METSAT, INC.

Specializing in METeorological SATellite Systems and Related Computer Technology

NASA-CR-195481

ANNUAL REPORT

NASA CONTRACT - NASW-4715

for

"Production of Long-Term Global Water Vapor and Liquid Water Data Set Using Ultra-Fast Methods to Assimilate Multi-Satellite and Radiosonde Observations"

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July 1, 1993

Approved By

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1.0   INTRODUCTION

This is the first annual report for Contract #NASW-4715, entitled "Production of Long-term Global Water Vapor and Liquid Water Data Set Using Ultra-fast Methods to Assimilate Multi-Satellite and Radiosonde Observations". Included is a brief review of the problem, as well as our plan for producing these new products, and a progress report for work completed.

The development of a complete and accurate global water vapor data set is critical to the adequate understanding of the Earth's climate system. Examples of climate research which are dependent on accurate water budget data include, but are not limited to: poleward energy transport research, general circulation model (GCM) verification, and global change baseline measurements. During the next decade, many programs and experiments under the Global Energy and Water Cycle Experiment (GEWEX) [WCRP, 1990] will utilize present day and future data sets to improve our understanding of the role of moisture in climate, and its interaction with other variables such as clouds and radiation. An important element of GEWEX will be the GEWEX Water Vapor Project (GVaP), which will eventually initiate a routine, real-time assimilation of the highest quality, global water vapor data sets including information gained from future data collection systems, both ground and space based.

The comprehensive global water vapor data set being produced by METSAT Inc. uses a combination of ground-based radiosonde data, and infrared and microwave

microwave satellite retrievals. This data is needed to provide the desired foundation

from which future GEWEX-related research, such as GVaP, can build.

2.0   BACKGROUND - Global Water Vapor Database

The need for improved knowledge of the global water vapor distribution are well documented. The majority of large-scale water vapor climatological studies have, to date, relied wholly upon analysis of radiosonde data [Bannon and Steele, 1960, and Oort, 1983]. Data collected at each site may not be representative of the surrounding atmospheric conditions as significant humidity gradients exist between the limited resolution of stations. Analyses of such data sets tend to smooth out mesoscale gradients, which are important to the cloudiness, precipitation, and the radiation balance fields. Data gaps over the oceans and even some land areas limit the extent with which inferences may be made about the nature of the global water vapor distribution. Additional data sources, such as infrared and microwave satellite data sets, can greatly enhance the global coverage on a daily basis.

To satisfy these needs, *STC*-METSAT is producing a pre-GVaP, five year global water vapor data set for use by the scientific research community using the best available existing satellite and *in-situ* data.

3.0 YEAR ONE PLAN

The first year of this project was designed to use a combination of the best available atmospheric moisture data including: radiosonde (balloon/acft/rocket), HIRS/MSU (TOVS) retrievals, and SSM/I retrievals, to produce a one-year, global, high resolution data set of integrated column water vapor (precipitable water) with a horizontal resolution of 1 degree, and a temporal resolution of one day. The time period of this "pilot" product was to be determined by the availability of all of the input data sets. January 1988 through December 1988 were selected. In addition, a sample of vertically integrated liquid water content (LWC) was to be produced with the same temporal and spatial parameters. This sample was to be produced over ocean areas only. An outline of the main processing tasks and data sets is given in Figure 1.

Three main steps are followed to produce a merged water vapor and liquid water product. Input data from Radiosondes, TOVS and SSMI/I is quality checked in steps one and two. Processing is done in step 2 to generate individual total column water vapor and liquid water data sets. The third step, and final processing task, involves merging the individual output products to produce the integrated water vapor product. A final quality control is applied to the merged data sets.

Production of Hybrid Global Daily Integrated Water Vapor and Liquid Water Data for a Multiyear Period
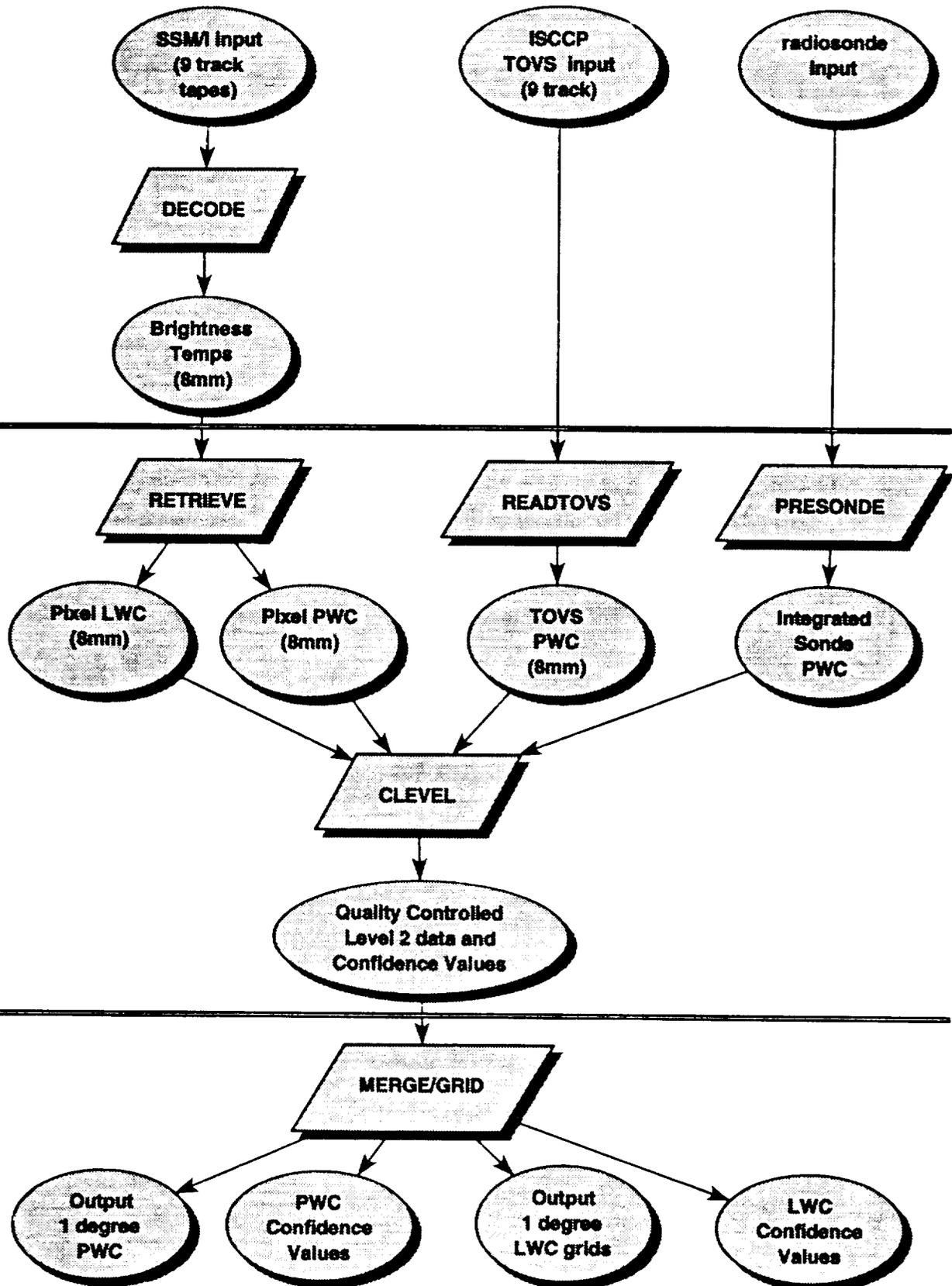

Figure 1: Outline of Main Processing Tasks and Data Sets

4.0   EQUIPMENT

A limited amount of equipment was purchased for the initial year. The plan was to use our existing equipment, with some modifications, to produce the pilot data set while examining possible techiques for improving the efficiency and increasing the throughput of data.

We found that the speed at which these large data sets can be read, processed, and stored is greatly dependent upon the equipment. Our year two plan includes a request for an equipment upgrade that will significantly increase the amount of data we can process during that year.

We have purchased and installed a 1.1 Gb disk drive and an 8mm tape drive. The 1.1 Gb disk drive is for storage of both input data sets (TOVS, Rawinsonde), and the output liquid water (LWC)/water vapor (PWC) product images during processing. The 8 mm tape drive is for the initial input of SSM/I data sets, and the archival of the PWC and LWC product image sets.

In addition, we now use a high-speed data line to allow us to access Internet for the transfer of ancillary data sets. We installed the operating system upgrade/license to allow us to install the tape drive on our HP workstation, and to mount the 1.1 Gb drive on the local area network. This enables us to read in data from 9-track tape, optical r/w drive, or 8mm tape drive, directly to the shareable disk. We also installed a networking software package (TVG) that allows us to access the data drive from both the HP and the VAX workstations. So far we are very pleased with the TVG networking

package and believe it has saved us at least 30% of the time that would normally be

spent in file transfer operations.

5.0   DATA PROCESSING

During the first year, our efforts have focused on the development and
modification of the software systems used for accessing, gridding, quality controlling
and merging of the three data sets. An outline of the work on each of the data sets and
some products are listed below.

SSM/I

The SSM/I data set required the most work in software and processing.
One of the first tasks was to convert the SSM/I processing code from FORTRAN to C.
This allows us to run the "DECODE" and "RETRIEVE" programs on the HP workstation
(our fastest machine, and one that is networked to two single-board processors). The
Decode module reads and processes the raw SSM/I antenna temperatures and
produces brightness temperatures, along with decoding and transferring necessary
information from the raw image header to the "processed" header. The Retrieve
module performs the retrieval of cloud liquid water (LWC) and Water Vapor (PWC)
which is stored for merging with the TOVS and Radiosonde retrievals. We modified the
routines to read and process an entire month of data from the archive tapes, then
tested the C versions against the original code.

With the code transported to our system, several modification were made
to the land/sea mask, ice detection, and gridding modules of the SSM/I retrieval
program. The original retrievals exhibited excessive contamination. The land mask was
improved to a 1° resolution and a separate module was written to account for land/sea

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boundary "contamination" in the retrieval. The ice detection module was modified to include a higher resolution database (Reynold's), and the gridding module was modified to streamline the gridding process.

Another improvement was the addition of a new module to the SSM/I retrieval algorithm to account for bad orbital times. A secondary data file with corrections and time flags is read in during the processing and adjustments are made to account for the errors. This data is not stored with the original data tapes, but is supplied as a separate data field. The corrections have been tested and verified and will be implemented in the Version 1 processing phase.

With the modifications to the code, and the use of the more efficient processor, we have cut the original processing time for one month of data from 4 days to 42 hours. A detailed description of the SSM/I processing can be found in Appendix B (NVAP Users Manual).

TOVS

The TOVS data set has required the least amount of work. Input routines were written to parse the PWC fields from the archive data tapes and reformat and grid the TOVS fields to a 1° resolution. One modification significant to our original plan has been to include the GFDL climatology that is available for polar regions. This is a sparse data set, however it provides us with valuable data points in the polar regions. Figure 2 shows the TOVS "pre-merge" processing diagram.
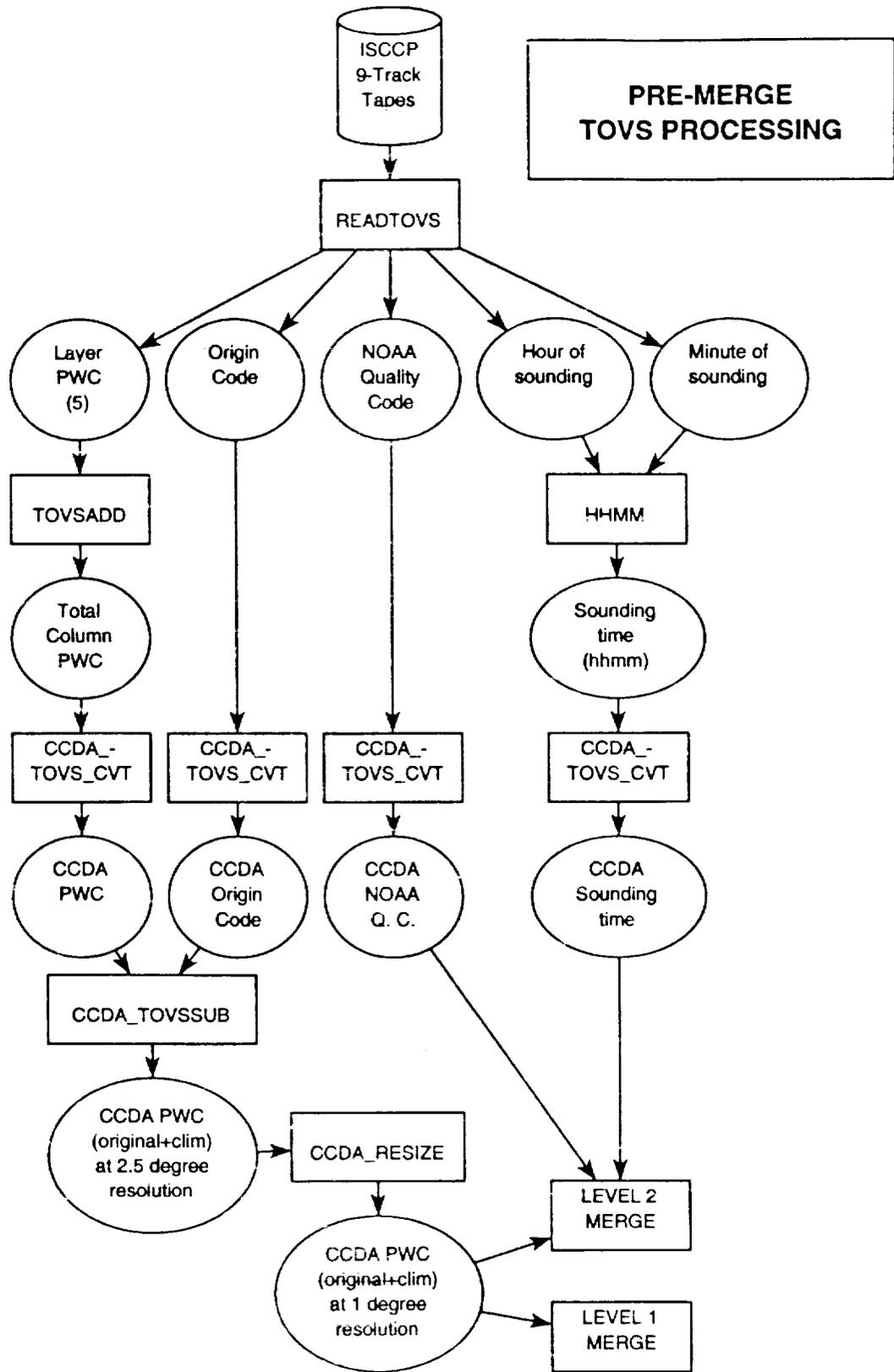
Figure 2: TOVS Pre-Merge Processing Diagram

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RAWINSONDE

The rawinsonde data required software development to read and process

raw sounding data from the ETAC tapes and process it into PWC grids (see

Figures 3-5). Since the data set had only limited quality control, we were required to

produce a set of criteria to be used in filtering the data during the PWC retrievals.

RAWINSONDE PROCESSING

Raw Data Tape to Year Files: (see Figure 3)

```
                          ┌ ─ ─ ─ ─ ─ ┐
                          │ MOUNT TAPE │
                          └ ─ ─ ─ ─ ─ ┘
                                │
      ┌─────────────────────────▼─────────────────────────┐
  ┌──▶│          READ SOUNDINGS FROM 9-TRACK              │◀──┐
  │   └──────────────────────────┬────────────────────────┘   │
  │                              │                             │
  │                          ╱   ▼   ╲                         │
  │                        ╱   PASS    ╲          NO           │
  │                      ◀╱      QC      ╲────────────────────▶│
  │                        ╲   CHECKS?  ╱
  │                          ╲   │   ╱
  │                              │ YES
  │                    ┌ ─ ─ ─ ─ ▼ ─ ─ ─ ┐
  │                    │  CALCULATE PWC   │
  │                    └ ─ ─ ─ ─│─ ─ ─ ─ ┘
  │                              │
  │                    ┌─────────▼────────┐
  │                    │ WRITE TO YEAR FILE │
  │                    └─────────┬────────┘
  │                              │
  │              NO          ╱   ▼   ╲
  └─────────────────────────◀  END OF  ╲
                              ╲  TAPE? ╱
                                ╲  │  ╱
                                   │ YES
                               ┌ ─ ▼ ─ ┐
                               │ END │
                               └ ─ ─ ┘
```

Figure 3:

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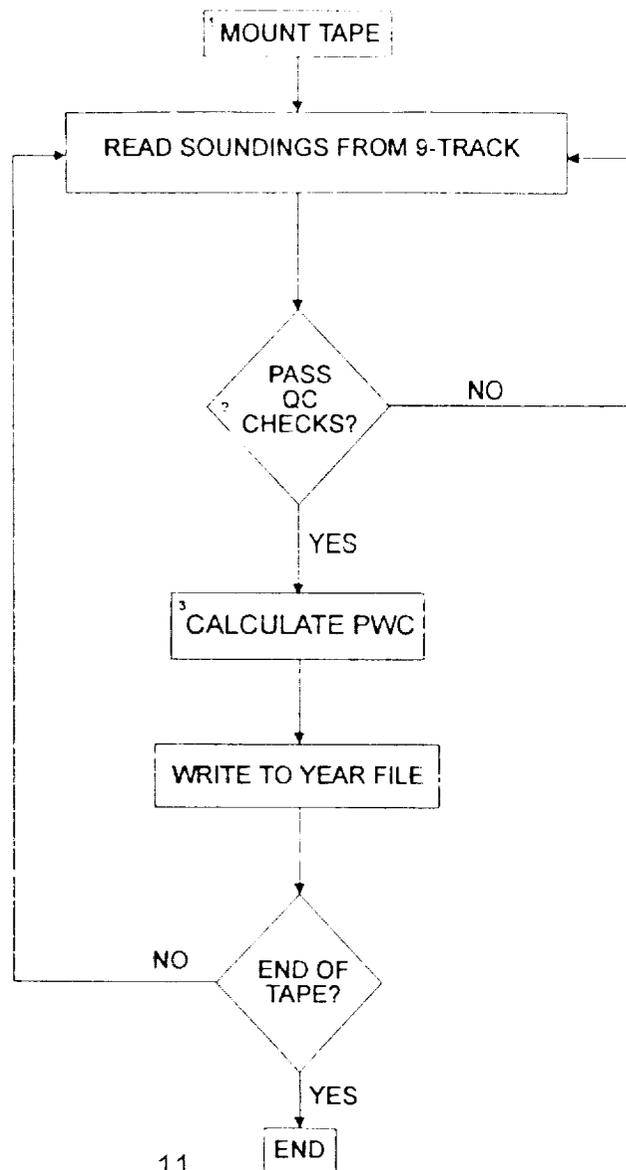
1. Each Raw rawinsonde tape contains a year's worth for a given section of the earth. It takes eight 9-track tapes to cover the globe.

2. Quality control checks include:

   a) Date and time

   b) Temperature and dewpoint checks for each level

      1) Both are above -100°C

      2) Dewpoint is less than or equal to Temperature

3. Calculate PWC by first calculating mixing ratio for each level of sounding, then use the equation:

$$PWC = \frac{1}{g}\int_{P2}^{P1} r\,dP$$ where: r = mixing ratio

   g = acceleration of gravity

   P = pressure

<u>For Each Month</u>:

Step 1: Parse individual monthly data files from "Year tapes". There are 8 tapes for each year, with each month spread across each of the 8 tapes. The data is stored by WMO region vs. by data. (see Figure 4)

Figure 4:

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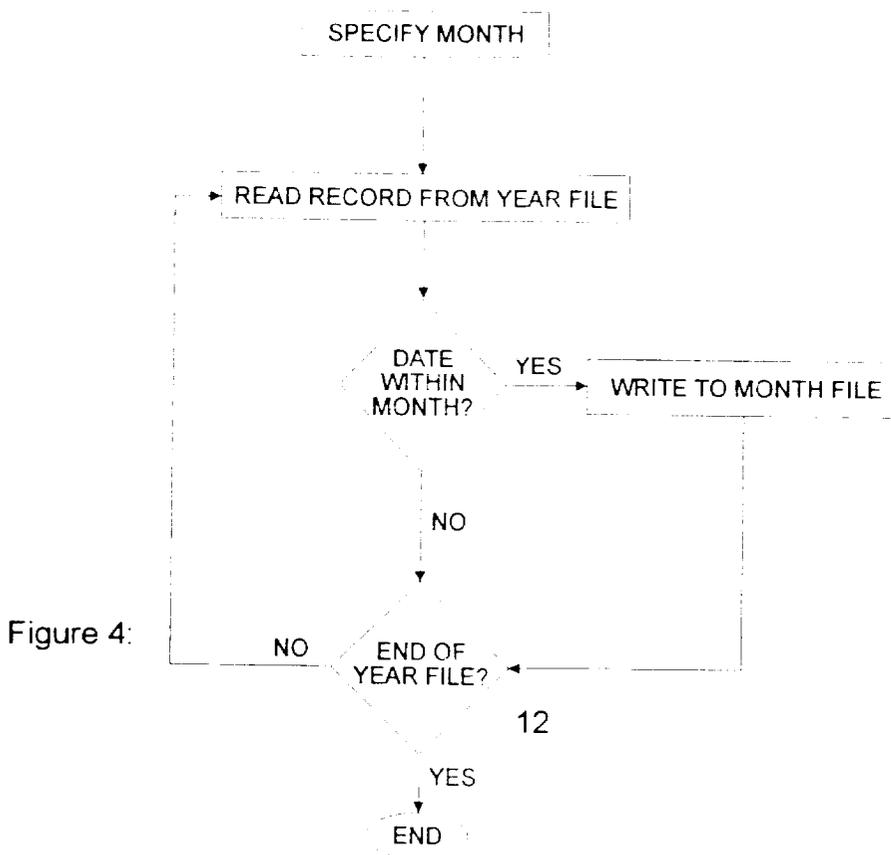
Step 2: Append eight month files together

Step 3: Process month files to produce the PWC gridded files for the merge
processor. (see Figure 5)
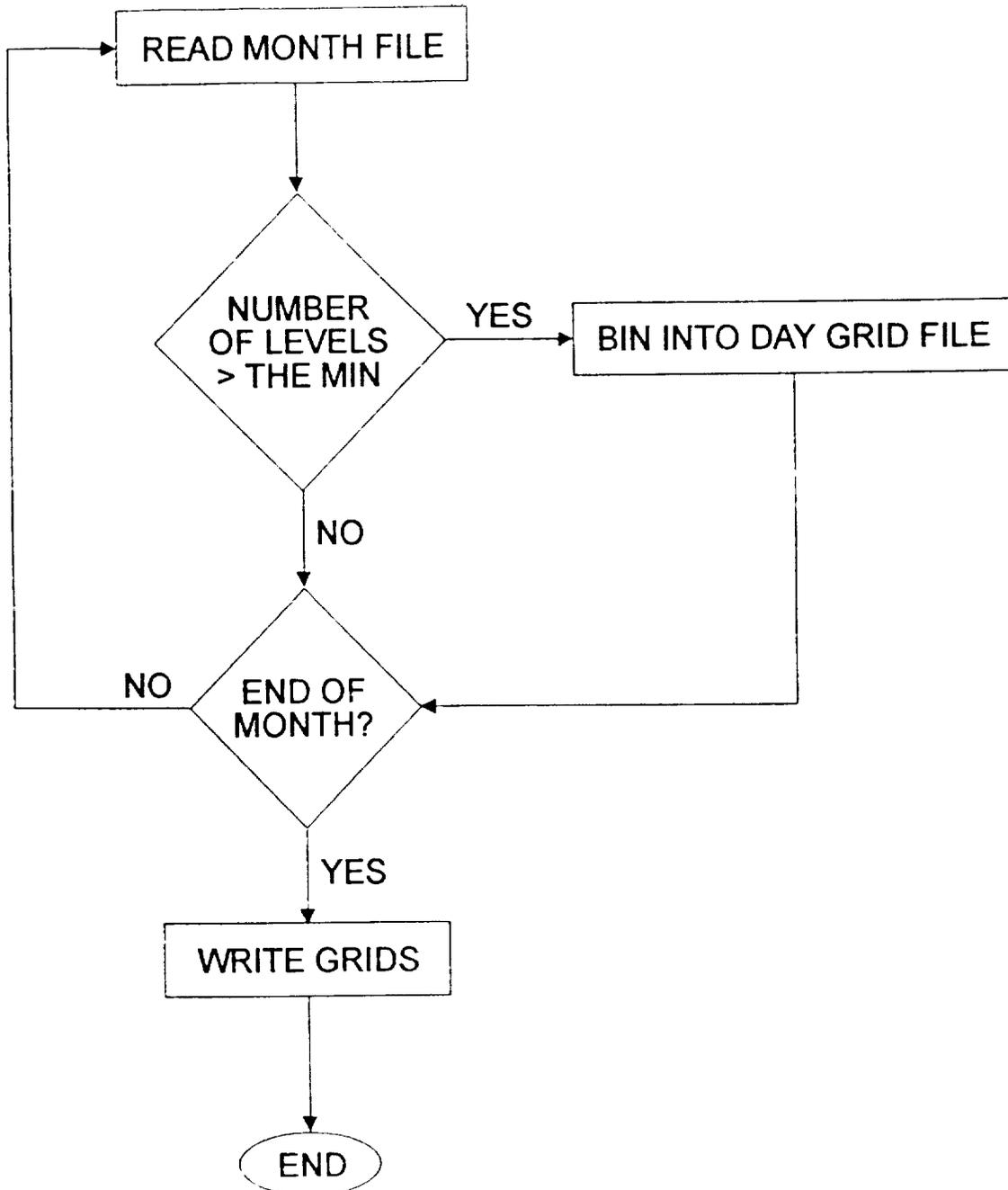
Figure 5:

We have run a number of analyses to determine both the expected error and the optimum temperature/pressure thresholds for PWC computation. The findings were in general agreement with our initial assumption that using a cutoff of 300 mb and/or a temperature of -25 degrees will not induce more than a 1% error, on a global average, in the PWC retrievals vs. taking the sounding to the highest available level (see Appendix D). This will allow us to standardize the sounding retrieval processor and to have a point of comparison between stations. The highest level will be stored in the output data set so the actual error can be calculated. When compared to the uncertainties of the satellite data sets, the rawinsonde errors are quite small.

MERGE/GRID

The "MERGE/GRID" module has been written to produce a pilot (Version 1) product. We create the initial product by combining all three of the main input data sets, using a hierarchical weighting scheme. This "merging" of the data is the only part of the processing we expect to evolve in time. The first year of merged products was created using the Version 1 merge scheme. This algorithm uses the radiosonde, when available, as truth and then applies a weighting scheme to the TOVS and SSM/I. Finally linear interpolation routines are run to fill missing data points. The final products from the Version 1 processing are: complete global fields of LWC over the oceans from SSM/I, the merged PWC from TOVS, SSM/I, and radiosonde, and a data source map which is ordered by estimated data error in the merged field.

CLEVEL

We have completed preliminary work on a module called "CLEVEL". This module produces a "confidence level" image, representing a percentage confidence level determined by the data source flag. Figure A-6 (see Appendix A) shows a sample of a CLEVEL output image with numbers representing, in order of lowest to highest confidence.

1. Missing Data
2. Interpolated and Filled
3. TOVS Monthly Climatology
4. TOVS only
5. SSM/I interpolated
6. SSM/I interpolated/TOVS combination
7. SSM/I only
8. TOVS/SSM/I combination
9. Radiosondes

6.0 YEAR ONE RESULTS

We have processed the entire 1988 data set. Examples of the Version 1 products can be found in Appendix B and on a video tape that is included with this report. (Attachment 1, videotape of 365 daily PWC fields, and monthly averages)

Some comments:

1)   Each of the individual input data sets has significant limitations; radiosonde measurements are made primarily over land, global humidity analysis fields from national forecast centers are highly model dependent, infrared satellite techniques only work in absence of significant cloud cover, and microwave retrievals are presently feasible only over oceans. A comprehensive global data set must draw upon the strengths of each of these methods, and use the advantages of each for all meteorological and geographical scenarios. The result is a combined effort far better than any one single input data set.

2)   It was necessary to do more manual quality control than we originally anticipated.

3)   A modest investment in additional equipment will make a dramatic improvement in the SSM/I processing (see Section 8.0, Equipment).

7.0 PAPERS AND PRESENTATIONS

In the past year several presentations on the results of this work have been made. In November Dr. David Randel presented a paper to the International Symposium on Spectral Sensing Research (ISSSR). "Combining Multi-Satellite Measurements with Different Spatial and Temporal Resolutions into a New High Resolution Water Vapor Data Product" by Randel, et al. describes the production of our Version 1 product.

In January, Dr. Thomas H. Vonder Haar presented "A New High-Resolution Water Vapor Data Product for Global Climate Studies" at the 1993 American Meterorological Society Conference on Climate and Global Change. Copies of the significant new results were provided at that meeting to Dr. James Dodge of NASA. In early February, the early results and methods were also presented to the GEWEX Science Steering Group and the Joint Scientific Committee and the WGRF of the World Climate Research Program (by Dr. Thomas Vonder Haar) and to the Climate Research Committee of the U.S National Academy of Science (by Dr. Graeme Stephens). On each occasion the early water vapor data set results were well-received by the scientific groups.

8.0   YEAR TWO WORK PLAN

Version 2

The Version 2 merge routine to be implemented in the following year is currently in development. This algorithm is based on the works of Oort and Rasmusson (1971) and Reynolds (1988) on merging different meteorological data sets. It will also use the radiosondes to anchor the TOVS and SSM/I to a truth field but will do it by weighting the values away from the radiosonde point. This has been shown in the literature to accurately combine observations from quite different observing systems into a smooth and defendable solution. Also in the Version 2 scheme will be a matching of the closest radiosonde time to the TOVS sounding, and a complete error estimate map based mainly on the data type and geographical location.

Specifically in Year 2 we will:

1)   Process and quality control the remaining data sets for the last 4 years (January 1989 - December 1992).

2)   Produce a Version 2 merge product for the 5 year period.

3)   Produce a sample, layered PWC merge product.

4)   Produce a Version 2 "Quality Index" product.

5)   Produce a 5-year cloud liquid water product from SSM/I.

6)   Examine the use of "over-land" algorithms for LWC retrievals from SSM/I.

Equipment

With the algorithms now in place to move into a "production" phase, we are examining the acquisition of a more powerful CPU. We are currently running the bulk of our retrievals, gridding, and product generation on an HP 900-360 series computer. It has a "speed" rating of about 2.5 units. The standard today is much closer to 40 units for a cost of approximately $12,000. When we begin the task of processing the remaining four years worth of data, a faster unit would cut the computer run time significantly. A normal run of SSM/I, for example, would be cut from two days (42 hours) to about 4 hours (the time difference is not a direct function of the speed differential because the I/O time does not improveas significantly by using a faster processor). In addition to being able to cut the total time required for the processing of the data sets, it also has a significant impact on algorithm development and modification. For example, if we run through a month of data and the process fails after 30 hours of run time, we have to troubleshoot, correct the problem, and then run the job for another 30 hours to see if we can get past the original problem. This is the one area we feel would make a significant impact on the efficiency of our data processing plan.

As we discuss, our second year budget with NASA (to begin in early July, 1993), we will request that some small adjustments be made in several other budget categories so the new workstation can be accommodated without increasing the total cost presently planned for Year 2.

9.0　REFERENCES

Bannon, J.K. and L.P. Steele, 1960: Average Water Vapor Content of the Air. Geophysical Memoir No. 102, British Met. Office, London.

Oort, A.H., 1983: Global Atmospheric Circulation Statistics, 1958-1973 NOAA professional paper No. 14, 180 pp. + microfiche.

Oort, A.H. and E.M. Rasmusson, 1971: Atmospheric Circulation Statistics. NOAA Professional Paper No. 5, Stock Number 0317-0045, 323 pp.

Reynolds, R.W., 1988: A Real-Time Global Sea Surface Temperature Analysis. J. of Climate, Vol. 1, p. 7.

APPENDIX A

Appendix A - SAMPLE IMAGES

Images   Page

Figure 1.

SSM/I ATMOSPHERIC WATER PRODUCTS
JULY 1, 1988
SSM/I WATER VAPOR W/LQW CORRECTION (mm)

Figure 2.   METSAT INC. (303) 221-5420
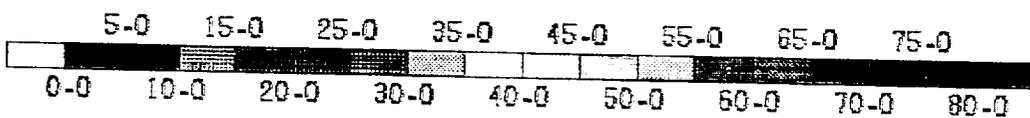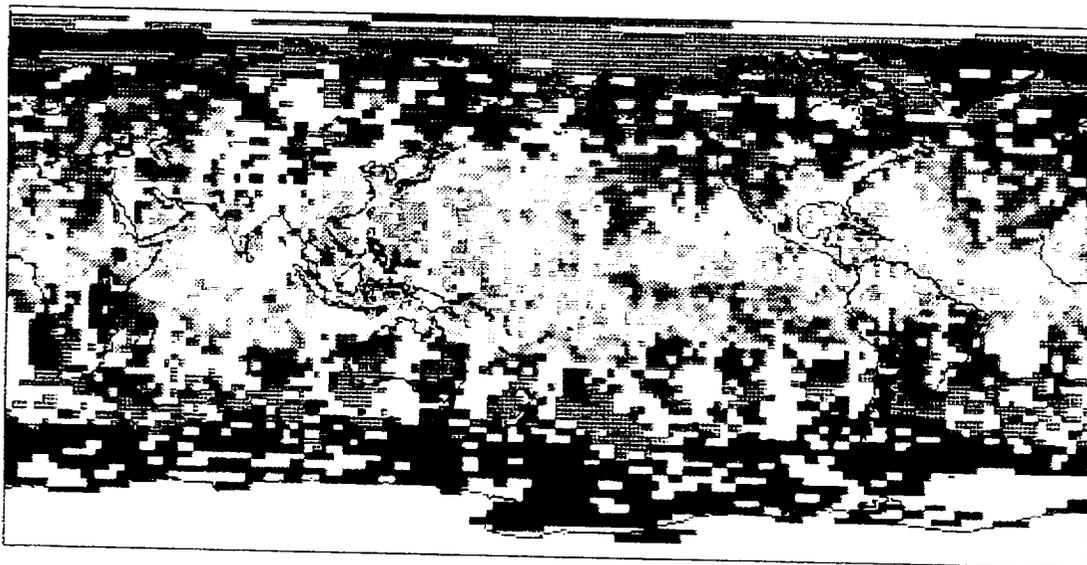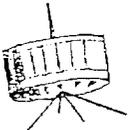
ISCCP TOVS WATER VAPOR
JULY 1, 1988
Total Water Vapor   (mm)

Figure 3.
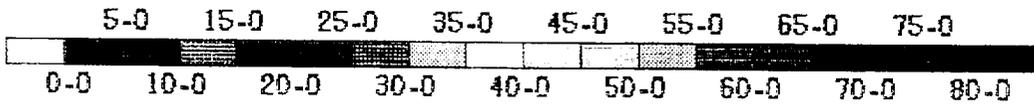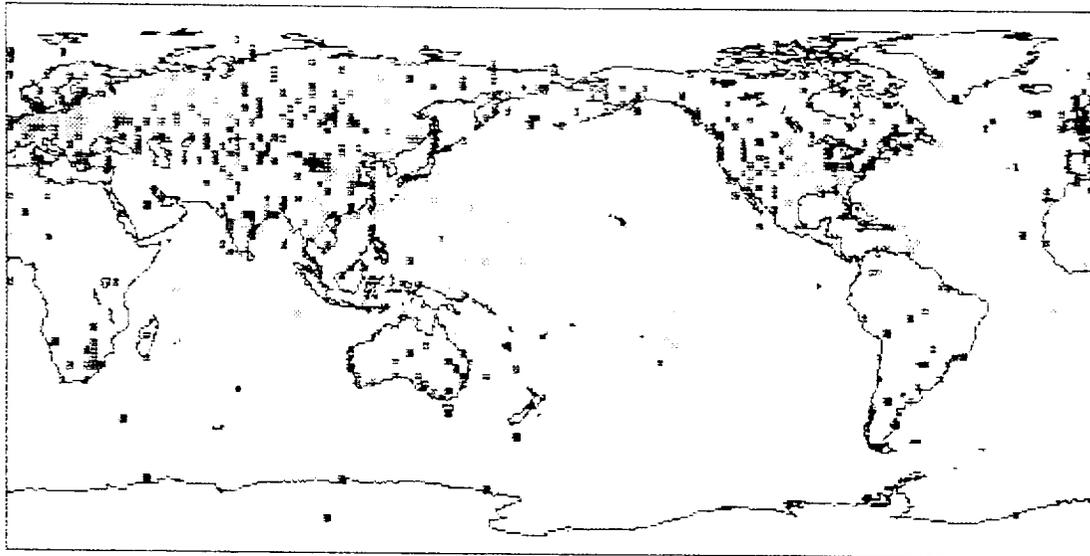
RAWINSONDE PRECIPITABLE WATER
JULY 1, 1988
Water Vapor - Rawinsondes (mm)

METSAT INC. (303) 221-5420
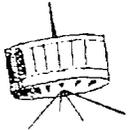
Figure 4.
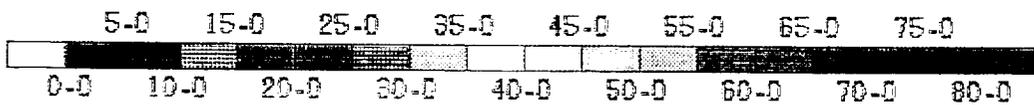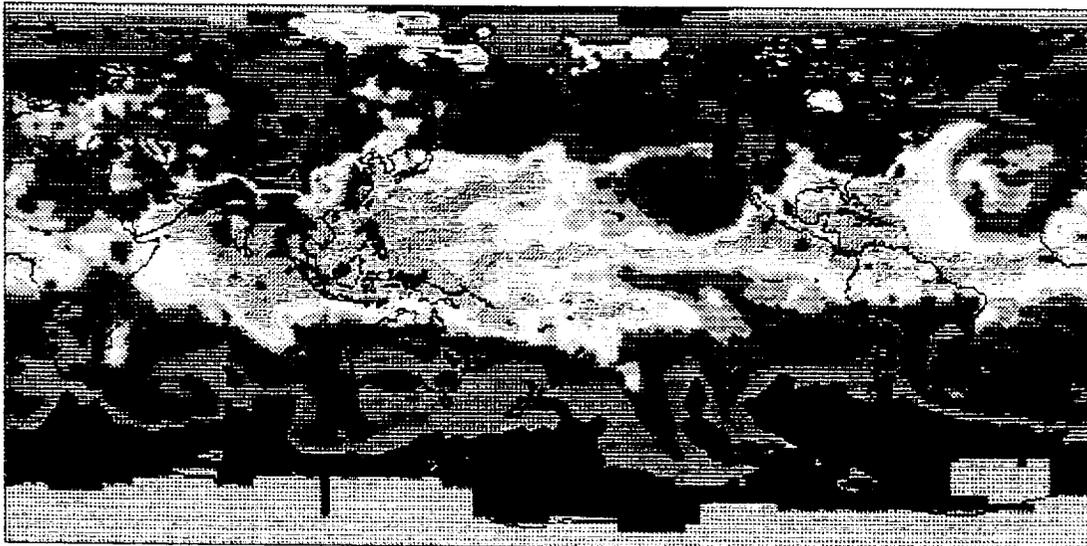
GLOBAL WATER VAPOR PRODUCT
TOVS : SSM/I : RAWINSONDE COMBINATION
JULY 1, 1988 Precipitable Water (mm)

A-2

Figure 5.

CIRA

0.2   0.4   0.6   0.8   1.0   1.2   1.4   1.6
0.1   0.3   0.5   0.7   0.9   1.1   1.3   1.5   1.7
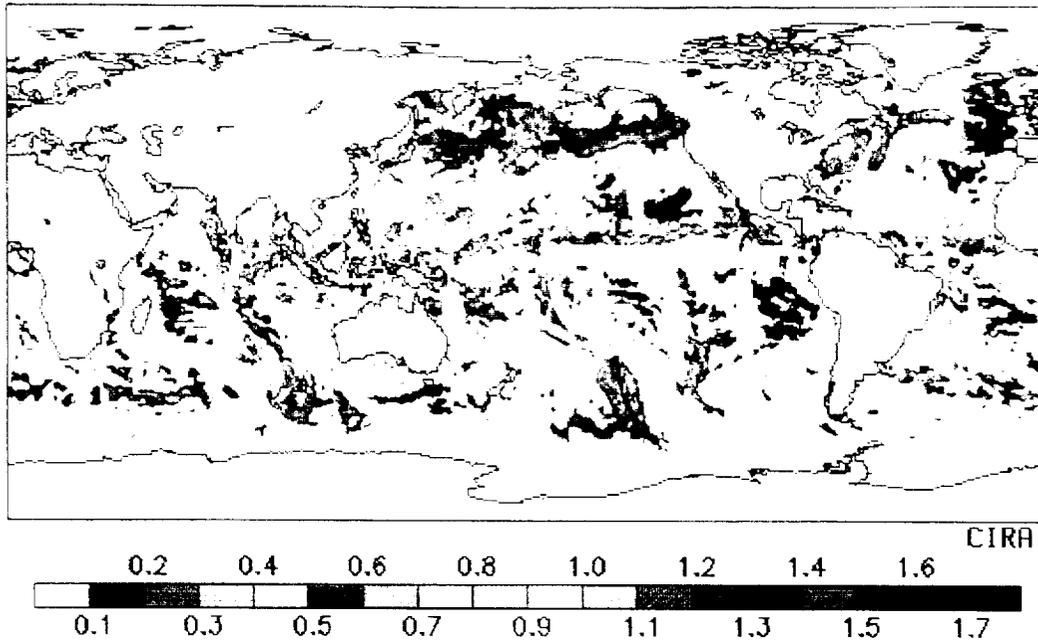
Total Integrated Cloud Liquid Water (mm)
July 1,1988
Figure 6.   From SSM/I Retrievals

CIRA

2.0   4.0   6.0   8.0
1.0   3.0   5.0   7.0
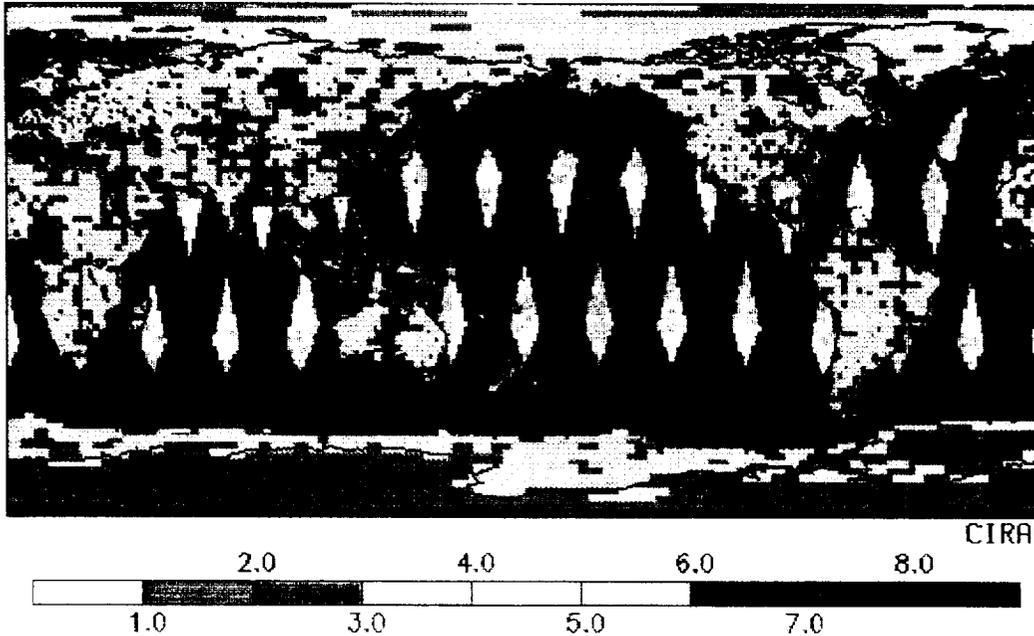
Data Source Code Information
Ordered by data Accuracy
Merge Version 1 for July 1,1988

Figure 7.

METSAT

```
      5.0      15.0      25.0      35.0      45.0      55.0      65.0      75.0
```

```
   0.0     10.0      20.0      30.0      40.0      50.0      60.0      70.0      80.0
```
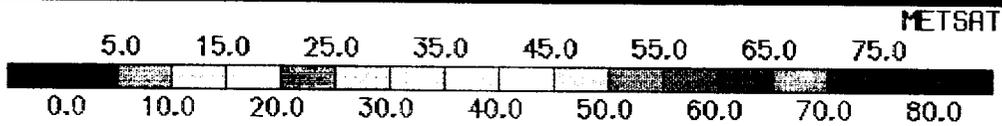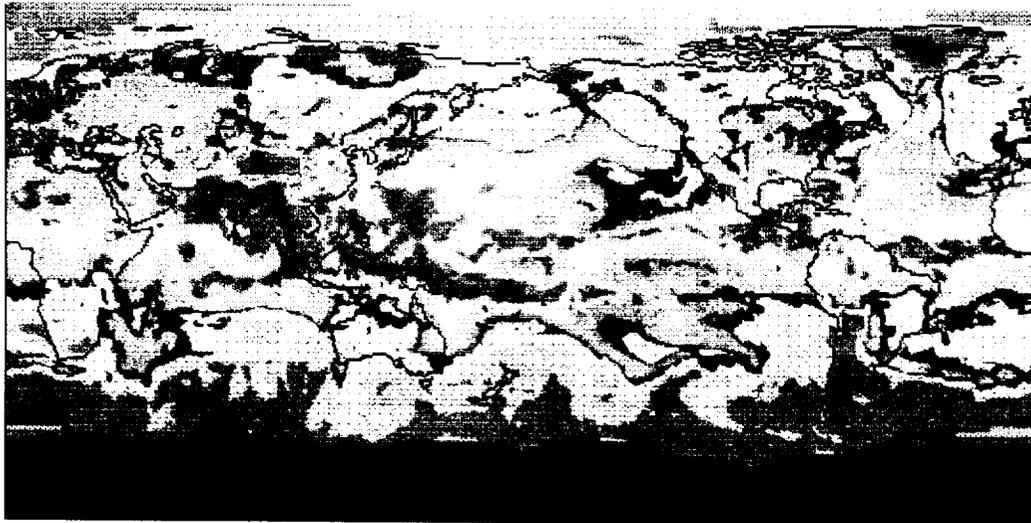
Version 1 Merge Precipitable Water (mm)
July 4, 1988

Figure 8.

METSAT

```
      5.0      15.0      25.0      35.0      45.0      55.0      65.0      75.0
```

```
   0.0     10.0      20.0      30.0      40.0      50.0      60.0      70.0      80.0
```
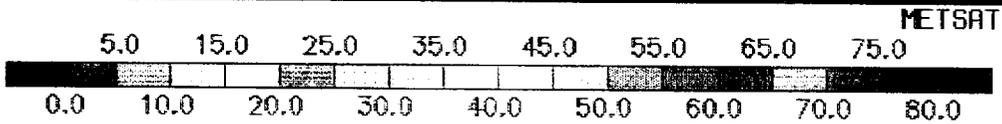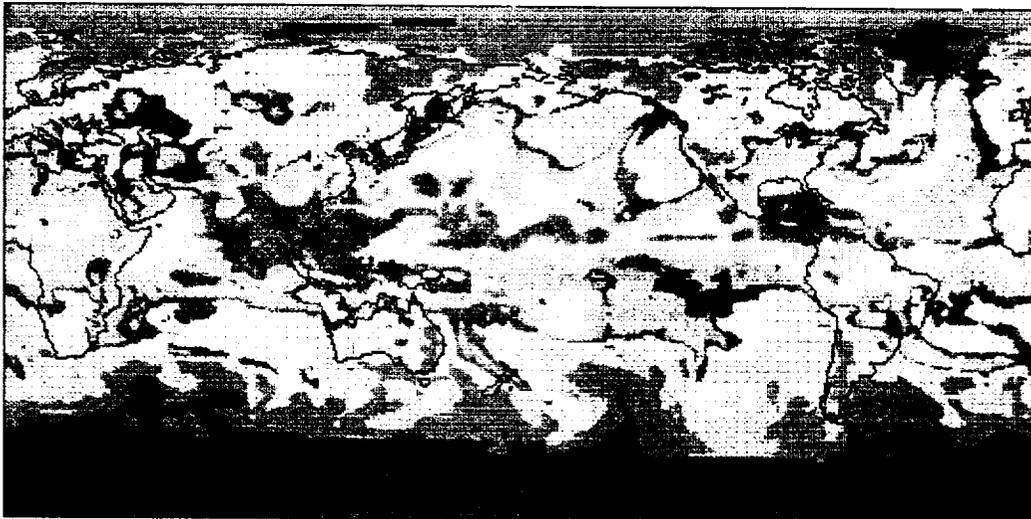
Version 1 Merge Precipitable Water (mm)
September 20, 1988

A-4

Figure 9.

Version 1 Merge Precipitable Water (mm)
January 1988

Figure 10.

Version 1 Merge Precipitable Water (mm)
February 1988

Figure 11.

Version 1 Merge Precipitable Water (mm)
March 1988

Figure 12.

Version 1 Merge Precipitable Water (mm)
April 1988
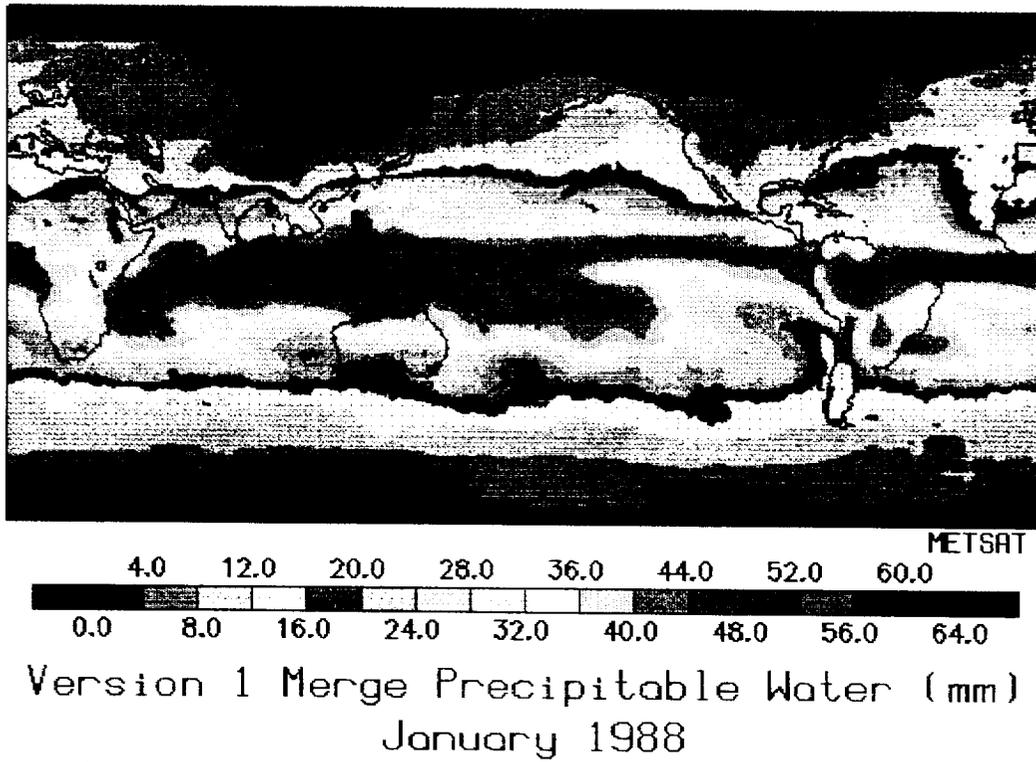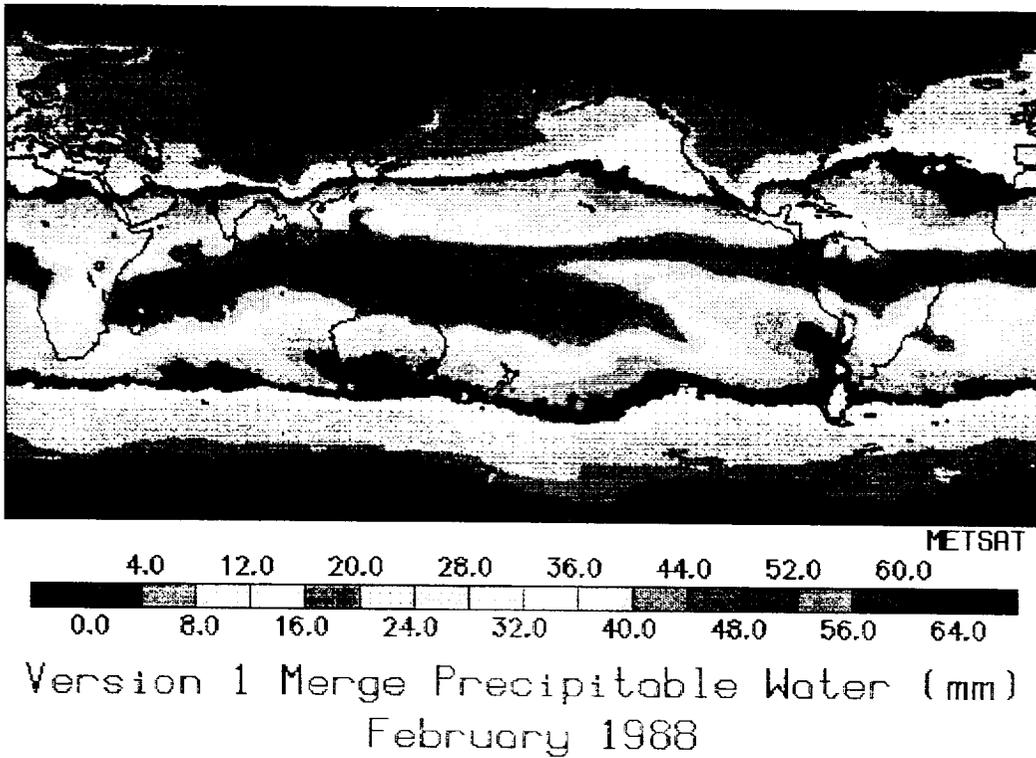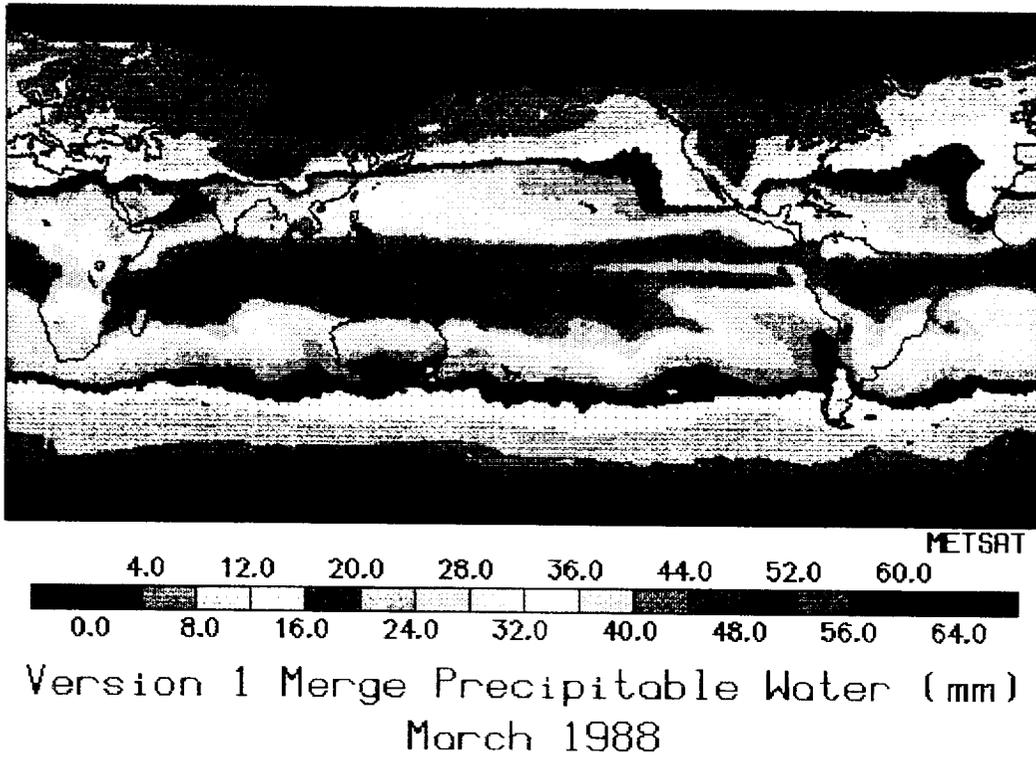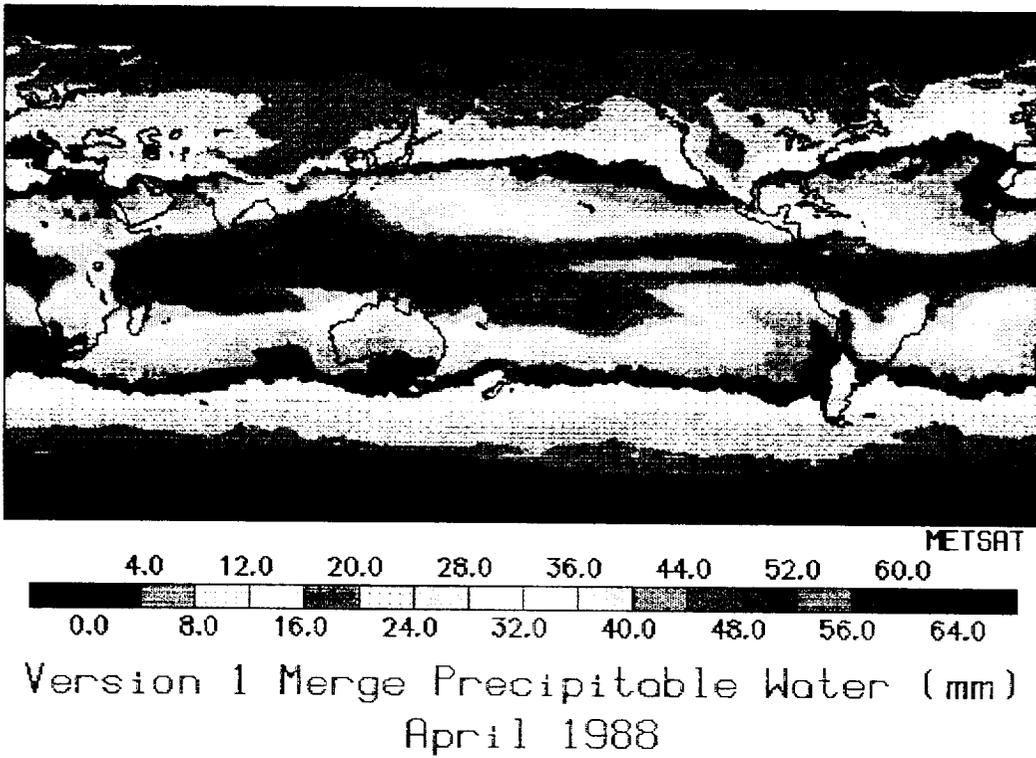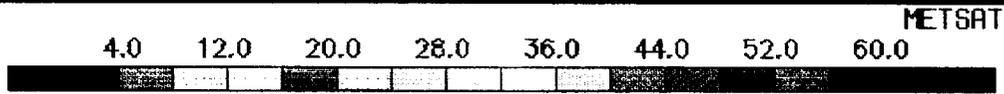
Figure 13.

Version 1 Merge Precipitable Water (mm)
May 1988

Figure 14.
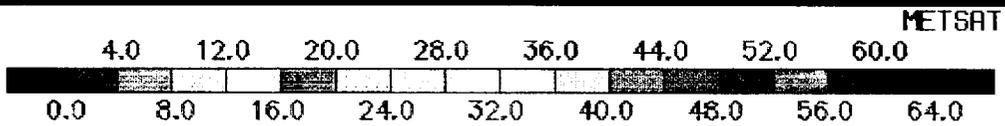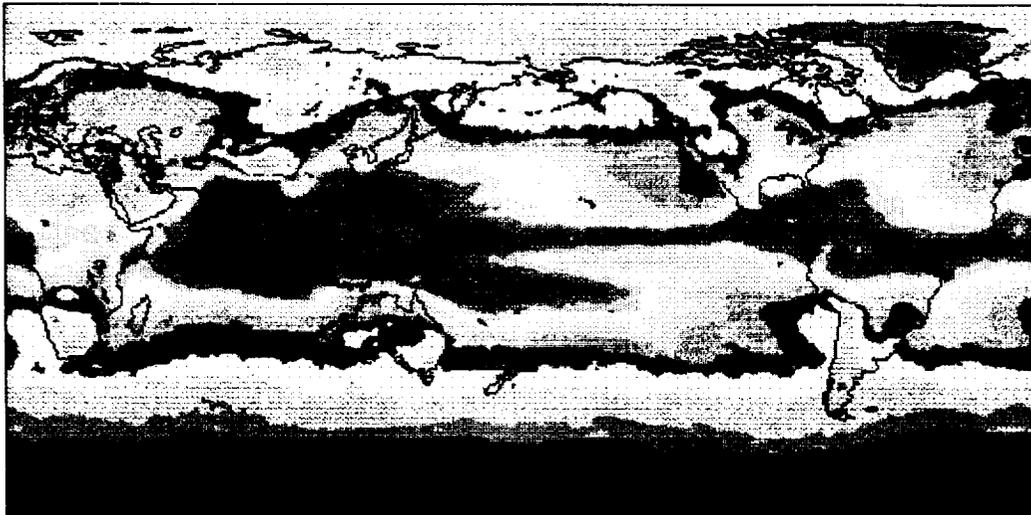
Version 1 Merge Precipitable Water (mm)
June 1988

Figure 15.
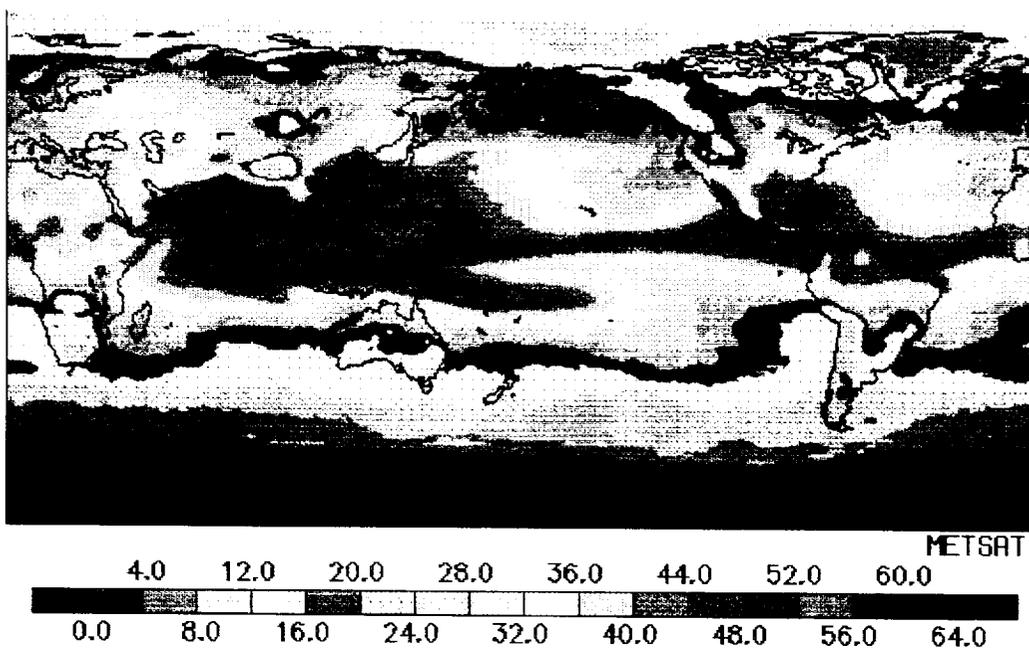
Version 1 Merge Precipitable Water (mm)
July 1988

Figure 16.
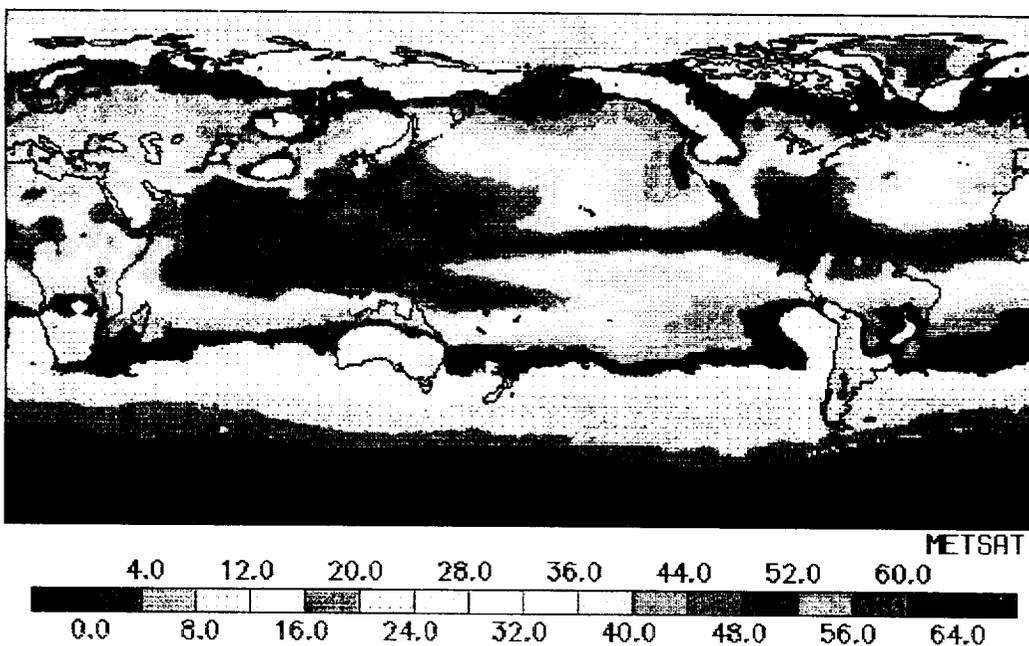
Version 1 Merge Precipitable Water (mm)
August 1988

Figure 17.
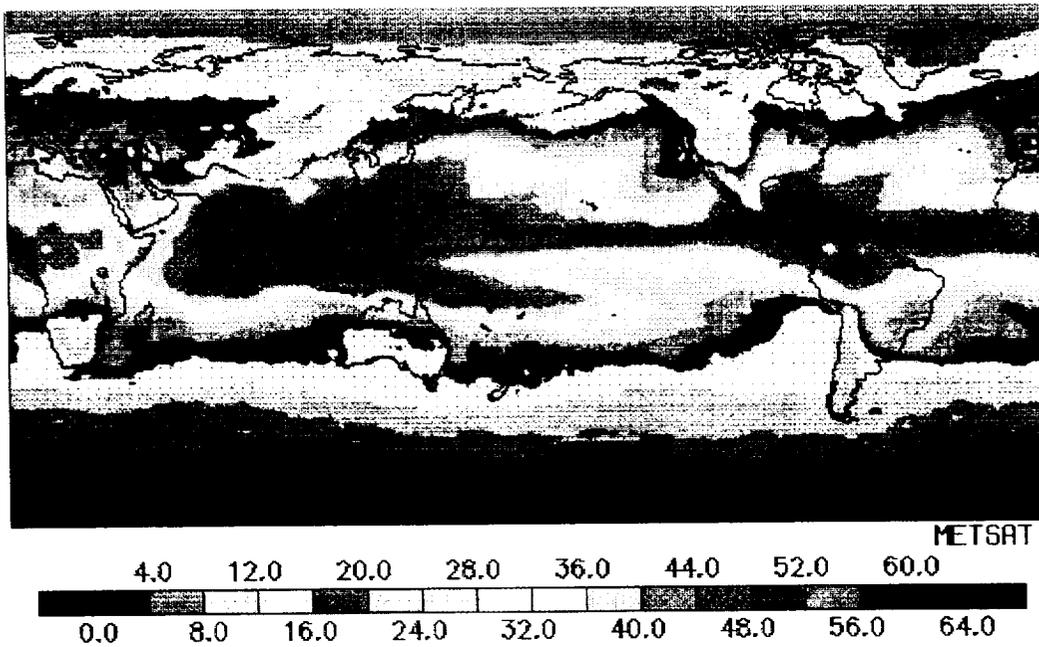
Version 1 Merge Precipitable Water (mm)
September 1988

Figure 18.
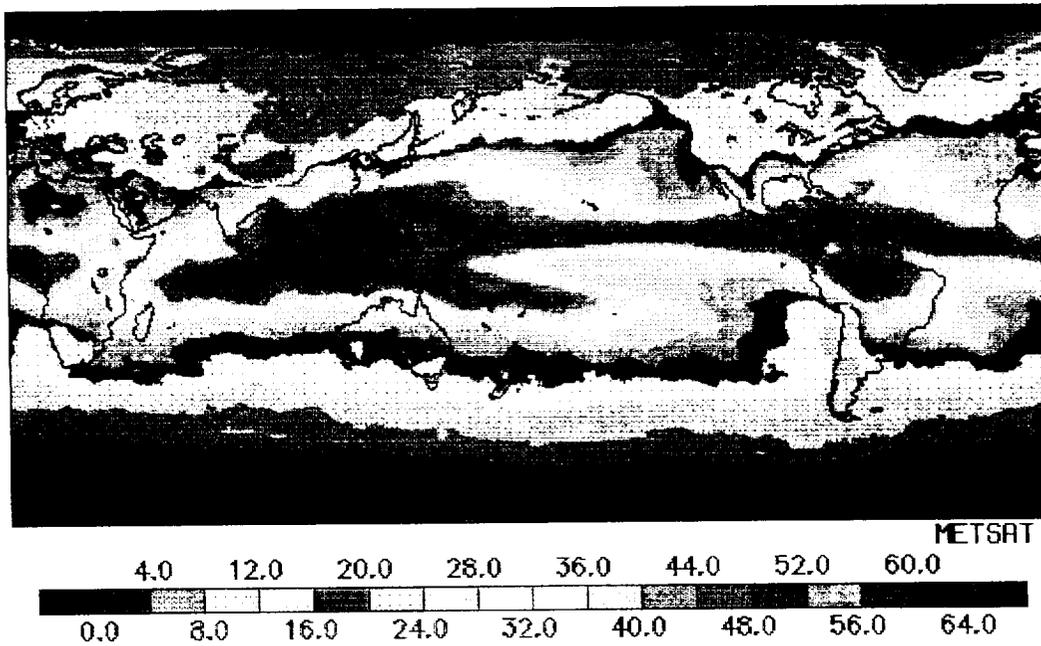
Version 1 Merge Precipitable Water (mm)
October 1988

Figure 19.
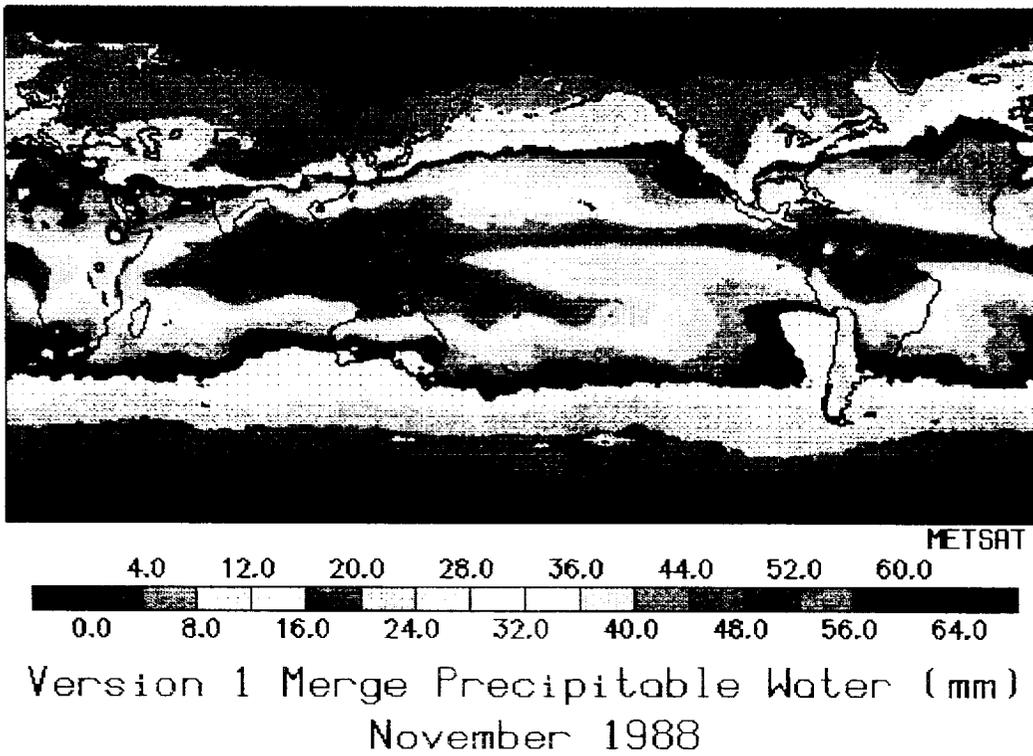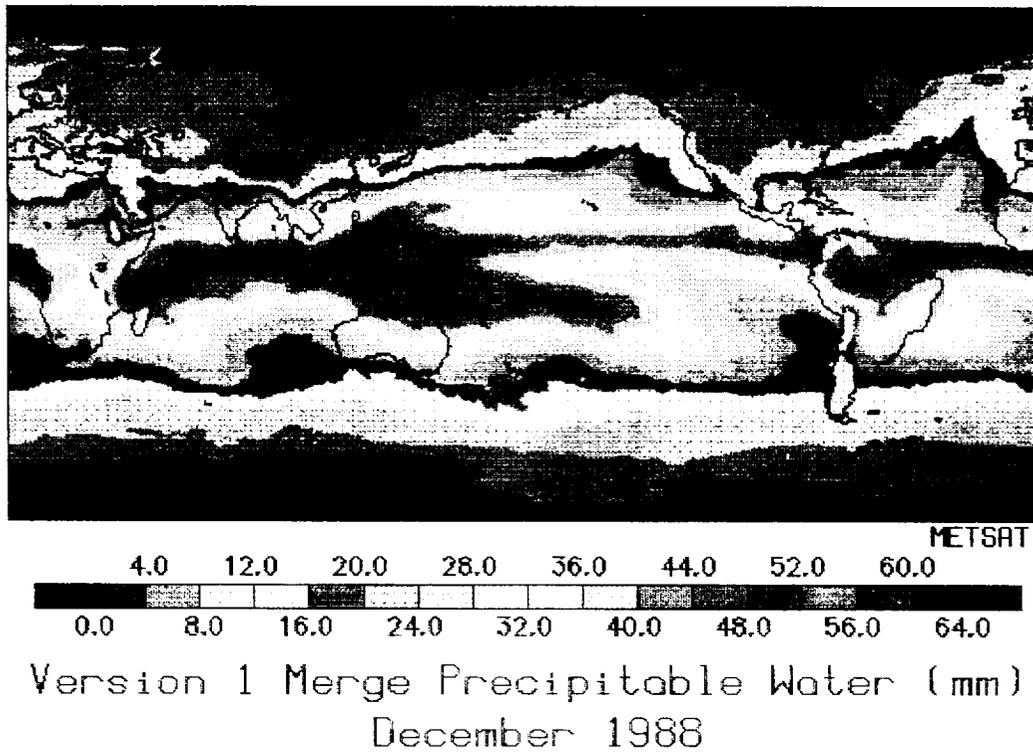
Version 1 Merge Precipitable Water (mm)
November 1988

Figure 20.

Version 1 Merge Precipitable Water (mm)
December 1988

APPENDIX B

USERS' MANUAL

NVAP DECODE AND RETRIEVE SOFTWARE

(Prepared on NASA Contract NASW-4715)

by

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and

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June. 1993 (revised)

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I. INTRODUCTION

This document describes the structure and use of the DECODE and RETRIEVE software that has been developed for the NVAP NASA Contract NASW-4715. The software represents a synthesis of pre-existing and original code that carries out the decoding of Wentz antenna temperature tapes and liquid/vapor retrievals in one easy step.

The software consists of three main modules: DRIVER, DECODE, and RETRIEVE. DRIVER is the main module which is in charge of input and output from the exabyte, hard disk, and memory. It is also responsible for calling DECODE and RETRIEVE, and for calling other small functions. DECODE processes the packed SSM/I data (see Users Manual SSM/I Antenna Temperature Tapes by Frank J. Wentz) and returns the decoded data to DRIVER. DRIVER passes the information to RETRIEVE where liquid water and water vapor retrievals are done. The retrievals are then passed back to DRIVER where they are archived on hard disk in coded form.

Chapter II will describe in more detail the three modules mentioned above in addition to all the minor functions used in the software package. Chapter III will describe the structure of the output files, and Chapter IV will describe, step by step, the processing of a Wentz tape. Chapter V will explain the use of the Makefile which should be used to compile the code should any changes be made and finally, Chapter VI will describe the use of supplemental software that has been written to peruse, bin, and grid the retrieved data.

II. FUNCTION DESCRIPTIONS

Most of the functions in this software package are written in ANSI standard C which should allow for the porting of the code to other UNIX machines. The exception to this is the DRIVER module which contains HP specific device I/O function calls. A large percentage of the code was pre-existing Fortran code. DECODE descends from the FORTRAN code provided by Wentz, and RETRIEVE was translated from the FORTRAN version of the Tjemkes and Greenwald code. DRIVER was developed to link DECODE and RETRIEVE together to achieve "on the fly" data processing.

In addition to the functions contained in the three main modules, there are four other minor functions, get_julian_day(), detect_sea_ice(), get _season(), and get_sst(), which preform necessary tasks, but do not functionally belong to any of the modules. The sea ice detection scheme was provided in FORTRAN via Tom Greenwald. For a complete description of the function algorithms in modules DECODE and RETRIEVE, refer to the Wentz Tape Users Manual and Tom Greenwald, respectively.

The remainder of this chapter will be devoted to a somewhat quasi-semi in depth discussion of the individual functions that make up the software package. Each description will begin with name of the source file, which module it belongs to (DRIVER, DECODE or RETRIEVE), who it is called by, and who it calls. This will be followed by an explanation of the code. The header files used by the functions will also be discussed.

The gridding routine, sgrid.c, is now complete and will be considered a fourth module, GRID. GRID uses the ~300mb output file from DRIVER to grid/bin the data.

```
function name: main (called by "ssmi")
source code:  driver.c
module:  DRIVER
called by:  UNIX shell
calls:  decode, retrieve, detect_sea_ice, get_sst,
        get_julian_day,  get_season
```

This function is the brains of the software. Its primary purpose is to perform input/output, although it is also responsible for communication between the three modules.

Upon execution the function opens the 8mm device which contains the Wentz formatted data, a file called ssmi.log, where messages generated during the processing will be sent, and an output file which is given a pathname based on the first file on the tape. The first file on the tape is the header file which is read in and dumped to the log file. Two important pieces of information are gleaned from the header file: 1) the number of data files on the tape, and 2) the year and month of the data. Once the date of the data is determined, calls to get_sst and get_season are performed.

A loop is set up from 1 to the number of files on the tape. Within the loop, blocks of data (generally 28544 bytes) are read from each file. One record at a time from each block (1784 bytes) is passed to decode. Then, a call to detect_sea_ice is made to determine whether or not to do a retrieval. In the absence of sea ice, a retrieval is done. Finally, some low level checks are done on the data and flagged appropriately, and the data are written in coded form to the output file.

function name: int get_season(char *date)
source code: get_season.c
module: DRIVER
called by: main
calls: none

This function is used to determine the season flag that is passed to detect_sea_ice. It translates the character string obtained from the header file (1988_JUL, for example) to either "season=0" for Spring and Summer months (months 3-8) or "season=1" for Autumn and Winter (months 1-2 and 9-12).

function name: int detect_sea_ice(int t19v, int t19h, int t37v, int
                      t37h, int season)
source code: sea_ice.c
module: DRIVER
called by: main
calls: none

This function performs checks and calculations on the brightness temperatures to determine the presence of sea ice. If sea ice is detected a value of TRUE (1) is returned. Otherwise a value of FALSE (0) is returned.

function name: int get_sst (char *sst_file)
source code: get_sst.c
module: DRIVER
called by: main
calls: fgets (stlib function)

This function creates an array of sea surface temperatures for that month from a data file (yyyy-MMM.sst) in directory /common/users/ssmi/sst.

function name: get_julian_day (int time, int *year, int *day, int *hour,
                               int *minute, int *second)
source code: get_jday.c
module: DRIVER and GRID
called by: main
calls: none

This function takes the scan time and decodes it into the year, day, hour, minute and second of the scan.

function name: void decode(short int *pibuf)
source code: decode.c
module: DECODE
called by: main
calls: adjloc, fdta, fdltln. fdtb00, fdtb08

This function is the call for the DECODE module. It calls the appropriate functions necessary to decode the Wentz formatted data. It also performs some preliminary decoding.*

function name: void fdltln(int j85ghz,int iold,float yaw,short int *pibuf)
source code: fdltln.c
module: DECODE
called by: decode
calls: none

This function uncodes the latitude and longitude points for the cells within a scan*.

function name: void fdta(int i85ghz, short int *pibuf)
source code: fdta.c
module: DECODE
called by: decode
calls: none

This function uncodes the antenna temperatures and surface types. *

function name: void fdtb00(int i85ghz, short int *pibuf)
source code: fdtb00.c
module: DECODE
called by: decode
calls: none

This function calculates the brightness temperatures for satellites other tnan the F08.*

function name: void fdtb08(int i85ghz, short int *pibuf)
source code: fdtb08.c
module: DECODE
called by: decode
calls: none

This function calculates the brightness temperatures for the F08 satellite.*

function name: void adjloc(float trakadj)
source code: adjloc.c
module: DECODE
called by: decode
calls: none

This function does an along track navigation adjustment to the latitude and longitude locations.*

function name: void retrieve(double t19v, double t19h, double
t22v, double t37v, double t37h)
source code: retrieve.c
module: RETRIEVE
called by: main
calls: vecret

This function is the main function for the module RETRIEVE. Its sole purpose is to start the retrieval process by calling the function vecret.*

function name: void vecret(double t19v, double t19h, double t22v,
double t37v, double t37h)
source code: retrieve.c
module: RETRIEVE
called by: retrieve
calls: emiss

This function calls emiss to get the surface emissivities and then computes the mass absorption coefficients.*

function name: void emiss(int ifreq, double speed, double sst,
                        double view, double *emissh, double *emissv)
source code: retrieve.c
module: RETRIEVE
called by: vecret
calls: roughem

      This function computes the surface emissivities. The emissivities are passed back to the function roughem via the pointers emissh and emissv.*

function name: void roughem(int ifreq, double gx2, double sst,
                        double view, double *remv, double *remh)
source code: retrieve.c
module: RETRIEVE
called by: emiss
calls: spemiss

      This function computes the effective surface slope variance needed to calculate the emissivities.*

function name: void spemiss(double f, double sst, double view,
                        double ssw, double *semv, double *semh)
source code: retrieve.c
module: RETRIEVE
called by: roughem
calls: epsalt

      This function computes the specular emissivity of sea water. A large portion of the code for this function differs from the Fortran version because C contains no library functions for complex numbers. Therefore, complex algebra must be explicitly done in the C version by representing the numbers with angles and magnitudes in the complex plane (i.e., vectors). In general, the name of the variable representing the imaginary part of the complex number will begin with the letter "i".*

function name: void epsalt(double f, double tc, double ssw,
                        double*epsr, double*epsi)
source code: retrieve c
module: RETRIEVE
called by: spemiss
calls: none

      This is the final call necessary to determine the emissivities.*

header file: driver.h
used by: main

This header file defines all the global constants used by DRIVER. The file also declares the functions used during execution of the DRIVER and DECODE modules.

header file: decode.h
used by: All the functions in the module DECODE and DRIVER.

This header file declares the structure "c" which is used to substitute the common block "outdat" that is found in the Fortran version. As the module DECODE is executed, the structure is filled up.

header file: retrieve.h
used by: All the functions in the module RETRIEVE and the function main.

This header file declares the constants π and the natural number e. It also declares the global variables wspd, sst, pwc, lwp and view. The value of these variables are computed in the module RETRIEVE, and rather than being passed back to the module DRIVER using pointers, they are simply declared as globals. The functions used by the RETRIEVE module are also declared here.

header file: get_sst.h
used by: function get_sst and main

This header file declares the global variable array seatemp. This array is loaded in get_sst. The function main uses the array to send the correct sst to the RETRIEVE module.

header files: math.h, stdio.h, stdlib.h
used by: all functions

These header files contain information for use of ANSII standard functions.

header files: ctype.h, time.h
used by: main

These header files contain information for functions isdigit (), and time (), and ctime(), used in main.

header files: fcntl.h, errno.h
used by: main

These header files contain information for use of HP specific I/O.

function name: main (called by sgrid)
source code: sgrid.c
module: GRID
called by: UNIX shell
calls: newfdltln, get_julian_day, read_bad_times, check_bad_times,
        header_out.

This function takes processed ssmi data for a one-month period and creates
gridded data of each day for liquid water (lwp), precipitable water (pwc), wind (wnd),
and data population (num). The input consists of two data files, one (.nex) containing
the first hour approximately (0, if none) from the previous month's overlap, and two, the
huge ssmi datafile. The output also consists of a log file (.log) and it dumps out the
beginning of the next month's data (.nex).

function name: void newfdltln (int iold, float yaw, unsigned char lat,
                unsigned char lon, float nlat, float nlon)
source code: new ltln.c
module: GRID
called by: main (sgrid)
calls: none

This function is the same as fdltln. It unccdes the latitude and longitude points
for the cells within a scan, except for a few minor changes for sgrid to use.

function name: void header_out (FILE * fpout, int par_code,
                long s_time, long e_time, float scale_value,
                char name_string)
scurce code: header_out.c
module: GRID
called by: main (sgrid)
calls: none

This function prints the header to each output file.

function name: int check_bad_times (int *year, int *day, int *hour,
                int *minute, int *seconds, int *rec_count)
source code: check_btimes.c
module: GRID
called by: main (sgrid)
calls: none

This function compares the bad orbital times array with the time of the current
record being processed. If it finds it is a bad time, a check is set and the program will
skip the bad time.

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function name: int read_bad_times ()
source code: read_btimes.c
module: GRID
called by: main (sgrid)
calls: none

This function is run once. It looks for the bad times data file and produces an array within the program containing these times.

header file: badtimes.h
used by: sgrid, read_bad_times, check_bad_times

This header file declares some constants for sgrid and its function. This file sets up the structure format for the bad times data array.

* To aid in the translation from FORTRAN to C, some multi-dimensioned arrays have had their subscripts reversed, and most array indices have been decremented by one. Most variables passed by subroutines in FORTRAN have been replaced by pointers.

III. OUTPUT DESCRIPTION

This chapter describes the format of the archived decoded and retrieved SSM/I data that is sent to the output file during program execution. Each record within the file contains the information for one scan which is equivalent to 64 individual retrievals.

The file is binary. The first four (4) bytes are the time group which is coded in the same manner as on the Wentz tapes. Next are the 19 latitude and longitude pairs that are used to interpolate to the 64 retrieval location. They are stored in the same format as the Wentz tapes. Thus there are 19 two byte latitude points followed by 19 two byte longitude points for a total of 76 bytes. Following the lat/lon are the 64 values each of precipitable water, liquid water and wind speed obtained from the retrieval. The precipitable water is scaled by 100 and stored as a two byte integer. The liquid water is scaled by 1000 and stored as a two byte integer. The wind speed is scaled by two (2) and stored in a single byte. Finally, 64 one byte values are stored. These are quality control flags corresponding to the 64 individual retrievals. Of course, the last byte is an end of record marker (\n).

In summary, the format is:

Field No.	First Byte	Field Bytes	Items	Description
1	1	4	1	time
2	5	38	19	lat
3	43	38	19	lon
4	81	128	64	precip
5	209	128	64	liquid
6	337	64	64	wind
7	401	64	64	quality
8	465	1	1	END REC

The meaning of the quality control flags are as follows:

1) If the flag is 201. no sst data was available for that location and no retrieval was done;

2) If the flag is 202, sea ice was detected and no retrieval was done;

3) If the units digit is a one (1). the retrieval returned a liquid water (LWP) value less than -0.25. This value is contaminated, so do not use. SGRID checks if negative values.

4) If the units digit is a two (2), the retrieval returned a liquid water value greater than or equal to 9.0. The value is then set to 9.999;

5) If the tens digit is a one (1), the retrieval returned a negative precipitable (pwc) water. This value is contaminated, so do not use.

6) If the tens digit is a two (2), the retrieval returned a precipitable water value greater than or equal to 99.0. The value is then set to 99.99;

7) If the hundredths digit is a one (1), the retrieved wind speed was greater than or equal to 99.0, the wind speed is then set to 49.5 (because of scaling = 2).

The scaling is done to preserve decimal values and for economic storage of data.

IV. HOW TO PROCESS A WENTZ TAPE

It takes about forty (40) hours to process a month of data (one tape). Therefore, the software should generally be run in batch so that others can utilize the terminal. You will need to define the environment variabies SSMI and VCS. You will also need to place your username in the batch cron files to permit batch job executions.

To set up the environment variables, do the following:
If you are using the Bourne shell, edit the file .profile in your home directory. Enter the following lines before the variable PATH is defined:

SSMI=/common/users/ssmi   :export SSMI
VCS=/common/vcs ;export vcs

On the line where the variable PATH is defined you will need to add additional search paths. The final definition should look something like this:

PATH=$PATH:$SSMI:$VCS/bin:/usr/local/bin

Then, be sure that PATH is exported:

export PATH

Finally, to invoke the new version of .profile, type:

.profile

If you are using C shell, edit the file .cshrc in your home directory. Enter the following lines before the variable PATH is defined:

setenv SSMI /common/users/ssmi
setenv VCS /common/vcs

C shell automatically exports the variables.

Next find the line defining the variable path and add the following path names:

$SSMI $VCS/bin /usr/local/bin

Save the file and type:

source .cshrc

to invoke the .cshrc file.

The variable SSMI defines the pathname where all the software data files reside. The variable VCS defines the pathname where the Version Control System resides. The VCS catalog "ssmi" contains all the source code and header files that constitute the software, and the library "libssmi.a" which contains the compiled code. The VCS variable in PATHNAME will allow access to the source code, header files, and library if revisions are required. The path /usr/local/bin is where the executables are placed.

One final note about variable definitions and path names. The new HP operating system (which runs HPVUE), unlike every other normal UNIX machine on the planet, may not automatically execute the shell files (.profile .cshrc). You may need to add commands to the file ".vueprofile". To be sure that your variables have been defined, type "env" and examine the output list it generates.

To gain batch job permission you need to edit the files

/usr/lib/cron/cron.allow
/usr/lib/cron/at.allow

and place your username in the list. Cron checks this file before batch jobs are submitted. Your username must appear in this file or the job will not be submitted. The files may be owned by the super user and write protected. If this is the case, type:

su root

You are now super user. BE CAREFUL! You will now need to add write privileges. Type:

chmod u+w cron.allow

Repeat the procedure for the file at.allow. You should now be able to edit the files. After you have added your username, remove the write privileges using the command:

chmod u-w filename

substituting filename appropriately. Exit the super user account by typing:

exit

Assuming that you have all the necessary variables defined, and your username in the cron.allow and at.allow files, follow these easy steps to run in batch mode:

1) Insert the tape into the drive and make sure it is positioned to the beginning.

2) Type "batch" and hit return. This enters you into batch mode.

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3) Type "ssmi" <ret>

* 4) Type "sgrid < sgrid.in" <ret>

5) Type "<ctrl>-d". This submits your commands to the batch que and exits the batch mode.

Assuming things go smoothly, the file "ssmi.log" will be created in the directory from where you executed the program. This file logs the status of the processing that has been completed, and any error messages that are generated from the code. The output file that contains the decoded and retrieved data will be given a name based on information contained in the header file on the beginning of the tape. An example file name would be 1988_JUL.ssmi. The file will be located in the path defined by SSMI under the directory data (/common/users/ssmi/data).

* Note: Gridding of the ssmi data can be done in the batch mode along with "ssmi". The file, sgrid.in, needs to be updated before the batch is run. SGRID is described in the next section. Recommend running the batch from the processing directory, /common/users/ssmi/process, since it contains three files sgrid needs to run: sgrid.in, ssmi_badloc.times and landmask.ing.

V. SUPPLEMENTAL SOFTWARE

There are a couple of other useful software utilities that are available. The first is called uncode, and the source code can be found in the file uncode.c (in VCS). This utility reads and decodes the output file created by the NVAP software. The second utility grids/bins the data in the NVAP output file. The source code is contained in the file sgrid.c (in VCS).

The uncode utility reads from standard input the name of the file to decode and sends the output to standard output. To execute the uncode utility type

uncode filename

This utility was designed simply to peruse the data. If the output is re-directed to a file, be careful not to let the program run to completion or the output data file will become to large to store on any of the disks.

The second utility decodes the NVAP output file, applies a one-half degree land mask, and bins the data into a one by one degree grid. Several files are created from this utility. All the output files are formatted for use in the CCDA (CIRA Climate Data Archive) software. The utility is run by typing:

sgrid < sgrid.in

The program will prompt for the names of two input files (include the pathname) and the prefix of the output file. UNIX allows input to executable code (sgrid) from a file (sgrid.in, a small data file containing the input and output filenames). This also allows sgrid to be run as a batch job. The first input file is the beginning hour or so of a new month; the data came from the tail of the previous month (e.g., jul88.nex is the beginning of August 1988). All the files have an extension which specifies the type of the data. Extensions are: 1) pwc, 2) lwp, 3) wnd, 4) num and sent to directory /common/users/nvap/ssmi. The extensions represent precipitable water, liquid water, wind speed and data population density respectively. The file with extension .nex is created in the directory /common/users/ssmi/data. A log file is also created, extension .log, in your current directory with information about the sgrid output. As time permits additional files will also be created, such as one containing quality control indicators.

The files created by sgrid that take on the specified output prefix must be processed through Dave Randel's software in order to create imx/imgman compatible image files. The "raw" files are pure byte images which can be displayed on imx without further processing. Be sure to define the size of the image to 360 x 180 or imx will not be able to read the image file.

VI. HOW TO COMPILE THE SOFTWARE

If any changes are made to the software source code or header files, the software must be re-compiled. Various levels of compilation will be required depending on what files have been altered. If any of the main functions of the software have been changed (driver.c, sgrid.c or uncode.c) you will need only to use the UNIX "make" command. The make command uses the information contained in a "Makefile" to automatically compile the software correctly. The Makefiles for the software have been checked into the Version Control System software as "ssmi.mak", "sgrid.mak", and "uncode.mak".

For example, lets suppose that the file driver.c has been changed. Check out the file "ssmi.mak" from VCS. Now type:

make -f "ssmi.mak"

to compile it, link it to the ssmi library, and create a new executable called ssmi. Now move the executable to /usr/local/bin.

If you change any of the other ".c" files besides "driver.c", "sgrid.c", or "uncode.c" you will need to rebuild the ssmi library. For example, if the file "fdltln.c" has been changed, type:

filebuild ssmi fdltln.c ssmi

Now you will need to compile the associated main function and re-link it to the new library. In this particular case, you would need to checkout ssmi.mak, run it through the makefile to create a new executable, and then move the executable to /usr/local/bin.

Finally, if any of the header files are changed, you will need to rebuild the entire catalog. Type:

catbuild ssmi ssmi

Now be sure to re-compile and re-link (using the Makefiles) the three main functions and move the executables to /usr/local/bin.
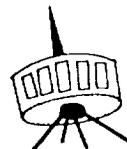
METSAT, INC.

APPENDIX C

I. INPUT DATA

• TOVS

ISCCP TOVS data was procured by CIRA/CSU from Lola Olson at NSSDC. The data was sent on 9-track tapes, each of which contains a full year of ISCCP ancillary data (see table 1 below for a complete parameter list). Via a cooperative agreement with CIRA/CSU, this dataset was obtained by METSAT. Software was created to access specific parameters on these tapes, and to change format to serve the purposes of this project. What follows is a description of the path by which data is prepared in the desired form for use in the merge process.

TOVS data might come in 2 forms from the ISCCP TOVS water vapor climatology. Either in an ASCII list or a simple grid. Also data comes in different levels that must be integrated to get total PWC.

a) **TOVSADD**	: creates/adds tovs levels
b) **TOVS_TOTAL**	: converts ASCII list to simple grid format
c) **TOVS_IAN**	: converts simple grid format to CCDA format
d) **CCDA_RESIZE**	: resize the TOVS 2.5 degree file to 1.0 degree
e) **CCDA_TOVSSUB**	: applies the TOVS "data origin" code to the data. Set to "indefinite" for the filled data points. Keep only data code 1, and climatology data at poles.

Input data fields: TOVS data listing or grid file
TOVS HHMM listing or grid file
TOVS origin CODE listing or grid file

The final product is a "data only" TOVS field of daily 1x1 degree resolution. Also the HHMM file is available with daily grids of the hour and minute for each sounding, but in version 0 processing we will not use this time information. Only one sounding was processed for each original TOVS resolution 2.5x2.5 degree area. In the CCDA_TOVSSUB routine all data other than the original points plus climatology has been set to "indefinite". The climatology data has been set to the negative of the PWC value in order for the merge routine to recognize it a climatology data

Data must first be read from the ISCCP TOVS 9-track magnetic tapes. This is accomplished by using program READTOVS, which can produce direct access files of layer PWC, data origin

codes, quality codes, sounding times (hour and minute), and other parameters (see Table 1 for a complete list). Each file contains a header record plus 72 data records for each grid in the file. The hour and minute files are combined by program HHMM, and then converted to a common data format called CCDA (CIRA Climate Data Archive) using program CCDA_TOVS_CVT. These sounding times are to be used in the Level 2 merge process. Similar steps are taken to prepare the data origin and quality codes for the Level 2 merge routines.

Processing of the layer PWC files begins with the routine TOVSADD, which computes total column PWC from the input layer data. The total column PWC output is converted to CCDA format (via CCDA_TOVS_CVT), and then is used by program CCDA_TOVSSUB (along with the data origin code files) which produces PWC data files containing original TOVS data only, with climatological fill for high latitude regions. Other filled data types provided by ISCCP are not used. Grid boxes which contain no original or climatological data are identified by an indefinite value. The PWC dataset at this point is at 2.5 degree resolution on a cylindrical equidistant grid. These daily data fields are then interpolated to 1 degree grids by program CCDA_RESIZE to conform to the resolution of SSM/I grids produced in a separate process. The 1 degree TOVS PWC dataset may then be utilized by the Level 1 merge scheme, or used in conjunction with the data quality codes and sounding times in the Level 2 merge routines.

Table 1. Available Original TOVS Products
****
*

Param. number	Parameter description	Param. number	Parameter description
1	Latitude Index	16*	Water Vapor 1000 - 800mb (mm)
2	Longitude Index	17*	Water Vapor 800 - 680mb (mm)
3*	Data Origin Code	18*	Water Vapor 680 - 560mb (mm)
4	Original Latitude Index	19*	Water Vapor 560 - 440mb (mm)
5	Original Longitude Index	20*	Water Vapor 440 - 310mb (mm)
6*	Hour of Sounding	21	Temperature 1000 - 800mb (K)
7*	Minute of Sounding	22	Temperature 800 - 680mb (K)
8*	NOAA Quality Code	23	Temperature 680 - 560mb (K)
9	Cloud Top Pressure (mb)	24	Temperature 560 - 440mb (K)
10	Cloud Amount (%)	25	Temperature 440 - 310mb (K)
11	Surface Elevation (m)	26	Temperature 310 - 180mb (K)
12	Surface Temperature (K)	27	Temperature 180 - 50mb (K)
13	Surface Pressure (mb)	28	Temperature 70 - 30mb (K)
14	Tropopause Temp (K)	29	Temperature 30 - 5mb (K)
15	Tropopause Press (mb)	30	Ozone Column Abundance (DU)

Specific steps for processing TOVS data:

1. Log on to luna. Mount one of the ISCCP 9 track tapes. There are symbols set up on this account to do the mount, such as msa, msb, and pmsa (for luna$msa0:, luna$msb0:, and phobos$msa0:, respectively). These command files will ask you to enter a tape logical. Type in "tape" for this.

2. Run the READTOVS program to select data types to extract from the tape. This should be self explanatory. One slightly tricky part could be where you are asked to enter a set of parameter numbers (a table will be shown for your reference). Simply enter a number at the prompt, and hit return, enter the next, hit return, etc, until you are done, and then just hit return again to continue. You will next be shown the parameters you have selected, so check those to be sure you entered them correctly.

3. Output from READTOVS is a direct access file. I suggest doing one month at a time, but the capability to do the whole tape exists. You will need to know the number of days dumped for use in subsequent programs.

4. If you dumped sounding times (hour and minute), run the HHMM program to combine them. Then run CCDA_TOVS_CVT to get the data in CCDA format. use an output filename convention like this: YYMMparam.std. 8807origin.std, for example, would be July 1988 origin codes in ccda format.

5. If you dumped origin codes or quality codes, run CCDA_TOVS_CVT on the file to convert to CCDA format.

6. If you dumped the 5 layers of PWC, run the TOVSADD program on your layer data file to sum for total column PWC. Then, run CCDA_TOVS_CVT on the total column data file to convert to CCDA format. Then, run CCDA_TOVSSUB on the PWC and origin code data files to produce the origin+clim dataset. Then, run CCDA_RESIZE by typing in "ccdaresize" (a symbol is already set up for this program which does not reside in this directory). The output 1 degree PWC data file is now ready to be used in the merge schemes.

• SSM/I

The SSM/I data will be processed at METSAT with the Greenwald, Stephens and Tjemkes schemes. Output at this time is to the /common disk as a sequential access file but the grids are in CCDA format. Output resolution is 1x1 degree spatial and daily temporal. Output grid files include: LWC, PWC, winds and data population fields. After the gridded data file has been completed, the CCDAFILE command must be run from the VMS side to alter the file characteristics to a direct access, no implied carriage control. This change enables the VAX CCDA software to read and operate on the data.

   a) **DRIVER**   : main SSM/I processing routine on HP
   b) **SGRID**   : main SSM/I gridding routine on HP
   c) **CCDAFILE** : change file attributes of SSM/I file on common disk for CCDA routines

Specific steps for processing the SSM/I data are contained in the SSM/I processing manual prepared by METSAT, Inc.

• RADIOSONDE

The radiosonde comes from ETAC on 9-track tapes. The sounding data is read off the tape and the PWC is calculated and dumped with other station and sounding information and time to a ASCII file. Eight tapes are needed to cover the entire globe for a year. The ASCII list for each tape is stored on optical disk. Another program is run (PWC_select) to subset the 8 files into monthly files. The 8 files for a given month are appended together to form one large month file. Finally the gridding program is run to put all radiosonde data into daily grids.

   a) **PWC_PRODUCT** : reads ETAC tapes, calc PWC and creates ASCII list.
   b) **PWC_SELECT**   : subsets annual PWC file in selected month
   c) **PWC_BIN_MM**   : bins and grids the radiosonde list data - averages all soundings
                          within the bin.

The result is daily 1x1 degree PWC gridded CCDA formatted fields.

• SEA SURFACE TEMPERATURE

The SST data comes from the Reynolds SST climatology data. This is 2x2 degree monthly averaged global data fields. These grids are in a CCDA formatted data file. An ASCII listing of this file is read in on the HP in the main DRIVER SSM/I processing routine. To make this listing from the CCDA file:

   CCDAPRINT   : creates an ASCII list from a CCDA grid file

use the 'F' format qualifier when prompted. Copy the ASCII text file to the HP into the SST directory , NFS2:[ssmi.sst], using the copy (cp) command on the HP side.

II. MERGE PROCESSING

• VERSION 1 MERGE

The version 1 merge routine (Merge1) processes uses a weighting scheme for combining the different CCDA formatted grids. Assumptions are made that the radiosonde are 'truth' therefore whenever balloon data is present it is used without averaging.

method 1) (new_way)

    a) **CCDA_MERGEV1**: combines radiosonde,SSM/I and TOVS, interpolates missing data and outputs merged field and data source code field.

method 2) (old way)

    a) **CCDA_COMBINE** : combine radiosonde and TOVS data using weighting of 1.0 for radiosondes and 0.0 for TOVS. This creates a radiotovs std file.

    b) **CCDA_COMBINE** : combine radiosonde and SSM/I data using weighting of 1.0 for radiosondes and 0.0 for SSM/I. This creates a radiossmi.std file.

    c) **CCDA_COMBINE** : combine radiotovs and radiossmi fields using weighting 0.9 for ssmi and 0.1 for tovs.

    d) **CCDA_FILL**   fill missing data points through interpolation

The final output product is a weighted combination of the three data sources. It's resolution is daily fields at 1 degree spatial resolution

• MONTHLY AVERAGES

Monthly averages of the PWC, and LWC should be created from the daily fields. The routine:
    CCDAAVE
will average the daily fields and create the global average file.

III. QUALITY CONTROL

During the processing scheme many of the individual products should be examined. All products are in the same CCDA grid format which allows for use of the CCDA software package. The data processing grid products that can be looked at include:

1) TOVS data from all sources (2.5x2.5)
2) TOVS data from source 1 plus climatology (2.5x2.5)
3) TOVS data from source 1 plus climatology (1.0x1.0)
4) Radiosonde gridded data (1.0x1.0)
5) SSM/I PWC, LWC and data population fields
6) Version 0 merged PWC product
7) Version 0 data source code

The main CCDA routines for examining the gridded products are:

1) **CCDAHEADF**   : List out full header information
2) **CCDAHEADB**   : List out brief header information
3) **CCDAGLBAVE**   : Creates and lists global and hemispheric averages
4) **CCDAZOOM**   : COLOR IM-4000 or IMX image plot
5) **CCDAPRINT**   : ASCII list of data

IV. SOFTWARE EXECUTION

• Prepare and quality control the RADIOSONDE gridded data

a) run **PWC_PRODUCT** to pull data off 9-track ETAC data tape, calculate
PWC and product annual ASCII list

b) run **PWC_SELECT** to subset the annual files into selected month

c) run **PWC_BIN_MM** to grid daily data fields

d) run **CCDAZOOM** to produce color plots global PWC

e) use **IM-4000** to view global images

f) copy gridded file to: nfs2:[nvap.rawin]
- filename = rawin_yrmm.std

• Prepare and quality control the TOVS GRIDDED DATA

a) pull data off **ISCCP 9-track tape**, 1 tape per year.

b) run **TOVSADD**   to add the tovs levels and create integrated PWC

c) run **TOVS_TOTAL** to convert ASCII list to simple grid format

d) run **TOVS_IAN**   to convert simple grid format to CCDA format

e) run **CCDA_TOVSSUB** to indefinite out all but required TOVS values

f) run **CCDA_RESIZE** to change grid resolution to 1X1 degree grid

g) run **CCDAZOOM** to produce color plots global PWC

h) use **IM-4000** to view global images

i) copy tovs gridded file to: nfs2:[nvap.tovs]
- filename = tovs_yrmm.std

• Prepare and quality control the SSM/I GRIDDED DATA

a) **check out** the correct month **exabyte tape**

b) run **CCDAPRINT** on the SST file d1:[nvap.sst], and move correct month ASCII file to the HP SST directory, using the copy comand (cp) on the HP side.

c) start SSM/I processing and grid routine from the nfs2: [ssmi.process] directory (/common/users/ssmi/process)

   This puts:

   1) the SSM/I processing log file and the grid routine log file on this directory
   2) the SSM/I 300 mb file on /common/users/ssmi/data directory
   3) the gridded data on /common/users/nvap/ssmi directory

d) run **DRIVER** (SSMI)

e) examine log file from **DRIVER** (on directory where SSMI was started)

f) run **SGRID** routine to produce daily PWC, LWC, data population grids from ~300Mb SSM/I data file on /common/users/ssmi/data.

g) **change file attributes** of grid file on the common disk. Do this on DRACO with the VMS command: CCDAFILE

   This will modify the file attributes in order for CCDA software to read the file. An old way to do this was to convert the file with the program:

   d1:[nvap exe]ssmi_convrt.

h) run **CCDAZOOM** to produce color plots global PWC and LWC

i) use **IM-4000** to view global images

• Create and quality control the version 0 MERGED PRODUCT

a) edit and execute d1:[nvap.merge]**MERGEV0.COM** (inputs are the radiosonde, SSM/I, and TOVS gridded CCDA formatted files)

b) run **CCDAAVE** to create monthly average field

c) run **CCDAZOOM** to produce color plots of the global PWC distribution

d) use **IM-4000** to view global images

V. EXECUTABLE LOCATIONS

The VMS program executables for the NVAP processing tasks currently reside on the d1:[nvap.exe] directory. The main library CCDA routines are run by executing symbols. These are set up by executing @d1:[ccda.include]ccdalog.com The CCDA executables reside on the CCDAEXE: directory = d1:[ccda.exe] on d1:[nvap.exe]

TOVSADD	: creates/adds tovs levels
TOVS_TOTAL	: converts ASCII list to simple grid format
TOVS_IAN	: converts simple grid format to CCDA format
CCDA_TOVSSUB	: filters out all but real and climo TOVS data
PWC_PRODUCT	: reads ETAC tapes. calc PWC and creates ASCII list
PWC_SELECT	: subsets annual PWC file in selected month
PWC_BIN_MM	: bins and grids the radiosonde list data

To execute the CCDA routines set the logicals up with a single command:

@D1:[ccda.include]CCDALOG

In the NVAP processing and quality control effort these include:

CCDACOMB	: runs CCDA_COMBINE to combine data fields with weighting
CCDAAVE	: runs CCDA_AVERAGE to average many CCDA fields into 1
CCDAHEADF	: runs CCDA_HEADERF to dump out full CCDA headers
CCDAHEADB	: runs CCDA_HEADERB to dump out 'brief' CCDA headers
CCDAGLBAVE	: runs CCDA_GLBAVE to calculate global and hemis aves
CCDAZOOM	: runs CCDA_ZOOM which creates a color image of grid data
CCDAPRINT	: runs CCDA_PRINTER to create an ASCII list of grid data
CCDACONT	: runs CCDA_CONTOUR to create a GKS contour plot
CCDACFILL	: runs CCDA_CLRFILL to create a GKS color filled plot
CCDARESIZE	: runs CCDA_RESIZE to change grid resolution
CCDAZON	: runs CCDA_ZONALAVE to dump out a list of zonal averages

VI. PROCESSING SCHEDULE

• 1988 Daily Level 0 products

Scope: January 1988 - December 1988, daily gridded
products, monthly mean products

Timetable: 8 March - 15 May 1993
(approx. 2 months of data per week)

Data Processing Responsibility:
SSM/I (Mark)
TOVS (Ian)
Rawinsonde (Cindy)
Merge0 (Mark)

Notes:

1) Mark will be the person driving the schedule since he is doing the SSM/I and the Merge0 processing. The TOVS and Rawinsonde processing should proceed at a pace to keep about two "data months" ahead of the SSM/I processing (ie. when Mark is processing the January SSM/I we should have the January and February Rawin and TOVS on disk and ready for the merge0 processor.

2) Finished products will be stored on 8mm tape, and also on optic disk. In addition, keep all "pre-merge0" gridded data files on a single 8mm tape, with one backup, and, if space permits, keep the pre-merge0 rawin and TOVS gridded files on an optic disk.

3) Make modifications/updates to this document as the processing procedures or other information changes in your area of responsibility. Annotate changes to a copy of this document and give them to Sharon or Dee. An updated version will be distributed when significant changes warrant.

APPENDIX D

COMPARISION OF VARIOUS TEMPERATURE CUTOFFS FOR RADIOSONDE DATA

July 1988, stations 01-16
[Europe and Mediterrain]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	24.11	-----	----	174.38	----	----	5356	-----
PWC 30	23.98	99.46	0.13	337.96	208	5148	5148	96.11
PWC 25	23.86	98.96	0.25	372.56	133	2142	5223	97.51
PWC 20	23.66	98.13	0.45	416.91	92	454	5264	98.28

(5148 comparison points)

July 1988, stations 16-28
[Russia and Siberia]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	25.41	-----	----	222.44	----	----	6321	-----
PWC 30	25.29	99.53	0.12	326.92	1739	4582	4582	72.49
PWC 25	25.19	99.13	0.22	354.28	791	2633	5530	87.48
PWC 20	24.95	98.19	0.46	405.37	452	538	5869	92.85

(4582 comparison points)

July 1988, stations 28-37
[rest of former USSR]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	28.83	-----	----	224.01	----	----	6420	-----
PWC 30	28.70	99.55	0.13	313.13	1342	5078	5078	79.10
PWC 25	28.61	99.24	0.22	336.46	657	3139	5763	89.77
PWC 20	28.35	98.33	0.48	388.22	332	715	6088	94.83

(5078 comparison points)

July 1988, stations 37-48
[Middle East thru Southeast Asia]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	41.08	-----	----	204.88	----	----	6510	-----
PWC 30	41.00	99.80	0.08	269.51	1785	4725	4725	72.58
PWC 25	40.91	99.59	0.17	298.15	1331	1795	5179	79.55
PWC 20	40.77	99.24	0.31	324.51	1087	735	5423	83.30

(4725 comparison points)

COMPARISION OF VARIOUS TEMPERATURE CUTOFFS FOR RADIOSONDE DATA

July 1988, stations 48-67
[China and most of Africa]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	37.20	-----	----	167.33	----	----	8524	-----
PWC 30	37.05	99.60	0.15	272.72	1191	7333	7333	86.03
PWC 25	36.93	99.27	0.27	299.75	921	3384	7603	89.19
PWC 20	36.84	99.03	0.36	318.73	823	1745	7701	90.34

(7333 comparison points)

July 1988, stations 67-72
[South Africa, Alaska, Canada]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	25.53	-----	----	221.70	----	----	5247	-----
PWC 30	25.42	99.57	0.11	331.99	153	5094	5094	97.08
PWC 25	25.34	99.25	0.19	360.93	104	2389	5143	98.02
PWC 20	25.19	98.67	0.34	398.41	71	939	5176	98.65

(5094 comparison points)

July 1988, stations 72-91
[USA, Mexico, Central & South America, Antarica, Pacific]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	30.84	-----	----	258.60	----	----	5653	-----
PWC 30	30.78	99.80	0.06	311.82	303	5350	5350	94.64
PWC 25	30.72	99.61	0.12	331.68	256	3221	5397	95.47
PWC 20	30.60	99.22	0.24	365.29	216	1600	5437	96.18

(5350 comparison points)

July 1988, stations 91-99
[Australia, Pacific and ship reports]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	25.29	-----	----	198.72	----	----	2725	-----
PWC 30	25.19	99.60	0.10	337.04	213	2512	2512	92.18
PWC 25	25.11	99.28	0.18	370.55	146	1042	2579	94.64
PWC 20	24.98	98.77	0.31	405.99	124	431	2601	95.45

(2512 comparison points)

COMPARISION OF VARIOUS TEMPERATURE CUTOFFS FOR RADIOSONDE DATA

January 1988, stations 01-16
[Europe and Mediterrain]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	11.36	-----	----	226.14	----	----	5000	-----
PWC 30	11.20	98.59	0.16	430.83	4811	6	4811	96.22
PWC 25	11.07	97.45	0.29	472.78	1895	480	4882	97.64
PWC 20	10.87	95.69	0.49	519.64	477	2850	4919	98.38

(4811 comparison points)

January 1988, stations 16-28
[Russia and Siberia]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	7.86	-----	----	301.51	----	----	4300	-----
PWC 30	7.67	97.58	0.19	493.14	413	3887	3887	90.39
PWC 25	7.55	96.05	0.31	528.01	192	2184	4108	95.53
PWC 20	7.39	94.02	0.47	567.44	105	1157	4195	97.56

(3887 comparison points)

January 1988, stations 28-37
[rest of former USSR]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	6.80	----	----	342.70	----	----	4700	-----
PWC 30	6.64	97.65	0.16	486.85	570	4130	4130	87.87
PWC 25	6.49	95.44	0.31	533.27	223	1962	4477	95.25
PWC 20	6.29	92.50	0.51	577.84	124	867	4576	97.36

(4130 comparison points)

July 1988, Carribean stations
[lat 12-25N, lon 60-85W]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	47.42	-----	----	256.31	----	----	315	-----
PWC 30	47.35	99.85	0.07	298.79	28	287	287	91.11
PWC 25	47.31	99.77	0.11	308.15	26	211	289	91.75
PWC 20	47.24	99.62	0.18	324.64	22	152	293	93.01

(287 comparison points)

COMPARISION OF VARIOUS PRESSURE CUTOFFS FOR RADIOSONDE DATA

July 1988, stations 01-16
[Europe and Mediterrain]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	24.03	-----	----	156.61	----	----	5315	-----
PWC 350	23.93	99.58	0.10	314.75	587	4728	4728	88.95
PWC 400	23.84	99.21	0.19	348.05	101	2177	5214	98.10
PWC 450	23.59	98.15	0.44	413.65	89	51	5226	98.32

(4728 comparison points)

July 1988, stations 16-28
[Russia and Siberia]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	26.59	-----	----	185.30	----	----	6272	-----
PWC 350	26.46	99.51	0.13	307.50	2507	3765	3765	60.02
PWC 400	26.39	99.25	0.20	327.11	479	2610	5793	92.36
PWC 450	26.08	98.08	0.51	403.66	425	85	5847	93.22

(3765 comparison points)

July 1988, stations 28-37
[rest of former USSR]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	28.50	-----	----	210.70	----	----	5928	-----
PWC 350	28.37	99.54	0.13	308.04	1670	4258	4258	71.83
PWC 400	28.28	99.23	0.22	329.47	330	2916	5598	94.43
PWC 450	27.95	98.07	0.55	402.32	304	158	5624	94.87

(4258 comparison points)

July 1988, stations 37-48
[Middle East thru Southeast Asia]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	32.22	-----	----	217.24	----	----	3913	-----
PWC 350	32.10	99.63	0.12	306.11	1134	2779	2779	71.02
PWC 400	32.00	99.32	0.22	329.01	711	1745	3202	81.83
PWC 450	31.69	98.35	0.53	394.58	625	248	3288	84.03

(2779 comparison points)

COMPARISION OF VARIOUS PRESSURE CUTOFFS FOR RADIOSONDE DATA

July 1988, stations 48-67
[China and most of Africa]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	27.13	-----	----	180.35	----	----	4363	-----
PWC 350	26.99	99.48	0.14	303.35	861	3502	3502	80.26
PWC 400	26.96	99.37	0.17	316.52	790	2787	3573	81.89
PWC 450	26.64	98.19	0.49	387.45	786	557	3577	81.98

(3502 comparison points)

July 1988, stations 67-72
[South Africa, Alaska, Canada]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	22.30	-----	----	212.38	----	----	4547	-----
PWC 350	22.21	99.60	0.09	315.01	239	4308	4308	94.74
PWC 400	22.14	99.28	0.16	342.69	58	2286	4489	98.72
PWC 450	21.94	98.38	0.36	412.35	45	42	4502	99.01

(4308 comparison points)

July 1988, stations 72-91
[USA, Mexico, Central and South America, Antartica, Pacific]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	26.66	-----	----	252.87	----	----	4634	-----
PWC 350	26.60	99.77	0.06	310.79	364	4270	4270	92.14
PWC 400	26.53	99.51	0.13	333.62	261	2594	4373	94.37
PWC 450	26.29	98.61	0.31	410.30	202	44	4432	95.64

(4270 comparison points)

July 1988, stations 91-99
[Australia, Pacific and ship reports]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	20.56	-----	----	177.28	----	----	2324	-----
PWC 350	20.50	99.71	0.06	314.81	299	2025	2025	87.13
PWC 400	20.44	99.42	0.12	348.89	117	902	2207	94.96
PWC 450	20.28	98.64	0.28	409.61	88	72	2236	96.21

(2025 comparison points)

COMPARISION OF VARIOUS PRESSURE CUTOFFS FOR RADIOSONDE DATA

January 1988, stations 01-16
[Europe and Mediterrain]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total	
PWC		11.57	-----	----	135.07	----	----	5782	-----
PWC 350	11.51	99.48	0.06	313.27	1764	4018	4018	69.49	
PWC 400	11.48	99.22	0.09	340.48	711	2291	5071	87.70	
PWC 450	10.36	89.54	1.21	409.96	378	54	5404	93.46	

(4018 comparison points)

January 1988, stations 16-28
[Russia and Siberia]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	7.42	-----	----	78.06	----	----	8100	-----
PWC 350	7.30	98.38	0.12	303.65	4736	3364	3364	41.53
PWC 400	7.29	98.25	0.13	322.02	3820	2382	4280	52.84
PWC 450	7.20	97.03	0.22	399.24	3628	106	4472	55.21

(3364 comparison points)

January 1988, stations 28-37
[rest of former USSR]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	6.60	-----	----	90.62	----	----	8800	-----
PWC 350	6.44	97.57	0.16	300.58	5789	3011	3011	34.21
PWC 400	6.43	97.42	0.17	317.04	4452	2266	4348	49.41
PWC 450	6.34	96.06	0.26	393.13	4203	207	4597	52.24

(3011 comparison points)

July 1988, Carribean stations
[lats 12-25N lons 60-85W]

Type	Mean PWC	% of PWC	Diff PWC	Mean Level	Number Missing	Nearest to PWC	Total Number	% of Total
PWC	45.49	-----	----	257.28	----	----	243	-----
PWC 350	45.40	99.80	0.09	308.09	26	217	217	89.30
PWC 400	45.32	99.63	0.17	329.41	18	145	225	92.59
PWC 450	45.03	98.99	0.46	407.89	17	2	226	93.00

(217 comparison points)