Too_Long -- The user specified character string was too small to contain the data when converted to character format. Increase the size of the string and try again.

SID_ACQUIRE

SID_Acquire is an Integer*4 function used to access the conventional meteorological station data base, returning full station information on an individual station or group of stations.

Format   Istatus = SID_Acquire(SID, Flags, Index)

Returns   Status return values are listed under Condition Values Returned.

Arguments:

SID is a record of the structure GLOBAL_STN which is defined in the SID include file AIMS_Includes:SIDDef.For. It consists of the following elements:

> **Character*4 ID**, a three or four letter station identifier (e.g., BOS for Boston/Logan)

> **Character*6 Num**, a 6-digit code number for a station (e.g., 72509 for Boston). Note that character position 6 is frequently a space.

> **Integer*2 Lat**, the latitude of the station in degrees*100. Latitudes range from 9000 to -9000, positive north.

> **Integer*2 Lon**, the longitude of the station in degrees*100. Longitudes range from 18000 to -18000, positive west.

> **Character*2 State**, the state or province of the station.

> **Character*2 Cntry**, the country of the station.

> **Integer*2 Hgt**, the elevation of the station in meters.

> **Character*19 Loc**, a text description of the station location.

> **Byte Class**, a bit mask used to represent the types of reports that a station is normally expected to report. Each bit is representative of whether a station reports any of 8 different types of reports. Class is defined by the logical 'or'ing of the types of reports a station is known to produce. Bits one to eight indicate respectively that a station produces Service A, METAR, Radar, Upper Air, Trajectory, Guidance, MOS, or Synoptic reports.

Flags is an Integer*2 which indicates how the station data base is to be accessed, the type of stations of interest, and whether all stations of the specified type are to be returned or if only those stations present in the AIMS conventional database are to be returned.

Flag access designation parameters: *

> SID__Number -- Stations are to be accessed by passing one station number in each element of the declared SID station data structure.

> SID__NumList -- Stations are to be accessed by passing a partial station number in the first element of the declared SID station data structure. All stations with station numbers matching the passed portion of the number will be returned.

> SID__ID -- Stations are to be accessed by passing one station id in each element of the declared SID station data structure.

> SID__LatLon -- Stations are to be accessed by passing the latitude and longitude of the northwest and southeast corners of a box in records one and two of the user declared SID station data structure.

> SID__Country -- Stations are to be accessed by country which is defined in the 'Cntry' element of the first entry of the SID station data structure.

> SID__State -- Stations are to be accessed by state which is defined in the 'State' element of the first entry of the SID station data structure.

> SID__Continue -- A flag modifier that indicates when the initial array is too small to continue the previously requested group of stations at the point terminated on the previous call. Do not set any other flag modifiers on any number of subsequent calls.

Flag station-type modifying parameters:

> SID__Synoptic -- Only stations that broadcast synoptic reports will be returned.

> SID__MOS -- Only stations that broadcast MOS reports will be returned.

> SID__Guidance -- Only stations that broadcast LFM/NGM Guidance reports will be returned.

> SID__Trajectory -- Only stations that broadcast MOS trajectory reports will be returned.

> SID__RAOB -- Only stations that broadcast Raob or upper air reports will be returned.

> SID__Radar -- Only stations that broadcast Radar reports will be returned.

> SID__METAR -- Only stations that broadcast METAR reports will be returned.

> SID__Service_A -- Only stations that broadcast Service A reports will be returned.

> * -- By convention parameters are indicated by the utility id followed by two underscores, in this case SID__. Functions and return codes are indicated by the utility id followed by a single underscore.

SID__ADB_Only -- A modifier indicating the only stations of the requested type actually in the AIMS conventional data base that should be returned.

Index is an Integer*2 which in being passed indicates how many structures for the station information have been declared and in returning indicates how many of those structures were filled.

Description:

The ability to acquire station information and in particular, the latitude and longitude of stations within given geographical bounds, is an important part of the ability to access the AIMS conventional meteorological data base. SID_Acquire is the standard programming interface to access the global station database. An interactive implementation of SID_Acquire is available through the AIMS DCL command SID (see the AIMS applications documentation or on-line Help for the use of SID).

Two examples of use:

1) To retrieve a single station:

```
Program GET_Sid
Include 'AIMS_Includes:SIDDef.For'
Integer*2 Index, Sid_Flags
Record /Global_Stn/ Sid
        .
        .
        .
Sid.Id = 'BOS '
Flags = SID__ID
Index = 1
Iret = SID_Acquire(SID, Flags, Index)
        .
        .
        .
```

Sid Structure Returns:

```
Sid.Id = 'BOS '
Sid.Number = '725090'
Sid.Hgt = 9
Sid.Loc = 'BOSTON/LOGAN INTL &'
Sid.Lat = 4236
Sid.Lon = 7103
Sid.Class = 'F1'X
Sid.State = 'MA'
Sid.Cntry = 'US'
```

Index returns a value of 1.

Iret returns a value of 1 (normal).

2) To retrieve all Service A stations within given geographical bounds:

```
Program GET_Sid
Include 'AIMS_Includes:SIDDef.For'
```

```
        Integer*2 Index, Sid_Flags
        Record /Global_Stn/ Sid(20)
                .
                .
                .
        Sid(1).Lat = 4000
        Sid(1).Lon = 10000
        Sid(2).Lat = 3500
        Sid(2).Lon = 9500
        Flags = SID__ID .or. SID__Service_A .or. SID__ADB_Only
        Index = 20
        Iret = SID_Acquire(SID, Flags, Index)
```

Sid Structure Returns:

```
        Sid(1).Id = 'HBR '   !Hobart, Oklahoma

        to

        Sid(20).Id = 'RSL '   !Russell, Kansas
```

Index is 20, indicating that all the station structures were filled.

Iret is equal to SID__LimExced indicating that there are more stations in the given bounds to be retrieved. SID_Acquire is subsequently called again:

```
        Flags = SID__Continue
        Index = 20
        Iret = SID_Acquire(SID, Flags, Index)
                .
                .
                .
```

Sid Structure Returns:

```
        Sid(1).Id = 'FOE '   !Topeka/Forbes Kansas

        to

        Sid(6).Id = 'CNK '   !Concordia/Blosser Kansas
```

Index = 6

Iret = 1, indicating a normal completion of the acquisition

Condition Values Returned:

SID_Limerr -- A zero or negative value for Index was passed to the routine.

SID_IllOpt -- An illegal value of Flags was passed to the routine (most likely more than one mode of access was specified).

SID_LatOrd -- The latitudes in a lat/lon search were passed out of order.

SID_LonOrd -- The longitudes in a lat/lon search were passed out of order.

SID_OpnFail -- The routine could not open the data files. Notify the system manager.

SID_KeyNotFnd -- No records satisfying the request could be found.

SID_LimExced -- There are more stations satisfying the request than records available to place them. The routine may be recalled with Flags set to SID_Continue which will pick up where the former call ended.

AML_TRANSFORM

AML_Transform is an Integer*4 function that converts a coordinate or array of coordinates from one projection to another.

Format   Iret = AML_Transform(Proj_In,Proj_Out,X_In,Y_In,X_Out,Y_Out,Count)

Returns   Status return values are listed under Condition Values Returned.

Arguments:

Proj_In is a structure defined in AIMS_Includes:AMLDef.For with the structure name Projection_Structure. This structure is composed of a fixed element and multiply-mapped element sets that are projection specific. **Proj_In** contains information relevent to the input or "from" projection.

Fixed element:

Projection is an **Integer*4** that indicates the projection type. Valid values are defined in AIMS_Includes:AMLDef.For and include the following:

AML__From_Latlon
AML__From_Mercator
AML__From_PSG
AML__From_Lambert
AML__From_Geostationary

In addition, Projection is used to specify bit-wise modifiers that control certain aspects of the transformation procedure. These modifiers are defined in AIMS_Includes:AMLDef.For and include the following:

AML__Initialize - Perform initialization prior to transformation
AML__IJ_Coords - Coordinates are relative (I,J)

Mapped element set #1:

Lat_1 is a Real*4 that specifies the latitude of projection. Valid for Mercator, polar-stereographic, and Lambert-conformal projections. For Lambert-conformal **Lat_1** is the primary latitude.

Lat_2 is a **Real*4** that specifies the secondary latitude of projection. Vaild for Lambert-conformal projections only.

Long is a Real*4 that specifies the longitude of orientation. Valid for Mercator, polar-stereographic, and Lambert-conformal projections.

Grid_Width is a **Real*4** that specifies the geometric spacing in kilometers if relative (I,J) coordinates are used. Valid for Mercator, polar-stereographic, and Lambert-conformal projections.

I_np is a **Real*4** that specifies the column position of the North Pole for polar-stereographic and Lambert-conformal projections or the column position of the equator for Mercator projection.

J_np is a **Real*4** that specifies the row position of the North Pole for polar-stereographic and Lambert-conformal projections or the column position of the equator for Mercator projection.

As an alternative, this element set can be specified using logicals. Default values exist in the system logical name table under the following logical definitions:

AML_PRIMARY_LAT_FROM
AML_SECONDARY_LAT_FROM
AML_LONG_OF_ORIENTATION_FROM
AML_GRID_WIDTH_FROM
AML_I_NP_FROM
AML_J_NP_FROM

By specifying new definitions in one's process logical name table, these defaults can be easily overridden.

Mapped element set #2:

SSYYDDD is an Integer*4 that specifies the satellite, year, and julian date of interest. Valid for geostationary projection.

HHMMSS is an Integer*4 that specifies the time of interest. Time is in packed integer format. Valid for geostationary projection.

Channel is an Integer*4 that specifies the channel of interest. Values are specified as holleriths with blank fill. Valid values include:

Visible = 'VIS '
Small detector IR = 'SIR ' (11 um)
Large detector IR = 'LIR ' (3.7, 6.7, 12 um)

Center_Lat is an Integer*4 that specifies the center point latitude in degrees and hundredths x 100. Valid for geostationary projection.

Center_Long is an Integer*4 that specifies the center point longitude in degrees and hundredths x 100. Valid for geostationary projection.

Line_Res is an Integer*4 that specifies the satellite line resolution in kilometers. Valid for geostationary projection.

Element_Res is an Integer*4 that specifies the satellite element resolution in kilometers. Valid for geostationary projection.

Number_Lines is an **Integer*4** that specifies the number of satellite lines. Valid for geostationary projection.

Number_Elements is an **Integer*4** that specifies the number of satellite elements per line. Valid for geostationary projection.

As an alternative this element set can be specified using logicals. Default values exist in the system logical name table under the following logical definitions:

AML_SSYYDDD_FROM (no default)
AML_HHMMSS_FROM (no default)
AML_CHANNEL_FROM
AML_CENTER_LAT_FROM
AML_CENTER_LONG_FROM
AML_LINE_RESOLUTION_FROM
AML_ELEMENT_RESOLUTION_FROM
AML_NUMBER_LINES_FROM
AML_NUMBER_ELEMENTS_FROM

By specifying new definitions in the process logical name table, these defaults can be easily overridden.

Proj_Out is also a structure defined in AIMS_Includes:AMLDef.For with the structure name Projection_Structure. Proj_Out contains information relevant to the output or "to" projection and is specified in almost identical fashion to Proj_In. The exceptions are projection type and logical names which are identified as follows:

AML__To_Latlon
AML__To_Mercator
AML__To_PSG
AML__To_Lambert
AML__To_Geostationary
AML_PRIMARY_LAT
AML_SECONDARY_LAT
AML_LONG_OF_ORIENTATION
AML_GRID_WIDTH
AML_I_NP
AML_J_NP
AML_SSYYDDD (no default)
AML_HHMMSS (no default)
AML_CHANNEL
AML_CENTER_LAT
AML_CENTER_LONG
AML_LINE_RESOLUTION
AML_ELEMENT_RESOLUTION
AML_NUMBER_LINES
AML_NUMBER_ELEMENTS

X_In is a **Real*4** that specifies the input (from) x coordinate(s).

Y_In is a **Real*4** that specifies the input (from) y coordinate(s).

X_Out is a **Real*4** that specifies the output (to) x coordinate(s).

61

Y_Out is a **Real*4** that specifies the output (to) y coordinate(s).

Icount is an **Integer*4** that specifies the number of (x,y) coordinates.

Description:

AML_TRANSFORM is a function that converts a coordinate or array of coordinates from one projection to another. Currently supported projections include latitude-longitude, Mercator, polar-stereographic, Lambert-conformal, and geostationary (spin-scan GOES). AML_TRANSFORM performs transformations using a three-step procedure:

      1) Initialization
      2) Convert input coordinates to latitude,longitude
      3) Convert latitude,longitude to output coordinates

All projections (with the exception of latitude-longitude) require initialization whether specified on the input or output side of the transformation. This is accomplished by setting the appropriate bit in the "projection" structure element and providing relevant initialization parameters either through the projection structure or as logical definitions. If logicals are used, corresponding structure elements must be set undefined using preset data type dependent mask values defined in the include file (see example). Default logical definitions exist in the system logical name table and can be overridden by specifying the logical names in the process logical name table. Note that some logicals do not have defaults and must therefore be explicitly defined by the user before program activation.

Transformations from latitude-longitude to any other projection will preserve the contents of X_In,Y_In. All other combinations replace the contents of these two calling arguments with intermediate latitude,longitude calculations.

Latitudes range from -90.0 to +90.0, north positive.

Longitudes range from -180.0 to +180.0, east positive.

Example Code Stub:

```
Include 'AIMS_Includes:AMLDef.For/NOLIST'
Record /Projection_Structure/ Proj_In, Proj_Out

           .
           .
           .

Proj_In.Projection = AML__From_Latlon
Proj_Out.Projection = AML__To_PSG .OR. AML__Initialize .OR. AML__U_Coords

C
C  Use defaults from the system logical name table
C

Proj_Out.Lat_1 = AML__Undefined
Proj_Out.Lat_2 = AML__Undefined
Proj_Out.Long = AML__Undefined
Proj_Out.Grid_Width = AML__Undefined
Proj_Out.I_NP = AML__Undefined
Proj.Out.J_NP = AML__Undefined
```

```
C
        Xlat = 90.0
        Xlon = -105.0
        Iret = AML_Transform(Proj_In,Proj_Out,Xlon,Xlat,Xi,Xj,1)
```

Returns:

```
        Xi = 0.0
        Xj = 0.0
        Iret = AML__Normal
```

Condition Values Returned:

Normal completion status code is AML_Normal. Error return codes relate to undefined or illegal values for passed structure elements or logical definitions.

CLK_GETTIM

CLK_Gettim is an Integer*4 function that converts date and time given in any one of several formats to all other formats, possibly adjusted by a time offset.

Format   Iret = CLK_Gettim(Function, Clock, Time_Offset)

Returns   Status return values are listed under Condition Values Returned.

Arguments:

Function is an **Integer*4** that indicates the time format that is being passed to CLK_Gettim. The following formats defined in AIMS_Includes:CLKDef.For are allowed:

CLK__Current requests the current time passed into all formats. For this format request, no elements of the clock structure need be defined.

CLK__ASCII indicates that time is being passed in VAX Time String Format in the clock structure element 'Time'.

CLK__NanoS indicates that time is being passed in quadword format in hundreds of nanoseconds in the clock structure element 'Nanos'.

CLK__Julian indicates that time is being passed in Julian date format (YYJJJHHMM) in the clock structure element 'Julian'.

CLK__Integer indicates that time is being passed as integer components in the clock structure elements 'Year', 'Month', 'Day', 'Hour', 'Minute', 'Second', and 'Hundredths'.

Clock is a structure defined in AIMS_Includes:CLKDef.For with the structure name CLK_Structure. When passed, **Clock** contains one or more elements that are defined according to the **Function** requirement. Upon successful completion all elements are defined. These elements are described below:

Year is an **Integer*2** that indicates the year in the form 19XX.

Month is an **Integer*2** that indicates the month in numeric form from 1 to 12.

Day is an **Integer*2** that indicates the day in numeric form from 1 to 31.

Hour in an **Integer*2** that indicates the hour in the range 0 to 23.

Minute is an **Integer*2** that indicates the minute.

Second is an **Integer*2** that indicates the second.

Hundredths is an **Integer*2** that indicates the hundredth of second.

DayOfWeek is an **Integer*4** that indicates the day of the week where Monday is day 1 and Sunday is day 7.

Julian is an **Integer*4** that indicates the Julian date in the form YYJJJHHMM.

NanoS(2) is an **Integer*4** array that indicates the quadword time in hundreds of nanoseconds or tenths of microseconds.

Time is a **Character*23** that indicates the time in VAX Time String Format as given by the runtime library routine LIB$Date_Time or the DCL command Show Time.

Description:

CLK_Gettim is a function used to convert from one time format to another, adding a time offset if requested. It is particularly useful for converting between Julian time and VAX String Time for use in data base requests or for converting local time to GMT (in conjunction with CLK_Offset). The use of this function requires the include file AIMS_Includes:CLKDef.For.

Example Code Stub:

```
Integer*4 Time_Offset(2) /0,0/, Iret, CLK_Gettim
Record /CLK_Structure/ Clock
       .
       .
       .
Clock.Time = '06-OCT-1956 00:29:00.00'
Iret = CLK_Gettim(CLK__ASCII,Clock,Offset)
```

Clock Structure Returns:

```
Clock.Year = 1956
Clock.Month = 10
Clock.Day = 6
Clock.Hour = 0
Clock.Minute = 29
Clock.Second = 0
Clock.Hundredths = 0
Clock.Julian = 562810029
Clock.DayOfWeek = 6
Clock.Nanos(1) = '4DC4EE00'X
Clock.Nanos(2) = '006DBE0F'X
Clock.Time = '06-OCT-1956 00:29:00.00'
```

Condition Values Returned:

CLK__Ok indicates successful completion.

CLK__BadArgs indicates that one of the input arguments is invalid.

CLK__BadFunct indicates that an illegal clock function was requested.

66

CLK_OFFSET

CLK_Offset is an Integer*4 function that converts a Modified Vax Time String to a two's complement quadword (I*8) for time offset calculations.

Format   Iret = CLK_Offset(Time_Offset, Logical_Table, Logical_Name, Time_String)

Returns   Status return values are listed under Condition Values Returned.

Arguments:

Time_Offset is a two element **Integer*4** array into which the quadword time offset is written in hundreds of nanoseconds.

Logical_Table is a **Character*n** that indicates which logical table to refer to for the logical name of the clock offset. For example, `LNM$SYSTEM_TABLE' or '*' when the **Time_String** offset is given.

Logical_Name is a **Character*n** holding the time offset in Modified Vax Time String format. Examples are `CLK_GMT_DIFFERENCE' for the offset from local time and `*' when the **Time_String** offset is given.

Time_String is a **Character*24** containing a Modified Vax Time String indicating the desired time offset. Since the offset represents a departure from VAX `0' time they have a format such as `+17-NOV-1858 04:00:00.00' for an offset of positive 4 hours. If the logical name approach is used then **Time_String** is passed as a '*'.

Description:

CLK_Offset is used primarily in conjunction with another Clock function (CLK_Gettim) in order to facilitate the computation of a single time or series of times offset from some known time. An example of such a use would be for requesting data observations for a series of times or determining GMT time from local time. If Time_String = '*' then the logical table specified in **Logical_Table** is searched for the Modified Vax Time (and then returned to **Time_String**). **Time_Offset** is returned with the number of hundreds of nanoseconds representing **Time_String**.

Example Code Stub:

```
      Integer*4 Time_Offset(2), Iret, CLK_Offset
      Character*24 Time_String /*/
            .
            .
            .
      Iret = CLK_Offset(Time_Offset,'LNM$SYSTEM_TABLE',
                        'CLK_GMT_DIFFERENCE',Time_String)
            .
            .
            .
```

67

Returns:

       Iret = CLK__Ok

       Time_String = '+17-NOV-1958 05:00:00.00'

       Time_Offset(1) = '0E8D60800'X

       Time_Offset(2) = '00000029'X

Condition Values Returned:

CLK_Offset returns either CLK__Ok or the error codes from $Trnlnm or $Bintim.

CLK_DAYOFWEEK

CLK_DayOfWeek is an Integer*4 function that given a day, will determine clock data for a given day of the week around that day.

Format   Iret = CLK_DayOfWeek(Clock, Ref_Day, Julian_String)

Returns   Status return values are listed under Condition Values Returned.

Arguments:

Clock is a structure defined in AIMS_Includes:CLKDef.For with the structure name CLK_Structure. When passed, Clock must contain at a minimum the 'Nanos' element of the day of interest. Upon successful completion all elements are defined concerning the day of the week around the original date for which clock data was requested. These elements are described below:

      Year is an **Integer*2** that indicates the year in the form 19XX.

      Month is an **Integer*2** that indicates the month in numeric form from 1 to 12.

      Day is an **Integer*2** that indicates the day in numeric form from 1 to 31.

      Hour in an **Integer*2** that indicates the hour in the range 0 to 23.

      Minute is an **Integer*2** that indicates the minute.

      Second is an **Integer*2** that indicates the second.

      Hundredths is an **Integer*2** that indicates the hundredth of second.

      DayOfWeek is an **Integer*4** that indicates the day of the week where Monday is day 1 and Sunday is day 7.

      Julian is an **Integer*4** that indicates the Julian date in the form YYJJJHHMM.

      NanoS(2) is an **Integer*4** array that indicates the quadword time in hundreds of nanoseconds or tenths of microseconds.

      Time is a **Character*23** that indicates the time in VAX Time String Format as given by the runtime library routine LIB$Date_Time or the DCL command Show Time.

Ref_Day is an **Integer*4** that defines the day of the week about which clock data is requested. It is defined by parameters listed in AIMS_Includes:CLKDef.For.

      CLK__Monday, CLK__Tuesday, CLK__Wednesday, CLK__Thursday, CLK__Friday, CLK__Saturday, and CLK__Sunday indicate interest in those days of the week.

CLK_M_Last when logically 'or'ed with one of the above day parameters indicates interest in that day of the week for the *preceding* week.

CLK_M_Next when logically 'or'ed with one of the above day parameters indicates interest in that day of the week for the *following* week.

Julian_String is a **Character*5** which upon return from the routine contains the Julian date (in the format 'YYJJJ') for the day of reference.

Description:

CLK_DayOfWeek is a function used to determine, given any calendar day, the date of occurrence of some day of the week either in the week before, the week of, or the week following that day. CLK_DayOfWeek is used primarily in conjunction with the ADB functions in order to facilitate the computation of the conventional meteorological data file generation dates. CLK_DayOfWeek requires use of the include file AIMS_Includes:CLKDef.For.

Example Code Stub:

```
Integer*4 Time_Offset(2), Iret, CLK_Gettim, CLK_DayOfWeek
Character*5 Julian_String
          .
          .
          .
Clock.Time = '02-OCT-1956 00:29:00.00'
Iret = CLK_Gettim(CLK__ASCII,Clock,Offset)
Iret = CLK_Day_Of_Week(Clock,CLK__Saturday,Julian_String)
```

Clock Structure Returns:

```
Clock.Year = 1956
Clock.Month = 10
Clock.Day = 6
Clock.Hour = 0
Clock.Minute = 29
Clock.Second = 0
Clock.Hundredths = 0
Clock.Julian = 562810029
Clock.DayOfWeek = 6
Clock.Nanos(1) = '4DC4EE00'X
Clock.Nanos(2) = '006DBE0F'X
Clock.Time = '06-OCT-1956 00:29:00.00'
Julian_String = '56281'
```

Condition Values Returned:

CLK_DayOfWeek returns either CLK__Ok or the error codes from $Trnlnm, $Bintim, or CLK_Gettim.

Appendix E: General Purpose AIMS Applications

Plot_Wx

This application generates a plot of conventional data and associated geopolitical map on the graphics display based on an input day, time, geographic location and meteorological parameter(s). The location defines an area that can be centered on a station, state, sectional area or latitude-longitude box. Options allow the user to control both the color and the display projection. All data sources are supported; valid data types are source-dependent. An example of output produced by Plot_Wx is shown in Figure E-1.

Contour_Wx

This application generates a contoured analysis of conventional data and associated geopolitical map on the graphics display based on an input day, time, geographic location and meteorological parameter(s). The location defines an area with the same options as Plot_Wx. Other options allow the user to control color, contour increment and mid-level contour, display projection and aspects of the spatial objective analysis. All data sources are supported; valid data types are source dependent. An example of output produced by Contour_Wx is shown in Figure E-2.

Skew_T

Skew_T plots a skew-T/log-P thermodynamic diagram on the graphics display based on an input day, time and station. The plot includes wind flags drawn at mandatory pressure levels and calculations of the K Index, Lifted Index and Lifted Condensation Level. Options allow the user to select an alternate range for the axes, plot the thermodynamic path of a hypothetical air parcel, plot an additional sounding as an overlay and include moist adiabats as part of the diagram. Figure E-3 is an example of output produced by Skew_T.

XSection

This application generates a cross-sectional analysis on the graphics display from a collection of upper air soundings bounded by a latitude-longitude box defined from user-specified end points. The end points define a 2-dimensional analysis plane that is generated using the raw sounding data, interpolated to the analysis plane using the empirical technique of Barnes (1964). The display consists of contoured fields of temperature, wind speed, potential temperature and specific humidity. The visibility of each field can be

71

independently controlled by the user. An example of output produced by XSection is shown in Figure E-4.

MDR

This application generates a radar depiction on the graphics display using Manually Digitized Radar (MDR) data based on an input day, time and geographic location. Values of the Digital Video Integrator Processor (DVIP) Scale (related to rain rate) are plotted and color coded to visually depict the scale. The location defines an area with the same options as Plot_Wx. Cloud top heights and cell motion are also plotted if available. Figure E-5 is an example of output produced by MDR.

Bolt

Bolt produces a plot of lightning strike locations and a background geopolitical map based on an input day, time and geographic location. The location defines an area with the same options as Plot_Wx. Options also allow the user to control both the color and the display projection. The user can also generate a time series of lightning strikes based on input begin- and end-times and a time interval. The resulting output display is color coded according to time interval. An example of output produced by Bolt is shown in Figure E-6.

List_ADB

This application generates a text listing of conventional meteorological data. For a geographic-based listing, the user specifies a single day, time and location. Location can be a single station, multiple stations or an area centered on a station, state, country, sectional area or latitude-longitude box. For a time series listing, the user specifies a start and stop date/time and a time increment for a single station. The user has control over the output format of the listing and can direct the output to either the terminal or a disk file. All data sources are supported; valid data types are source dependent. Table E-1 is a sample listing of output produced by List_ADB.

Observation_Wx

This application generates a text listing of Service A data to the terminal screen or to a disk file. For a geographic based listing, the user specifies a single day, time and location. Location can be a single station, multiple stations or an area centered on a state or province. For a time series based listing, the user specifies a start and stop date and time increment for a single station. Table E-2 is an example listing produced by Observation_Wx.

72

SID

SID generates a text listing of station data based on an input geographic location. Location can be a single station, multiple stations or an area centered on a station, state, province, country or latitude-longitude box. Station data include station identifier, station number, latitude, longitude, elevation, descriptive location, state or province, country of origin and reporting class (e.g., synoptic, guidance). Options allow the user to list stations of a particular reporting class and to list only those stations that report on a regular basis. A example of output produced by SID is shown in Table E-3.

Fous

Fous generates a text listing of LFM-based guidance, MOS (Model Output Statistics) or trajectory forecasts based on an input day, time and station. An option allows the user to direct output to a disk file. Table E-4 is an example of output generated by this application.

Foue

Foue generates a text listing of NGM-based guidance based on an input day, time and station. An option allows the user to direct output to a disk file. Table E-5 is an example of output generated by Foue.

Upper_Air

This application generates a text listing of an upper-air report based on an input day, time and station. Data include temperature, dewpoint temperature and winds at mandatory pressure levels; temperature and dewpoint temperature at significant pressure levels; and winds at significant height levels. An example of output produced by Upper_Air is shown in Table E-6.
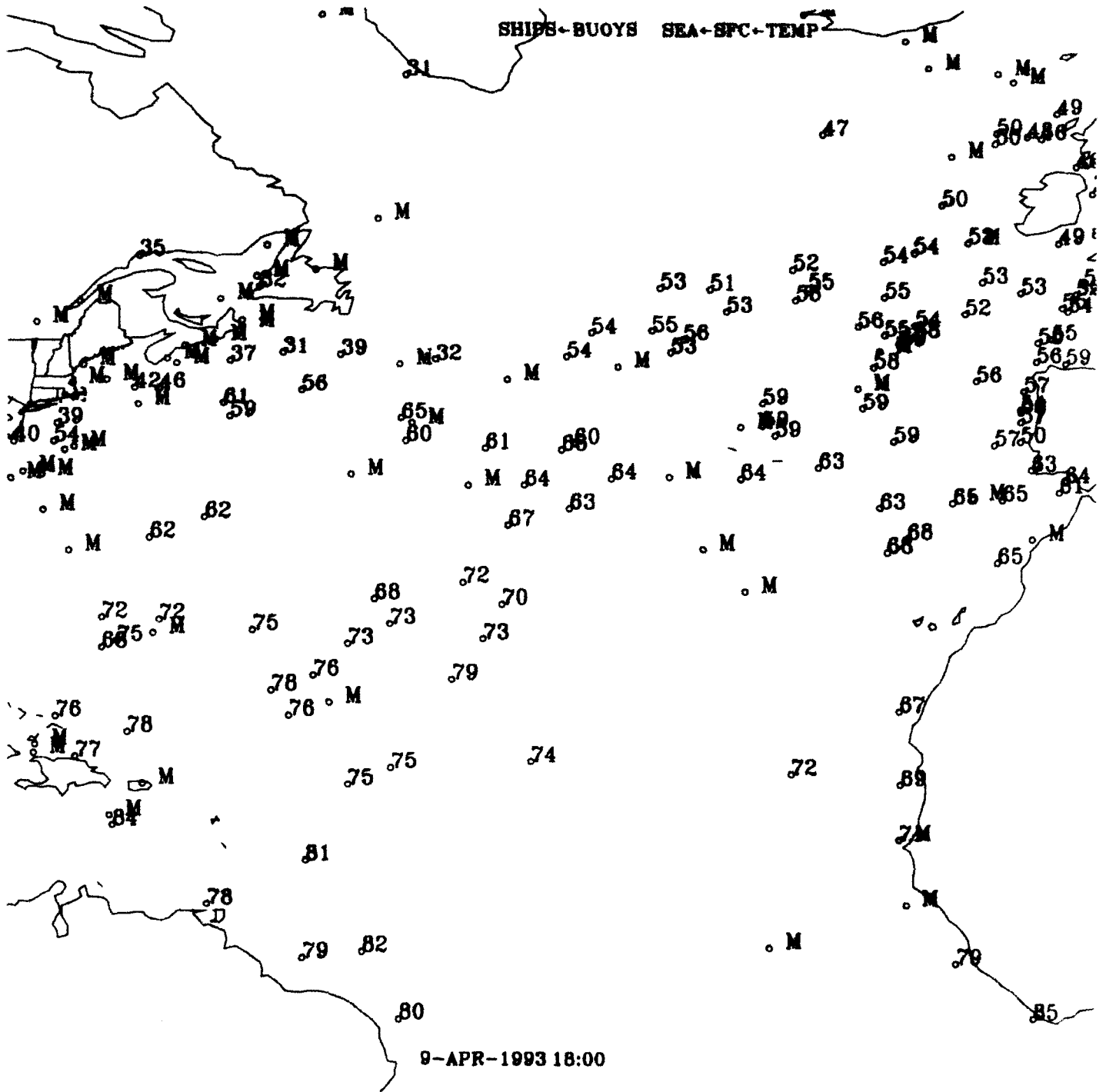
Figure E-1. Plot of Sea Surface Temperature Using Ship and Buoy Reports for the North Atlantic Ocean at 18Z on April 9, 1993.
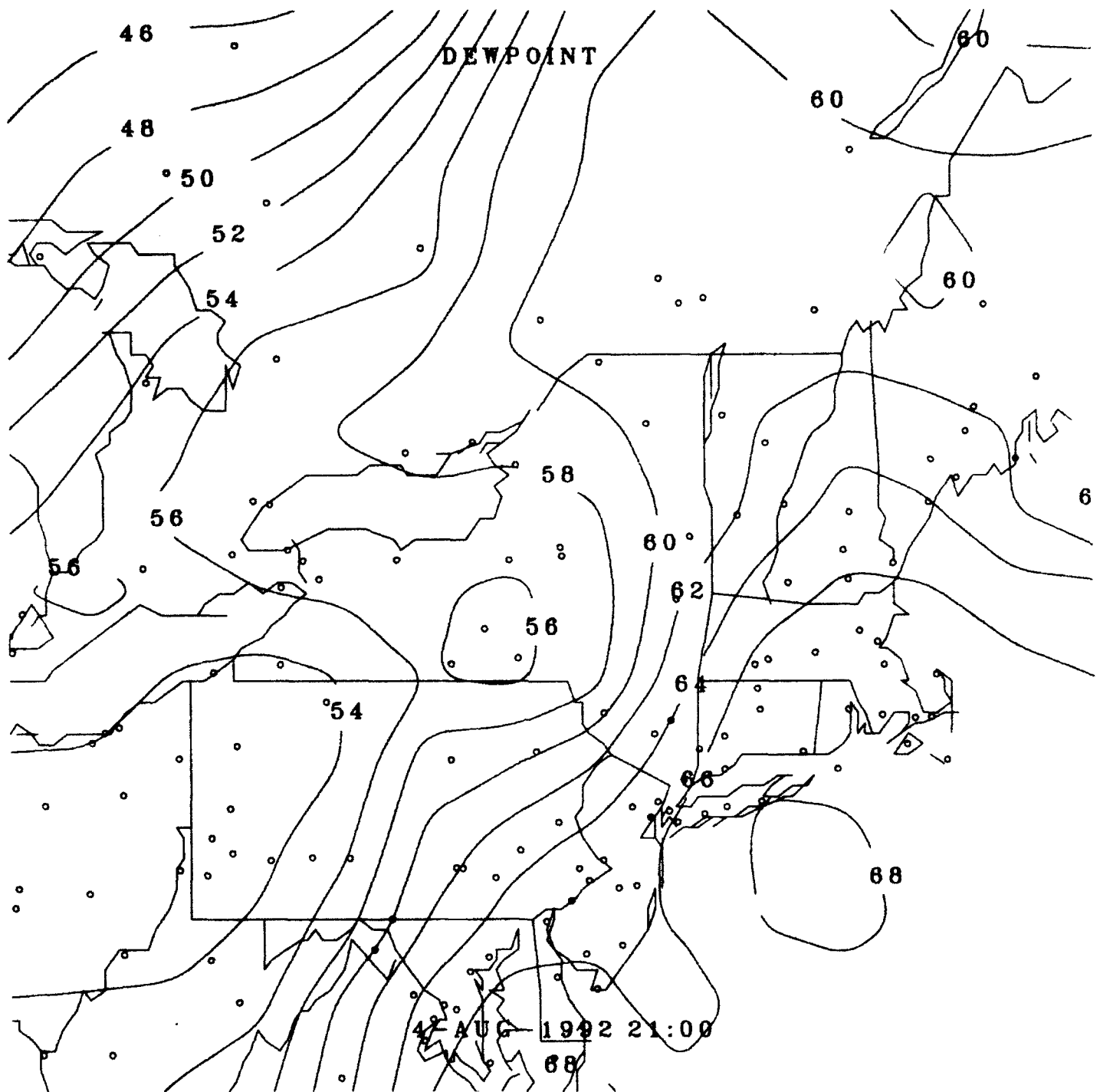
Figure E-2. Contour Analysis of Dewpoint Temperature Using Service A Reports for an Area Centered on New York at 21Z on August 4, 1992.

ALB ALBANY COUNTY ARPT
   21-JUL-1992 12:00
LCL: 957.5
L INDEX: 0.2
K INDEX: 32.4
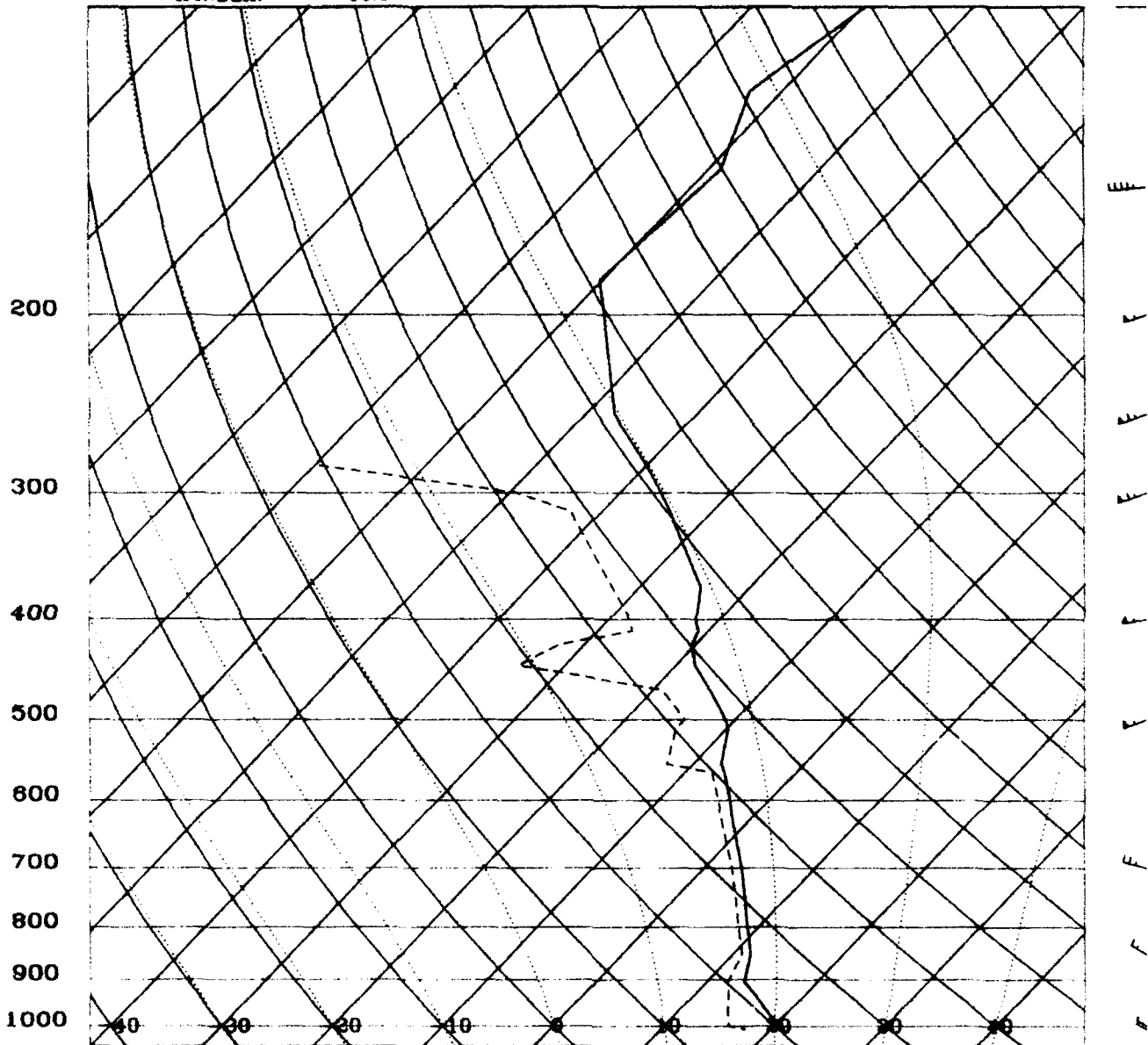
Figure E-3. Skew-T/Log-P Diagram Generated from the Upper Air Report for Albany, NY at 12Z on July 21, 1992.

Cross Sectional Analysis
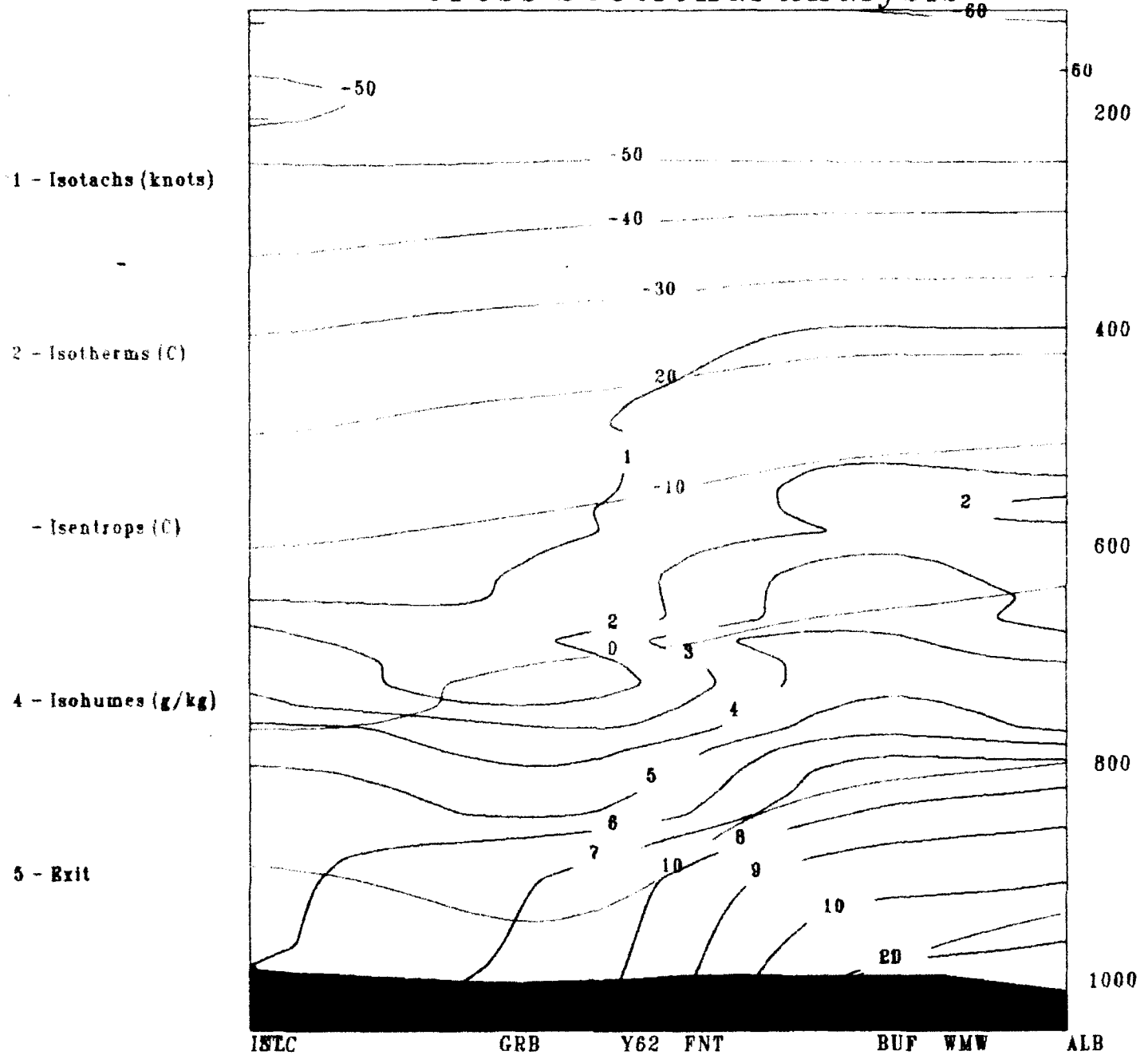
Figure E-4. Cross Sectional Analysis of Temperature and Mixing Ratio for a Line Between International Falls, MN and Albany, NY at 0Z on July 21, 1992.

Figure E-5. Plot of MDR Digital Video Integrator Processor (DVIP) Intensity Values for the U.S. at 19Z on July 2, 1992.

LIGHTNING   27-JUN-1992 19:00 TO 27-JUN-1992 19:59
1900 – 1914   ●
1915 – 1929   ●
1930 – 1944   ●
1945 – 1959   ●

Figure E-6. Plot of Lightning Strikes for a One-Hour Period Beginning at 19Z on June 27, 1992 for an Area Centered on Vermont. Strikes are Color Coded by 15 Minute Time Intervals.

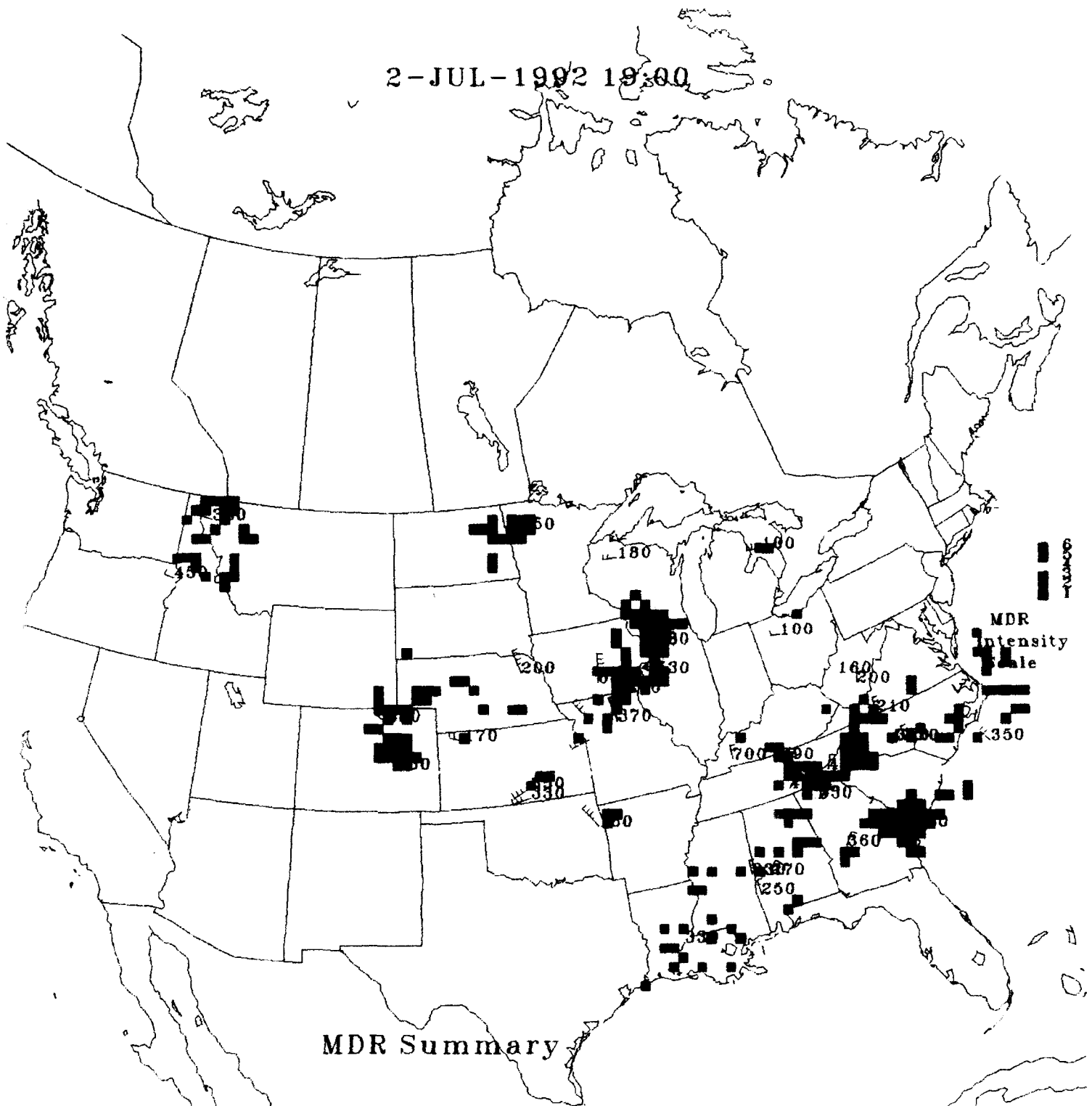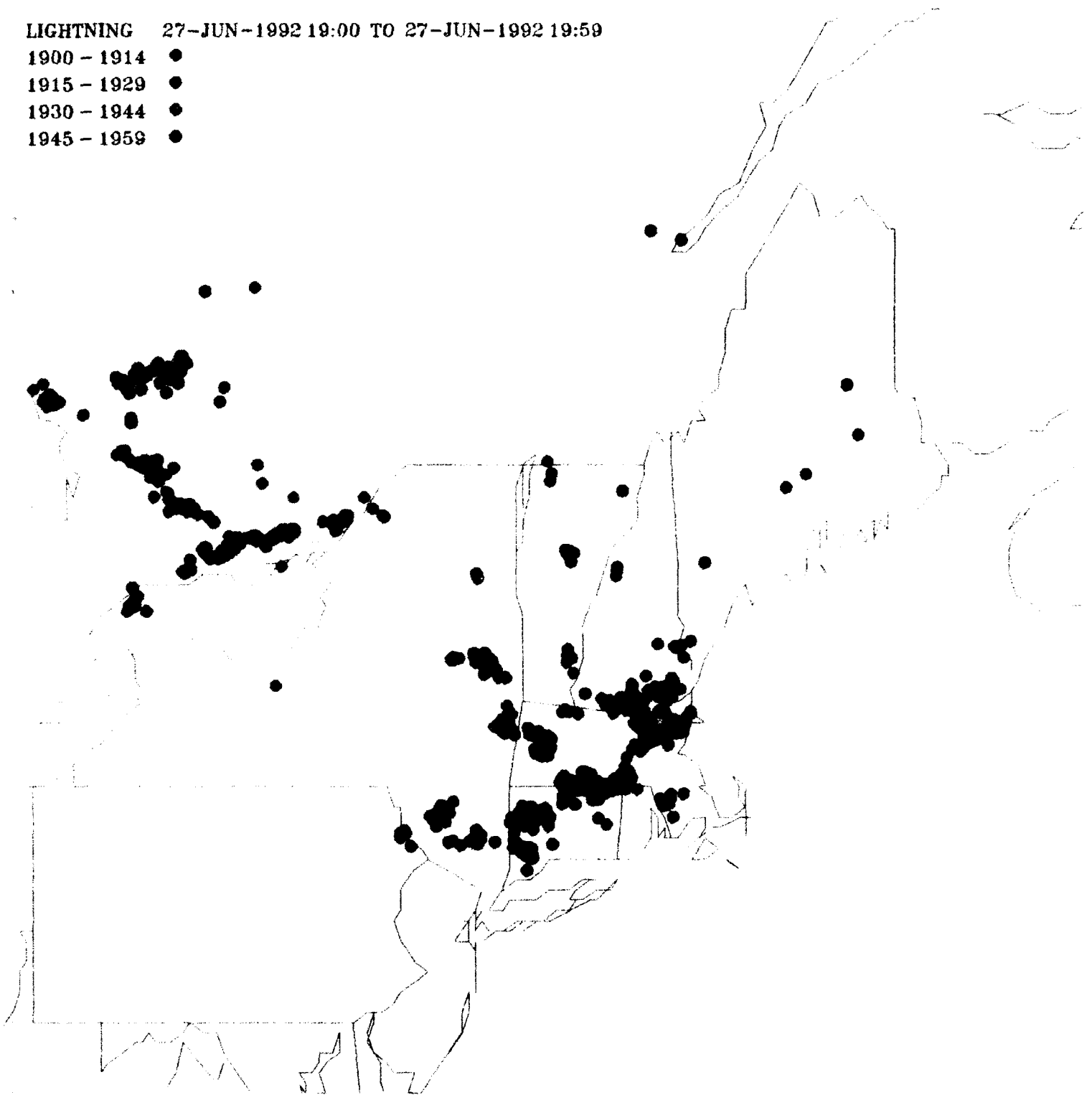| ID	HH	T	Dpt	Press	ddff	Vis	Wx	Prec	Location
	18	50	49	1024.1	2719	1/2	L-	T	LERWICK-IN-SH
EGPA	18	52	51	1027	2614	4	L-	T	KIRKWALL
EGPL	18	51	49	1030.4	2706	7		T	BENBECULA
EGPO	18	51	47	1029.4	2505	8		M	STORNOWAY
	18	45	41	1030.2	2603	40		T	AVIEMORE
EGQK	18	48	42	1029.1	2304	20		T	KINLOSS RAF
EGPD	18	50	43	1029.2	3005	20		M	ABERDEEN/DYCE
EGPU	18	51	45	1030.6	2905	15		T	TIREE
EGPK	18	49	44	1030.3	3307	20		T	PRESTWICK/AIR
	18	47	44	1029.9	3402	25		M	ESKDALEMUIR
EGQL	18	47	42	1029.3	2603	20	H	M	LEUCHARS RAF
EGNS	18	51	43	1030.1	3206	25		M	ISLE OF MAN/R
EGQM	18	49	42	1029.6	3304	15		T	BOULMER RAF
EGXE	18	51	42	1029.7	3606	20		T	LEEMING RAF
EGOV	18	52	44	1029.9	103	30		M	VALLEY RAF
EGCC	18	51	42	1029.6	307	11		T	MANCHESTER AI
EGXW	18	50	44	1028.6	107	15		T	WADDINGTON RA
	18	54	48	1026.2	214	15		T	HEMSBY-IN-NOR
EGUC	18	51	41	1029.1	1011	15		M	ABERPORTH
EGBB	18	50	44	1028.6	107	8		T	BIRMINGHAM AR
EGUY	18	51	46	1027.7	3612	20		T	WYTON RAF
EGXH	18	52	47	1026.7	3507	20	R-	T	HONINGTON RAF
EGVN	18	51	45	1027.4	112	9		T	BRIZE NORTON
EGFF	18	51	44	1028.2	408	12		M	CARDIFF
EGDM	18	51	46	1027	3611	11	R-	T	BOSCOMBE DOWN
EGLL	18	54	48	1026.2	207	15		M	LONDON/HEATHR
EGUM	18	55	50	1024.8	416	10		T	MANSTON RAF
EGDR	18	54	42	1026.5	413	6	H	M	CULDROSE RNAF
EGDG	18	53	43	1027.2	309	13		M	ST MAWGAN RAF
EGDB	18	53	43	1026.4	309	15		M	PLYMOUTH/MOUN
EGHH	18	54	46	1025.9	210	13		M	BOURNEMOUTH/H
EGAA	18	51	44	1030.6	3405	25		M	BELFAST/ALDER
EGPC	18	52	48	1027.6	2808	20		T	WICK-IN-CAITH
EGPF	18	49	44	1029.7	0	15		M	GLASGOW AIRPO
EGPH	18	48	44	1029.4	0	9	H	M	EDINBURGH APR
EGNC	18	49	42	1030.2	1103	30		M	CARLISLE
EGXI	18	51	43	1029.3	110	15		T	FINNINGLEY RA
EGOS	18	50	41	1029.4	307	9		M	SHAWBURY RAF
EGVW	18	50	46	1027.7	111	9	R-	T	BEDFORD
EGDL	18	50	45	1027.2	313	8		M	LYNEHAM RAF
EGKK	18	55	47	1025.3	3411	14		M	LONDON/GATWIC
EGDY	18	53	51	1027.1	409	6	H	M	YEOVILTON RNA

Table E-1. Listing of Synoptic Observations for the United Kingdom at 18Z on October 7, 1992.

ID	HH	T	TD	PRE	WIND	VIS	WX	LYR1	LYR2	LYR3	LYR4	dPR	PTT	TXN
4BQ	18	50	37	1022.6	1507	10		060S	080O			-1.2	T	42
GDV	18	41	35	1026.1*	1412	M	M							
WEY	18	41	34	1023.0	0108	2SW-		010O				0.3	0.04	20
BIL	18	37	35	1025.2	3213	10RW-		011O				1.2	0.09	35
LWT	18	32	30	1026.4*	3613	M	M					1.2	0.19	32
BTM	18	37	35	1030.2	3511	15		005S	014S	030B	080O	2.0	0.03	33
BZN	18	40	34	1028.9	3017G22	30		020S	050B			2.9	0.08	37
LVM	18	39	32	1027.5	2614	20		017S	035B	060O		2.0		
GGW	18	42	38	1029.6	0903	7RW-		015O				1.2	0.09	40
JDN	18	44	36	M	1307	M	M							37
SDY	18	50	29	1026.4*	0000	M	M							
HLN	18	39	31	1032.3	3414	7		008S	029B	040O		1.7	0.05	36
MSO	18	52	33	1031.1	0410	15		035S	040B	090B	300O	1.5		39
3DU	18	43	36	M	0000	15		045O				0.7	0.13	34
GTF	18	35	34	1033.7	3512	4S-F		003S	005O			1.7	0.10	33
GFA	18	37	34	1032.2	3612	21/2R-S-F		002S	004B	010B	020O	1.5	0.15	
HVR	18	39	37	1032.6	0408	9R-		010B	025O					
FCA	18	51	29	1030.8	0412	50		055S				0.2		36
CTB	18	37	32	1031.2*	3313	M	M					3.2		30
MLS	18	45	36	1024.8	1210	20		019B	040O			-0.7	0.08	44

Table E-2. Listing of Service A Observations for Montana at 18Z
on October 6, 1992.

HOUR	RH	R1R2R3	VVLI	HHDDFF	TBPSPTT
00	85	999461	///02	663604	9312///
06	65	937042	-1303	692106	9412000
12	56	856428	00003	712509	9511000
18	52	825430	-0202	722216	9610000
24	55	825441	-0600	722416	9709000
30	58	835941	00299	722515	9710000
36	57	825940	00200	702712	9711000
42	52	795041	-0301	672912	9614000
48	47	734245	-0304	653210	9416000

MOS Forecast
BOS , 72509
BOSTON/LOGAN INTL &
10-AUG-1992 12:00Z

DAY/GMT	10/18	11/00	11/06	11/12	11/18	12/00	12/06	12/12	13/00
POP06		5	2	0	5	20	10	2	
POP12				2		20		10	10
QPF06		000/1	000/1	000/1	000/1	100/1			
QPF12				0000/1		1000/1		1000/1	
TSTORM				24		22		18	
MIN/MAX				67		90		68	80
TEMP	75 75	72 69	69 68	72 83	87 86	80 76	73 70	71 76	
DEWPT	66 65	65 65	65 66	67 69	67 67	66 65	63 61	60 60	
WINDS	1807	2009	2311	2410	2412	2411	2709	3008	
CLOUDS	0433/3	2323/2	3214/3	1423/3	1522/2	1422/2	3313/2	3312/2	
CIG	033202	111106	121106	121115	000127	000027	110116	100117	
VIS	014202	002224	102114	112223	000226	000126	101116	001216	
CV	3/3	4/3	2/2	2/1	6/5	6/5	1/6	1/6	
OBVIS	2107/4	4204/4	41X5/4	32X5/4	64X0/2	63X1/2	61X3/1	62X2/1	

LFM Trajectory Forecast
BOS , 72509
BOSTON/LOGAN INTL &
10-AUG-1992 12:00Z

	700mb			850mb			Surface		
HH	LAT	LON	PRES	LAT	LON	PRES	LAT	LON	PRES
00	433	805	709	420	775	846	404	752	991
06	426	784	703	417	763	849	403	746	999
12	421	762	704	416	750	852	406	737	1004
18	420	737	702	418	731	850	412	725	1004
24	423	710	700	423	710	850	423	710	1005

Stability Index: 15

Temp:	8.9	Temp:	15.8	Temp:	21.0
Dewpt:	-11.3	Dewpt:	10.6	Dewpt:	17.6

Table E-4. Listings of LFM Guidance, MOS, and Trajectory Forecasts Valid 12Z for Boston, MA on August 10, 1992.

Upper Air Data
SBSP, 837800
SAO PAULO/CONGONHAS
7-OCT-1992 12:00:Z

Mandatory Levels

PRES	TEMP	TD	DIR	SPEED	HEIGHT
927	168	133	140	4	803
1000					153
850	120	98	160	16	1538
700	40	3	305	25	3148
500	-107	-247	290	42	5820
400	-201	-421	270	55	7500
300	-343	-553	260	82	9580
250	-451		260	59	10830
200	-565				12280
150	-645				14050
100	-715				16450
115	-763				Tropopause

Upper Air Data
SBSP, 837800
SAO PAULO/CONGONHAS
7-OCT-1992 12:00:Z

Significant Levels

PRES	TEMP	TD	PRES	TEMP	TD
927	168	133	180	-605	
900	142	125	155	-681	
720	60	20	150	-645	
580	-51	-65	115	-763	
550	-53	-90			
520	-81	-301			
510	-101	-121			
500	-107	-247			
470	-131	-151			
430	-179	-221			
420	-177	-387			
390	-211	-451			
380	-209	-449			
270	-401	-601			
220	-529				

Table E-6. Upper Air Report for Sao Paulo, Brazil at 12Z on October 7, 1992.