An Ocean Model Processor for Climate Studies

Thomas W. Bettge
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Preface

The purpose of this technical note is to describe and demonstrate the capabilities of an ocean model processor for climate studies. The processor is a tool for the analysis of history data from a particular family of oceanic general circulation models, and can be used for a wide class of ocean investigations ranging from eddy resolving modeling studies to global climate simulations. It is designed to execute within the NCAR Scientific Computing Division environment on the CRAY supercomputers using datasets which reside on the mass storage system.

The primary product from the processor is a two-dimensional contour analysis of data which was represented originally in the four dimensions of space and time. Data can be averaged over any dimension and plotted within any two-dimensional cross-section subset. Several examples are given in order to illustrate the capabilities of the processor.

This technical note does not provide a comprehensive description of the processor code or of the datasets upon which it operates.
Acknowledgements

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1. Introduction

The Ocean Processor (OP) is a tool for the analysis of data from oceanic general circulation models (OGCM) of the form described by Semtner (1974). One such model (e.g., Bryan, 1969; Meehl et al., 1982; Semtner, 1986; a derivation of basic model equations is contained in Washington and Parkinson, 1986) is used for climate ocean studies and carbon dioxide climatic impact research in the Climate Section of the Atmospheric Analysis and Prediction Division. A more sophisticated version of the Semtner (1974) model currently is under development as part of a joint project between scientists at NCAR and the Naval Postgraduate School (Monterey, California).

Most of the state variables which comprise an instantaneous sample from the ocean model integration are three-dimensional in space. Usually, a history of the model integration contains a time series of these three-dimensional datasets, and thus a fourth-dimension (time) becomes eligible for diagnostic analysis. The OP operates upon these four dimensions and is capable of performing the following functions:

1. Time Averaging
2. Zonal Averaging
3. Meridional Averaging
4. Vertical Averaging
5. Horizontal Cross-Section Plotting
6. Meridional Cross-Section Plotting
7. Zonal Cross-Section Plotting
8. Time Cross-Section Plotting
9. Limited Area Plotting (cross-section enlargement, i.e., zoom)
10. Color Plotting

The primary purpose of this technical note is to describe and demonstrate the processing options available with OP. The sections which follow describe the processing philosophy, the input datasets, the internal program parameters, and the user input options. A sample deck is given and several examples are shown which demonstrate the capabilities of OP.

It is not the purpose of this note to provide a comprehensive description of the OP code. Undoubtedly, more complicated data analyses can be performed through code modifications. Such modifications will probably require consultation with the author of this note.

Input to OP is limited to datasets which conform to the types which are used by the ocean models mentioned above. At the present time two such datasets are acceptable as input to OP.

OP is designed to execute within the NCAR Scientific Computing Division envi-
enronment on the CRAY supercomputers using datasets which reside on the mass storage system. The code itself also resides on the mass storage system as an UPDATE program library. It employs the NCAR GKS graphics system. The primary product of OP - meta-code plot files - can be disposed (by means of CRAY JCL) either to the Dicomed graphics processor or to a selected remote device for storage and subsequent display on a monitor with graphics capability.

The contents of this technical note represent a snapshot description of the capabilities of the OP code. The development of the processor is ongoing, and additional functions are planned. A few of these include diagnostic field computations (i.e., derived fields), field differences, generation of datasets which can be saved for subsequent OP analysis, and generation of datasets suitable as input into the Interactive Data Analysis Processor (IDAP).

2. Philosophy and Terminology

The major product from OP is a two-dimensional contour analysis of data which was represented originally in four dimensions. It is important that the user understand the data collapse procedure in order that he can successfully manipulate the input option requests to produce the desired result. The intent of this section is to outline the processing philosophy and terminology employed by OP.

Variables which are being processed within OP are usually available in four dimensions - three spatial dimensions and time (x, y, z, t). In this case x is longitude, y is latitude, z is depth in the ocean, and t is time. Single-leveled variables, for example, or variables which are constant in time are treated as subsets of the general four-dimensional dataset. The two dimensions which define the final product of the analysis of the full four-dimensional dataset are referred to as the included dimensions. The remaining two dimensions are defined as the excluded dimensions.

From the four-dimensional datasets, six primary two-dimensional analyses can be constructed. Within OP these six are defined as \(xy, xz, yz, xt, ty, and tz\) cross-sections. When the final cross-sections are constructed, the first dimension listed is the abscissa of the plot, and the second dimension is the ordinate. Thus, a \(yz\) construct is a zonal cross-section. Note that these six cross-sections are the only ones which OP is capable of producing.

The six primary cross-sections can be broken into two classes. The primary spatial cross-sections are comprised of the space dimensions only (\(xy, xz, and yz\)). The primary temporal cross-sections consist of time and one space dimension (\(xt, ty, and tz\)). The reason that spatial sections are distinguished from temporal sections involves definition of the excluded dimensions.
After the primary dimensions have been specified, the data are collapsed onto a two-dimensional plane by averaging the data in the excluded dimensions over specified ranges. If time is one of the excluded dimensions (a spatial cross-section), then OP offers the user the choice of either averaging the data over time followed by collapsing (space-averaging) the time average within the range of the excluded spatial dimension, or constructing primary sections for each time requested by collapsing the data within the range of the excluded spatial dimension. If time is a primary dimension (a temporal cross-section), then the data are collapsed within the ranges requested for the two excluded spatial dimensions.

Once the primary cross-section is constructed, OP offers the user the choice of plotting and analyzing the data within any subset of the full area comprising the included dimensions of the cross-section. The full area is defined by the input dataset.

3. Input Datasets

At the present time only two types of dataset formats are acceptable as input to OP. These formats are the ones used by the ocean models mentioned in the introduction section of this technical note.

One type of dataset format is used by the ocean model which is under development as part of a joint project between scientists at NCAR and the Naval Postgraduate School. It is identified in this note as format type OGCM1. These datasets are comprehensive; that is, they contain information within a header which fully describes the dataset contained in the history file.

The other dataset format type is utilized by the ocean models used for general climate ocean studies and carbon dioxide climatic impact research. It is identified in this note as format type OGCM2. These datasets are somewhat limited in their informational content, and have been included as input into OP for historical reasons. The format follows closely that found in Semtner (1974).

It is recommended that if one wishes to use OP with datasets which do not correspond to one of these two formats, then the data should be reformatted into the OGCM1 type.

4. Program Parameterization

The OP code is parameterized through the UPDATE common deck *COMDECK PARAM with eight major parameters. In addition, a special set of parameters exist for those runs
which involve OGCM2 datasets. They are contained in the UPDATE common deck *COMDECK POGCM2.

Under normal circumstances, the OP parameters will not need to be modified because their default values will suffice. However, special circumstances may arise in which the default values must be changed in order that the storage requirements be allocated properly. A common reason to change a parameter, for example, could involve a change in the grid resolution of the model output.

The important parameters contained in *COMDECK PARAM are summarized in Table 4.1. Note that each parameter is defined as a maximum value. The default values are given. The UPDATE sequence number is also given so that the user can modify a parameter if the need arises.

The parameters contained in *COMDECK POGCM2 are summarized in Table 4.2. The parameter defaults and the UPDATE sequence number for each parameter are given.

The processing of OGCM2 datasets is an obvious example which demonstrates when the user may wish to change the OP parameters. The general parameters MIX and MJY can be set to the values of the OGCM2 parameters IMT and JMT. Parameter MKZ should be set to the value of (KM+1) because the OGCM2 definition of KM is for the number of vertical layers not the maximum number of vertical levels. These changes will greatly reduce the amount of memory allocated for OP and will result in quicker job turnaround and lower cost.
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Default Value</th>
<th>UPDATE Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIX</td>
<td>maximum number of grid points in the z-direction</td>
<td>162</td>
<td>PARAM. 6</td>
</tr>
<tr>
<td>MJY</td>
<td>maximum number of grid points in the y-direction</td>
<td>42</td>
<td>PARAM. 7</td>
</tr>
<tr>
<td>MKZ</td>
<td>maximum number of grid points in the z-direction</td>
<td>15</td>
<td>PARAM. 8</td>
</tr>
<tr>
<td>MVARSM</td>
<td>maximum number of multi-leveled variables to be processed</td>
<td>2</td>
<td>PARAM. 9</td>
</tr>
<tr>
<td>MVARSS</td>
<td>maximum number of single-leveled variables to be processed</td>
<td>1</td>
<td>PARAM. 10</td>
</tr>
<tr>
<td>MAREAS</td>
<td>maximum number of areas to be processed for each cross-section requested</td>
<td>5</td>
<td>PARAM. 11</td>
</tr>
<tr>
<td>MRANGES</td>
<td>maximum number of excluded dimension ranges to be processed for each cross-section requested</td>
<td>5</td>
<td>PARAM. 12</td>
</tr>
<tr>
<td>MTIMES</td>
<td>maximum number of time samples to be processed in temporal cross-section plots</td>
<td>50</td>
<td>PARAM. 13</td>
</tr>
</tbody>
</table>

Table 4.1. Parameters in *COMDECK PARAM.
Table 4.2. Parameters in *COMDECK POGCM2.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Default Value</th>
<th>UPDATE Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMT</td>
<td>actual number of grid points in the z-direction in model output</td>
<td>74</td>
<td>POGCM2.6</td>
</tr>
<tr>
<td>JMT</td>
<td>actual number of grid points in the y-direction in model output</td>
<td>37</td>
<td>POGCM2.7</td>
</tr>
<tr>
<td>KM</td>
<td>number of vertical layers in the model output</td>
<td>4</td>
<td>POGCM2.8</td>
</tr>
<tr>
<td>NKMFLD</td>
<td>number of multi-leveled variables in the model output</td>
<td>4</td>
<td>POGCM2.9</td>
</tr>
<tr>
<td>NSLFLD</td>
<td>number of single-leveled variables in the model output</td>
<td>5</td>
<td>POGCM2.10</td>
</tr>
<tr>
<td>OGCM2N</td>
<td>northern latitude on model grid</td>
<td>87.5</td>
<td>POGCM2.11</td>
</tr>
<tr>
<td>OGCM2S</td>
<td>southern latitude on model grid</td>
<td>-87.5</td>
<td>POGCM2.12</td>
</tr>
</tbody>
</table>
5. Input Control Keywords

The processing within OP is controlled by a series of user specified input control keywords. These are the user requests which appear at the end of the OP deck prior to the last end-of-file statement.

The input control keywords can be classified generally into four groups which address slightly different processing functions. They are the general processing requests, the spatial cross-section processing requests, the temporal cross-section processing requests, and the color plotting processing requests.

Table 5.1 lists the keywords used to control the general processing flow of OP. They are subdivided into mandatory keywords and optional keywords. The mandatory control keywords must appear and be given valid arguments or the OP processing will be aborted. Thus, the keywords TAPES, VARS, and either ITER or DAYS must appear among the users processing requests. The optional control keywords will default to predetermined values and do not have to be specified explicitly.

In conjunction with the keyword VARS, the variable names which should be used are dependent upon the type of ocean dataset being processed. For OGCM1 type datasets, the user should simply request the variable name abbreviation which appears on the history file header. For OGCM2 type datasets, the requested variable names must be given the appropriate abbreviation as listed in Table 5.2.

The control keywords used to request and specify spatial cross-section processing are given in Table 5.3. All of the partial keywords in Table 5.3 must be preceded by a two letter prefix which identifies the spatial cross-section being requested. For example, if a horizontal (xy) cross-section plot is desired, the . .PLOT keyword is XYPL0T. The keyword . .RNG requires that a third letter, the excluded spatial dimension, be included in the prefix (e.g., XYZRNG).

Keywords to control special features for the spatial cross-section processing are given in Table 5.4. They include two special keywords for horizontal (xy) cross-sections, and one special keyword for zonal (yz) cross-sections.

Table 5.5 contains the control keywords for temporal cross-section processing. As with the keywords which control the spatial cross-section processing, the partial temporal cross-section keywords in Table 5.5 must be preceded by a two letter prefix which identifies the temporal cross-section being requested.

The keywords for color plotting options are listed in Table 5.6. The numerical values for the colors correspond to a user established color table on a target graphics device.

It is important to note the subtle differences in a few of the keywords which request...
## General Processing Input

### Mandatory Keywords

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
<th>Default</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAPES</td>
<td>mass storage system pathnames of input datasets; each entry must be 129 characters or less in length; first character must be a blank (' ')</td>
<td></td>
<td>TAPES=' OP/UGIH04', ' OP/UGIH05'</td>
</tr>
<tr>
<td>VARS</td>
<td>list of variables to be processed</td>
<td></td>
<td>VARS='T', 'P'</td>
</tr>
<tr>
<td>ITER</td>
<td>group of three iteration values; defines first iteration, last iteration, and increment between iterations to be processed; if third value is -1, all time samples between first and last iterations (inclusive) will be processed</td>
<td></td>
<td>ITER=0, 5000, 250</td>
</tr>
<tr>
<td>DAYS</td>
<td>used in place of ITER, defines days rather than iterations; real values</td>
<td></td>
<td>DAYS=10.0, 30.0, -1.0</td>
</tr>
</tbody>
</table>

### Optional Keywords

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
<th>Default</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>type of ocean model being processed; either 'OGCM1' or 'OGCM2'</td>
<td>'OGCM1'</td>
<td>TYPE='OGCM2'</td>
</tr>
<tr>
<td>TIMAVG</td>
<td>option to time average over the requested iterations; 'YES' or 'NO'</td>
<td>'NO'</td>
<td>TIMAVG='YES'</td>
</tr>
<tr>
<td>TITLE</td>
<td>user specified title which will appear on all film frames; maximum of 40 characters</td>
<td>blank</td>
<td>TITLE='Exp 29'</td>
</tr>
<tr>
<td>ITRACE</td>
<td>flag to control amount of printed diagnostic output; a value of 0 will cause minimum output; a value of 4 will permit maximum output</td>
<td>2</td>
<td>ITRACE=1</td>
</tr>
<tr>
<td>DEPTHS</td>
<td>layer depths for 'OGCM2' type ocean model (meters)</td>
<td>none</td>
<td>DEPTHS= 50., 450., 1500., 2000.</td>
</tr>
</tbody>
</table>

Table 5.1. General Processing Input Control Keywords.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>'T'</td>
</tr>
<tr>
<td>Salinity</td>
<td>'S'</td>
</tr>
<tr>
<td>U Velocity</td>
<td>'U'</td>
</tr>
<tr>
<td>V Velocity</td>
<td>'V'</td>
</tr>
<tr>
<td>W Velocity</td>
<td>'W'</td>
</tr>
<tr>
<td>Mass Stream Function</td>
<td>'P'</td>
</tr>
<tr>
<td>Bottom Topography</td>
<td>'TOPOG'</td>
</tr>
<tr>
<td>Sea Ice</td>
<td>'SEAICE'</td>
</tr>
<tr>
<td>Surface Heat Flux</td>
<td>'HF'</td>
</tr>
<tr>
<td>Surface Wind Stress X</td>
<td>'SX'</td>
</tr>
<tr>
<td>Surface Wind Stress Y</td>
<td>'SY'</td>
</tr>
<tr>
<td>Surface Precipitation</td>
<td>'P-E'</td>
</tr>
</tbody>
</table>

Table 5.2. Variable Request Abbreviations for OGCM2 Datasets.
<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
<th>Default</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>.PLOT</td>
<td>type of cross-section request; either 'YES' or 'NO'</td>
<td>'NO'</td>
<td>XYPLOT='YES'</td>
</tr>
<tr>
<td>.AREA</td>
<td>cross-section area; request as [west, east, south, north] or [west, east, top, bottom] or [south, north, top, bottom]; multiple areas allowed</td>
<td>full</td>
<td>XZAREA= -180.,180., 0.,400., 130.,290.,50.,300.</td>
</tr>
<tr>
<td>.RNG</td>
<td>range of excluded dimension; request as [lower range, upper range, 'I' or 'A']; 'I' ('A') to process (average) all individual points within the range; 'A' is assumed; multiple ranges allowed</td>
<td>none</td>
<td>XZYRNG= -60.,-60., -60.,-20.,'A', -20.,20.,'I', 20.,60.</td>
</tr>
<tr>
<td>.CINT</td>
<td>contour interval specification; request as [variable, excluded dimension value, interval]; all ranges at and greater than value specified will be given that interval unless additional triplet specified; if interval is negative, no plot is produced</td>
<td>chosen by OP</td>
<td>XYCINT= 'T', 0., 4.0, 'T',250., 2.5, 'U', 75.,20.0</td>
</tr>
<tr>
<td>.CDIV</td>
<td>contour dividing value; either for dashed or two-color plots; request similar to .CINT</td>
<td>0.0</td>
<td>YZCDIV= 'T',180.,13.5</td>
</tr>
<tr>
<td>.CSCA</td>
<td>contour label scale factor; request similar to .CINT</td>
<td>1.0</td>
<td>XYCSCA= 'U',0.0,10.0</td>
</tr>
<tr>
<td>.ZERO</td>
<td>include zero contour; either 'YES' or 'NO'</td>
<td>'YES'</td>
<td>YZZERO='NO'</td>
</tr>
<tr>
<td>.DLIN</td>
<td>dash specified contours (.CDIV); either 'YES' or 'NO'</td>
<td>'YES'</td>
<td>XZDLIN='NO'</td>
</tr>
<tr>
<td>.DPAT</td>
<td>10-bit dashed contour pattern</td>
<td>1252B</td>
<td>YZDPAT=666B</td>
</tr>
<tr>
<td>.ULC</td>
<td>number of unlabeled contours between labeled contours</td>
<td>0</td>
<td>XZULC=2</td>
</tr>
</tbody>
</table>

Table 5.3. Spatial Cross-Section Processing Input Control Keywords.
<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
<th>Default</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>XYPROJ</td>
<td>type of projection; 'RECT' is cylindrical equidistant;</td>
<td>'RECT'</td>
<td>XYPROJ='RECT'</td>
</tr>
<tr>
<td></td>
<td>(no other options presently available)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XYDOT</td>
<td>dotted continental outlines; either 'YES' or 'NO'</td>
<td>'NO'</td>
<td>XYDOT='YES'</td>
</tr>
<tr>
<td></td>
<td>'YES' for southern-most latitude at left; 'NO' for northern-most latitude at left</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
<th>Default</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>YZYPOS</td>
<td>positive direction of abscissa; 'YES' for southern-most latitude at left; 'NO' for northern-most latitude at left</td>
<td>'YES'</td>
<td>YZYPOS='NO'</td>
</tr>
</tbody>
</table>

Table 5.4. Special Spatial Cross-Section Processing Input Control Keywords.
<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
<th>Default</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>.PLOT</td>
<td>type of cross-section request; either 'YES' or 'NO'</td>
<td>'NO'</td>
<td>TYPLOT='YES'</td>
</tr>
<tr>
<td>..AREA</td>
<td>spatial part of cross-sectional area; request as [west, east], or [south, north], or [top, bottom]; all times requested will be analyzed; only one area allowed</td>
<td>full area of dataset</td>
<td>XTAREA=-180.,180.</td>
</tr>
<tr>
<td>..RNGS</td>
<td>range of excluded spatial dimensions; request as [west, east, south, north], or [west, east, top, bottom], or [south, north, top, bottom]; multiple ranges allowed; averaging always implied</td>
<td>none</td>
<td>XTRNGS=-60.,-60., 0.,400., -60.,-20.,250.,1000.</td>
</tr>
<tr>
<td>.CINT</td>
<td>contour interval specification; request as [variable, interval]; variable will be given requested interval; if contour interval is negative, no plot is produced</td>
<td>chosen by OP</td>
<td>TYCINT='T', 4.0, 'U',20.0</td>
</tr>
<tr>
<td>..CDIV</td>
<td>contour dividing value; either for dashed or two-color plots; request similar to .CINT</td>
<td>0.0</td>
<td>TZCDIV='T',13.5</td>
</tr>
<tr>
<td>.CSCA</td>
<td>contour label scale factor; request similar to .CINT</td>
<td>1.0</td>
<td>XTCSCA='U',10.0</td>
</tr>
<tr>
<td>..ZERO</td>
<td>include zero contour; either 'YES' or 'NO'</td>
<td>'YES'</td>
<td>TYZERO='NO'</td>
</tr>
<tr>
<td>..DLIN</td>
<td>dash specified contours (..CDIV); either 'YES' or 'NO'</td>
<td>'YES'</td>
<td>TZDLIN='NO'</td>
</tr>
<tr>
<td>..DPAT</td>
<td>10-bit dashed contour pattern</td>
<td>1252B</td>
<td>XTDPAT=666B</td>
</tr>
<tr>
<td>..ULC</td>
<td>number of unlabeled contours between labeled contours</td>
<td>0</td>
<td>TZULC=2</td>
</tr>
</tbody>
</table>

Table 5.5. Temporal Cross-Section Processing Input Control Keywords.
### Color Plotting Input

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
<th>Default</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLCNTNT</td>
<td>color of continental outlines in xy cross-sections</td>
<td>'001'</td>
<td>CLCNTNT='008'</td>
</tr>
<tr>
<td>CLCTRGE</td>
<td>color of contours greater than or equal to dividing value</td>
<td>'001'</td>
<td>CLCTRGE='003'</td>
</tr>
<tr>
<td>CLCTRLT</td>
<td>color of contours less than dividing value</td>
<td>'001'</td>
<td>CLCTRLT='004'</td>
</tr>
<tr>
<td>CLLABEL</td>
<td>color of plot labels and borders</td>
<td>'001'</td>
<td>CLLABEL='002'</td>
</tr>
<tr>
<td>CLHIGHS</td>
<td>color of marked highs</td>
<td>'001'</td>
<td>CLHIGHS='005'</td>
</tr>
<tr>
<td>CLLOWS</td>
<td>color of marked lows</td>
<td>'001'</td>
<td>CLLOWS='006'</td>
</tr>
<tr>
<td>CLPNTVL</td>
<td>color of values plotted with marked highs and lows</td>
<td>'001'</td>
<td>CLPNTVL='007'</td>
</tr>
</tbody>
</table>

Table 5.6. Color Plotting Input Control Keywords.
spatial or temporal cross-section processing. The differences originate from the definitions used to characterize a spatial or temporal cross-section. One major difference between the two cross-section types involves the specification of the general processing keyword TIMAVG. For spatial cross-sections, the TIMAVG request will dictate whether individual time samples or a time average will be presented. For temporal cross-sections, the TIMAVG request makes no difference - all individual time samples will be presented on the cross-sectional plots.

The ..AREA request for spatial cross-sections must contain four values - two for each included spatial dimension. The order of the value pairs should be alphabetical (i.e., xy, xz, or yz). For temporal cross-sections, the ..AREA request contains only two values - the included spatial dimension. All of the requested time samples will be included in the temporal cross-section analysis. Multiple areas (up to the maximum specified by the parameter MAREAS) are allowed for spatial cross-sections, while only one area can be requested for temporal cross-sections.

The keyword option . .RNG for spatial cross-sections specifies the range of the excluded spatial dimension only. The range of time is dictated by the specification of the general processing keyword TIMAVG. If TIMAVG is 'YES', all time samples requested are averaged, then presented on a single spatial cross-section; otherwise, if TIMAVG is 'NO', a spatial cross-section plot is produced for each time sample requested. The keyword . .RNGS for temporal cross-sections is used to specify the ranges of the two excluded spatial dimensions. Averaging is always implied for the . .RNGS values unless only one point exists within the requested range. The value pairs should be given alphabetically (i.e., xy, xz, or yz).

For all keywords which involve the specification of a geographical area or a range of an excluded dimension, the user should adhere to the following conventions. Longitudinal values should be between -360.0 and 360.0 with the 'western' value listed first. Latitudinal values should be between -90.0 and 90.0 with the 'southern' value listed first. Ocean depths (positive implied) should be in meters with the 'top' level listed first.

The ..AREA and . .RNG or . .RNGS requests will conform to the following conditions:

1. for the ..AREA requested, if there are less than two data points in either direction a diagnostic will be printed and no plot produced;

2. the ..AREA requested will comprise the exact boundaries of the plot, and the area contoured will include all points which lie on or inside the boundaries;

3. if a requested . .RNG or . .RNGS contains no data points, a diagnostic will be printed and no plot produced;

4. if a requested . .RNG or . .RNGS contains only one point, and
averaging was specified or implied, the single point will be processed as an individual point;

(5) for requested ...RNG in individual mode ('I'), if that point does not exist in the dataset, the next numerically lower point will be processed in the 'I' mode;

(6) for requested ...RNG or ...RNGS, when averaging is performed, the integral is computed over the exact requested range using all points within the range (with proper cosine weighting in the latitudinal direction).

The specification of the contour interval, contour dividing value, and contour label scale factor keywords .CINT, .CDIV, and .CSCA are slightly different for spatial and temporal cross-section requests. For spatial cross-sections, these keywords are composed of a triplet which identify the variable, a range level value, and the specification. The range level value indicates that all points at that level and greater are given the specification contained in the triplet. When an average of several levels is requested, the lower and upper range levels are averaged in order to seek a specification. If a variable appears in two or more triplets, the specification for a particular range level is extracted from the triplet which contains the next lower range level value (i.e., the at that level and greater rule strictly applies). For temporal cross-sections, the keywords are used to identify only the variable and specification.

The use of the input control keywords is demonstrated later in this technical note through numerous examples of output from OP.
6. Sample Deck

A sample deck which can be used to create similar decks with which to run OP is given below. This deck includes an example of how modifications are made to the program library to change a few of the OP parameter statements. Note that the current OP program library file is not given. It is recommended that the user obtain the current OP program library file name from the author prior to using the processor.

```
JOB,JN=jobname,US=uuuupppppppp, T=20, OLM=600, *MS, CL=FG1.
ACCOUNT,AC=uuuupppppppp.
*
* =====> Acquire the OP Program Library.
* ACQUIRE,DN=PL, MF=MS, PDN=name, ID=OP, TEXT='FLNM=/BETTGE/OP/name'.
* * =====> Update - Compile - Load - Execute
* UPDATE, P=PL, I, F.
CFT, I=$CPL, L=O.
LDR.
*
* =====> Dispose the plot file.
*
DISPOSE, DN=$PLT, DC=ST, MF=IO, DF=BI, TEXT='FLNM=OP, FLTY=C02PLOT'.
*
EXIT.
*
\EOF
*/
*/ Resolution Modifications.
*ID RESMOD1
*DELETE PARAM.6,7
C Maximum number of grid points in x direction.
   PARAMETER (MIX=80)
C Maximum number of grid points in y direction.
   PARAMETER (MJY=40)
*/
\EOF
C
C Input Control Keywords
C
ENDOFDATA
\EOF
```
7. OP Examples

This section contains examples of the plots produced from several jobs which used OP. These plots illustrate many of the capabilities of OP.

A list of the input control keywords appears first followed by the cross-section output from OP. There is at least one example for each of the six cross-sections which OP is capable of producing.
Example 1. Horizontal (xy) Cross-Section.

C
C General Processing
C
TAPES=' /LEO/MFE/0CAVG01'
VARS='U'
ITER=708624,708624,0
TYPE='OGCM2'
TIMAVG='NO'
TITLE='U VELOCITY (CM/SEC) EXPERIMENT 11B'
C
OGCM2 Ocean Layer Depths (Meters)
C
DEPTHS= 50.0 ,
        450.0 ,
        1500.0 ,
        2000.0
C
Horizontal Cross-Sections
C
XYPLOT='YES'
XYPROJ='RECT'
XYZERO='YES'
XYDLIN='YES'
XYDPAT=1252B,
XYZRNG=0.0,300.0,'I'
C
18
Example 2. Meridional (xz) Cross-Section.

C
C General Processing
C
TAPES=' /CHERVIN/UGIH05'
     ' /CHERVIN/UGIH15'
VARS='T'
ITER=2500,20000,2500
TYPE='OGCM1'
TIMAVG='YES'
TITLE='EQUATORIAL TEMPERATURE PROFILE'
C
C Meridional Cross-Sections
C
XZPLOT='YES'
XZULC=1
XZCINT='T',-20.0,1.0
XZAREA=130.0,290.0,0.0,1500.0
,130.0,290.0,0.0,400.0
XZYRNG=-5.0,5.0,'A'
C

CASE 5 TIME AVERAGE 2500 - 20000
EQUATORIAL BASIN VARIABLE GRID IN MERIDIONAL DIRECTION, ONE DEGREE IN THE ZONAL TEMPERATURE LATITUDINAL INTEGRAL (4.7S-4.7N)

EQUATORIAL TEMPERATURE PROFILE
CONTOUR INTERVAL = 1.00 FIELD MINIMUM = 4.91
SCALE FACTOR = 1.00 FIELD MAXIMUM = 24.8

CASE 5 TIME AVERAGE 2500 - 20000
EQUATORIAL BASIN VARIABLE GRID IN MERIDIONAL DIRECTION, ONE DEGREE IN THE ZONAL TEMPERATURE LATITUDINAL INTEGRAL (4.7S-4.7N)

EQUATORIAL TEMPERATURE PROFILE
CONTOUR INTERVAL = 1.00 FIELD MINIMUM = 11.1
SCALE FACTOR = 1.00 FIELD MAXIMUM = 24.8

C
C   General Processing
C
TAPES=' /CHERVIN/UGIH05'
   ' /CHERVIN/UGIH15'
VARS='U'
ITER=2500,20000,2500
TYPE='OGCM1'
TIMAVG='YES'
TITLE='EQUATORIAL UNDERCURRENT IN OGCM1'
C
C   Zonal Cross-Sections
C
YZPLOT='YES'
YZYPOS='NO'
YZZERO='NO'
YZCINT= 'U',0.0,20.0
YZAREA=-10.0,10.0,0.0,400.0
YZXRNG=180.0,180.0,'I'
   ,190.0,260.0,'A'
C
Example 4. Time-Depth (tz) Cross-Section.

C
C  General Processing
C
TAPES=' /CHERVIN/UGIH05'
,' /CHERVIN/UGIH15'
VARS='T', 'U'
ITER=2500, 20000, 2500
TYPE='OGCM1'
TIMAVG='NO'
TITLE='OGCM1 TWO YEAR INTEGRATION'

C
C  Time-Depth Cross-Sections
C
TZPLOT='YES'
TZZERO='NO'
TZDLIN='YES'
TZDPAT=666B
TZCINT='T', 1.0
, 'U', 10.0
TZCDIV='T', 15.0
, 'U', 0.0
TZAREA=0.0, 350.0
TZRNGS=230.0, 230.0, -5.0, 5.0
C
CASE 5
EQUATORIAL BASIN VARIABLE GRID IN MERIDIONAL DIRECTION, ONE DEGREE IN THE ZONAL LONGITUDE 129.5W

TEMPERATURE LATITUDINAL INTEGRAL (4.7S-4.7N)

CONTOUR INTERVAL = 1.00 FIELD MINIMUM = 11.0
SCALE FACTOR = 1.00 FIELD MAXIMUM = 22.6
OGCM1 TWO YEAR INTEGRATION

CASE 5
EQUATORIAL BASIN VARIABLE GRID IN MERIDIONAL DIRECTION, ONE DEGREE IN THE ZONAL LONGITUDE 129.5W

U VELOCITY LATITUDINAL INTEGRAL (4.7S-4.7N)

CONTOUR INTERVAL = 10.0 FIELD MINIMUM = -63.3
SCALE FACTOR = 1.00 FIELD MAXIMUM = 25.6
OGCM1 TWO YEAR INTEGRATION
Example 5. Time-Latitude (ty) Cross-Section.

C General Processing
C
TAPES=' /CHERVIN/UGIH05', ' /CHERVIN/UGIH15'
VARS='T'
ITER=2500,20000,2500
TYPE='OGCM1'
TIMAVG='NO'
TITLE='OGCM1 TWO YEAR INTEGRATION'

C Time-Lat Cross-Sections
C
TYPLOT='YES'
TYDLIN='YES'
TYCINT='T',1.0
TYCDIV='T',18.0
TYAREA=-20.0,20.0
TYRNGS=230.0,230.0,0.0,25.0,
       230.0,230.0,75.0,100.0
CASE 5
EQUATORIAL BASIN VARIABLE GRID IN MERIDIONAL DIRECTION, ONE DEGREE IN THE ZONAL LONGITUDE 129.5W
LEVEL 12.5M

TEMPERATURE

2500 5000 7500 10000 12500 15000 17500 20000
20N

10N

0

10S

20S

ITERATION

CONTOUR INTERVAL = 1.00 FIELD MINIMUM = 16.4
SCALE FACTOR = 1.00 FIELD MAXIMUM = 25.0
OGCM1 TWO YEAR INTEGRATION

87.03.18
14.07.36

CASE 5
EQUATORIAL BASIN VARIABLE GRID IN MERIDIONAL DIRECTION, ONE DEGREE IN THE ZONAL LONGITUDE 129.5W
LEVEL 87.5M

TEMPERATURE

2500 5000 7500 10000 12500 15000 17500 20000
20N

10N

0

10S

20S

ITERATION

CONTOUR INTERVAL = 1.00 FIELD MINIMUM = 13.2
SCALE FACTOR = 1.00 FIELD MAXIMUM = 24.3
OGCM1 TWO YEAR INTEGRATION

87.03.18
14.07.36

C
C General Processing
C TAPES=' /CHERVIN/UGIH05'
,, ' /CHERVIN/UGIH15'
VARS='U'
DAYS=156.25,1250.0,156.25
TYPE='OGCM1'
TIMAVG='NO'
TITLE='OGCM1 TWO YEAR INTEGRATION'
C
C Meridional Cross-Sections
C XTPLOT='YES'
XTZERO='NO'
XTAREA=200.0,260.0
XTRNGS=0.0,0.0,62.5,62.5
C
CASE 5

EQUATORIAL BASIN VARIABLE GRID IN MERIDIONAL DIRECTION, ONE DEGREE IN THE ZONAL LATITUDE 0.0

U VELOCITY LEVEL 62.5M

160W 150W 140W 130W 120W 110W 100W

DAY

OGCM1 TWO YEAR INTEGRATION

CONTOUR INTERVAL = 5.00
SCALE FACTOR = 1.00
FIELD MINIMUM = -22.0
FIELD MAXIMUM = 52.9

87.03.18
14.45.19
References


