NOAA Technical Memorandum NWS TDL CP 83-1

CROSS SECTIONAL ANALYSIS OF WIND SPEED
AND RICHARDSON NUMBER

Silver Spring, Md.
May 1983

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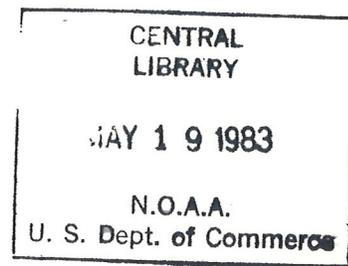
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CROSS SECTIONAL ANALYSIS OF WIND SPEED
AND RICHARDSON NUMBER

David B. Gilhousen, James E. Kemper,
and David J. Vercelli

Techniques Development Laboratory
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CROSS SECTIONAL ANALYSES OF WIND SPEED
AND RICHARDSON NUMBERS

David B. Gilhousen, James E. Kemper, and David J. Vercelli

1. INTRODUCTION

An AFOS applications program is available that prepares extensive vertical analyses of individual rawinsonde reports (Jannuzzi, 1980). The two AFOS applications programs described here combine up to ten user-selected rawinsonde reports to produce objective vertical cross sectional analyses of wind speed and Richardson numbers. The programs also generate AFOS graphics products for display on a background isentropic cross section. The cross section can be produced by running another applications program (Gilhousen and Person, 1981).

The combined product, wind speeds and Richardson numbers superimposed on an isentropic cross section, will help forecasters locate areas of clear air turbulence, strong winds, and strong wind shears (see Cahir, et al., 1976).

2. METHODOLOGY AND SOFTWARE STRUCTURE

Fig. 1 illustrates the data flow and program relationships necessary to produce isentropic cross sections for AFOS display. The decoder program, TTBBD (Gilhousen and Person, 1981), is run first, and just once, on the available significant level (cccSGLxxx) data. The cross section program, CRS (Gilhousen and Person, 1981), is run next. Fig. 2 shows an example of the AFOS display graphic (NMCGPHTM1) produced by CRS for the data date of 0000 GMT February 17, 1982. The isentropic cross section graphic (NMCGPHTM2) produced by CRS for the same date will be the background for the products of the wind speed and Richardson number programs, which are next to be run in the series of cross section programs.

The wind speed analysis program, WSANAL, and the Richardson number analysis program, RICHNO, both read the observed data processed by the cross section program, CRS. The station locations relative to the section are read from the CRS-produced file COEF.DT. The station data, composed of pressures, temperatures, dewpoints, winds, and elevation, are read from the file CRSRD.DT, also produced by CRS. To prepare another cross section for a different set of stations, the cross section program, CRS, must be rerun for the new combination of stations.

The analysis grid for WSANAL and RICHNO is the grid adopted in CRS. It is a vertical projection with the base near the ground. The vertical coordinate is linear in the natural logarithm of pressure extending from a pressure of 1050 mb at the base to 100 mb at the top. Horizontally, the coordinate is linear distance along the path of the cross section. Grid points are equally spaced in each coordinate direction.

A. Wind speed analysis program: WSANAL

After reading the observed data, WSANAL assigns each wind sounding to the nearest grid column in the section. In the columns with assigned data, the

winds are linearly interpolated in height to grid points. Since the vertical coordinate of the section is the logarithm of pressure and the heights of the grid points are required for the interpolation, hydrostatics are used to find the heights.

Wind speeds for grid points in columns not having assigned soundings are determined by a distance weighted combination of grid point data from columns with assigned data. Speeds for grid points in the columns with assigned data for which vertical interpolation was not possible are also determined this way. The Cressman (1959) weight function,

$$W(d) = (D^2 - d^2)/(D^2 + d^2)$$

defines the weighting, where D is the limiting distance beyond which W is zero, and d is the separation between a grid point with interpolated data and the grid point without data. The influence area for W is elliptical with respect to a displayed cross section (see Fig. 3). The major axis is along the horizontal and the length of the axis is a function of the number of stations in the section. The length of the minor axis is set to two grid intervals. The selection of an elliptical influence area is motivated by the apparent larger correlation in the horizontal than in the vertical for winds. No attempt was made to define a ratio of the lengths of the axes that was representative of actual atmospheric structure. If no data are available within the influence area for a grid point, the length of the axes is doubled for that point. After all grid points have wind speeds, the grid values are smoothed with a simple 3 point filter. The filtering operation is performed first in one coordinate direction, then in the other, with the relative weighting 1-4-1. The boundary points are adjusted only along the boundary. The corners of the grid are not adjusted.

The output graphics product, NMCGPHTM3, is stored first on DPO. Then a call to FSTOR (from the BG.LB) is made to store the product into the AFOS database. An attempt is made to delete the copy of TM3 from DPO after the return from a successful call to FSTOR. However, if the file is still in use as part of the call to FSTOR, the delete cannot be performed, and the file remains on DPO.

Fig. 3 shows an example of the isotachs produced by WSANAL on an isentropic cross section. The isotachs are labeled in small numerals at both sides of the cross section and at field maxima and minima.

The cross section shown in Fig. 3 runs from PIA (2532) to CHS (2208) and indicates a jet core of greater than 45 m/s over BNA (2327). There is also a secondary maximum centered over AHN (2311). The isentropes in the troposphere slope gently downward from SLO (2433) to AHN, showing a large scale weak frontal surface.

        B. Richardson Number Analysis Programs: RICHNO and RIANAL

RICHNO calculates the Richardson number, defined as

$$Ri = \frac{g}{\theta} \frac{\Delta\theta}{\Delta z} \Big/ \left(\frac{\Delta v}{\Delta z}\right)^2$$

where $\overline{\theta}$ is the average potential temperature in a layer, and $\Delta\theta$ and Δv are the differences in potential temperature and wind speed over a vertical increment Δz. The computed numbers are restricted to the interval 0 to 3.

The program assigns each sounding to the nearest grid column and calculates the wind shear over the reported height intervals. The potential temperature shear is calculated over the reported pressure intervals nearest to each wind interval. The Δz for the pressure intervals is determined hydrostatically. The Richardson numbers are calculated from these shears. Each number is given a vertical position in terms of a representative pressure for the height interval.

RICHNO then chains to RIANAL which maps the computed Richardson numbers to the cross section grid. Each number is assigned to the nearest vertical grid point. "Nearest" is judged by finding the smallest difference between the representative pressures defined in RICHNO and the grid point pressure. Values for grid points not having assigned data are determined the same way as in WSANAL--a distance weighted combination of grid point data available after the vertical assignment step. Smoothing passes with a 1-4-1 filter, as in WSANAL, are made after all grid points have values. Also as in WSANAL, the output graphics product, NMCGPHTM4, is stored first on DPO, and then sent to the AFOS database via a call to FSTOR. The program attempts to delete TM4 from DPO if the call to FSTOR is made successfully. If the file is in use because of the call to FSTOR, the delete cannot be performed, and the file remains on DPO.

Cahir, et al. (1976) found that analyzed Richardson numbers less than 1.5 enclosed areas where aircraft reported moderate and severe turbulence. The Richardson number analysis produced by RICHNO differs slightly from Cahir's, so the critical value may be different. Fig. 4 shows a RICHNO analysis of Richardson number overlaid on an isentropic cross section. The computed values have been multiplied by 10 and contoured every 10 starting at 5, so that the Cahir critical value is less than 15.

The Richardson number contours in Fig. 4, shown on the same isentropic cross section as in Fig. 3, suggest two areas for turbulence. A small region at 300-mb over AHN (2311) and a region near 600-mb over BNA (2327) contain values less than 15. The values above 200-mb should be ignored (see Section 3).

Richardson numbers are very sensitive to the method of calculation and the resolution of the upper air data (Dutton and Panofsky, 1970). Consequently, Richardson numbers, as calculated by RICHNO, have to be regarded as an approximation to a large scale number. This is because the vertical shears are calculated over depths of several hundred meters.

With these limitations in mind, the diagnostic value of the Richardson numbers in Fig. 4 is the indication of a higher likelihood of turbulence at 300-mb over AHN (Ri=1.3) than at 300-mb over BNA (Ri=2.7). Looking at just the wind speeds in Fig. 3, a forecaster may not have reached such a conclusion.

C. Graphical Contouring

Contouring for both WSANAL and RICHNO is done in subroutine CNTR3. It applies the same approach to contouring as CONTUR (Gilhousen, 1980), providing the added features of labeling the product and drawing the contours in the vicinity of cols.

3. CAUTIONS

Because the analysis grid extends to 100 mb, occasionally exceeding the height of some rawinsonde reports, there may not be reliable analyses produced near the top of the cross section. Consequently, the primary utility of this product is within and slightly above the troposhere.

The critical values for the Richardson numbers produced by this analysis have not been determined. Forecaster experience will be the best guide until such determinations have been made.

4. REFERENCES

Cahir, J. J., J. Norman, W. Lottes, and J. Toth, 1976: New tools for fore-casters: Real-time cross sections produced in the field. Bull. Amer. Meteor. Soc., 57, 1426-1433.

Cressman, G. P., 1959: An operational objective analysis system. Mon. Wea. Rev., 87, 367-374.

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Gilhousen, D. B., 1980: "CONTUR"--A program to contour a field for GDM display. Unpublished manuscript, Integrated Systems Laboratory, National Weather Service, NOAA, U.S. Department of Commerce, 20 pp.

_____, and A. Person, 1981: Isentropic cross sections for AFOS. ISL Office Note 81-2, National Weather Service, NOAA, U.S. Department of Commerce, 13 pp.

Jannuzzi, J. A., 1980: RAOB plot and analysis routines. NOAA Western Region Computer Programs and Problems NWS WRCP-No. 8, NOAA, U.S. Department of Commerce, 43 pp.

Person, A. A., and D. B. Gilhousen, 1980: "An enhanced AFOS graphics library". Unpublished manuscript, Integrated Systems Laboratory, National Weather Service, NOAA, U.S. Department of Commerce, 9 pp.

5. PROGRAM INFORMATION and PROCEDURES for INSTALLATION and EXECUTION

CROSS SECTIONAL ANALYSIS OF WIND SPEED

PART A: PROGRAM INFORMATION and INSTALLATION PROCEDURE

PROGRAM NAME: WSANAL   AAL ID: MOH002
                                                       Revision no.: 01.00

FUNCTION: Produces isotachs for overlaying on an isentropic cross section that
          has been previously generated by applications program CRS (AAL ID:
          MOH001). Creates a local use graphics product stored on both DPO and
          in the AFOS database.

PROGRAM INFORMATION:

Development Programmer(s):   Maintenance Programmer(s):

  David B. Gilhousen   James E. Kemper
  James E. Kemper
  David J. Vercelli   Location: Techniques Development
                                                    Laboratory
Location: Techniques Development   Phone: FTS - 427-8065
            Laboratory
Phone: FTS - 427-7639

Language: FORTRAN IV/ Rev 5.20   Type: Standard program.

Save file creation dates:
  Original release/ Revision 01.00   -   July 28, 1982

Running time: About one minute

Disk space: Program files   -   57 RDOS blocks
             Data files   -   52 RDOS blocks

PROGRAM REQUIREMENTS

Program files:
  NAME   COMMENTS

  WSANAL.SV

Data files:

NAME	DP location	READ/WRITE	COMMENTS
COEF.DT	DPO	R	Created by CRS.
CRSRD.DT	DPO	R	Created by CRS.
NMCGPHTM3	DPO	W	Created by program, may remain on disk.

AFOS Products:

ID	ACTION	COMMENTS
NMCGPHTM3	Stored	TM3 can be selected by the user at runtime. Default is TM3=T67.

LOAD LINE

RLDR WSANAL RDCOEF CRSSET SMOOTH CNTR3 COLPT MAXMN1 LABEL ASCII GRS.LB
    BG.LB UTIL.LB FORT.LB

PROGRAM INSTALLATION

1. Move the program file, WSANAL.SV, to an operational disk pack. Create
    links on DPO to WSANAL.SV if it is not going to be on DPO.

2. Both the significant level data decoder, TTBBD (AAL ID: DBC002, ISL OFFICE
    NOTE 81-1), and the isentropic cross section generator, CRS (AAL ID:
    MOH001, ISL OFFICE NOTE 81-2), need to be run before WSANAL. WSANAL
    expects to use two data files on DPO, COEF.DT and CRSRD.DT, generated by
    CRS. If the two files aren't on DPO when WSANAL is to be run, be sure to
    establish links on DPO to the files.

3. Make sure the appropriate key for the output graphics product is in the
    PIL. The program expects to use a temporary graphics key, NMCGPHTM3 with
    the slot number (TM3) defined either by the user at run time or, by default,
    as T67.

CROSS SECTIONAL ANALYSIS OF WIND SPEED

PART B: PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME: WSANAL   AAL ID: MOH002
                                              Revision no.: 01.00

PROGRAM EXECUTION

1. Run the upper air decoder, TTBBD (AAL ID: DBC002). The decoder has
   to be run only once for a particular cycle.

2. Run the cross section program, CRS (AAL ID: MOH001), which will create
   current CRSRD.DT and COEF.DT files on DPO requiring about 18 RDOS blocks.

3. From an ADM, enter: RUN:WSANAL TM3 N/I

   TM3 specifies the output product identifier as part of NMCGPHTM3.
   If TM3 is omitted, the program assumes TM3=T67. The I switch sets the
   isotach contour interval to N m/s. If N/I is omitted, N is assumed
   to be 5.

   For a different set of stations to form another cross section, CRS
   must be rerun to generate the appropriate data. WSANAL is then
   rerun on the newly written data files, CRSRD.DT and COEF.DT.

   The message "JOB WSANAL COMPLETED--PRODUCT NMCGPHTM3 STORED" will appear
   at the initiating ADM when the job is successfully completed.

   The file NMCGPHTM3 is created on DPO by the program and the contents
   are stored into the AFOS database. The file is deleted from DPO by
   the program, unless the storing process isn't finished when the delete
   command is issued. If that happens, it has to be manually deleted.

7

ERROR CONDITIONS

Error conditions other than those listed here, appearing at the Dasher, denote problems that occur while accessing files, most likely caused by system/disk problems rather than program failures. Check the RDOS error code and rerun WSANAL if appropriate.

ADM MESSAGES	MEANING
1- "JOB ABORTED--ERROR CONDITION: CRSRD.DT MSG"	CRSRD.DT probably does not exist. Check to see if it's either on DPO or on DPOF with a link to it on DPO. If it is, there's a system problem. If it isn't, run program CRS to a successful completion, then rerun WSANAL.
2- "JOB ABORTED--ERROR CONDITION: COEF.DT MSG"	COEF.DT probably does not exist. Check to see if it's either on DPO or on DPOF with a link to it on DPO. If it is, there's a system problem. If it isn't, run program CRS to a successful completion, then rerun WSANAL.
3- "JOB WSANAL ABORTED--ERROR CONDITION: FSTOR PBLMS"	Error occurred while trying to store TM3 into the AFOS database. If a copy of NMCGPHTM3 is on DPO, display from there. Otherwise, rerun WSANAL.

DASHER MESSAGES	MEANING
1- "SOMETHING WRONG WITH REPORTED SURFACE PRESSURE--NOT WITHIN GRID-- SKIPPING TO NEXT REPORT"	Probable observation or coding error. Program fix is automatic-- complete wind report eliminated from the wind speed analysis.

CROSS SECTIONAL ANALYSIS OF RICHARDSON NUMBER

PART A: PROGRAM INFORMATION and INSTALLATION PROCEDURE

PROGRAM NAME: RICHNO   AAL ID: MOHOO3
                                                 Revision no.: 01.00

FUNCTION: Produces Richardson number analysis for overlaying on an isentropic
            cross section that has been previously generated by applications
            program CRS (AAL ID: MOHOO1). Creates a local use graphics product
            stored on DPO and also in the AFOS database.

PROGRAM INFORMATION:

Development Programmer(s):   Maintenance Programmer(s):

  David B. Gilhousen   James E. Kemper
  James E. Kemper
  David J. Vercelli   Location: Techniques Development
                                                    Laboratory
Location: Techniques Development   Phone: FTS - 427-8065
            Laboratory
Phone: FTS - 427-7639

Language: FORTRAN IV/ Rev 5.20   Type: Complete program with
                                                 a chain to RIANAL.SV

Save file creation dates: RICHNO.SV
   Original release/ Rev 01.00   –   July 7, 1982

Save file creation dates: RIANAL.SV
   Original release/ Rev 01.00   –   July 28, 1982

Running time: About one minute

Disk space: Program files   –   63 RDOS blocks
             Data files   –   33 RDOS blocks

PROGRAM REQUIREMENTS

Program files:
  NAME   COMMENTS

  RICHNO.SV   RICHNO chains to RIANAL.
  RIANAL.SV

Data files:

NAME	DP location	READ/WRITE	COMMENTS
COEF.DT	DPO	R	Created by CRS.
CRSRD.DT	DPO	R	Created by CRS.
NMCGPHTM4	DPO	W	Created by program, may remain on disk.

AFOS Products:

ID	ACTION	COMMENTS
. NMCGPHTM4	Stored	TM4 can be selected by the user at runtime. Default is TM4=T68.

LOAD LINE

RICHNO: RLDR RICHNO RDCOEF BG.LB UTIL.LB FORT.LB
RIANAL: RLDR RIANAL CRSSET SMOOTH CNTR3 COLPT MAXMN1 LABEL ASCII GRS.LB
         UTIL.LB FORT.LB

PROGRAM INSTALLATION

1. Move the program files, RICHNO.SV and RIANAL.SV, to an operational disk
    pack. Create links on DP0 to RICHNO.SV and RIANAL.SV if they are not going
    to be on DP0.

2. Both the significant level data decoder, TTBBD (AAL ID: DBC002, ISL OFFICE
    NOTE 81-1), and the isentropic cross section generator, CRS (AAL ID:
    MOH001, ISL OFFICE NOTE 81-2), need to be run before RICHNO. RICHNO
    expects to use two data files on DP0, COEF.DT and CRSRD.DT, generated by
    CRS. If the two files aren't on DP0 when RICHNO is to be run, be sure to
    establish links on DP0 to the files.

3. Make sure the appropriate key for the output graphics product is in the
    PIL. The program expects to use a temporary graphics key, NMCGPHTM4 with
    the slot number (TM4) defined either by the user at run time or, by default,
    as T68.

CROSS SECTIONAL ANALYSIS OF RICHARDSON NUMBER

PART B: PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME: RICHNO   AAL ID: MOH003
                                              Revision no.: 01.00

PROGRAM EXECUTION

1. Run the upper air decoder, TTBBD (AAL ID: DBC002). The decoder has
   to be run only once for a particular cycle.

2. Run the cross section program, CRS (AAL ID: MOH001), which will create
   current CRSRD.DT and COEF.DT files on DPO requiring about 18 RDOS blocks.

3. From an ADM, enter: RUN:RICHNO TM4

   TM4 specifies the output product identifier as part of NMCGPHTM4.
   If TM4 is omitted, the program assumes TM4=T68.

   For a different set of stations to form another cross section, CRS
   must be rerun to generate the appropriate data. RICHNO is then
   rerun on the newly written data files, CRSRD.DT and COEF.DT.

   The message "JOB RICHNO COMPLETED--PRODUCT NMCGPHTM4 STORED" will appear
   at the initiating ADM when the job is successfully completed.

   The file NMCGPHTM4 is created on DPO by the program and the contents
   are stored into the AFOS database. The file is deleted from DPO by
   the program, unless the storing process isn't finished when the delete
   command is issued. If that happens, it has to be manually deleted.

ERROR CONDITIONS

   Error conditions other than those listed here, appearing at the Dasher,
   denote problems that occur while accessing files, most likely caused by
   system/disk problems rather than program failures. Check RDOS error code and
   rerun program if appropriate.

ADM MESSAGES	MEANING
1- "JOB ABORTED--ERROR CONDITION: COEF.DT MSG"	COEF.DT probably does not exist. Check to see if it's either on DPO or on DPOF with a link to it on DPOF. If it is, there's a system problem. If it isn't, rerun program CRS to a successful completion, then rerun RICHNO.

2- "JOB RICHNO ABORTED--ERROR CONDITION: CRSRD.DT probably does not exist.
    CRSRD.DT MSG"   Check to see if it's either on DPO
or on DPOF with a link to it on DPOF.
If it is, there's a system problem.
If it isn't, rerun program CRS to a
successful completion, then rerun
RICHNO.

3- "JOB RICHNO ABORTED--ERROR CONDITION: Error occurred while trying to
    FSTOR PBLMS"   store TM4 into the AFOS database.
If a copy of NMCGPHTM4 is on DPO,
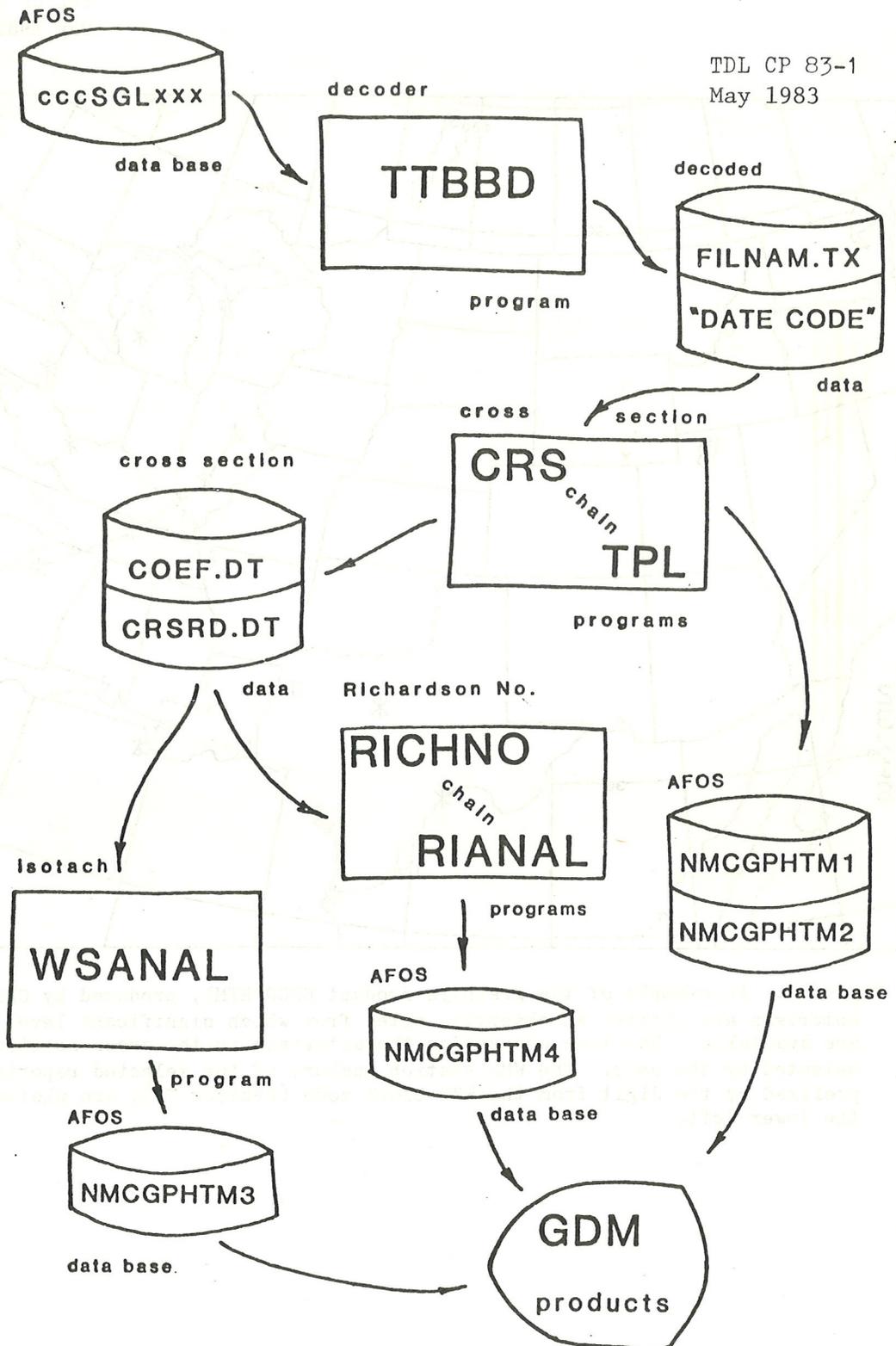display from there. Otherwise,
rerun RICHNO.

Figure 1. Data flow and program relationships for the programs in the cross section series. Program names are inside boxes. Disk and AFOS data sets are indicated by a disk platter symbol with the name of the set inside the symbol. The actual label for the decoded data, indicated by "Date code", is formed by TTBBD at runtime and stored in FILNAM.TX.
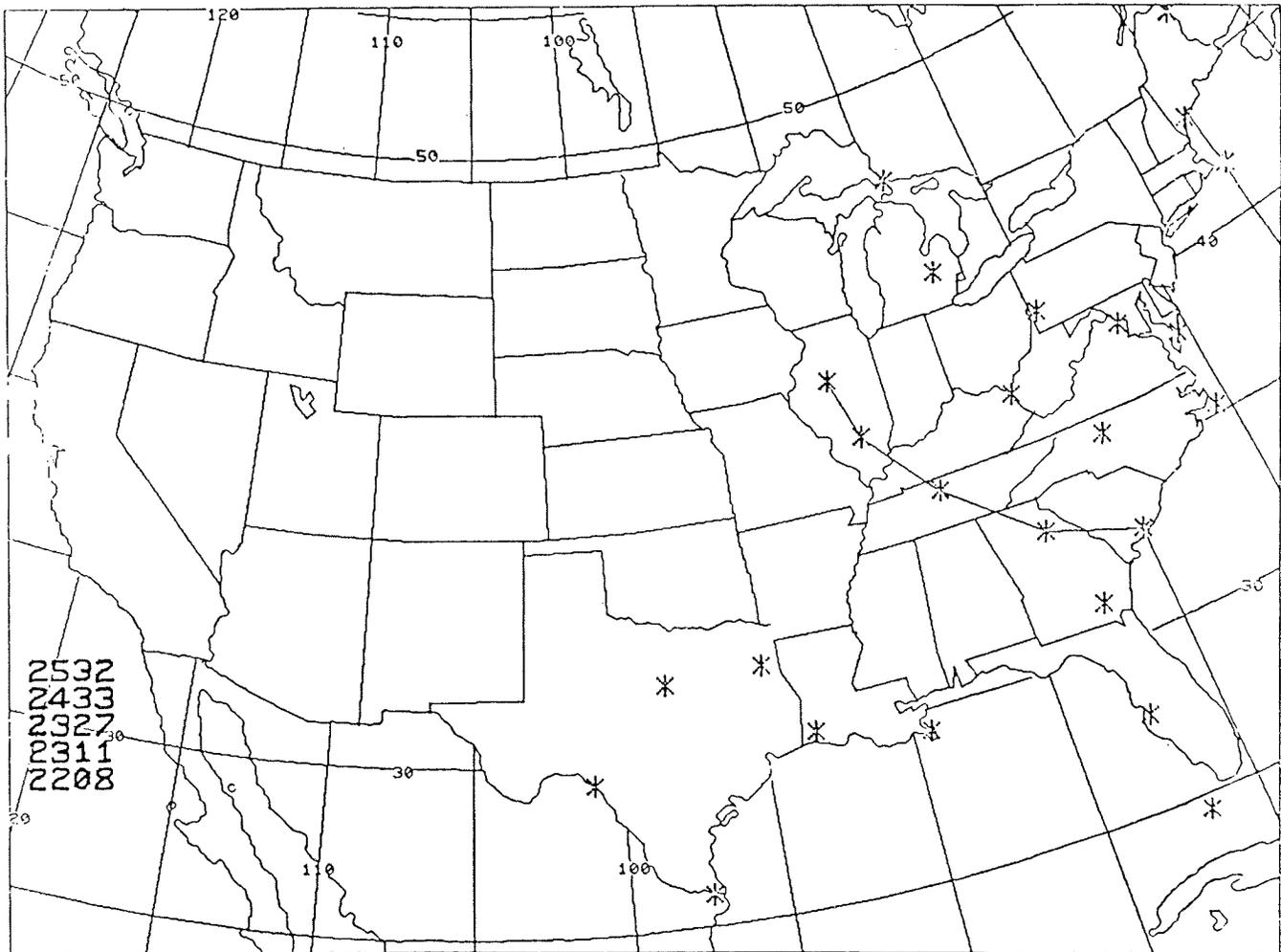
13

Figure 2. An example of the graphics product NMCGPHTM1, produced by CRS. The asterisks are plotted at observing sites from which significant level data are available. The line connecting the asterisks is the cross section path selected by the user. The WMO station numbers of the selected reports, prefixed by the digit from the WMO block code (2=block 72), are plotted at the lower left.
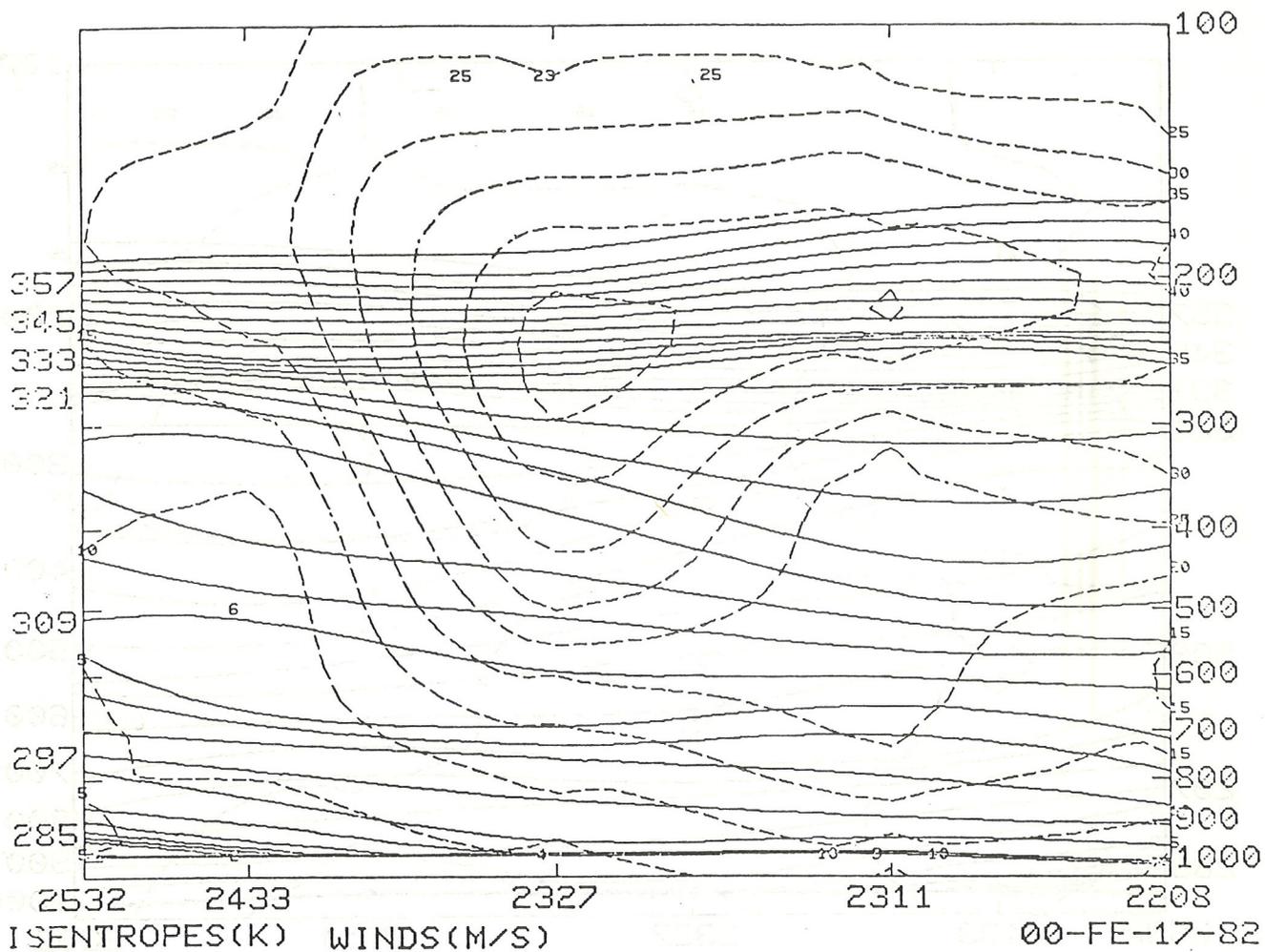
Figure 3. Isentropes (solid contours) and wind speeds (dashed contours) for the cross section indicated in Fig. 2. The data are for 0000 GMT February 17, 1982. This is graphics product NMCGPHTM3 (dashed) overlaid on NMCGPHTM2 (solid).
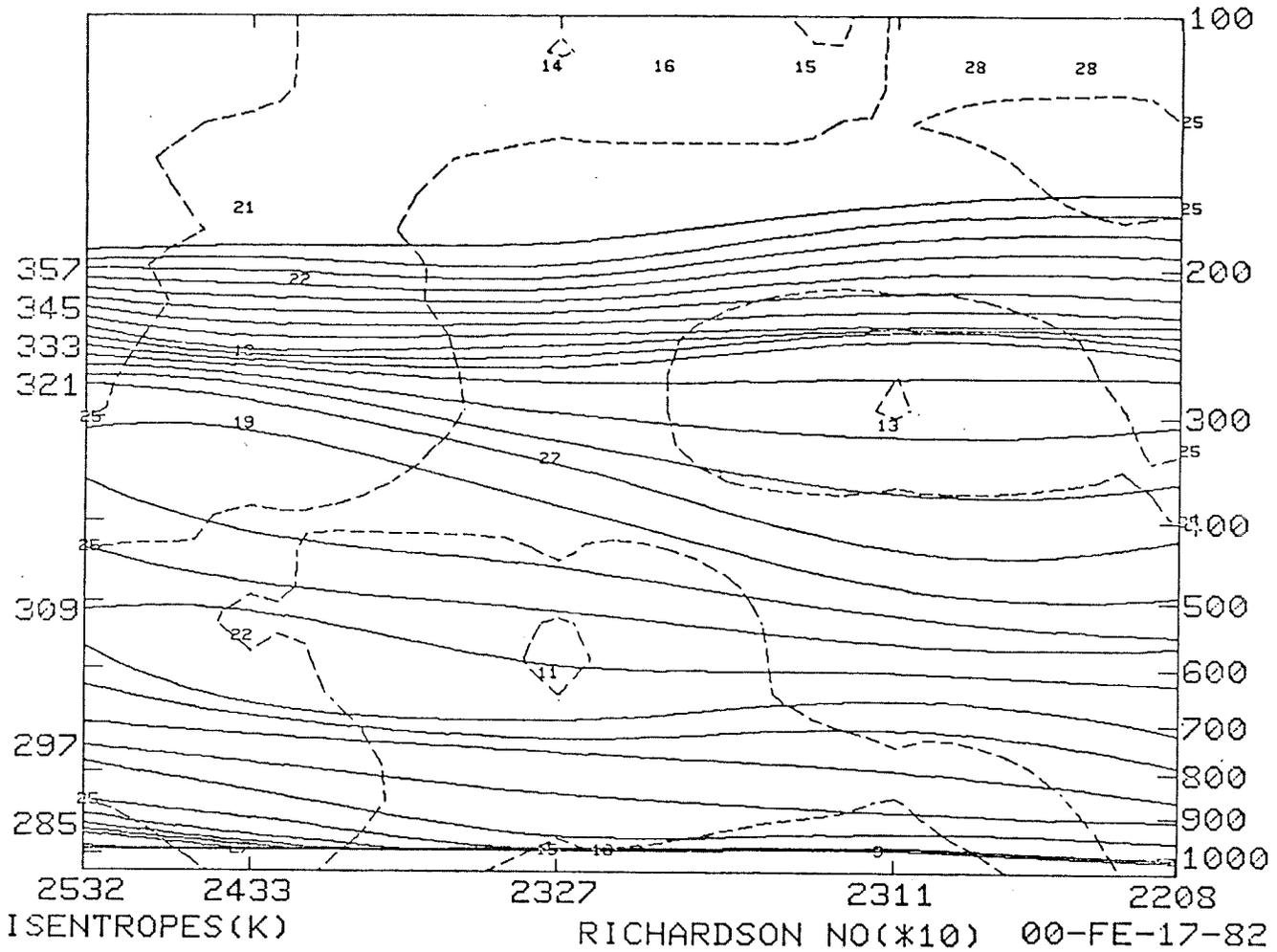
15

Figure 4. Isentropes (solid contours) and contours of Richardson number (dashed) for the cross section indicated in Fig. 2. Richardson numbers have been multiplied by 10. The data are for 0000 GMT February 17, 1982. This is graphics product NNCGPHTM4 (dashed) overlaid on NMCGPHTM2 (solid).

WSANAL

MAIN PROGRAM

    WSANAL

    SUBROUTINES
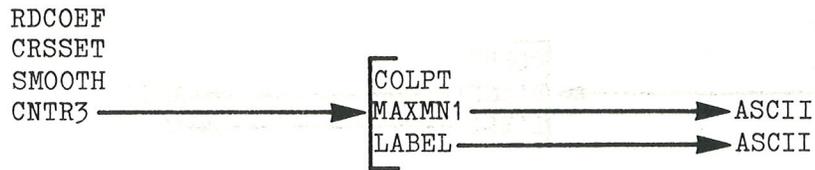
```
    RDCOEF
    CRSSET          ┌COLPT
    SMOOTH          │MAXMN1 ────────▶ ASCII
    CNTR3 ─────────▶│LABEL ─────────▶ ASCII
                    └
```

LOAD LINE

    RLDR WSANAL RDCOEF CRSSET SMOOTH CNTR3 COLPT MAXMN1 LABEL
       ASCII GRS.LB BG.LB UTIL.LB FORT.LB

RICHNO

MAIN PROGRAM

    RICHNO

    SUBROUTINES

    RDCOEF

LOAD LINE

    RLDR RICHNO RDCOEF BG.LB UTIL.LB FORT.LB

Figure 5. Software structure and load line for programs
WSANAL and RICHNO.

RIANAL

MAIN PROGRAM

   RIANAL

   SUBROUTINES


```
CRSSET
SMOOTH                    ┌COLPT
CNTR3  ─────────────────▶ │MAXMN1 ─────────────────▶ ASCII
                          │LABEL  ─────────────────▶ ASCII
                          └
```

LOAD LINE

   RLDR RIANAL CRSSET SMOOTH CNTR3 COLPT MAXMN1 LABEL ASCII
      GRS.LB BG.LB UTIL.LB FORT.LB

Figure 6. Software structure and load line for program
  RIANAL.

CROSS SECTIONAL ANALYSIS OF WIND SPEED

PART A: PROGRAM INFORMATION and INSTALLATION PROCEDURE

PROGRAM NAME: WSANAL   AAL ID: MOH002
                                        Revision no.: 01.00

FUNCTION: Produces isotachs for overlaying on an isentropic cross section that
            has been previously generated by applications program CRS. Creates a
            local use graphics product stored on both DPO and in the AFOS
            database.

PROGRAM INFORMATION:

Development Programmer(s):   Maintenance Programmer(s):

  David B. Gilhousen   James E. Kemper
  James E. Kemper
  David J. Vercelli   Location: Techniques Development
                                                  Laboratory
Location: Techniques Development   Phone: FTS - 427-8065
            Laboratory
Phone: FTS - 427-7639

Language: FORTRAN IV/ Rev 5.20   Type: Standard program.

Save file creation dates:
  Original release/ Revision 01.00   -   July 28, 1982

Running time: About one minute

Disk space: Program files   -   57 RDOS blocks
             Data files   -   52 RDOS blocks

PROGRAM REQUIREMENTS

Program files:
  NAME   COMMENTS

  WSANAL.SV

Data files:

NAME	DP location	READ/WRITE	COMMENTS
COEF.DT	DPO	R	Created by CRS.
CRSRD.DT	DPO	R	Created by CRS.
NMCGPHTM3	DPO	W	Created by program, may remain on disk.

AFOS Products:

ID	ACTION	COMMENTS
NMCGPHTM3	Stored	TM3 can be selected by the user at runtime. Default is TM3=T67.

LOAD LINE

      RLDR WSANAL RDCOEF CRSSET SMOOTH CNTR3 COLPT MAXMN1 LABEL ASCII GRS.LB
          BG.LB UTIL.LB FORT.LB

PROGRAM INSTALLATION

1. Move the program file, WSANAL.SV, to an operational disk pack. Create
    links on DPO to WSANAL.SV if it is not going to be on DPO.

2. Both the significant level data decoder, TTBBD (AAL ID: DBC002, ISL OFFICE
    NOTE 81-1), and the isentropic cross section generator, CRS (AAL ID:
    MOH001, ISL OFFICE NOTE 81-2), need to be run before WSANAL. WSANAL
    expects to use two data files on DPO, COEF.DT and CRSRD.DT, generated by
    CRS. If the two files aren't on DPO when WSANAL is to be run, be sure to
    establish links on DPO to the files.

3. Make sure the appropriate key for the output graphics product is in the
    PIL. The program expects to use a temporary graphics key, NMCGPHTM3 with
    the slot number (TM3) defined either by the user at run time or, by default,
    as T67.

CROSS SECTIONAL ANALYSIS OF WIND SPEED

PART B: PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME: WSANAL   AAL ID: MOHOO2

Revision no.: 01.00

PROGRAM EXECUTION

1. Run the upper air decoder, TTBBD (AAL ID: DBCOO2). The decoder has
   to be run only once for a particular cycle.

2. Run the cross section program, CRS (AAL ID: MOHOO1), which will create
   current CRSRD.DT and COEF.DT files on DPO requiring about 18 RDOS blocks.

3. From an ADM, enter: RUN:WSANAL TM3 N/I

   TM3 specifies the output product identifier as part of NMCGPHTM3.
   If TM3 is omitted, the program assumes TM3=T67. The I switch sets the
   isotach contour interval to N m/s. If N/I is omitted, N is assumed
   to be 5.

   For a different set of stations to form another cross section, CRS
   must be rerun to generate the appropriate data. WSANAL is then
   rerun on the newly written data files, CRSRD.DT and COEF.DT.

   The message "JOB WSANAL COMPLETED--PRODUCT NMCGPHTM3 STORED" will appear
   at the initiating ADM when the job is successfully completed.

   The file NMCGPHTM3 is created on DPO by the program and the contents
   are stored into the AFOS database. The file is deleted from DPO by
   the program, unless the storing process isn't finished when the delete
   command is issued. If that happens, it has to be manually deleted.

ERROR CONDITIONS

Error conditions other than those listed here, appearing at the Dasher,
denote problems that occur while accessing files, most likely caused by
system/disk problems rather than program failures. Check the RDOS error
code and rerun WSANAL if appropriate.

ADM MESSAGES	MEANING
1- "JOB ABORTED--ERROR CONDITION: CRSRD.DT MSG"	CRSRD.DT probably does not exist. Check to see if it's either on DPO or on DPOF with a link to it on DPO. If it is, there's a system problem. If it isn't, run program CRS to a successful completion, then rerun WSANAL.
2- "JOB ABORTED--ERROR CONDITION: COEF.DT MSG"	COEF.DT probably does not exist. Check to see if it's either on DPO or on DPOF with a link to it on DPO. If it is, there's a system problem. If it isn't, run program CRS to a successful completion, then rerun WSANAL.
3- "JOB WSANAL ABORTED--ERROR CONDITION: FSTOR PBLMS"	Error occurred while trying to store TM3 into the AFOS database. If a copy of NMCGPHTM3 is on DPO, display from there. Otherwise, rerun WSANAL.

DASHER MESSAGE	
1- "SOMETHING WRONG WITH REPORTED SURFACE PRESSURE--NOT WITHIN GRID-- SKIPPING TO NEXT REPORT"	Probable observation or coding error. Program fix is automatic-- complete wind report eliminated from the wind speed analysis.

CROSS SECTIONAL ANALYSIS OF RICHARDSON NUMBER

PART A: PROGRAM INFORMATION and INSTALLATION PROCEDURE   .

PROGRAM NAME: RICHNO   AAL ID: MOHO03
                                                       Revision no.: 01.00

FUNCTION: Produces Richardson number analysis for overlaying on an isentropic
            cross section that has been previously generated by applications
            program CRS (AAL ID: MOHO01). Creates a local use graphics product
            stored on DPO and also in the AFOS database.

PROGRAM INFORMATION:

  Development Programmer(s):   Maintenance Programmer(s):

   David B. Gilhousen   James E. Kemper
   James E. Kemper
   David J. Vercelli   Location: Techniques Development
                                                    Laboratory
   Location: Techniques Development   Phone: FTS - 427-8065
               Laboratory
   Phone: FTS - 427-7639

   Language: FORTRAN IV/ Rev 5.20   Type: Complete program with
                                                 a chain to RIANAL.SV

   Save file creation dates: RICHNO.SV
      Original release/ Rev 01.00   -   July 7, 1982

   Save file creation dates: RIANAL.SV
      Original release/ Rev 01.00   -   July 28, 1982

   Running time: About one minute

   Disk space: Program files   -   63 RDOS blocks
                Data files   -   33 RDOS blocks

PROGRAM REQUIREMENTS

  Program files:
    NAME   COMMENTS

    RICHNO.SV   RICHNO chains to RIANAL.
    RIANAL.SV

  Data files:

NAME	DP location	READ/WRITE	COMMENTS
COEF.DT	DPO	R	Created by CRS.
CRSRD.DT	DPO	R	Created by CRS.
NMCGPHTM4	DPO	W	Created by program, may remain on disk.

AFOS Products:

ID	ACTION	COMMENTS
NMCGPHTM4	Stored	TM4 can be selected by the user at runtime. Default is TM4=T68.

LOAD LINE

```
RICHNO:  RLDR RICHNO RDCOEF BG.LB UTIL.LB FORT.LB
RIANAL:  RLDR RIANAL CRSSET SMOOTH CNTR3 COLPT MAXMN1 LABEL ASCII GRS.LB
         UTIL.LB FORT.LB
```

PROGRAM INSTALLATION

1. Move the program files, RICHNO.SV and RIANAL.SV, to an operational disk pack. Create links on DPO to RICHNO.SV and RIANAL.SV if they are not going to be on DPO.

2. Both the significant level data decoder, TTBBD (AAL ID: DBC002, ISL OFFICE NOTE 81-1), and the isentropic cross section generator, CRS (AAL ID: MOH001, ISL OFFICE NOTE 81-2), need to be run before RICHNO. RICHNO expects to use two data files on DPO, COEF.DT and CRSRD.DT, generated by CRS. If the two files aren't on DPO when RICHNO is to be run, be sure to establish links on DPO to the files.

3. Make sure the appropriate key for the output graphics product is in the PIL. The program expects to use a temporary graphics key, NMCGPHTM4 with the slot number (TM4) defined either by the user at run time or, by default, as T68.

CROSS SECTIONAL ANALYSIS OF RICHARDSON NUMBER

PART B: PROGRAM EXECUTION and ERROR CONDITIONS

PROGRAM NAME: RICHNO   AAL ID: MOH003
                                                  Revision no.: 01.00

PROGRAM EXECUTION

1. Run the upper air decoder, TTBBD (AAL ID: DBC002). The decoder has
   to be run only once for a particular cycle.

2. Run the cross section program, CRS (AAL ID: MOH001), which will create
   current CRSRD.DT and COEF.DT files on DPO requiring about 18 RDOS blocks.

3. From an ADM, enter: RUN:RICHNO TM4

   TM4 specifies the output product identifier as part of NMCGPHTM4.
   If TM4 is omitted, the program assumes TM4=T68.

   For a different set of stations to form another cross section, CRS
   must be rerun to generate the appropriate data. RICHNO is then
   rerun on the newly written data files, CRSRD.DT and COEF.DT.

   The message "JOB RICHNO COMPLETED--PRODUCT NMCGPHTM4 STORED" will appear
   at the initiating ADM when the job is successfully completed.

   The file NMCGPHTM4 is created on DPO by the program and the contents
   are stored into the AFOS database. The file is deleted from DPO by
   the program, unless the storing process isn't finished when the delete
   command is issued. If that happens, it has to be manually deleted.

ERROR CONDITIONS

Error conditions other than those listed here, appearing at the Dasher,
denote problems that occur while accessing files, most likely caused by
system/disk problems rather than program failures. Check RDOS error code and
rerun program if appropriate.

ADM MESSAGES	MEANING
1- "JOB ABORTED--ERROR CONDITION: COEF.DT MSG"	COEF.DT probably does not exist. Check to see if it's either on DPO or on DPOF with a link to it on DPOF. If it is, there's a system problem. If it isn't, rerun program CRS to a successful completion, then rerun RICHNO.

2- "JOB RICHNO ABORTED--ERROR CONDITION: CRSRD.DT MSG"

CRSRD.DT probably does not exist. Check to see if it's either on DPO or on DPOF with a link to it on DPOF. If it is, there's a system problem. If it isn't, rerun program CRS to a successful completion, then rerun RICHNO.

3- "JOB RICHNO ABORTED--ERROR CONDITION: FSTOR PBLMS"

Error occurred while trying to store TM4 into the AFOS database. If a copy of NMCGPHTM4 is on DPO, display from there. Otherwise, rerun RICHNO.

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