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The CAMS Interactive Atlas Package

***A Computerized Program for the Archiving
and
Presentation of Oceanographic Data***

by

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Technical Report

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Abstract

The CAMS Interactive Atlas Package allows a user to computer contour any hydrographic quantity on any isosurface in any global projection. It consists of two parts: a large, and growing, data base which can be easily supplemented with user-supplied data, and a set of computer software routines that manage the data, interpolate onto the isosurface, and draw the maps.

The data base presently includes the Levitus Climatological Atlas, IGY data, GEOSECS, TTO, and many NODC stations, all in a common format. In addition, the WHOI CTD data set can be easily accessed. This data base will be supplemented as new data becomes available.

The software routines allow the user to interpolate the data vertically on to a selected isopleth, such as an isobaric or isopycnal surface, and then horizontally interpolate the station data onto a regular grid for final contouring. Land mass areas can be automatically blanked out. The continental boundaries are drawn in and the contouring done in any one of fifteen projections. Station locations, cruise tracks, and bottom topography can all be included. The contour map can be plotted on either a vector plotter or a raster device, allowing the use of color in the final product.

1. Introduction

The CAMS Interactive Atlas Package is designed for fast and simple mapping of hydrographic data in a variety of modes. Display types supported by this package are contour maps, profiles, and ship tracks. These can be produced for either a vector-type plotter (e.g. a CALCOMP) or a raster device (e.g. the APPLICON), which, incidentally, allows the use of color. The data can also simply be posted, and with the help of an auxiliary graphics program, property-property scatter plots, contoured sections, and T-S curves are all possible. While any of these plots can be made by hand, the task takes quite a bit of effort, and should the data base change, the process must be started all over again. We do not claim that the problem of subjectivity in "objective" mapping and contouring has been solved. Rather, we hope that the Atlas package can provide an aid to the scientist who wishes to look at the data with a minimum of fuss.

The package consists of two parts: a CAMS data base consisting of standard hydrographic measurements covering the world ocean, and the software, which performs the actual plotting of data, as well as some data management functions. These will be reviewed separately.

We have taken great pains to develop the package as a system. For example, throughout the package "null" data values have been supported. Those are signified by the value 1.0E35. This can tremendously simplify data editing and the calculation of "derived" hydrographic values.

Whenever a data "window" must be specified, the convention is always (lower left corner, upper right corner). I.e., (min x, min y) then (max x, max y). Another convention is that the "x" variable longitude always precedes latitude. This differs from the navigational convention latitude, longitude.

2. Software

The software package consists of three programs, ATLAS, PROFILER, and PLOT5. ATLAS does interpolation and makes maps of the data. PROFILER creates a string of vertical property profiles for profiling a section. PLOT5, not a true part of the package, is simply a "front-end" plotting package whose data interface meshes conveniently with ATLAS.

2.1 ATLAS

The ATLAS program is the heart of the whole mapmaking package. All the other software is auxiliary. It does most of the data manipulation and plotting. It searches the data base for data types specified by the user and can do vertical interpolation to put those data onto any arbitrary isopleth. It can also do horizontal interpolation to put data onto a grid using either of two algorithms (see section 2.1.2. under ZGRID and INGRID). The resulting grid can then be contoured and displayed in any of a variety of map projections (see PROJECTION). It has access to the Mappack coastline data, and can draw them in on the plot. It can overlay plots, post data values, track courses, and issue polite error messages. It can even "handshake" between density levels to avoid errors due to the nonlinearity of the equation of state of seawater (see MSEARCH in part 5).

As an introduction to the ATLAS Program it is an instructive exercise to review the separate steps required to transform irregular or randomly spaced data points into finished contour maps. This is especially important since ATLAS was written as an interpreter that issues a prompt and requires a command to tell it what to do.

The raw data for ATLAS resides in a "CAMS Archive Format" (CAF) file. A description of this format can be found in section 3.2. Each file contains data from many stations and each station in the file contains data from many different levels in the ocean. Since the object is to create a map of data at some specific level, the first step in the process is to vertically interpolate the data from each station onto some isopleth (a surface of constant something: pressure, density, temperature or whatever) with the SEARCH command. Using vertical Laplacian interpolation, the routine will produce a two-dimensional field of single valued data points, and store it in an external file, the "Searchfile," described in section 3.4.

Now, in general, the points in this field will not lie in any systematic pattern. Some data sets, such as the Levitus Climatological Atlas, will lie in an orderly way, but these are rarely true raw data. More likely, there may be discernable ship tracks, at best. In order to draw contours, the field must lie on a grid. Therefore, a horizontal interpolator must be called to create a field of gridded data points equivalent to the original field of randomly spaced values.

ATLAS contains two such interpolators, ZGRID, and INGRID. They each produce results comparable to the other, but the difference in algorithm is large enough to produce substantial discrepancies, both in computer time used, and in accuracy. ZGRID, the much faster of the two, uses a spline/relaxation method to turn a good first guess into a good approximation of the whole field. Unfortunately, there is only rudimentary control over the scale of correlation it uses. This scale is a measure of the distance over which any data point can be expected to influence the value of any grid point, and it is a significant factor in this type of interpolation. With ZGRID, the "stiffness" of the spline used implicitly defines the scale. There is no explicit realization, except qualitative. It is true that the "stiffer" the spline, the longer the scale, but this is only useful in a very limited sense. The correlation function aside from being variable only with the stiffness parameter, is also constrained to be both isotropic and homogeneous.

Unfortunately, in many oceanographic applications, this is not desirable. For example, in general circulation applications, the east-west correlation scale is much larger than in the north-south direction. Similarly, the scales tend to be shorter near the active western boundary of an ocean than in the eastern part. Consequently, an anisotropic, inhomogeneous correlation function is sometimes desired. This is where INGRID, the other interpolator comes in. INGRID uses a completely arbitrary correlation function defined by the user (see section 5.2 for more about these functions, including how to write your own). Using this function, with some corrections for "shadowing" of data points by one another and for the gradient of the interpolated field, INGRID can produce gridded data of higher quality than ZGRID. However, there is a compensating increase in time spent, INGRID being roughly eight times slower than ZGRID.

After the data has been vertically and horizontally interpolated, it is in a form suitable for the contouring algorithm. Next, a PROJECTION is specified and the labelling parameter checked. It is then simply a matter of choosing contour levels with the CLEVEL command and issuing the CONTOUR command. If a color map is desired, the SETCOLOR and COLOR commands are used before the CONTOUR command. ATLAS will automatically draw and label the boundaries, draw the appropriate coastlines, and draw and label the contours.

It is sometimes desirable to smooth the contour lines to make a prettier picture. ATLAS provides three distinct ways in which to do this. The first is simply to smooth the gridded field. There is a SMOOTH command for doing just that, which essentially applies a Laplacian diffusion equation NSM times to remove much of the small scale part of the field. This technique is fast, but must be used with caution to avoid obliterating the data. An overly smooth field is rarely very interesting.

The other two smoothing methods act during the actual contouring. One way is to simply divide each segment of the contour line into a given number of subsegments (see the NARC feature of the CONTOUR command), and then fit a polynomial to the actual curve of the contour line. This is again a fast technique, but can, in some cases, cause two contours to cross.

The third alternate method of smoothing the contour lines is to create a finer grid of data values, interpolated with polynomials, and then to contour that new, higher resolution grid. Mathematically, this method does no more or less damage to the data than the previous one, but has the advantage of never producing crossed contour lines. It is, however, substantially, though not unacceptably, slower. (The number of times the grid is subdivided is controlled by the NDIV parameter of CONTOUR.)

For more on the details of producing a map, the sample sessions in section 4 are useful. Also, a list of all the available commands with their definitions can be found in section 2.1.2, below.

2.1.1 Usage of ATLAS

Some preparation is required in order to use the ATLAS program. First, a coast line file must be assigned to FORTRAN unit 8 (e.g. \$ASSIGN DSKA:[PUBLIC.MAP]MPWORLD FOR008). These files are found in DSKA:[PUBLIC.MAP] on the BLUE system. Some of the less frequently used files are stored on tape, and must be requested from IPC.

The "Searchfile" should be assigned to logical unit 47, while the output from the plot defer system should, as usual, be assigned to unit 95. Defaults will be FOR47.DAT and FOR95.DAT, respectively. Raster type plots will appear in the UNIRAS format.

Definitions

These are some of the definitions used in the ATLAS documentation:

SEARCHBUFFER

Searchbuffer: The Searchbuffer consists of three arrays: latitude (YSRCH), longitude (XSRCH), and data (ZSRCH) which are the source of data for the horizontal interpolators ZGRID and INGRID. The Searchbuffer is filled from the Searchfile by using the READSEQ command. Which of the available data types in the Searchfile that will be used to fill ZSRCH is determined by the MAPVAR command. In this version of ATLAS you are limited to 5,000 points in the Searchbuffer.

MAPGRID

Mapgrid: In order to draw contours, the data from the Searchbuffer must be put onto the grid of the Mapgrid using ZGRID or INGRID. This matrix is then used to compute the contour lines. The buffer dimensions and position are controlled with the GRID command. In this version, the maximum size of the Mapgrid is 360 x 180 data pts.

SEARCHLIST

These are the variable types that will be interpolated and written to the Searchfile when the SEARCH command is issued. Pressure, salinity, and potential temperature are automatically included. You can add variable types with the ADDVAR command, and delete them with DELVAR. Use SHOW,VAR to see what variables are in the current list.

MNEMONICS

These are some of the four letter codes for each of the data types:

<u>mnemonic</u>	<u>variable</u>
DPTH	Depth (positive)
P	Pressure (db)
T	Temperature (°C)
THØ	Potential temperature (°C)
S	Salinity (PSU)
SIGØ	Potential density
PVQD	Potential vorticity ($\times 10^{-13} \text{s}^{-1}$)

<u>mnemonic</u>	<u>variable</u>
SIGn	Sigma $n \times 10^8$ (n is 1 to 4)
O2	Oxygen (mL/L)
NULL	(No data type)
PO4	Phosphate ($\mu\text{M/kg}$)
SIO3	Silicate ($\mu\text{M/kg}$)
NO3	Nitrate ($\mu\text{M/kg}$)
NO2	Nitrite ($\mu\text{M/kg}$)
H3	Tritium ($\mu\text{M/kg}$)

Coastlines

The Coastlines that are used by the ATLAS package must be in a file assigned to FOR008, and in the format used by the MAPPACK subroutines. (The MAPPACK subroutines have their own documentation available from IPC.) Some of these files can be found in DSKA:[PUBLIC.MAP], others must be retrieved from tape. The available files are:

MPWORLDC: is a rough outline of the entire world. Use it for tests where not a lot of accuracy is needed.

MPWORLD2: is a somewhat less rough outline of the world.

MPUS: is a U.S. map of greater detail, including state borders.

MPNATL: is a map of the North Atlantic, in detail comparable to MPUS.

On tape at IPC:

MPSATL, MPINDO, MPNPAC, MPSPAC: all of comparable detail to MPNATL.

MPWORLD: The concatenation of all the detailed ocean files. This file is necessary if the boundaries of the region of interest do not fall cleanly within any single ocean basin. Also available is the C.I.A. data base, of even greater detail. (e.g. MPNATL includes a fair rendition of Nantucket. This data has an equally fair outline of Cuttyhunk and Penzance Point.)

Blanking

In many cases it is desirable to blank out portions of the map where no contours should be drawn. For example, for most oceanographic purposes, the land masses should remain free of contours. The interpolating and contouring routines have been specially trained to ignore grid values of 1.0E35 so if the Mapgrid contains this value wherever there is land, the land will remain blank. Blanking to one degree of resolution is available with the GRID,MASK command. For finer resolution, the Mapgrid will have to be prepared with the READMAT command.

Updates

The ATLAS program contains a help facility with short summaries of all the commands, as well as other valuable information. Type HELP to see a list of the available topics. The help file will always be updated to reflect recent changes, and so will stay more current than this publication.

2.1.2 Commands

This is the command set of the ATLAS program, in alphabetical order. The command format is:

COMM,p1,p2,...,pn,label

where COMM is the ATLAS command. Only the minimum number of characters to specify a unique command needs to be typed in. The parameters pn are numbers in any FORTRAN format (e.g. 1.0E-05, -6, 10.23) or blank. If blank, the input is considered null and no replacement is made. The parameter "label" is a character string and is at the end of the list of parameter numbers. In the documentation that follows the character strings are denoted by lower case letters. If there is no label parameter then more than one command may be entered on the same line by separating them with semi-colons.

All parameters must be separated by commas or blanks, except null entries which must have separating commas. Null entries are allowed except where noted in the specific command descriptions.

If a null value is specified, then one of two defaults will apply, depending on the command parameter. Either ATLAS will use the old value (the initial value is denoted by brackets [] in the documentation), or it will supply a value (denoted by double brackets [[]]).

ADDVAR

ADDVAR adds data types to the 'Searchlist'. The data types on this list are interpolated onto an Isopleth and written to the Searchfile when executing the SEARCH command.

Formats:

ADDVAR,mnem

mnem: The four letter mnemonic of the data type to be added.

or:

ADDVAR

ATLAS will prompt you for the variable type. Salinity, potential temperature, and pressure are automatically included in the Searchlist. See DELVAR if you are not interested in these.

ASSIGN

The ASSIGN command will do a DCL \$ASSIGN from within ATLAS. It is for use in case the user has forgotten to assign a coastline file to FOR008, or a name to FOR047 or FOR095. It only does assignments to FORTRAN unit numbers (names of the form FORxxx).

Format:

ASSIGN, unit, file spec

Example:

ASSIGN,8,DSKA:[PUBLIC.MAP]MPWORLD.C.DAT will assign that file to FOR008 giving ATLAS access to the low resolution coastlines in that file.

BOTTOM

The BOTTOM command allows the user to create a Searchfile containing the water column depth as the only datum (mnemonic = 'WDEP'). This can be useful when trying to map the ocean floor, but is primarily useful in mapping station positions of a complete data set in conjunction with the POST command. Note that files created by SEARCH do not necessarily have a data point at every station. The target isopleth will outcrop or go too deep for some of the stations. The BOTTOM command is the only way to be certain a Searchfile contains all the stations of the original data set.

Format:

BOTTOM

CLEVEL

The CLEVEL command defines and changes contour levels to be put on the map.

Formats:

CLEVEL,oldz,newz,lwgt,ndig

oldz is the old value of the contour.

newz is the new value of the contour.

lwgt is the line type of the new contour.

ndig is the number of digits in the new contour label.

or:

CLEVEL,oldz

ATLAS will prompt for new values.

or:

CLEVEL

ATLAS will allow you to change (or initialize) all contour levels.

or: CLEVEL,nlevnom,AUTO

To pick nlevnom nominal contour levels automatically.

nlevnom: The nominal number of contours [8].

LWGT indicates the weight of the contour line:

[[-1]]: Pick automatically (less than zero will be dashed, zero will be heavy, greater than zero regular)

0: No line

1: Regular line

2: Heavy line

3: Dashed line

NDIG sets the number of digits in the contour label

-2: No label

[[-1]]: Pick automatically

0: Label as integer

k: Use k digits to the right of the decimal points

COLOR

The COLOR command will create a contour map of the information in the Mapgrid, in color, using UNIRAS software to produce a map for an ink jet color plotter. (n.b. It is important to have at least a passing familiarity with the use of the UNIRAS package to use this command.) The color levels must first be specified with the SETCOLOR command. This will only work if PLOTTYPE,6 has been issued. Note also that the colors will cover anything that has already been drawn, including contours, ship tracks, and data points. If any of these are desired, draw them after using COLOR.

Format:

COLOR,ndiv,xcoscl,ycoscl

ndiv is equal to 1, 2, or 4. The Mapgrid is subdivided ndiv times, using polynomials to interpolate within the grid. ndiv=1 has no effect, and this is the default.

xcoscl, ycoscl: use these to specify (in inches) the position of a color scale relative to the origin of the map. If these are not specified, no color scale will be drawn. In this case, contour identification can be made by calling the CONTOUR command after the COLOR command. This will superimpose the standard vector contours on top of the color map.

CONTOUR

The CONTOUR command creates a contour map of the information in the Mapgrid, using the contour values from CLEVEL.

Format:

CONTOUR,hgt,narc,ndiv

hgt is the optional height of the contour labels, in inches. [.07]
 narc is a parameter that controls smoothing of the contour lines. Each segment of the contour will be divided into narc subsegments using a polynomial fit to the contour curve. narc = 1 has no effect, and this is the default condition. [1]
 ndiv is equal to 1, 2, or 4. The Mapgrid is subdivided ndiv times in both directions, using polynomials to interpolate within the grid. This is another way of producing smoother contour lines. ndiv = 1 has no effect, and this is the default condition. (Execution time increases quickly with the value of ndiv.) [1]

DELVAR

DELVAR deletes variable types from the Searchlist.

Formats:

DELVAR,mnem

mnem: The four letter mnemonic of the variable to be deleted.

or:

DELVAR

ATLAS will prompt for the variable type.

DLEVEL

The DLEVEL command can delete contour levels from the list of levels to be contoured.

Format:

DLEVEL,zlev

zlev is the value of the contour level to be deleted.

There are no defaults.

DUMP

DUMP prints the entire contents of the Searchbuffer. (Careful!)

DUMPMAT

Dumps the Mapgrid onto a specified file along with its dimensions, grid corner locations, and spacing. The grid can be restored by using RESTMAT. This is a much faster (but less versatile) method of saving the grid than using MWRITE.

Format:

DUMPMAT,filenm

filenm is the name of the file into which the dump is done.

The dump file is two unformatted records looking like so:

record 1: NX,NY,DX,DY,XLL,YLL,XUR,YUR,MAPVAR
 record 2: ((AMAT(I,J),I=1,NX),J=1,NY)

where:

(NX,NY): X and Y grid dimensions.
 (DX,DY): X and Y grid spacing.
 (XLL,YLL): Latitude,longitude of the lower left corner.
 (XUR,YUR): Latitude,longitude of the upper right corner.
 MAPVAR: The four character mnemonic of the type of data on the grid.

EXIT

EXIT exits.

FILE

FILE specifies the CAF source data file for an isopleth search. See section 3.2 for a description of the file format in use here.

Format:

FILE,filespec

GRID

The GRID command is used to set up the Mapgrid for use by one of the interpolating routines (INGRID or ZGRID). It can also perform blanking of land masses to prevent the formation of unsightly contours in Des Moines, Madison, and many other places. The blanking is only as fine as the grid being used, and can be no finer than one degree squares in the current edition of ATLAS.

Format:

GRID,xll,yll,xur,yur,nx,ny,frac,label

xll,yll is the lower left corner (long,lat) of the grid.

xur,yur is the upper right corner.

nx and ny are the number of grid points to a side.

frac... If the percentage of land in a given square of the grid is greater than frac, that square will be blanked.[0.3]

label ='MASK' will produce a blanked matrix using the ATLAS land mass data set. The blanking is relatively crude at present, with only one degree of resolution.

See the OCEAN command for the default grid. A grid specified with the GRID command will always override the default grid specified by OCEAN.

GRID,AUTO will restore the default values. The default grid does not have blank land masses.

HELP

HELP produces help on any of the commands or definitions in ATLAS.

Format:

HELP,commandname

ILEVEL

ILEVEL is used to insert contour levels into the existing list.

Format:

ILEVEL,zlev,lwgt,ndig

zlev is the value of the contour.

lwgt is the line type of the contour. [[-1]]

ndig is the number of digits in the contour label. [[-1]]

See the CLEVEL command for more on lwgt and ndig.

INGRID

The INGRID command interpolates randomly spaced data in the Searchbuffer onto the matrix in the Mapgrid, using an explicitly defined correlation function. The user can change the function as necessary. See section 5.2 on the interpolaters. This routine is slower than ZGRID, but allows more control of the results. If blanking of portions of the map is desired, the routine should be fed a pre-blanked matrix (see GRID), much the same way that the contouring routine likes it.

Format:

INGRID,nx,ny,dx,dy,xll,yll,rx,ry

nx,ny are the dimensions of the output matrix.

dx,dy are the distances between adjacent rows of the matrix. [1,1]

xll,yll is the lower left corner of the matrix in the map space.

rx,ry are the maximum radii in grid points of influence of data points on the grid points. [5,5]

LABSET

LABSET sets various labelling parameters.

Format:

LABSET,tclon,tclat,tclabsiz,ltcont

tclon: Interval between longitude tick labels [10].

tlat: Interval between latitude tick labels [10].

tclabsiz: Size of the tick labels in inches [0.15].

ltcont: Line type with which to draw the continents [1].

Line types:

0: No line

1: Regular line

2: Heavy line

3: Dashed line

MAPSET

MAPSET changes three parameters which have to do with the scaling of the maps:

Format:

MAPSET,icd,sc,bs

icd, the scaling option, is a value from 1 to 6, specifying the uses of sc and bs.

icd =

1	sc = height of map in inches	bs = meaningless
2	sc = map distance per bs units of latitude (inches)	
3	sc = map distances per bs units of longitude (inches)	
4	sc = scale ratio, earth to map	bs = base parallel
5	sc = scale ratio, earth to map	bs = base meridian
6	sc = radius of display window	bs = ?

when using icd = 6, it is best to let bs = 90 and let happen what will.

Defaults:

[icd = 1, sc = 8.0]

See WHOI MAPPACK documentation for more details.

MAPVAR

MAPVAR allows you to specify which data type to retain when reading from a Searchfile into the Searchbuffer when using commands READSEQ or READMAT.

Format:

MAPVAR,mnem

mnem: The four character mnemonic.

MWRITE

MWRITE writes the contents of the Mapgrid to an external file [whose default name is SRCHMAT]. The file is written to look like a Searchfile, and must be re-entered with the READMAT command.

Format:

MWRITE,imin,imax,jmin,jmax,filename

(imin,imax): min,max x subscript to write [[all]].

(jmin,jmax): min,max y subscript to write [[all]].

filename: the name of the file to which the data is to be written
[[FOR047]].

NEWMAP

NEWMAP moves the plotter pen to a clean sheet of paper so that another map can be drawn. Maps can be (and frequently are) overlaid by omitting this command.

Format:

NEWMAP

OCEAN

OCEAN specifies the boundaries of the area to map. You may use catalogued ocean boundaries, or specify your own.

Format:

OCEAN,ocmnem

ocmnem: The mnemonic of the catalogued ocean that you wish to work with [NATL].

mnemonic (minlon,minlat) (maxlon,maxlat) basemeridion

NATL:	(-100, 0)	(30,70)	-50
SATL:	(-70,-70)	(30, 0)	-20
NPAC:	(-260, 0)	(-80,70)	-170
SPAC:	(-260,-70)	(-50, 0)	-155
INDN:	(20,-70)	(120,30)	70
ATL:	(-100,-70)	(30,70)	-50
PAC:	(-260,-70)	(-60,70)	-160

or:

OCEAN,minlon,minlat,maxlon,maxlat,basemeridion

minlon,minlat: minimum longitude and latitude of the ocean boundaries. This marks the southwest corner.

maxlon,maxlat: maximum longitude and latitude. This is the northeast corner.

basemeridion: The meridian specified here will be straight and vertical in most projections. It is usually best to put it in the center of the area of interest.

Unless the user has explicitly defined a Mapgrid via the GRID command, OCEAN will also specify a default Mapgrid. This default grid is one degree smaller on each side than the ocean boundaries specified in the OCEAN command. I.e. the grid corners will be:

(minlon+0.5,minlat+0.5), (maxlon-0.5,maxlat-0.5).

with one degree spacing.

In any case, a grid specified with the GRID command will always override this default grid.

ORIGIN

Sets the position of the southwest corner of the map in inches. Use this with the SIZE command, and note that ATLAS will clip any lines that would go beyond the limits specified there.

Format:

ORIGIN,xorg,yorg

(xorg,yorg): The (x,y) position of the page space origin in inches.
[5.0,5.0]

PARAM

The PARAM command is used to pass up to 20 arguments to the user defined subroutine DRIVE used in the SEARCH subroutine. The parameters need only be entered once, unless DRIVE changes any of them. See section 5.1 about details on how to write your own DRIVE to calculate derived quantities.

Format:

PARAM,p1,p2,p3.... (up to 20)

POST

POST creates a map of the information in the Searchbuffer, writing data values directly onto a map of the indicated area.

Format:

POST,imrk,hgtmrk,hgtlab,angle

imrk: The symbol code for the symbol that will be put at each data point. Specify -1 for no mark, [3 (a plus)]. See below for symbol examples.

hgtmrk: The height of the mark [.05].

hgtlab: The height of the label to be drawn. Use zero to suppress the label. [0.0]

angle: The angle at which the labels are drawn [0.0].

The integer next to each symbol is the imrk value used to request that symbol.

0 6 11 17 Table 2

1 7 12 18

2 8 13 19

3 9 14 20

4 10 15 21

5 16

PLOTTYPE

Sets the type of plot.

Format:

PLOTTYPE, jptype

jptype: [0] Plot defer
 1 Tekterminal
 2 Tek + plot defer
 3 Calcomp
 6 Raster (color)

PROJECTION

PROJECTION specifies the map projection to be used in any mapping functions.

Format:

PROJECTION, proj, tplanes

Proj	Projection Type	Scale options available
1	Mercator	1,3,4
2	Miller	1,3
3	Square	1,2,3
4	Cylindrical Stereographic	1,3
5	Lambert Cylindrical	1,3
6	Flat Polar	1,2
7	Sinusoidal	1,2
8	Mollweide	1
9	Lambert Conic Conformal	1
10	Universal Transverse Mercator	1
13	Azimuthal Equal Area	1,6
14	Azimuthal Equidistant	1,6
15	Azimuthal Orthographic	1,6
16	Azimuthal Perspective	1,6
17	Azimuthal Stereographic	1,6

[Default: Mercator]

The scaling options code is one of the arguments of the command MAPSET

tplanes This is a special argument for two of the projections.

For the Lambert Conic Conformal projection, tplanes is two numbers, separated by a comma, specifying the lowest and highest latitude of cone intersection, respectively.

For the Azimuthal Perspective projection, tplanes specifies the height above the surface of the earth, just one value.

PSET

There are a minimum and a maximum pressure which influence the search, PSET can be used to change these. When the SEARCH routine finds two depths in a single station where the search quantity is equal to the target value, the shallowest depth is the one written to file. Specifying a range of pressures to search is one way to get the deeper value to be recorded.

Format:

PSET, pmin, pmax

or

PSET, AUTO

which returns the values to the defaults of 0 and 10000 db.

READCOM

READCOM reads ATLAS commands from a specified command file. Do NOT try to READCOM from a trace file while the trace is enabled.

Format:

READCOM, file

READMAT

READMAT fills the Mapgrid from an external Searchfile. Note that this command fills a different buffer (the Mapgrid) than READSEQ (the Searchbuffer). The data type to be read is specified by the MAPVAR command. Because the READMAT command reads data directly into the Mapgrid, the data must already lie on a grid (which must have the same dimensions as the Mapgrid). There is no provision for horizontal interpolation. A search of the Levitus climatological data set will produce a Searchfile with data already on a grid. So will the MWRITE command. The READMAT command uses the Searchfile longitudes and latitudes to put each data point at its corresponding grid point.

Format:

READMAT, filename

READSEQ

READSEQ fills the Searchbuffer from an external Searchfile. See section 2.1.1 for a description of the Searchbuffer, section 3.4 for a description of Searchfiles. The MAPVAR command specifies the data type to be read. Once in the Searchbuffer, the data can be POSTed, TRACKed, or horizontally interpolated onto the Mapgrid (see ZGRID or INGRID).

Format:

READSEQ,npts,apflg,file

npts is the number of points to read from the file. [[all]]
 apflg, if set to 1, will prevent the Searchbuffer from being cleared
 before each read. Use to to append Searchfiles in the buffer. [[0]]
 file is the name of the file [[defaults to FORTRAN unit 47]].

RESTMAT

Restores the Mapgrid from a specified dump file. The file must have been created by DUMPMAT or a clever program. See DUMPMAT if you're really interested in the dump format. Note that after this command is issued, the Mapgrid will be exactly as it was when the DUMPMAT command was used.

Format:

RESTMAT,filenm

SEARCH

The SEARCH command creates a file on FORTRAN unit 47 of the values of the quantities in the Searchlist interpolated onto the specified isopleth. Special considerations are provided for isopycnal searches. These are explained in detail in section 5.1. The CAF source file is specified with the FILE command.

Format:

SEARCH,val,ihnd,quan

val is the value of quan on the isopleth.

ihnd is a switch for handshaking.

quan is a four-character string specifying the type of isopleth.

Defaults: quan and val have no defaults, ihnd is off by default.

Example: SEARCH 26.5, SIGØ would interpolate data onto the 26.5
 potential density surface.

The handshaking feature, if enabled, allows the user to specify a density referenced to a low pressure in interpolating onto a much deeper surface, or vice versa. See the section 5.1 for more information.

If ihnd is absent, there is no attempt at handshaking. If ihnd is negative one (-1), the program scans for handshaking with surfaces shallower than the one specified. If positive one (+1), it searches for deeper surfaces. Other values of ihnd can be used only at great personal risk.

SETCOLOR

The SETCOLOR command is used to select contour levels and colors for the COLOR command. It should be issued before the COLOR command. In many

respects it is similar to the CLEVEL command. Note that there is one more color than contour level.

Formats:

SETCOLOR,oldz,newz,cyan,magenta,yellow

oldz is the old contour value

newz is the new value

cyan, magenta, and yellow are numbers from 0 to 16, inclusive, denoting the relative amount of each primary color to use for any contour level. 16 is for full intensity, 8 for half intensity, and zero for zero intensity.

or:

SETCOLOR, oldz

ATLAS will prompt for new values

or:

SETCOLOR

ATLAS will allow the user to change all contour levels. Use END, cyan, magenta, yellow to specify the last color level.

ATLAS will also allow the user to specify a color for those parts of the map that are land, or where there is no data, as well as the color of the background around the map.

SETCOLOR,cyan,magenta,yellow,area

area is either 'LAND', 'UNDEFINED', or 'BACKGROUND' specifying the area to fill with the given color. The default color of each area is white.

SHOW

The SHOW command displays the values of the various parameters used by other ATLAS commands.

Format:

SHOW,ptype

ptype is the type of parameter you wish displayed.

STATS: displays the minimum and maximum values in the Searchbuffer, and the Mapgrid.

CLEVEL: shows the current contour levels, line types, and desired label precision.

VARS: shows the current Searchlist and map variable.

GRID: shows the current Mapgrid corners and spacing.

MAP: shows the map corners and other associated parameters.

COLOR: shows the current contour levels, and colors assigned to each.

SIZE

Sets the size of the sheet of paper the plotting will be done on. Any line of the plot attempting to cross this invisible boundary will be brutally clipped. This goes for labels, too. It is usually wise to recheck the origin position (ORIGIN command) when changing the size parameters. When plotting on a graphics terminal, the screen is assumed by the program to be the dimensions in the SIZE command. ATLAS does not stretch one axis relative to the other and thus retains the true perspective. Note that this command has nothing to do with the actual size of the map. Use the MAPSET command for this.

Format:

SIZE,xsize,ysize

(xsize,ysize): The x and y dimension of the sheet in inches. [20.0,20.0]

SMOOTH

SMOOTH smooths the data in the Mapgrid using Laplace's equation. Variable "diffusion" coefficients allow the user to control the extent of smoothing in each direction.

Format:

SMOOTH,nsm,xdfuse,ydfuse

nsm is the number of times the smoothing routine is to be called. Each call to the routine can be thought of as advancing one time step. If xdfuse and ydfuse are thought of as being in units of $1.0/(\text{relaxation time})$, then a call with $\text{xdfuse} = 1/\text{nsm}$ will result in a reduction in the height of the peaks by a factor of e .

xdfuse is the "diffusion" coefficient in the x-direction.

ydfuse is in the y-direction. If omitted, it will take on the same value as xdfuse. Neither of these parameters can be larger than 0.5.

STATUS

STATUS allows the user (you) to append Searchfiles. At first, STATUS is NEW, and each Searchfile created is a new one. If STATUS is changed to OLD, then each new Searchfile will be appended to the last one. Searchfiles are always FORTRAN Unit 47 (FOR047). Do not use this to append two Searchfiles containing the same stations, as an error will occur.

TIME

TIME shows the date and time.

TRACE

TRACE creates a command file (trace file) consisting of all the commands issued between the TRACE,ON and the TRACE,OFF commands. The output appears in a file labelled TRACE.DAT, or to wherever the logical name TRACE points.

Format:

TRACE,arg

arg is either ON, or OFF [OFF].

TRACK

TRACK produces a map with a line connecting each of the points in the Searchbuffer. No use is made of the data values, just the longitudes and latitudes.

Format:

TRACK,lwgt

lwgt: line weight of track
 1: Regular line
 2: Heavy line
 3: Dashed line

ZGRID

The ZGRID command interpolates randomly spaced data in the Searchbuffer onto the matrix in the Mapgrid, using a correlation function implicitly defined by its spline/relaxation algorithm.

This is a faster interpolater than INGRID, but does not allow much control of the correlation between points. See section 5.2. If blanking of portions of the map is desired, the routine must be fed a pre-blanked matrix (see GRID or READMAT).

Format:

ZGRID,cay,nrng

cay is a parameter that effects the "stiffness" of the spline used to fit the data to the grid. [5.0]

nrng: any grid point farther than nrng grid points from the nearest data point will be set to undefined (1.0E35). [10,000]

2.2 Profiler

This program provides output like that in Fig. 3, a string of profiles of data in a data archive file. It is an interactive program also, but will prompt the user for the necessary information. Because the variation in a

given parameter is so much greater near the surface than down deep, the profile is divided into a shallow part and deep part, so that the scaling can be different above and below. See section 4 under 'profile' for a sample session with this program.

2.3 PLOT5

PLOT5 is not a part of the ATLAS package. Rather, it is a sophisticated general purpose graphics program whose usage meshes nicely with the ATLAS requirements. It has documentation all its own, available from Tom Keffer. See section 4 for notes on how it is used, and for sample sessions.

3. The CAMS data base

The data base is the original source of information to be used by the package's software. Note that it is, however, quite independent of the programs. Any data can be used by the package as long as it is in the format described below, referred to as the CAMS Archive Format (i.e. CAF files). The CAMS data base is supplied for convenience and its high quality. It can be supplemented with user supplied data, or subsampled to include only a part of the available data base. (See section 3.3 for software to make these tasks simple.)

3.1 Coverage

At the time of this writing, the greater part of the available data is from five different sources: IGY (North Atlantic only), GEOSECS, TTO, and Sydney Levitus's version of the NODC world ocean, as well as a large selection of the NODC archives. While this assortment covers the entire world, it is rather sparse in some areas. We hope to update the CAMS data base as new data is made available.

3.2 The CAMS Archive Format (CAF)

The CAMS Archive formatted Files are written in "unformatted" format, to save space. Each file contains bottle data from many different stations. These have been grouped into files by a variety of different common characteristics. For example, the file BIGB:[CAMSARK]IGY.DAT contains most of the IGY North Atlantic data set. BIGB:[CAMSARK]NPAC.DAT contains all the North Pacific data from the Levitus Climatological World Atlas. Not surprisingly, the file [CAMSARK]ELTANIN29.DAT contains only stations from R/V Eltanin Cruise 29. There is a file, called BIGB:[CAMSARK]KAMSNO.DOC which contains short comments on the available data files.

A single CAF file consists of a sequential string of many stations, each separated by what is (unfortunately) referred to as an end-of-file (EOF) mark. Each station consists of a "station" header record, then a "data" header record, then any number of data records. The EOF then follows and a new station begins. At the absolute end of the CAF file there are two EOFs. The "station" header contains information pertaining to the entire station, such as position, water depth, number of observations, etc. The "data" header record identifies the

types of data available to that station. Following this are the data records themselves, one for each depth. Most of the available stations are bottle data, but by sub-sampling in the vertical direction, CTD data can also be included in these files. (See section 3.3.4 for a short description of some conversion software.)

3.2.1 Station Header

The station header consists of information pertaining to the entire station, e.g. latitude, longitude, data, time, ship, nationality, cruise and station number. Also included are the number of data records that follow, their range of pressure, and a unique CAMS station number.

The following FORTRAN command will write one header record for the CAMS archive station:

```
WRITE(3) KAMSNO,CCODE,SHIP,CRUISE,STA,CAST,UPDN,  
*YEAR,MNTH,DAY,TIME,DDLAT,DDLON,PRMIN,PRMAX,NDEPS,  
*WDEP,BLNK1,BLNK2,COMNT
```

KAMSNO: A unique integer assigned to each station. Within a CAF file the KAMSNO must monotonically increase.

CCODE: A three character code specifying the nationality of the ship that took the data (e.g. the U.S.S.R. is '90 ', and the USA is '31 '). These follow the NODC convention.

SHIP: A six character variable to specify the name of the ship (e.g. 'OC ', 'BE ', etc.). These also follow the NODC convention.

CRUISE: Three characters for the cruise number.

STA: Nine characters for the NODC station code.

UPDN: This is only applicable to CTD stations. If the data was taken on the uptrace, these two characters read 'UP', otherwise, 'DN' or 'NA'.

YEAR,MNTH,DAY,TIME: These are all integers. Time is read on the 24-hour clock. YEAR only refers to the last two digits of the calendar year. This may seem improvident to some, but the author, at least, does not expect this program (or this computer) to remain in action for the next 17 years.

DDLAT,DDLON: These are the latitude and longitude, respectively, expressed in decimal degrees. A negative longitude indicates West, and a negative latitude South.

PRMIN,PRMAX: These refer to the minimum and maximum pressure sampled at each station. These are floating point numbers.

NDEPS: This is the number of data records that follow.

BLNK1,BLNK2: We included these two four-character blanks in the header just in case we had forgotten some vital piece of header information. At the time of this writing, it seems that we hadn't. However, a user who wishes to use his or her own data may use them for any pertinent data.

COMNT: This is just 80 characters of space for some descriptive comment about the station, the cruise, the data set, the weather, or the name of the winch operator.

3.2.2 Data header

The data header is simply a record of the data types found in the station. It consists of a number, specifying how many data types are included, followed by a string of four character mnemonics, e.g. P, T, S, DPTH, O2, SIG2, etc., written using an unformatted WRITE statement. We routinely carry seven data types: pressure, depth, salinity, temperature, oxygen, potential temperature, and potential densities, referenced to various pressures. While the last two are derived quantities, they are included to avoid continual recalculation. (The UNESCO eq. of state (Millero et al.) is used throughout the Atlas package. There is a Knudsen-Ekman version available which does not use the catalogued values.) Many of the stations carry other data types as well, including carbon dioxide, nitrite, nitrate, silicate, phosphate, and tritium. Other data types can easily be added to user supplied data.

Here is a FORTRAN WRITE statement for one typical data header:

```
WRITE(3) NDTYP,(DATYP(I),I=1,NDTYP)
```

NDTYP: The number of data types included in the station.

DATYP: This is an array, NDTYP long, of 4 character mnemonics, one mnemonic for each available data type. A list of the mnemonics currently in use can be found near the beginning of section 2.1.1.

3.2.3 Data records

Each data record in a station consists of a string of floating point (REAL*4) numbers in the order specified by the mnemonics in the data header and represent observations for one depth. The data within each station is sorted

by depth, with the shallowest level immediately after the data header. Where the data was bad or missing, a "null" value of 1.0E35 has been inserted which will be ignored by the software package.

All the data records for a single station can be written like this:

```
DO 10 I=1,NDEPS
10  WRITE(3) (DATA(I,J),J=1,NDTYP)
```

The DATA array is a NDEPS*NDTYP matrix of the actual data values for each depth, and for each data type. Data records are written in order of increasing depth. After the data records have been written the EOF should be written:

```
ENDFILE 3
```

A new station can then begin.

(It is important to note that while the above scraps of FORTRAN will write one complete station to an external file in the archive format, it is not the easy way to do it. The easy way is outlined below under INPUT and OUTPUT, section 3.3.2.)

3.3 Data base software aids

These programs are not a true part of the mapmaking facility of the package, but are included to simplify the handling of the data base.

3.3.1 CAMSEE

CAMSEE is an interactive data editor designed for use in managing the CAMS data archive. Use it for preliminary reviewing and editing of the data. It can search for a station in a file by a variety of criteria, and can even plot data at any single station (e.g. T-S diagrams or property profiles).

To use CAMSEE, simply \$RUN BIGB:[CAMSOFT]CAMSEE, and answer the questions about input and output filenames. If you plan to edit data, an output file must be specified. Having done this, CAMSEE will present you with a prompt for a command. The command format is the same as in the ATLAS program. A list of available commands and their functions follows, and there is also a HELP facility within the program. Default parameters are indicated with brackets. If you are editing data, it is important to remember that CAMSEE always has one station (the 'current' station) in its buffers, and consequently, that data is not written to the output file until you advance to the next station. If the NOCOPY option is used, the current station is not written out, nor are any other stations after that one and before (but not including) the "target" station.

CCODE

CCODE searches the input file for a specified country code. If no country code is specified or if it begins with a number, CAMSEE will prompt. Note that if you want the NOCOPY flag to be turned on then you will have to let CAMSEE prompt. If the country code is in capital letters then capital letters must be specified. Generally, country codes are always either capital letters or numbers.

Format:

CCODE,countrycode

-or-

CCODE,copyswitch

countrycode: The character string country code (e.g. Germany is 06).

copyswitch: NOCOPY to not copy files to output.

COMMENT

This command changes the comment field of the current station.

Format:

COMMENT,comment

-or-

COMMENT

and you will be prompted for your comment.

DENSITY

DENSITY calculates theta, sigma-0, sigma-1, sigma-2, sigma-3, and sigma-4 from the available temperature and salinity data of the current station. If no record numbers are specified, then CAMSEE will prompt. If only one number is specified, then CAMSEE will do only that number. If DENSITY,ALL is typed then CAMSEE will calculate densities for all record numbers.

Format:

DENSITY,first,last

first: The first data record for which the density is to be calculated.

last: The last data record for which the density data is to be calculated [first].

EDIT

EDIT allows editing the data of the current station. There are no defaults.

Format:

EDIT,recno,newvalue,mnemonic

recno: The record number of the data point to be changed.

newvalue: The new value of the data point.
 mnemonic: The mnemonic (e.g. SIG0) of the data point to be changed.

EXIT

EXIT exits the program. (Imagine that.)

FILE

FILE skips to the desired file number. If CAMSEE is already positioned at the desired file, nothing happens. If no file number is entered, CAMSEE will prompt for one.

Format:

FILE,fileno,copyswitch

fileno: The file number of the target file.

copyswitch: NOCOPY to not copy files to output.

KAMSNO

KAMSNO searches for a specific CAMS number (see section 3.2). If CAMSEE is already past that number, it will chide you. If no KAMSNO is entered CAMSEE will prompt for one.

Format:

KAMSNO,kamsno,copyswitch

copyswitch: NOCOPY to not copy files to output.

LONLAT

LONLAT allows the user to search for stations in a specific longitude/latitude rectangle. Not entering any parameters causes CAMSEE to search for the next occurrence of the last min,max longitude and latitude (except for the first time, when it will prompt). Use POLYGON to search for stations within a generalized polygon.

Format:

LONLAT,minlon,maxlon,minlat,maxlat,copyswitch

(minlon,maxlon): Min,max longitude of the rectangle.

(minlat,maxlat): Min,max latitude of the rectangle.

copyswitch: NOCOPY to not copy files to output.

NEXT

NEXT causes CAMSEE to position itself to the next CAF file. This command is no different from entering SKIP,1. No parameters.

Format:

NEXT,copyswitch

copyswitch: NOCOPY to not copy files to output.

PLOT

PLOT allows plotting data from the current station. Specifying a data mnemonic implies a plot versus pressure. If no data mnemonic is specified, then CAMSEE will prompt for an x and y data mnemonic, allowing a T/S type plot. Typing simply PLOT, mnemonic will cause CAMSEE to automatically pick appropriate axes ends. The PLOT command can, of course, only be used at a graphics terminal (e.g. a VT100 with RETROGRAPHICS).

Format:

PLOT, xmin, xmax, xinc, ymin, ymax, yinc, mnemonic

(xmin, xmax): X axis min, max values. [pick automatically]
 xinc: X axis increment. [pick automatically]
 (ymin, ymax): Y axis min, max values. [pick automatically]
 yinc: Y axis increment. [pick automatically]
 mnemonic: The mnemonic (e.g. SIG0) of the data type to be plotted.

POLYGON

POLYGON is a generalized version of the command LONLAT. It allows finding all stations within a user specified polygon. Because it is less efficient than LONLAT it is not recommended for a simple rectangle. CAMSEE will prompt for the vertex coordinates. Simply typing OLD will cause CAMSEE to use the old coordinates.

Format:

POLYGON, copyswitch

copyswitch: NOCOPY to not copy files to output.

PRHEAD

PRHEAD prints the header of the current CAF station.

There are no parameters.

Format:

PRHEAD

PRREC

PRREC prints requested data records from the current CAF station. If no parameters are entered, CAMSEE will prompt.

Format:

PRREC, first, last

first: The first data record to be printed.

last: The last data record to be printed [first].

Entering PRREC, ALL prints all data records. Entering PRREC, recno just prints record number "recno".

QEDIT

QEDIT allows editing of the data of the current station. It is identical to the EDIT command except that DENSITY is called afterwards to calculate the new theta and densities.

There are no defaults.

Format:

QEDIT,recno,newvalue,mnemonic

recno: The record number of the data point to be changed.

newvalue: The new value of the data point.

mnemonic: The mnemonic (e.g. SIG0) of the data point to be changed.

SHIP

SHIP searches the input file for a specified ship code. If no ship code is specified or if it begins with a number, CAMSEE will prompt. Note that if you want the NOCOPY flag to be turned on, then you will have to let CAMSEE prompt. If the ship code is in capital letters then capital letters must be specified (i.e. ME is not the same as Me or me). Generally, ship codes are always capital letters.

Format:

SHIP,shipcode

-or-

SHIP,copyswitch

shipcode: The character string ship code (e.g. Meteor is ME).

copyswitch: NOCOPY to not copy files to output.

SKIP

SKIP causes CAMSEE to skip the requested number of stations.

Format:

SKIP,nskp

nskp: The number of stations to skip [1].

copyswitch: NOCOPY to not copy files to output.

TOSS

Using TOSS is identical to specifying SKIP,nskp,NOCOPY. I.e. nskp stations will be bypassed and not copied to output.

Format:

TOSS,nskp

nskp: The number of stations to bypass [1].

3.3.2 IPUT, OPUT, and CAMSDAT

IPUT and OPUT are subroutines that read or write one station from or to an external CAF file. These can be of great use in creating, editing, or subsampling a data file. To use OPUT, for example, a program must set values to the variables in the COMMON blocks below, then simply call OPUT, and one complete station will be written to the file. It is, of course, necessary to OPEN the file before calling either of these. Use the FORM='UNFORMATTED' qualifier in the OPEN statement (as well as the READONLY qualifier, when using the CAMS data base, please).

IPUT reads one station from an external file.

```
CALL IPUT(LUNIT,NF)
```

LUNIT: Logical unit number of the data file.

NF: = 0 Normal read

= 1 End of file encountered.

OPUT writes a station to an external file.

```
CALL OPUT (LUNIT,NF)
```

LUNIT: Logical unit number of external file.

NF: If NF = 0, OPUT writes one station with an EOF at the end. When NF = 1, OPUT only writes an EOF mark.

Both these subroutines require four common block definitions. These can be INCLUDED with BIGB: [CAMSOFT]CAMSDAT.CMN, which contains the following (see section 3.2.1 for the variable definitions):

```
PARAMETER ENULL=1.0E35, MXDTYP=20, MXREC=500
CHARACTER DATYP(MXDTYP) *4
```

```
CHARACTER CCODE*3, SHIP*6, STA*9, CRUISE*3, UPDN*2
```

```
CHARACTER BLNK1*4, BLNK2*4, COMNT*80
```

```
DIMENSION DATA (MXREC, MXDTYP)
```

```
INTEGER CAST, YEAR, MNTH, DAY, TIME, WDEP
```

```
COMMON /HSCHAR/CCODE, SHIP, CRUISE, STA, UPDN, BLNK1, BLNK2, COMNT, DATYP
```

```
COMMON /HSINT/KAMSNO, CAST, YEAR, MNTH, DAY, TIME, NDEPS, WDEP, NDTYP
```

```
COMMON /HSFIX/DDLAT, DDLON, PRMIN, PRMAX
```

```
COMMON /CONTENTS/DATA
```

Note that DDLAT and DDLON are in decimal degrees, and that the DATA array is ordered by increasing depth.

Here is a FORTRAN program that uses IPUT and OPUT to carve a chunk out of a data file. The program will select any stations in the IGY data set that fall between 27° and 50° North latitude and 53° West and 10° East longitude. These stations will be written to the output file ('OUTPUT') on logical unit 2. One

can easily use other selection criteria, such as water depth, date, or nationality.

```

PROGRAM CARVE
INCLUDE'BIGB:[CAMSOFT]CAMSDAT.CMN'
OPEN(1,FILE='IGY',FORM='UNFORMATTED',STATUS='OLD',READONLY)
OPEN(2,FILE='OUTPUT',FORM='UNFORMATTED',STATUS='NEW')

10  CALL IPUT(1,NF)
    IF(NF.EQ.1) STOP 'ALL DONE'
    IF(DDLAT.LE.50. AND. DDLAT.GT.27.AND.DDLON.GT.-53
2   .AND.DDLON.LE.10) CALL OPUT(2,NF)
    GO TO 10
END

```

3.3.3 CTD Format

There is available a pre-packaged program to convert data from the WHOI CTD format to CAF format. CTDCAMS is an interactive program that will prompt the user for the necessary information. Some familiarity with the CTD format is necessary.

To use CTDCAMS, the default directory must be the directory that contains the CTD format files. The program will prompt for all the other necessary information.

The program works by subsampling the CTD trace to produce data points separated by a user specified depth interval. Provisions are made to change the depth interval below a "break pressure," also given by the user. There is no filtering done to the data, points are merely picked out of the CTD trace.

If filtering is desired the program BIGB:[CAMSOFT]CTDFILT is available. It will read a CTD format file, filter and (optionally) subsample it, then write it back out as another CTD format file.

3.4 Secondary Data Files (Searchfiles)

A CAF file can be thought of as representing three spatial dimensions: longitude, latitude, and depth. A map, however, can only have longitude and latitude. To get around this, ATLAS can interpolate the data vertically onto a specified isopleth (e.g. a surface of constant depth or potential density). This produces a two dimensional representation of the data which is stored in a "Searchfile" for later mapping. (The Searchfile can be read by ATLAS with the READSEQ command, or the READMAT command if the data falls on a regular grid. See section 2.1 for details.) These files are typically created within the

ATLAS program, but for some purposes, such as the tracking of drift buoys, they are a more suitable form of input than the CAMS Archive Format. (This data, consisting only of longitudes and latitudes, is already two dimensional, and can be mapped directly.) Searchfiles are of the unformatted type, and consist of a header record followed by any number of data records.

The header record contains the number of data types in each record, and their corresponding four character mnemonics. The data records consists of the CAMS station number (or some other integer (*4)), the longitude and latitude in decimal degrees, and then the string of data variables. This header record of the Searchfile has the same format as the data header of the archive file (see section 3.2). (In the case of drift buoys, or ship tracks, the longitude and latitude are the data. In this case, no data values need be included in the Searchfile.)

The following FORTRAN WRITE command will write one typical Searchfile header record in the correct format:

```
WRITE(47) 4,'S ','THO ','P ','SIO3'
```

The data records would then be written like this:

```
WRITE(47) KAMSNO,DDLON,DDLAT,(DATA(I),I=1,4)
```

4. Display modes

Following are examples of some of the display modes available with this package, and the terminal session that produced it.

4.1 Contour map (Fig. 1)

In the following examples, the user's responses are underlined.

```
$ RUN ATLAS
ATLAS VERSION 1.2      14-Mar-1983
      7-MAY-83      23:42:35
ATLAS > FILE,BIGB: [CAMSARK] NATL
CURRENT DATA FILE:  BIGB: [CAMSARK] NATL.DAT;1
ATLAS > SEARCH,27.15,SIG0
INPUT FILE OPENED:  BIGB: [CAMSARK] NATL.DAT;1
      4555 stations have been read from the file
ATLAS > MAPVAR,P
ATLAS > READMAT
      3698 points read; 0 out of range; 3698 retained non-null values
ATLAS > CONTOUR
ATLAS > EXIT
      1 Map has been produced in this session
ATLAS FINISHED
```

Here the data set from the Levitus climatological atlas was used. This data is already on a grid, so no horizontal interpolation onto a grid needs to be done, and the READMAT command can be used to read the Searchfile directly onto the mapgrid. This session uses virtually every default value available, from the default mapgrid to the projection and labelling parameters, to the automatic choice of contour levels. This is as few commands as can be used to produce one contour map (Figure 1a).

Below is a more complete sample session, beginning with the irregularly spaced IGY data. The result is Figure 1b.

```
$ RUN ATLAS
ATLAS VERSION 1.2      14-Mar-1983
      6-MAY-83      17:07:06
ATLAS > OCEAN,NATL
ATLAS > FILE,BIGB: [CAMSARK] IGY
CURRENT DATA FILE:  BIGB: [CAMSARK] IGY.DAT;1
ATLAS > ADDVAR,O2
ATLAS > SEARCH,26.8,SIG0
INPUT FILE OPENED:  BIGB: [CAMSAR] IGY.DAT;1
      941 stations have been read from the file.
ATLAS > MAPVAR,O2
ATLAS > READSEQ
      595 Points read      595 points kept.
ATLAS > GRID,-70,0,0,60,35,30,,MASK
```



```

ATLAS > ZGRID,5,4
ATLAS > SMOOTH,7
ATLAS > PROJECTION,8
ATLAS > LABSET,30,10,,2
ATLAS > CLEVEL

```

GIVE NEW CONTOUR LEVEL, LINE TYPE, # OF DIGITS.
 TERMINATE WITH 'END' OR 'REST'

```

CONTOUR 1 WAS 0.000E+00 LINE TYPE: -1 NDIG: -1
NEW VALUES: 3

```

```

CONTOUR 2 WAS 0.000E+00 LINE TYPE: -1 NDIG: -1
NEW VALUES: 3.5

```

```

CONTOUR 3 WAS 0.000E+00 LINE TYPE: -1 NDIG: -1
NEW VALUES: 4

```

```

CONTOUR 4 WAS 0.000E+00 LINE TYPE: -1 NDIG: -1
NEW VALUES: 4.5

```

```

CONTOUR 5 WAS 0.000E+00 LINE TYPE: -1 NDIG: -1
NEW VALUES: 5

```

```

CONTOUR 6 WAS 0.000E+00 LINE TYPE: -1 NDIG: -1
NEW VALUES: END

```

```

ATLAS > CONTOUR,,3

```

```

ATLAS > EXIT

```

1 Map has been produced in this session.

ATLAS FINISHED

OCEAN: This specifies that the boundaries of the plot are the bounds of the North Atlantic. There are a few catalogued boundaries, such as NATL,SATL,INDN etc. Note that NATL is the default, rendering this command superfluous. The user can also just specify the corners of the plot in longitude and latitude.

FILE: This identifies the source of the original (raw) data in CAMS Archive Format (CAF). BIGB:[CAMSARK] is the home of all the ATLAS data files.

ADDVAR,O2: Add oxygen to the Searchlist. Oxygen values on the isopleth will now be written to the Searchfile, in addition to the defaults of pressure, potential temperature, and salinity.

SEARCH,26.8,SIG0: Creates a Searchfile containing values for the above four data types on the 26.8 surface of potential density.

MAPVAR,O2

READSEQ: The SEARCH command created an external file with the data in it. In order for ATLAS to use it again, it must be read into the Searchbuffer with the READSEQ command. The MAPVAR command merely specifies which data type to read.

GRID: Now that the data has been entered into the Searchbuffer, it must be put onto a grid. The GRID command defines the corners, and the resolution of the grid to be used in the interpolation.

ZGRID: This is the interpolator. A "stiffness" of 5 has been specified for the spline to be used, and any point more than 8 degrees latitude or longitude (4 grid spaces) from a grid point will have no effect on the value of the field at that point.

SMOOTH: Some rudimentary Laplacian smoothing of the field is done before contouring.

PROJECTION: This specifies the projection used in drawing the map. 8 indicates a Mollweide (equal area) projection.

LABSET: Sets labelling parameters, in this case the space between longitude and latitude tick marks, and the line type to use for the continents.

LABSET can also change the label size, and define a line type for meridians and parallels, if these lines are desired.

CLEVEL: Is used to define the contour levels to be used by the contour routine.

CONTOUR: Tells ATLAS to create a contour map according to the preceding specifications. The '3' is a request to smooth the contour lines with splines, subdividing each segment into 3 subsegments. This is not the same as subdividing the grid.

Figure 1a: Pressure on SIG0 = 27.15.

Figure 1b: Oxygen on SIG0 = 26.8, Mollweide projection.

4.2 Drifter track (Fig. 2)

```

$ RUN ATLAS
ATLAS VERSION 1.2          14-Mar-1983
    6-MAY-83      17:09:01
ATLAS >OCEAN,-75,36,-70,43
ATLAS >LABSET,1,1,,2
ATLAS >MAPVAR,NULL
ATLAS >READSEQ,DRIFTER
    179 Points read      179 points kept.
ATLAS >TRACK
ATLAS >EXIT
    1 Map has been produced in this session.
ATLAS FINISHED

```

To make this map, a special Searchfile (logical name 'DRIFTER') was created by another program containing the longitudes and latitudes of a recent drifter experiment (including the time spent on the ship). The Searchfile should include dummy CAMS numbers (see section 3.2) and a header record (which will not be read and, hence, can contain anything). Because the TRACK command does not make use of any of the data types in the Searchfile (just the longitudes and latitudes), no data type need be specified. The MAPVAR,NULL serves this purpose.

Figure 2: Drifter track.

Figure 3a: These are the station locations for the profile on page 43.

4.3 Profile (Fig. 3)

```

$ RUN ATLAS
ATLAS VERSION 1.2          14-Mar-1983
      6-MAY-83    11:00:13
ATLAS > FILE,BIGB:[CAMSARK] IGY50W
CURRENT DATA FILE:  BIGB:[CAMSARK] IGY50W.DAT;1
ATLAS > BOTTOM
      19 files have been read.
ATLAS > MAPVAR,WDEP
ATLAS > READSEQ
      19 Points read    19 points kept.
ATLAS > POST,11,0.08
ATLAS > EXIT
      1 Map has been produced in this session.
ATLAS FINISHED

```

BOTTOM: This is the command that creates a "Searchfile" from the water depths in the header of each station.

POST: Puts data marks at the latitude-longitude positions in the Searchbuffer.

```

$ RUN BIGB:[CAMSOFT] PROFILER
Give input file name: BIGB:[CAMSARK] IGY50W
GIVE QUANTITY: S
GIVE UPPER AND LOWER BOUNDS OF S : 35,34.9
GIVE UPPER AND LOWER BOUNDS OF S : 36,35
GIVE QUANTITY: STOP
LAST PLOT DONE

```

Note that the light ledger lines in the profile on the next page are drawn with the second pen on the Calcomp plotter.

Figure 3b: Profile of IGY50W Section.

Figure 4: Scatter plot from PLOT5.

4.4 Scatter plot (Fig. 4)

```

$ RUN ATLAS
ATLAS VERSION 1.2          14-Mar-1983
      6-MAY-83   11:10:59
ATLAS > FILE,BIGB:[CAMSARK]TTO
CURRENT DATA FILE:  BIGB:[CAMSARK]TTO.DAT;1
ATLAS > SEARCH,27.1,SIG0
INPUT FILE OPENED:  BIGB:[CAMSARK]TTO.DAT;1
      249 stations have been read from the file.
ATLAS > EXIT
ATLAS FINISHED

```

```

$ RUN BIGB:[CAMSOFT]PLOT5
PLOT5 VERSION 3.4      26 MAY 1982
      6-MAY-83   11:34:43
? VAR,4,5
? XLAB,SALINITY
? YLAB,POTENTIAL TEMPERATURE
? FORM,UNFORMATTED
? SKPREC,1,FOR 47
? READSEQ,FOR 47
      216 POINTS READ
PLOT BUFFER FULL
? PLOT,0
? LINE,1,,0
? PLOT
PLOT      1 COMPLETE
? EXIT
END OF RUN
      1 PLOTS PRODUCED
NORMAL TERMINATION OF PLOT5

```

PLOT5 is a completely independent interactive graphics program, that actually has little to do with the ATLAS package. See the PLOT5 documentation (or any other general purpose graphics program) for more information.

5. SUBROUTINES

These subroutines are referenced by the ATLAS program. For special applications, it may be desirable to access them independently of ATLAS. For this purpose, they have been collected into a library, BIGB:[CAMSOFT]ATLIB.OLB. The ZGRID subroutine is in BIGB:[CAMSOFT]CAMSPLOT.OLB.

5.1 SEARCH

The search routine performs a search of a CAMS archive file along an arbitrary isopleth, producing a "Searchfile" from the CAF file specified. It uses Laplacian interpolation to derive values on the isopleth for each of the quantities in the Searchlist.

The SEARCH routine is called like this:

```
CALL SEARCH (QUAN, VAL, SRCHLST, NSRCH, FNAME, STAT)
```

QUAN: The four character mnemonic specifying the type of isopleth.
 VAL: The value of QUAN at the isopleth.
 SRCHLST: The Searchlist of four character mnemonics specifying what data types are to be interpolated onto the isopleth.
 NSRCH: How many quantities are in SRCHLST.
 FNAME: Name of archive file to read from.
 STAT: Status of Searchfile.
 = 'NEW' will create a new Searchfile.
 = 'OLD' will append the new Searchfile onto the tail of whatever is on FORTRAN unit 47. Do not use this to combine two Searchfiles containing the same stations.

Search also requires the following common blocks, which are used to subsample the data. The common block

```
/SELFIX/MAXLON, MINLON, MAXLAT, MINLAT, MAXPRES, MINPRES
```

specifies the boundaries of the search.

```
/SELINT/KAMSNO, CAST, YEAR, MNTH, DAY, TIME, NDEPS, WDEP
```

is used to specify any of the integer data in the archives (e.g. search only the (19)57 stations). Set each of them equal to -1 if not interested in this feature.

MSEARCH

When interpolating onto isopycnal surfaces, it is possible to specify a density referenced to a low pressure, only to find that the surface in question goes much deeper than that low pressure. For example, in the North Atlantic, the 27.0 surface of density referenced to the surface outcrops to the north,

but also goes down as deep as 800 meters, where the density referenced to 1000 meters (catalogued under SIG1) would be more appropriate. This subroutine, used in place of SEARCH, will "handshake" between density levels, using the data to determine the appropriate value of the deeper surface. For example, with the SIG0 = 27.0 surface, MSEARCH will use all the data within the range 450 to 550 meters to determine that this surface is equivalent to the SIG1 = 31.41 surface in the North Atlantic. (At least that's what it is for the IGY data.) Note that specifying a deep SIG0 surface (e.g. 27.7) will not work, as there will be no points between 450 and 550 meters.

CALL MSEARCH (QUAN, VAL, LIST, NLIST, FNAME, STAT, IHND)

all the arguments are the same as in SEARCH except

IHND = 1 handshaking will proceed from the top down.

= -1 handshaking will proceed from deep levels up.

(i.e. don't specify IHND = -1 for a SIG0 surface)

MSEARCH calls SEARCH, so the other aspects of their usage (common blocks, DRIVE) are identical.

DRIVE

Derived quantities other than potential density and potential temperature can be included in the Searchlist. These include potential vorticity, Brunt-Väisälä frequency, and dynamic height, and many more. However, in order to use any of these, the user must supply his or her own subroutine to calculate them in the following format:

SUBROUTINE DRIVE (PREQ, JLAST, ARG, SRCHLST, SRCHVAL, NSRCH)

PREQ: The pressure at the isopleth.

JLAST: The number of the first bottle above PREQ.

ARG: A variable parameter list, 20 arguments long (see the PARAM command).

SRCHLST: An array of four character mnemonics NSRCH long.

SRCHVAL: An array of returned values NSRCH long. This array is what DRIVE calculates and returns.

NSRCH: The number of quantities in SRCHLST, as well as the length of the SRCHVAL array (not a coincidence).

DRIVE can also INCLUDE 'BIGB: [CAMSOFT] CAMSDAT.CMN' (see section 3.3.2 on IPUT and OPUT) for access to all the station's data, as well as the header information. DRIVE accepts the Searchlist (SRCHLST) of quantities desired, and scans it for the mnemonics corresponding to quantities it can calculate. If there

are none, it simply returns. If one is found, the value of that quantity on the isopleth at pressure PREQ is calculated using the DATA array or the header information in CAMSDAT.CMN, and any arguments in the ARG array. (If this is being used as a part of ATLAS, the ARG array is specified with the PARAM command at the interpreter level.) The calculated value is then assigned to the SRCHVAL array in the same position as the mnemonic was in the SRCHLST array.

An object version of SEARCH (and ATLAS) is available to link with this, as well as a special command file to do the LINKing.

5.2 Interpolators

There are two interpolating routines used by ATLAS: INGRID and ZGRID. ZGRID is by far the faster of the two, but does not allow much control of the "correlation" between points. INGRID, on the other hand, allows the user to define his or her own function which can be inhomogeneous, anisotropic and otherwise completely arbitrary. (e.g. It can include the isthmus of Panama, to prevent Atlantic data points from affecting Pacific data points.) Use ZGRID for fast production, where accuracy is not as important as speed. Use INGRID for the other cases. It is generally not wise to use INGRID at all without specifying your own correlation function.

ZGRID

This routine interpolates a set of arbitrarily spaced data points $XP(K), YP(K), ZP(K), K=1, NPTS$ onto a rectangular grid $Z(I, J)$ of arbitrary size. On input, the areas of Z that the user does not wish to be contoured should be set to "undefined" (1.0E35). All other points should be 0.0. On output all of the 0.0 values will be replaced with either Z values interpolated from data points XP, YP, ZP or set to undefined if too far from a data point to be reliably interpolated.

```
CALL ZGRID(Z, NXSIZE, NYSIZE, NX, NY, XLOW, YLOW, DX, DY,
```

```
XP, YP, ZP, NPTS, CAY, NRNG)
```

Z: The 2 dimensional array onto which the points are to be interpolated. Areas that are not to be contoured should be set to "undefined" (1.0E35).

NXSIZE: The dimensioned width of Z .

NYSIZE: The dimensioned height of Z .

NX: The width of the area in Z that is actually used.

NY: The height of the area in Z that is actually used.

XLOW: The x-coordinate of the lower left hand corner of Z in user's units.
 YLOW: The y-coordinate of the lower left hand corner of Z in user's units.
 DX: The x grid interval = $(XHIG - XLOW)/(NX-1)$
 DY: The y grid interval = $(YHIG - YLOW)/(NY-1)$
 XP: An array containing the x coordinates of the data points to be interpolated onto Z.
 YP: An array containing the y coordinates of the data points to be interpolated onto Z.
 ZP: An array containing the z coordinates of the data points to be interpolated onto Z.
 NPTS: The number of data points in XP,YP,ZP.
 CAY: The interpolation scheme. If CAY=0.0, Laplacian interpolation is used. The resulting surface tends to have rather sharp peaks and dips in the data points (like a tent pole with pole pushing up into it). There is no chance of spurious peaks appearing. As CAY is increased, spline interpolation predominates over the Laplacian, and the surfaces passes through the data points more smoothly. However, as the "stiffness" of the splines increase with increasing CAY, there is a possibility of generating spurious peaks away from the real peaks. A value of CAY=5.0 usually works well.
 NRNG: Any grid point farther than NRNG grid points away from the nearest data point will be set to "undefined" (1.0E35).

Important! ZGRID requires three labelled common arrays:

COMMON/WORK1/WORKA (a)

COMMON/WORK2/WORKB (a)

COMMON/WORK3/WORKC (b)

where:

a is dimensioned at least NPTS long

b is dimensioned at least NY long.

An over-relaxation method is used to perform the interpolation. To get a good rate of convergence, it is wise to make the grid not much finer than is needed to resolve most of the data points onto separate grid squares. I.e. NPTS should be comparable to $NX \times NY$.

If ZGRID is called with data points XP,YP that happen to be already exactly on an evenly spaced grid, a floating point error will occur. If there is a possibility of this happening, a small amount of "noise" should be added to either XP or YP.

INGRID

This routine is a good deal slower than ZGRID, but the user defined 'correlation' function gives it a far greater versatility. In many cases, for

example, the scale of influence in the east-west direction, is much greater than in the north-south. The user can define CORR to reflect this discrepancy, or to include the effects of the Isthmus of Panama, the Gulf Stream, or whatever.

```
CALL INGRID(Z,NXSIZE,NYSIZE,NX,NY,DX,DY,XLOW,YLOW,XP,YP,ZP,NPTS,RX,RY)
```

All the arguments are the same as in ZGRID, except RX and RY which are the maximum radii of influence of a point in the X and Y direction.

The format of the user supplied "correlation" function is:

```
REAL FUNCTION CORR(X1,Y1,X2,Y2,DX,DY)
```

DX and DY refer to the grid spacing.

The other arguments are two x,y pairs locating the two points whose influence on one another is to be determined by the function. The value of the correlation is returned in CORR. It is probably not wise to use INGRID without defining a CORR.

Some hints on defining CORR: Gaussian curves are the most widely used sort of correlation function, and it is usually sufficient simply to adjust the parameters of such a curve until it covers an appropriate range in each direction. Other frequently used functions are inverse powers of the cartesian distance from one point to the other. (These are usually defined to be equal to one when the distance nears zero.) In general, any function with a finite integral may be used as a correlation function. Note that the function's maxima correspond to maxima of influence, and vice versa. For instance, when there is no distance between two points, one would expect a great deal of correlation, as the points are then identical. Alternatively, two very distant points can expect to have little to do with one another, so their correlation will be very low. (In a strict mathematical sense, this is not true for periodic fields, where two points in phase will have a high correlation no matter how far apart, but for these purposes, it is a good rule of thumb.)

INGRID provides some improvements on the standard area-averaging brand of objective mappers (e.g., Gordon and Baker in the Southern Ocean Atlas, and Levitus in his Climatological Atlas) by providing corrections for different directional distributions around a grid point of the same data, and for the gradient of the interpolated field. A complete explanation of the algorithm may be found in the DTIC technical report #15, March 1968 "A Two-Dimensional Interpolation Function for Computer Mapping of Irregularly Spaced Data," by Donald Shepard. (This is in the WHOI document library.)

6. Accessing the Atlas

All of the software mentioned here can be found in the BIGB:[CAMSOFT] directory on the Blue VAX. The CAMSDAT.CMN file, containing the common blocks needed to use IPUT and OPUT are also there. All the subroutines, except the user-defined routines DRIVE and CORR are in the library BIGB:[CAMSOFT]ATLIB.OLB. For the user who wishes to write his or her own routines (see section 5), there is a command procedure, ATLAS.COM that will prompt for their location, and then link with ATLAS and all the libraries.

(For those who must have it, there is a version of ATLAS that uses the Knudsen-Ekman equation of state throughout. This is not in the [CAMSOFT] directory to avoid confusion. Contact an author for your very own copy of this gem.)

The data base is stored in the BIGB:[CAMSARK] directory. The files and their contents are listed below. Note that the data from the Levitus Climatological Atlas has been broken up into separate ocean basins. There is some redundancy between them, and some of the high latitude data is not there. If the area you wish to map either extends above 70° of latitude (north or south) or beyond the boundaries of the ocean basin given below, the entire data set must be retrieved from tape, and subsampled. Alternatively, it may be possible to subsample and concatenate files to cover the desired area.

<u>File</u>	<u>Contents</u>
GEOSECS.DAT	Contains GEOSECS Atlantic and Pacific
TTO.DAT	TTO North Atlantic until May, 1982
IGY.DAT	Data from the IGY North Atlantic
CLASSICS.DAT	A selection of old favorite cruises from the North Atlantic and Northern South Atlantic. Many long transoceanic sections, as well as the Gulf Stream '60 and Hudson '67 data.

The following five files are all from the Levitus Atlas. They are all condensed from NODC data, interpolated onto a grid, and smoothed over seven degrees in each direction.

NATL.DAT	100° West to 30° East, 0° to 70° North
SATL.DAT	70° West to 30° East, 70° South to 0°
NPAC.DAT	100° East to 80° West, 0° to 70° North
SPAC.DAT	100° East to 50° West, 70° South to 0°
INDN.DAT	20° East to 120° East, 70° South to 30° North

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17. Document Analysis a. Descriptors 1. Oceanographic Data Archiving 2. Oceanographic Data Mapping 3. Contouring b. Identifiers/Open-Ended Terms c. COSATI Field/Group				
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