NOAA Western Region Computer Programs and
Problems NWS WRCP - NO. 55

CONVECTIVE CROSS SECTION ANALYSIS

Salt Lake City, Utah
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U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

PREFACE

This Western Region publication series is a subset of our Technical Memorandum series. This series will be devoted exclusively to the exchange of information on and documentation of computer programs and related subjects. This series was initiated because it did not seem appropriate to publish computer program papers as Technical Memoranda; yet, we wanted to share this type of information with all Western Region forecasters in a systematic way. Another reason was our concern that in the developing AFOS-era there would be unnecessary and wasteful duplication of effort in writing computer programs in National Weather Service (NWS). Documentation and exchange of ideas and programs envisioned in this series hopefully will reduce such duplication. We also believe that by publishing the programming work of our forecasters, we will stimulate others to use these programs or develop their own programs to take advantage of the computing capabilities AFOS makes available.

We solicit computer-oriented papers and computer programs from forecasters for us to publish in this series. Simple and short programs should not be prejudged as unsuitable.

The great potential of the AFOS-era is strongly related to local computer facilities permitting meteorologists to practice in a more scientific environment. It is our hope that this series will help in developing this potential into reality.

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1 Standardized Format for Computer Series. Revised January 1984. (PB85 109668)
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36 Soaring Forecast Program. D.S. Toronto and G. R. Lussky, Revised March 1986. (PB86 173523/AS)
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54 Hemispheric Spectral Analysis Program. Craig C. Peterson, April 1986. (PB 183662/AS)

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I. Introduction

The programs described in this document generate cross sections of a variety of fields to help identify areas of potential instability, symmetric instability, and the evolution of potentially unstable layers with time. The identification and location of such instabilities can be very helpful in identifying areas likely for convection during short range forecasts. The main purpose of this document is to fully describe the programs which produce these cross section graphics.

It is well-known that cold advection aloft and warm advection at lower levels increases the lapse rate at a site and hence create a more unstable airmass. Potential instability, as defined by Wallace and Hobbs (1977), exists when the airmass can be destabilized totally through lifting, without any advection. This occurs when a layer is lifted adiabatically and the lower part of the layer saturates before the upper part. During any further lifting, the lower part of the layer will cool more slowly than the upper part because of the latent heat released by condensing water in the lower part. This tends to destabilize the layer and can even create very unstable lapse rates in layers that were absolutely stable before lifting.

Potential instability exists when the equivalent potential temperature (the temperature a parcel would have if it were lifted adiabatically until all its water was condensed out and then lowered dry adiabatically down to 1000mb) decreases with height. However, since it may take an enormous amount of lifting before the lower layers saturate, the dew-point depressions should also be examined in these potentially unstable layers to see how much lifting is required before the destabilization will begin. Generally speaking, if the equivalent potential temperature decreases with height through a layer and the dew-point depressions near the bottom part of the layer are low, then the layer will quickly begin to destabilize with any lifting.

As described by Lee and Rilling (1987), the change of the potential instability pattern with time can be helpful in determining when convection is more likely at a particular site. In addition, the spatial pattern of potential instability may show areas that are more likely for convective development when lifted. This may help pinpoint heavier precipitation areas during frontal or orographic lifting episodes. Spatial cross sections of equivalent potential temperature can also be combined with cross sections of constant momentum to identify symmetric instability. This kind of instability is described in case studies of symmetrically unstable events by Sanders and Bosart (1985) and Lussky (1987). In a very simplified sense, convection can occur "slantwise" instead of "straight up" if the equivalent potential temperature decreases upward along a line of constant momentum. For more information on the interpretation of such charts refer to Lussky (1987).

These programs were developed to calculate the necessary values of equivalent potential temperature (θ_e, hereafter referred to as Theta-E temperature), dew-point depression, and momentum and graphically display these variables in a cross section format. These programs all create a standardized gridded data file which is transformed into a cross section graphic by a final contouring program. It is hoped that this standardization will permit the quick and simple development of other cross section programs by using the contouring routines and file structure described here.

II. Methodology and Software Structure

All the programs in this package are written in Data General FORTRAN IV revision 5.57. Three programs create space cross sections. Two other programs create time cross sections. One program is used for all the contouring of the data.

A. Space Cross Section Programs

There are three programs that produce spatial cross sections from upper air radiosonde observations. TECROSS produces a cross section of Theta-E temperature. DPCROSS produces a cross section of dew-point depressions. MOCROSS produces a cross section of momentum. A data file, CROSS.xx, contains the list of stations to be used in each cross section. Switches within each program specify the filename extension for the CROSS.xx file. This allows sites to have many different CROSS.xx files available for different cross sections (for example, one for north-south cross sections and another for east-west cross sections). At least two, and up to five stations can be listed in each CROSS.xx file. There is no limit to the distance between these stations, however each station must be listed in the STDIR.MS file, and the station radiosonde data must be decoded by TTBBD. Any stations where the radiosonde data is missing, not decoded by TTBBD, or ends before reaching 100mb are noted on the graphic. The algorithm, switches and error messages for these programs are nearly the same.

1. TECROSS

a) General Description

The flow of the TECROSS program is as follows: First, the command line switches are decoded. Then the specified CROSS.xx file is opened and read to determine which stations are to be in the cross section. Using the subroutine BNSCH, the STDIR.MS file is searched for each of these stations to determine their latitude and longitude. The subroutine DIST is then called to calculate distances along the cross section. The X-coordinates along the plot are fixed, based on the distance data, and then the tick mark interval is fixed.

Then for each station the following is done: The TTBBD decoded data is read. The subroutine HTHETA is called to calculate the Theta-E temperatures at each significant level. The subroutine LININT is called to interpolate the Theta-E temperatures at significant levels to 50 levels spaced equally (with respect to pressure) between the surface and 100mb. Finally, if smoothing in the vertical direction is desired, these Theta-E temperatures are smoothed by calling subroutine SMOOTH.

After all the available TTBBD decoded data has been read for all of the stations, subroutine INTERP is called to interpolate data for any missing stations or stations where radiosonde data ended before reaching 100mb. Finally, the data is written to a VCRSGRID file, and TECROSS chains to VCROSS to contour the data. An example of the graphic product produced is shown in Figure 1.

b) Special Subroutines

Subroutine HTHETA calculates the Theta-E temperature at every significant level. The calling sequence is:

```
CALL HTHETA(IPR,ITM,IDT,THETAE,ITROP)
```

where IPR is an integer array containing the pressure (mb) of each significant level. ITM and IDT are integer arrays containing the temperature and dew-point temperature (^{o}Celsius*10), respectively. THETAE is a floating point array containing the Theta-E temperature (Kelvin) upon return from the subroutine. ITROP is an integer variable which contains the Theta-E temperature (Kelvin) at the tropopause upon return from the subroutine. The tropopause is defined as the first level above 400mb where the Theta-E temperature increases by more than 0.4K per mb.

c) Command Line

This program can be initiated at an ADM, the Dasher, or from within a macro. The command line is:

```
TECROSS/F xx/I xxx/O nn/C n/M
```

The global switch /F specifies that the contouring should continue to 100mb or as high as possible. If no /F switch is specified the contouring stops at the warmest tropopause calculated among the stations along the cross section. The xx/I switch specifies the two character extension of the CROSS.xx file to be used for input. This switch is optional with the default input file being CROSS.01. The xxx/O switch specifies the output graphic name NMCGPHxxx. This switch is optional with the default graphic being NMCGPHECR. The nn/C switch specifies the contour interval in integer degrees Celsius. This switch is optional with the default contour interval being 2°C. The n/M switch specifies the number of smoothing passes (1-9) to be applied to the data. This switch is optional with the default being no smoothing. For specific hints about smoothing, refer to the Cautions and Restrictions section of this document.

2. DPCROSS

a) Differences from TECROSS program

DPCROSS calls subroutine GDEWP in place of HTHETA to calculate dew-point depression. DPCROSS also calls subroutine DWINTR instead of INTERP to interpolate missing data. Data is only contoured up to the point when dew-point depression data is lost from all the radiosonde observations along the cross section. An example of the output graphic is shown in Figure 2.

b) Special Subroutines

Subroutine GDEWP calculates the dew-point depression at each significant level. The calling sequence is:

```
CALL GDEWP(IPR,ITM,IDT,FDP)
```

where IPR is an integer array containing the pressure (mb) of each significant level. ITM and IDT are integer arrays which contain the temperature and dew-point temperature (°C * 10), respectively, at each significant level. FDP is a floating point array containing the dew-point depression at each significant level.

Subroutine DWINTR is a modified version of INTERP (described later) which doesn't allow dew-point depressions of more than 30°C or less than 0°C. The calling sequence is exactly the same as subroutine INTERP.

c) Command Line

This program can be initiated at an ADM, the Dasher, or from within a macro. The command line is:

DPCROSS xx/I xxx/O nn/C n/M

The xx/I switch specifies the two letter extension of the CROSS.xx file to be used for input. This switch is optional with the default input file being CROSS.01. The xxx/O switch specifies the output graphic name NMCGPHxxx. This switch is optional with the default graphic being NMCGPHDCR. The nn/C switch specifies the contour interval in integer degrees Celsius. This switch is optional with the default contour interval being 2°C. The n/M switch specifies the number of smoothing passes (1-9) to be applied to the data. This switch is optional with the default being no smoothing. For specific hints about smoothing, refer to the Cautions and Restrictions section of this document.

3. MOCROSS

a) Differences from the TECROSS program

MOCROSS calls subroutine GWIND followed by subroutine GMOM instead of HTHETA to calculate momentum values. An example of the output graphic is shown in Figure 3.

b) Special Subroutines

Subroutine GWIND calculates the wind component perpendicular to the cross section at each significant level (positive values indicate wind into the cross section). The calling sequence is:

CALL GWIND(IHGT,IDIR,ISPD,U,V,ATON,ADD,IER)

where IHGT, IDIR and ISPD are integer arrays containing the height (hundreds of feet), direction (degrees) and speed (knots) of the wind at each significant level respectively. U and V are floating point arrays containing the wind along and into the cross section (meters per second), respectively, upon return from the subroutine. ATON is a floating point variable containing the angle (radians) between North and the direction of the cross section at this station. IERR is an integer variable which equals -1 upon return if no wind data could be decoded.

Subroutine GMOM calculates the momentum at each significant level. The calling sequence is:

```
CALL GMOM(V,ADD,FMO)
```

where V is a floating point array containing the wind into the cross section (meters per second). ADD is a floating point variable containing the correction for momentum based on the Coriolis parameter and the distance along the cross section. FMO is a floating point array which contains the momentum (meters per second) at each significant level upon return from the subroutine.

c) Command Line

This program can be initiated at an ADM, the Dasher, or from within a macro. The command line is:

```
MOCROSS xx/I xxx/O nn/C n/M
```

The xx/I switch specifies the two letter extension of the CROSS.xx file to be used for input. This switch is optional with the default input file being CROSS.01. The xxx/O switch specifies the output graphic name NMCGPHxxx. This switch is optional with the default graphic being NMCGPHMCR. The nn/C switch specifies the contour interval in integer meters per second. This switch is optional with the default contour interval being 10m/s. The n/M switch specifies the number of smoothing passes (1-9) to be applied to the data. This switch is optional with the default being no smoothing. For specific hints about smoothing, refer to the Cautions and Restrictions section of this document.

4. Error Messages

Most of the error messages from the space cross section programs are the same and are listed below with a probable explanation of the problem. These fatal errors halt program execution and are followed by the message, 'xxxxx-- FATAL ERROR --', with xxxxx specifying the program in which the error occurred. IF initiated at an ADM, the program will also alert to the ADM with the message, 'xxxxx ABORTED! - ERROR CONDITION: SEE DASHER'.

INVALID INPUT FILE -	CROSS.xx extension must be two characters long - check command line

INVALID XXX FOR OUTPUT - Graphic name XXX must be three characters long- check command line

INVALID STATION IN CROSS.XX LIST - Stations in CROSS.xx list must be three characters long followed by a return character - check CROSS.xx file

TOO MANY STATIONS IN CROSS.XX LIST - Limit of five stations along a cross section- check CROSS.xx file

NOT ENOUGH VALID STATIONS IN CROSS.XX LIST - Must be two stations in a cross section - check CROSS.xx file

ONLY n VALID STATIONS - NOT ENOUGH TO PROCEED - Too many stations in CROSS.xx list are not in STDIR.MS file- check CROSS.xx file

COMMAND LINE ERROR - COM.CM file cannot be read - check files and links

CROSS SECTION HAS ZERO LENGTH - Last station in cross section cannot be same as first station - check CROSS.xx file

xxxxx COULD NOT BE OPENED - Specified file could not be opened - check files and links

In addition to fatal errors, warning messages may be printed to the Dasher during program execution. These messages are preceded by the program name in which the warning occurred.

INVALID SWITCH - Bad switch - check command line

INVALID CONTOUR INTERVAL - Contour interval must be integer number - default will be used - check command line

INVALID SMOOTHING PARAMETER - Smoothing parameter must be integer 0-9 - check command line

STDIR.MS DOES NOT CONTAIN STATION xxx - Specified station is not in STDIR.MS list- it will be deleted from cross section - check command line

B. Time cross section programs

Two programs are necessary to produce a time cross section at a particular site. Program THTE produces and maintains a history file of Theta-E temperatures for each station. This program should be run every time new radiosonde observations are decoded with program TTBBD. For example, to keep 12 hour continuity in the history file, TTBBD and THTE should be run after the radiosonde significant and mandatory level data are received for each radiosonde observation. Radiosondes released at "non-synoptic" times can also be incorporated in the history file if they can be decoded by TTBBD (usually this means adding a DDHH group onto the TTBBD command line). Program TTCROSS reads the history file and creates a VCRSGRID gridded data file for contouring by program VCROSS.

1. THTE

a) General Description

The flow of the THTE program is as follows: The first station switch is processed. The TTBBD decoded data file is searched for this station's data and read if it exists. The time history file THTExxx.DB is read to make sure that the current TTBBD decoded data is more recent than the last one in the history file. If the TTBBD data is more current, subroutine HTHETA (described earlier) is called to calculate the Theta-E temperature at each significant level. This data is added to the first record of the history file and all the remaining data are moved down one record. Finally, the THTExxx.DB file is written to disk and the command line is checked for more station switches.

b) Command Line

This program can be initiated at an ADM, the Dasher, or from within a macro. The command line is:

THTE xxx/S [xxx/S]

The xxx/S switch specifies the three letter identifier of the station to be used as input. The xxx/S switch may be repeated with other stations as often as desired. However when running THTE from an ADM, the command line cannot exceed 24 characters.

c) Error Messages

There are several possible fatal errors in program THTE associated with disk file problems. The error messages listed below are printed at the Dasher followed by the message 'THTE -- FATAL ERROR --', and program execution is halted. If the program was started from an ADM, the ADM is alerted with the message: 'THTE ABORTED! ERROR CONDITION: SEE DASHER'.

COMMAND LINE ERROR -	COM.CM file could not be opened or read - check files and links
xxxxxx COULD NOT BE OPENED -	Specified file could not be opened - check files and links
DECODED DATA ERROR -	TTBBD decoded data could not be read - check files and links
HISTORY FILE ERROR -	THTExxx.DB file could not be read properly - check files and links

In addition to fatal errors, THTE also prints the following self-explanatory messages to the Dasher if new radiosonde data for a station could not be incorporated into the THTExxx.DB file.

NO LATER RAOBS FOR STATION xxx
RAOB NOT DECODED FOR STATION xxx
TTBBD DOES NOT DECODE STATION xxx

2. TTCROSS

a) General Description

The flow of the TTCROSS program is as follows: First the switch information is processed. The data for one radiosonde observation is read from the THTExxx.DB file. If this is the first observation then the time is saved and the program loops back to read data for the next observation. If it is not the first observation, then subroutine TIMDIF is called to determine the time difference between this radiosonde observation and the first one. Subroutine LININT is called to interpolate the Theta-E data at significant levels to 50 levels spaced equally (with respect to pressure) between the surface and 100mb. If smoothing is desired, subroutine SMOOTH is called. Finally, the data is inserted in the gridded file and the program loops back to read in more observations. When all 10 observations in the history file, or all observations within the last five day period, are read and processed, subroutine INTERP is called to interpolate any missing data. Finally, a VCRSGRID file is written and the program chains to VCROSS to contour the data. An example of the output graphic is shown in Figure 4.

b) Special Subroutines

Subroutine TIMDIF calculates the time difference between two sounding times. The calling sequence is:

```
CALL TIMDIF(IY,IM,ID,IT,JY,JM,JD,JT,IHR)
```

where IY, IM, ID and IT are integer variables containing the year, month, day and time (0 - 2359) of the most recent sounding. JY, JM, JD and JT are integer variables containing the year, month, day and time (0 - 2359) of the older sounding. IHR contains the number of hours separating the two times upon return. If the two times are more than 7 days apart, IHR will be 999. This routine handles leap years, and will work past the year 2000.

c) Command Line

This program can be initiated at an ADM, the Dasher, or from within a macro. The command line is:

```
TTCROSS/F xxx/S xxx/O nn/C n/M
```

The global switch /F specifies that the contouring should continue to 100mb or as high as possible. If no /F switch is specified, the contouring stops at the warmest tropopause calculated among all the radiosonde observations along the cross section. The xxx/S switch specifies the three letter identifier of the station to be used for input. This switch is mandatory. The xxx/O switch specifies the output graphic name NMCGPHxxx. This switch is optional with the default graphic being NMCGPHTCR. The nn/C switch specifies the contour interval in integer degrees Celsius. This switch is optional with the default contour interval being 2^{o}C. The n/M switch specifies the number of smoothing passes (1-9) to be applied to the data. This switch is optional with the default being no smoothing.

d) Error Messages

Several fatal errors can occur with program TTCROSS which halt program execution. The error messages listed below are printed at the Dasher, followed by the message: 'TTCROSS -- FATAL ERROR --'. If the program was initiated at an ADM, the ADM is alerted with the message: 'TTCROSS ABORTED! ERROR CONDITION: SEE DASHER'.

COMMAND LINE ERROR -	COM.CM switches file could not be opened or read-check files and links
THTEXXX.DB COULD NOT BE	xxxxx - History file could not be opened or read for the specified station-check files and links
NO STATION SPECIFIED -	No station switch xxx/S has been specified - check command line
INVALID STATION SPECIFIED -	Station specified with xxx/S switch must be three characters long - check command line
VCRSGRID FILE COULD NOT BE OPENED -	Gridded data file cannot be opened-check files and links

In addition to fatal errors, several warning messages may be printed to the Dasher during program execution. These messages are all preceded by the program name in which the error occurred and are listed below with an explanation of each message.

INVALID SWITCH -	Bad switch - check command line
INVALID CONTOUR INTERVAL -	Contour interval must be integer number - default will be used - check command line
INVALID OUTPUT FILENAME -	Output xxx must be three characters long - default will be used - check command line
INVALID SMOOTHING PARAMETER -	Smoothing parameter must be integer 0-9-default will be used-check command line

C. Common Subroutines

The following subroutines are common to all or several of the cross section programs.

1. LININT

Subroutine LININT calculates values of a variable at 50 linearly spaced pressure levels between 100mb and the surface pressure at the station. The calling sequence is:

```
CALL LININT(IPR,FTH,IPRL,FTHL)
```

where IPR and IPRL are integer arrays containing the pressure (mb) for the significant levels and linearly spaced levels respectively. Likewise, FTH and FTHL are floating point arrays containing the variable at the significant levels and linearly spaced levels respectively. Arrays IPRL and FTHL are output arrays.

2. SMOOTH

Subroutine SMOOTH smooths the vertical distribution of a variable by applying one pass of a running mean smoother. The calling sequence is:

```
CALL SMOOTH(FTHL)
```

where FTHL is a floating point array used for input and output of the variable to be smoothed.

3. INTERP

Subroutine INTERP interpolates any missing data using cubic spline interpolation. The subroutine starts at the bottom level and works its way to the top level. If a point is missing at any level, the other points are used to generate a cubic polynomial or "spline" interpolating function, and the missing point is replaced with this interpolated value. If the missing point is on the edge of the cross section, a cubic polynomial cannot be produced and the nearest valid point is used to replace the missing point. The calling sequence is:

```
CALL INTERP(IGRID,IXC,IYC,INX,INY)
```

where IGRID is an integer array containing the gridded data, with -999 at any point that needs to be interpolated. IXC is an integer array that contains the X-coordinates of each grid point. IYC is an integer array that contains the Y-coordinates of each grid point. INX is an integer variable containing the number of X grid points. INY is an integer variable containing the number of Y grid points. INY may be changed within the subroutine if no valid points exist at a level. In that case, INY is reduced to the number of levels below the invalid level.

4. DIST

Subroutine DIST calculates the distance between each station along the cross section. The cross section is taken along a straight line between the first station and the last station. The positions of the intermediate stations are calculated by projecting each station perpendicularly onto the cross section line. The calling sequence is:

```
CALL DIST(LAT,LON,NSTA,IDIS,ITOT)
```

where LAT and LON are floating point arrays containing the latitude and longitude (degrees West of Greenwich) of each station. NSTA is an integer variable containing the number of stations. IDIS is an integer array containing the distance (kilometers) between each station and the next station. For example, IDIS(1) contains the distance between station 1 and 2, IDIS(2) contains the distance between station 2 and 3, etc. ITOT is an integer variable which contains the distance (kilometers) between the first and last stations.

5. BNSCH

Subroutine BNSCH is a binary search routine used to quickly find the station latitude and longitude data in the STDIR.MS file. Using the BNSCH subroutine in this manner is described by Scott (1984) and will not be discussed further here.

D. Contouring Program

The program VCROSS reads a VCRSGRID gridded data file and produces a cross section graphic. The contouring routine is a slightly modified version of the contouring routine used in the Western Region MESO programs by Anderson and Spry (1984). The VCROSS program is essentially the MESO ATUR subroutine modified to use the AG.LB graphics library routines described by MacDonald (1981). Subroutine D1 is essentially the MESO DRAW subroutine modified so that contour line labels are not printed along the bottom of the cross section at a 1:1 display ratio. The labels are shown at higher zooms, but removed at the 1:1 display ratio to reduce clutter. Subroutine MNMX is the MESO MAXMIN subroutine with a slightly modified routine to print relative maximums or minimums. Otherwise the subroutines are the same as those described in Anderson and Spry and will not be further described here.

E. Data Files

Several files from the TTBBD significant level decoder are read by the cross section programs. These files (FILNAM.TX, TTBBSTAS.DB and MMDDYYU.HH) are described by Person and Gilhousen (1985) and will not be further described here.

The cross section programs create and use several files for the transfer and storage of data.

1. CROSS.xx

CROSS.xx contains the list of three letter identifiers for stations to be used in space cross sections. The two character file extension 'xx' can be replaced by any two characters. This allows multiple CROSS.xx files to exist so that different cross sections can be produced without having to edit the CROSS.xx file each time. The specific CROSS.xx file that you wish to use must be specified in the command line switches when running a cross section program, or the default CROSS.01 will be used. Each CROSS.xx file can contain from two to five stations and can easily be created at an AFOS ADM console by:

a) Entering E:F/CROSS.xx
b) Filling out the file information data (specify the file type as sequential).
c) When in message composition, enter the three letter identifier for the stations you want to include in the cross section. The stations should be in the correct order with the first station being at the left of the cross section and the last station at the right. Each three letter identifier should be typed on a separate line followed by a return key.
d) Press the ENTER key to terminate message composition and store the file.

2. THTExxx.DB

The THTExxx.DB files contain the time history data needed for time cross sections. These files are created and written by program THTE and read by program TTCROSS. The xxx is replaced with the three letter station identifier, so that a separate THTExxx.DB file exists for every station specified when running program THTE. A THTExxx.DB file must exist before running TTCROSS or an error message will be printed at the Dasher and program execution will halt.

Each THTExxx.DB file contains ten records of 65 words. The first record contains the most recent radiosonde data. The last record contains the oldest radiosonde data. The format of the information in each record is described in Table 1.

3. VCRSGRID

The VCRSGRID file contains gridded data and station information needed by program VCROSS to create an AFOS graphic. The format is very general so that other programs can create a VCRSGRID file and chain to program VCROSS to create other cross section graphics. A VCRSGRID file should be 1135 words long. The format of the data is listed in Table 2.

F. Map Background

All the cross section programs utilize a special map background provided with the software. The dimensions of this background are listed here to assist programmers creating other cross section programs using the VCROSS program. The map background is a "large-size" graphic (4095 X 3071) with a smaller cross section "window" with lines of constant pressure drawn in a logarithmic fashion similar to a Skew-T/Log-P diagram. The left and right edges of the window are at X-coordinates 448 and 3688 respectively. The top edge of the window is labelled as 100mb and is at a Y-coordinate of 3030. The bottom edge of the window is at 1050mb and is at a Y-coordinate of 360. To determine the Y-coordinate for any pressure, use the following lines of FORTRAN code:

```
XX=ALOG(100./1050.)
P=ALOG(PRESS/1050.)/XX
IYC=INT(P*(3030.-360.))+360
```

where PRESS is the pressure (mb) and IYC is the y-coordinate. For wind data which is reported by heights instead of by pressure, the heights should be converted to pressure before using the FORTRAN code above.

III. Cautions and Restrictions

These programs were designed for versatility in creating cross section graphics. The flexibility allows the creation of graphics which may cause strain on the AFOS system, or which may be meaningless.

Specifically, very small contour intervals should not be specified since they may require considerable time to contour. For example, specifying a contour interval of 1 m/s for a momentum chart would take approximately 30 minutes to contour. The default contour intervals provide reasonable graphics under most situations, and take approximately 3 minutes to contour.

Care should be exercised in specifying stations along space cross sections. The cross section computed by the programs runs along a straight line from the first station to the last station in the CROSS.xx list. The intermediate stations should not lie very far from this line since distant stations will probably not have the same airmass characteristics as those near the cross section line.

The stations are also placed along the cross section in the order in which they appear in the CROSS.xx list. This means that stations should be listed in CROSS.xx as they actually lie along the cross section. For example, a cross section running along the U. S. West Coast from Oakland, California to Quillayute, Washington could be produced by a CROSS.xx file like this:

```
OAK
MFR
SLE
UIL
```

However, meaningful results would not be obtained if the CROSS.xx file looked like this:

```
OAK
SLE
MFR
UIL
```

because Salem, Oregon (SLE) lies north of Medford, Oregon (MFR). The space cross section programs would interpret the latter CROSS.xx file as a cross section from Oakland north to Salem, then south to Medford and then north again to Quillayute. The resulting graphic would have many overlapping and crossing contours and would be meaningless.

Specific hints and suggestions for each of the programs are listed below.

A. <u>TECROSS</u>

Little or no smoothing is suggested for Theta-E cross sections. Small stable or unstable layers may be smoothed out by using too many passes of the smoothing filter.

B. <u>DPCROSS</u>

A moderate or large number of smoothing passes is suggested for dew point depression cross sections. The instruments found on most upper air radiosonde packages are very sensitive to dew point depression. This creates a dew point depression graphic which is very busy and hard to interpret. A large number of smoothing passes produces a graphic which is more pleasing and still gives a general idea of the location of moist and dry layers.

C. MOCROSS

No smoothing is recommended for momentum cross sections. There is very little need for smoothing, since smoothing would mask the small changes in momentum that describe the "slantwise" parcel trajectories. Optional smoothing is still provided to be consistent with the other cross section programs.

D. THTE

Problems may result if data with a bad date gets into the THTExxx.DB file. New data will store in the file only if it is more recent than the data within the file. If the file has data with a bad date it may prevent the storage of new data. At this time (5/87) there is no simple way to correct this. An octal edit of the THTExxx.DB file can change the bad date, but this is a rather complex process. As a last resort, the bad THTExxx.DB file could be deleted and THTE would run as normal. However this solution deletes all the previously stored history data.

E. TTCROSS

Little or no smoothing is suggested for time cross sections of Theta-E temperature for the same reasons noted above. In addition, at least two entries must exist in the THTExxx.DB file before TTCROSS can be run. If TTCROSS is taking longer than usual to run, it may be that bad data has been entered into the THTExxx.DB file. There is no gross error check of the data, so bad data may prompt the drawing of an enormous number of contour lines. As above, there is no simple way to solve this problem. An octal edit of the THTExxx.DB file could remove the bad data, or the THTExxx.DB file could be deleted.

F. VCROSS

The key for the AFOS product specified must exist in the AFOS data base or an error will occur. A temporary disk file with the same name as the AFOS product is created and deleted by this program. Any file with that name that exists when this program is run is deleted.

IV. Acknowledgements

I would like to thank the programmers of the many programs that produce data used by these programs, and also those programmers from whom I got working subroutines and FORTRAN code. In particular, I would like to thank Jeffrey Anderson, Mark Mathewson, and Jim Fors for their clear and well documented FORTRAN code which is incorporated within these programs. The success of these programs is a direct result of their efforts. I would also like to thank

Glenn Rasch, SSD Chief in the NWS Western Region, Ken Mielke, SSD Assistant Chief in the NWS Western Region, Glenn Lussky and Glenn Sampson, both of NWS Western Region, SSD for their input and help with this project.

V. References

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Theta-E History File Format

Each record contains the following data

Word	No. of words	Data type	Description
1	1	Integer	Observation time (0-2359)
2	1	Integer	" day
3	1	Integer	" month
4	1	Integer	" year
5	1	Integer	Theta-E temperature at the calculated tropopause. (Kelvin)
6-35	30	Integer	Theta-E temperature at each significant level. (Kelvin * 10)
36-65	30	Integer	Pressure at each significant level. (mb)

Table 1. Format of Theta-E history file THTExxx.DB. Up to ten records are allowed with the most recent data in record 1 and the oldest data in record 10. If there are less than 30 significant levels the remaining levels are filled by repeating the last pressure and Theta-E temperature.

Gridded Data Format

Word	No. of words	Data type	Description
1	1	Integer	Number of X grid points (up to 10)
2	1	Integer	Number of Z grid points (up to 50)
3	1	Integer	Minimum contour (-999 if it is to be calculated)
4	1	Integer	Maximum contour (-999 if it is to be calculated)
5	1	Integer	Contour Interval
6	1	Integer	Tick mark interval (screen coordinates per tick)
7	1	Integer	Tick mark interval (km per tick)
8-17	10	Integer	Ending pressure (mb) of sounding at each X grid point (100mb if no ending message is to be printed)
18-19	2	ASCII	Three letter product identifier (followed by null)
20-39	20	ASCII	Three letter station identifiers at each X grid point (each followed by a space) ISTN(10,2) -- See note below.
40-99	60	ASCII	Special message space (12 characters) available below each X grid point. IMSG(10,6)-- See note below.
100-119	20	ASCII	Caption to be printed on graphic
120-125	6	ASCII	Program name (12 characters) that made gridded data
126-135	10	Integer	Screen X coordinates for each cross section X grid point
136-635	500	Integer	Screen Y coordinates for each cross section Z grid point. IYC(10,50) -- See note below.
636-1135	500	Integer	Gridded data (* 10). IGRID(10,50) -- See note below.

Table 2. Format of VCRSGRID gridded data file. NOTE: Multiply dimensioned arrays should be written using WRS(IC,IAR,NB,IER) where IAR is dimensioned IAR(NX,NY), IC is the channel number, IER is an error return and NB=NX*NY*2.

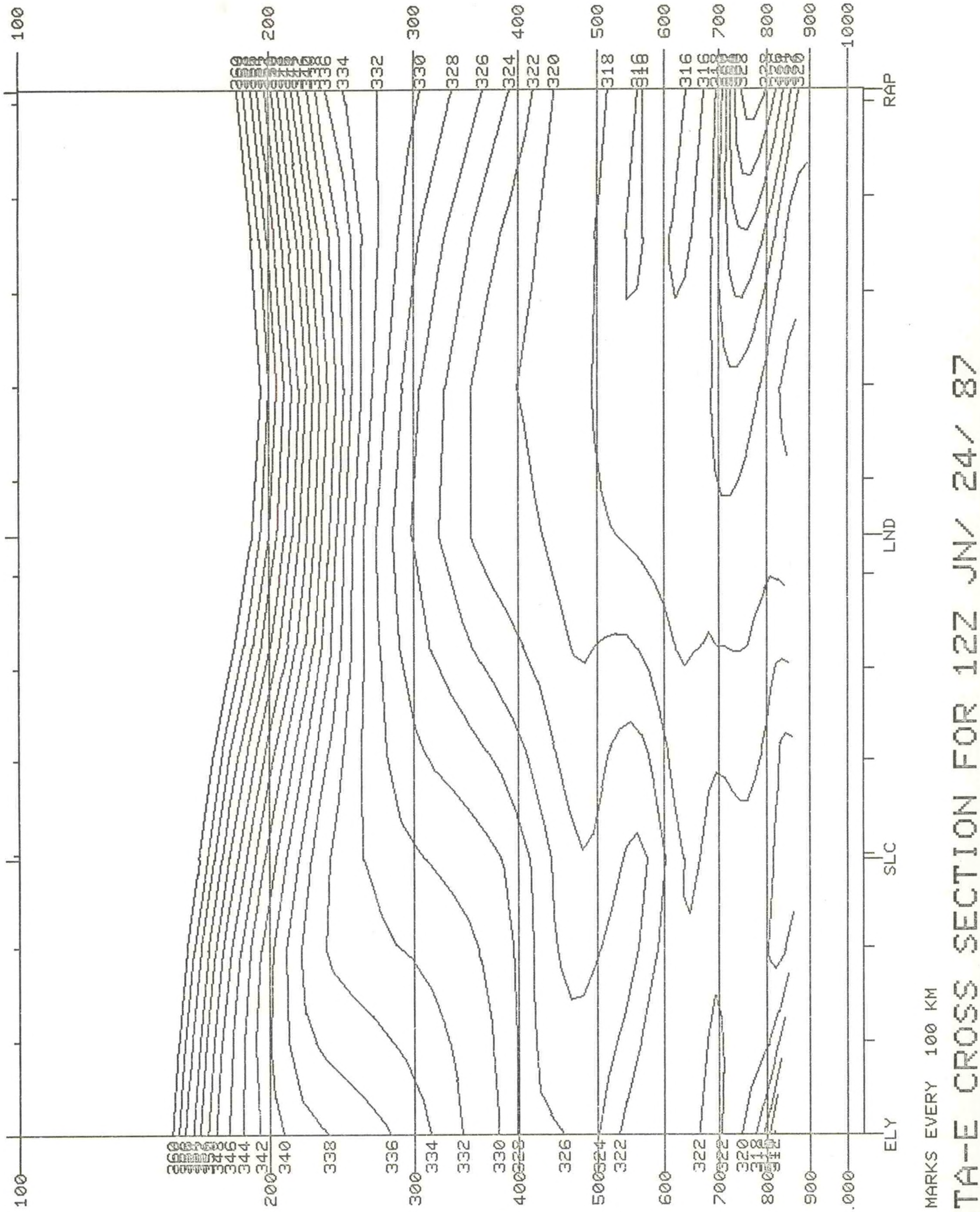


FIGURE 1. Theta-E temperature space cross section from Ely, NV to Rapid City, SD. Two vertical smoothing passes were applied to the data.

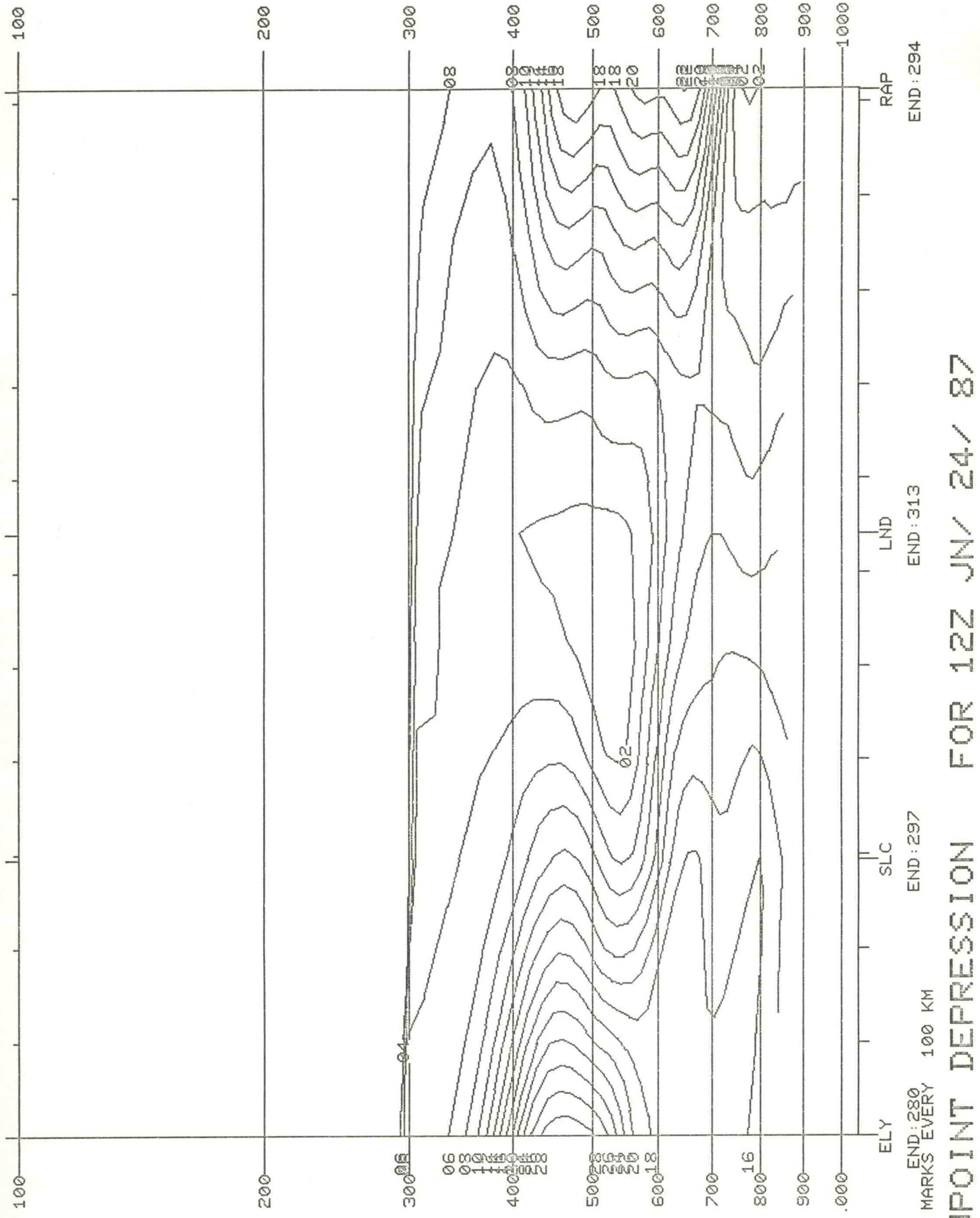


FIGURE 2. Dew-point depression cross section from Ely, NV to Rapid City, SD. Six vertical smoothing passes were applied to the data.

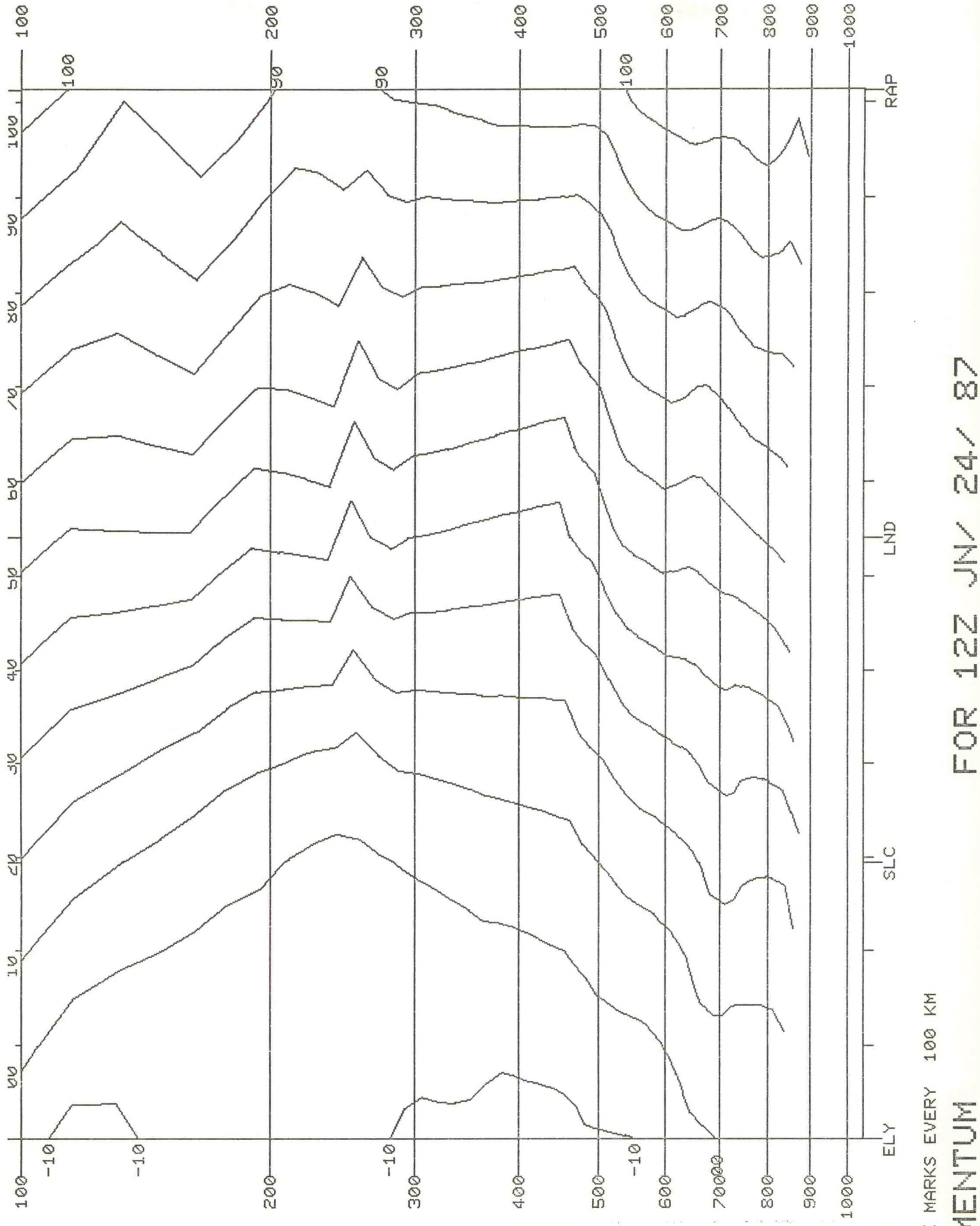


FIGURE 3. Momentum cross section from Ely, NV to Rapid City, SD. No smoothing was applied to the data.

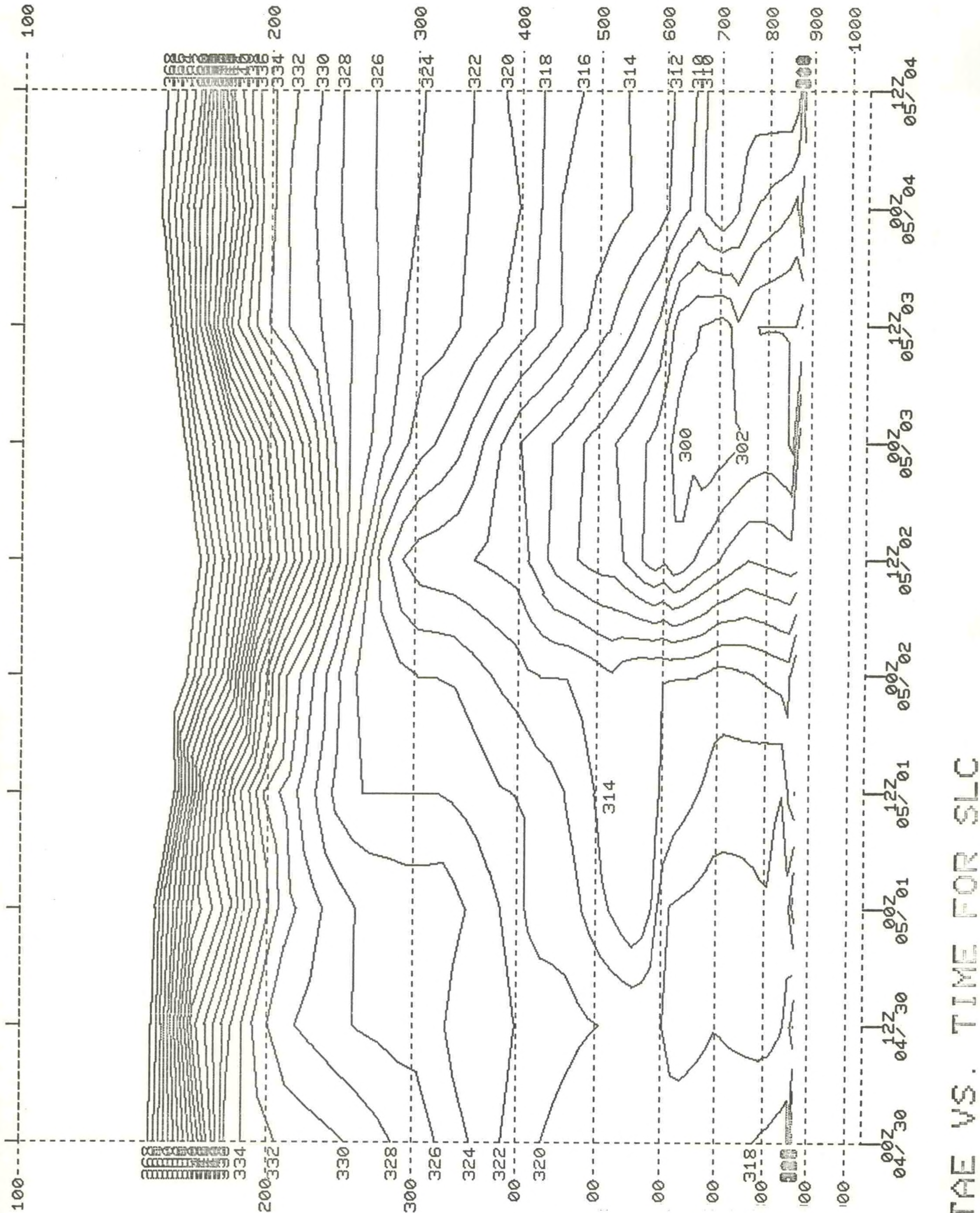


FIGURE 4. Time cross section of Theta-E temperature at Salt Lake City, UT (SLC). Two vertical smoothing passes were applied to the data.

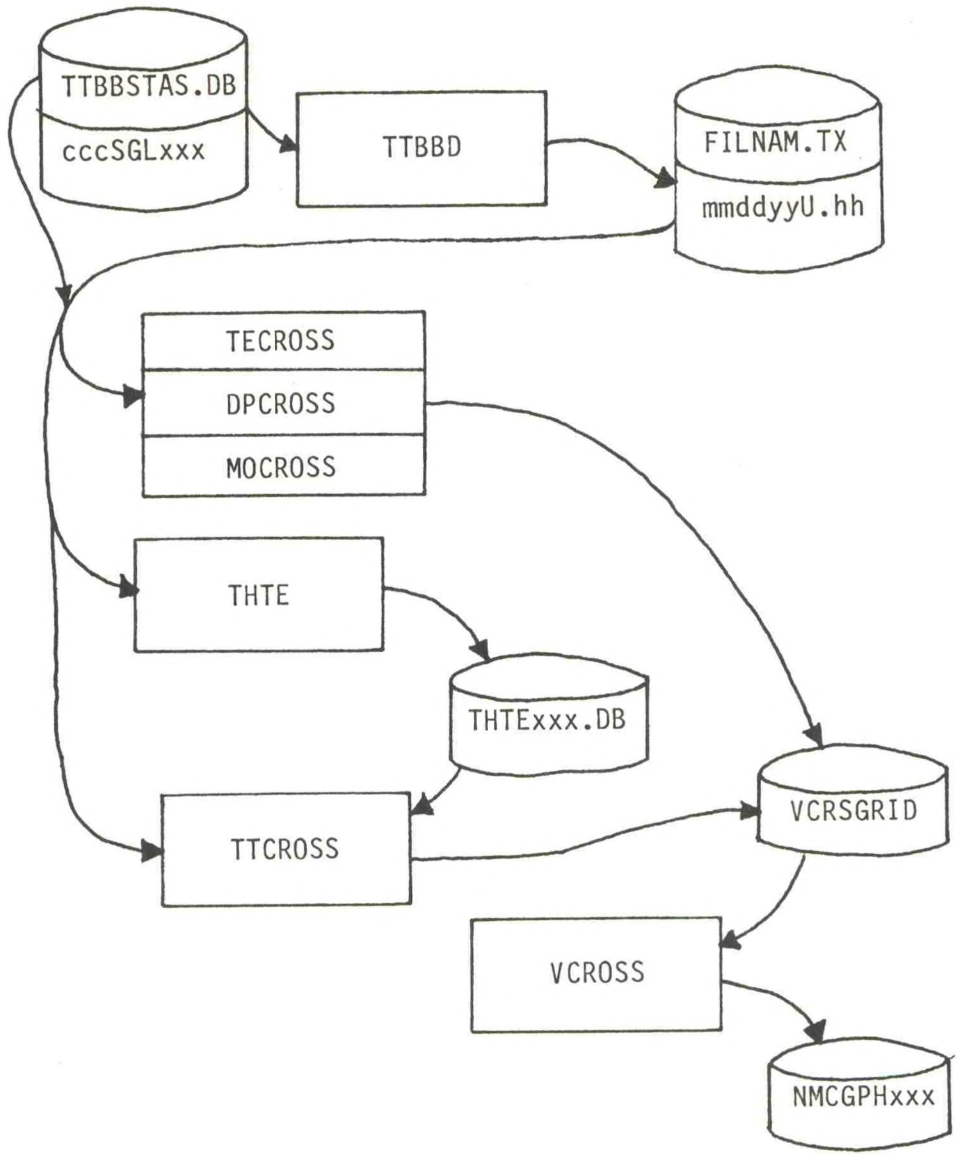
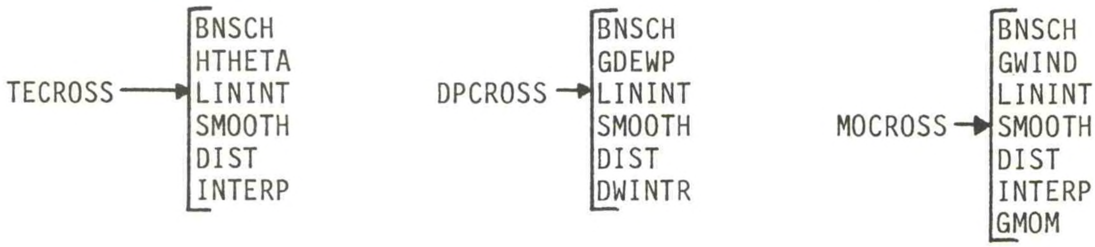
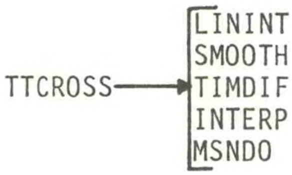


Figure 5. Data and Program Flow Illustration.

SPACE CROSS SECTION PROGRAMS

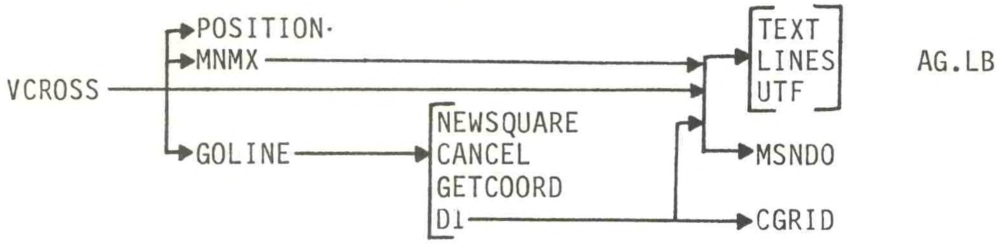


TIME CROSS SECTION PROGRAM



THETA-E TIME HISTORY FILE MAINTENANCE PROGRAM

CROSS SECTION GRAPHICS CREATION



LOAD LINES

RLDR/N/P TECROSS BNSCH HTHETA LININT SMOOTH DIST INTERP BG.LB UTIL.LB FORT.LB AFOSE.LB

RLDR/N/P DPCROSS BNSCH GDEWP LININT SMOOTH DIST DWINTR BG.LB UTIL.LB FORT.LB AFOSE.LB

RLDR/N/P MOCROSS BNSCH GWIND GMOM LININT SMOOTH DIST INTERP BG.LB UTIL.LB FORT.LB AFOSE.LB

RLDR/N/P THTE HTHETA UTIL.LB FORT.LB AFOSE.LB

RLDR/N/P TTCROSS LININT SMOOTH TIMDIF INTERP MSNDO BG.LB UTIL.LB FORT.LB AFOSE.LB

RLDR/N/P VCROSS GOLINE D1 MNMX CGRID CANCEL GETCOORD NEWSQUARE POSITION MSNDO AG.LB BG.LB UTIL.LB FORT.LB AFOSE.LB

Figure 6. Software structure and load lines.

CONVECTIVE SPATIAL CROSS SECTIONS

PART A: PROGRAM INFORMATION AND INSTALLATION PROCEDURE

PROGRAM NAMES: TECROSS.SV, DPCROSS.SV, MOCROSS.SV   REVISION NO.: 1.00

PURPOSE: These programs produce spatial cross section graphics of fields useful in prediction of convection. TECROSS.SV produces Theta-E temperature cross sections, DPCROSS.SV produces dew-point depression cross sections, and MOCROSS.SV produces momentum cross sections. These programs chain to VCROSS.SV to complete the contouring and create the AFOS graphics.

PROGRAM INFORMATION:

Development Programmer: Tim Barker
Maintenance Programmer: WRH SSD

Location:WRH/SSD
Phone: FTS 588-5131
Language: FORTRAN IV - Rev. 5.57
Save File Creation Dates
  Original Release/Rev. 1.00 - 6/16/87
Running time:Variable - Normally under 3 minutes
Disk Space:

Program Files		
TECROSS.SV	-	57 RDOS Blocks
DPCROSS.SV	-	54 RDOS Blocks
MOCROSS.SV	-	56 RDOS Blocks
VCROSS.SV	-	48 RDOS Blocks
Data Files		
VCRSGRID	-	5 RDOS Blocks

PROGRAM REQUIREMENTS:

Program Files:	Comments:
TECROSS.SV	Theta-E temperature
DPCROSS.SV	Dew-point depression
MOCROSS.SV	Momentum
VCROSS.SV	Contouring

Data Files:	Action:	Comments:
mmddyyU.hh	R	Produced by TTBBD.SV
FILNAM.TX	R	Produced by TTBBD.SV
TTBBSTAS.DB	R	TTBBD list of stations
VCRSGRID	R/W	Gridded data file

AFOS Products:	Action:	Comments:
NMCGPHECR (default)	Stored	Theta-E temperature
NMCGPHDCR (default)	Stored	Dew-point depression
NMCGPHMCR (default)	Stored	Momentum

LOAD LINES:

```
RLDR/N/P TECROSS BNSCH HTHETA LININT SMOOTH DIST INTERP BG.LB
    UTIL.LB FORT.LB AFOSE.LB
RLDR/N/P DPCROSS BNSCH GDEWP LININT SMOOTH DIST DWINTR BG.LB UTIL.LB
    FORT.LB AFOSE.LB
RLDR/N/P MOCROSS BNSCH GWIND GMOM LININT SMOOTH DIST INTERP BG.LB
    UTIL.LB FORT.LB AFOSE.LB
RLDR/N/P VCROSS GOLINE D1 MNMX CGRID CANCEL GETCOORD NEWSQUARE
    POSITION MSNDO AG.LB BG.LB UTIL.LB FORT.LB AFOSE.LB
```

PROGRAM INSTALLATION:

1. The save files (TECROSS.SV, DPCROSS.SV, MOCROSS.SV, VCROSS.SV) should be moved from the program diskette to an applications directory, and corresponding links established on the default directory.

2. The map background provided for the cross sections should be stored into the AFOS data base by typing the following at an ADM:

   STORE:DPx:MAPBACK NMCGPHBxx

   where DPx specifies which diskette drive the program diskette is in, and NMCGPHBxx specifies the map background you wish to use.

3. The AFOS products identifiers should be added to the AFOS data base either on the WISH LIST or with a PILEDIT. The default product names are:

   NMCGPHECR - Theta-E temperature
   NMCGPHDCR - Dew-point depression
   NMCGPHMCR - Momentum

   The special map background should also be keyed to these graphics.

CONVECTIVE SPATIAL CROSS SECTIONS

PART B: PROGRAM EXECUTION AND ERROR CONDITIONS

PROGRAM NAMES:TECROSS.SV, DPCROSS.SV, MOCROSS.SV   Revision No.: 1.00

PROGRAM EXECUTION:

1. These programs use nearly the same optional switches among all the programs:

```
TECROSS[/F]  [xx/I]   [xxx/O]   [nn/C]   [n/M]
DPCROSS      [xx/I]   [xxx/O]   [nn/C]   [n/M]
MOCROSS      [xx/I]   [xxx/O]   [nn/C]   [n/M]
```

The global switch /F causes Theta-E graphics to extend to the top of the graphic instead of stopping at a calculated tropopause. The local switch xx/I is used to specify the two character extension of the CROSS.xx file to be used as input. The default is CROSS.01. The local switch xxx/O is used to specify the output graphic name NMCGPHxxx. The defaults vary among the programs (TECROSS-NMCGPHECR, DPCROSS-NMCGPHDCR, MOCROSS-NMCGPHMCR). The local switch nn/C is used to specify the contouring interval. The defaults vary among the programs (TECROSS-2K, DPCROSS-2^{o}C, MOCROSS-10m/s). The local switch n/M is used to specify the number of vertical smoothing passes. The default for all of the programs is no smoothing.

2. Each of the programs can be initiated from an ADM, the Dasher, a macro, or a procedure. When the programs are initiated at an ADM, the programs will alert the ADM when the graphic is stored.

ERROR CONDITIONS:

Fatal errors can occur which will halt program execution. When these occur the ADM will alert with the message 'xxxxx ABORTED!-ERROR CONDITION: SEE DASHER', where xxxxx is the program name. The following messages will be printed at the Dasher followed by the message, 'xxxxx-- FATAL ERROR --'. For specific hints about the causes these errors refer to the Error Messages section earlier in this document.

1. INVALID INPUT FILE
2. INVALID XXX FOR OUTPUT
3. INVALID STATION IN CROSS.XX LIST
4. TOO MANY STATIONS IN CROSS.XX LIST
5. NOT ENOUGH VALID STATIONS IN CROSS.XX LIST
6. ONLY n VALID STATIONS - NOT ENOUGH TO PROCEED
7. COMMAND LINE ERROR
8. CROSS SECTIONS HAS ZERO LENGTH
9. xxxxx COULD NOT BE OPENED

In addition to fatal errors, warning messages may be printed to the Dasher during program execution. The following messages will be printed along with the name of the program in which the warning occurred. For specific hints about the causes of these warnings refer to the Error Messages section earlier in this document.

1. INVALID SWITCH
2. INVALID CONTOUR INTERVAL
3. INVALID SMOOTHING PARAMETER
4. STDIR.MS DOES NOT CONTAIN STATION xxx

CONVECTIVE TIME CROSS SECTIONS

PART A: PROGRAM INFORMATION AND INSTALLATION PROCEDURE

PROGRAM NAMES: THTE.SV, TTCROSS.SV   Revision No.: 1.00

PURPOSE: THTE.SV and TTCROSS.SV create cross sections of Theta-E temperature vs. time at a particular site. The THTE.SV program maintains a history file of Theta-E temperatures and the TTCROSS.SV program produces the graphics. Like the space cross section programs, TTCROSS.SV produces a gridded data file which is contoured by VCROSS.SV.

PROGRAM INFORMATION:

Development Programmer:
Tim Barker
Location: WRH/SSD
Phone: FTS 588-5131

Maintenance Programmer
WRH SSD

Language: FORTRAN IV Revision 5.57
Save file creation dates:
Original Release/Rev. 1.00 - 6/16/87
Running time: THTE.SV - approximately 20 seconds/station
TTCROSS.SV - variable (normally under 2 minutes)

Disk Space:

Program files		
THTE.SV	-	32 RDOS Blocks
TTCROSS.SV	-	44 RDOS Blocks
VCROSS.SV	-	48 RDOS Blocks
Data files		
THTExxx.DB	-	3 RDOS Blocks
VCRSGRID	-	5 RDOS Blocks

PROGRAM REQUIREMENTS:

Program Files:	Comments:
THTE.SV	History file maintenance
TTCROSS.SV	Time cross section
VCROSS.SV	Contouring

Data Files:	Action	Comments:
mmddyyU.hh	R	Created by TTBBD.SV
FILNAM.TX	R	Created by TTBBD.SV
TTBBSTAS.DB	R	TTBBD.SV list of stations
THTExxx.DB	R/W	History file
VCRSGRID	R/W	Gridded data file

AFOS Products:	Action	Comments:
NMCGPHTCR (default)	stored	Time cross section

LOAD LINES:

```
RLDR/N/P THTE HTHETA UTIL.LB FORT.LB AFOSE.LB
RLDR/N/P TTCROSS LININT SMOOTH TIMDIF INTERP MSNDO BG.LB UTIL.LB
     FORT.LB AFOSE.LB
```

PROGRAM INSTALLATION:

1. The save files (THTE.SV and TTCROSS.SV) should be moved from the program diskette to an applications directory, and corresponding links created on the default directory.

2. If not already done for the space cross sections, store the special map background into the AFOS data base by typing the following at an ADM:

   STORE:DPx:MAPBACK NMCGPHBxx

   where DPx specifies which diskette drive the program diskette is in, and NMCGPHBxx specifies the map background you wish to use.

3. Add the AFOS product identifier for the time cross section graphic to the AFOS data base using the WISH LIST or a PILEDIT. The default graphic name is NMCGPHTCR. The special map background should also be keyed to this graphic.

CONVECTIVE TIME CROSS SECTIONS

PART B: PROGRAM EXECUTION AND ERROR CONDITIONS

PROGRAM NAMES: THTE.SV, TTCROSS.SV REVISION NO.: 1.00

PROGRAM EXECUTION:

1. To keep the history file up to date for a station, THTE.SV should be run every time new radiosonde observations are decoded for that station using TTBBD. After TTBBD has run, THTE.SV may be initiated from an ADM, the Dasher, a macro or a procedure. The command line is:

   RUN:THTE xxx/S [xxx/S] [xxx/S] etc.

   where xxx/S specifies the three letter identifier for the station. This switch may be repeated for as many stations as is desired, but be careful not to exceed the legal length of the command line when initiating the program from an ADM.

2. TTCROSS.SV must be run to produce the time cross section graphic. The program may be initiated at an ADM, the Dasher, a macro or a procedure. The command line is:

   RUN:TTCROSS[/F] xxx/S [xxx/O] [nn/C] [n/M]

   where the global switch /F is used to force contouring of the entire graphic. When this switch is omitted, contouring ends at the warmest tropopause calculated among the observations shown on the graphic. The xxx/S switch is a mandatory switch used to specify the three letter identifier for the station desired. The xxx/O switch is an optional switch used to specify the output graphic name. The default graphic name is NMCGPHTCR. The nn/C switch is an optional switch used to specify the contouring interval (in Kelvin). The default contouring interval is 2K. The n/M switch is an optional switch used to specify the number of vertical smoothing passes desired (0-9). The default is no smoothing.

ERROR CONDITIONS:

1. Several fatal errors can occur in the THTE.SV program. These errors halt program execution and print the messages listed below followed by the message: 'THTE -- FATAL ERROR --' at the Dasher. In addition, if the program was initiated at an ADM, the ADM is alerted with the message: 'THTE ABORTED! ERROR CONDITION: SEE DASHER'. For specific hints about the possible causes of these errors refer to the Error Messages section earlier in this document.

   1. COMMAND LINE ERROR
   2. xxxxx COULD NOT BE OPENED
   3. DECODED DATA ERROR

4. HISTORY FILE ERROR

In addition to fatal errors, THTE also prints the following self-explanatory messages to the Dasher if new radiosonde data for a station could not be incorporated into the THTExxx.DB file.

1. NO LATER RAOBS FOR STATION xxx
2. RAOB NOT DECODED FOR STATION xxx
3. TTBBD DOES NOT DECODE STATION xxx

2. Several fatal errors can also occur within program TTCROSS.SV. These errors halt program execution and print the messages listed below followed by the message: 'TTCROSS -- FATAL ERROR --' at the Dasher. In addition, if the program was initiated at an ADM, the ADM is alerted with the message: 'TTCROSS ABORTED! ERROR CONDITION: SEE DASHER'. For specific hints about the causes of these error messages refer to the Error Messages section earlier in this document.

1. COMMAND LINE ERROR
2. THTEXXX.DB COULD NOT BE xxxxx
3. NO STATION SPECIFIED
4. INVALID STATION SPECIFIED
5. VCRSGRID FILE COULD NOT BE OPENED

In addition to fatal errors, several warning message may be printed to the Dasher during program execution. These warning messages are listed below. For specific hints about the causes of these error messages refer to the Error Messages section earlier in this document.

1. INVALID SWITCH
2. INVALID CONTOUR INTERVAL
3. INVALID OUTPUT FILENAME
4. INVALID SMOOTHING PARAMETER

NOAA SCIENTIFIC AND TECHNICAL PUBLICATIONS

The National Oceanic and Atmospheric Administration was established as part of the Department of Commerce on October 3, 1970. The mission responsibilities of NOAA are to assess the socioeconomic impact of natural and technological changes in the environment and to monitor and predict the state of the solid Earth, the oceans and their living resources, the atmosphere, and the space environment of the Earth.

The major components of NOAA regularly produce various types of scientific and technical information in the following kinds of publications:

PROFESSIONAL PAPERS — Important definitive research results, major techniques, and special investigations.

CONTRACT AND GRANT REPORTS — Reports prepared by contractors or grantees under NOAA sponsorship.

ATLAS — Presentation of analyzed data generally in the form of maps showing distribution of rainfall, chemical and physical conditions of oceans and atmosphere, distribution of fishes and marine mammals, ionospheric conditions, etc.

TECHNICAL SERVICE PUBLICATIONS — Reports containing data, observations, instructions, etc. A partial listing includes data serials; prediction and outlook periodicals; technical manuals, training papers, planning reports, and information serials; and miscellaneous technical publications.

TECHNICAL REPORTS — Journal quality with extensive details, mathematical developments, or data listings.

TECHNICAL MEMORANDUMS — Reports of preliminary, partial, or negative research or technology results, interim instructions, and the like.

Information on availability of NOAA publications can be obtained from:

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