

VONDERHAAR

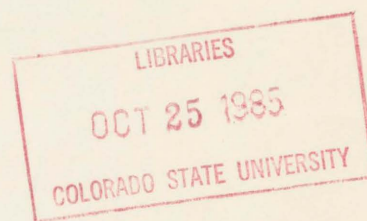
AN OVERVIEW OF THE PRESENT AND FUTURE

USES OF THE CSU IRIS/DRSES

by

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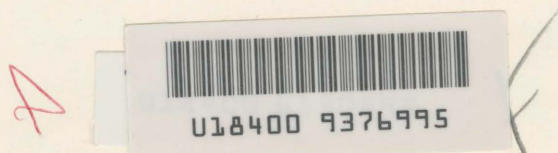
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July 1983

ABSTRACT

The purpose of this report is to inform potential scientific users of the capabilities of the CSU IRIS/DRSES. This report is intended to be a descriptive reference which is organized into three chapters. The first chapter presents the facilities which comprise the IRIS/DRSES. The next chapter describes the specific routines necessary to produce research oriented meteorological products presently operational at this time. Current plans for future additions to IRIS/DRSES are described in the last chapter.



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## LIST OF ACRONYMS USED IN REPORT

AFOS- Automated Forecast Operational System  
CMV- Cloud Motion Vector  
CSU - Colorado State University  
DCP - Data Collection Platform  
DEC - Digital Equipment Corporation  
DRSES - Direct Readout Satellite Earth Station  
EPA - Environmental Protection Agency  
ESA - European Space Agency  
ESP - Estimated Satellite Product  
GOES - Geostationary Operational Environmental Satellite  
HIPLEX - High Plains Experiment  
IRIS - Interactive Research Imaging System  
ISCCP - International Satellite Cloud Climate Project  
METEOSAT - Meteorological European Satellite  
NCAR - National Center for Atmospheric Research  
NESDIS - National Environmental Satellite Data \_Information Service  
NESS - National Environmental Satellite Service  
NOAA - National Oceanic and Atmospheric Administration  
NWS - National Weather Service  
ODIS - Off Line Data Ingest System  
PDP 11/60 - DEC Mini Computer  
PDP 11/34 - DEC Mini Computer  
POWS - Prototype Operational Weather Station  
PROFS- Program for Regional Observing and Forecast Service  
SSEC - Space Science and Engineering Center  
TAE - Transportable Applications Executive  
VAS - VISSR Atmospheric Sounder  
VAX 11/780 - DEC Mini Computer  
VISSR - Visible and Infrared Spin-Scan Radiometer



### INTRODUCTION

The CSU Department of Atmospheric Science has designed and implemented a computer facility capable of acquiring and processing numerous types of data for meteorological research and development work. The philosophy of this facility's architecture is research oriented more so than operationally oriented. The reason for this research emphasis is to allow the user (research scientists and graduate students) the flexibility of modular programs rather than being limited by operationally oriented canned procedures such as the PROFS's POWS (Reynolds, 83). IRIS provides the tools for user software development and encourages creative use of the system. Since this facility is comprised of state of the art imaging technology, changes in hardware and software configurations occur frequently. Thus, it is the goal of this report to present the current situation of this facility and its expected potential for the future. The reader of this "overview" document is referred to the continuously updated IRIS Users Guide for detailed instructions.

## CHAPTER 1

### FACILITIES

#### 1.1 DIRECT READOUT SATELLITE EARTH STATION (DRSES)

Figure 1 presents a block diagram of IRIS/DRSES. The left-hand side of Figure 1 represents the DRSES. A ten meter antenna is positioned to receive stretched VISSR data from the GOES-West satellite and a five meter antenna receives data from GOES-East satellite. The data stream is switched by the antenna selector to one of the two receivers within the DRSES. From this point, the data streams can follow various avenues depending on the switching in operation at that time. The DRSES comprises two separate operational receiving stations. The purpose of having two receiving stations is to insure that data collection can continue if one of the components within the system fails. This redundancy of the DRSES permits CSU engineers to effect changes in the path of the data stream much sooner than the failing device can be repaired.

The primary path of the collected satellite data for use by the CSU scientists is into one or both of the DRSES DEC PDP 11/34 minicomputer systems. These computers are programmed to collect and store the project requested sectors to disk. The projects may archive VISSR data on nine track tapes for analysis at a later date, or use the



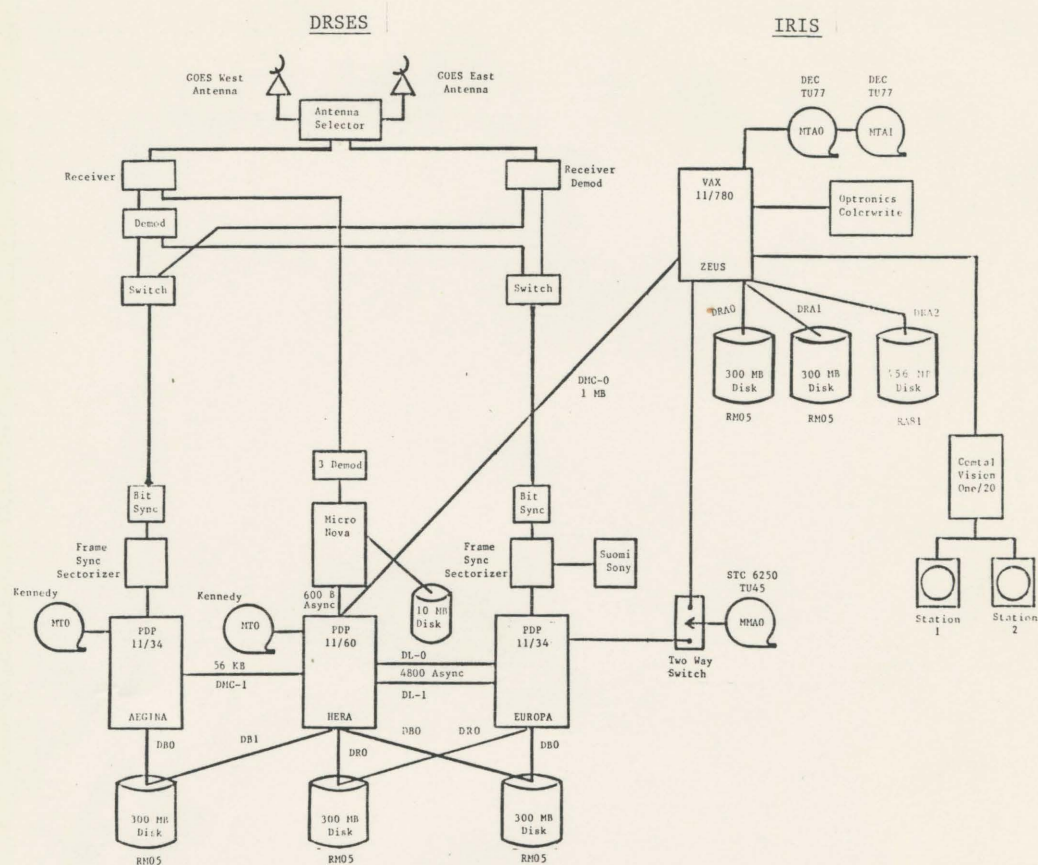


Figure 1. Block diagram of the IRIS/DRSES at the Colorado State University's Department of Atmospheric Science.

data in real-time. For real-time use, the DRSES data files can be accessed by the main applications computer (DEC VAX 11/780) and immediately be displayed and analyzed.

The GOES-East and GOES-West are geostationary satellites stationed at 75° W and 135° W, respectively (NOAA Tech. Rep., 79). On a normal day, each transmits two images per hour of the entire disk of the earth in both the visible and infrared spectral wavelengths. The GOES East satellite begins on the hour and half-hour; the GOES West at 15 and 45 minutes past the hour. During "RAPIDSCAN", a smaller area is scanned and images are transmitted more frequently. "RAPIDSCAN" refers to a research mode of image transmission from the GOES satellite system. High temporal frequency VISSR data is transmitted every 3, 5, or 15 minutes instead of every half hour. These data are used for studies such as severe weather case studies or any study requiring this temporal frequency.

#### 1.1.1 Data Collection Platform (DCP)

A DCP is a data collection platform consisting of a data acquisition system, platform, and assorted sensors. These platforms are typically in remote environments powered by an internal 12-volt battery source and charged by a solar panel. The GOES Data Collection System (DCS) offers "real-time" data, remote locations independent of power or phone lines, and high reliability.

GOES DCS (NOAA Tech. Rep., 79) are data collection platforms transmitting data via one of the GOES satellites, through the services offered by NESDIS. NESDIS re-transmits the data to both satellites



(East-West) allowing collection at the users processing center.

The system is designed to accommodate 10,000 individual sensor platform transmissions per hour operating in three possible modes:

- (1) Interrogated; the sensor platform trasmits its data in responce to an interrogation signal.
- (2) Self timed; the sensor plaform transmits its data at fixed (synoptic) intervals controlled by a timer located within the sensor platform.
- (3) Emergency; the sensor platform transmits its data after a predetermined sensor threshold (trigger) level has been exceeded.

The Department of Atmospheric Science has several DCPs which have been located in remote geographical areas to support various field projects that required automatic collection of data for real time use. These DCPs transmit meteorological data such as temperature, relative humidity, wind speed and direction, precipitation, and solar insolation. These data are stripped from the incoming data stream in the DRSES and sent to the DRSES Micro Nova microprocesser for decoding of the data and storage. These data may then be transferred to the DRSES PDP 11/60 for distribution(magnetic tape or print). For more information concerning DCP data contact Mr. Tom Cipriani (303/491-8363).

#### 1.1.2 VISSR Data Collection

VISSR infrared and visible data from GOES-East and GOES-West satellites can be collected automatically 24 hours a day, 7 days a week. The maximum resolution of the infrared and visible data that can be collected by the DRSES are 4 miles x 2 miles and .5 miles x .5 miles, respectively. Infrared VISSR data is always collected at the maximum resolution. Visible VISSR data can be collected at .5, 1, 2, or 4 mile

resolution. For more information concerning the DRSES or data collection, the reader is referred to Mr. Neil Allen (303/491-8233).

The cost for collecting an image is the sum of a fixed and variable rate. The fixed rate is \$21.47/image. The variable rate depends on the size of the image. The size affects operation time and storage requirements. The larger the sector size the longer it takes to process the image from disk to tape and it also takes more storage on disk and tape. In other words, the amount of operating time and mass storage usage are directly related to the size of the sector.

The cost to collect a specified set of images is variable. A sliding cost scale is used to determine the charges to the user. This sliding cost scale is based on volume and thus depends on user requirements. For more information contact Mr. Walt Naylor (303/491-8682).

## 1.2 IRIS

The right side of Figure 1 presents a block diagram of the IRIS. The IRIS is composed of a host computer (DEC VAX 11/780) which is used in conjunction with an image processing system. The image processing system is a model Vision One/20 manufactured by the COMTAL Corporation.

### 1.2.1 COMTAL VISION ONE/20

The CSU COMTAL VISION ONE/20 configuration has two work stations that share a common set of eight image planes (512 x 512 x 8 bits) which may be allocated as needed. Each station has a high-resolution color monitor, a cursor control device (data tablet or trackball), a keyboard to directly control the image processing system, and a terminal



connected to the host computer for controlling the data flow. The image display system also includes a video camera (Model 700SV EYECOM Image Scanner) digitizing option for input and a high speed computer driven digital film recorder (System C-4300 COLORWRITE) for output. The COLORWRITE is described in section 2.5.2. The video input camera and data tablet provide an excellent and rapid means to input hand drawn maps or to draw frontal and mesoscale analysis directly into a graphics or image frame. The design of the internal processing software and hardware of the system provides the scientist a highly interactive environment in which to try an idea and then quickly modify to improve the idea. The fast interactive capability is achieved on this system by building several of the more commonly used functions into high speed electronic circuits. The onboard controlling computer (LSI 11/23) then routes the digital data stream from the image planes through the proper circuit before arriving at the display monitor. Most of these functions are accomplished within one thirtieth of a second -- the video monitor refresh rate. Since many of the standard functions are self-contained in the display system, the host computer is relieved of many time consuming tasks and is used more as a data manager. For more information concerning specific applications of the COMTAL VISION ONE/20 the reader is referred to the COMTAL Operating Guide and the VISION ONE/20 Users Manuale available from Mr. Neil Allen (303/491-8233).

#### 1.2.2 VAX 11/780

The host computer for the CSU IRIS configuration is a DEC VAX 11/780. The VAX 11/780 is a mini computer which also provides an excellent resource for applications work. The VAX 11/780 will support

several users simultaneously, allow very large software programs to be executed by having only a portion of the program in memory at any given time, and has sufficient computing speed for significant processing of satellite imagery data and other meteorological data such as in modeling. There are various types of terminals available to system users, two of which have special capabilities. The LA-100 terminals have a special key pad for use with a line-oriented text editor. The ADM-5 terminals have graphics capabilities. Also available to users is a SPINWRITER line printer which can produce letter quality output from the VAX 11/780 (this report was output on the SPINWRITER). The VAX 11/780 uses a VMS operating system which supports Fortran and Pascal languages. A list of VAX/VMS Software Document Set is available from Mr. Neil Allen (303/491-8233).

#### 1.2.3 IRIS Costs

Because the IRIS is a combination of a host computer (VAX 11/780) and an imaging display system (COMTAL VISION ONE/20), charges incurred for its use are the sum of VAX 11/780 and COMTAL VISION ONE/20 charges.

Use of a COMTAL VISION ONE/20 station is recorded in logbooks located at each user station and the user is required to log the time used. The rates for COMTAL VISION ONE/20 use depend the current rate structure. For more information contact Mr. Walt Naylor (303/491-8682).

Billing charges for the VAX 11/780 are determined automatically by an internal accounting system. The billing charges for VAX 11/780 usage depend on the time of day and the system resources used (e.g. disc space used, CPU time, etc.). For more information contact Mr. Walt



Naylor (303/491-8682)

### 1.3 OTHER DATA INGEST SYSTEMS

#### 1.3.1 Link To Bureau Of Reclamation

The DRSES PDP 11/60 (see Figure 1) is used as a communications handler for computer network links between all the computers that comprise the IRIS/DRSES. This computer also has a dedicated link to the Bureau of Reclamation in Denver, Colorado. Current NWS surface observations, upper air data and model output fields are examples of data which are accessible via this link. A complete reference of all data types which are available from the Bureau of Reclamation are documented in a users guide (Project Skywater Environmental Data Network Users Manual). A special routine has been developed which uses a RAOB sounding acquired from the Bureau of Reclamation and outputs the sounding to either the Zeta graphics plotter (see section 1.4.1) or an ADM graphics terminal. An example of Zeta plotter output is shown in Figure 2. Procedures for acquiring these data reside in the IRIS Users Guide.

#### 1.3.2 Link To CSU And NCAR

The DRSES 11/60 has a communication link into the Atmospheric Science Department's Remote Job Entry terminal computer to provide data and program flow to the CSU main campus computer facility and the NCAR computer facility. For more information concerning the CSU and NCAR computing facilities, the reader is referred to the appropriate users guide (see references).

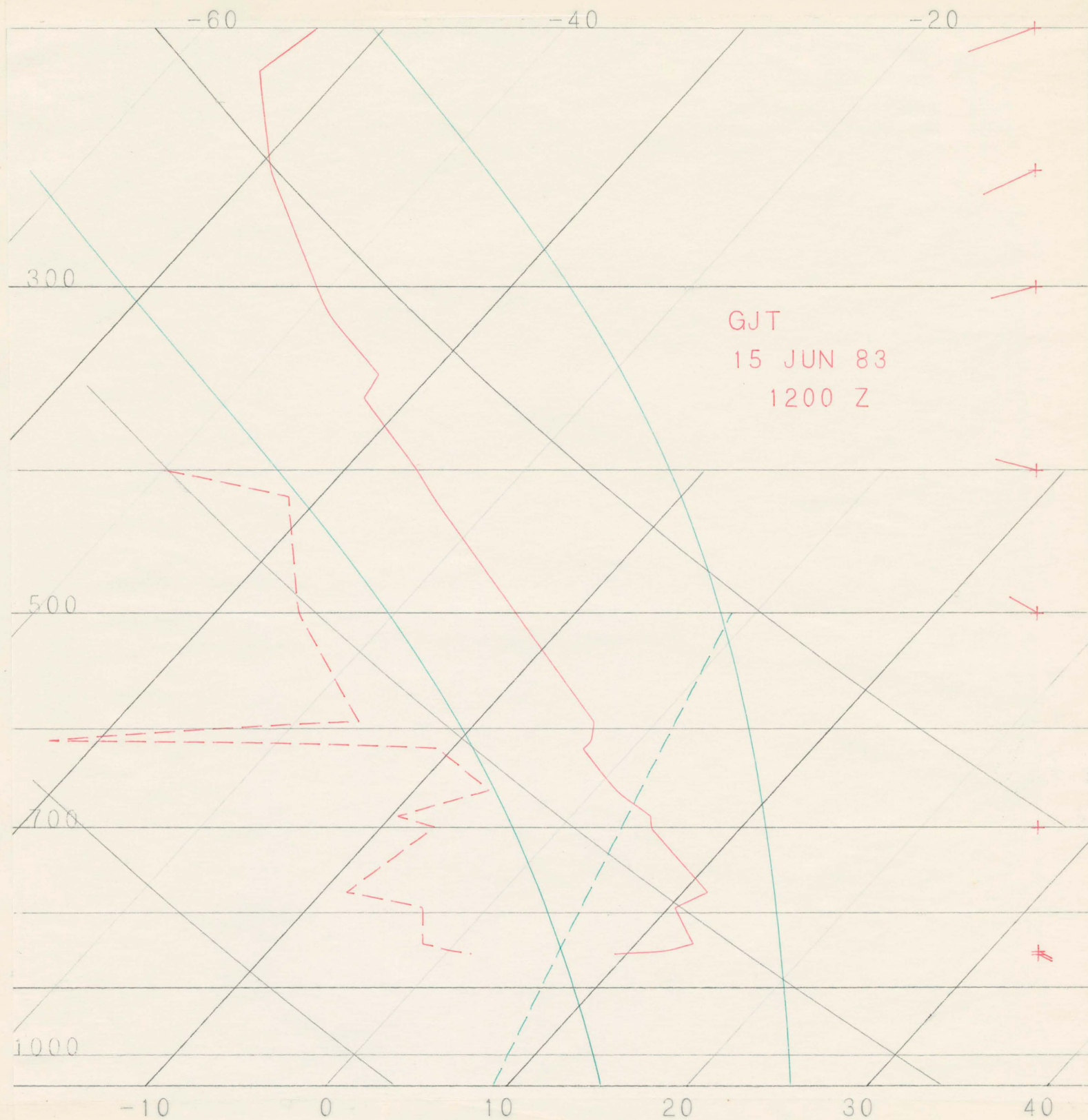


Figure 2. RAOB Sounding from the Bureau of Reclamation and plotted on the ZETA-8 Digital Pen Plotter.



### 1.3.3 Link To PROFS

The VAX has a link to the PROFS computing facility in Boulder, Colorado. This link provides the IRIS with lightning data, PROFS mesonet data, Denver RAOB soundings and Limon radar data in near real-time. The PROFS mesonet (Reynolds,83) is a mesoscale network of 22 surface meteorological stations. The geographic location of these stations are shown in Figure 3. This data is sent to CSU 20 minutes after each hour and contains 12 data sets of 5 minute averages ( $12 \times 5$  minutes = 1 hour) of temperature, dew point, wind direction and speed, precipitation, and solar insolation (see figure 4). Procedures for plotting these data reside in the IRIS User Notes. Denver RAOB soundings at 0000 and 1200 GMT can be acquired from the PROFS AFOS system and displayed on the COMTAL (see figure 5) or an ADM-5 terminal. Procedures for displaying the sounding data reside in the IRIS Users Guide. Limon Radar data every half hour is automatically sent (one hour after the fact) to the CSU VAX from PROFS. Display of this radar data can be achieved on the COMTAL (see figure 6) or any VAX supported terminal (see figure 7). Procedures to display Limon radar reside in the IRIS Users Guide.

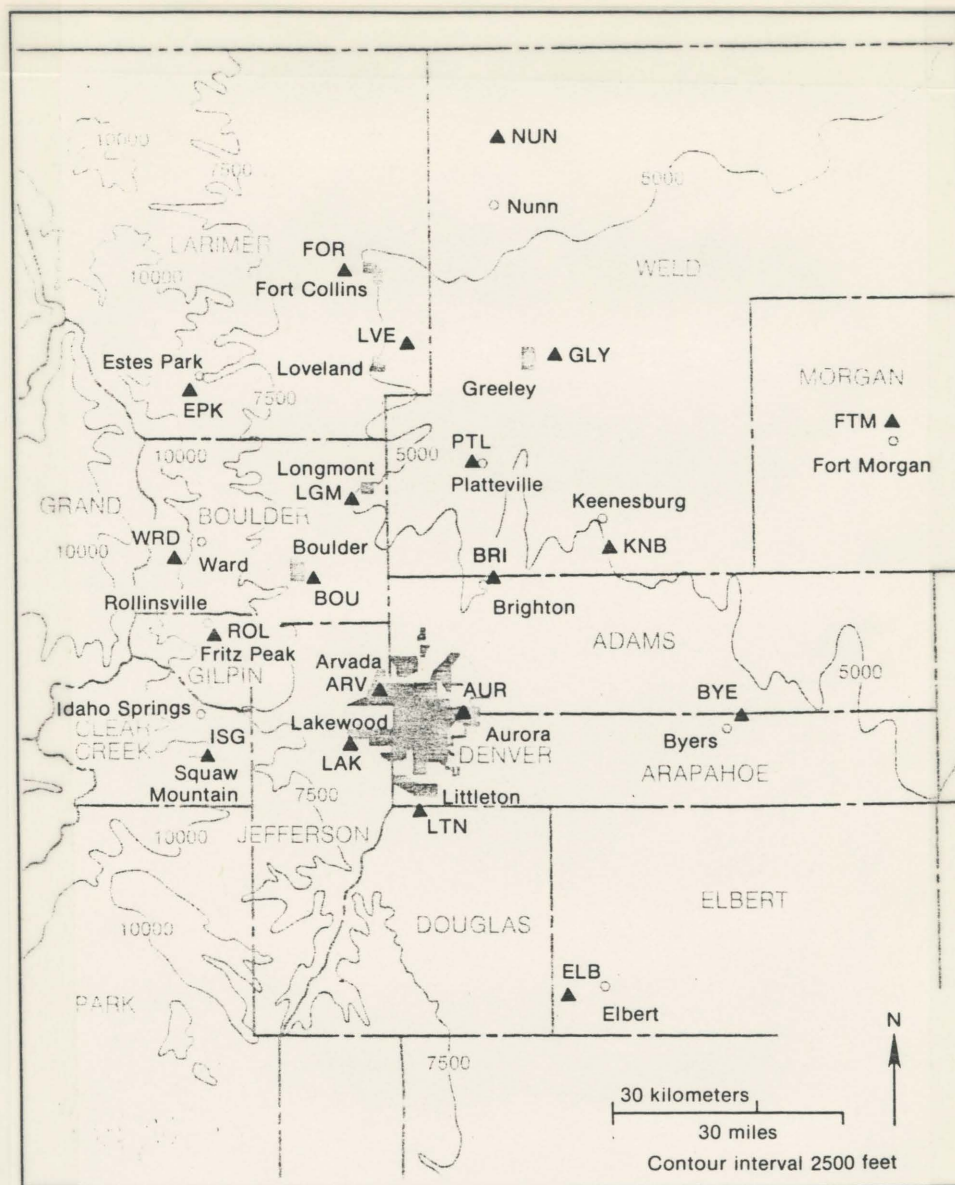


Figure 3. PROFS mesonet stations. Each station reports temperature, dew point, wind direction and speed, precipitation, and solar insolation.



30 JUN 2055Z 84.38./33.1

85.32./32.4 87.40./33.0

87.29./33.0 90.33./32.8

74.31./33.1 91.30./31.7

88.42./32.7

87.38./32.2 88.37./32.8

87.33./33.5 86.43./35.6

65.23./33.1 86.43./34.4

73.25./32.8

86.40./32.3 87.34./33.6 84.39./33.5

83.34./32.8

60.25./\*\*\*\* 86.40./32.3

TT.ID./BPP.P

78.36./32.4

30 JUN 2055Z 310. 6./ 8.7

214. 5./ 7.7 209. 9./13.1

243.15./19.9 201. 7./11.9

190. 6./12.5 289. 8./ 9.9

142. 5./ 7.1

105. 5./10.1 104. 5./ 8.8

119. 2./ 6.6 79. 8./10.7

264.11./21.9 70. 5./ 8.8

262.10./19.8

45. 3./ 6.4 83. 4./ 7.1 180. 3./ 4.4

342. 6./ 9.2

232.12./18.0 94. 7./10.9

OR DDD.VV./GG.G

Figure 4. Plots of PROFS Mesonet data.  
 Slash marks station location(see Figure 3).  
 Legend at bottom right for top and bottom plots.

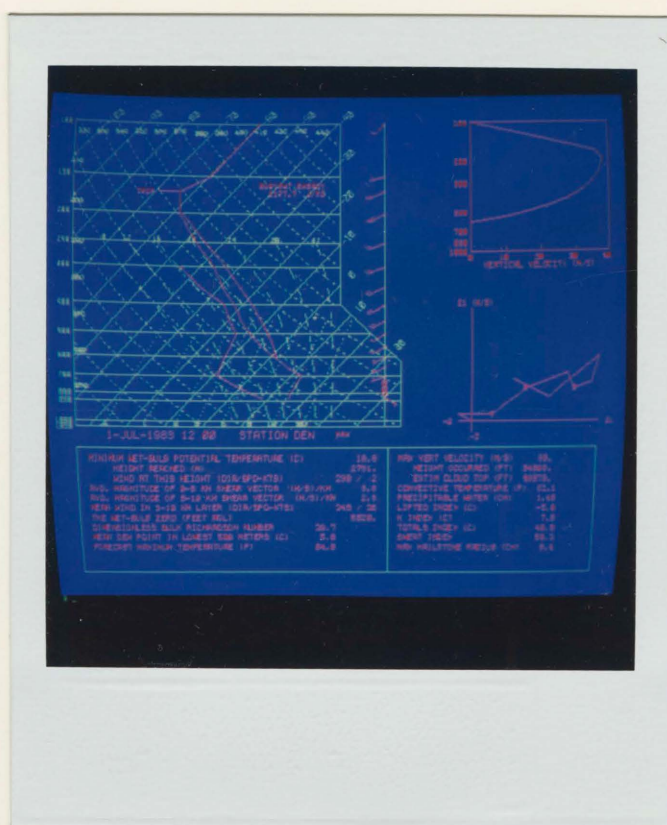


Figure 5. Denver sounding from PROFS and displayed on Comtal Vision One/20.



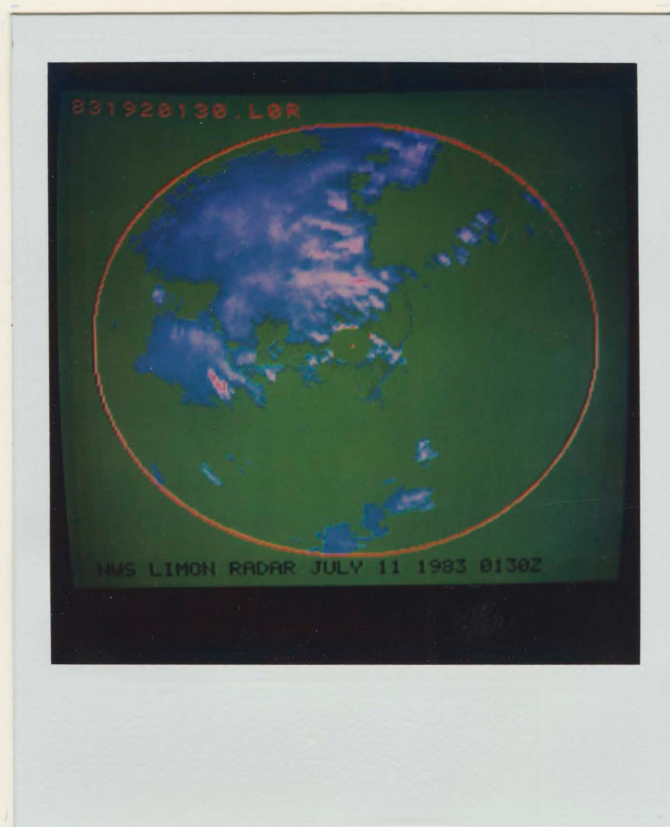


Figure 6. Limon radar data from PROFS and displayed on Comtal Vision One/20.

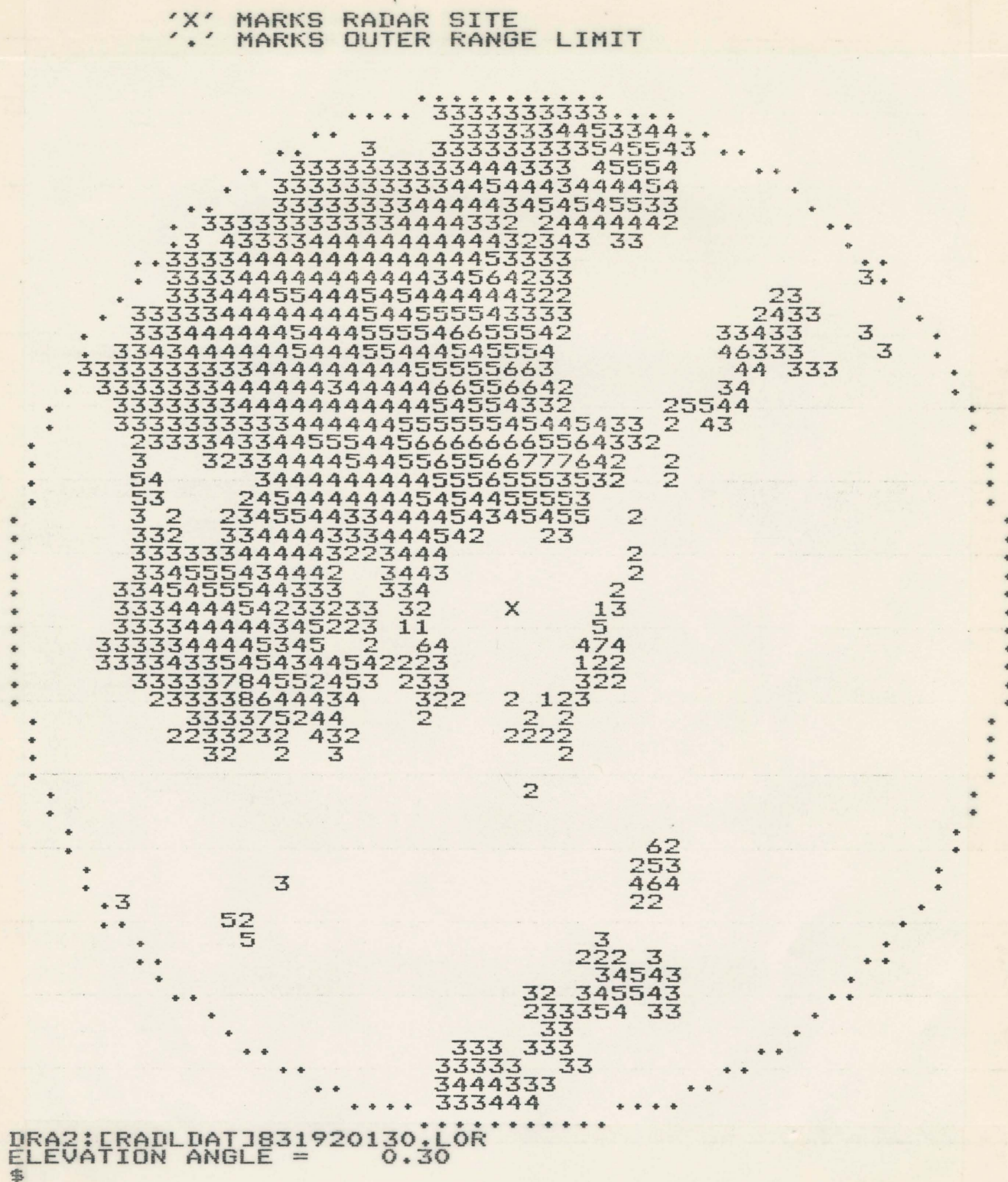


Figure 7. Limon radar data from PROFS and displayed on Comtal Vision One/20.



#### 1.4 PERIPHERAL EQUIPMENT

##### 1.4.1 ZETA 8 Digital Pen Plotter (NICOLET ZETA CORP)

The Zeta 8 is an 8-pen, high speed drum plotter which provides quality and fine resolution output (see figure 2). The plotter can be operated on-line, off line or, remotely via communication lines such as the CSU VAX computer. Pen types supported are liquid roller and nylon tip. Plotting media include translucent, vellum, high gloss bond papers, and clear film for overhead projection transparencies. The hardware character generator produces over 200 different characters, including uppercase, lowercase, Greek letters, and mathematical symbols. A user manual for this plotter is located with the plotter.

##### 1.4.2 Colorwrite C-4300 (OPTRONICS)

The Colorwrite C-4300 is a high precision, high speed color film recorder. It is designed to produce high resolution color transparencies from digital data bases by moving unexposed color film over a computer controlled light source (see figure 8). An unexposed film sheety is clamped onto a removable drum and the film is exposed by modulation of a light beam from a white-light source focussed onto the film plane through a precision aperture and lens system. Color writing is accomplished by three sequential exposures through selected red, blue and green filters. For monochromatic image reconstruction an LED light source is provided.

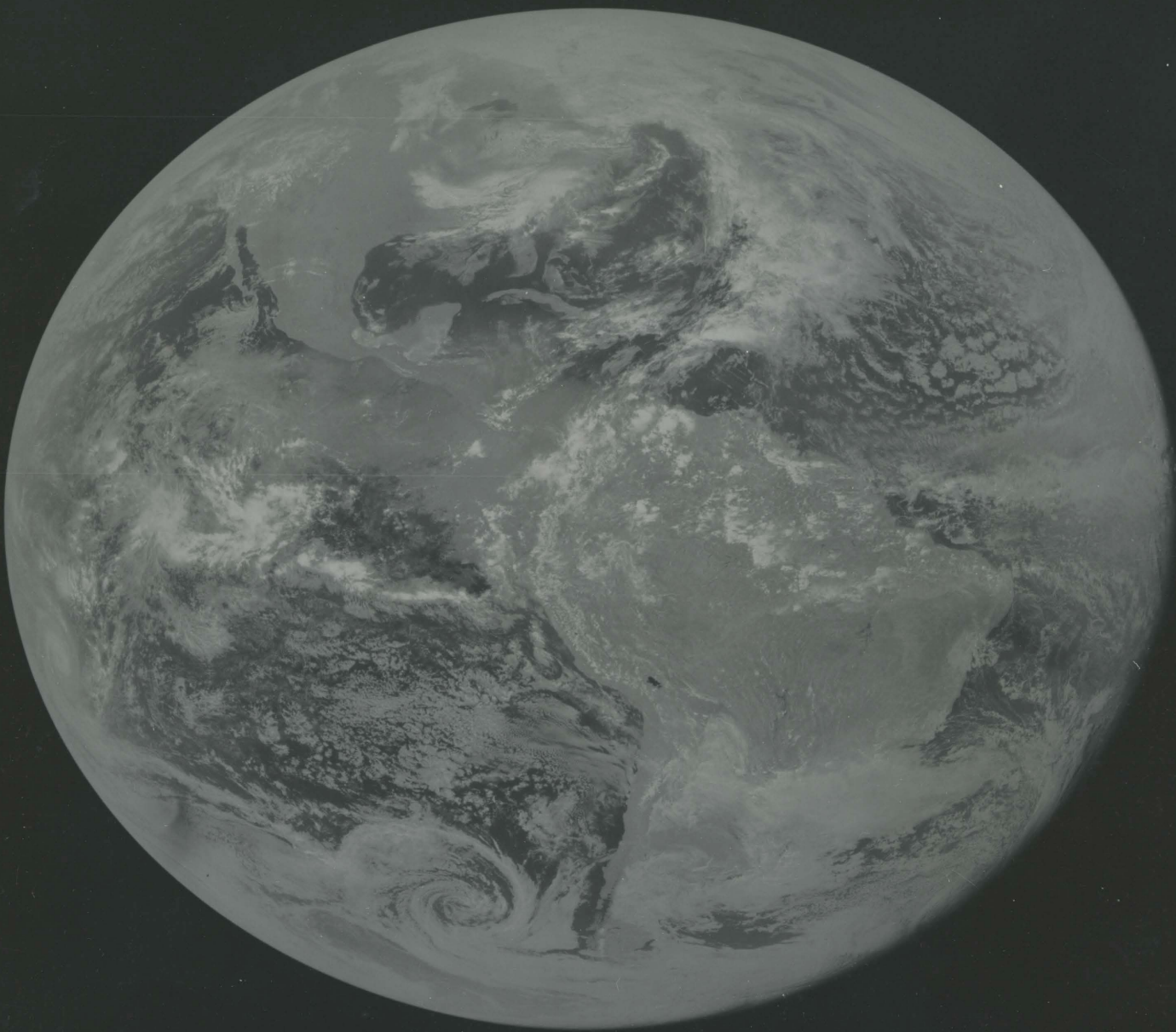
The film may be exposed at every raster point along the

circumference of the drum (y-direction) up to a maximum dimension of 25 cms. After each rotation the optical carriage is stepped in the axial (x) direction at the selected raster interval, and the process is repeated until the total area of interest has been exposed. There are 32 repeatable density levels per primary color, or 64 repeatable gray levels in black and white operation, depending on film gamma and developing method. Spatial resolution on the film ranges from 20 to 2.5 line pairs per millimeter or 25 to 200 microns. Operation of this device is supported by DMS(see section 2.1.1 and section 2.2.2.5).

#### 1.4.3 Portable Color Video Cassette Recorder

A portable color video cassette recorder (Panasonic Omni Vision II NV-8410) can be used to directly record (in VHS format) images from the COMTAL. Cassette tapes produced in this manner can be played back on any VHS standard cassette deck. Since the COMTAL signal rate is different than what is necessary for cassette recording, special procedures must be followed before recording. These procedures are documented in the CSU COMTAL Users Guide.





GOESVISSR IR  
EAST

0 0  
0: 0

FULLDSK

EXPOSED: 18-APR-83 19:11

COLORADO STATE UNIVERSITY  
INTERACTIVE RESEARCH IMAGING SYSTEM

Figure 8. GOES East visible full disk image reproduced by the Colorwrite Optronics C-4300.

## CHAPTER 2

### PRESENT USES OF THE IRIS

This chapter describes the present capabilities of IRIS. The first part of this chapter describes the Data Management System (DMS). The last part describes specialized uses of IRIS.

#### 2.1 DMS OVERVIEW

DMS is a VAX implemented system for managing meteorological data sets. It was designed to be a device-independent, interactive data handler which is modular, expandable and flexible enough for a wide range of meteorological applications.

DMS includes a user interface, TAE (Transportable Applications Executive) from NASA/GODDARD. TAE is a collection of "executive" programs which interact with a user to manage the execution of application programs. The purpose of TAE is to:

- Standardize the user interface to application programs. All applications programs running under TAE have a consistent, friendly, human interface. Since TAE is to be implemented on several computer systems, the interface is standardized among several computers.
- Shield the user from the host operating system. The TAE user does not have to know the command language of the host computer. TAE manages the entire interactive session.



- Provide a user-friendly environment. TAE is designed to be operated by the first-time user and the experienced user. Features exist to request assistance from TAE at each stage of an interactive session.

The user has facilities available to operate TAE in one of three modes:

- Menu mode, where the user selects from a list of options presented on a CRT. An entry in a menu refers to an application function or to another menu.
- Command mode, where the user communicates with TAE via a simple command language.
- Tutored Input mode, where the user establishes and reviews a set of parameters to be supplied to an applications program.

TAE is designed to be user-friendly: for example, typing "HELP" in response to a TAE prompt causes TAE to display instructions for using the current mode.

Also included in DMS is a data base. Each user has his own personal copy to which he can make additions, modifications, or deletions. It contains descriptions of any data set (usually image data) with which the user is currently working or has worked with in the past and chosen not to delete. It also contains time dependent information such as navigation parameters, and area dependent information which aids the user in specifying a geographical area of interest.

Data handling is segregated into two general sets of processing software pertinent to: (1) image type files such as satellite and radar scans, and (2) sparsely located surface and upper-air observations and grid files which are handled as graphical information. At present, DMS supports handling of image type files only, however, special routines are presently available for graphical data manipulation (see section 2.2).

### 2.1.1 DMS Menu Descriptions

The DMS supported processing software is presented in a menu format. The following root menu of DMS is used here to organize into groups, similar type routines.

#### Root Menu:

- 1) VMS operations.
- 2) RIM database operations.
- 3) TAE operations.
- 4) Raw data operations.
- 5) Image data base operations.
- 6) Navigation data base operations.
- 7) Other data base operations.
- 8) Image manipulation operations.
- 9) COMTAL operations.
- 10) Composite image operations and Optronics Colorwrite procedures.

#### 1) VMS operations

Operations provided by the VMS command language. Operations include file directory, file delete and purge, copying, logical name commands, etc.

#### 2) RIM database operations

Basic RIM database operations, such as database compressing and the RIM query language. RIM query language allows the user to look directly into the user database.

#### 3) TAE operations

Provides functions performed by TAE (user interface).

#### 4) Raw data operations

Operations that function on raw data sets. Normally, an input processor is run from this menu which will translate raw image data such as Goes VISSR, METEOSAT, and ODIS (see Appendix A) imagery into DMS standard image data formats. Other programs provided are general and specific tape file analyzers.

#### 5) Image data base operations

Operations that are used to manage image data sets -- operations such as displaying image parameters, copying, deleting, renaming, etc. This menu also includes programs used to archive and retrieve images from DMS archive format tapes.

#### 6) Navigation database operations

Operations dealing with satellite navigation data contained in the database. Operations include displaying entries present in the database, deleting entries from the database, inserting and extracting entries from the database, and performing landmark navigation



7) Other database operations

Operations that can be performed on all other database entries. The database image structure definitions, sector definitions, and coordinate system projection definitions can be defined, deleted or listed by programs from this menu.

8) Image manipulation operations

Operations that can be applied to images. Programs here include functions to extract a sub-region of an image, zoom, reduce, and remap images. Also included are various other image manipulation routines.

9) COMTAL operations

Operations that are pertinent mostly only to images resident in the COMTAL. Included are programs to upload and download COMTAL macros, send commands to the COMTAL, plot standard image annotation, plot geo-political datasets, read the COMTAL target position, and perform image pizel analysis.

10) Composite image operations and Optronics Colorwrite

Composite image operations and procedures used to simplify writing out images to the Optronics Colorwrite system.

## 2.2 SPECIALIZED USES OF IRIS

Specialized software which is not necessarily supported by DMS, but made available to users is presented. In many instances, DMS is used to manipulate data (e.g. display VISSR data) in anticipation for use by the following specialized routines.

## 2.2.1 Cloud Climatology Related Programs

## 2.2.1.1 Software Developed For CSU's Support To HIPLEX -

Software developed for CSU's support to HIPLEX are described (Reynolds and VonderHaar 79). These programs run on the VAX 11/780.

JOYO - This is a user interactive program which uses as input a displayed VISSR infrared or visible image. This program allows the user to define a brightness threshold differentiating cloud-no cloud for input to the CLOUD program. It passes to tape the coordinates, the threshold, and the user defined cloudy area of interest.

CLOUD - This program reads the tapes produced by JOYO and outputs

one record for each cloud found to tape.

FIX - This program eliminates bad or duplicate header records from CLOUD output.

SPLIT - This program splits output from FIX into four categories; VIS MLS, VIS BGS, IR MLS, IR BGS.

VAX SORT UTILITY The VAX SORT UTILITY is used to sort each of the four files produced by SPLIT. The SORT is with respect to date, time, and cloud size.

CLFREQ - This program uses the sorted VIS files to calculate cloud statistics on a daily and seasonal basis. The frequencies accumulated are for:

- a) Time versus number of clouds for the entire area of displayed image.
- b) Time versus number of clouds within 150 km of reference.
- c) Size versus number of clouds for the entire area of the displayed image.
- d) Size versus number of clouds within 150 km of reference.
- e) Direction versus number of clouds for the entire area of the displayed image.
- f) Direction versus number of clouds within 150 km of reference.
- g) Distance range versus size of clouds versus number of clouds.

IRANAL - This program uses the sorted IR files and prints the following on a daily and seasonal basis:

- a) Temperature (at specified intervals) versus number of clouds.
- b) Number of clouds for each temperature interval versus time.
- c) Time versus number of clouds for each temperature interval.

CLDSEP - This program calculates the minimum separation distance between clouds of similar size at a given date/time. The output is a plot of relative frequency versus radii apart for each cloud size range.

For more information about these programs the reader is referred to Mr. Behunek (303/491-8398).



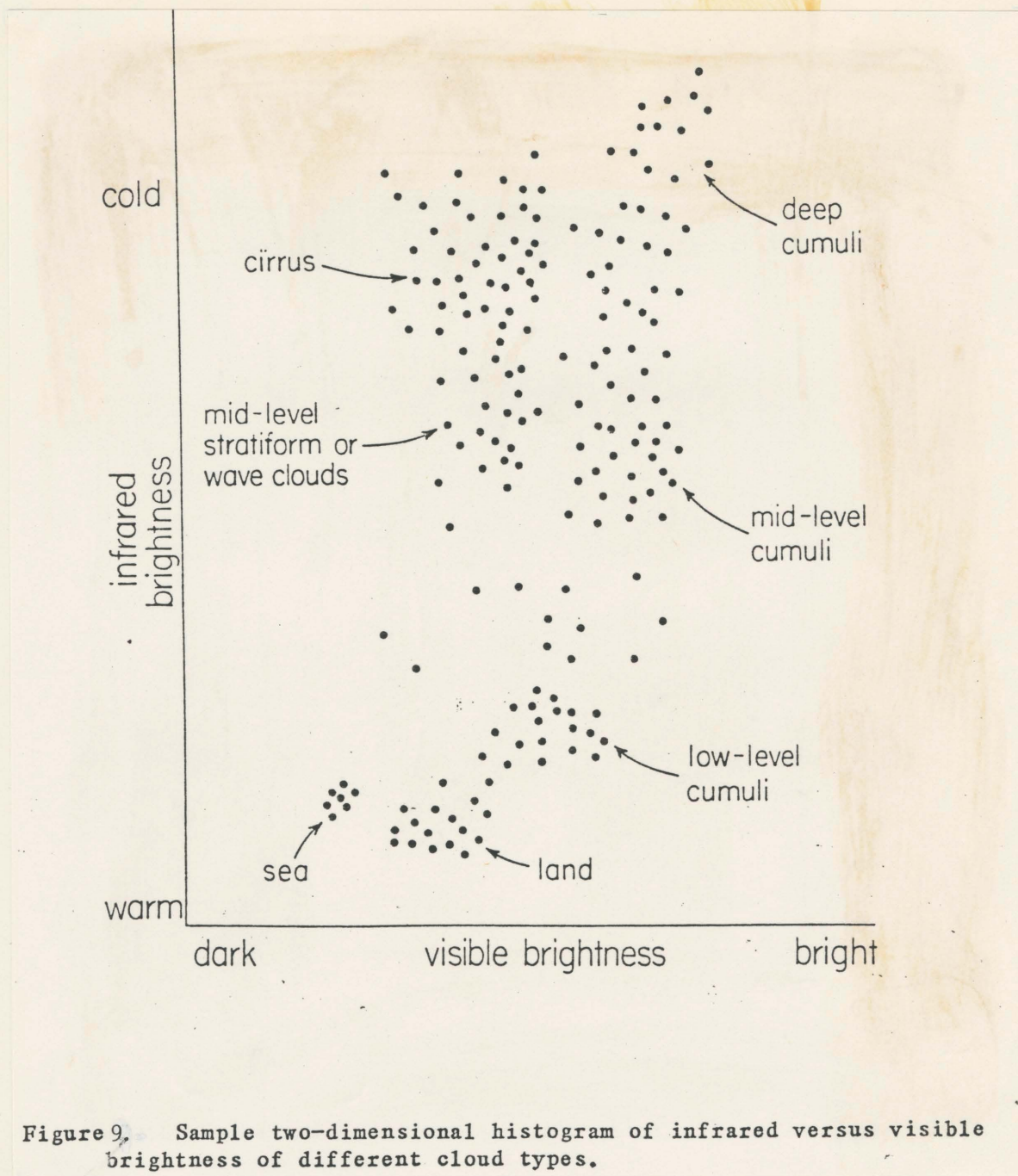
## 2.2.1.2 Regional Scale Cloud Parameter Determination -

DMS supported software was developed to satisfy requirements to determine cloud parameters for input to an EPA regional scale pollution model (Vonderhaar, Behunek, Laybe, 83). These programs are supported by DMS.

The cloud parameters determined by these programs are total cloud amount, cumulus cloud amount and either a frequency distribution of cloud top temperature within each grid cell (program CLDFREQ) or a mean cloud top temperature within each grid cell (program CLDSTAT). The grid cells are rectangular with respect to earth coordinates (latitude and longitude) and their size is variable according to user specification.

These programs utilize an interactive technique which is bispectral in nature. Simultaneous analysis of coincident (in space and time) visible and infrared images allow the user to distinguish cumulus clouds from clouds of other types. The physical basis for this method is illustrated in Figure 8<sup>9</sup>. It is founded on the observation that different cloud types usually fall on different parts of a two-dimensional histogram of visible brightness versus infrared brightness. For instance, cirrus clouds appear colder than the underlying surface, but they generally are slightly darker in the visible wavelengths than deep cumuli.

Thresholds for the visible and infrared channels are interactively selected by color coding their effects on the cloud classification and displaying the result on the COMTAL monitor. The color coding of the cloud classification is facilitated by a hard-wire function built into the COMTAL which is referred to as the classifier (see IRIS Users Guide). Once the user is satisfied with the selected thresholds the programs are allowed to separately count the number of picture elements





(pixels) which correspond to cumulus clouds and other types of clouds. These figures are then compiled into statistics of cloud parameters for each grid cell.

An important consideration regarding the rather large area covered by a single infrared pixel was taken into account. Because many cumulus clouds were smaller than the projection of the infrared sensor's field of view on the earth, the satellite-observed temperature for a spot including such a cloud was contaminated by the apparent background surface temperature. This effect was corrected by computing the cloud top temperature as a function of the observed temperature, the background surface temperature, and the percent cloud cover. The weighted brightness temperature of a single observed IR pixel is given by:

$$T_O = N \times TCT + (1 - N) T_B \quad (1)$$

where  $T_O$  is the temperature of the observed pixel,  $TCT$  is the cloud top temperature,  $T_B$  is the background surface temperature, and  $N$  is the fractional cloud amount within the IR pixel. This equation was inverted to give the cloud top temperature:

$$TCT = (T_O - (1 - N) T_B) / N \quad (2)$$

In applying Equation 2,  $T_B$  was estimated from the minimum  $T_O$  within the grid cell being processed, and  $N$  was calculated from the higher resolution visible channel. For more information concerning these programs the reader is referred to Mr. Behunek (303/491-8398).

## 2.2.1.3 Cloud Lifetime Analysis -

A special program has been developed to diagnose cloud lifetimes, areas, parameters, and cloud top temperatures through the analysis of coincident VISSR visible and infrared "RAPIDSCAN" data (3 minute frequency). This program allows the user to define a cloud from the background scene by using a thresholding technique of the COMTAL. Another facility of the COMTAL allows the user to LOOP consecutive visible images to determine how the cloud changes and its ultimate fate. This program is supported by DMS. For more information about this program contact Mr. Behunek (303/491-8398).

## 2.2.1.4 ISCCP -

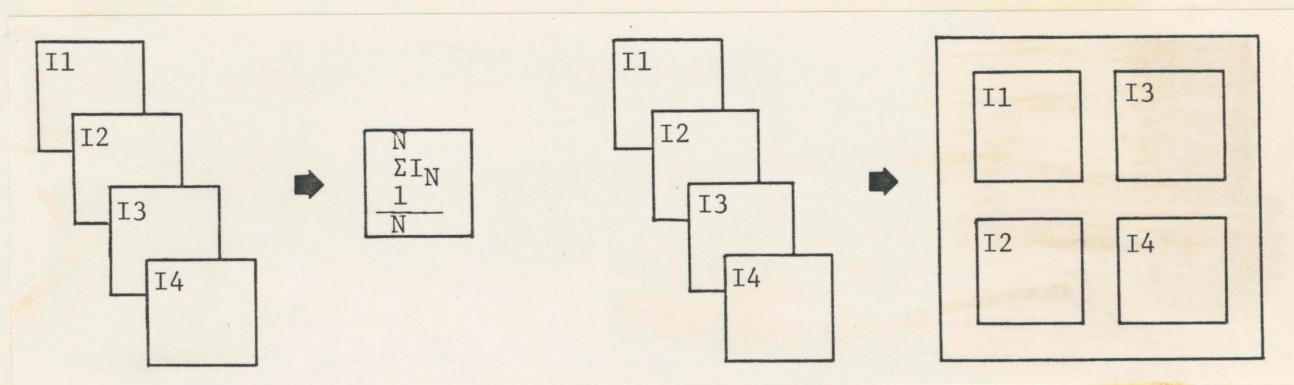
CSU is responsible for VISSR data collection for the International Satellite Cloud Climatology Project. This is an ongoing project to acquire global scale cloud climatologies. This responsibility to collect full disk visible and infrared from GOES West requires intensive use of the DRSES. Special collection routines were developed to satisfy these requirements. Automatic cloud analysis routines are currently being developed for this project. For more information concerning ISCCP's use of the DRSES contact Dr. Campbell (303/491-8497).



## 2.2.2 Image Compositing

The term compositing is used to refer to either averaging any number of images or the process of mapping a collection of subimages to create a larger image. The difference between the two meanings of composite are diagramed in the figure below.

Composite Averaging\*\*\*\*\*Composite of Subimages



The compositing of subimages to create a larger image is a useful routine to prepare an output image for the Colorwrite (OPTRONICS). These routines are supported by DMS and thus are presented in section 2.1.1 .

Composite averaging is not supported by DMS and special procedures are necessary which utilize facilities of both the VAX 11/780 and COMTAL VISION ONE/20. The composit average technique has been extensively used by many different users for many different purposes (Kelly, 83; Klitch, VonderHaar, 82; Reiter et. al., 83; Weaver, Kelly, 82). For an example of a composite (average) product see figure 10. For information concerning the specific COMTAL commands and VAX programs necessary for image compositing contact Mr. Green (303/491-8448) or see the references.

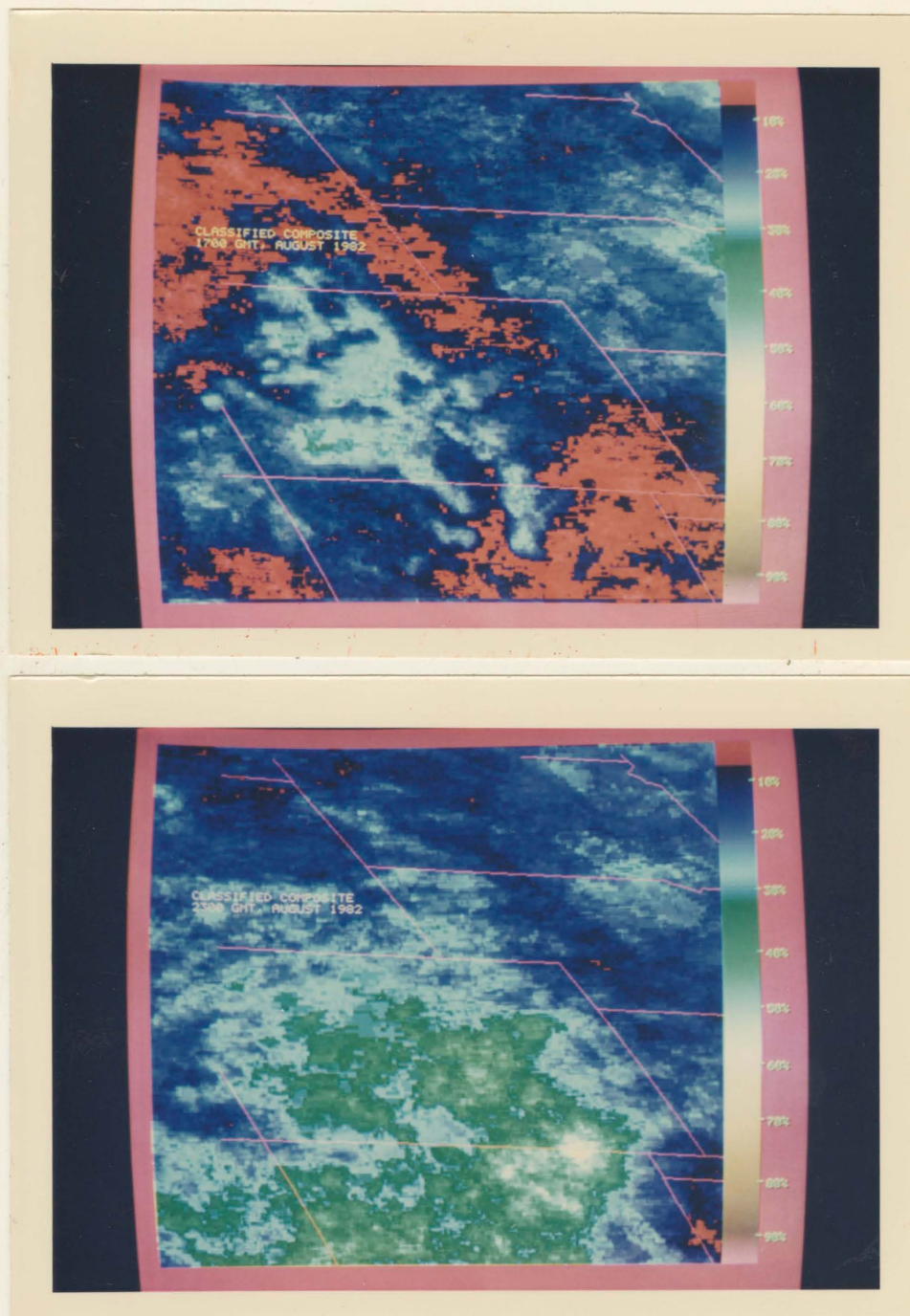


Figure 10. Composite images showing percent occurrence of convection for the month of August 17Z (Top) 23Z (Bottom).



### 2.2.3 Other Special Uses Of IRIS

#### 2.2.3.1 Estimated Satellite Products (ESP) -

Software was developed which used digital satellite data to monitor the accuracy of model output derived cloud fields (Reinke 82; Reinke, Laybe, 82). Cloud fields are produced from ceiling and cloud amount forecasts based on Model Output Statistics (MOS) equations run by the National Weather Service. These cloud fields are displayed on a coordinate display of digitized GOES satellite data. The model output cloud fields are displayed over a 12-hour forecast period to depict what the satellite cloud field should "look like" at some future time. When the GOES satellite images are received, they are used to varify the model output forecast performance and an assessment is made to accept or alter the forecast.

Software was developed to satisfy the above mentioned technique by displaying the model output cloud fields and the GOES satellite data on both the COMTAL and an ordinary line printer (see figure 11).





Figure 11A. Model output cloud fields displayed on the Comtal Vision One/20.

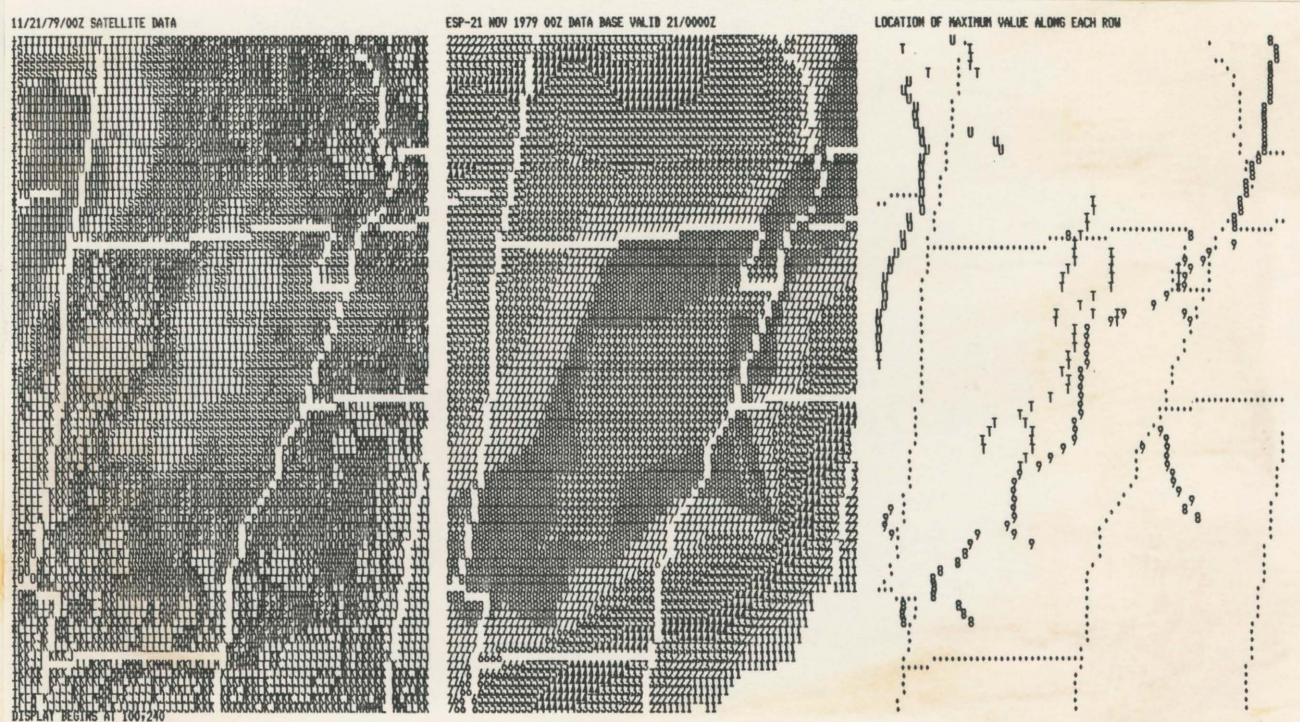


Figure 11B. Combined display of satellite, model output cloud fields, and bridge. Bridge is a display of satellite fields greater than 'S', and ESP fields greater than '9'.



#### 2.2.3.2 Satellite Plus Radar Display -

An operationally oriented forecast product to present both satellite and radar data for analysis of severe thunderstorms has been developed (Green, Parker 83; Parker 83; Purdum, Green, Parker 82). The satellite and radar merged product (see Figure 12) is generated with currently available data and can be computer assembled in a usable time frame and within reasonable computer resource limitations.

The satellite data used is a "smoothed" GOES VISSR infrared image remapped into a polar stereographic coordinate system. At present, the NCAR doppler radar images are produced at NCAR on a similar VAX-COMTAL imaging system, written to tape, and then read into the IRIS. Future plans to have NCAR doppler radar (CP2) available through computer links to PROFS during the summer of 1983 and the necessary software to read and format the radar data will permit near real-time use of this product at CSU. This software is now available and will soon be operational on the VAX. Also, it will soon be possible to use the NWS radar data presently being sent to CSU from PROFS with this product.

Some points to consider concerning the merged satellite and radar products are included here. In order to merge the satellite data with the radar data the satellite data is remapped to the same coordinate projection as the radar data. There is a time matching problem (plus or minus 5 minutes) due to the different ways the two types of data are collected. Navigational errors inherent in both the satellite and radar data reduce the accuracy of locating areas of interest. Optical parallax due to the satellite view angle and cloud height is another problem inherent in this product. Finally, a perception problem arises

due to the way the satellite and radar data are enhanced on the COMTAL imaging system. For example, coloring of certain reflectivity radar values may blend and obscure important satellite data. For further information contact Mr. Green (303/491-8446).

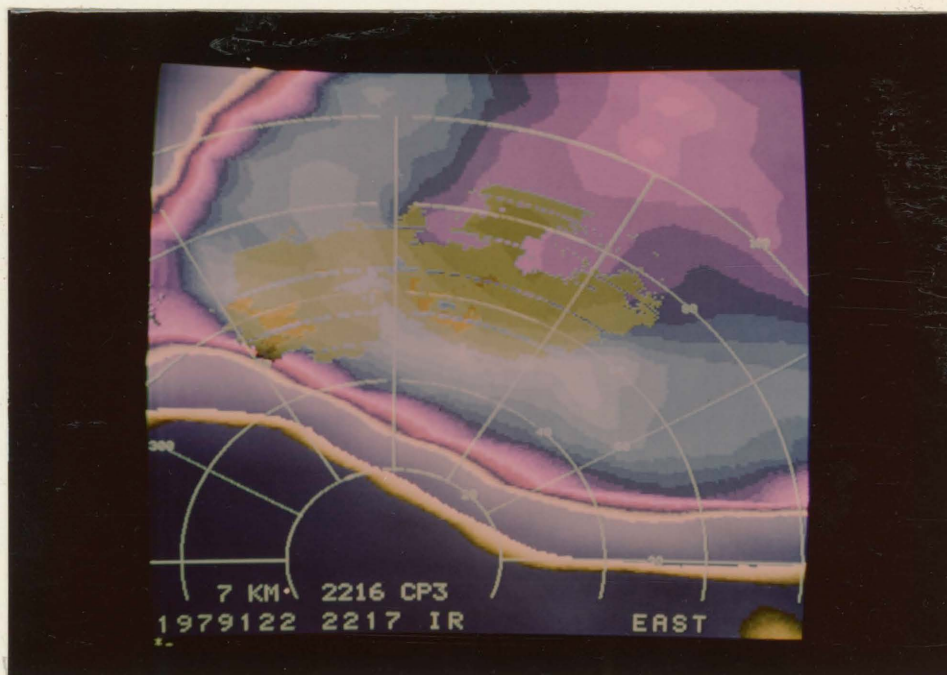


Figure 12. Satellite and radar merged product.



#### 2.2.3.3 Sparse Data Graphical Display -

Routines are available which plot surface data in the standard station model format. These data are earth located and plotted in the appropriate position with respect to the satellite navigation. These routines specifically plot PROFS mesonet data (see figure 13) and DCP data. For more information contact Ms. Kruidenier (303/491-8498).

Routines are also available which will plot wind barbs. These data are plotted with respect to screen coordinates (see figure 14). For more information contact Mr. Laybe (303/491-8423).

#### 2.2.4 Other Useful Routines

##### 2.2.4.1 Math And Statistics Libraries -

Two IMSL (International Math and Statistics Libraries) software packages are currently available on the VAX (see references). They are abbreviated statistics and mathematics routine libraries. These packages can produce FORTRAN code for the user. For more information contact Mr. Allen (303/491-8233).

##### 2.2.4.2 Monte Carlo Radiation Program -

A Monte Carlo radiation program is available on the VAX. For more information contact Mr. Durkee (303/491-8398).

##### 2.2.4.3 Elevation Database -

An elevation database for the western United States is on the VAX. It can be used with images, graphics, etc. For an example of this database displayed as an image see Figure 15. For more information on elevation database contact Ms. Kruidenier (303/491-8498).

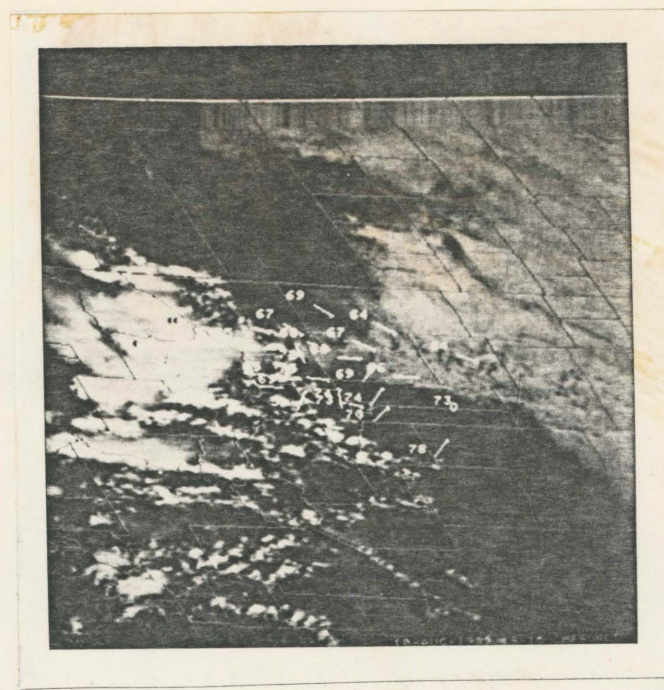


Figure 13. PROFS mesonet data (temperature and winds) plotted over satellite image.

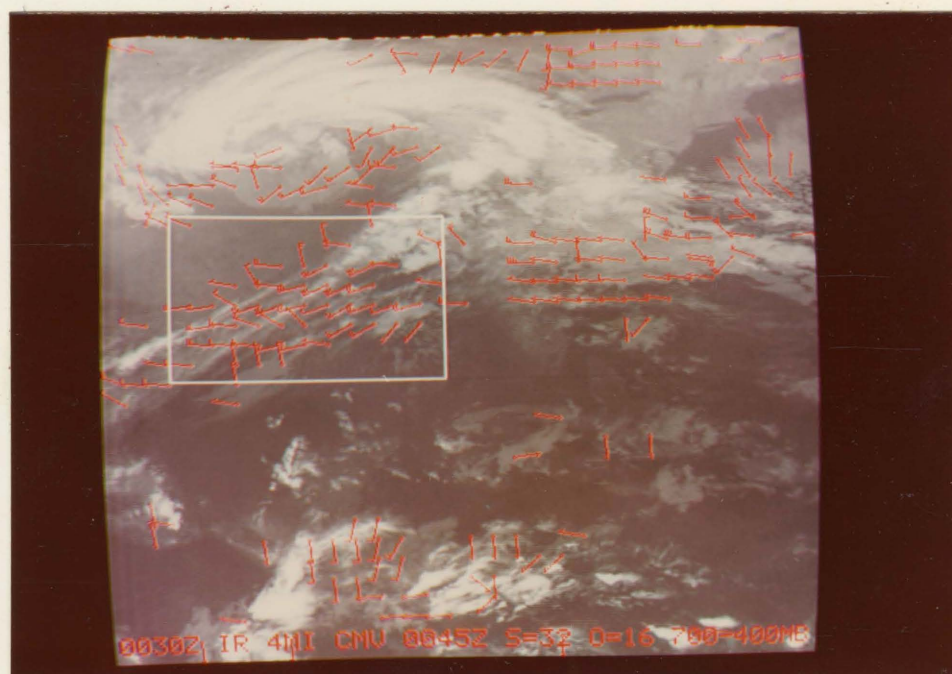


Figure 14. Wind vectors plotted over satellite image.



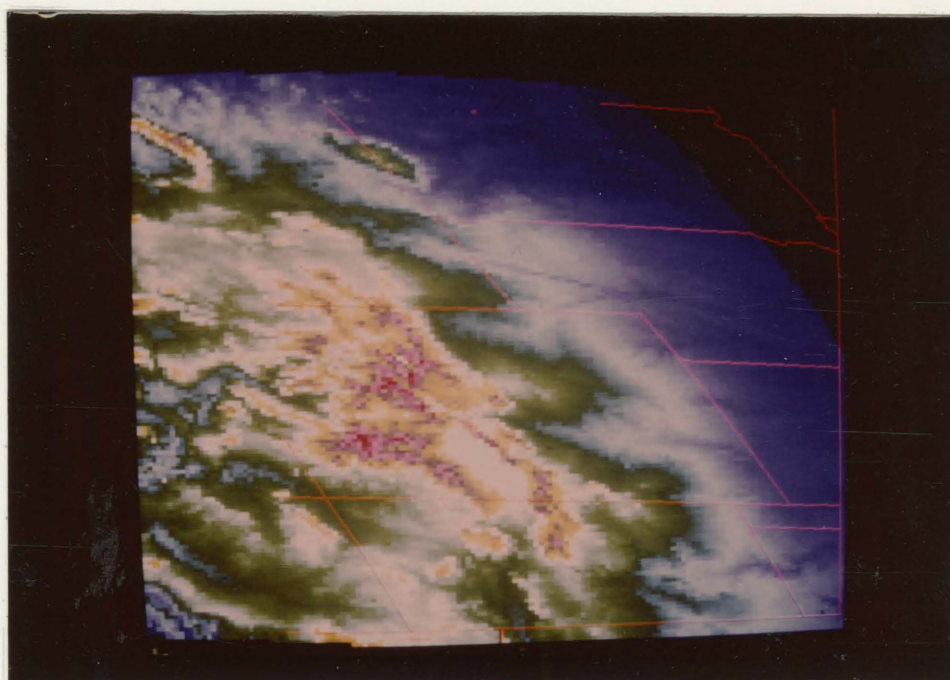


Figure 15. Elevation data base for Colorado.

#### 2.2.4.4 Visible Brightness Normalization For Solar Elevation -

A program is available which performs a brightness normalization for solar elevation (see IRIS Users Guide). This program uses as input a displayed visible image on a COMTAL image frame and outputs a normalized image on another COMTAL image frame. To allow the user to normalize part of the image, the x, y coordinates of the upper left hand corner and the lower right hand corner must be entered interactively to the program.

The algorithm used to normalize a pixel is documented on Pages 23-24 of Air Force Surveys in Geophysics, No. 377, "Estimates from Satellites of Weather Erosion Parameters for Reentry Systems".

#### 2.2.4.5 Parallax Correction -

A program is available which performs a parallax correction necessary to accurately earth-locate clouds, especially clouds with great vertical extent such as cumulonimbus clouds (see IRIS Users Guide). Input is the latitude, longitude and height as seen from either the GOES East or West satellite. Output is the corrected latitude and longitude and the displacement in kms between the noncorrected and corrected earth locations.



## CHAPTER 3

### FUTURE USES OF IRIS

#### 3.1 ADDITIONS TO IRIS/DRSES

##### 3.1.1 Data Collection Scheduling

Routines will be available which will facilitate the routine collection of VISSR,VAS,and DCP data. These routines will also make these data easily available to users of IRIS.

##### 3.1.2 Mercator Image Remapping

A mercator remapping projection will be added to DMS remapping routines. At present DMS supports remapping to polar stereographic, lambert conformal and a user defined coordinate system (see section 2.1.1).

##### 3.1.3 Math And Statistics Libraries

The complete IMSL (International Math and Statistics Library) package will be installed and made available later this year. These libraries will reside on the VAX.

#### 3.1.4 Graph Plotting

A graph making package (GRAPHMAKE) will be purchased later this year. This package contains canned procedures for graph making.

#### 3.1.5 Cloud Tracking

An interactive cloud tracking program is currently being developed which can produce a field of Cloud Motion Vectors (CMVs) from up to seven VISSR visible or infrared images.

This program allows the user to zoom in on the cloudy area to be analyzed to better delineate fine scale features of the clouds. The image looping feature of the COMTAL is then invoked by the program to inspect the zoomed area in the successive manner. This permits the user to easily follow and isolate a particular cloud. Once the user has isolated a suitable cloud, the last image is roamed so that the location of the cloud in the last image matches the location in the first image. The program then computes and plots a velocity vector for that particular cloud. A redisplay and loop of the seven images in a cloud relative format is done such that the analyzed cloud does not move from the first image to the last image. This looping of the cloud relative images checks the CMV by making sure the user is tracking the same cloud. If for any reason the computed CMV is not satisfactory, the CMV may at this point be deleted and the process repeated until the desired field of CMV's are generated.

True stereo images will be used to determine heights for each of the computed CMVs. Divergence, vorticity may be generated from the computed fields of CMV after an interpolation to a grid is accomplished. Streamline and isotack analysis can also be displayed over the CMV



field. For more information contact Mr. Purdom (303/491-8443).

### 3.1.6 Graphics And Sparse Data Plotting

DMS will support graphical display of sparse data sets for specific locations and time periods desired by the user. The data sets must be supplied by the user, although some data types can be acquired with the dedicated links to other data bases, such as the Bureau of Reclamation or PROFS (see section 1.3.1). Once the data set is in a suitable format for the DMS plotting routines, many options for alternation of the display format are possible by requiring the user to write a specific preprocessor for each data type.

### 3.1.7 DI-3000 Graphics Package

DI-3000 is a device independent graphics package created and supported by Precision Visuals Inc. of Boulder, Colorado. The graphics package consists of an extensive set of Fortran callable subroutines that perform various graphics functions. Device independence allows for the output of a graphics routine to more than one graphics device without the need to alter the routine.

DI-3000 is divided into three levels of capabilities: A, B, and C. This facility has acquired and supports levels A and B. Level A simply allows output to a graphics device while Level B allows both input and output to and from the device (the device must be interactive).

The graphics devices presently available on the VAX for use with DI-3000 are:

ADM5 Retrographics Terminal

- Interactive Capabilities
- Tektronix 4027 Emulation
- 640 x 480 Resolution

#### ZETA 8 Digital Pen Plotter

- Output Device Only
- Calcomp Type Primitives  
(transparent under DI-3000)
- Virtually Continuous Resolution

#### Line Printer (DEC LA-120 DECWRITER III)

- Output Device Only
- 60 x 132 Resolution
- Low Quality Economy Graphics

#### PVI DI-3000 Standard Metafile

- Output Device Only
- Graphics Recombination and Processing Capabilities
- "Off-Line" Graphics

The COMTAL Image Processing system will also be available in the future. For more information contact Mr. Naqvi(303/491-8363).

### 3.1.8 NCAR Graphics Package

NCAR graphics software will be supported by DMS in the future. These routines will utilize the DI-3000 graphics primitives and output graphics products to the devices mentioned in the previous section. The capabilities of the NCAR graphics software include routines for streamlins, contouring, and velocity displays.

### 3.1.9 VISSR Atmospheric Sounder (VAS)

The VAS, carried onboard the GOES satellites, is a radiometer with 8 visible channel detectors and 6 thermal detectors that detect infrared radiation in 12 spectral bands. A filter wheel in front of the detector is used to achieve the spectral selection. The spatial resolution is



0.9 kilometer in the visible and 7 or 14 kilometers in the infrared depending on the detector used. Full earth-disk coverage is accomplished by spinning in the west to east direction at 100 RPM and by stepping a scan mirror from north to south. Additional VAS instrument characteristics are summerized in the following table.

Spectral Channel	Central Wavelength ( $\mu\text{m}$ )	Central Wavenumber ( $\text{cm}^{-1}$ )	Weighting Function Peak (mb)	Absorbing Constituent	Typical Spin Budget*
1	14.7	678	70	$\text{CO}_2$	2
2	14.5	691	125	$\text{CO}_2$	4
3	14.3	699	200	$\text{CO}_2$	7
4	14.0	713	500	$\text{CO}_2$	7
5	13.3	750	920	$\text{CO}_2$	4
6	4.5	2209	850	$\text{CO}_2$	7
7	12.7	787	surface	$\text{H}_2\text{O}$	3
8	11.2	892	surface	window	1
9	7.3	1370	600	$\text{H}_2\text{O}$	9
10	6.8	1467	400	$\text{H}_2\text{O}$	2
11	4.4	2254	300	$\text{CO}_2$	7
12	3.9	2540	surface	window	1

\*Number of spins sensed by the same detector with filter and mirror positions fixed.

The VAS has three operating modes: the operational VISSR mode, the mutispectral imaging (MSI) mode, and the dwell sounding (DS) mode. The operational VISSR mode is used by NOAA/NESS for its operational products, which include a visible picture and an 11-micrometer infrared (channel 8) picture at half-hour intervals. The other modes are VAS unique. The MSI mode combines the operational VISSR capability (visible plus infrared window) with two additional spectral channels to provide half hourly full earth disk imagery of atmospheric water vapor, temperature, and cloud distribution. The DS mode is used primarily for sounding to obtain the temperature and moisture profiles. In this mode, multiple spins on the same scan line in a given spectral band are averaged to obtain the required signal-to-noise ratio for sounding.

### 3.1.9.1 DRSES Support For VAS -

The frame synchronizer/sectorizer (see figure 1) operates on the incoming raw image data stream and allows the operator to select and collect only the desired part of the full disk image (see figure 6). A new frame synchronizer/sectorizer was designed and built to collect VAS image data (Plomondon 82; Plomondon, Cipriani 82). This was necessary because the existing frame synchronizer/sectorizer can process only VISSR image data (the old frame synchronizer/sectorizer was built to process only VISSR image data). At present the new frame synchronizer/sectorizer can process VISSR image data as before and is being debugged for VAS image data processing. The VAS/VISSR frame/sectorizer will be able to collect a full resolution image of interlaced image data (VAS/VISSR) to tape. Disk routine necessary to store these VAS/VISSR data will be written after the sectorizing routines are finished. The end result will be a VAS tape/disk file which will resemble the present VISSR tape/disk file.

### 3.1.9.2 IRIS Support For VAS -

Support of VAS data similar to what can be done with VISSR data (e.g. image display and navigation) is underway. Temperature retrieval software acquired from the University of Wisconsin is working on the VAX 11/780. This software is documented and available from Mr. Robert Green (303/491-8446). Navigation of VAS data is described in a CIRA publication (Saufley, 1982).



## APPENDIX A

### ASSOCIATED RESEARCH EQUIPMENT

#### Suomi Sony Video Cassettes Archive System and the ODIS

VISSR image data can also be output to a high density data archiving device designed by the Space Science and Engineering Center (SSEC) at the University of Wisconsin. The unit is based on a modified video tape recorder with storage medium being video cassettes. All data received by the antenna is recorded (full-disk and .5 mile visible) with one cassette holding about four hours of data. The cassettes may be played back through the DRSES sectorizers as if the data stream were from the antenna or the cassettes may be read on an Offline Data Ingest System (ODIS), also designed by SSEC, which produces computer compatible nine-track magnetic tapes with user-specified sectors of full images. This record/playback system allows great flexibility for short-term projects since all data over a span of a few hours to a few days may be economically recorded and, after the fact, processed for only those images specifically needed. Also, it provides for an archive backup to the rest of the DRSES in case of equipment failure. Procedures for operating the cassette archive system are located with the system as is the procedural manual for the ODIS. Procedures to input ODIS tapes into IRIS are documented within DMS (see section 2.1.1).

#### A.0.1 Time Lapse Video Tape Recorder And Camera System.

This system consists of a Panasonic Time Lapse Video Tape Recorder (NV-8030), a Panasonic Black and White Camera (WV-1350), a Time-Date Generator (WI-800), and a small black and white television monitor. The video recorder uses 0.5 inch open reel video tape and records in only black and white. Time recording speeds permit real-time recording at 30 video frames per second down to 1 frame every 2 seconds (at normal playback speed this amounts to about 120 x time compression). A full reel of tape will hold about 120 hours of data.

The camera has a Newvicon tube which has greater sensitivity than a standard Vidicon tube, has less of a tendency to "burn-in" on a stationary scene and has a peak sensitivity close to the near-infrared region which provides greater definition of cloud structures. Two lenses are available -- a 65° and a 95° angular field of view. The Time/Data Generator provides a signal which imbeds a time/data annotation into the video signal before being recorded. This means each video frame is documented to the nearest second. For more information contact Mr. Green (303/491-8446).

#### A.0.2 Laser Videodisk Player (Pioneer PR-8210)

A laser disk player which can "play" laser disk recordings is available for departmental use. A disk of over 20,000 images of PROFS products from 1982 is available. For more information contact Mr. Robert Green (303/491-8446).



## APPENDIX B

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