Geosoft eXecutables (GX's) Developed by the U.S. Geological Survey, Version 2.0, with Notes on GX Development from Fortran Code

By Jeffrey D. Phillips

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Geosoft eXecutables (GX's) Developed by the U.S. Geological Survey, Version 2.0, with Notes on GX Development from Fortran Code

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Introduction

Geosoft executables (GX's) are custom software modules for use with the Geosoft Oasis montaj™ geophysical data processing system, which currently runs under the Microsoft Windows™ 2000 or XP operating systems. The U.S. Geological Survey (USGS) uses Oasis montaj™ primarily for the processing and display of airborne geophysical data. The ability to add custom software modules to the Oasis montaj™ system is a feature employed by the USGS in order to take advantage of the large number of geophysical algorithms developed by the USGS during the past half century.

This main part of this report, along with Appendix 1, describes Version 2.0 GX's developed by the USGS or specifically for the USGS by contractors. These GX's perform both basic and advanced operations. Version 1.0 GX's developed by the USGS were described by Phillips and others (2003), and are included in Version 2.0. Appendix 1 contains the help files for the individual GX's.

Appendix 2 describes the new method that was used to create the compiled GX files, starting from legacy Fortran source code. Although the new method shares many steps with the approach presented in the Geosoft GX Developer manual, it differs from that approach in that it uses free, open-source Fortran and C compilers and avoids all Fortran-to-C conversion.

Download and Installation

The executable GX files, which will only work from within Geosoft Oasis montaj™, and the source code files used to develop them can be downloaded using a web browser from **ftp://ftpext.usgs.gov**. The files are in the **/pub/cr/co/denver/musette/pub/gx** directory. This location is subject to change, so the best way to locate the files is through the following link.

<GO TO FTP SITE>

Each compiled GX consists of a compiled GX file with the suffix **.gx**. In addition, there is a global file containing error messages called **usgs.err** and two menu files called **usgs.omn** and **usgsv.omn**. The **usgs.omn** menu file is intended for use with the licensed version of Oasis montaj™, and the **usgsv.omn** menu is intended for use with the free Oasis montaj™ viewer. Many GX's require a dynamically-linked library file with the suffix **.dll**, and a few require an executable file with the suffix **.exe**. In the current release of Oasis montaj™ (version 6.4), compiled GX files are installed in the **gx** subdirectory of the **\Program Files\Geosoft\Oasis montaj** directory for the licensed version, and in the **\Program Files\Geosoft\Oasis montaj Viewer** directory for the free viewer; error files are installed in the corresponding **ger** subdirectory, menu files are installed in the corresponding **omn** subdirectory, and dynamic-link library and executable files are installed in the corresponding **bin** subdirectory.

The USGS Menu Files and Short GX Descriptions

The GX's described here can be accessed from a USGS menu that can be added to the menu bar in Oasis montaj™. The menu structure for use with the licensed version of Oasis montaj™ is defined in a text file called **usgs.omn** (<Table 1>). The menu structure for use with the unlicensed (free) Oasis montaj Viewer™ is defined in a text file called **usgsv.omn** (<Table 2>). These files can be easily modified to add additional categories and custom GX's as they are developed. Some of the GX's referenced in the **usgs.omn** menu file (those with names that do not start with **usgs_**) are part of the licensed Oasis montaj™ package; others (with names that do start with **usgs_**) use Geosoft library routines that are part of the licensed package. All of the GX's referenced in the **usgsv.omn** menu file work with the free Oasis montaj viewer as of version 6.4. There is no guarantee that these GX's will work with later versions of the viewer.

The following GX's, listed by menu category, are described in this report. GX's that originally appeared in version 1.0 (Phillips and others, 2003) are indicated by "(from version 1.0)". New GX's that did not appear in version 1.0 are indicated by "(new)". GX's that will likely run only in the licensed version of Oasis montaj are so indicated; all others will run in either the licensed version or the unlicensed Viewer version.

Grid Utilities

- usgs_addgrid.gx - perform arithmetic operations (including masking) using two grids or using a grid and a constant (new).
- usgs_decimate.gx - decimate (or replicate) a grid by removing (or duplicating) nodes (new).
- usgs_dvaltest.gx - test for dummy (no data) values in a grid (from version 1.0).
- usgs_gridmask.gx - restore holes to a grid from a masking grid (from version 1.0).
- usgs_gridplug.gx - plug holes in a grid by using minimum curvature iterations (from version 1.0).

- usgs_gridprox.gx - create a grid containing distance to the nearest data point (from version 1.0).
- usgs_pluggrid.gx - plug holes in a grid by regridding (from version 1.0; better than gridplug.gx, but requires a license for gridding).
- usgs_prep4.gx - prepare a grid for Geosoft Fourier transform by plugging holes (if any), and extending the rows and columns (from version 1.0; requires a license for gridding).
- usgs_transpos.gx - transpose a grid (from version 1.0).
- usgs_analytic.gx - total gradient ("3D analytic signal") from three derivative grids (new).
- usgs_trimgrd.gx - trim a grid back to its data area by removing borders of dummy values (new).

Grid Spatial Filtering

- usgs_decor.gx - decorrugation of east-west or north-south flight-line noise (new).
- usgs_gradcomp.gx - compute filtered horizontal derivative grids and the horizontal gradient magnitude grid using the gradient-component method of Thurston and Brown (1994) (from version 1.0).
- usgs_gradxyh.gx - compute horizontal derivative grids and the horizontal gradient magnitude grid using local quadratic surfaces (new).
- usgs_hgrad.gx - calculate the magnitude of the horizontal gradient of a grid (from version 1.0; requires licensed grid filtering).
- usgs_surfit.gx - fit a polynomial surface to a grid and calculate the residual grid (new).

Grid Fourier Filtering – Step-by-Step

- usgs_gridplug.gx - plug holes in a grid by using minimum curvature iterations (from version 1.0).
- usgs_ftprep.gx - prepare (extend) a plugged input grid for Fourier transformation (new).

- usgs_ftfwd.gx - compute the Fourier transform of a (prepared) grid (new).
- usgs_ftfil.gx - basic Fourier domain filtering (new).
- usgs_htfil.gx - Fourier domain Hilbert transform components of a grid (new).
- usgs_rtfil.gx - regularized Fourier domain filtering (new).
- usgs_bpfil.gx - Fourier domain bandpass, highpass, or lowpass filtering (new).
- usgs_ctfil.gx - Fourier domain transformation of any component (total field, X, Y, or Z) to all other components (new).
- usgs_vdfil.gx - Fourier domain vertical derivative from horizontal derivatives (new).
- usgs_ftinv.gx - compute the inverse Fourier transform of a grid (new).

Grid Fourier Filtering – All-in-One

- usgs_tgrad.gx - one-step total gradient (3D analytic signal) of a potential-field data grid using either the gradient-component method with optional low-pass filtering or local quadratic surfaces (new).
- usgs_lw.gx - one-step local wavenumber of a potential-field data grid using either the gradient-component method with optional low-pass filtering or local quadratic surfaces (new).
- usgs_psdgrv.gx - one-step pseudogravity transformation of a total-field magnetic data grid (new).
- usgs_psdmag.gx - one-step pseudomagnetic transformation of a gravity data grid (new).
- usgs_redpol.gx - one-step simple reduction-to-the-pole transformation of a grid (new).
- usgs_upcont.gx - one-step upward or downward continuation of a potential-field grid (new).
- usgs_t2vect.gx - one-step total-field grid to vector component grids (new).
- usgs_vertint.gx - vertical integral or derivative of a potential-field grid (new)

Grid Matched Filtering

- usgs_mfdesign.gx - design matched bandpass filters (new).
- usgs_mffilter.gx - apply matched bandpass filters (new).
- usgs_mfinit.gx - initialize the matched filtering process (new).
- usgs_mfplot.gx - plot the current matched filters (new).

Grid Interpretation

- usgs_tgrad.gx - one-step total gradient (analytic signal) of a data grid (new).
- usgs_lw.gx - one-step local wavenumber of a potential-field data grid (new).
- usgs_curv4.gx - extract extrema (highs, lows, ridges, troughs) from a grid using curvature (new).
- usgs_seteuler.gx - prepare a grid for extended Euler deconvolution (new).
- usgs_eulerave.gx - magnetic source location using extended Euler deconvolution (new).
- usgs_gridsamp.gx - sample a grid at the locations of a USGS post file (new).
- usgs_rcdep.gx - magnetic source location using profile analysis on grid rows and columns (new).
- usgs_sfdepth.gx - magnetic source location from a special function (total gradient or local wavenumber) grid (new).

Database Utilities

- usgs_impost.gx - import a USGS post file into a new database (new).
- usgs_openpost.gx - import a USGS post file into a new database (new; faster but requires license).
- usgs_renumlns.gx - renumber selected lines in a database (from version 1.0).

Map Utilities

- usgs_digvecs.gx - digitize vectors from a map and place them in an ASCII XYZ file (from version 1.0).
- usgs_lnplot.gx - plot lines from an ASCII line file (new).
- usgs_pdraw.gx - draw, redraw, or append polygons from a .ply file to a specified map group (from version 1.0).
- usgs_pgplot.gx - draw a crude page-sized map surround (new).

General Utilities

- usgs_igrfpt.gx - calculate the International Geomagnetic Reference Field (IGRF) at a specified location (new).
- usgs_mbase.gx - generate diurnal corrections for magnetic anomaly measurements using data from multiple magnetic base stations (new).

Temporary and Ancillary Files Generated and Used by the GX's

Many of the GX's generate and use temporary or ancillary files. Temporary files are deleted by the GX prior to a successful completion. Temporary grid files are generated in the default Geosoft format, unless a different default grid format has been selected (licensed version only). Ancillary files are not deleted by the GX, but are left for use by other computer programs. Ancillary files include DXF (AutoCad) drawings, Geosoft ASCII XYZ point and line data files, and USGS binary post files. The USGS post files contain point data with x (east) and y (north) coordinates, and six z-channels. The post files, along with USGS PC binary grid files, provide an interface between Oasis montaj and the USGS DOS-based potential-field software package (Phillips, 1997).

The GX's in this report do not access Geosoft's proprietary **.gi** files, which contain projection information for grid files. As a consequence, grid files produced by these GX's will have corresponding **.gi** files with unknown projections. This is a limitation of this software.

Help Files for the Individual GX's

The help files in Appendix 1 are RTF-formatted files that are compiled into each GX. The help file can be displayed in WordPad by pressing the **"?"** button in the upper right corner of the GX dialog box. Each help file contains several sections, including a general description of the function of the GX, a list of the interactive parameters that can be entered through the dialog box, a list of the batch parameter names that can be used to call the GX from within another GX, and application notes providing additional information.

Source Code Files and Tutorials

Each GX is built from a number of source code files. These include, at a minimum, an RTF help file with the suffix **.rtf**, a GX source code file with the suffix **.gxc**, and a resource file with the suffix **.grc**. Some GXs use a dynamic link library compiled from Fortran code. In addition to the three source code files described above, these GXs require the Fortran source code file with a suffix of **.f**, a C code wrapper function for the Fortran subroutine calls, usually called **gxx_*.c**; the generic wrapper functions **wfuncs.c**; the C header file and **wrappers.h**, and a **.gxh** prototype file. The interrelationships of these files are described in Appendix 2, which is a tutorial on GX development from Fortran code.

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Table 1. Listing of usgs.omn

```
MENU "&USGS"
SUBMENU "Grid &Utilities"
SUBMENU "Grid &Spatial Filtering"
SUBMENU "Grid &Fourier Filtering"
SUBMENU "Grid M&Atched Filtering"
SUBMENU "Grid &Interpretation"
SUBMENU "&Database Utilities"
SUBMENU "&Map Utilities"
SUBMENU "&General Utilities"
MENU "&USGS/Grid &Utilities"
ITEM "Test for Dummy &Values"                      ,usgs_dvaltest.gx
ITEM "Plug holes by &Regriding"                    ,usgs_pluggrid.gx
ITEM "Plug holes by &Iterating"                    ,usgs_gridplug.gx
ITEM "&Mask a grid"                                ,usgs_gridmask.gx
ITEM "&Algebraic operations"                       ,usgs_addgrid.gx
ITEM "&Decimate or replicate"                      ,usgs_decimate.gx
ITEM "&Transpose"                                  ,usgs_transpos.gx
ITEM "Total &Gradient from derivatives"            ,usgs_analytic.gx
ITEM "Tr&Im a grid to the data area"               ,usgs_trimgrd.gx
ITEM "&Prepare grid for Geosoft FFT"               ,usgs_prep4.gx
ITEM "Pro&Ximity of data points"                   ,usgs_gridprox.gx
SEPARATOR
MENU "&USGS/Grid &Spatial Filtering"
ITEM "&Horizontal gradient magnitude"              ,usgs_hgrad.gx
ITEM "&Horizontal gradients"                       ,usgs_gradxyh.gx
ITEM "&Filtered gradients"                         ,usgs_gradcomp.gx
ITEM "&Polynomial surface fitting"                 ,usgs_surfit.gx
ITEM "&Decorrugation"                              ,usgs_decor.gx
SEPARATOR
MENU "&USGS/Grid &Fourier Filtering"
SUBMENU "&Step-by-step"
SUBMENU "&All-in-one"
SEPARATOR
MENU "&USGS/Grid &Fourier Filtering/&Step-by-step"
ITEM "&Plug holes by iterating"                    ,usgs_gridplug.gx
ITEM "&Extend grid for FFT"                        ,usgs_ftprep.gx
ITEM "&Forward Fourier transform"                  ,usgs_ftfwd.gx
ITEM "&Basic Fourier domain filtering"             ,usgs_ftfil.gx
ITEM "B&Andpass Fourier domain filtering"          ,usgs_bpfil.gx
ITEM "&Regularized Fourier domain filtering"       ,usgs_rtfil.gx
ITEM "&Hilbert transform components"               ,usgs_htfil.gx
ITEM "&Vertical derivative from horizontal"        ,usgs_vdfil.gx
ITEM "&Magnetic component transformations"         ,usgs_ctfil.gx
ITEM "&Inverse Fourier transform"                  ,usgs_ftinv.gx
SEPARATOR
MENU "&USGS/Grid &Fourier Filtering/&All-in-one"
ITEM "&Total gradient and gradient components"     ,usgs_tgrad.gx
ITEM "&Local wavenumber and gradient components",usgs_lw.gx
ITEM "Total field to vector &Components"           ,usgs_t2vect.gx
ITEM "Pseudo-&Gravity transformation"              ,usgs_psdgrv.gx
ITEM "Pseudo-&Magnetic transformation"             ,usgs_psdmag.gx
ITEM "&Reduction-to-the-pole transformation"       ,usgs_redpol.gx
ITEM "&Upward or downward continuation"            ,usgs_upcont.gx
```

```
ITME "&Vertical integral or derivative"         ,usgs_vertint.gx
SEPARATOR
MENU "&USGS/Grid M&atched Filtering"
ITEM "&Initialization"                          ,usgs_mfinit.gx
ITEM "&Design filters"                          ,usgs_mfdesign.gx
ITEM "&Apply filters"                           ,usgs_mffilter.gx
ITEM "&Show filters"                            ,usgs_mfplot.gx
SEPARATOR
MENU "&USGS/Grid &Interpretation"
ITEM "&Total gradient and gradient components"  ,usgs_tgrad.gx
ITEM "&Local wavenumber"                        ,usgs_lw.gx
ITEM "&Grid extrema from curvature analysis"    ,usgs_curv4.gx
ITEM "S&Ample a grid to a post file"            ,usgs_gridsamp.gx
ITEM "Euler &Setup"                             ,usgs_seteuler.gx
ITEM "&Euler depth analysis"                    ,usgs_eulerave.gx
ITEM "Apply &Profile depth analysis to a grid"  ,usgs_rcdep.gx
ITEM "Special &Function depth analysis"         ,usgs_sfdepth.gx
SEPARATOR
MENU "&USGS/&Database Utilities"
ITEM "&Open USGS POST file into a new database" ,usgs_openpost.gx
//ITEM "&Open USGS POST file into a new database" ,usgs_impost.gx
ITEM "&Renumber selected lines"                 ,usgs_renumlns.gx
SEPARATOR
MENU "&USGS/&Map Utilities"
ITEM "&Create new base map from a grid"         ,usgs_pgplot.gx
//ITEM "&Display color-shaded grid"             ,gridimgs.gx
//ITEM "Plot &Symbols"                          ,symbols.gx
ITEM "Plot &Line file"                          ,usgs_lnplot.gx
ITEM "Digitize &Vectors"                        ,usgs_digvecs.gx
ITEM "Draw &Polygons to a specified group"      ,usgs_pdraw.gx
SEPARATOR
MENU "&USGS/&General Utilities"
ITEM "&Geomagnetic field values"                ,usgs_igrfpt.gx
ITEM "&Diurnal from multiple base stations"     ,usgs_mbase.gx
```

Table 2. Listing of usgsv.omn

```
MENU "&USGSV"
SUBMENU "Grid &Utilities"
SUBMENU "Grid &Spatial Filtering"
SUBMENU "Grid &Fourier Filtering"
SUBMENU "Grid M&Atched Filtering"
SUBMENU "Grid &Interpretation"
SUBMENU "&Database Utilities"
SUBMENU "&Map Utilities"
SUBMENU "&General Utilities"
MENU "&USGSV/Grid &Utilities"
ITEM "Test for Dummy &Values"                   ,usgs_dvaltest.gx
//ITEM "Plug holes by &Regriding"               ,usgs_pluggrid.gx
ITEM "Plug holes by &Iterating"                 ,usgs_gridplug.gx
ITEM "&Mask a grid"                             ,usgs_gridmask.gx
ITEM "&Algebraic operations"                    ,usgs_addgrid.gx
ITEM "&Decimate or replicate"                   ,usgs_decimate.gx
ITEM "&Transpose"                               ,usgs_transpos.gx
ITEM "Total &Gradient from derivatives"         ,usgs_analytic.gx
ITEM "Tr&Im a grid to the data area"            ,usgs_trimgrd.gx
//ITEM "&Prepare grid for Geosoft FFT"          ,usgs_prep4.gx
ITEM "Pro&Ximity of data points"                ,usgs_gridprox.gx
SEPARATOR
MENU "&USGSV/Grid &Spatial Filtering"
//ITEM "&Horizontal gradient"                   ,usgs_hgrad.gx
ITEM "&Horizontal gradients"                    ,usgs_gradxyh.gx
ITEM "&Filtered gradients"                      ,usgs_gradcomp.gx
ITEM "&Polynomial surface fitting"              ,usgs_surfit.gx
ITEM "&Decorrugation"                           ,usgs_decor.gx
SEPARATOR
MENU "&USGSV/Grid &Fourier Filtering"
SUBMENU "&Step-by-step"
SUBMENU "&All-in-one"
SEPARATOR
MENU "&USGSV/Grid &Fourier Filtering/&Step-by-step"
ITEM "&Plug holes by iterating"                 ,usgs_gridplug.gx
ITEM "&Extend grid for FFT"                     ,usgs_ftprep.gx
ITEM "&Forward Fourier transform"               ,usgs_ftfwd.gx
ITEM "&Basic Fourier domain filtering"          ,usgs_ftfil.gx
ITEM "B&Andpass Fourier domain filtering"       ,usgs_bpfil.gx
ITEM "&Regularized Fourier domain filtering"    ,usgs_rtfil.gx
ITEM "&Hilbert transform components"            ,usgs_htfil.gx
ITEM "&Vertical derivative from horizontal"     ,usgs_vdfil.gx
ITEM "&Magnetic component transformations"      ,usgs_ctfil.gx
ITEM "&Inverse Fourier transform"               ,usgs_ftinv.gx
SEPARATOR
MENU "&USGSV/Grid &Fourier Filtering/&All-in-one"
ITEM "&Total gradient and gradient components"  ,usgs_tgrad.gx
ITEM "&Local wavenumber and gradient components",usgs_lw.gx
ITEM "Total field to vector &Components"        ,usgs_t2vect.gx
ITEM "Pseudo-&Gravity transformation"           ,usgs_psdgrv.gx
ITEM "Pseudo-&Magnetic transformation"          ,usgs_psdmag.gx
ITEM "&Reduction-to-the-pole transformation"    ,usgs_redpol.gx
ITEM "&Upward or downward continuation"         ,usgs_upcont.gx
```

```
ITME "&Vertical integral or derivative"         ,usgs_vertint.gx
SEPARATOR
MENU "&USGSV/Grid M&atched Filtering"
ITEM "&Initialization"                          ,usgs_mfinit.gx
ITEM "&Design filters"                          ,usgs_mfdesign.gx
ITEM "&Apply filters"                           ,usgs_mffilter.gx
ITEM "&Show filters"                            ,usgs_mfplot.gx
SEPARATOR
MENU "&USGSV/Grid &Interpretation"
ITEM "&Total gradient and gradient components"  ,usgs_tgrad.gx
ITEM "&Local wavenumber"                        ,usgs_lw.gx
ITEM "&Grid extrema from curvature analysis"    ,usgs_curv4.gx
ITEM "S&Ample a grid to a post file"            ,usgs_gridsamp.gx
ITEM "Euler &Setup"                             ,usgs_seteuler.gx
ITEM "&Euler depth analysis"                    ,usgs_eulerave.gx
ITEM "Apply &Profile depth analysis to a grid"  ,usgs_rcdep.gx
ITEM "Special &Function depth analysis"         ,usgs_sfdepth.gx
SEPARATOR
MENU "&USGSV/&Database Utilities"
//ITEM "&Open USGS POST file into a new database" ,usgs_openpost.gx
ITEM "&Open USGS POST file into a new database" ,usgs_impost.gx
ITEM "&Renumber selected lines"                 ,usgs_renumlns.gx
SEPARATOR
MENU "&USGSV/&Map Utilities"
ITEM "&Create new base map from a grid"         ,usgs_pgplot.gx
ITEM "&Display color-shaded grid"               ,gridimgs.gx
ITEM "Plot &Symbols"                            ,symbols.gx
ITEM "Plot &Line file"                          ,usgs_lnplot.gx
ITEM "Digitize &Vectors"                        ,usgs_digvecs.gx
ITEM "Draw &Polygons to a specified group"      ,usgs_pdraw.gx
SEPARATOR
MENU "&USGSV/&General Utilities"
ITEM "&Geomagnetic field values"                ,usgs_igrfpt.gx
ITEM "&Diurnal from multiple base stations"     ,usgs_mbase.gx
```

Appendix 1: Help files for the individual GX's

USGS_ADDGRD

```
USGS_ADDGRID GX

Node by node algebraic operations between two grids or between one
grid and a constant.  Operations include addition, subtraction,
multiplication, division, masking (moving dummy (no data) values from
the second grid into the first grid), and percent difference
(100*(grid1-grid2)/grid1).

INTERACTIVE PARAMETERS

  First input grid file
  Operator (+,-,*,/,m,%)
  Second input grid file
  Flag to use constant instead of second grid
  Constant
  Output grid file

BATCH PARAMETERS

USGS_ADDGRID.INGRID1       First input grid file
USGS_ADDGRID.OPR           Operator ("+","-","*","/","m","%")
USGS_ADDGRID.INGRID2       Second input grid file
USGS_ADDGRID.ICON          Flag = 1 to use constant instead of second grid
                                = 0 to use second grid
USGS_ADDGRID.ZC            Constant
USGS_ADDGRID.OUTGRID       Output grid file

APPLICATION NOTES

The two input grids must have the same origin, number of rows, number of
columns, and grid interval.  The maximum column dimension of the grids is
8,000.  Grid projection information is ignored.

Original Fortran code by Mike Webring.
GX written by Jeff Phillips (jeff@usgs.gov) 1/8/2003.
```

USGS_ ANALYTIC

USGS_ANALYTIC GX

Computes the total gradient (“3D analytic signal”) grid from three first-derivative grids of a potential field. At each grid node, the three input values are squared and summed, then the square root of the sum is written to the output grid.

INTERACTIVE PARAMETERS

  Input x-derivative grid file
  Input y-derivative grid file
  Input z-derivative grid file
  Output total gradient grid file

BATCH PARAMETERS

USGS_ANALYTIC.INGRIDX	input x-derivative grid
USGS_ANALYTIC.INGRIDY	input y-derivative grid
USGS_ANALYTIC.INGRIDZ	input z-derivative grid
USGS_ANALYTIC.OUTGRID	output total gradient grid

APPLICATION NOTES

The three input grids must have the same origin, number of rows, number of columns, and grid interval. The maximum column dimension of the grids is 8,000. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 1/2/2003.

USGS_BPFIL

USGS_BPFIL GX

Applies highpass, lowpass, bandpass, or notch Fourier filters to a Fourier transform grid file produced by USGS_FTFWD.GX. Standard, Butterworth, and continuation-based filters are provided. The output filtered transform grid should be inverse Fourier transformed using USGS_FTINV.GX.

INTERACTIVE PARAMETERS

```
  Input Fourier transform grid file
  Output filtered Fourier transform grid file
  Filtering operation flag (lowpass, highpass, bandpass, notch)
  Filter type flag (standard, Butterworth, continuation)
  Short or lowpass/highpass wavelength cutoff (grid units)
  Long wavelength cutoff for bandpass/notch (grid units)
  Order of filter (1 to 8)
```

BATCH PARAMETERS

```
  USGS_BPFIL.INFFT           Input Fourier transform grid
  USGS_BPFIL.OUTFFT          Output filtered Fourier transform grid
  USGS_BPFIL.IOPR            Operation flag
                              1 = Lowpass
                              2 = Highpass
                              3 = Bandpass
                              4 = Notch
  USGS_BPFIL.ITYP            Filter type flag
                              1 = Standard
                              2 = Butterworth
                              3 = Continuation
  USGS_BPFIL.WLEN1           Short or lowpass/high wavelength cutoff
                               (grid units)
  USGS_BPFIL.WLEN2           Long wavelength cutoff for bandpass/notch
                               (grid units)
  USGS_BPFIL.NORDER          Order of Butterworth filter (1 to 8)
```

APPLICATION NOTES

Higher Butterworth filter orders have steeper slopes and greater ringing.

Output post file bpfil.pst and database bpfil.gdb contain these fields:

```
   X  = radial wavenumber
   Y  = radial wavelength
   Z1 = input  amplitude
   Z2 = filter amplitude
   Z3 = output amplitude
   Z4 = input  log10 amplitude
   Z5 = filter log10 amplitude
   Z6 = output log10 amplitude
```

Written by Jeff Phillips (jeff@usgs.gov) 02/07/2005.

USGS_CTFIL

USGS_CTFIL GX

Computes all remaining magnetic field components in the Fourier domain from an input Fourier transform grid file of one magnetic field component as generated by USGS_FTFWD.GX.

INTERACTIVE PARAMETERS

Input Fourier transform grid file
Input component type (Total field, X (north), Y (east), or Z (down))
Geomagnetic inclination (degrees)
Geomagnetic declination (degrees)

BATCH PARAMETERS

```
USGS_CTFIL.INFFT    Input Fourier transform grid file
USGS_CTFIL.INTYPE   Input component type (0=total field, 1=X, 2=Y, 3=Z)
USGS_CTFIL.INCL     Geomagnetic inclination (degrees)
USGS_CTFIL.DECL     Geomagnetic declination (degrees)
```

APPLICATION NOTES

The output Fourier transform grid files have the same prefix as the input file and suffixes .FXC for the x-component, .FYC for the y-component, .FZC for the z-component, and .FTF for the total field. Use USGS_FTINV.GX to inverse Fourier transform the output files.

This routine is not intended for use at low magnetic latitudes within 20 degrees of the magnetic equator.

Written by Jeff Phillips (jeff@usgs.gov) 06/05/2003.

USGS_CURV4

USGS_CURV4 GX

Locates local extrema in a grid file using curvature analysis.

INTERACTIVE PARAMETERS

```
  Input grid file
  Output post file (new database will have the same prefix)
  Flag for finding ridges
  Flag for finding troughs
  Flag for finding highs
  Flag for finding lows
  Flag for finding saddles
```

BATCH PARAMETERS

```
USGS_CURV4.INGRID         Input grid file
USGS_CURV4.OUTPOST        Output post file (new database will have the
                            same prefix)
USGS_CURV4.RIDGES         Flag for finding ridges  (Y=1,N=0)
USGS_CURV4.TROUGHS        Flag for finding troughs (Y=1,N=0)
USGS_CURV4.HIGHS          Flag for finding highs   (Y=1,N=0)
USGS_CURV4.LOWS           Flag for finding lows    (Y=1,N=0)
USGS_CURV4.SADDLES        Flag for finding saddles (Y=1,N=0)
```

APPLICATION NOTES

```
The output post file and database have the following channels:
 id          type of feature (ridge, high, etc)
 x           x(east)-coordinate of solution
 y           y(north)-coordinate of solution
 z1  g(x,y)  grid value at the solution as estimated from the
                 quadratic surface
 z2  elong   elongation factor of the feature from the ratio of the
                 two eigenvalues
 z3  strike  degrees clockwise from north
 z4  e1      first eigenvalue of the curvature matrix
 z5  e2      second eigenvalue of the curvature matrix
 z6  type    integer value indicating type of feature (ridge=1,
                 trough=2, etc)
```

The maximum column dimension of the input grid is 8,000.

Reference:

Phillips, J.D., Hansen, R.O., and Blakely, R.J., 2007, The use of curvature in potential-field interpretation: Exploration Geophysics, v.38, p.111-119.

Written by Jeff Phillips (jeff@usgs.gov) 9/14/2006.

USGS_DECIMATE

USGS_DECIMATE GX

Decimate or enlarge a grid.

INTERACTIVE PARAMETERS

```
  Input grid file
  Output grid file
  Function (Decimate = 1, Enlarge = -1)
  Factor (positive integer)
```

BATCH PARAMETERS

```
  USGS_DECIMATE.INGRID    Input grid file
               .OUTGRID   Output grid file
               .FUNCTION  Function (Decimate = 1, Enlarge = -1)
               .FACTOR    Factor (positive integer)
```

APPLICATION NOTES

The maximum number of input columns for decimation is 16000. The maximum number of output columns for replication is 16000. Grids are decimated by removing rows and columns. Grids are enlarged by duplicating rows and columns. Grid projection information is ignored.

Original Fortran code by Mike Webring.
GX written by Jeff Phillips (jeff@usgs.gov) 2/24/2003.

USGS_DECOR

USGS_DECOR GX

Decorrugation of flight line noise using the method of Urquhart (1988). The flight line direction must correspond to either the row or the column direction of the grid.

INTERACTIVE PARAMETERS

Input plugged potential-field grid file
Output decorrugated grid file
Output noise grid file
Flight line direction flag (N-S = 1, E-W = 0)
Filter length for filtering along the flight line direction
Filter length for filtering across the flight line direction
Save intermediate grids (No = 0, Yes = 1)

BATCH PARAMETERS

USGS_DECOR.INGRID	Input plugged potential-field grid
.OUTGRID	Output decorrugated grid file
.OUTNOISE	Output noise grid file
.NS	Flight line direction flag (N-S = 1, E-W = 0)
.NFL	Filter length for filtering along the flight line direction
.NFX	Filter length for filtering across the flight line direction
.TSAVE	Save intermendiate grids (No = 0, Yes = 1)

APPLICATION NOTES

Decorrugation of flight line noise in a grid using the method of Urquhart (1988). The flight line direction must correspond to either the row or the column direction of the grid. The algorithm is as follows:

1. The input grid USGS_DECOR.INGRID is checked for dummy values.

1a. For north-south flight lines the input grid is transposed to DECOR0.TMP.

2. A Blackman filter (Oppenheim and Schafer, 1975, p.242) is used to lowpass filter the input grid (or DECOR0.TMP) along the flight line direction, with the result stored in grid DECOR1.TMP.

2a. The highpass component along the flight lines, DECOR2.TMP, is computed as the difference between the input grid (or DECOR0.TMP) and DECOR1.TMP.

3. DECOR1.TMP is transposed to DECOR3.TMP.

4. DECOR3.TMP is lowpass filtered perpendicular to the flight line direction using a different Blackman filter, with the result stored in DECOR4.TMP. This step is intended to remove the corrugations.

5. DECOR4.TMP is transposed back to DECOR5.TMP.

6. DECOR2.TMP is added to DECOR5.TMP to restore the short wavelengths along the flight lines and produce the final decorrugated grid, USGS_DECOR.OUTGRID (or DECOR6.TMP for north-south flight lines).

6a. For north-south flight lines, DECOR6.TMP is transposed back to USGS_DECOR.OUTGRID.

7. The difference between the input grid and the decorrugated grid is calculated as USGS_DECOR.OUTNOISE.

The length (number of non-zero coefficients) of each Blackman filter is specified as an odd number. Longer filters remove longer wavelengths.

Tests on grids containing sine waves suggest the following optimum filter lengths:

Flight line spacing (grid intervals)	Optimum filter length
2	11
3	11
4	11
5	13
6	13
7	17
8	19
9	23
10	25

Normally the same filter length is used along and across the flight lines.

To experiment, the best strategy is to try several filter combinations and display the decorrugated and noise results. The decorrugated images will tell you if you are removing the correct wavelengths; the noise images will tell you if you are removing too much geologic signal.

The maximum column dimension of the input grid is 8,000. Grid projection information is ignored.

References:

Oppenheim, A.V., and Schafer, R.W., 1975, Digital Signal Processing, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Urquhart, Ted, 1988, Decorrugation of enhanced magnetic field maps: Society of Exploration Geophysicists Fifty-Eighth Annual Meeting, Expanded Abstracts, p.371-372.

Original code by Bob Bisdorf, USGS. Modified for PC memory limitations and to allow for specification of filter lengths by Jeff Phillips, USGS. GX written by Jeff Phillips (jeff@usgs.gov) 2/21/2003.

USGS_DIGVECS

USGS_DIGVECS GX

Digitize vectors from a map and place them in an ASCII XYZ file.

INTERACTIVE PARAMETERS

```
  Output ASCII XYZ File
  Append or Overwrite
  Grid name
  Line Thickness
  Line Color
```

BATCH PARAMETERS

```
USGS_DIGVECS.XYZ             output ASCII XYZ file name
USGS_DIGVECS.APPEND          overwrite file = 0; append to output = 1
USGS_DIGVECS.GRID            grid name
USGS_DIGVECS.LINETHICK       line thickness (mm)
USGS_DIGVECS.LINECOLOR       line color
```

APPLICATION NOTES

If the output file does not exist, you must specify overwrite mode. If the file does exist and you specify overwrite mode, you will be asked to confirm the overwrite.

If no grid is specified, only LINE,X,Y coordinates will be placed in the output file. If a grid is specified, LINE,X,Y and Z values will be placed in the output file. A header record in the output file identifies the channel names. To use this header record when importing the XYZ file into a database, blank out the 'Import template' field.

A map group corresponding to the output file name prefix will be used to hold the vectors drawn on the map.

Multi-point vectors are digitized using the left mouse button. The right mouse button is used to terminate a vector (using the "Done" menu item) and start a new vector. Digitizing is terminated by using the right mouse button and selecting "Done" twice in a row. The "Cancel" menu item is equivalent to the "Done" menu item, it does not remove the digitized vector from the file or the map. The "Exit Menu" menu item will cancel the menu and return to digitizing the current vector.

Because the map cannot be redrawn inside a GX, the digitized vectors will not be drawn until the GX is exited. For the same reason, the remaining right mouse menu items won't work properly.

Written by Jeff Phillips (jeff@usgs.gov) 2/9/99, modified 3/21/02.

USGS_DVALTEST

USGS_DVALTEST GX

Tests for dummy (no data) values in a grid.

INTERACTIVE PARAMETERS

  Input grid file

BATCH PARAMETERS

  USGS_DVALTEST.INGRID   input grid

Written by Jeff Phillips (jeff@usgs.gov) 01/07/00.

USGS_EULERAVE

USGS_EULERAVE GX

Two-step extended Euler depth analysis with averaged results in each data window. Use USGS_SETEULER.GX to generate input derivative grid files.

INTERACTIVE PARAMETERS

```
  Input observation surface grid file
    OR input constant observation surface elevation (elevation units)
  Input minimum depth surface
    OR input constant minimum depth surface elevation (elevation units)
  Conversion factor (elevation units / horizontal grid units)
  Input potential-field grid file
  Input x-derivative of potential-field grid file
  Input y-derivative of potential-field grid file
  Input z-derivative of potential-field grid file
  Input Hilbert transform x-component grid file
  Input x-derivative of Hilbert transform x-component grid file
  Input y-derivative of Hilbert transform x-component grid file
  Input z-derivative of Hilbert transform x-component grid file
  Input Hilbert transform y-component grid file
  Input x-derivative of Hilbert transform y-component grid file
  Input y-derivative of Hilbert transform y-component grid file
  Input z-derivative of Hilbert transform y-component grid file
  Minimum structural index (0.0 to force shallowest magnetic solutions)
  Window size (odd number between 3 and 25)
  Type of depth error to use (0=Absolute, 1=Percent)
  Maximum error in depth (in horizontal grid units or percent)
  Maximum horizontal distance of solutions from center of window
  Maximum depth of solutions below the observation surface (in
    horizontal grid units)
  Output post file (output database will have the same prefix)
```

BATCH PARAMETERS

```
  USGS_EULERAVE.OSGRID       Input observation surface grid
               .OSELEV       OR input observation surface elevation
               .MDSGRID      Input minimum depth surface grid
               .MDSELEV      OR input minimum depth surface elevation
               .CONV         Conversion factor
                               (elevation units / horizontal units)
               .INGRIDD      Input potential-field grid
               .INGRIDDX     Input x-derivative of potential-field grid
               .INGRIDDY     Input y-derivative of potential-field grid
               .INGRIDDZ     Input z-derivative of potential-field grid
               .INGRIDHX     Input Hilbert transform x-component grid
                               file
               .INGRIDHXX    Input x-derivative of Hilbert transform
                               x-component grid file
               .INGRIDHXY    Input y-derivative of Hilbert transform
                               x-component grid file
               .INGRIDHXZ    Input z-derivative of Hilbert transform
```

	x-component grid file
.INGRIDHY	Input Hilbert transform y-component grid file
.INGRIDHYX	Input x-derivative of Hilbert transform y-component grid file
.INGRIDHYY	Input y-derivative of Hilbert transform y-component grid file
.INGRIDHYZ	Input z-derivative of Hilbert transform y-component grid file
.SIMIN	Minimum structural index
.IWIN	Window size
.ITYPE	Type of depth error to use
.MAXERR	Maximum error in depth
.MAXDIST	Maximum horizontal distance of solutions from center of window
.MAXDEPTH	Maximum depth of solutions
.OUTPOST	Output post file

METHOD DESCRIPTION

USGS_EULERAVE.GX estimates the parameters of isolated magnetic sources from gridded magnetic anomaly data using Euler's equation (Reid and others, 1990). Analysis can be done on any combination of the magnetic anomaly grid and its Hilbert transform components (Nabighian and Hansen, 2001). Successful results are averaged for each window.

USGS_SETEULER.GX is used to generate the Hilbert transform component grids and the horizontal and vertical derivative grids used by USGS_EULERAVE.GX. Optional input grids include the elevation of the observation surface and the elevation of a reference surface, such as the topography or the seismic basement, that represents the top of the shallowest expected sources.

Because the depth and structural index cannot be estimated simultaneously (Barbosa and others, 1999), analysis is done in two stages (Phillips, 2002) by passing a window over the data grids. First an attempt is made to estimate a source location and background constant (xo,yo,zo,K) from the data within the window using an initial structural index (usually zero). If the attempt is successful, and the resulting source lies on or below the reference surface, the source is retained as valid. If the attempt is successful, but the resulting source lies above the reference surface, the source is moved down to the reference surface and a solution for the horizontal location, structural index, and background constant (xo,yo,si,K) is attempted. If this second stage is successful, the source on the reference surface is retained as valid. If the initial structural index is set to zero (the default), then the combined solutions on and below the reference surface will represent the shallowest possible magnetic basement surface. For a more traditional Euler analysis, the initial structural index can be specified and the reference surface can be set equal to the observation surface.

APPLICATION NOTES

All input grids must have the same origin, number of rows, number of columns, and grid intervals. The maximum column dimension of the input grids is 8,000.

Leave the input observation surface grid file entry blank to use the constant observation surface elevation.

Leave the input minimum depth surface grid file entry blank to use the constant minimum depth surface elevation. Examples of minimum depth surfaces are the topography, bathymetry, or seismic basement.

Leave the Hilbert transform component grid file entries blank to force conventional Euler depth analysis.

The input potential-field grid entry can be left blank to generate solutions due solely to the Hilbert transform components.

If the maximum horizontal distance entry is left blank, a value of (window_size-1)*(|dx|+|dy|)/4 is used, where dx and dy are the grid intervals in the east and north directions respectively.

Output of the program is contained in the specified binary post file and in a database with the same name as the post file, both containing the following fields:

- id blank
- x the average x (east) coordinate of the source
- y the average y (north) coordinate of the source
- z1 the average elevation (positive upward) of the source
- z2 the average estimated elevation error (either absolute or as % of depth)
- z3 a dummy value for the strike of the feature
- z4 the information index = z5/z2
- z5 the number of solutions in the average
- z6 the average estimated structural index of the source

Output horizontal and vertical units are the same as the input horizontal grid units.

ADDITIONAL APPLICATION NOTES FROM BEN DRENTH

Initial Considerations

1. The Euler deconvolution method is insensitive to magnetic remanence and inclination effects, so it is preferable to use a standard total-field anomaly grid (i.e., not reduced-to-pole).
2. This implementation is not affected by holes in the total-field anomaly grid. It is preferable that the grid not be plugged, so that spurious solutions in plugged regions are avoided.
3. The total-field anomaly grid must be free of excessive flight-line noise (or other types of obvious noise).
4. Before starting, decide on a window size or an appropriate range of window sizes to test. Window size should be ideally chosen large enough so that full anomalies just fit within the window, yet small enough so that adjacent anomalies cannot contaminate that window. This can easily be examined using the ruler function in Oasis.
5. Window sizes are expressed in terms of grid spacing, so for a grid with a 400 meter interval, a window size of 25 would produce a window 10,000 meters on a side. If this is too small a window (see #4), then re-grid the total-field anomaly grid to a larger interval in order to appropriately represent anomaly width using

window sizes of 25 or less.
6. Before starting, make sure that you know the surface elevation and flight surface for the total-field anomaly grid. You will be making grids of each in the following steps.

Euler Setup
1. The total-field anomaly, ground surface elevation, and flight surface grids must all be perfectly coincident. In order to most easily achieve this, save the total-field anomaly grid to a database. Next, create new database channels for the ground and flight surface elevations and interpolate from the appropriate grids into those channels.
2. Make the following grids, using the same gridding parameters for each: total-field anomaly, ground elevation, and flight surface.
3. Run the Euler setup GX. The input grid file is the total-field anomaly grid from the previous step. Use the defaults for all of the listed parameters.

Euler Depth Analysis
1. This is mostly self-explanatory as most of the fields are automatically populated after running the Euler setup. However, there are a few tricks. After specifying the observation (flight) surface and minimum depth (ground elevation) surface, enter the factor for elevation units/horizontal units. This factor is 1000 if the grid units are in kilometers and the elevation units are in meters.
2. The structural index values for magnetic sources are listed below. An advantage of using an index of 0 is that it will yield the minimum possible depths to the tops of the magnetic sources. An index of 1 will yield the maximum possible depths to the tops of most geological magnetic sources, so these two sets of solutions can be compared in a meaningful way.

Structural Index	Geologic Model	Depth Type
0	high-throw contact/fault	depth to top
1	low-throw contact/fault	depth to top
2	line source	depth to center
3	sphere	depth to center

3. Run the program with different window sizes and compare the solutions. A 25 percent error gives a nicely large number of solutions for later gridding. Always set the maximum horizontal distance parameter to 0, which suppresses horizontal location errors. The maximum depth should be set to a very large number, so that there is no risk of excluding deeper solutions.

Manipulating the Results
1. If an observation surface grid has been used, the depth solutions are listed in horizontal grid units above sea level, so these must be converted to depths by being subtracted from the surface elevation. An elevation grid can be sampled into the database for this purpose. Negative depth solutions are commonly present in the database; these can be masked out prior to gridding.
2. Gridding the depths at 3-6 times the original total-field anomaly grid interval is pretty good for displaying results over a large

area. Multiply the depth grid by -1 so that “cold” color solutions appear “deep” on a color shaded image map.

References

Barbosa, V.C.F., Silva, J.B.C. and Medeiros, W.E., 1999, Stability analysis and improvement of structural index estimation in Euler deconvolution: Geophysics, v.64, no.1, p.48-60.

Nabighian, M.N., and Hansen, R.O., 2001, Unification of Euler and Werner deconvolution in three dimensions via the generalized Hilbert transform: Geophysics, v.66, no.6, p.1805-1810.

Phillips, J.D., 2002, Two-step processing for 3D magnetic source locations and structural indices using extended Euler or analytic signal methods: Society of Exploration Geophysicists, Expanded Abstracts, 4p.

Reid, A.B., Allsop, J.M., Granser, H., Millett, A.J., and Somerton, I.W., 1990, Magnetic interpretation in three dimensions using Euler deconvolution: Geophysics, v.55, no.1, p.80-91.

Written by Jeff Phillips (jeff@usgs.gov) 04/10/2003.

USGS_FTFIL

USGS_FTFIL GX

Applies basic Fourier filters to a Fourier transform grid file produced by USGS_FTFWD.GX. The output filtered transform grid should be inverse Fourier transformed using USGS_FTINV.GX.

INTERACTIVE PARAMETERS

```
  Input Fourier transform grid file
  Output filtered Fourier tranform grid file
  Lanczos filter flag (Yes = On, No = Off)
  Hanning filter flag
  Reduction TO the pole flag
  Current inclination (degrees)
  Current declination (degrees)
  Reduction FROM the pole flag
  Desired inclination (degrees)
  Desired declination (degrees)
  Continuation flag
  Continuation distance (positive up)
  Vertical derivative or integral flag
  Order of derivative or integral (positive for derivative)
  Multiplication flag
  Multiplication factor
```

BATCH PARAMETERS

```
USGS_FTFIL.INFFT           Input Fourier transform grid
USGS_FTFIL.OUTFFT          Output filtered Fourier transform grid
USGS_FTFIL.ILANC           Lanczos filter flag (1 = On, 0 = Off)
USGS_FTFIL.IHANN           Hanning filter flag
USGS_FTFIL.IPOLE           Reduction TO the pole flag
USGS_FTFIL.AINCL           Current inclination (degrees)
USGS_FTFIL.ADECL           Current declination (degrees)
USGS_FTFIL.IFROM           Reduction FROM the pole flag
USGS_FTFIL.BINCL           Desired inclination (degrees)
USGS_FTFIL.BDECL           Desired declination (degrees)
USGS_FTFIL.ICONT           Continuation flag
USGS_FTFIL.HEIGHT          Continuation distance (positive up)
USGS_FTFIL.IVERT           Vertical derivative or integral flag
USGS_FTFIL.RORDER          Order of derivative or integral
                                     (positive for derivative)
USGS_FTFIL.IMULT           Multiplication flag
USGS_FTFIL.AMULT           Multiplication factor
```

APPLICATION NOTES

```
  Lanczos filter - slight lowpass to reduce Gibbs effects.
  Hanning filter - mild lowpass to correct for the data window.
  Reduction TO or FROM the pole
                 - not valid within approximately ten degrees of
                        the geomagnetic equator.
                 - assumes that the input grid to the USGS_FTFWD GX
```

```
                        contains potential-field data measured on
                        a flat, horizontal surface.
   Continuation   - assumes that the input grid to the USGS_FTFWD GX
                        contains potential-field data measured on
                        a flat, horizontal surface.
   Vertical derivative or integral
                  - non-integer orders are supported.
                  - assumes that the input grid to the USGS_FTFWD GX
                        contains potential-field data measured on
                        a flat, horizontal surface.

   Useful combinations of operations include:

   Pseudogravity transformation of magnetic anomaly data
      = Reduction-to-Pole + 1st vertical integral (+ optional
        multiplication for scaling).

   Pseudomagnetic transformation of gravity anomaly data
      = Reduction-from-Pole + 1st vertical derivative (+ optional
        multiplication for scaling).

 Written by Jeff Phillips (jeff@usgs.gov) 12/26/2002.
```

USGS_FTFWD

```
USGS_FTFWD GX

Fourier transforms an extended grid produced by USGS_FTPREP.GX. The
output Fourier transform grid can be filtered using:
  USGS_FTFIL.GX   - basic potential-field filters
  USGS_BPFIL.GX   - lowpass,highpass, bandpass, notch filters
  USGS_CTFIL.GX   - magnetic component transformations
  USGS_RTFIL.GX   - regularized basic potential-field filters
  USGS_HTFIL.GX   - Hilbert transform components
  USGS_VDFIL.GX   - Vertical derivative from horizontal derivatives

INTERACTIVE PARAMETERS

  Input grid file
  Output Fourier transform file

BATCH PARAMETERS

USGS_FTFWD.INGRID           input grid
USGS_FTFWD.OUTFFT           output Fourier transform

APPLICATION NOTES

The maximum column dimension of the input grid is 16,384.

Written by Jeff Phillips (jeff@usgs.gov) 12/18/2002.
```

USGS_FTINV

USGS_FTINV GX

Inverse Fourier transforms a filtered Fourier transform grid file produced by USGS_FTFIL.GX, USGS_BPFIL.GX, etc. back to the space domain. The output grid will cover the same area and be dummied in the same places as a specified masking grid, which is usually the starting grid for the filtering process.

INTERACTIVE PARAMETERS

Input Fourier transform grid file
Input masking grid file
Output masked grid file

BATCH PARAMETERS

USGS_FTINV.INFFT	input Fourier transform grid
USGS_FTINV.MASKGRID	input Space-domain masking grid
USGS_FTINV.OUTGRID	output Space-domain masked grid

APPLICATION NOTES

The maximum column dimension of the masking and output grid files is 16,384.

Written by Jeff Phillips (jeff@usgs.gov) 12/26/2002.

USGS_FTPREP

USGS_FTPREP GX

Prepares a plugged grid for Fourier transform by USGS_FTFWD.GX
The grid is extended to a size required by USGS_FTFWD.GX and
made to be periodic.

INTERACTIVE PARAMETERS

Input plugged grid file
Output extended grid file
Minimum percent expansion (e.g., 25)

BATCH PARAMETERS

USGS_FTPREP.INGRID	input plugged grid
USGS_FTPREP.PREPGRID	output extended grid
USGS_FTPREP.PCT	minimum percent expansion

APPLICATION NOTES

Maximum dimensions of the extended grid are 16,384 x 16,384.
The input grid should be smaller than this.

The input grid is processed through the following 8 steps:
1. Get the min/max of the grid edge values for use as limits on the extended data.
2. Extend the grid to the right using prediction filtering.
3. Transpose the extended grid.
4. Extend the transposed grid to the right.
5. Smooth across the first extension.
6. Transpose back.
7. Smooth across the second extension.
8. Center the data in the grid.

Written by Jeff Phillips (jeff@usgs.gov) 12/18/2002.

USGS_GRADCOMP

USGS_GRADCOMP GX

Computes filtered horizontal derivative and horizontal gradient magnitude (HGM) grids using the gradient-component method of Thurston and Brown (1994).

INTERACTIVE PARAMETERS

Input grid file
Output HGM grid file
Output x(east)-derivative grid file
Output y(north)-derivative grid file
Window size (odd and < 22)
Polynomial order (< Window size)

BATCH PARAMETERS

USGS_GRADCOMP.GRID	input grid
USGS_GRADCOMP.HGRID	output HGM grid
USGS_GRADCOMP.XGRID	output x-derivative grid
USGS_GRADCOMP.YGRID	output y-derivative grid
USGS_GRADCOMP.WINDOW	window size
USGS_GRADCOMP.POLY	polynomial order

APPLICATION NOTES

Computes filtered horizontal derivative and horizontal gradient magnitude grids using the gradient-component method of Thurston and Brown (1994). The user must specify a window size, w, and a polynomial order, n < w. The standard first-difference operator corresponds to w = 3, n = 2. For this and similar operators having n = w-1, there is no attenuation of short wavelengths. For operators having n < w-1, short wavelength features will be attenuated.

Source code modified from Thurston and Brown (1994) by Jeff Phillips. The maximum number of columns in the grid is limited to 8,000. Grid projection information is ignored.

Reference:

Thurston, J.B., and Brown, R.J., 1994, Automated source-edge location with a new variable pass-band horizontal-gradient operator: Geophysics, v.59, no.4, p.546-554.

Written by Jeff Phillips (jeff@usgs.gov) 10/13/99.

USGS_GRADXYH

USGS_GRADXYH GX

Computes horizontal derivative and horizontal gradient magnitude (HGM) grids using local quadratic surface fitting in 3x3 data windows. Gradient values are computed to the edges of the data coverage, so there are no gaps in coverage around the outside edge of the grid or around holes in the data coverage.

INTERACTIVE PARAMETERS

Input grid file
Output x(east)-derivative grid file
Output y(north)-derivative grid file
Output HGM grid file

BATCH PARAMETERS

USGS_GRADXYH.INGRID	input grid
USGS_GRADXYH.XGRID	output x-derivative grid
USGS_GRADXYH.YGRID	output y-derivative grid
USGS_GRADXYH.HGRID	output HGM grid

APPLICATION NOTES

The maximum column dimension of the input grid is 8,000. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 7/16/2007.

USGS_GRIDMASK

USGS_GRIDMASK GX

Masks a grid file by inserting dummy (no data) values. The inserted dummy values correspond either to the dummy values in a second grid file (normal masking) or to the non-dummy (data) values in the second grid file (inverse masking).

INTERACTIVE PARAMETERS

```
  Grid file to be masked
  Grid file containing the masking values
  Output masked grid file
  Normal or inverse masking
```

BATCH PARAMETERS

```
USGS_GRIDMASK.INGRID1       input grid file to be masked
USGS_GRIDMASK.INGRID2       input masking grid file
USGS_GRIDMASK.OUTGRID       output masked grid file
USGS_GRIDMASK.MTYPE         type of masking (Normal=1, Inverse=0)
```

APPLICATION NOTES

The two input grids must have the same origin, number of rows, number of columns, and grid interval. The maximum column dimension is 16,384 for all grids. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 01/18/00.

USGS_GRIDPLUG

USGS_GRIDPLUG GX

Plugs dummy values in a grid file by using polynomial or local median initialization followed by minimum curvature iterations.

INTERACTIVE PARAMETERS

```
  Grid file to be plugged
  Output plugged grid file
  Polynomial order (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations
```

BATCH PARAMETERS

```
USGS_GRIDPLUG.INGRID        input grid file to be plugged
USGS_GRIDPLUG.OUTGRID       output plugged grid file
USGS_GRIDPLUG.IORDER        polynomial order for initialization
                              (0 to 3 or -1 for local median)
USGS_GRIDPLUG.NITER         number of minimum curvature iterations
                              (e.g., 100)
```

APPLICATION NOTES

The maximum column dimension of the grids is 10,000. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 12/16/2002.

USGS_GRIDPROX

USGS_GRIDPROX GX

Use this GX to create a grid containing distance to nearest data point.

INTERACTIVE PARAMETERS

```
  X channel
  Y channel
  Input grid (used to determine size and spacing of output grid)
  Output grid
```

BATCH PARAMETERS

```
USGS_GRIDPROX.DB        input database
USGS_GRIDPROX.XCH       input x-channel
USGS_GRIDPROX.YCH       input y-channel
USGS_GRIDPROX.INGRID    input grid file
USGS_GRIDPROX.OUTGRID   output grid file
```

APPLICATION NOTES

This GX is written entirely in native gxc code - it is slow.

Written by Rick Saltus, USGS (saltus@usgs.gov)

USGS_GRIDSAMP

USGS_GRIDSAMP GX

Sample a grid at points of a post file using bilinear interpolation.
The output post file is imported into a new Geosoft database.

INTERACTIVE PARAMETERS

```
  Input post file
  Output post file and database
  Input grid file
  Post channel to overwrite
```

BATCH PARAMETERS

```
  USGS_GRIDSAMP.INPOST          Input post file
               .OUTPOST         Output post file and database
               .INGRID          Input grid file
               .ICHAN           Post channel to overwrite (1 to 6)
```

APPLICATION NOTES

The maximum column dimension of the grid is 8,000.

Written by Jeff Phillips (jeff@usgs.gov) 04/14/2003.

USGS_HGRAD

USGS_HGRAD.GX

This GX calculates the magnitude of the horizontal gradient of a grid.

INTERACTIVE PARAMETERS

```
        Input grid
        Output horizontal gradient magnitude grid
```

BATCH PARAMETERS

```
        USGS_HGRAD.IN  = Input grid
        USGS_HGRAD.OUT = Output horizontal gradient magnitude grid
```

APPLICATION NOTES

The HORIZONTAL GRADIENT MAGNITUDE is the square root of the sum of the squares of the derivatives in the x and y directions:

```
        hgrad = sqrt ( dx*dx + dy*dy )
```

Written by Northwest Geophysical Associates for the USGS.
Requires licensed grid filtering.

USGS_HTFIL

USGS_HTFIL GX

Computes Hilbert transform components in the Fourier domain from an input Fourier transform grid file generated by USGS_FTFWD.GX

INTERACTIVE PARAMETERS

Input Fourier transform grid file

BATCH PARAMETERS

USGS_HTFIL.INFFT   input Fourier transform grid

APPLICATION NOTES

The output Fourier transform grid files have the same prefix as the input file and suffixes .FHX for the x-component and .FHY for the y-component. Use USGS_FTINV.GX to inverse Fourier transform the output files.

References

Nabighian, M.N., 1984, Toward a three-dimensional automatic interpretation of potential field data via generalized Hilbert transforms: Fundamental relations: Geophysics, v.49, no.6, p.780-786.

Nabighian, M.N., and Hansen, R.O., 2001, Unification of Euler and Werner deconvolution in three dimensions via the generalized Hilbert transform: Geophysics, v.66, no.6, p.1805-1810.

Written by Jeff Phillips (jeff@usgs.gov) 12/27/2002.

USGS_IGRFPT

USGS_IGRFPT GX

Geomagnetic field values at a specified point location and time.

INTERACTIVE PARAMETERS

```
  Month
  Day
  Year (1945 +)
  North latitude (decimal degrees)
  East longitude (decimal degrees)
  Altitude (meters)
```

BATCH PARAMETERS

```
  USGS_IGRFPT.MONTH      Month (1 to 12)
             .DAY        Day (1 to 31)
             .YEAR       Year (1945 to 2015)
             .LAT        North latitude (decimal degrees)
             .LON        East longitude (decimal degrees)
             .ALT        Altitude (meters)
```

APPLICATION NOTES

The coefficients were last updated using the IGRF 1900-1940, the Definitive IGRF 1945-2000, the IGRF 2005, and the IGRF 2005 secular change.

Original Fortran code by Mike Webring and Ron Sweeney, USGS.
GX written by Jeff Phillips (jeff@usgs.gov) 2/12/2003.

USGS_IMPOST

USGS_IMPOST GX

Imports an existing USGS post file with six data channels into a new database.

INTERACTIVE PARAMETERS

  Input post file
  Output database

BATCH PARAMETERS

USGS_IMPOST.INPOST	Input post file
USGS_IMPOST.OUTGBD	Output database

APPLICATION NOTES

A USGS post file is a Microsoft Fortran sequential binary file with the following nine fields in each record:

```
id    station id (character*8)
x     x(east)-coordinate (real*4)
y     y(north)-coordinate (real*4)
z1    first data value (real*4)
z2    second data value (real*4)
...
z6    sixth data value (real*4)
```

Reference

Phillips, J.D., 1997, Potential-field geophysical software for the PC, version 2.2: U.S. Geological Survey Open-File Report 97-725, 34p.

Written by Jeff Phillips (jeff@usgs.gov) 1/9/2003.

USGS_LNPLOT

USGS_LNPLOT GX

Creates a DXF file from an ASCII line file (in one of two formats) and plots it to the current map.

INTERACTIVE PARAMETERS

```
  Input ASCII line file in .LX or XYP format
  Output .DXF file
  Group Name
  Color for plotting lines
```

BATCH PARAMETERS

```
USGS_LNPLOT.INLINE    Input ASCII line file
           .OUTDXF    Output DXF file containing the lines
           .GROUP     Group Name in the DXF file
           .COLOR     Color to use
                        "retain colours"
                        "black"
                        "red"
                        "green"
                        "blue"
                        "cyan"
                        "magenta"
                        "yellow"
                        "grey"
                        "light grey"
                        "light red"
                        "light green"
                        "light blue"
                        "light cyan"
                        "light magenta"
                        "light yellow"
                        "white"
```

APPLICATION NOTES

An LX file such as myfile.lx is an ASCII file containing two columns separated by one or more spaces. The left column contains the x(east)-coordinates of the polylines; the right column contains the y(north)-coordinates. The end of each polyline is indicated by a value of 1.e38 in each column.

An XYP file, which can have any extension other than .lx, is an ASCII file containing three columns separated by one or more spaces. The left column contains the x(east)-coordinates of the polylines, the center column contains the y(north)-coordinates, and the right column contains the polyline number. When the value in the right column changes, a new line is started.

The GX assumes that the x and y coordinates in the line file are in the same projection and distance units as the map.

Written by Jeff Phillips (jeff@usgs.gov) 03/03/2005.

USGS_LW

USGS_LW GX

One-step computation of the local wavenumber grid of a potential-field data grid, with optional low-pass filtering, and including all related first derivative grids.

INTERACTIVE PARAMETERS

```
  Input potential-field grid file
  Output local wavenumber grid file
  Output total gradient grid file
  Output horizontal gradient grid file
  Output x(east)-derivative grid file
  Output y(north)-derivative grid file
  Output z(down)-derivative grid file
  Order of initializing polynomial for plugging horizontal derivative
    grids (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging horizontal
    derivative grids (e.g., 100)
  Gradient operator size (odd and < 22, normally 3, or 0 for local
    quadratic)
  Gradient operator order (Gradient operator size minus 1 for no
    filtering, smaller values for low-pass filtering, normally 2)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
  USGS_LW.INGRID          Input potential-field grid
         .OUTLGRID        Output local wavenumber grid
         .OUTTGRID        Output total gradient grid
         .OUTHGRID        Output horizontal gradient grid
         .OUTXGRID        Output x(east)-derivative grid
         .OUTYGRID        Output y(north)-derivative grid
         .OUTZGRID        Output z(down)-derivative grid
         .IORDER          Polynomial order for plugging holes
         .NITER           Iterations for plugging holes
         .WINDOW          Gradient operatior size
         .POLY            Gradient operator order
         .PCT             Minimum percent expansion
```

APPLICATION NOTES

The equation for the local wavenumber is given by Phillips (2000) and Phillips and others (2007).

If gradient operator size is 3 or greater, horizontal gradients are computed using differences (usgs_gradcomp.gx). If gradient operator order is less than gradient operator size minus one, low-pass filtering will result (Thurston and Brown, 1994).

If gradient operator size is 0, horizontal gradients are computed using local quadratic surfaces (usgs_gradxyh.gx). Gradient operator order is ignored.

Vertical gradients are computed from the horizontal gradients using Hilbert transform components (Nabighian, 1984).

Holes in the input grid, if any, are plugged before processing. All output grids will be completely plugged, except for the z-derivative, the total gradient, and the local wavenumber, which are masked to the input grid.

The maximum column dimension of the input grid is 8,000. Grid projection information is ignored.

References:

Nabighian, M.N., 1984, Toward a three-dimensional automatic interpretation of potential field data via generalized Hilbert transforms: Fundamental relations: Geophysics, v.49, no.6, p.780-786.

Phillips, J.D., 2000, Locating magnetic contacts: a comparison of the horizontal gradient, analytic signal, and local wavenumber methods: Society of Exploration Geophysicists, Expanded Abstracts with Biographies, 2000 Technical Program, v.1, p.402-405.

Phillips, J.D., Hansen, R.O., and Blakely, R.J., 2007, The use of curvature in potential-field interpretation: Exploration Geophysics, v.38, p.111-119.

Thurston, J.B., and Brown, R.J., 1994, Automated source-edge location with a new variable pass-band horizontal-gradient operator: Geophysics, v.59, no.4, p.546-554.

Written by Jeff Phillips (jeff@usgs.gov) 09/28/2005.

USGS_MBASE

USGS_MBASE GX

Create a diurnal correction channel from multiple magnetic base stations.

INTERACTIVE PARAMETERS

```
  X(east) channel name
  Y(north) channel name
  Z(elevation) channel name
  Output diurnal channel name
  Number of base stations
  Base station 1 channel name
  Base station 1 X-coordinate
  Base station 1 Y-coordinate
  Base station 1 Z-coordinate
  Base station 1 DC value
  Base station 2 channel name
  Base station 2 X-coordinate
  Base station 2 Y-coordinate
  Base station 2 Z-coordinate
  Base station 2 DC value
  ...
  Base station 6 channel name
  Base station 6 X-coordinate
  Base station 6 Y-coordinate
  Base station 6 Z-coordinate
  Base station 6 DC value
```

BATCH PARAMETERS

```
USGS_MBASE.XCHAN           X(east) channel name
USGS_MBASE.YCHAN           Y(north) channel name
USGS_MBASE.ZCHAN           Z(elevation) channel name
USGS_MBASE.OUTCHAN         Output diurnal channel name
USGS_MBASE.NBASE           Number of base stations
USGS_MBASE.B1CHAN          Base station 1 channel name
USGS_MBASE.B1X             Base station 1 X-coordinate
USGS_MBASE.B1Y             Base station 1 Y-coordinate
USGS_MBASE.B1Z             Base station 1 Z-coordinate
USGS_MBASE.B1DC            Base station 1 DC value
USGS_MBASE.B2CHAN          Base station 2 channel name
USGS_MBASE.B2X             Base station 2 X-coordinate
USGS_MBASE.B2Y             Base station 2 Y-coordinate
USGS_MBASE.B2Z             Base station 2 Z-coordinate
USGS_MBASE.B2DC            Base station 2 DC value

...
USGS_MBASE.B6CHAN          Base station 6 channel name
USGS_MBASE.B6X             Base station 6 X-coordinate
USGS_MBASE.B6Y             Base station 6 Y-coordinate
USGS_MBASE.B6Z             Base station 6 Z-coordinate
USGS_MBASE.B6DC            Base station 6 DC value
```

APPLICATION NOTES

For one base station, the base station value is returned.
For two base stations, the returned value is on the "most level" plane
  defined by the two base station values.
For three base stations, the returned value is on the plane defined by
  the three base station values.
For more than three base stations, the returned value is on a plane
  fitting all base station values, weighted by inverse distance.

Base station DC values are typically an average of quiet-time values near local midnight. The averages should be performed over the same set of days for all base stations.

Written by Jeff Phillips (jeff@usgs.gov) 11/28/2006.

USGS_MFDESIGN

USGS_MFDESIGN GX

Design matched bandpass filters for a potential-field data grid.

INTERACTIVE PARAMETERS

```
  Input spectrum file from USGS_MFINIT.GX
  Output layer file
  Background color (1 = black, -1 = white)
```

BATCH PARAMETERS

```
USGS_MFDESIGN.SPEC          Input spectrum file from USGS_MFINIT.GX
USGS_MFDESIGN.LAYER         Initial layer type
USGS_MFDESIGN.BKGRND         1 = black
                            -1 = white
```

APPLICATION NOTES

This GX requires files generated by USGS_MFINIT.GX.

Start by fitting the the right-hand side of the plot with the shallowest equivalent layer, usually a dipole layer (magnetics) or a density layer (gravity). Then move to the left for each subsequent equivalent layer.

Use thin-layer models for the shallowest layers; switch to half-space models at the depth where you want the greatest spectral separation.

You can try different models for the current layer. Remember to move on to the next layer when you are happy with the fit, and select "all done" after fitting the deepest (left-most) layer.

The non-linear least squares iterative improvement is performed until the RMS error is minimized. This step is recommended.

Use USGS_MFFILTER.GX to apply the bandpass filters to the data.

Reference

Phillips, J.D., 2001, Designing matched bandpass and azimuthal filters for the separation of potential-field anomalies by source region and source type: Australian Society of Exploration Geophysicists, 15th Geophysical Conference and Exhibition, Expanded Abstracts CD-ROM, 4p.

Written by Jeff Phillips (jeff@usgs.gov) 2/10/2003.

USGS_MFFILTER

USGS_MFFILTER GX

Apply matched bandpass filters to a potential-field data grid in order to approximately separate anomalies produced at different equivalent layer depths.

INTERACTIVE PARAMETERS

```
  Input Fourier transform grid file (generated by USGS_MFINIT.GX)
  Input layer file                  (generated by USGS_MFDESIGN.GX)
  Filter type (Amplitude or Wiener)
  Input masking grid file    (same as input grid to USGS_MFINIT.GX)
  Output lowpass grid file   (anomalies from the deepest layer)
  Output bandpass1 grid file (anomalies from the next deepest layer)
  Output bandpass2 grid file (anomalies from the next deepest layer)
  Output bandpass3 grid file (anomalies from the next deepest layer)
  Output bandpass4 grid file (anomalies from the next deepest layer)
  Output bandpass5 grid file (anomalies from the next deepest layer)
  Output bandpass6 grid file (anomalies from the next deepest layer)
  Output bandpass7 grid file (anomalies from the next deepest layer)
  Output bandpass8 grid file (anomalies from the next deepest layer)
```

BATCH PARAMETERS

```
USGS_MFFILTER.INFFT      Input Fourier transform grid file(from
                           USGS_MFINIT.GX)
USGS_MFFILTER.INLAY      Input equivalent layer file (from
                           USGS_MFDESIGN.GX)
USGS_MFFILTER.FTYPE      Filter type ("a" or "w")
USGS_MFFILTER.MASKGRD    Masking grid to be applied to the bandpass
                           grids (the input grid to USGS_MFINIT.GX)
USGS_MFFILTER.OUTGRD0    Output lowpass grid file   (deepest layer)
USGS_MFFILTER.OUTGRD1    Output bandpass1 grid file (the next deepest
                           layer)
USGS_MFFILTER.OUTGRD2    Output bandpass2 grid file (the next deepest
                            layer)
USGS_MFFILTER.OUTGRD3    Output bandpass3 grid file (the next deepest
                            layer)
USGS_MFFILTER.OUTGRD4    Output bandpass4 grid file (the next deepest
                            layer)
USGS_MFFILTER.OUTGRD5    Output bandpass5 grid file (the next deepest
                            layer)
USGS_MFFILTER.OUTGRD6    Output bandpass6 grid file (the next deepest
                            layer)
USGS_MFFILTER.OUTGRD7    Output bandpass7 grid file (the next deepest
                            layer)
USGS_MFFILTER.OUTGRD8    Output bandpass8 grid file (the next deepest
                            layer)
```

APPLICATION NOTES

Requires files generated by USGS_MFINIT.GX and USGS_MFDESIGN.GX.

You only need to specify as many output grids as you have layers in the layer file.

The maximum column dimension of the masking and output grids is 8,000. Grid projection information is ignored.

Reference

Phillips, J.D., 2001, Designing matched bandpass and azimuthal filters for the separation of potential-field anomalies by source region and source type: Australian Society of Exploration Geophysicists, 15th Geophysical Conference and Exhibition, Expanded Abstracts CD-ROM, 4p.

Written by Jeff Phillips (jeff@usgs.gov) 2/10/2003.

USGS_MFINIT

USGS_MFINIT GX

Initialize the matched bandpass filtering process for a potential-field data grid.

INTERACTIVE PARAMETERS

```
  Input potential-field grid file
  Output Fourier transform grid file
  Output radial spectrum file
  Output residual spectrum grid file
  Order of initializing polynomial for plugging horizontal derivative
    grids (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging horizontal
    derivative grids (e.g., 100)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
  USGS_MFINIT.INGRID       Input potential-field grid
             .OUTFFT       Output Fourier transform grid
             .OUTSPC       Output radial spectrum file
             .OUTGRID      Output residual spectrum grid file
             .IORDER       Polynomial order for plugging holes
             .NITER        Iterations for plugging holes
             .PCT          Minimum percent expansion
```

APPLICATION NOTES

Follow up with USGS_MFDESIGN.GX, which uses the radial spectrum file, and USGS_MFFILTER.GX, which uses the Fourier transform grid. The maximum column dimension of the input grid is 8,000.

Reference

Phillips, J.D., 2001, Designing matched bandpass and azimuthal filters for the separation of potential-field anomalies by source region and source type: Australian Society of Exploration Geophysicists, 15th Geophysical Conference and Exhibition, Expanded Abstracts CD-ROM, 4p.

Written by Jeff Phillips (jeff@usgs.gov) 2/11/2003.

USGS_MFPLOT

USGS_MFPLOT GX

Display matched bandpass filters designed by USGS_MFDESIGN.GX.

INTERACTIVE PARAMETERS

```
  Input radial spectrum file from USGS_MFINIT.GX
  Input layer file from USGS_MFDESIGN.GX
  Background color (1 = black, -1 = white)
```

BATCH PARAMETERS

```
USGS_MFPLOT.SPEC         Input radial spectrum file from USGS_MFINIT.GX
USGS_MFPLOT.LAYER        Input layer file from USGS_MFDESIGN.GX
USGS_MFPLOT.BKGRND        1 = black
                         -1 = white
```

APPLICATION NOTES

This GX requires files generated by USGS_MFINIT.GX and USGS_MFDESIGN.GX.

First the fit between the layer model and the radial spectrum is shown, then the bandpass filters corresponding to the model are shown.

Use USGS_MFFILTER.GX to apply the bandpass filters to the potential-field data grid.

Reference

Phillips, J.D., 2001, Designing matched bandpass and azimuthal filters for the separation of potential-field anomalies by source region and source type: Australian Society of Exploration Geophysicists, 15th Geophysical Conference and Exhibition, Expanded Abstracts CD-ROM, 4p.

Written by Jeff Phillips (jeff@usgs.gov) 2/11/2003.

USGS_OPENPOST

USGS_OPENPOST GX

Imports a USGS POST file to a new database. Requires a licensed version of Oasis montaj.

INTERACTIVE PARAMETERS

```
  Input USGS POST file (new database will have the same prefix)
  Maximum number of lines in the database
  Maximum number of channels in the database
```

BATCH PARAMETERS

```
USGS_OPENPOST.FILE      Input USGS POST file (new database will have
                          the same prefix)
USGS_OPENPOST.LINES     Maximum number of lines in the database
USGS_OPENPOST.CHANNELS  Maximum number of channels in the database
```

APPLICATION NOTES

A USGS POST file is a Microsoft Fortran unformatted sequential binary File in which each record contains a record identification ID (8 ASCII characters), X (real*4) and Y (real*4) coordinates, and any number of dependent variables Z1,Z2,... (real*4 for each one).

In addition to the data values, the file contains a first byte of Decimal 75, and a last byte of decimal 130. Each logical record is made up of one or more physical blocks of up to 128 data bytes with a preceding and trailing length-byte. If a logical record contains more than one physical block, the length-bytes of all but the last block are set to decimal 129.

Reference

Phillips, J.D., 1997, Potential-field geophysical software for the PC, version 2.2: U.S. Geological Survey Open-File Report 97-725, 34p.

Modified from Geosoft's OpenXYZ.gx and impost.gx
by Jeff Phillips (jeff@usgs.gov) 1/10/2003.

USGS_PDRAW

USGS_PDRAW GX

Draws the polygons from a polygon file into a specified group on the current map.

INTERACTIVE PARAMETERS

Polygon file name (.ply)	The name of the polygon file
Map view	Map view in which to draw, select from the list
Line thickness (mm)	The polygon outline line thickness in mm
Line colour	Enter a line colour of form RxxxGxxxBxxx
Fill colour	Enter a fill colour of form RxxxGxxxBxxx
Group Name	Enter the group name
Group Action	Enter a zero (0) to replace the group (i.e. erase and replot) and a one (1) to append polygons to the group

BATCH PARAMETERS

USGS_PDRAW.FILE	Polygon file
USGS_PDRAW.VIEW	Map view
USGS_PDRAW.LINETHICK	Line thickness
USGS_PDRAW.LINECOLO	Line color
USGS_PDRAW.FILLCOLO	Fill color
USGS_PDRAW.GROUPNAME	Group name
USGS_PDRAW.GROUPACTN	Group action

APPLICATION NOTES

Polygons are ASCII files with default extension .ply. A polygon file contains a list of X,Y coordinates that define one or more polygons. The file may contain any number of polygons, and each polygon may have any number of vertices. The first and last points in each polygon are assumed to connect. If the file will contain more than one polygon, each polygon must start with a line 'poly #' ('p' or 'P' in column 1). Comment lines are indicated by a '/' in column 1. Please note that the polygon coordinates are assumed to be in the same coordinate system as that of the map view on which the polygons will be drawn.

Following is an example of a single polygon file:

```
/
/  Sample single polygon file
```

```
/----------------------------
poly 1
    1376027.6061    6178025.9399
    1382846.3129    6178025.9399
    1382846.3129    6182748.8182
    1376027.6061    6182748.8182
    1376027.6061    6178025.9399
```

Following is an example of a three-polygon file:

```
/
/ Sample three polygon file
/---------------------------
poly 1
    1375594.6724    6181961.6718
    1378706.3838    6181961.6718
    1378706.3838    6184716.6842
    1375594.6724    6184716.6842
    1375594.6724    6181961.6718
poly 2
    1375757.0225    6178629.4188
    1379896.9516    6178629.4188
    1379896.9516    6181174.5254
    1375757.0225    6181174.5254
    1375757.0225    6178629.4188
poly 3
    1380546.3523    6175926.8828
    1384550.9896    6175926.8828
    1384550.9896     6179022.992
    1380546.3523     6179022.992
    1380546.3523    6175926.8828
```

TOPIC MODIFIED BY JOE DUVAL, USGS (03/04/2002)

USGS_PGPLOT

USGS_PGPLOT GX

Creates a DXF file containing a page size map surround from a grid file, then creates a new map from the DXF file.

INTERACTIVE PARAMETERS

```
  Input grid file
  Output grid file with added colorbar
  Output DXF file
  Colorbar flag
  Colorbar offset (grid columns)
  Colorbar width (grid columns)
  Colorbar units
  Distance units flag
  Map scale
```

BATCH PARAMETERS

```
USGS_PGPLOT.INGRID    Input grid file
           .OUTGRID   Output grid file with color bar
           .OUTDXF    Output DXF file containing map surround
           .YNCB      Color bar plotting flag
                            0 = No
                            1 = Yes
           .NOFF      Offset to color bar (grid columns)
           .NWID      Width of color bar (grid columns)
           .CBUNITS   Color bar label
           .IDIST     Distance units flag
                            0 = kilometers
                            1 = meters
                            2 = centimeters
                            3 = millimeters
                            4 = statute miles
                            5 = nautical miles
                            6 = kilofeet
                            7 = feet
                            8 = inches
                            9 = degrees
           .SCALE      Map scale (e.g., 50000)
```

APPLICATION NOTES

The scale button will attempt to return the largest scale factor that will fit on a letter-size page. For a page-sized plot, enter a scale factor greater than this.

If the output DXF file or grid exist, they will be overwritten. The output map will have the same name as the DXF file. If the output map exists, the user will be asked to verify the overwrite.

After the new map is created, the output grid with a colorbar (if any) can be plotted without shading, and the original grid can be plotted with shading.

Individual components of the base map can be displayed or hidden using the Group Manager.

Written by Jeff Phillips (jeff@usgs.gov) 03/02/2005.

USGS_PLUGGRID

USGS_PLUGGRID GX

Plugs holes in a grid using minimum curvature gridding.
Requires a license for Geosoft gridding.

INTERACTIVE PARAMETERS

  Input grid file
  Output plugged grid file

BATCH PARAMETERS

```
  USGS_PLUGGRID.INGRID            input grid
  USGS_PLUGGRID.PLUGGRID          output plugged grid
```

APPLICATION NOTES

  Tests input grid for dummy values. If dummy values are found, runs GRIDGDB.GX to copy valid grid values to a temporary database, then runs RANGRID.GX to create the plugged grid.

Written by Jeff Phillips (jeff@usgs.gov) 01/07/00.

USGS_PREP4

USGS_PREP4 GX

Prepares a grid for Geosoft Fourier transform by plugging holes, and extending the rows and columns. Requires a Geosoft license for gridding.

INTERACTIVE PARAMETERS

Input grid file
Output plugged and extended grid file
Percent expansion

BATCH PARAMETERS

USGS_PREP4.INGRID	input grid
USGS_PREP4.PREPGRID	output plugged and extended grid
USGS_PREP4.PCT	percent expansion

APPLICATION NOTES

Maximum dimensions of the extended grid are 16,384 x 16,384. The input grid should be smaller than this.

Initial processing tests the input grid for dummy values; if any exist, the valid grid values are copied into a temporary database called Prep4.gdb and regridded using minimum curvature into a new grid called Prep4.plg.

The input grid (or Prep4.plg) is then processed through the following 8 steps:
1. Get the min/max of the grid and the extended dimensions.
2. Extend the grid to the right using prediction filtering.
3. Transpose the extended grid.
4. Extend the transposed grid to the right.
5. Smooth across the first extension.
6. Transpose back.
7. Smooth across the second extension.
8. Center the data in the grid.

Written by Jeff Phillips (jeff@usgs.gov) 01/18/00.

USGS_PSDGRV

USGS_PSDGRV GX

One-step computation of a pseudo-gravity field grid from a total magnetic field grid.

INTERACTIVE PARAMETERS

```
  Input total field magnetic anomaly grid file
  Output pseudo-gravity anomaly grid file
  Geomagnetic inclination (degrees)
  Geomagnetic declination (degrees)
  Ratio of magnetization to density
  Order of initializing polynomial for plugging input
    grid (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging
    input grid (e.g., 100)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
  USGS_PSDGRV.INGRID          Input gravity grid
             .OUTGRID         Output pseudo-magnetic grid
             .INCL            Geomagnetic inclination (degrees)
             .DECL            Geomagnetic declination (degrees)
             .RATIO           Ratio of magnetization to density
             .IORDER          Polynomial order for plugging holes
             .NITER           Iterations for plugging holes
             .PCT             Minimum percent expansion
```

APPLICATION NOTES

Like standard reduction-to-the-pole, this will not work well at low magnetic latitudes (within 20 degrees of the magnetic equator). The maximum number of columns in the expanded input grid is 16,384. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 06/10/2003.

USGS_PSDMAG

USGS_PSDMAG GX

One-step computation of a pseudo-magnetic field grid from a gravity field grid.

INTERACTIVE PARAMETERS

```
  Input gravity anomaly grid file
  Output pseudo-magnetic anomaly grid file
  Geomagnetic inclination (degrees)
  Geomagnetic declination (degrees)
  Ratio of magnetization to density
  Order of initializing polynomial for plugging input
    grid (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging
    input grid (e.g., 100)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
  Lowpass filtering option (0 = None, 1 = Lanczos, 2 = Hanning)
```

BATCH PARAMETERS

```
  USGS_PSDMAG.INGRID          Input gravity grid
             .OUTGRID         Output pseudo-magnetic grid
             .INCL            Geomagnetic inclination (degrees)
             .DECL            Geomagnetic declination (degrees)
             .RATIO           Ratio of magnetization to density
             .IORDER          Polynomial order for plugging holes
             .NITER           Iterations for plugging holes
             .PCT             Minimum percent expansion
             .IFILT           Lowpass filtering option
```

APPLICATION NOTES

The maximum number of columns in the expanded input grid is 16,384. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 06/05/2003.

USGS_RCDEP

USGS_RCDEP GX

Profile depth analysis methods applied to the rows and/or columns of a magnetic anomaly grid.

INTERACTIVE PARAMETERS

Input magnetic anomaly grid (must be reduced-to-pole magnetics for horizontal gradient contacts or pseudogravity for horizontal gradient sheets)
Polynomial order for plugging
Iterations for plugging
Optional input observation surface grid
Elevation units per horizontal units
Method used for depth analysis: 1=analytic signal, 2=horizontal gradient, or 3=local wavenumber
Desired source type for analytic signal or horizontal gradient analysis: 0=contact or 1=sheet
Desired strike direction of features: 1=north, 2=east, or 3=both
Minimum amplitude of the derivative function
Output closed peaks only: 0=No, 1=Yes
Output post file (and database)

BATCH PARAMETERS

USGS_RCDEP.AGRID	Input magnetic anomaly grid (must be reduced-to-pole magnetic field for horizontal gradient contacts or pseudogravity for horizontal gradient sheets)
.IORDER	Polynomial order for plugging
.NITER	Iterations for plugging
.OSGRID	Optional input observation surface grid
.CONV	Elevation units per horizontal units
.TYPE	Method used for depth analysis: 1=analytic signal, 2=horizontal gradient, or 3=local wavenumber
.STYP	Desired source type for analytic signal or horizontal gradient analysis: 0=contact or 1=sheet
.SDIR	Desired strike direction of features: 1=north, 2=east, or 3=both
.AMP	Minimum amplitude of the derivative function
.IPEAK	Output closed peaks only: 0=No, 1=Yes
.OUTPOST	Output post file (and database)

APPLICATION NOTES

If an observation surface grid is used, it must have the same origin, number of rows and columns, and sample interval as the magnetic anomaly grid. The maximum number of columns in the input grids is 8,000.

Reference

Phillips, J.D., 2000, Locating magnetic contacts: a comparison of the horizontal gradient, analytic signal, and local wavenumber methods: Society of Exploration Geophysicists, Expanded Abstracts with Biographies, 2000 Technical Program, v.1, p.402-405

Written by Jeff Phillips (jeff@usgs.gov) 04/15/2003.

USGS_REDPOL

USGS_REDPOL GX

One-step computation of a reduced-to-the-pole magnetic field grid.

INTERACTIVE PARAMETERS

```
  Input total field magnetic anomaly grid file
  Output RTP magnetic anomaly grid file
  Geomagnetic inclination (degrees)
  Geomagnetic declination (degrees)
  Order of initializing polynomial for plugging input
    grid (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging
    input grid (e.g., 100)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
  USGS_REDPOL.INGRID           Input gravity grid
             .OUTGRID          Output pseudo-magnetic grid
             .INCL             Geomagnetic inclination (degrees)
             .DECL             Geomagnetic declination (degrees)
             .IORDER           Polynomial order for plugging holes
             .NITER            Iterations for plugging holes
             .PCT              Minimum percent expansion
```

APPLICATION NOTES

This standard reduction-to-the-pole filter will not work well at low magnetic latitudes (within 20 degrees of the magnetic equator). The maximum number of columns in the expanded input grid is 16,384. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 06/10/2003.

USGS_RENUMLNS

USGS_RENUMLNS GX

Renumber all selected lines. This is useful for changing line numbers prior to merging databases.

INTERACTIVE PARAMETERS

    The starting line number.
    The line number increment for numbering sequential lines.

BATCH PARAMETERS

USGS_RENUMLNS.STRTLN	Starting line number
USGS_RENUMLNS.INCRLN	Line number increment

APPLICATION NOTES

If any parameters are blank, the default parameter value is set to 1. The process will stop if the new name of a selected line already exists. All lines processed up to that point will be changed.

TOPIC WRITTEN BY JOE DUVAL, USGS (11/21/2000)

USGS_RTFIL

USGS_RTFIL GX

Applies regularized Fourier filters to a Fourier transform grid file produced by USGS_FTFWD.GX. The output filtered transform grid should be inverse Fourier transformed using USGS_FTINV.GX.

INTERACTIVE PARAMETERS

Input Fourier transform grid file
Output filtered Fourier tranform grid file
Lanczos filter flag (Yes = On, No = Off)
Hanning filter flag
Reduction TO the pole flag
Current inclination (degrees)
Current declination (degrees)
Terms in RTP series
Reduction FROM the pole flag
Desired inclination (degrees)
Desired declination (degrees)
Continuation flag
Continuation distance (positive up)
Vertical derivative or integral flag
Order of derivative or integral (positive for derivative)
Strike filtering flag
Central azimuth of strike filter (degrees)
Azimuthal half-width of strike filter (degrees)
Type of strike filter (enhance or suppress)
Multiplication flag
Multiplication factor
Regularization flag
Regularizing factor (0 for no regularization)

BATCH PARAMETERS

USGS_RTFIL.INFFT	Input Fourier transform grid
USGS_RTFIL.OUTFFT	Output filtered Fourier transform grid
USGS_RTFIL.ILANC	Lanczos filter flag (1 = On, 0 = Off)
USGS_RTFIL.IHANN	Hanning filter flag
USGS_RTFIL.IPOLE	Reduction TO the pole flag
USGS_RTFIL.AINCL	Current inclination (degrees)
USGS_RTFIL.ADECL	Current declination (degrees)
USGS_RTFIL.NPTS	Terms in RTP series
USGS_RTFIL.IFROM	Reduction FROM the pole flag
USGS_RTFIL.BINCL	Desired inclination (degrees)
USGS_RTFIL.BDECL	Desired declination (degrees)
USGS_RTFIL.ICONT	Continuation flag
USGS_RTFIL.HEIGHT	Continuation distance (positive up)
USGS_RTFIL.IVERT	Vertical derivative or integral flag
USGS_RTFIL.IORDER	Order of derivative or integral (positive for derivative)
USGS_RTFIL.ISTRK	Strike filtering flag
USGS_RTFIL.ASTRK	Strike central azimuth (degrees)
USGS_RTFIL.WSTRK	Strike asimuthal half-width (degrees)

```
USGS_RTFIL.IES            Strike filter type (Enhance=1 or Suppress=2)
USGS_RTFIL.IMULT          Multiplication flag
USGS_RTFIL.AMULT          Multiplication factor
USGS_RTFIL.IALFA          Regularization flag
USGS_RTFIL.ALPHA          Regularizing parameter

APPLICATION NOTES

  Lanczos filter - slight lowpass to reduce Gibbs effects.
  Hanning filter - mild lowpass to correct for the data window.
  Reduction-TO or -FROM the pole
                 - assumes that the input grid to the USGS_FTFWD GX
                   contains potential-field data measured on
                   a flat, horizontal surface.
                 - assumes induced magnetization.
  Reduction-TO-pole - the current magnetic inclination and declination
                   are required, as is the number of terms to keep
                   in the series expansion.  At low-latitudes
                   (<30 degrees), use few terms (15) and regularization.
                   At high latitudes, use 1000 terms and no regularization.
  Reduction-FROM-pole - to other latitudes.  The desired magnetic
                   inclination and declination are required.
  Continuation   - assumes that the input grid to the USGS_FTFWD GX
                   contains potential-field data measured on
                   a flat, horizontal surface.
  Vertical derivative or integral
                 - integer orders only.
                 - assumes that the input grid to the USGS_FTFWD GX
                   contains potential-field data measured on
                   a flat, horizontal surface.
  Strike filter  - The direction and half-angle width are required.
                   Strike suppression is more stable than strike
                   enhancement.  Regularization is supported.
  Regularization - If used, the default parameter alpha is 0.001.  A value
                   of zero for alpha is equivalent to no regularization.

  Useful combinations of operations include:

  Pseudogravity transformation of magnetic anomaly data
     = Reduction-to-Pole + 1st vertical integral (+ optional
       multiplication for scaling).

  Pseudomagnetic transformation of gravity anomaly data
     = Reduction-from-Pole + 1st vertical derivative (+ optional
       multiplication for scaling).

Written by Jeff Phillips (jeff@usgs.gov) 01/13/2005.
```

USGS_SETEULER

USGS_SETEULER GX

Set up derivative grids for Euler depth analysis using USGS_EULERAVE.GX.

INTERACTIVE PARAMETERS

```
  Input potential-field grid file
  Order of initializing polynomial for plugging input and horizontal
    derivative grids (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging input and
    horizontal derivative grids (e.g., 100)
  Gradient operator size (odd and < 22, normally 3)
  Gradient operator order (operator size - 1 for no filtering,
    smaller for low-pass filtering, normally 2)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
  Output x(east)-derivative grid file
  Output y(north)-derivative grid file
  Output z(vertical)-derivative grid file
  Output Hilbert transform x-component grid file
  Output x-derivative of x-component grid file
  Output y-derivative of x-component grid file
  Output z-derivative of x-component grid file
  Output Hilbert transform y-component grid file
  Output x-derivative of y-component grid file
  Output y-derivative of y-component grid file
  Output z-derivative of y-component grid file
```

BATCH PARAMETERS

```
  USGS_SETEULER.INGRID          Input potential-field grid
               .IORDER          Polynomial order for plugging holes
               .NITER           Iterations for plugging holes
               .WINDOW          Gradient operatior size
               .POLY            Gradient operator order
               .PCT             Minimum percent expansion
               .OUTGRIDX        Output x-derivative grid file
               .OUTGRIDY        Output y-derivative grid file
               .OUTGRIDZ        Output z-derivative grid file
               .OUTGRIDHX       Output Hilbert transform x-component grid file
               .OUTGRIDHXX      Output x-derivative of x-component grid file
               .OUTGRIDHXY      Output y-derivative of x-component grid file
               .OUTGRIDHXZ      Output z-derivative of x-component grid file
               .OUTGRIDHY       Output Hilbert transform y-component grid file
               .OUTGRIDHYX      Output x-derivative of y-component grid file
               .OUTGRIDHYY      Output y-derivative of y-component grid file
               .OUTGRIDHYZ      Output z-derivative of y-component grid file
```

APPLICATION NOTES

The maximum number of columns in the input grid is 8,000. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 04/07/2003.

USGS_SFDEPTH

USGS_SFDEPTH GX

Estimates potential field source locations from a special function grid.

Model-specific special function grids require that a specific source type be assumed and the field be transformed before the special function is calculated. Model-specific special functions include the Horizontal Gradient Magnitude (HGM) and the Absolute Value (ABS) of the transformed field. The possible transformations include Reduction-to-Pole (RTP), Reduction-to-Pole plus Vertical Integral (RTP+VI), Vertical Derivative (VD), or None. The following model-specific special functions are Supported (SI is structural index):

Assumed_Source_Type	SI	Transform	Model-Specific_Special_Function
Vertical_Magnetic_Contact	0	RTP	HGM of RTP magnetic field
Vertical Magnetic Sheet	1	RTP	ABS of RTP magnetic field
Horizontal Magnetic Sheet	1	RTP+VI	HGM of VI of RTP magnetic field
Horizontal Magnetic Line	2	RTP+VI	ABS of VI of RTP magnetic field
Vertical Magnetic Line	2	RTP+VI	ABS of VI of RTP magnetic field
Magnetic Dipole	3	RTP+VI	ABS of VI of RTP magnetic field
Vertical Density Contact	-1	VD	HGM of VD of gravity field
Vertical Density Sheet	0	VD	ABS of VD of gravity field
Horizontal Density Sheet	0	None	HGM of gravity field
Horizontal Density Line	1	None	ABS of gravity field
Vertical Density Line	1	None	ABS of gravity field
Point Mass	2	None	ABS of gravity field

Model-independent special functions include the Total Gradient (TG) and the Local Wavenumber (LW). These are calculated directly from the potential field or from a vertical integral (VI) of the potential field. The total gradient requires that a structural index (SI) be assumed for the source.

INTERACTIVE PARAMETERS

- Input special function grid file
- Output post file (and database)
- Minimum special function amplitude to use in the analysis (normally zero)
- Type of special function (ABS, HGM, TG, LW)
- Type of feature to locate (Ridge, High, Both)
- Assumed source type for ABS analysis
- Assumed source type for HGM analysis
- Assumed structural index for TG analysis
- Order of vertical integral used for TG
- Minimum structural index for LW analysis
- Maximum structural index for LW analysis
- Flag to adjust or discard LW solutions outside SI range
- Order of vertical integral used for LW

BATCH PARAMETERS

```
USGS_SFDEPTH.INGRID          Input grid
USGS_SFDEPTH.OUTPST          Output post file
USGS_SFDEPTH.AMPMIN          Minimum amplitude
USGS_SFDEPTH.TYP             Type of input grid (a,h,t,l)
USGS_SFDEPTH.FTYP            Feature type (r,h,b)
USGS_SFDEPTH.ATYP            Assumed source type for ABS (vms,hml,vds,
                               hdl,vml,vdl,mdp,ptm)
USGS_SFDEPTH.HTYP            Assumed source type for HGM (vmc,hms,vdc,
                               hds)
USGS_SFDEPTH.TSI             Assumed SI for TG
USGS_SFDEPTH.TVI             Order of VI for TG
USGS_SFDEPTH.SIMIN           Minimum SI for LW
USGS_SFDEPTH.SIMAX           Maximum SI for LW
USGS_SFDEPTH.ICOR            Flag for LW solutions outside range
                               (1=adjust, 0=discard)
USGS_SFDEPTH.LVI             Order of VI for LW
```

APPLICATION NOTES

The output post file and database have the following channels:

```
 id           type of feature (ridge, high)
 x            x(east)-coordinate of solution
 y            y(north)-coordinate of solution
 z1    depth  z-coordinate of solution (negative)
 z2    g(x,y) grid value at the solution as estimated from the
                quadratic surface
 z3    strike degrees clockwise from north
 z4    e1     first eigenvalue of the curvature matrix
 z5    e2     second eigenvalue of the curvature matrix
 z5    si     assumed or calculated structural index
```

The maximum number of columns on the input grid is 8,000.

Reference

Phillips, J.D., Hansen, R.O., and Blakely, R.J., 2007, The use of curvature in potential-field interpretation: Exploration Geophysics, v.38, p.111-119.

Written by Jeff Phillips (jeff@usgs.gov) 9/19/2006.

USGS_SURFIT

USGS_SURFIT GX

Fits a polynomial surface to a grid and generates the residual grid.

INTERACTIVE PARAMETERS

```
  Input grid file
  Output residual grid file
  Output surface grid file
  Polynomial order (0 to 3)
```

BATCH PARAMETERS

```
  USGS_SURFIT.INGRID    Input grid file
             .OUTGRID   Output residual grid file
             .OUTSURF   Output surface grid file
             .ORDER     Polynomial order (0 to 3)
```

APPLICATION NOTES

Removes a polynomial surface of order 0 to 3 from an input grid. Creates both the residual grid and the polynomial surface grid. No data (DUMMY) areas are maintained in the output grids. The maximum number of columns is 8,000. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 2/21/2003.

USGS_T2VECT

USGS_T2VECT GX

One-step computation of magnetic field components from a total field magnetic anomaly grid.

INTERACTIVE PARAMETERS

```
  Input total field grid file
  Output X(north)-component grid file
  Output Y(east)-component grid file
  Output Z(down)-component grid file
  Geomagnetic inclination (degrees down from horizontal)
  Geomagnetic declination (degrees clockwise from north)
  Order of initializing polynomial for plugging input grid
    (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging input grid
    (e.g., 100)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
  USGS_T2VECT.INGRID          Input total field grid
             .OUTGRIDX        Output X-component grid
             .OUTGRIDY        Output Y-component grid
             .OUTGRIDZ        Output Z-component grid
             .INCL            Geomagnetic inclination (degrees)
             .DECL            Geomagnetic declination (degrees)
             .IORDER          Polynomial order for plugging holes
             .NITER           Iterations for plugging holes
             .PCT             Minimum percent expansion
```

APPLICATION NOTES

This will not work well at low magnetic latitudes (within 20 degrees of the magnetic equator). The maximum number of columns in the expanded input grid is 16,384. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 06/05/2003.

USGS_TGRAD

USGS_TGRAD GX

One-step computation of the total gradient grid, and related derivative grids.

INTERACTIVE PARAMETERS

```
 Input potential-field grid file
 Output total gradient grid file
 Output horizontal gradient grid file
 Output x(east)-derivative grid file
 Output y(north)-derivative grid file
 Output z(vertical)-derivative grid file
 Order of initializing polynomial for plugging horizontal
   derivative grids (0 to 3, or -1 for local median replacement)
 Number of minimum curvature iterations for plugging
   horizontal derivative grids (e.g., 100)
 Gradient operator size (odd and < 22, normally 3 or 0 for local quadratic)
 Gradient operator order (operator size - 1 for no filtering,
   smaller for low-pass filtering, normally 2)
 Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
 USGS_TGRAD.INGRID          Input potential-field grid
           .OUTTGRID        Output total gradient grid
           .OUTHGRID        Output horizontal gradient grid
           .OUTXGRID        Output x(east)-derivative grid
           .OUTYGRID        Output y(north)-derivative grid
           .OUTZGRID        Output z(down)-derivative grid
           .IORDER          Polynomial order for plugging holes
           .NITER           Iterations for plugging holes
           .WINDOW          Gradient operatior size
           .POLY            Gradient operator order
           .PCT             Minimum percent expansion
```

APPLICATION NOTES

If gradient operator size is 3 or greater, horizontal gradients are computed using differences (USGS_GRADCOMP.GX). If gradient operator order is less than gradient operator size minus one, low-pass filtering will result (Thurston and Brown, 1994).

If gradient operator size is 0, horizontal gradients are computed using local quadratic surfaces (USGS_GRADXYH.GX). Gradient operator order is ignored.

Vertical gradients are computed from the horizontal gradients using Hilbert transform components (Nabighian, 1984).

Holes in the input grid, if any, will be plugged before processing. All output grids will be completely plugged, except for the z-derivative and the total gradient, which are masked to the input grid.

The maximum number of columns in the input grid is 8,000. Grid projection information is ignored.

References:

Nabighian, M.N., 1984, Toward a three-dimensional automatic interpretation of potential field data via generalized Hilbert transforms: Fundamental relations: Geophysics, v.49, no.6, p.780-786.

Thurston, J.B., and Brown, R.J., 1994, Automated source-edge location with a new variable pass-band horizontal-gradient operator: Geophysics, v.59, no.4, p.546-554.

Written by Jeff Phillips (jeff@usgs.gov) 07/17/2007.

USGS_TRANSPOS

USGS_TRANSPOS GX

Transpose the rows and columns of a grid.

INTERACTIVE PARAMETERS

```
  Input grid file
  Output grid file
```

BATCH PARAMETERS

```
USGS_TRANSPOS.INGRID           input grid
             .OUTGRID          output grid
```

APPLICATION NOTES

This is useful for row- or column-based processing such as filtering, extension, or depth analysis. The maximum number of columns in the input grid is 10,000.

Written by Jeff Phillips (jeff@usgs.gov) 1/11/00.

USGS_TRIMGRD

USGS_TRIMGRD GX

Removes outer grid rows and columns that contain only dummy values.

INTERACTIVE PARAMETERS

```
  Input grid file
  Output trimmed grid file
```

BATCH PARAMETERS

```
USGS_TRIMGRD.INGRID        Input grid file
USGS_TRIMGRD.OUTGRID       Output trimmed grid file
```

APPLICATION NOTES

Borders of dummy values typically result from window-based filtering. The output grid will be the same size or smaller than the input grid. The maximum number of columns in the input grid is 8,000. Grid projection information is ignored.

Original Fortran code by V.J.S. (Tien) Grauch.
GX written by Jeff Phillips (jeff@usgs.gov) 12/26/2006.

USGS_UPCONT

USGS_UPCONT GX

One-step computation of an upward (or downward) continued field from a potential-field grid.

INTERACTIVE PARAMETERS

```
 Input potential-field anomaly grid file
 Output upward (or downward) continued grid file
 Continuation distance (positive up)
 Order of initializing polynomial for plugging input
   grid (0 to 3, or -1 for local median replacement)
 Number of minimum curvature iterations for plugging
   input grid (e.g., 100)
 Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
 USGS_UPCONT.INGRID          Input gravity grid
            .OUTGRID         Output pseudo-magnetic grid
            .DISTANCE        Continuation distance (positive up)
            .IORDER          Polynomial order for plugging holes
            .NITER           Iterations for plugging holes
            .PCT             Minimum percent expansion
```

APPLICATION NOTES

Assumes the input data are on a flat, horizontal surface. Upward continuation is stable, but downward continuation may require additional low-pass filtering. The maximum number of columns in the expanded input grid is 16,384. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 06/10/2003.

USGS_VDFIL

USGS_VDFIL GX

Computes the vertical derivative in the Fourier domain from input Fourier transform grid files of the two horizontal derivatives.

Use USGS_FTFWD.GX to generate the input Fourier transform grid files.
Use USGS_FTINV.GX to inverse Fourier transform the output grid file.

INTERACTIVE PARAMETERS

Input x(east)-derivative Fourier transform grid file
Input y(north)-derivative Fourier transform grid file
Output z(vertical)-derivative Fourier transform grid file

BATCH PARAMETERS

```
USGS_VDFIL.INFFTX       input x-derivative Fourier transform grid
USGS_VDFIL.INFFTY       input y-derivative Fourier transform grid
USGS_VDFIL.OUTFFTZ      output z-derivative Fourier transform grid
```

APPLICATION NOTES

The vertical derivative is computed from the horizontal derivatives using Hilbert transform components (Nabighian, 1984).

Reference:

Nabighian, M.N., 1984, Toward a three-dimensional automatic interpretation of potential field data via generalized Hilbert transforms: Fundamental relations: Geophysics, v.49, no.6, p.780-786.

Written by Jeff Phillips (jeff@usgs.gov) 12/27/2002.

USGS_VERTINT

USGS_VERTINT GX

One-step computation of a vertical integral or derivative from a potential-field grid.

INTERACTIVE PARAMETERS

```
  Input potential-field anomaly grid file
  Output vertical integral or derivative grid file
  Order of integral or derivative (positive for derivative)
  Order of initializing polynomial for plugging input
    grid (0 to 3, or -1 for local median replacement)
  Number of minimum curvature iterations for plugging
    input grid (e.g., 100)
  Minimum percent expansion prior to Fourier transform (e.g., 25)
```

BATCH PARAMETERS

```
  USGS_VERTINT.INGRID         Input potential-field grid file
             .OUTGRID         Output vertical integral or derivative
                                grid file
             .ORDER           Order of derivative or integral
                                (positive for derivative)
             .IORDER          Polynomial order for plugging holes
             .NITER           Iterations for plugging holes
             .PCT             Minimum percent expansion
```

APPLICATION NOTES

Assumes the data are on a flat horizontal surface. Non-integer orders are supported. The maximum column dimension of the expanded input grid is 16,384. Grid projection information is ignored.

Written by Jeff Phillips (jeff@usgs.gov) 06/10/2003.

Appendix 2: Converting FORTRAN code to a Geosoft GX using the GNU g77 and gcc compilers

To convert Fortran code to a dynamic link library (dll) that can be called from a GX, Geosoft recommends using their version of the Fortran-to-C conversion program, f2c.exe, and the Microsoft Visual C++ compiler. This approach is described in the Geosoft GX Developer's Manual, available at *http://www.geosoft.com*, and was outlined in the version 1.0 GX release (Phillips and others, 2003).

An alternative approach for compiling dynamic link libraries from Fortran code for use with compiled GX's has been developed by Jim Roy and Tom Popowski of Northwest Geophysical Associates. This approach does not require the use of either f2c or Microsoft Visual C++. Instead, it uses the free, open-source compilers g77 and gcc. The object code placed in the dll is compiled directly from the Fortran source code along with the ancilliary C source code.

To use this alternate approach, the GX developer must install the free compilers and utilities of the open-source software package MinGW along with the command-line window system MSYS (described at *http://www.mingw.org/* and available at *http://sourceforge.net/*). Also required are the free Geosoft GX Developer Toolkit (available at *http://www.geosoft.com/downloads/*), and either the free Geosoft Viewer (also available at *http://www.geosoft.com/downloads/*), or a licensed version of Geosoft Oasis montaj. In summary, the GX developer will need:

1. Either Geosoft Oasis montaj (licensed version) or the free Geosoft Viewer.
2. The free GX Developer software from Geosoft.
3. The free MinGW and MSYS software packages from sourceforge.net.
4. A text editor such as PFE32.EXE or Notepad.

INSTALLATION AND SETUP

The Geosoft web site (*http://www.geosoft.com*) contains instructions for downloading and installing the current Geosoft Viewer (required if a licensed Oasis version is not installed) and the current GX Development software.

The MinGW and MSYS home page (*http://www.mingw.org/*) contains much useful information, but the current software versions are available only from sourceforge (*http://sourceforge.net/*). The installation files for the current versions are MinGW-5.1.3.exe and MSYS-1.0.10.exe. MinGW should be installed first, making sure **g77** and **g++** are checked and **make** is not checked. The installation will create a directory, C:\MinGW, containing a minimalist GNU system. MSYS should be installed next, resulting in a directory, C:\msys\1.0\, containing the user file system.

A text editor will also be required. Two options are Windows Notepad or PFE, currently available from *http://www.lancs.ac.uk/people/steveb/cpaap/pfe/default.htm*. Either can be accessed from a shortcut on the Windows desktop.

GETTING STARTED

GX development can be done under the /home/user_name directory of MSYS. You should be in this directory when you start MSYS by clicking on the blue "M" icon on your desktop. Create a new subdirectory called **gxdev** and move into it with the commands:

```
mkdir gxdev
cd gxdev
```

This new directory will eventually contain:

1. Some library files, such as **libGEODIST6.4.a** and **libGEOGX6.4.a**.
2. A file called **Makefile** that we will use to create the libraries.

3. The C source-code file **wfuncs.c**, containing the common source code for the wrapper functions called by the Fortran code to access the Geosoft library functions.
4. The C header file **wrappers.h**, containing the definitions for the wrapper functions.
5. Subdirectories for each GX to be developed.

STEP 0: CREATING THE LIBRARIES AND FORTRAN WRAPPER FUNCTIONS

The library files **geogx.dll** and **geodist.dll,** as supplied by Geosoft, cannot be used within the MinGW system. They must be converted to MinGW-compatible libraries. For GX Developer, version 6.4, this is a matter of running **make** within the MSYS window on the makefile of <Table A1>, which has the name **Makefile**. This makefile will need to be modified for later versions of GX Developer, hopefully only by changing the line assigning the OMVERS variable. Note that some long lines in <Table A1> have been wrapped.

I have chosen to use a single set of wrapper functions for all of my GX code. These wrapper functions are contained in the files **wfuncs.c** and **wrappers.h**, which reside in the **gxdev** directory. As new wrapper functions are needed, they can be added to these files. If old wrapper functions need to be modified, they should be thoroughly tested on all previously compiled GX code. If Geosoft makes changes to their basic library functions, as they did with the release of version 6.3, some wrapper functions may need to be rewritten.

CONVERTING AN EXAMPLE FORTRAN PROGRAM TO A GX

We will be converting an example Fortran program (**curv4.for**) that reads a USGS binary grid file, operates on the grid file, and outputs a USGS binary post file. The resulting GX (**usgs_curv4.gx**) will read any grid file format supported by Geosoft, operate on the grid file, and output a USGS binary post file. It then calls another GX, either **usgs_impost.gx** for the free viewer or **usgs_openpost.gx** for the licensed version, to import the post file into a Geosoft database. The compiled GX files **usgs_impost.gx** and **usgs_openpost.gx** are included in the **/gx** directory on the ftp site. Copy them to the **\Program Files\Geosoft\ Oasis montaj\ gx** directory or to the **\Program Files\Geosoft\ Oasis montaj Viewer\ gx** directory on your computer. The compiled dynamic-link library files **usgs_impost.dll** and **usgs_openpost.dll** are included in the **/binx** directory on the ftp site. Copy them to the **\Program Files\Geosoft\ Oasis montaj\ bin** directory or to the **\Program Files\Geosoft\ Oasis montaj Viewer\ bin** directory on your computer. The source code files for **usgs_curv4.gx** are included in the **/src/usgs_curv4** subdirectory on the ftp site.

Start by creating a working directory under your gxdev directory called usgs_curv4 with the command:

```
mkdir usgs_curv4
```

This directory will contain the many files needed to create the GX. All GX's need:

1. A GX resource file that defines the user interface. This file has the suffix **.grc** and is compiled into a **.gr** file and a **.grh** file using the Geosoft **grc** compiler.
2. An **rtf** help file, created using WordPad, that is compiled along with the resource file.
3. A GX source code file with the suffix **.gxc**. This file is compiled, along with the output of the **grc** compiler, using the Geosoft **gxc** compiler to create the **.gx** file.

In addition, GX's that use Fortran code need:

1. A Fortran source code file that has been modified to (a) remove all user interaction, (b) replace file I/O with calls to Geosoft wrapper functions, and (c) replace the main routine with a subroutine. This file has the suffix **.f**.
2. The C source code file for the wrapper functions. This file, which we call **wfuncs.c**, is kept in the **gxdev** directory.
3. The C header file for the wrapper functions. This file, which we call **wrappers.h**, is also kept in the **gxdev** directory.
4. A GX header file with suffix **.gxh** containing the prototype for the Fortran function called from the GX.
5. Another C source code file called **gxx_<gx_name>.c** that contains the wrapper function called by the GX to access the Fortran code in the dynamic link library.
6. A file called **Makefile** for compiling the dynamic link library.

STEP 1: EDITING THE FORTRAN SOURCE CODE

The first file needed is the original Fortran source file **curv4.for**. Copy it from the **\src\usgs_curv4** subdirectory of the ftp site to your **usgs_curv4** subdirectory. We will be editing this file to remove all user interaction, to replace all file I/O with calls to Fortran wrapper functions, and to convert it into a subroutine. The edited file will be called **usgs_curv4.f**, and it is also available on the ftp site. Here we examine the edited file a section at a time. The changes to the file are shown in uppercase bold text.

In this first section of code (<Table A2>), we have turned the program into a subroutine, using parameters in the call list to replace filenames and other parameters previously entered interactively by the user. The input character strings must be declared **character*(*)**. Instead of testing for **dvals**, the USGS dummy value, we will be testing for the Geosoft **DUMMY**. The file unit numbers **INF** and **IOF** are initialized to zero. I have not found a successful way to pass an array to the subroutine, so the **ITYPE** array elements are passed as individual parameters.

In this second section of code (<Table A3>), the input grid file is opened using a wrapper function. The grid header is read using another wrapper function. If the grid contains too many columns, error message number 5007 in file **usgs.err** is displayed with the actual and maximum number of columns. The file **usgs.err** is contained on the ftp site in the **/ger** directory. It should be copied to either the **\Program Files\Geosoft\ Oasis montaj\ ger** subdirectory or the **\Program Files\Geosoft\ Oasis montaj Viewer\ ger** subdirectory.

In this section (<Table A4>), the output post file is opened using a wrapper function. The first two rows of the input grid are read into the data array using another wrapper function.

Here (<Table A5>), a progress indicator is created and initialized using wrapper functions. The indicator is updated during each iteration of loop 2000 using another wrapper function. The next row of the input grid is read using a wrapper function.

Here (<Table A6>), the test for **dvals** is replaced by a test for the Geosoft **DUMMY** value. The output post record is written by a wrapper function. Not much else is changed in the data processing code.

In this final section (<Table A7>), another post record is written using a wrapper function. The progress indicator is updated to 100% at the end of all processing. If the input and output files exist, they are closed using wrapper functions. We are done with the Fortran code.

STEP 2: CREATING THE USER INTERFACE

The next step is to design the user interface for the GX. This is done in a resource file called **usgs_curv4.grc**, displayed in <Table A8> and available on the ftp site. The interface uses two filename entry boxes for the input grid file and the output post file, and five list entries for the options. There are three buttons – **OK**, which returns 0, **Cancel**, which returns -1, and **Help**, which calls the help resource text file **usgs_curv4.rtf**.

Another common interface element not seen in this example is the text entry box. Here is an example:

```
EDIT,,,10,"Minimum amplitude",,REAL,-1.e30
```

Before we forget, let's create the help file, **usgs_curv4.rtf** (<Table A9>). This is just a text file that has been converted to RTF format using Wordpad. You can copy it from the ftp site.

STEP 3: CREATING THE GX SOURCE CODE

Next we will create the GX source code file, **usgs_curv4.gxc** (<Table A10>). Like all the source code, this can be found on the ftp site.

The example text entry box, which was not used in the resource file, has been carried through in the gxc code using lines that have been commented out. The GX should create and open a new database, so there is no need for a closing message. For more information on **.grc** and **.gxc** file formats, see the GX Developer Users Guide and Reference Manual available from the Geosoft website. Details on the use of Geosoft library functions, such as DisplayMessage_SYS, can be found in C:\Program Files\Geosoft\GX Developer\gx\include*.gxh.

The GX source code file requires a GX header file called **usgs_curv4.gxh** (<Table A11>).

STEP 4: COMPILING THE GX

At this point, we can compile the GX resource and help files using:

```
grc usgs_curv4
```

Then we can compile the GX using:

```
gxc usgs_curv4
```

This assumes that the PATH environment variable contains the location of the **grc** and **gxc** compilers, C:\Program Files\Geosoft\GX Developer\gx\bin. The output of the **gxc** compiler is the file **usgs_curv4.gx**. This can be copied to the Oasis montaj gx directory using Windows drag-and-drop or by using the MSYS command

```
cp usgs_curv4.gx /c/Program\ Files/Geosoft/Oasis\ montaj\ Viewer/gx
```

for the viewer, or

```
cp usgs_curv4.gx /c/Program\ Files/Geosoft/Oasis\ montaj/gx
```

for the licensed version.

STEP 5: CREATING THE DYNAMIC LINK LIBRARY

To create the dynamic link library (DLL), you will need the libraries, **libGEOGX6.4.a** and **libGEODIST6.4.a**, which are located in the **gxdev** directory and which were created in Step 0 above. You will need the edited Fortran source code file, **usgs_curv4.f**, located in the **gxdev/usgs_curv4** subdirectory and created in Step 1 above, and the wrapper function source code file **wfuncs.c**, located in the **gxdev** directory. You will need to edit the wrapper function header file, **wrappers.h** in the **gxdev** directory to include the definition for the new **curv4** wrapper function just before the final **#endif**

(<Table A12>). You will also need one more source code file called **gxx_curv4.c** in the **gxdev/usgs_curv4** subdirectory (<Table A13>).

The final file needed is a makefile, called **Makefile**, which resides in the **gxdev/usgs_curv4** subdirectory (<Table A14>). This makefile is set up to compile the DLL and copy it to the bin directory of the Geosoft viewer. You can change the final destination to the **bin** directory of the licensed version by using the line that is commented out. Run the makefile using the command **make** in the MSYS window while in the **gxdev/usgs_curv4** subdirectory.

STEP 6: TESTING AND DEBUGGING

Fire up Oasis montaj or the Oasis montaj Viewer and test the GX. You will need to authorize the GX the first time you run it. At this point, several things can happen:

1. The GX can run and produce the desired output. Congratulations, you have created a successful GX!
2. The GX can exit without producing output or messages.
3. The GX can produce an error message.
4. The GX can crash Oasis.

Debugging a GX is difficult. There are often many source code files involved, and an error in any one of them, even as insignificant as a missing semicolon, can lead to failure. Problems involving syntax errors can be avoided by referring to the many successful examples on the ftp site. Problems involving logic errors in the Fortran code can be tracked down through a combination of:

1. Placing **go to 9999** statements in various places in the Fortran code, until you can isolate the loop or subroutine generating the problem.

2. Using error wrapper functions to print out the values of suspect variables. For example, error number 6001 in the usgs.err file will print the values of up to five variables, using code such as

```
call RegisterErr_WF(6001,'usgs')
call SetErrParmR_WF(1,radius)
call SetErrParmI_WF(2,indx)
```

Table A1. Listing of Makefile for creating the Geosoft libraries.

```
################################################################
#
#   Prepare Geosoft libraries for use with MinGW compilers
#
################################################################
#
#   The basic idea here is to convert Geosoft's geogx.dll and
#   geodist.dll ( MSVC import libraries?? ) to libGEOGX.a and
#   libGEODIST.a ( MinGW/gcc style import libraries ).  First
#   use nm to extract the symbol names from geogx.lib and
#   geodist.lib to GEOGX.def and GEODIST.def. Second build the
#   .a files using dlltool.
#
#   To use, name this file Makefile and move it to a directory
#   where you can run the MSYS command 'make' on it.
#
#   Original code from Jim Roy (jim@nga.com) and Tom Popowski
#     (tom@nga.com), Northwest Geophysical Associates
#   Assembled into a single makefile by Jeff Phillips
#       (jeff@usgs.gov), U.S. Geological Survey
#
################################################################

OMVERS = 6.4

GLIBDIR = /c/Program\ Files/Geosoft/GX\ Developer/apps/lib
GDLLDIR = /c/Program\ Files/Geosoft/GX\ Developer/apps/dll

GEOGX_IMP = $(GLIBDIR)/geogx.lib
#GEOGX_DLL = $(GDLLDIR)/geogx.dll
GEOGX_DLL = geogx.dll
GEODIST_IMP = $(GLIBDIR)/geodist.lib
#GEODIST_DLL = $(GDLLDIR)/geodist.dll
GEODIST_DLL = geodist.dll

GEOGX_LIB   = GEOGX$(OMVERS)
GEOGX_DEF   = $(GEOGX_LIB).def
GEODIST_LIB = GEODIST$(OMVERS)
GEODIST_DEF = $(GEODIST_LIB).def

all dlls LINKLIBS:  lib$(GEOGX_LIB).a lib$(GEODIST_LIB).a

lib$(GEOGX_LIB).a: $(GEOGX_DEF) $(GEOGX_IMP)
      @echo "building lib$(GEOGX_LIB).a"
      dlltool --dllname $(GEOGX_DLL) --def $(GEOGX_DEF) --output-lib
lib$(GEOGX_LIB).a

lib$(GEODIST_LIB).a: $(GEODIST_DEF) $(GEODIST_IMP)

ifeq ($(OMVERS),5.1.8)
            echo "not building lib$(GEODIST_LIB).a"
else
            @echo "building lib$(GEODIST_LIB).a"
```

```
            dlltool --dllname $(GEODIST_DLL) --def $(GEODIST_DEF) --output-lib
lib$(GEODIST_LIB).a
endif

$(GEOGX_DEF): $(GEOGX_IMP)
      echo "building $(GEOGX_DEF)"
      echo EXPORTS > $(GEOGX_DEF)
#     nm --demangle --defined-only $(GEOGX_IMP) | grep ' T ' | grep -v '.text' |
sed 's/.* T //' >> $(GEOGX_DEF)
      nm --demangle --defined-only $(GEOGX_IMP) | grep ' T \w' | sed 's/.* T //' |
egrep -v '^[A-Z0-9]{7}_\w{23}' >> $(GEOGX_DEF)
#     You may need to manually edit the .def file at this point

$(GEODIST_DEF): $(GEODIST_IMP)
ifeq ($(OMVERS),5.1.8)
      echo "not building $(GEODIST_DEF)"
else
      echo "building $(GEODIST_DEF)"
      echo EXPORTS > $(GEODIST_DEF)
#     nm --demangle --defined-only $(GEODIST_IMP) | grep ' T ' | grep -v '.text' |
sed 's/.* T //' >> $(GEODIST_DEF)
      nm --demangle --defined-only $(GEODIST_IMP) | grep ' T \w' | sed 's/.* T //'
| egrep -v '^\?' >> $(GEODIST_DEF)
#     You may need to manually edit the .def file at this point
endif

clean:
      rm -f $(GEOGX_DEF)
      rm -f lib$(GEOGX_LIB).a
      rm -f $(GEODIST_DEF)
      rm -f lib$(GEODIST_LIB).a
```

Table A2. Part 1 of the edited Fortran source code file, usgs_curv4.f.

```
      SUBROUTINE CURV4(IFILE,OFILE,ITYPE1,ITYPE2,ITYPE3,ITYPE4,ITYPE5,
     1                 IERR)
C UPPERCASE TEXT INDICATES LINES ADDED FOR GX CONVERSION
C UPPERCASE C IN COLUMN 1 INDICATES LINES COMMENTED OUT
C LOWERCASE C IN COLUMN 1 INDICATES PRE-EXISTING COMMENT
      parameter(MAXCOL=8000)
C      character ifile*80,ofile*80,id*56,sta*8,prompt*80
      CHARACTER*(*) IFILE,OFILE
      CHARACTER STA*8
      dimension f(MAXCOL,3),post(8),b(9),d(6),itype(5)
C      data ddval/1.e30/
      DATA DUMMY/-1.E32/
      DATA INF/0/,IOF/0/
      DATA ITYPE/5*0/
      ITYPE(1)=ITYPE1
      ITYPE(2)=ITYPE2
      ITYPE(3)=ITYPE3
      ITYPE(4)=ITYPE4
      ITYPE(5)=ITYPE5
```

Table A3. Part 2 of the edited Fortran source code file.

```
C       call pfinit('curv4')
C       call user('curv4')
C       call askin
c
C       ifile=' '
C       prompt='Data grid'
C       call askc(prompt,ifile,ierr)
C       if(ierr.lt.0) stop
C       call gopen(10,ifile,'old','read',ierr)
C       if(ierr.ne.0) stop 'error opening file'
C       call gheader('r',10,id,nc,nr,xo,dx,yo,dy,ierr)
C       if(ierr.ne.0) stop 'error reading header'
C       if(nc.gt.MAXCOL) stop 'too many columns'
      CALL OPENGRID_WF(IFILE,INF,IERR)
      IF(IERR.NE.0) GO TO 9999
      CALL GETGRIDINFO_WF(INF,NC,NR,XO,YO,DX,DY,ROT,IERR)
      IF(IERR.NE.0) GO TO 9999
      IF(NC.GT.MAXCOL) THEN
        CALL REGISTERERR_WF(5007,'USGS')
        CALL SETERRPARMI_WF(1,NC)
        CALL SETERRPARMI_WF(2,MAXCOL)
        IERR=1
        GOTO 9999
      ENDIF
      xmax=xo+(nc-1)*dx
      ymax=yo+(nr-1)*dy
```

Table A4. Part 3 of the edited Fortran source code file.

```
      type='r'
c       print*,'Get highs, lows, saddles, or all_extrema; ridges, troughs, or all'
c       prompt='  (h,l,s,e,r,t,a)?'
c       call askc(prompt,type,ierr)
c       call gccvc(type,2)
c       ampin=-1.e38
c       prompt='Minimum amplitude?'
c       call askf4(prompt,ampin,err)
c       ampax=1.e38
c       prompt='Maximum amplitude?'
c       call askf4(prompt,ampax,err)

C       prompt='find ridges?'
C       ians=0
C       call aski4l(prompt,ians,ierr)
C       itype(1)=ians
C       prompt='find troughs?'
C       ians=0
C       call aski4l(prompt,ians,ierr)
C       itype(2)=ians
C       prompt='find highs?'
C       ians=0
C       call aski4l(prompt,ians,ierr)
C       itype(3)=ians
C       prompt='find lows?'
C       ians=0
C       call aski4l(prompt,ians,ierr)
C       itype(4)=ians
C       prompt='find saddles?'
C       ians=0
C       call aski4l(prompt,ians,ierr)
C       itype(5)=ians

C       call xopen1(14,'curv4.pst','unknown','write',8,ierr)
      CALL NEWPOSTFILE_WF(OFILE,IOF,IERR)
      IF(IERR.NE.0) GO TO 9999
C       call grow('r',10,1,f(1,1),nc,ierr)
C       call grow('r',10,2,f(1,2),nc,ierr)
      CALL GETROW_WF(INF,1,NC,F(1,1),IERR)
      IF(IERR.NE.0) GO TO 9999
      CALL GETROW_WF(INF,2,NC,F(1,2),IERR)
      IF(IERR.NE.0) GO TO 9999
```

Table A5. Part 4 of the edited Fortran source code file.

```
C
C ADD A PROGRESS INDICATOR
C
      CALL PROGNAME_WF('PROCESSING GRID',1)
      CALL PROGUPDATE_WF(0)
       nsol=0
c main loop through rows
       do 2000 j=2,nr-1
         CALL PROGUPDATEL_WF(J-1,NR)
C         call grow('r',10,j+1,f(1,3),nc,ierr)
         CALL GETROW_WF(INF,J+1,NC,F(1,3),IERR)
         IF(IERR.NE.0) GO TO 9999
         yc=yo+(j-1)*dy
```

Table A6. Part 5 of the edited Fortran source code file.

```
c main loop through columns
         do 1000 i=2,nc-1
           xc=xo+(i-1)*dx
           b(1)=f(i-1,1)
           b(2)=f(i,1)
           b(3)=f(i+1,1)
           b(4)=f(i-1,2)
           b(5)=f(i,2)
           b(6)=f(i+1,2)
           b(7)=f(i-1,3)
           b(8)=f(i,3)
           b(9)=f(i+1,3)
           do k=1,9
C             if(b(k).ge.ddval) go to 1000
             IF(B(K).EQ.DUMMY) GO TO 1000
           enddo
      d(1)=(5.*b(5)+2.*(b(2)+b(4)+b(6)+b(8))-(b(1)+b(3)+b(7)+b(9)))/9.
      d(2)=(b(3)+b(6)+b(9)-(b(1)+b(4)+b(7)))/(6.*dx)
      d(3)=(b(7)+b(8)+b(9)-(b(1)+b(2)+b(3)))/(6.*dy)
      d(4)=(b(1)+b(3)+b(4)+b(6)+b(7)+b(9)-2.*(b(2)+b(5)+b(8)))/
     1     (6.*dx*dx)
      d(5)=(b(1)-b(3)-b(7)+b(9))/(4.*dx*dy)
      d(6)=(b(1)+b(2)+b(3)+b(7)+b(8)+b(9)-2.*(b(4)+b(5)+b(6)))/
     1     (6.*dy*dy)
c Get the eigenvalues of the curvature matrix
        bb=d(4)+d(6)
        term=(d(4)-d(6))**2+d(5)**2
        e1=bb+sqrt(term)
        e2=bb-sqrt(term)
c        print*,'eigenvalues=',e1,e2
c get the corresponding eigenvectors
        xx1=1.0
        if(d(5).ne.0.0) then
          yy1=(e1-2.*d(4))/d(5)
        else if(e1.ne.2.*d(6)) then
          yy1=d(5)/(e1-2.*d(6))
        else
          yy1=1.e38
        endif
        xx2=1.0
        if(d(5).ne.0.0) then
          yy2=(e2-2.*d(4))/d(5)
        else if(e2.ne.2.*d(6)) then
          yy2=d(5)/(e2-2.*d(6))
        else
          yy2=1.e38
        endif
c        print*,'eigenvectors=',xx1,yy1,xx2,yy2
c fix infinite eigenvectors
        if(yy1.eq.1.e38) then
          xx1=0.0
          yy1=1.0
        endif
        if(yy2.eq.1.e38) then
          xx2=0.0
          yy2=1.0
        endif
c get the strike
        if(e1.eq.e2) then
          s=1.e38
```

```
        else
          if(abs(e1).gt.abs(e2)) then
            s=57.29578*atan2(xx2,yy2)
          else
            s=57.29578*atan2(xx1,yy1)
          endif
          if(s.gt.90.) s=s-180.
          if(s.lt.-90.) s=s+180.
        endif
c        print*,'strike=',s
c Find the critical point
        if(abs(e1).eq.abs(e2)) then
c          print*,'no critical point'
          go to 500
        else if(abs(e1).gt.abs(e2)) then
          den=(d(4)*xx1**2+d(5)*xx1*yy1+d(6)*yy1**2)
          if(den.eq.0.0) then
c            print*,'no critical point'
            go to 500
          else
            t0=-0.5*(d(2)*xx1+d(3)*yy1)/den
            x0=xx1*t0
            y0=yy1*t0
          endif
        else
          den=(d(4)*xx2**2+d(5)*xx2*yy2+d(6)*yy2**2)
          if(den.eq.0.0) then
c            print*,'no critical point'
            go to 500
          else
            t0=-0.5*(d(2)*xx2+d(3)*yy2)/den
            x0=xx2*t0
            y0=yy2*t0
          endif
        endif
        if(x0.lt.-dx/2..or.x0.gt.dx/2.) go to 500
        if(y0.lt.-dy/2..or.y0.gt.dy/2.) go to 500
c        print*,'critical point=',xc,yc
        g0=d(1)+d(2)*x0+d(3)*y0+d(4)*x0*x0+d(5)*x0*y0+d(6)*y0*y0
c        write(10) xc,yc,g
          if(e1.gt.0.0.and.e1.gt.abs(e2)) then
            sta='trough  '
            post(8)=2.0
            if(itype(2).eq.0) go to 500
          else if(e2.gt.0.0.and.e2.gt.abs(e1)) then
            sta='trough  '
            post(8)=2.0
            if(itype(2).eq.0) go to 500
          else if(e1.lt.0.0.and.abs(e1).gt.abs(e2)) then
            sta='ridge   '
            post(8)=1.0
            if(itype(1).eq.0) go to 500
          else if(e2.lt.0.0.and.abs(e2).gt.abs(e1)) then
            sta='ridge   '
            post(8)=1.0
            if(itype(1).eq.0) go to 500
          endif
c get the maximum curvature
c          if(abs(e1).gt.abs(e2)) then
c            rat=yy1/xx1
c          else
c            rat=yy2/xx2
c          endif
c          ak=2.0*(d(4)+(d(5)+d(6)*rat)*rat)
```

```
c get the depth
c          zz=-2.0*g0/e2
c          if(zz.ge.0.0) then
c            zz=-sqrt(zz)
c          else
c            go to 500
c          endif
          post(1)=x0+xc
          post(2)=y0+yc
          post(3)=g0
          post(4)=zz
          post(5)=s
          post(6)=e1
          post(7)=e2
          post(4)=abs(post(6)/post(7))
c          post(8)=0.0
C          call xiopst('w',14,sta,post,8,ierr)
          CALL WRITEPOST_WF(IOF,STA,POST(1),POST(2),POST(3),IERR)
          IF(IERR.NE.0) GO TO 9999
          nsol=nsol+1
```

Table A7. Part 6 of the edited Fortran source code file.

```
c Find the extremum
500   den=d(5)**2-4.*d(4)*d(6)
      if(den.eq.0.0) then
c        print*,'no extremum'
        go to 1000
      else
        xe=(2.*d(6)*d(2)-d(3)*d(5))/den
        ye=(2.*d(4)*d(3)-d(5)*d(2))/den
        if(xe.lt.-dx/2..or.xe.gt.dx/2.) go to 1000
        if(ye.lt.-dy/2..or.ye.gt.dy/2.) go to 1000
        ge=d(1)+d(2)*xe+d(3)*ye+d(4)*xe*xe+d(5)*xe*ye+d(6)*ye*ye
c        write(10) xe,ye,g
        if(e1.lt.0.0.and.e2.lt.0.0) then
          sta='high    '
          post(8)=3.0
          if(itype(3).eq.0) go to 1000
        else if(e1.gt.0.0.and.e2.gt.0.0) then
          sta='low     '
          post(8)=4.0
          if(itype(4).eq.0) go to 1000
        else if(e1*e2.lt.0.0) then
          sta='saddle  '
          post(8)=5.0
          if(itype(5).eq.0) go to 1000
        endif
      endif
          post(1)=xe+xc
          post(2)=ye+yc
c          if(post(1).lt.xo.or.post(1).gt.xmax) go to 1000
c          if(post(2).lt.yo.or.post(2).gt.ymax) go to 1000
          post(3)=ge
c          post(4)=0.0
          post(5)=s
          post(6)=e1
          post(7)=e2
          post(4)=abs(post(6)/post(7))
c          post(8)=0.0
C          call xiopst('w',14,sta,post,8,ierr)
          CALL WRITEPOST_WF(IOF,STA,POST(1),POST(2),POST(3),IERR)
          IF(IERR.NE.0) GO TO 9999
          nsol=nsol+1
 1000    continue
c End of loop through columns
         do 1500 i=1,nc
           f(i,1)=f(i,2)
           f(i,2)=f(i,3)
 1500    continue
 2000    continue
         CALL PROGUPDATE_WF(100)
c End of loop through rows
C         close(10)
C         call xclose(14,'keep')
C         print*,nsol,' solutions written to curv4.pst'
C         stop
 9999    CONTINUE
         IF(INF.NE.0) CALL CLOSEGRID_WF(INF,IERR)
         IF(IOF.NE.0) CALL CLOSEPOSTFILE_WF(IOF,IERR)
         RETURN
         end
```

Table A8. The GX resource source code file, usgs_curv4.grc.

```
// USGS_CURV4.GRC
//-----------------------------------------------------------------------

RESOURCE,FORM,CURV4,"Grid Local Extrema from Curvature Analysis",-1
FEDIT,,,40,"Input grid",R,OLD,,,*.grd
FEDIT,,,40,"Output post file",R,,,,*.pst
LEDIT,,,15,"Find Ridges",R,FORCE,"Y",RIDGES
LEDIT,,,15,"Find Troughs",R,FORCE,"N",TROUGHS
LEDIT,,,15,"Find Highs",R,FORCE,"N",HIGHS
LEDIT,,,15,"Find Lows",R,FORCE,"N",LOWS
LEDIT,,,15,"Find Saddles",R,FORCE,"N",SADDLES

EBUT,&OK,0
EBUT,&Cancel,-1,CANCEL
HBUT,&Help,help

RESOURCE,LIST,RIDGES
ITEM,"Y",1
ITEM,"N",0

RESOURCE,LIST,TROUGHS
ITEM,"Y",1
ITEM,"N",0

RESOURCE,LIST,HIGHS
ITEM,"Y",1
ITEM,"N",0

RESOURCE,LIST,LOWS
ITEM,"Y",1
ITEM,"N",0

RESOURCE,LIST,SADDLES
ITEM,"Y",1
ITEM,"N",0

RESOURCE,HELP,help,.\usgs_curv4.rtf
```

Table A9. The GX help file, usgs_curv4.rtf.

```
USGS_CURV4 GX

Locates local extrema in a grid file using curvature analysis

INTERACTIVE PARAMETERS

  Input grid file
  Output post file (new database will have the same prefix)
  Flag for finding ridges
  Flag for finding troughs
  Flag for finding highs
  Flag for finding lows
  Flag for finding saddles

BATCH PARAMETERS

USGS_CURV4.INGRID          Input grid file
USGS_CURV4.OUTPOST         Output post file (new database will have the
                             same prefix)
USGS_CURV4.RIDGES          Flag for finding ridges  (Y=1,N=0)
USGS_CURV4.TROUGHS         Flag for finding troughs (Y=1,N=0)
USGS_CURV4.HIGHS           Flag for finding highs   (Y=1,N=0)
USGS_CURV4.LOWS            Flag for finding lows    (Y=1,N=0)
USGS_CURV4.SADDLES         Flag for finding saddles (Y=1,N=0)

APPLICATION NOTES

The output post file and database have the following channels:
       id      type of feature (ridge, high, etc)
       x       x-coordinate of solution
       y       y-coordinate of solution
 p(1)  g(x,y)  grid value at the solution as estimated from the
                 quadratic surface
 p(2)  elong   elongation factor of the feature from the ratio of the
                 two eigenvalues
 p(3)  strike  degrees clockwise from north
 p(4)  e1      first eigenvalue of the curvature matrix
 p(5)  e2      second eigenvalue of the curvature matrix
 p(6)  type    integer value indicating type of feature (ridge=1,
                 trough=2, etc)

Reference:

Phillips, J.D., Hansen, R.O., and Blakely, R.J., 2007, The use of
  curvature in potential-field interpretation: Exploration Geophysics,
  v.38, p.111-119.

Written by Jeff Phillips (jeff@usgs.gov) 9/14/2006.
```

Table A10. The GX source code file, usgs_curv4.gxc.

```
//===========================================================================
NAME          = "FORTRAN Code CURV4"
VERSION       = "v1.00  U.S. Geological Survey 2006"
DESCRIPTION   = "

        USGS_CURV4.INGRID          Input grid
        USGS_CURV4.OUTPOST         Output post file
        USGS_CURV4.RIDGES          Flag for finding ridges
        USGS_CURV4.TROUGHS         Flag for finding troughs
        USGS_CURV4.HIGHS           Flag for finding highs
        USGS_CURV4.LOWS            Flag for finding lows
        USGS_CURV4.SADDLES         Flag for finding saddles

"
//===========================================================================

RESOURCE = "usgs_curv4.gr"
#include "usgs_curv4.grh"

//===========================================================================

#include <all.gxh>
#include "usgs_curv4.gxh"

//===========================================================================
//                             GLOBAL VARIABLES
//===========================================================================

DGW        Diag;              // Dialogue handle
string(GS_MAX_PATH) sInGrid, sOutPost, sOutGDB;
int(5) iType;
//real rAmpin;

//===========================================================================
//                                    CODE
//===========================================================================

{

  if (iInteractive_SYS()) {

    // --- Create the Dialogue ---

    Diag = Create_DGW("CURV4");

    // --- Set any Defaults from INI ---

    SetInfoSYS_DGW(Diag,_CURV4_0,DGW_FILEPATH,"USGS_CURV4","INGRID");
    SetInfoSYS_DGW(Diag,_CURV4_1,DGW_FILEPATH,"USGS_CURV4","OUTPOST");
    SetInfoSYS_DGW(Diag,_CURV4_2,DGW_LISTALIAS,"USGS_CURV4","RIDGES");
    SetInfoSYS_DGW(Diag,_CURV4_3,DGW_LISTALIAS,"USGS_CURV4","TROUGHS");
    SetInfoSYS_DGW(Diag,_CURV4_4,DGW_LISTALIAS,"USGS_CURV4","HIGHS");
    SetInfoSYS_DGW(Diag,_CURV4_5,DGW_LISTALIAS,"USGS_CURV4","LOWS");
    SetInfoSYS_DGW(Diag,_CURV4_6,DGW_LISTALIAS,"USGS_CURV4","SADDLES");
//    SetInfoSYS_DGW(Diag,_CURV4_7,DGW_TEXT,"USGS_CURV4","AMPIN");

    // --- Run the Dialogue ---

    if (iRunDialogue_DGW(Diag) != 0)
       Cancel_SYS();
```

```
    // --- Get the Strings and replace in INI ---

    GetInfoSYS_DGW(Diag,_CURV4_0,DGW_FILEPATH,"USGS_CURV4","INGRID");
    GetInfoSYS_DGW(Diag,_CURV4_1,DGW_FILEPATH,"USGS_CURV4","OUTPOST");
    GetInfoSYS_DGW(Diag,_CURV4_2,DGW_LISTALIAS,"USGS_CURV4","RIDGES");
    GetInfoSYS_DGW(Diag,_CURV4_3,DGW_LISTALIAS,"USGS_CURV4","TROUGHS");
    GetInfoSYS_DGW(Diag,_CURV4_4,DGW_LISTALIAS,"USGS_CURV4","HIGHS");
    GetInfoSYS_DGW(Diag,_CURV4_5,DGW_LISTALIAS,"USGS_CURV4","LOWS");
    GetInfoSYS_DGW(Diag,_CURV4_6,DGW_LISTALIAS,"USGS_CURV4","SADDLES");
//    GetInfoSYS_DGW(Diag,_CURV4_7,DGW_TEXT,"USGS_CURV4","AMPIN");

    // --- Destroy the Dialogue ---

    Destroy_DGW(Diag);

 }

 // --- Get Parameters ---

 GetString_SYS("USGS_CURV4","INGRID",sInGrid);
 GetString_SYS("USGS_CURV4","OUTPOST",sOutPost);
 iType[0] = iGetInt_SYS("USGS_CURV4","RIDGES");
 iType[1] = iGetInt_SYS("USGS_CURV4","TROUGHS");
 iType[2] = iGetInt_SYS("USGS_CURV4","HIGHS");
 iType[3] = iGetInt_SYS("USGS_CURV4","LOWS");
 iType[4] = iGetInt_SYS("USGS_CURV4","SADDLES");
// rAmpin = rGetReal_SYS("USGS_CURV","AMPIN");

// --- Check for null input and output file name strings ---

//   DisplayMessage_SYS("Input grid",sInGrid);
//   DisplayMessage_SYS("Output post file",sOutPost);

 if(!iStrlen_STR(sInGrid))
    Abort_SYS("Input grid not specified");

 if(!iStrlen_STR(sOutPost))
    Abort_SYS("Output post file not specified");

 Progress_SYS(1);

 ProgName_SYS("Processing Grid",1);

 USGS_Curv4(sInGrid, sOutPost, iType[0], iType[1], iType[2], iType[3],
           iType[4]);

 Progress_SYS(0);

// --- Write the post file into a new database ---

      FileNamePart_STR(sOutPost,sOutGDB,STR_FILE_PART_NAME);
      Strcat_STR(sOutGDB,".GDB");
      SetString_SYS("USGS_IMPOST","INPOST",sOutPost);
      SetString_SYS("USGS_IMPOST","OUTGDB",sOutGDB);
      SetInteractive_SYS(0);  // Interactive mode off
      if (iRunGX_SYS("usgs_impost.gx")) Cancel_SYS();

// --- Print Message ---

//   if (iInteractive_SYS())
//     DisplayMessage_SYS("Post File Created",sOutPost);

}
```

Table A11. The GX header file, usgs_curv4.gxh.

```
//===========================================================================
//
// usgs_curv4.gxh - Prototype for wrappers for CURV4 Fortran subroutine
//
//
//===========================================================================

#ifndef CURV4_GXH_DEFINED
#define CURV4_GXH_DEFINED

#define USGS_Curv4(A,B,C,D,E,F,G) IUSGS_Curv4(A,sizeof(A),B,sizeof(B),C,D,E,F,G)

[usgs_curv4] void
IUSGS_Curv4(string,   // input grid file
              int,    // string length
              string, // output post file
              int,    // string length
              int,    // itype1
              int,    // itype2
              int,    // itype3
              int,    // itype4
              int);   // itype5
//              int(5));    // itype

#endif
```

Table A12. Code fragment added to the end of the wrapper functions header file, wrappers.h.

```
// USGS_Curv4.f

int curv4_(char *pcInfile, char *pcOutfile, long *itype1, long *itype2,
        long *itype3, long *itype4, long *itype5, long *ierr,
        long infile_len, long outfile_len);
```

Table A13. The C source code file, gxx_curv4.c.

```
//===========================================================================
//static char *__THIS_FILE_NAME__ = "$Id: //depot/src/usgs/gxx_usgs.c#4$";
//===========================================================================
//===========================================================================
//
//   gxx_curv4.c
//
//   USGS FORTRAN method wrappers.
//
//===========================================================================

#define C_MICROSOFT

#include <gx_define.h>
#include <gx_lib.h>
#include <gx_extern.h>

#include "../wrappers.h"

//---------------------------------------------------------------------------
__declspec(dllexport)                      // add this to be safe
GX_WRAPPER_FUNC GX_LONG GX_WRAPPER_CALL
IUSGS_Curv4(void       *pGeo,
            const char *pcInfile,
            long       *plInfile_len,
            const char *pcOutfile,
            long       *plOutfile_len,
            long       *plType1,
            long       *plType2,
            long       *plType3,
            long       *plType4,
            long       *plType5)
//            long       *plType[5])

{
   const char *modn = "IUSGS_Curv4";

   long lErr=0;

   // --- Load the global structure ---

   InitGlobals(pGeo);

   // --- Convert doubles to floats for REAL*4 ---

   // --- Process the grid ---

   curv4_((char *)pcInfile, (char *)pcOutfile, plType1, plType2,
           plType3, plType4, plType5, &lErr,
           *plInfile_len, *plOutfile_len);

   // --- Convert returned values back to doubles ---

   return 0;
}
```

Table A14. The makefile for creating the GX dynamic-link library, Makefile.

```
################################################################
#
#  MinGW Makefile for usgs_curv4 Fortran GX
#
################################################################
#
#  Creates a dynamic-link library, usgs_curv4.dll, from Fortran
#  and C code that can be accessed from the compiled GX,
#  usgs_curv4.gx.  Does not use f2c or Microsoft Visual C++.
#
#  Besides this Makefile, you will need:
#     usgs_curv4.f
#     ../wfuncs.c
#     gxx_curv4.c
#     ../wrappers.h
#
#  You will also need libGEOGX6.4.a and libGEODIST6.4.a as
#  created using the other Makefile.  Edit $(LIBDIR) so it
#  points to the directory containing these files.
#
#  Written by Jeff Phillips (jeff@usgs.gov) based on original
#     code by Jim Roy (jim@nga.com) and
#           Tom Popowski (tom@nga.com).
#
################################################################

OMVERS = 6.4
GEOGX_LIB   = GEOGX$(OMVERS)
GEODIST_LIB = GEODIST$(OMVERS)

TARGETDLL = usgs_curv4
TARGETGX = usgs_curv4

CMODULES = \
        gxx_curv4 \
        ../wfuncs

CMODULESOBJ = $(CMODULES:%=%.o)
CMODULESSRC = $(CMODULES:%=%.c)

FMODULES = \
      usgs_curv4

FMODULESOBJ = $(FMODULES:%=%.o)
FMODULESSRC = $(FMODULES:%=%.f)

LIBDIR = -L /home/jeff/gxdev

LIBS = $(LIBDIR)/lib$(GEOGX_LIB).a \
      $(LIBDIR)/lib$(GEODIST_LIB).a

INCDIR = /c/Program\ Files/Geosoft/GX\ Developer/apps/include

CC = gcc
CFLAGS = -I $(INCDIR) -DC_MICROSOFT -DMINGW

FC = g77
FFLAGS = -fugly-assumed

#INCLUDES = ../wrappers.h
```

```
$(TARGETDLL): $(FMODULESOBJ) $(CMODULESOBJ)
            dlltool --export-all-symbols -z $(TARGETDLL).def $^
            dlltool -d $(TARGETDLL).def -l $(TARGETDLL).a -D $(TARGETDLL).dll -e
exports.o $^
            g77 -shared -o $(TARGETDLL).dll $(LIBDIR) $^ exports.o -lGEOGX$(OMVERS)
-lGEODIST$(OMVERS)
            cp $(TARGETDLL).dll /c/Program\ Files/Geosoft/Oasis\ montaj\ Viewer/bin
            cp $(TARGETDLL).dll /c/Program\ Files/Geosoft/Oasis\ montaj/bin
            cp $(TARGETGX).gx /c/Program\ Files/Geosoft/Oasis\ montaj\ Viewer/gx
            cp $(TARGETGX).gx /c/Program\ Files/Geosoft/Oasis\ montaj/gx

$(CMODULESOBJ):   $(CMODULESSRC)
      $(CC) -c $*.c  $(CFLAGS) -o $*.o


$(FMODULESOBJ):   $(FMODULESSRC)
      $(FC) -c $*.f  $(FFLAGS) -o $*.o


clean:
      rm -f core $(TARGETDLL) *.o *.a *.def


.c.o: Makefile
      $(CC) $(CFLAGS) -c $< -o $@

.f.o: Makefile
      $(FC) $(FFLAGS) -c $< -o $@
```