NOAA Technical Memorandum NMFS

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ENVIRONMENTAL DATA CONTOURING PROGRAM

EDMAP2

Laurence E. Eber

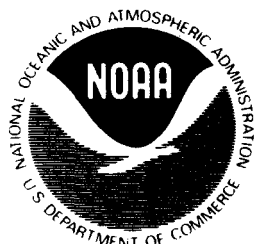NOAA-TM-NMFS-SWFC-18   *Obsolete see LJ-87-25*

NOAA Technical Memorandum NMFS

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ENVIRONMENTAL DATA

MAPPING PROGRAM - EDMAP

By

L. E. Eber

INTRODUCTION

This progam was designed for computing two-dimensional contour plots of environmental data fields defined at grid points on a rectangular grid. It is written in Burroughs B7800 ALGOL and consists of five components which include a host program and four external procedures. These must be linked together with the System BINDER program for execution.

The functions of the host program, <CONTROL>, are to process control cards submitted at run time, initialize the grid (as a two-dimensional array), set program control parameters and call the external procedures, as required.

The four external procedures are <FETCHDAT>, <ANALFLD>, <TRACFLD> and <PLOTFLD>. The function of <FETCHDAT> is to read data from a source file, extract parameter values to be processed and transform the actual data coordinates to those of the grid. This procedure contains input routines for a general purpose file format and several special purpose file formats in use at SWFC.

<ANALFLD> takes the data procured by <FETCHDAT>, which may be randomly distributed over the grid, and fits them to grid points. An editing option is provided whereby data values may be accepted or rejected. An interpolation routine, also optional, computes values at intermediate grid points which remained undefined after fitting the source data. <ANALFLD> also contains a numerical smoothing routine which can be applied to the grid.

The purpose of <TRACFLD> is to scan the grid and compute contour coordinates for contours of the field variable at specified intervals. The coordinates are stored for subsequent retrieval and plotting by <PLOTFLD>. The latter is the only component of EDMAP2 that contains program statements which reference the <CALCOMP> plot routines. These routines (specifically: <PLOT>, <ENDPLT>, <PENPOS>, <LIMITS>, <SYMBOL>, and <NUMBER>) must be compiled directly into the host program, <CONTROL>, by means of the <INCLUDE> dollar card option before the components of EDMAP2 are bound. <PLOTFLD> contains routines to plot contours or digital data on either Mercator or azimuthal equal area projections for use when the grid represents a geographical area.

Data and intermediate outputs are transferred between components of EDMAP2 by means of disk files, of which there are three kinds: data files, grid files and plot files. <IJVAL> is the internal name associated with data files. It is created by <FETCHDAT> and retrieved by <ANALFLD>, for fitting data to a grid, and by <PLOTFLD>, for plotting digital data values at their original locations.

There are five internal names for grid files: <FIELD1>, <FIELD2>, <FIELD3>, <FIELD4> and <GRDFIL>. They are used to save the contents of the grid (grid point values) at various places in the host program so that data fields can be recalled at a later time for printing, digital plotting, computing contours, smoothing or combining with other fields. Plot files are associated with three internal names: <PLTFIL>, <CSTFIL> and <CONCAT>. Plot files are created by <TRACFLD> and may also be created by programs external to EDMAP2 to make plot files with non-standard or added scales, labels, etc.

<PLOTFLD> can retrieve plot files under all three names to plot overlays or to contatenate plot sections computed in separate runs of EDMAP2.

Program control is exercised by the user through program control cards submitted at run time. There are two kinds: (1) specification cards, which set parameter values for a particular run and (2) option cards, which determine what the program does in a particular run.

The format to be used for control cards is essentially free-field with two exceptions: (1) on the first specification card, Cols. 1-30 are reserved for a title, and (2) all specification parameters must be preceded by a 3-letter parameter name and an equal (=) symbol, for example: XZO=121.13W. Parameters on option cards may vary in length from 6 to 12 characters. Only the first six characters are tested for validity by the program. All parameters must be separated by field delimiters, defined to be one or more blank characters. Specification cards are to be submitted first, followed by the option cards. The <#> symbol represents the termination field and must be entered after the last specification parameter and after the last option parameter in each set of program control cards. Multiple sets of control cards may be submitted in one task. At the end of each run, the program branches back to a starting point and tries to read another set of control cards. If none is present, it terminates.

A description of each specification and option parameter is given in the following sections. All specification parameters must be assigned a value, either by means of a specification card or by default. The first six

parameters listed, following <TITLE>, define the grid to which the source data will be fitted and must always be included. The last specification parameter must be followed by at least one space and a <#> symbol.

SPECIFICATION PARAMETERS

<TITLE>. Cols. 1-30 on the first specification card of each set of control cards are read into a character string designated as the <TITLE>. This string is passed to <FETCHDAT> and scanned for information identifying the source file and the data parameter to be analyzed in a particular run. For this purpose, it is interpreted as having five fields of six characters each. The format for the <TITLE> is described in Table 1. The call to <FETCHDAT> can be bypassed using one of the three options, <BYPASS>, <SKIPSORCDATA> or <ZOOMFLD>, in which case all fields of the <TITLE> are optional. In all cases, the <TITLE> will be copied to printer and disk output files, and plotted below the lower left border of plot outputs.

<XZO>, <XMX>, <YZO>, <YMX>. These four parameters define the left, right, lower and upper boundaries, respectively, of the grid to which data will be analyzed. They must be entered in the actual units represented by the X and Y coordinates of the data field. If the data field is a geographical surface, then one of the letters N, S, E or W must be appended to each parameter value, as appropriate.

<XGD>, <YDG>. These parameters define the interval between the grid

points (mesh length) along the X and Y coordinates, respectively. They

must be entered in the same units as the corresponding boundary

parameters. For analysis and plotting, the (X, Y) coordinates are

transformed to (I, J) coordinates in which the range of I is 1 to <IMX>,

inclusive, that of J is 1 to <JMX>, inclusive, and the grid origin (1, 1)

is defined as the lower left corner. The grid dimensions, <IMX> and

<JMX>, are computed from the grid parameters as follows:

$$IMX = ENTIER ((XMX-XZO)/XGD + 1.5)$$

$$JMX = ENTIER ((YMX-YZO)/YGD + 1.5)$$

where ENTIER means the evaluated expression is truncated to an integer.

<PJC>. Parameter values 1-3 identify the grid as a geographical field,

where 1=Mercator projection, 2=equal area projection and 3=rectangular

field (no projection). Parameter value 4 indicates a vertical section

(for oceanographic data), and 5 indicates any rectangular field.

<GSS>. The parameter value is assigned as an initial field value for

each point of the grid, when the option <GUESSFLD> is set. Can be used

along with <REJ> to edit source data.

<ANL>. Affects program flow in <ANALFLD>. A parameter value of 0

(zero) causes an immediate jump to the end of <ANALFLD>. This may be

used when source data are to be plotted as digital values at their actual

locations in the field and not fitted to grid points, or when the

numerical smoothing routine in <ANALFLD> is to be applied to a previously

analyzed field. A parameter value of 1 causes an exit from <ANALFLD>
after the source data values have been fitted to grid points. No
interpolation to undefined grid points is performed. Parameter values of
2 or more set range criteria for interpolation to grid points not defined
by source data. In essence, <ANL> specifies the maximum number of grid
intervals across which interpolation will be performed for determining
values at target grid points. It may be entered with a fractional part
(one decimal digit only) in which case the integer part will be used to
set the horizontal range and the fractional part, multiplied by 10, will
be used to set the vertical range; however, if the fractional part is .1
it will be multiplied by 100. Default value = 3.

<NUL>. The value of this parameter will be assigned to all grid points
which remain undefined after the analysis of source data to the grid is
completed, provided that the option <SETNUL> has been set. Default value
= 99.

<SCL>. Grid point values are packed into binary fields during certain
stages of processing to minimize core usage. The value of this parameter
specifies the number of decimal places to be saved when packing grid
values. Default = 0.

<REJ>. This parameter provides a means of editing source data. If its
value is zero, no editing is performed. Otherwise, the grid field should
be initialized, prior to fitting of source data, either with a constant
specified by the parameter <GSS>, or by loading a previously prepared

guess field from disk file <FIELD 1>. In the editing process, the value of the guess field at the location of each source data value is determined by interpolation and compared with the data value. If the absolute value of the difference exceeds the value of <REJ>, the data value is rejected. Default = 0.

<SMH>. Selection code for numerical smoothing routine in <ANALFLD>.
If the parameter value is zero no smoothing occurs. When the value is 1, grid point values are smoothed with a 9-point primary smoothing operator. When <SMH> = 3 the primary operator is passed over the grid field twice. When <SMH> = 2, the first pass of the primary operator is followed by a pass with a secondary operator, which partially restores amplitude at wave lengths greater than two grid intervals. Additional passes can be invoked by adding multiples of 3 to any of these codes. For example, the action described for <SMH> = 3 will be repeated twice if <SMH> = 3 + (2*3) = 9.

<MPR>. Map reference longitude used for transforming (X, Y) coordinates to (I, J) coordinates when <PJC> is less than or equal to 3. Positive values indicate west longitude, negative values indicate east longitude. <MPR> should be chosen so as to be within 180° of longitude of both <XZO> and <XMX>.

<SQD>. This parameter affects the separation, or spacing, of consecutive contour points computed in <TRACFLD>. Its value is squared

to get a subsquare division factor defined as the number of subsquares, into which each grid square will be divided for the purpose of tracking contours. Coordinates are computed at each intersection of a contour with a subsquare boundary. Larger values of <SQD> yield smoother contours but require longer process times. Default = 4.

<CIN>. This parameter specifies the interval at which contours will be computed. Default = 1.

<COG>. The contour origin, defined as the lowest-valued contour to be tracked, is determined by <CIN> + <COG>. There is no upper limit on contour values for tracking purposes. Default = 0.

<CTL>. A dual purpose parameter, it controls both selection (in <TRACFLD>) and labeling (in <PLOTFLD>) of contours by separate interpretation of the integral and fractional parts. If the fractional part is zero then the contour interval is specified by the value of <CIN>. Otherwise the fractional part, multiplied by 10, determines a base for exponential spacing of contours; however, if the fractional part is .1, the base will be changed to 10. The first (lowest-valued) contour will be equal to (<COG> + <CIN>) where <CIN> must be greater than zero and <COG> must not be less than minus <CIN>. For example, if the base were B and <CIN> = 1 and <COG> = -1 then the contours selected for tracking (if present in the data field) would be 0, B^0, B^1, B^2,....B^{12}. The integral part of the value of <CTL> determines which contours will be labeled in the plot. If the value is zero, all labels will be

suppressed. If it is 1, all contours will be labeled, provided a suitable location along the contour is found. Otherwise, every (INT)th contour (where INT is the integer part of <CTL>) will be labeled.

<MFX>, <MFY>. Map factors for the X and Y coordinate axes, respectively. They must be expressed in inches per coordinate unit. To determine <MFX>, divide the desired plot frame width in inches by (<XMX> - <XZO>). To determine <MFY>, divide the desired frame height by (<YMX> - <YZO>). The second parameter need not be entered if <PJC> is less than 3.

<HGT>. A dual purpose parameter; the fractional part specifies the heights (in inches) of contour labels, coordinate axis labels and the <TITLE>. The integral part is multiplied by the fractional part to set the plot origin on the y-axis. <PLOTFLD> draws the plot title 5 * HT inches (where HT is the fractional part of <HGT>) below the lower plot border. If HT is greater than 0.2 and the integer part of <HGT> is less than 5, some or all of the title may be lost. Default = 5.12.

<XTC>, <YTC>. Dual purpose parameters which control placement of tic marks along the plot borders. The integral part in each case sets the spacing (number of grid intervals) between the marks. The fractional part, multiplied by 10, indicates the number of grid intervals to be skipped before plotting the first tic mark, starting from the lower left corner of the grid. If either parameter value is zero, no tic marks will be plotted along the respective axis.

<XLB>, <YLB>. Dual purpose parameters which control placement of
coordinate axis labels; the first label will be plotted at the first tic
mark. Spacing between subsequent labels will be determined by the
integral part of the respective parameter values. The fractional part,
multiplied by 10, indicates the number of decimal places to be plotted in
each label. If the fractional part is zero or omitted, the decimal point
will be suppressed. If either parameter value is zero, the respective
labels will not be plotted.

<ZYM>. A multi-purpose parameter which controls the plotting of source
data values at their actual locations or the length of arrows in vector
plots and permits suppressing the plot border. Interpretation of the
parameter value at run time depends on the setting of certain options.
When the option <XYDATAPLT> is set, the integral part of <ZYM> specifies
either that the source data values are to be plotted (if its value is
zero) or that a symbol from the CALCOMP symbol table is to be plotted at
the location of each data value. In the latter case, the parameter value
is used as an index to select the symbol. In either case, the fractional
part, if different from zero, is multiplied by HT (see description of
<HGT>) to modify the height of the plotted values or symbols. When the
option <VECTORPLT> is set, the integral part of <ZYM> is ignored; the
fractional part is multiplied by the grid length along the X-axis, IMSH,
to determine the length in inches of the shafts of arrows plotted to
depict the direction of vectors, where IMSH = ABS (<XGD> * <MFX>). The
plot border can be suppressed in any plot by adding 50 to the value of
<ZYM>. This increment, if present, is subtracted before any other
interpretations are made.

<ROT>, <XPV>, <YPV>. These parameters provide for rotation of the grid
when contours are plotted in <PLOTFLD>. <ROT> specifies the amount of
rotation in degrees; positive values result in counterclockwise rotation,
negative values result in clockwise rotation. <XPV> and <YPV> specify
the X and Y coordinates, respectively, of the pivot point.

<SKP>. A special use parameter for a particular source file format
(CCOFI), which provides for more than one set of source data in a single
file. <SKP> specifies the consecutive sequence number of the data set to
be processed in the current run. For example, if <SKP> = 1, the first
data set in the source file will be read.

OPTION PARAMETERS

Option parameters are treated internally as <BOOLEAN> variables. Default
values are all <FALSE>. Option cards follow specification cards in the run
deck assembly. The number symbol, <#>, must be present after the last option
entered for each run. There are no mandatory options; however, the <#> symbol
must be entered on an option card even if no options are submitted. When
options are being processed at run time, only the first six characters are
scanned.

Options determine what actions are performed during each run and, when
they involve retrieving or saving gridfields on disk files, the order in which
they are performed. The EDMAP2 flow chart (Figure 1) shows the locations in
the program at which various options are tested and is provided as a guide in

selecting options for a particular job. Further discussion of option

selection is contained in the option parameter descriptions and in Appendix 5.

<ADDFLD>. Used to combine a grid field created and saved in a previous

    run with the current grid field in memory. Requires co-option <LOADF3>.

    Reads file <FIELD3> and adds grid values therein point by point to the

    grid field in memory, or assigns the <NUL> value if either operand is

    <NUL>.

<BYPASS>. Bypasses loading of data from a source file and analysis

    of data to a grid.

<CENTER>. Rounds the coordinates of each data value to the nearest grid

    point when fitting the data to a grid in <ANALFLD>.

<CONCATPLT>. Used to combine two plot segments, computed and saved as

    plot files during separate runs, into a single plot. It is used with co-

    option <PLOTCNTR>, which causes procedure <PLOTFLD> to make the 1st plot

    segment from file <PLTFIL>. <CONCATPLT> causes the 2nd plot segment to

    be made from file <CATFIL>.

<DIGITPLT>. Causes the numerical grid point values of a grid field to

    be plotted at their respective coordinates, in <PLOTFLD>. The grid

    field, saved in the current or in a previous run, is loaded from file

    <GRDFIL>.

<EDITFLD>. Invokes a call to an external procedure <ADJUSTFLD> to

permit ad-hoc modification of the grid field in memory, during a run.

The call will be made after exit from procedure <ANALFLD> and after

options <SAVEF1>, <SAVEF2>, and <LOADF2> are tested (see Figure 1). The

call will be made before the options <SAVEF3> and <SAVEF4> are tested.

Consequently, the latter should be used if the modified grid field is to

be saved. The actual name of the external procedure to be called,

terminated with a period, must be submitted on a card immediately

following the set of option cards in which <EDITFLD> is entered.

<FIXDBLBESSEL>. Constrains the double-Bessel quadratic interpolation

procedure for computing contour coordinates in procedure <TRACFLD>. It

can be used to suppress spurious features in the contoured field in

places where abrupt changes of gradients occur. However, contours will

appear less curvilinear (more segmented) when this option is set.

<GUESSFLD>. Causes the grid field in memory to be initialized before

procedure <ANALFLD> is entered. The initial grid values are loaded from

file <FIELD1> if option <LOADF1> is set. Otherwise, the field willl be

initialized with the value of the specification parameter <GSS>.

<GUESSFLD> provides a means of editing source data during the process of

fitting them to grid points in <ANALFLD>. If the value of the

specification <REJ> is not zero then each data value from the source file

will be compared to the initial field value interpolated to the exact

location of the data value. If the magnitude of the difference exceeds

<REJ>, the data value will be rejected. When the analysis is complete,

the initial (guess field) values will be left intact at grid points which were not reassigned with source data, either directly or by interpolation, provided that the option <SETNUL> was not set.

<LOADF1>, <LOADF2>, <LOADF3>, <LOADF4>. These options provide access to four files, <FIELD1>, <FIELD2>, <FIELD3>, <FIELD4>, which contain grid fields saved in previous runs. They are tested at different locations in the program and cause the contents of the respective files to be loaded into the grid field in memory. Selection depends on what is intended in a particular run, and can be made wth the aid of the program flow chart, Figure 1.

<MOREDATA>. Used to load data from more than one source file. Source files designated in the <TITLE> field on specification cards for successive runs within a job will be accumulated in a single data file by procedure <FETCHDAT>. The option is tested after exit from <FETCHDAT> and, if set, transfers control immediately back to the start of the next run.

<OVERLAYPLT>. Used to superimpose secondary features including boundaries, coordinate labels, scales, titles, and coastlines (for geographical plots) on a plot. Requires a specially formatted plot file, <CSTFIL> which will be accessed in procedure <PLOTFLD>. See Appendix 4.

<PLOTCNTRS>. Causes a contour plot to be made in <PLOTFLD> from contour coordinates saved in file <PLTFIL>.

<PRINTFLD>. Causes a printout of the grid field in memory which will
include the values at all grid points, including <NUL> values. The
number of decimal places printed will be determined by the value of the
specification parameter <SCL>. Column and row labels will designate
locations along the X and Y coordinate axes, respectively.

<SAVEF1>, <SAVEF2>, <SAVEF3>, <SAVEF4>. These options provide a means
of saving the grid field in memory on any of four files, <FIELD1>,
<FIELD2>, <FIELD3>, and <FIELD4>. As with the load options, they are
tested at different locations in the program, and reference to the
program flow chart can aid selection for a particular run.

<SETNUL>. Causes the value of the specification <NUL> to be assigned to
all grid points to which data values were not fitted or interpolated in
<ANALFLD>. The field is considered to be undefined in all primary grid
squares for which one or more corner points has been assigned the <NUL>
value, and contours will not be tracked through such squares in procedure
<TRACFLD>.

<SKIPSORCDATA>. Bypasses procedure <FETCHDAT>, thereby skipping the
loading of data from a source file and creation of a data file. Used
when the data file to be analyzed, <IJVAL>, already exists from a
preceding run. It also provides a means for entering <ANALFLD> with a
previously-analyzed, or partially-analyzed field, to perform smoothing or
to complete the analysis of a field for which fitting of source data to

grid points had been performed but interpolation to undefined grid points had not. Either <LOADF1> or <LOADF4> could be used as a co-option to load the desired grid field into memory before entering <ANALFLD>.

<SKIPFITDATA>. Used as a co-option with <SKIPSORCDATA> and either <LOADF1> or <LOADF4> in order to enter <ANALFLD> with a grid field to which source data had already been fitted in a previous run. Causes program control in <ANALFLD> to branch around the section in which source data are processed, to the section where interpolation to undefined grid points is performed.

<SUBTRACTFLD>. Used with co-option <LOADF1> to subtract a grid field saved from a previous run from the grid field in memory. Reads file <FIELD1> and subtracts the grid values, point by point, from the field in memory. The <NUL> value is assigned if either operand is <NUL>. This option may be used with <BYPASS> and <LOADF2>, in which case the grid field in file <FIELD1> will be subtracted from that saved in <FIELD2>. Alternatively, if file <FIELD1> represented some kind of normal, or mean, field then <LOADF1> and <SUBTRACTFLD> could cause the grid field in that file to be loaded for the purpose of getting an anomaly field representing the departures of the analyzed field from the normal field.

<TIMEPLT>. This is a special-purpose option for labeling time sections. In particular, the units of the X coordinate axis must be months, the value of the specification <XZO> must be a four-digit year-month code

(6902 = FEB 1969) and the value of <XMX> must be determined by (<XZO> +
N-1), where N is the total number of months to be represented in the time
section. The grid interval parameter, <XGD>, should be an integer if its
value is greater than 1. It may have a value less than 1; if so,
however, the value specified for <XLB> should be determined so as to
suppress plotting of labels at points where the X coordinate is a
fraction. <TIMEPLT> causes a symbol, J, F, M, A, M, J, J, A, S, O, N or
D to be plotted along the lower border of a plot at points representing
monthly intervals, and the appropriate year (1969, 1970, etc.) centered
below each July symbol. If <PRINTFLD> is set, the columns in the print-
out are labeled with the year-month code. If <XGD> is less than one, the
year-month code will have a fractional part. If the special labeling is
not required in a time section, the option need not be entered.

<TRACKCNTRS>. Causes contour coordinates to be computed in procedure
    <TRACFLD> and saved in file <PLTFIL>. <TRACFLD> uses the specification
    parameters <COG>, <CIN> and <CTL> to determine which contours to track.

<VECTORPLT>. Intended for plotting wind or wind stress fields; it
    can, however, be used for any vector field. Causes arrows to be plotted
    at grid points, in procedure <PLOTFLD>, to depict the direction of the
    vector. The magnitude is plotted as a number alongside the shaft of the
    arrow. If two or more source data values were fitted to a single grid
    point, then the arrow will show the resultant direction and two numbers
    will be plotted, one above the grid point and one below it. The upper
    number represents the resultant magnitude and the lower number represents

the average magnitude, regardless of direction. This option requires
that the source data be packed into a data file (in <FETCHDAT>), and
fitted to the grid (in <ANALFLD>), in a different manner than is used for
scalar data. The special handling is done automatically, provided that
<WIND> is designated as the variable to be processed in the <TITLE> field
of the run control card. Vector plots will show arrows only at grid
points at which source data were fitted in the first phase of analysis.
No interpolation to other grid points will be performed. The grid field
must be stored in file <GRDFIL> before <PLOTFLD> is entered. This can be
done with any of the four save options and a file attribute card to
designate the title change to <GRDFIL>.

<XYDATAPLT>. Causes the source data values to be plotted as numbers
at their actual locations in the field. The data values are read (in
<PLOTFLD>), from file <IJVAL>. The specification parameter <ZYM> can be
used to suppress plotting the numerical date value and to plot, instead,
a symbol selected from the Calcomp symbol table. This option and
<DIGITPLT> provide complementary means for producing digital plots of
scalar data fields. <XYDATAPLT> can be used when the data are
distributed so as not to overlap, or when it is necessary to show their
actual locations. <DIGITPLT> can be used with any data distribution and
plots only the analyzed values at grid points.

<ZOOMFLD>. Creates a new data file, <IJVAL>, from a grid field saved in
file <FIELD1> in a preceding run. It causes all or part of the saved
grid values to be stored in <IJVAL> with coordinates transformed

according to grid specification parameters for the current run. This option provides a means of making a grid field from all or part of an existing grid field, with altered grid lengths if desired, without reprocessing source data. Procedure <FETCHDAT> is automatically bypassed when <ZOOMFLD> is set.

Appendix 1. <TITLE> Field on Run Control Cards.

Columns 1-30 on the first control card submitted for running EDMAP2 are designated as the <TITLE>. Whenever data are to be accessed from a source file, the <TITLE> must contain specific information which will enable procedure <FETCHDAT> to read the file and select the data to be processed. Otherwise, the <TITLE> may be anything the user chooses or may be left blank. The <TITLE> will always be plotted below the lower left border of plots when any plot option is set, and printed at the top of each page of printer output when the <PRINTFLD> option is set. Procedure <FETCHDAT> contains routines for accessing four specific kinds of environmental source files used by SWFC, and one general purpose source file. These files have different formats and different data parameters. Each source file is described below with the particular keywords and other information required for <TITLE> entries. The <TITLE> is divided into five fields of six characters each. For the general purpose source file, fields 3 and 4 are each divided into two sub-fields of three characters each. Entries in all fields (and sub-fields) are right justified. The source file names listed are the actual internal file names declared in the program. Valid entries for <TITLE> fields are also listed in Table 1.

SOURCE FILE   DESCRIPTION

<XYDAT>. General purpose source file. Must be created as a simple

binary file so that it can be accessed with a read statement specifying

the number of 48-bit words to be read and an array row, i.e.,

READ (XYDAT, N, A[*]),

where N is the logical record length and A is the array. Each word is

expected to contain a number, either a data value or an X or Y coordinate

value. If one of the data parameters is wind (or some other vector) it

must be present in two consecutive words with direction in the first and

magnitude in the second. Direction must be expressed in degrees from

which the wind or other vector is coming, with 0 (or 360) on the positive

Y axis and increasing values in clockwise rotation.

<u>1st Field of <TITLE> (Cols. 1-6)</u>: Valid keywords are <WIND> and <DATA>.

The latter can be used for any scalar parameters.

<u>2nd Field (Cols. 7-12)</u>: <XYDAT>.

<u>3rd Field (Cols. 13-18)</u>: Enter logical record length (expressed in

words) in the first subfield (Cols. 13-15). Enter the location of the X

coordinate in the second subfield (Cols. 16-18). The location is the

word number in the logical record, counting from 1, that contains the

required value.

<u>4th Field (Cols. 19-24)</u>: Enter the location (word number) of the Y

coordinate in the first subfield (Cols. 19-21). Enter the location (word

number) of the desired parameter value in the second subfield (Cols. 22-

24). If the entry in the 1st Field is <WIND>, the word number entered

should point to the direction.

5th Field (Cols. 25-30): Optional.

<MWX00>, <MWX01>,...<MWX16>. ship's surface weather observations

collected at SWFC through marine weather data transmission services. The

data format conforms to the WMO code for ships' surface weather reports

except for minor modifications.

1st Field of <TITLE> (Cols. 1-6): Valid entries are <SST>, <WIND>,

<PRES>, <CLDS>, <EVAP>.

2nd Field (Cols. 7-12): <WXOB>.

3rd Field (Cols. 13-18): Enter a four-digit year-month code, i.e., 7805

for May 1978.

4th Field (Cols. 19-24): Enter (day from - day to) to specify the period

for which data are to be selected, i.e., 19-26. If (day from) is greater

than (day to), the latter will be interpreted as referring to the

following month.

5th Field (Cols. 25-30): Optional.

<MARDAT>. Twenty-year monthly means of marine weather observations

obtained by SWFC with the cooperation of the Pacific Environmental Group

(NMFS) and FNOC (Fleet Numerical Oceanography Center). The data

represent the period 1948-1967 and were averaged by month for areas 1

deg. latitude by 1 deg. longitude. Sea level pressure, <PRES>, is listed as a valid parameter but is not reliable due to contamination caused by a programming error.

1st Field of <TITLE> (Cols. 1-6): Valid entries are <SST>, <WIND>, <PRES>, <SSTD> (standard deviation of <SST>), <NWNDS> (number of observations associated with <WINDS>).

2nd Field (Cols. 6-12): <MEAN>.

3rd Field (Col. 13-18): Three-letter abbreviation for month. Valid entries are <JAN>, <FEB>, <MAR>, <APR>, <MAY>, <JUN>, <JUL>, <AUG>, <SEP>, <OCT>, <NOV>, <DEC>.

4th and 5th Fields (Cols. 19-30): Optional.

<FNSHIP>. Marine surface (unclassified) weather observations collected at the Fleet Numerical Oceanography Center. This file is in a packed binary format. Each report (logical record) is 300 bits long, and includes the complete observation; however, <FETCHDAT> extracts only the ten parameters listed.

1st Field of <TITLE> (Cols. 1-6): Valid entries are <SST>, <WIND>, <PRES>, <CLDS>, <AIR>, <DEW>, <EVAP>, <SWDIR>, <SWHGT>, and <WVEL>.

2nd Field (Cols. 7-12): <FNWC>.

3rd Field (Cols. 13-18): Enter a four-digit year-month code.

4th Field (Cols. 19-24): Enter (day from - day to) to specify period for which data are to be selected.

5th Field (Cols. 25-30): Physical tape record length (words).

<OCNDAT>. Physical and chemical oceanographic data from research ships collected at stations in the CalCOFI survey pattern. The file is in a simple binary format with a logical record length of 8 (48 bit) words. Data in the file are identified by the CalCOFI station code, year, month and day. The file includes values of six parameters at standard depths from 0 to 500 meters, with some deeper data.

1st Field of <TITLE> (Cols. 1-6): Valid entries are <TMP>, <SAL>, <OXY>, <SIGT>, <SPVA>, <DYNA>.

2nd Field (Cols. 7-12): <CCOFI>.

3rd, 4th and 5th Fields (Cols. 13-30): Optional.

Appendix 2. List of Specification Parameters For Run Control Cards.

This appendix is intended to provide a quick reference to the specification parameters. They are grouped as nearly as possible by function, rather than by alphabetical sequence. All specifications are optional except the first six listed. The latter are necessary to fully define the dimensions of the grid. Default values are assigned to specification parameters not entered on the run control cards.

PARAMETER NAME	DEFAULT VALUE	DESCRIPTION
--------	--------	SPECIFICATIONS RELATING TO THE GRID -----
XZO	-	sets left boundary of X coordinate.
YZO	-	sets lower boundary of Y coordinate.
XMX	-	sets right boundary of X coordinate.
YMX	-	sets upper boundary of Y coordinate.
XGD	-	sets grid interval along X coordinate axis.
YGD	-	sets grid interval along Y coordinate axis.
PJC	5	Projection code: 1 = Mercator projection; 2 = Equal area projection; 3 = Rectangular geographical grid; 4 = Oceanographic grid (Y coordinate is depth); 5 = Rectangular grid.
MPR	160	Map Reference Longitude. Valid only when PJC = 1, 2 or 3.

---------------------- SPECIFICATIONS RELATING TO THE DATA ------

GSS	0	Initializes the grid field.
ANL	3	Controls fitting and interpolation of data values to grid points.
NUL	99	Designates grid points at which the field is undefined.
SCL	0	Specifies the number of decimal places to be carried for grid values.
REJ	0	If not 0, specifies editing range for rejecting data values.
SMH	0	If not 0, causes the analyzed grid field to be smoothed.
SKP	1	Controls data selection during input for <OCNDAT> source files.

---------------------- SPECIFICATIONS RELATING TO CONTOUR TRACKING

SQD	4	Subsquare division factor for computing contours; larger values yield smoother contours.
CIN	1	Specifies contour internal.
COG	0	Specifies contour origin. Lowest contour value tracked will be <CIN> + <COG>.
CTL	1	Controls selection of contours with exponential spacing and suppression of contour labels.

		SPECIFICATIONS RELATING TO MAKING A PLOT ---
MFX	0.1	Horizontal scale factor in inches per unit along the X coorindate axis.
MFY	0.1	Vertical scale factor in inches per unit along the Y coordinate axis.
HGT	5.12	Specifies height of letters and numbers for titles and labels (.12 inches) and width of margin below plot border (5*.12 inches).
XTC	1	Controls spacing of tic marks along upper and lower borders.
YTC	1	Controls spacing of tic marks along left and right borders.
XLB	5	Controls spacing of coordinate labels along lower border.
YLB	5	Controls spacing of coordinate labels along left border.
ROT	0	Specifies plot rotation in degrees.
XPV	0	Specifies the X coordinate of a pivot point for plot rotation.
YPV	0	Specifies the Y coordinate of a pivot point for plot rotation.
ZYM	0	Control parameter for size of numbers and symbols in data plots and for suppressing plot border.

Appendix 3. List of Option Parameters For Run Control Cards.

    Option parameters control program flow at run-time. They are interpreted
by the program as boolean values, <TRUE> or <FALSE>, and cause associated
program variables to set to <TRUE> when entered on run control cards. All
option variables have a default value of <FALSE>.

OPTION NAME	DESCRIPTION
ADDFLD	Causes a field saved on disk to be added to the field in memory. Requires <LOADF3>.
BYPASS	Causes accessing and analysis of source data to be bypassed.
CENTER	Assigns each source data value to the nearest grid point during analysis.
CONCATPLT	Combines plot segments computed in separate runs.
DIGITPLT	Plots the analyzed grid point values at the respective grid points.
EDITFLD	Invokes call to an external PROCEDURE to modify the grid field in memory.
FIXDBLBESSEL	Constrains double quadratic interpolation used in computation of contour coordinates.
GUESSFLD	Causes an initial field (Guessfield) to be loaded into the grid in memory prior to analysis of source data.
LOADF1	Causes a field saved in file <FIELD1> to be loaded into the gridfield in memory.
LOADF2	Loads gridfield from file <FIELD2>.

LOADF3	Loads gridfield from file <FIELD3>.
LOADF4	Loads gridfield from file <FIELD4>.
MOREDATA	Accumulates source data from more than one source file before proceeding to analysis.
OVERLAYPLT	Causes custom plot features to be added to plots from file <CSTFIL>.
PLOTCNTRS	Causes a contour plot to be plotted from file <PLTFIL>.
PRINTFLD	Causes the grid field in memory to be printed, with column and row labels.
SAVEF1	Causes the grid field in memory to be saved in file <FIELD1>.
SAVEF2	Saves gridfield in file <FIELD2>.
SAVEF3	Saves gridfield in file <FIELD3>.
SAVEF4	Saves gridfield in file <FIELD4>.
SETNUL	Causes the null value <NUL> to be assigned to undefined grid points during analysis.
SIKPSORCDATA	Bypasses loading of data from a source file.
SKIPFITDATA	Branches around the section of analysis in which source data are fitted to the grid.
SUBTRACTFLD	Causes a field saved on disk to be subtracted from the field in memory. Requires <LOADF1>.
TIMEPLT	Invokes special labeling along the X coordinate axis on plots which represent time sections.
TRACKCNTRS	Causes contour coordinates to be computed from the grid field in memory, and saved in file <PLTFIL>.
VECTORPLT	Causes a plot to be made of a vector field, depicted by arrows for direction and numbers for magnitude.

XYDATAPLT   Plots the source data values at their actual locations
                 in the field.

ZOOMFLD   Causes the values of a grid field saved in file
                 <FIELD1> to be extracted and saved in a new data file
                 with coordinates transformed to those specified for the
                 current run.

Appendix 4. Creation of Overlay Plot Files with program <MAKSCTFIL>.

The option parameter <OVERLAYPLT> provides a means of superimposing

special titles, labels, scales and certain other features on a standard

contourplot, digitplot or vectorplot. The overlay elements must be prepared

in a special format and stored in plotfile <CSTFIL>. This file is accessed by

procedure <PLOTFLD> at run time, when <OVERLAYPLT> is set. An ancillary

program, <MAKCSTFIL>, has been written to facilitate the preparation of

overlay plotfiles from specifications punched on data cards. There are four

types of elements, identified by the keywords <SYMBOL>, <NUMBER>, <LINES>, and

<SCALES>, which can be included in an overlay file. Each of these is

described in the following paragraphs. When <CSTFIL> is created by

<MAKCSTFIL> the keywords are inserted into certain fields in the records which

normally contain contour identification, and cause the special overlay routine

to be executed. A normal plotfile created by procedure <TRACKFLD> can also be

re-named <CSTFIL> and used with the option <OVERLAYPLT> to combine more than

one set of contours into a single plot, in the same way that plotfile <CATFIL>

is used with the option <CONCATPLT>.

Data card formats for <MAKCSTFIL>.

Data cards are assembled in sets of one or more cards each. Each set

contains specifications for an overlay element. The sets of data cards are

preceded by two identification (ID) cards which contain information needed by

<MAKCSTFIL> to make a header record for the plotfile. The descriptions of ID

and data cards are given in terms of the ALGOL formats and lists with which
they are read.

ID Cards.

    FORMAT: <5A6, X2, 6R8.0/3R8.0>.

    LIST: (<TITLE>, <XZO>, <YZO>, <XMX>, <YMX>, <XGD>, <YGD>, <PJC>, <MPR>,
    <SQD>)

    The <TITLE> may be any 30-character string starting with "OVERLAY" in
cols. 1-7. The remaining list elements are specification parameters and must
match those submitted with the run in which the overlay is to be plotted.

Data Cards.

    FORMAT: <A6, X2, 5R8.0>.

    LIST: (PLTYPE, N. HT, ROT, X, Y)

    The first list element, PLTYPE, must be one of the four overlay keywords.
The values to be entered for the remaining list elements depend on PLTYPE.
If PLTYPE = <SYMBOL> then the overlay type is a character string:

    N is the number of characters in the string.

    HT is the height of the characters in inches.

    ROT is the rotation of the string in degrees (positive counterclockwise)
    using X, Y as the pivot point.

    X, Y are the location coordinates; if HT < 0 the string is centered on X,
    otherwise it starts on X. Y designates the bottom of the string
    characters.

The string to be plotted must be punched on a 2nd data card (of the set) starting with col. 1.

If PLTYPE = <NUMBER> then the overlay type is a sequence of numbers to be plotted at specified locations:

N is the number of numbers in the sequence.

HT is the height in inches. If it is negative, each number in the sequence will be centered on its respective X coordinate.

ROT is the rotation of each number in the sequence, in degrees.

X, Y are ignored if punched on the 1st data card of the set.

The sequence of numbers must be punched on one or more subsequent data cards using a secondary format and list.

FORMAT: <10R8.0>.

LIST: (X, Y, VAL, F) where the parentheses mean that the list is to be repeated N-1 times.

 X, Y are the location coordinates.

VAL is the number to be plotted.

F is the number of fractional digits to appear at the right of the decimal point.

IF PLYTYPE = <LINES> then line segments will be drawn connecting a sequence of points.

N. is the number of points in the sequence.

HT, ROT, X and Y will be ignored if punched on the 1st data card of the set.

The X and Y coordinates must be punched on one or more subsequent data

cards using a secondary format and list.

FORMAT: <10R8.0>.

LIST: (X, Y) where the parantheses mean that the list is to be repeated

N-1 times. X and Y are the location coordinates for the points in the

sequence.

If PLYTYPE = <SCALES> then a horizontal straight line with tic marks will be

plotted. This overlay type is intended for adding special scales to a plot

with less effort than would be required using <LINES>. The list parameters

for the data card are interpreted differently than for the other types.

N is the number of tic marks to be plotted.

HT is the spacing between tic marks expressed in X coordinate units.

(Thus, the length of the line will be (N-1) * HT units.)

ROT is the height of the 1st, 3rd, 5th, ... tic marks, expressed in Y

coordinate units. The 2nd, 4th, 6th, ... tic marks will have a height of

ROT/2 units.

X and Y are coordinates of one end of the line. The line will be drawn

to the right of X, Y if HT > 0 and to the left of X, Y if HT < 0. The

tic marks will be plotted above the line if ROT > 0 and below the line if

ROT < 0.

No subsequent data cards are needed.

As many data sets of each overlay type as needed may be submitted for

<MAKCSTFIL> at run time. The overlay features to be plotted may be either

inside or outside of the plot border, hence the values of the list parameters, X and Y, may exceed those defining the grid boundaries.

<MAKCSTFIL> can also be used to create an overlay file which contains coordinates for lines which are not field contours but which will be processed in the same way as contours. Coastlines of continents and islands and lines of constant latitude and longitude can be plotted just like any other contour by <PLOTFLD>, except that the "contour label," which is usually a sequence number, will not be plotted. <MAKSCTFIL> obtains gets the information needed for the <CSTFIL> header record from the two ID cards submitted at run time, and the point coordinates for the coastlines from a file named TEK. This file can be loaded from a terminal or from cards.

The list element <TITLE> may be any 30-character string and identifies the file; however, if the first seven characters are "OVERLAY" then <MAKCSTFIL> will attempt unsuccessfully to perform its special overlay function and terminate without doing anything. The remaining list parameters should match those which will be submitted to EDMAP2 for the run in which <CSTFIL> will be read.

The file TEK should be created with MAXRECSIZE = 14, BLOCKSIZE = 420, UNITS = WORDS. The first record of the file is for identification and will be read and printed only. Subsequent records should be written with the format

<X1, 12C6>

Each record will be interpreted as having six fields of 12 characters each. The digit strings representing the values should be left-justified in each field.

The list should have the following structure:

SEGID, N. X1, Y1, X2, Y2, X3, Y3, ..., XN, YN, SEGID, N, X1, Y1, etc. Where SEGID is a value chosen to identify the coastline segment (or other line), N is the number of points in the segment, and X1, X2, etc., are the X and Y coordinates of the points. If the coordinates represent longitude and latitude, then the values should be negative in the eastern and southern hemispheres.

Appendix 5, Deck Set-up for EDMAP2.

The general assemblage of control and data cards needed to run EDMAP2 is as follows:

```
?BEGIN
?RUN EDMAP2
?FILE FIELDN (file attributes)
?FILE IJVAL (file attributes)
?FILE PLTFIL (file attributes)
?DATA
 Run specification cards.
 Option cards.
? END JOB.
```

Either 1, 2, 3 or 4 should be substituted for N in the FILE name FIELDN. All of these files have internally-declared attributes and the file attribute cards are used normally to equate internal names to actual file directory names. For grid files (FIELD1, FIELD2, etc.), however, the MAXRECSIZE and BLOCKSIZE attributes need to be changed if the number of grid points along the X coordinate is going to exceed 60. This number, designated IMX, is determined by the program from the grid specification parameters with the formula:

$$IMX = ENTIER \left((XMX-XZO)/XGD + 1.5 \right) \text{ where}$$
ENTIER implies truncation.

The example below demonstrates one kind of application for which EDMAP2 was designed. It assumes the presence of two source files: <MARDAT>, containing 20-year monthly means of sea surface temperature for the Pacific Ocean, and <FNSHIP>, containing marine weather observations (including sea surface temperature) for the month of August 1981. The purposes of this set of runs are to prepare a mean August sea surface temperature field for a region off the west coast of North America and to use this field to (1) edit the corresponding data for August 1981 and (2) compute a sea surface temperature anomaly field for August, 1981.

The temperature field for August, 1981 will be displayed on one plot and the anomaly field, with the mean August isotherms superimposed, will be displayed on a second plot. Grid point values for all three fields will be printed. The job will take four runs through EDMAP2 (four sets of run control cards) and will be assembled as three tasks in order to maintain separate identities for each of three plot files containing the three sets of contour coordinates. The mean August field will be analyzed and contoured in the 1st run. The run control cards define the area to be represented by the grid as 116°-145°W, 25°-50°N, with unit grid areas of 1° Long. by 1° Lat. The plot projection will be Mercator (PJC = 1), grid values will be scaled to maintain a precision of three decimal places (SCL = 3), moderately heavy smoothing will be applied to the grid values before printing or contouring (SMH = 6), and interpolation to grid points will be performed using maximum ranges of 6° Long. and 4° Lat. (ANL = 6.4). Contours will be computed at intervals of 1 (CIN = 1) beginning at 1 (COG = 0) and every contour shall be labeled (CTL = 1).

In the second run, the August 1981 sea temperatures will be analyzed using the smoothed mean August field as a guess field for editing. Data values will be rejected if they differ from guess field values interpolated to the respective locations of the data values by 5 or more (REJ = 5). Interpolation to grid points will be performed with maximum ranges of 4° for both Lat. and Long. (ANL = 4). The map factor (MFX = 0.31) was computed so that the width of the plot would be 9 inches (9/(145-116)=0.31). The August 1981 temperature field will be saved in file <FIELD2> and the contours computed and plotted.

This field will be recalled in the third run, along with the mean August field in file <FIELD1>, in order to compute the anomalies, which will be saved in file <FIELD3>. They could alternately be saved in file <FIELD4>. In either case, the anomaly field must be recalled in the fourth run as file <FIELD4> in order to make it available to <ANALFLD> for smoothing before computing contours. <ANALFLD> will take no other action in this run (since ANL = 0) and the anomaly contours will be plotted along with the mean August contours computed in the first run.

The complete job assembly is listed below.

? BEGIN JOB . . .

? RUN EDMAP2

? FILE MARDAT (TITLE = MARDAT/AUG)

? FILE FIELD1 (TITLE = ENPAC/AUG)

? FILE PLTFIL (TITLE = SSTPLT/AUG)

? DATA

    (1st set of run control cards--b denotes blank)

bbbSSTbbMEANbbbAUGbbbbbbbbENPAC XZO=145W YZO=250N XMX=116W   YMX=50N   XGD=1

YGD=1   PJC=1   SCL=3 SMH=6   ANL=6.4   CIN=1   COG=0   CTL=1 #

CENTER   SETNUL   SAVEF1   PRINTFLD   TRACKCNTRS   #

? RUN EDMAP2

? FILE FNSHIP (TITLE = SOURCEDATA/AUG1981)

? FILE FIELD1 (TITLE = ENPAC/8108SST)

? FILE FIELD2 (TITLE = ENPAC/8108ANOM)

? FILE PLTFIL (TITLE = SSTPLT/8108SST)

? DATA

    (2nd set of run control cards)

bbbSSTbbFNWCbb8108b01-15bb3015   XZO=145W   YZO=25N   XMX=116W   YMX=50N

XGD=1   YGD=2   PJC=2   SCL=3 ANL=4 REJ=5   CIN=1   COG=0   SMH=6   MFX=0.31

#

 LOADF1   GUESSFLD   CENTER   SETNUL   SAVEF2   PRINTFLD   TRACKCNTRS

PLOTCONTRS   #

    (3rd set of run control cards)

TITLE OPTIONAL ON THIS RUN   XZO=145W   YZO=25N   XMX=116W   YMX=50N   XGD=1

YGD=1   PJC=1 #

BYPASS   LOADF2   LOADF1 SUBTRACTFLD   SAVEF3   #

```
? RUN EDMAP2

? FILE FIELD4 (TITLE = ENPAC/8108ANOM)

? FILE PLTFIL (TITLE = SSTPLT/8108ANOM)

? FILE CATFIL (TITLE = SSTPLT/AUG)

? DATA

  (4th set of run control cards)

SST MEAN & ANOM 8101 ENPAC    XZO=145W   YZO=25N   XMX=116W   YMX=50N   XGD=1

YGD=1 PJC=1   SMH=6   CIN=1   COG=-9   SCL=3   ANL=0   CTL=1 MFX=0.31  #

SKIPSORCDATA   LOADF4 PRINTFLD   TRACKCNTRS   PLOTCNTRS   CONCATPLT   #

? RUN SERVICE/PLOTREQUEST; DATA

   PLOT (1,2)

? END JOB
```

Figure 2 shows portions of the run-time messages generated by EDMAP2 for this job. The run control cards for each run are printed exactly as read. If a specification or option error occurs (usually a misspelled keyword), an error message is printed immediately after the card containing the error, and the run is terminated. Execution of subsequent runs (if any) will be attempted, even though they may depend on output from the terminated run. The messages also include listings of data values rejected during editing (if any) and counts of contour coordinates for each contour tracked or plotted. The number of source data values selected by <FETCHDAT> are printed and PROCESSTIMEs are given for each of the procedures <ANALFLD>, <TRACFLD> and <PLOTFLD>.

Figure 3 shows the first sheet of printer output invoked by <PRINTFLD> in the 1st run. Values of the mean August sea temperatures are printed with three

decimal places because <SCL> was set to three. The 99.000s in the upper right corner represent the default value for undefined grid points. This portion of the grid is over a land area. The grid print output can be used to find the locations and magnitudes of maxima and minima not precisely shown by the associated contour plot, and to identify unlabeled contours.

Figures 4 and 5 show the contourplots which the program produced. The shading in the second plot was added by hand to help set off the anomaly field from the mean field.

Appendix 6. Fitting Source Data to Gridpoints.

Source data are made available to procedure <ANALFLD> by means of the data file <IJVAL>, in which the coordinates of each data value have been transformed to the (I, J) coordinates of the grid as defined by specification parameters submitted for the current run. The determination of field values at grid points is achieved in two steps: 1) fitting source data values to adjacent grid points and 2) interpolation to other grid points not affected by step 1.

Each data value contributes to the grid field values at one or more surrounding grid points. If the option <CENTER> was set, the I and J coordinates for each data value are rounded to the nearest integer, effectively assigning the data values to the nearest respective grid points. Otherwise, unless the specification parameter <PJC> was set to 4, a weighing coefficient, W(i), is computed for each grid point, i, within one grid length from the data value from the formula:

$$W(i) = (1 - \Delta I(i) * \Delta J(i))\Big/ \sum_{i=1}^{n} (1 - \Delta I(i) * \Delta J(i))$$
$$\text{where } n \leq 4$$

and $\Delta I(i)$ and $\Delta J(i)$ are the increments of horizontal and vertical separation between the location of a data value (I ,J) and that of each nearby grid

point. The method gives each data value the same total weight whether it contributes to one, two, three or four grid point values.

The parameter value 4 for <PJC> designates a special kind of field for which the Y-coordinate is depth, and for which there is a coherence among data values distributed with depth at discrete values of x, such as those obtained with oceanographic instrumentation. Linear interpolation to horizontal grid lines is performed from vertically distributed values at each point along the x axis for which data exist. Horizontal interpolation to grid points is then performed, where necessary. The computational process requires that the data values in each coherent set be ordered in the data file from top to bottom in the grid (descending values of the J coordinate).

The parameter value 1 for the specification <ANL> causes an exit from <ANALFLD> after this 1st step of fitting data to grid points is completed, so that the grid field can be saved in a disk file or printed or plotted. Otherwise, interpolation to as-yet-undefined grid points is initiated as Step 2.

Step 2 is carried out in two scans over the grid field in order to locate undefined grid points, designated as target points. An attempt is made to interpolate a value for each target point from values at grid points in the surrounding area. In the first scan, only those grid points which were assigned values in step 1 are used for the interpolations. This restriction

makes the results independent of the starting point and direction of the scan. In the second scan, the values assigned as a result of interpolation during the first scan are also used.

The size of the area to be searched, around each target point, is determined from the value of the specification parameter <ANL> and the squares of the distances from surrounding grid points to the target point. If the coordinate of the target grid point is (I, J) and that of a nearby point is (I + L, J + K) then the squared distance separating the two points is (L * L + K * K). <ANL> is treated as a two-valued parameter: the integral part is used to set the horizontal search range ANLH and the fractional part is used to set the vertical search range ANLV. For example, if the value of <ANL> is 6.4 then ANLH = 6 and ANLV = 4. If <ANL> is an integer then ANLH = ANLV = <ANL>. The boundaries of the search area are then defined as (I $\pm$ (ANLH - 1)), (J $\pm$ (ANLV - 1)), with the added restriction that (L * L + K * K) <= MAX (ANLH - 1, ANLV - 1) ** 2 + 4, where the double asterisk denotes exponentiation and MAX (ANLH - 1, ANLV - 1) designates the larger of the two enclosed expressions as the value be to squared. The effect of the restriction is to cut off the corners of the rectangular search area.

The search is conducted in each of eight sectors, shown in Figure 6, in which each grid point is represented as a small square. The sectors are identified by numbers and defined by the signs of the relative coordinates L and K. Sector 5 is the target point. The nearest valid grid point value in each of the eight sectors surrounding the target point is selected for a possible role in the interpolation; however, in the corner sectors, 1, 3, 7

and 9, two values may be selected if they are equidistant from the target point.

The selected values are used to compute intercepts on both the horizontal and vertical grid lines passing through the target point. An intercept can be determined by any selected grid value in sectors 2, 4, 6 or 8, or by linear interpolation between grid values in adjacent corner sectors, or by linear interpolation between values in an even-numbered sector and an opposite corner sector, such as 2 and 7, or 4 and 9. Each intercept is assigned a weight, determined by the sum of the squared distances of the associated grid points, and a category, determined by its relative coordinates, (L, K). Gridpoint values in even-numbered sectors are treated as double-points in computing weights. The intercept categories are POS K, NEG K, POS L and NEG L. The intercept with the lowest weight is chosen from each category for the final interpolations, provided that the associated grid points satisfy the range criteria. The latter are applied to the sum of the distances of the two grid points used to compute the intercept, to the grid line on which the intercept is located. This sum must be less than or equal to ANLH for an intercept on the vertical grid line, or to ANLV for an intercept on the horizontal grid line. Finally, two interpolations to the target point are made, using the (POS K, NEG K) pair for one and the (POS L, NEG L) pair for the other, provided that both intercepts in each pair are valid and also meet the range criteria already defined. Each valid interpolation yields a solution to the value of the target grid point. If both solutions are obtained, a weighed average is computed using the weights associated with the intercepts involved in each solution.

In essence, this method attempts to provide a relatively simple, efficient linear interpolation to undefined grid points using a limited number of values at nearby grid points. It does not extrapolate into areas for which no data exist, and will not introduce local maxima or minima at target points.

There are many other methods of fitting source data to a grid, ranging from simple, weighed average schemes using data values in the neighborhood of a target point to those which employ complex least squares regression techniques. A discussion of some of these methods has been given by Sampson in his documentation of Surface II Graphics System[1].

[1]Sampson, R. J. , 1975, Surface II Graphics System. Series on Spatial Analysis, J. C. Davis, Ed. Kansas Geological Survey

Appendix 7. Tracking Contours Through a Grid field.

After the source data have been fitted to a grid, procedure <TRACFLD> is called upon to compute coordinates for the contours specified by the values of <CIN>, <COG> and <CTL>, and store them in a plot file.

The procedure scans the grid looking for contours, beginning at the lower left corner, (I, J)=(1, 1), and proceeding around the grid in a counterclockwise manner. The scan is controlled by two parameters: T, the parameter level indicator and P, the orientation of the scan vector. The values of T and P determine the starting point and direction of scan lines, which extend all the way across the grid, either horizontally or vertically. When P = 1 the scan direction is to the right. It is upward when P = 2, to the left when P = 3 and downward when P = 0. The perimeter level indicator, T, is 1 for scan lines along the outer-most perimeter of the grid, and is incremented by 1 each time the scan shifts inward. The scan vector has a magnitude of one grid length, and progresses along the scan lines between successive pairs of grid points. At each position, the grid point values at the tip and base of the scan vector are tested to determine whether a contour has been intercepted. If so, the tracking routine is initiated; otherwise, the scan vector advances to the next position along the scan line.

To initiate tracking, the coordinates of the contour intercept on the scan line are stored as the initial point of a contour segment. The tracking then proceeds into the grid square on the left side of the scan vector (inward). The selected grid square is expanded and divided into subsquares,

according to the value of the specification parameter <SQD>. In the expanded grid square the scan vector spans two adjacent subsquare points between which the initial point was found. The values of the field at subsquare points are computed with the Bessel central difference formula for quadratic interpolation:

$$P(\Delta x) = P_1 + \Delta x (P_2 - P_1) - \Delta x (1 - \Delta x)*(P_3 - P_2 + P_0 - P_1)/4$$

where P_0, P_1, P_2, P_3 are values at four successive grid points along a grid line and Δx is the fractional distance of a subsquare point, between the 2nd and 3rd of the four points, at which the interpolation is to be performed. Four vertical interpolations followed by one horizontal interpolation are required to compute a value for one subsquare point. If either of the outside values (P_0 or P_3) is undefined (equal to <NUL>), the interpolation becomes linear. When the interpolation is constrained by setting the option <FIXDBLBESSEL>, the larger (in absolute value) of the two differences $P_3 - P_2$ and $P_0 - P_1$ is replaced by the smaller for purposes of computation. This interpolation method is equivalent to fitting a quadratic to the four points by the method of least squares, with the constraint that the fitted curve must pass exactly through the two middle points (P_1 and P_2). The use of quadratic interpolation for subsquare points allows the possibility of maxima or minima in the grid field between the primary grid points. The main consideration for adopting it, however, is that it results in smoother contours.

The principal parameters involved in the tracking process are the grid indices (J1, I1) pointing to the lower left corner of the expanded grid square

in which the tracking is taking place, the subsquare indices (J2, I2) pointing to the left lower corner of the subsquare through which the contour is passing, the scan vector orientation, Q, which is initialized by P when an initial point in a contour is found, and the field values at the tip and base of the scan vetor. Each time a contour point is found, the grid square and subsquare indices and the scan vector orientation are adjusted as necessary to the new subsquare into which the contour is being tracked. Then the scan vector is shifted, from the side through which the new subsquare was entered, to each of the other sides in turn, until the exit point of the contour from that subsquare is found. The process is quite straightforward, unless the exit point is a corner. When the latter condition occurs, the program must determine which of three subsquares, sharing that corner point, the contour is entering. This is done by searching each of the three subsquares in turn, proceeding around the corner point in either a clockwise or counterclockwise sense. The latter depends on whether the exit point was encountered at the base or tip of the scan vector.

When the configuration of the field in a local area includes a saddle point, there is a possibility of a contour crossing itself. This situation will be detected by the tracking routine as a multiple exit condition and it will attempt to track the contour straight through the intersection, whether the crossing point is internal to a subsquare or at a corner. Situations with corner crossings may exist in which the tracking routine can not resolve a multiple exit condition due to the proximity of an internal or external boundary. In such cases, the contour segment being tracked may be terminated at the affected corner, or it may retrace part of another contour segment

which had already been tracked. The criterion for action in unresolved cases was based in the premise that it is preferable to plot a contour segment twice than to leave one unplotted.

In most situations, the tracking process will continue until an end point of the contour segment is reached. This happens when it terminates at a boundary, either external or internal, or closes on itself. Internal boundaries are created by undefined grid points; contours are not tracked into grid squares for which any one or more of the four corner grid points has been assigned the <NUL> value.

After finding an end point, the tracking indices J1, I1, J2, I2 and scan vector parameter Q are adjusted so that tracking of the current contour can be restarted in the opposite direction (outward) from the initial point. The tracking process then continues until the second end point of the contour is reached.

In brief, when the tracking routine encounters a contour during the perimeter scan, it suspends the scan and tracks the contour through the grid to its end points from the initial point of contact. As the perimeter scan proceeds around the grid and inward from level to level, the same contour may be encountered many times. In order to insure that the same contour is not plotted as a consequence of each new encounter, a test is employed which involves a reference array containing coordinates of certain points for contours already tracked. Points are stored in the reference array for each

contour tracked at each intersection with a grid line. Every point found by the perimeter scan is tested against the reference array before being accepted as an initial point of a new contour segment.

At the completion of each perimeter scan, the perimeter level indicator is increased (shifted inward) and the reference array is purged of all entries representing points outside the new perimeter. Thus the length of the reference array is kept at a minimum to reduce search time.

Table 1. TITLE FIELD on Run Control Cards.

SOURCE FILE NAME (INTERNAL)	1st FIELD	2nd FIELD	3rd FIELD	4th FIELD	5th FIELD
XYDAT	DATA or WIND	XYDAT	LOGICAL RECSIZE & LOCATION OF X COORD.	LOCATION OF Y COORD. & LOCATION OF PARAM. VALUE	OPTIONAL
MWX/00, MWX/01, MWX/02, etc.	SST or WIND or PRES or CLDS or EVAP	WXOB	Year-Month Code	(Day From) -(Day To)	OPTIONAL
MARDAT	SST or WIND or PRES or SSTD or NWNDS	MEAN	JAN or FEB or MAR etc	OPTIONAL	OPTIONAL
OCNDAT	TMP or SAL or OXY or SIGT or SPVA or DYNA	CCOFI	OPTIONAL	OPTIONAL	OPTIONAL
FNSHIP	SST or WIND or PRES or CLDS or AIR or DEW or EVAP or SWDIR or SWHGT or WVEL	FNWC	Year-Month Code	(Day From) -(Day To)	MAX. TAPE RECORD LENGTH
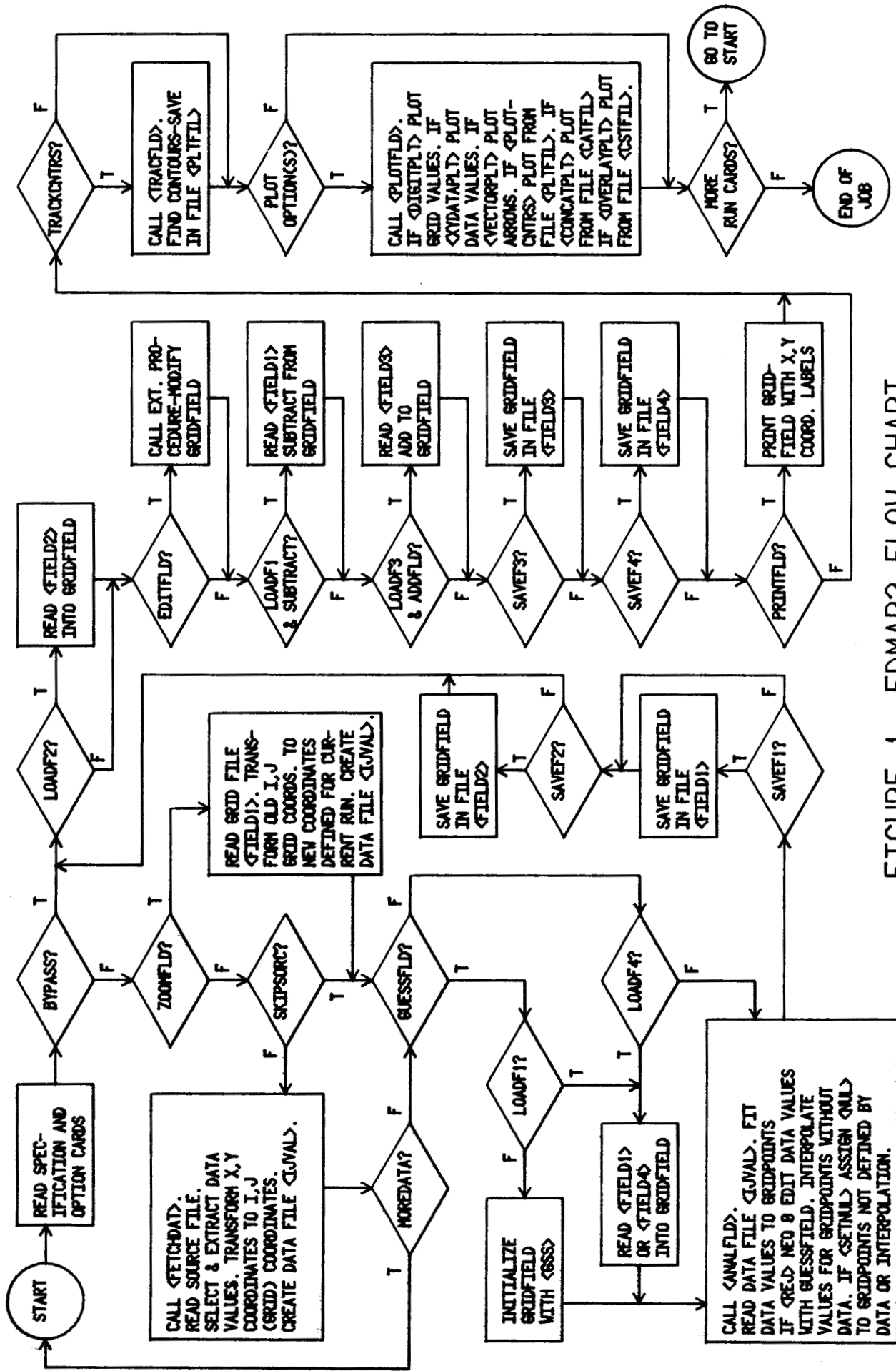
FIGURE 1. EDMAP2 FLOW CHART

FIGURE 2

```
   SST   MEAN   AUG        ENPAC  XZO=145W YZO=25N XMX=116W YMX=50N XGD=1 YGD=1
  PJC=1 SCL=3 SMH=6 ANL=6.4 CIN=1  COG=0  CTL=1 #
  CENTER PRINTFLD SAVEF1 SETNUL TRACKCNTRS  #                        (1ST RUN)


  XZO=15.0  YZO=25.0  XMX=44.0  YMX=50.0  XGD=1.0  YGD=1.0  IMX=  30  JMX=  26
       256  SOURCE RECORDS READ
       677  VALUES SELECTED BY FETCHDAT


    677  VALUES ACCEPTED FROM DATA FILE
      0  VALUES REJECTED
  SCAN 1 COMPLETED.    4 GRIDPOINTS ADDED.  SCAN TIME =    0.5 SEC

  SCAN 2 COMPLETED.    4 GRIDPOINTS ADDED.  SCAN TIME =    0.5 SEC

  ANALFLD PROC TIME =     2.6

  SAVED FIELD1        SST  MEAN    AUG        ENPAC  RS=  30   NR=  26




        SST  FNWC  8108 01-15  3015 XZO=145W YZO=25N XMX=116W YMX=50N XGD=1 YGD=1
       PJC=1 SCL=3 ANL=4 REJ=5 CIN=1 COG=0 SMH=6  MFX=0.31  #
      LOADF1 GUESSFLD CENTER SETNUL SAVEF2 TRACKCNTRS  PRINTFLD PLOTCNTRS  #    (2ND RUN)


  XZO=15.0  YZO=25.0  XMX=44.0  YMX=50.0  XGD=1.0  YGD=1.0  IMX=  30  JMX=  26
       668  SOURCE RECORDS READ
      2287  VALUES SELECTED BY FETCHDAT

  RETRIEVED FIELD1         SST  MEAN    AUG        ENPAC   RS=  30   NR=  26
  REJECT:  I 2200   J 1300   DATA   22000   D    5785
  REJECT:  I 1400   J 1700   DATA   13300   D   -5340
  REJECT:  I 2300   J  600   DATA    9800   D   -9664
  REJECT:  I 2500   J 2200   DATA   16100   D  -82900
  REJECT:  I 1100   J 1800   DATA   13300   D   -5308

   2161  VALUES ACCEPTED FROM DATA FILE
    126  VALUES REJECTED
  SCAN 1 COMPLETED.  169 GRIDPOINTS ADDED.  SCAN TIME =   1.3 SEC

  SCAN 2 COMPLETED.    1 GRIDPOINTS ADDED.  SCAN TIME =   0.6 SEC

  ANALFLD PROC TIME =    4.7

  SAVED FIELD2        SST  FNWC  8108 01-15  3015   RS=  30   NR=  26


  ENTERED PLOTFLD

  PLTFIL RETRIEVED:       SST  FNWC  8108 01-15  3015
     24 POINTS RETRIEVED FOR CONTOUR        22.000
     20 POINTS RETRIEVED FOR CONTOUR        14.000
     91 POINTS RETRIEVED FOR CONTOUR        15.000
     14 POINTS RETRIEVED FOR CONTOUR        15.000
    180 POINTS RETRIEVED FOR CONTOUR        19.000
    179 POINTS RETRIEVED FOR CONTOUR        20.000
    105 POINTS RETRIEVED FOR CONTOUR        21.000


   SST ANOMALY 8108 ENPAC         XZO=145W YZO=25N XMX=116W YMX=50N XGD=1 YGD=1
   PJC=1 #
   BYPASS LOADF2 LOADF1 SUBTRACTFLD SAVEF3 #        (3RD RUN)


  XZO=15.0  YZO=25.0  XMX=44.0  YMX=50.0  XGD=1.0  YGD=1.0  IMX=  30  JMX=  26
  RETRIEVED FIELD2        SST  FNWC  8108 01-15  3015   RS=  30   NR=  26
  RETRIEVED & SUBTRACTED FIELD1      SST  MEAN    AUG       ENPAC  RS=  30   NR=  26
  SAVED FIELD3      SST ANOMALY 8108 ENPAC          RS=  30   NR=  26



   SST MEAN & ANOM 8108 ENPAC    XZO=145W YZO=25N XMX=116W YMX=50N XGD=1 YGD=1
   PJC=1 SMH=6 CIN=1.0 COG=-09 SCL=3 CTL=1 MFX=0.31  ANL=0  #
   SKIPSORCDATA LOADF4 TRACKCNTRS PLOTCNTRS CONCATPLT PRINTFLD #    (4TH RUN)


  XZO=15.0  YZO=25.0  XMX=44.0  YMX=50.0  XGD=1.0  YGD=1.0  IMX=  30  JMX=  26
  RETRIEVED FIELD4      SST ANOMALY 8108 ENPAC          RS=  30   NR=  26
  ANALFLD PROC TIME =    1.2
```

FIGURE 3

MEAN AUG ENPAC FINAL(INTERPOLATED) DATA FIELD

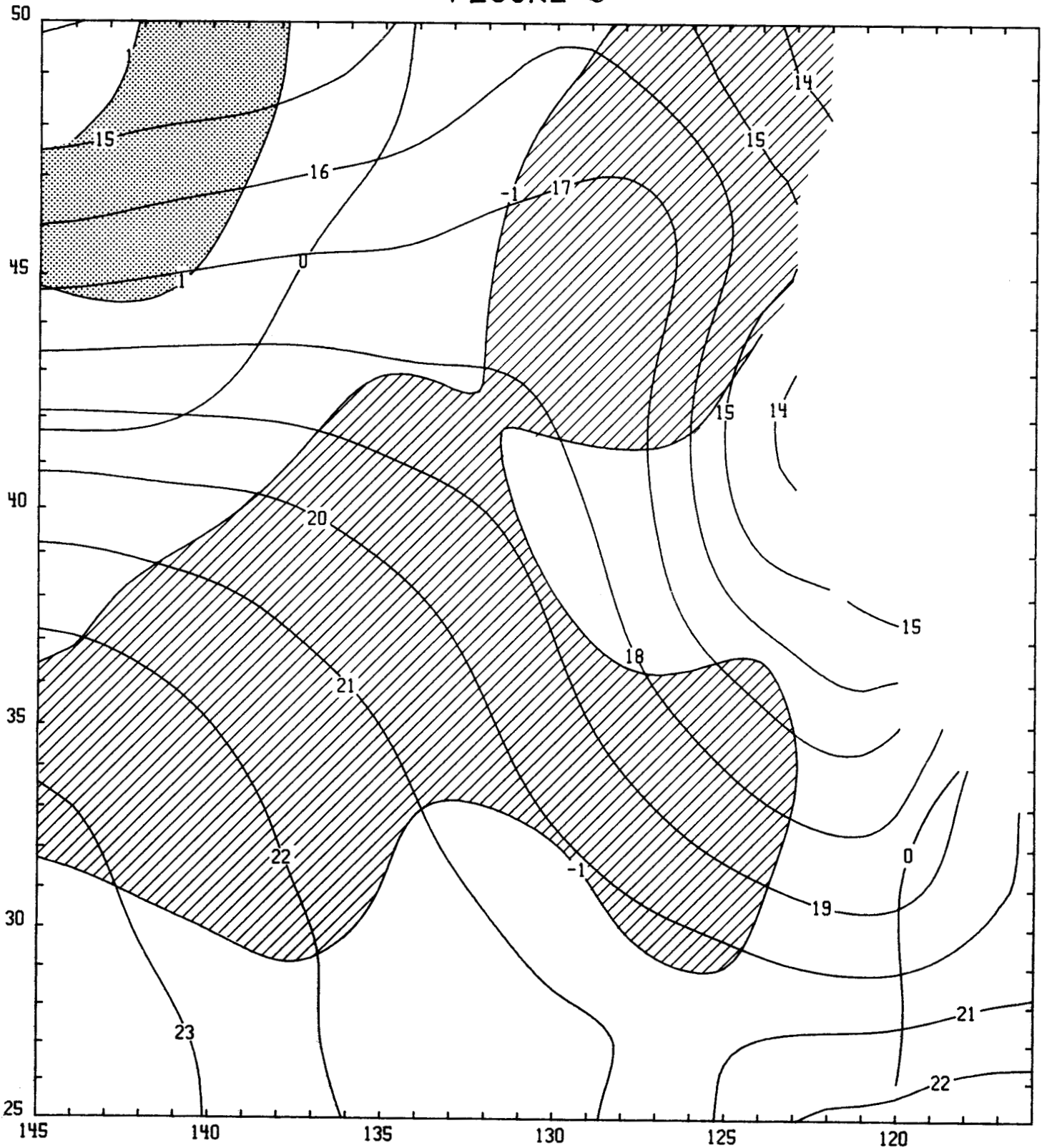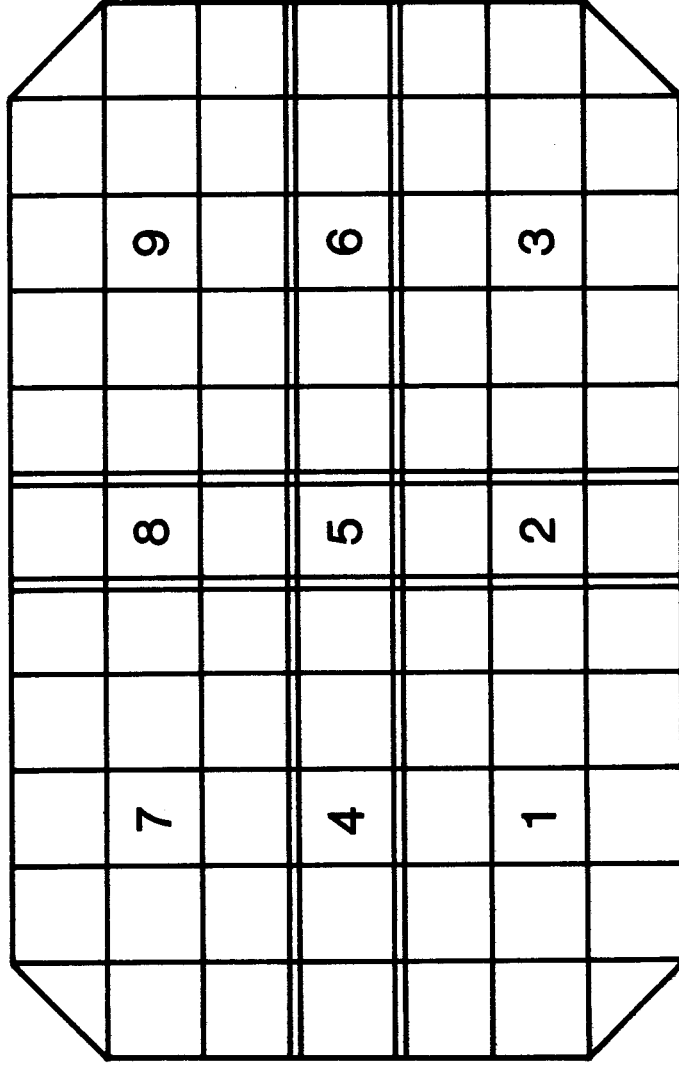| SST	130.00W	129.00W	128.00W	127.00W	126.00W	125.00W	124.00W	123.00W	122.00W	121.00W	120.00W	119.00W	118.00W	117.00W	116.00W
50.00N	15.875	15.850	15.678	15.362	14.960	14.542	14.157	13.879	13.727	99.000	99.000	99.000	99.000	99.000	99.000
49.00N	15.154	16.155	16.022	15.735	15.319	14.836	14.369	14.014	13.802	99.000	99.000	99.000	99.000	99.000	99.000
48.00N	16.555	16.593	16.525	16.236	15.880	15.339	14.798	14.360	14.045	99.000	99.000	99.000	99.000	99.000	99.000
47.00N	16.938	17.002	17.007	16.844	16.438	15.858	15.297	14.866	99.000	99.000	99.000	99.000	99.000	99.000	99.000
46.00N	17.204	17.260	17.297	17.154	16.719	16.083	15.513	15.153	99.000	99.000	99.000	99.000	99.000	99.000	99.000
45.00N	17.416	17.423	17.417	17.208	16.671	15.930	15.306	14.955	99.000	99.000	99.000	99.000	99.000	99.000	99.000
44.00N	17.626	17.550	17.432	17.089	16.407	15.540	14.845	14.472	99.000	99.000	99.000	99.000	99.000	99.000	99.000
43.00N	17.810	17.636	17.389	16.909	16.137	15.148	14.397	14.002	99.000	99.000	99.000	99.000	99.000	99.000	99.000
42.00N	17.965	17.702	17.352	16.787	15.934	14.941	14.161	13.742	99.000	99.000	99.000	99.000	99.000	99.000	99.000
41.00N	18.139	17.807	17.393	16.792	15.948	14.982	14.213	13.806	99.000	99.000	99.000	99.000	99.000	99.000	99.000
40.00N	18.356	17.971	17.512	16.903	16.106	15.225	14.529	14.201	99.000	99.000	99.000	99.000	99.000	99.000	99.000
39.00N	18.588	18.160	17.669	17.070	16.355	15.608	15.022	14.746	14.705	99.000	99.000	99.000	99.000	99.000	99.000
38.00N	18.807	18.359	17.859	17.297	16.699	16.093	15.607	15.299	15.103	14.908	14.712	99.000	99.000	99.000	99.000
37.00N	19.011	18.571	18.093	17.596	17.101	16.633	16.215	15.856	15.543	15.305	15.221	99.000	99.000	99.000	99.000
36.00N	19.204	18.794	18.363	17.937	17.532	17.150	16.777	16.408	16.083	15.923	16.091	99.000	99.000	99.000	99.000
35.00N	19.404	19.032	18.652	18.281	17.929	17.593	17.258	16.926	15.562	16.612	16.949	17.711	18.610	99.000	99.000
34.00N	19.630	19.300	18.964	18.625	18.297	17.983	17.684	17.408	17.208	17.210	17.544	18.201	18.962	19.613	99.000
33.00N	19.885	19.599	19.301	18.989	18.677	18.382	18.113	17.879	17.715	17.708	17.968	18.509	19.188	19.778	20.165
32.00N	20.153	19.905	19.649	19.374	19.096	18.831	18.588	18.375	18.215	18.279	18.343	18.764	19.337	19.838	20.144
31.00N	20.416	20.201	19.990	19.773	19.552	19.331	19.111	18.907	18.746	18.758	18.769	19.081	19.535	19.929	20.157
30.00N	20.667	20.482	20.319	20.168	20.017	19.845	19.651	19.464	19.317	19.242	19.296	19.527	19.874	20.168	20.325
29.00N	20.896	20.751	20.630	20.529	20.430	20.310	20.167	20.028	19.922	19.872	19.918	20.095	20.348	20.550	20.649
28.00N	21.065	20.976	20.875	20.782	20.715	20.671	20.634	20.596	20.562	20.553	20.611	20.753	20.927	21.050	21.103
27.00N	21.152	21.100	20.972	20.845	20.820	20.913	21.057	21.170	21.220	21.246	21.313	21.437	21.565	21.642	21.671
26.00N	21.186	21.122	20.918	20.737	20.775	21.050	21.402	21.661	21.773	21.809	21.872	21.990	22.110	22.180	22.208
25.00N	21.207	21.100	20.816	20.588	20.687	21.115	21.627	21.983	22.123	22.150	22.202	22.321	22.449	22.530	22.565

FIGURE 4

SST FNWC 8108 01-15 3015

FIGURE 5

SST MEAN & ANOM 8108 ENPAC

FIGURE 6

SEARCH AREA FOR INTERPOLATION
TO TARGET GRID POINTS WHEN
ANLH = 6 AND ANLV = 4

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