(A)GIS: A Geophysical Information System. User manual for version 0.5

Thorsten W. Becker* Alexander Braun†

May 25, 1998

Abstract

(A)GIS stands for "A Geophysical Information System". The software is a UNIX based Tcl/Tk script package that is built around the GMT mapping tools. (A)GIS is intended to assist in the creation of GMT scripts for mapping raster or polygon datasets and has built-in support for topography, sea-floor age, free air-gravity, the geoid and various polygon data files such as earthquake hypocenter lists or hot-spot locations.

The package should serve the earth scientist with limited experience with data set handling in all sorts of geophysical or geological mapping tasks. In addition, it provides the experienced user with a graphical user interface for the GMT parameter choice. After completing a session, the user ends up with a `agis_commands.gmt` file that is an executable script and contains the commands used to create the last map. It should serve as a starting point for more complex tasks that can't be achieved with (A)GIS.

This manual describes briefly how (A)GIS is used and explains some technical details that may be helpful if the user wishes to extent or modify the script.

*Harvard University, Department of Earth and Planetary Sciences, 20 Oxford St., Cambridge MA 02138, USA.

†Institut für Meteorologie und Geophysik, J.W.Goethe-Universität Frankfurt am Main, Feldbergstr. 47, D–60323 Frankfurt am Main, Germany

Contents

1 Copyright and warranty disclaimer

```
##############################################################################
#    (A)GIS: A Geophysical Information System. Using GMT and Tcl/Tk to map   #
#               geophysical data sets.                                       #
#                                                                            #
#    Copyright (C) 1998  Thorsten W. Becker, Alexander Braun                 #
#                                                                            #
#    This program is free software; you can redistribute it and/or modify    #
#    it under the terms of the GNU General Public License as published by    #
#    the Free Software Foundation; either version 2 of the License, or       #
#    (at your option) any later version.                                     #
#                                                                            #
#    This program is distributed in the hope that it will be useful,         #
#    but WITHOUT ANY WARRANTY; without even the implied warranty of          #
#    MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the           #
#    GNU General Public License for more details.                            #
#                                                                            #
#                                                                            #
#    You should have received a copy of the GNU General Public License       #
#    along with this program; see the file COPYING.  If not, write to        #
#    the Free Software Foundation, Inc., 59 Temple Place - Suite 330,        #
#    Boston, MA 02111-1307, USA.                                             #
#                                                                            #
##############################################################################
```

2 Credits

(A)GIS is based on the excellent GMT software by Wessel and Smith (1991, 1995) and the Tcl/Tk toolkit by John Ousterhout. Small parts of the routines and templates were taken directly from the Tcl/Tk book by Ousterhout (1993) or the GMT documentation. Some of the initial Tk frame packing was done with the `XF` software by Sven Delmas. (A)GIS makes use of the `convert` tool of the ImageMagick distribution.

Finally and most important, the researchers making the data sets available that (A)GIS works with have to be mentioned for their great contribution. Besides other sources datasets of NOAA (1988); Smith and Sandwell (1997); Sandwell and Smith (1997); Müller et al. (1997); DeMets et al. (1990); Dunbar et al. (1997); DeMets et al. (1990); Steinberger (1998); Simkin and Siebert (1994); Dziewonski and Woodhouse (1983) and Rapp et al. (1991) are processed by (A)GIS.

3 Software requirements

The current version of (A)GIS is intended for use on various UNIX systems[1] and was developed running IRIX 6.3. However, it could be modified to cross-compile on other hardware platforms without much effort given that the software that (A)GIS relies on or an equivalent is available for the operating systems in question. This is the case for Macs and PCs whereas I have no experience with the ported products in question.

The (A)GIS script package that comes with this documentation, some example plots and small datasets is available at the (A)GIS home page

`http://www.fas.harvard.edu/~becker/agis`.

This is also the place to check for updates, bug reports etc. (A)GIS assumes that you have the following software installed and accessible either via the user's `$path` variable or the binary paths set in `agis_configure.tcl` or the `agis_siteconfig.tcl` file (see the comments below). If this does not make sense to you, please ask your local system administrator.

Tcl/Tk: The Tcl script language and the Tk toolkit for the construction of graphical user interfaces (Ousterhout, 1993) are currently available under `http://www.scriptics.com/` or `http://sunscript.sun.com/`. Version 8.0 of Tcl/Tk was used for developing, older version may work as well. Tcl is available for UNIX, PC, Mac and other platforms.

GMT: The generic mapping tools (Wessel and Smith, 1991, 1995) do the work, (A)GIS wants version 3.0. The source code distribution as well as documentation is available at `http://www.soest.hawaii.edu/wessel/gmt.html`. GMT itself has some additional software requirements, such as the availability of the netcdf library (see the GMT documentation).

[1] It will be assumed that the user has some familiarity with the UNIX operating system and basics will not be explained here (for UNIX and shell scripting reference see, e.g., Gilly, 1994).

GMT could be compiled on other platforms but I am not aware of any working port at the moment.

awk: The `awk` command language is available on all UNIX systems such as AIX, IRIX, SOLARIS, HPUX or LINUX. AWK or some GNU flavors of it should run on a PCs and Macs.

showps: (A)GIS defaults to using the Adobe `showps` postscript display program. You can change this (like many other things) in the configuration file `agis_configure.tcl` that comes with the (A)GIS distribution. Another option to change parameters is to create a `agis_siteconfig.tcl` file and redefine site specific variables here. (This file gets sourced after (A)GIS reads `agis_configure.tcl`, hence variables will be overwritten by the user settings. By creating a site specific file it is easier to upgrade to future versions of (A)GIS.) A possible postscript viewer alternative would be `ghostscript` or `ghostview`, available for PC and Mac. (A)GIS works fine without any postscript displayer at all as long as you do not need to view the PS files before printing them.

convert: The `convert` tool of the ImageMagick software (`http://www.wizards.dupont.com/cristy/ImageMagick.html`) is used by default to convert from PS to the GIF format. You might as well use `ghostscript` or change the graphic format that is used for previewing to something completely different. (A)GIS works fine without a converting tool even though you get an error message when you use "Map it!", since this command includes not only postscript but GIF output (see below).

If you have installed the tools mentioned above you should be ready to use the basic version of (A)GIS. While the requirements above might seem complicated, it should be kept in mind that nowadays most UNIX or LINUX systems come with all of the above except GMT when the system software is installed. GMT, on the other hand, is widely in use in the earth sciences already. In addition, all of the software needed to run (A)GIS is freeware or shareware of some kind and most of it is subjected to an open developing policy.

4 Installation

To get (A)GIS running, extract the distribution `agis_v0.5.tar.gz` –if you have not already done so– in a directory where you store Tcl/Tk scripts. This could well be at the single user level on multi-user systems since the package itself is relatively small. Installing multiple copies would allow every user to modify the (A)GIS code themselve.

Next, an environment variable `$agis_root` must be set to point to the directory where (A)GIS resides. With `csh` this would be done by adding a line like

```
setenv agis_root $HOME/tcltk/agis_dir/
```

to the `$HOME/.login` file. The startup script file is `$agis_root/agis`. This script calls the Tcl/Tk shell `wish` using the path `/usr/freeware/bin/wish`. If `wish` is somewhere else, either change the corresponding line in `agis` or set the environment variable `$wish_cmd`. After verifying

the settings, `agis` should be executable and (A)GIS can be started by typing `$agis_root/agis` at the command line. (Of course this can be faciliated by adding an alias or linking `$agis_root/agis` to some place where your shell looks for executables.)

5 Datasets handled by (A)GIS

While (A)GIS is lacking the database query functions of full blown GIS systems it is capable of combining multiple geophysical data sets and handling large amounts of data in an efficient way. (Indeed, this is an achievement of the GMT software and (A)GIS' usage does not constrain this feature.) Excellent data is available on the web these days and (A)GIS is based upon these publicly available collections. Since GMT is growing into a *de-facto* standard in parts of the geophysical community, it seems natural to use GMT to handle the data.

With the requirements that are explained in sec. 3 you should now be able to interactively use the GMT command `pscoast` that is used for plotting maps of land and sea coverage with political boundaries etc. [2] If you want to take advantage of the built-in handling capabilities for various datasets, you need to get the data or tell (A)GIS where it can find it, if the data is already around on your system. All path names can be changed together with all other global variables in the `agis_configure.tcl` or a site specific `agis_siteconfig.tcl` file (see above). Furthermore, the user has the option to specify one raster grd-file and two custom polygon data sets. The `agis_configure.tcl` is commented so it should be easy to find what you are looking for. In addition, some of the datasets require special converting software.

5.1 Raster data

Besides `pscoast` land and sea coverage and shorelines, the following raster data files are supported:

ETOPO5 topography: The ETOPO5 topography/bathymetry (NOAA, 1988, available at `http://www.ngdc.noaa.gov/`) is supported in combination with the `grdraster` tool which is (as `psvelomeca`) part of the supplementary package that is available together with the GMT main distribution. The ETOPO5 data set is about 19MB in i2 binary format.

"GTOPO30" topography: The GTOPO30 DEM model (EDC, 1996) was greatly expanded by Smith and Sandwell (1997). It is supported in the form suggested by Smith & Sandwell using `img2latlongrd`. Data and other tools can be found at `http://topex.ucsd.edu/marine_topo/mar_topo.html`. The img format file is 137MB.

Sea-floor age: The sea-floor age data of Müller et al. (1997) was published as a GMT `grdfile` and is used in the form as available at `http://Omphacite.es.su.oz.au/StaffProfiles/`

[2] Man pages and other documentation are available for the GMT commands. Therefore, the usage will not be explained in this manual. Refer, e.g., to the man page function provided by (A)GIS or to `http://www.soest.hawaii.edu/wessel/gmt/gmt_doc.html`.

dietmar/Agegrid/agegrid.html. The data is about 23MB in grd format and roughly 10MB in i2 binary which could be read by grdraster as ETOPO5 (to do this, change the corresponding lines in agis_plotting.tcl).

Free-air gravity: Sea-floor gravity anomalies as published by Sandwell and Smith (1997) are used as a grdfile as found at http://topex.ucsd.edu/marine_grav/mar_grav.html. As GTOPO30, this file is 137MB big.

Geoid: (A)GIS supports plotting the geoid and comes with an adequate colormap. As an example, we evalutated the spherical harmonic coefficients of Rapp et al. (1991) from order 2 to 360 and included them in 20 arc minute resolution as a GMT grd-file in our raster data set.

Custom data: You can choose an arbitrary GMT grd file to be plotted as the base data layer and provide your own colormap, too.

5.2 Polygon data

Some example handling procedures for polygon data are included as well:

Plate boundary data: The plate boundaries as given by DeMets et al. (1990) are part of the (A)GIS distribution as the file nuvel.yx in a slightly modified form. Any polygon data file supported by psxy can be substituted for this data set.

Hotspot locations: (A)GIS uses a list of hotspots compiled by Steinberger (1998) to plot their location and a name tag, if selected.

Volcano locations: The Smithsonian Institution Global Volcanism Program's list of volcanoes (Simkin and Siebert, 1994) is supported in the form found at http://www.volcano.si.edu/gvp/volcdata/index.htm. As for the hotspot data, the user can select a symbol, the color and toggle a name tag. A version of this list as of April 1998 is included. If you want to install an update, just download the data from the web and replace the adequate file. The same holds true for the earthquake catalogs since (A)GIS was programmed to handle the original data.

CMT fault plane solutions: (A)GIS uses psvelomeca from the GMT supplements package to plot the double couple part of the Harvard CMT centroid moment tensor solutions (e.g. Dziewonski and Woodhouse, 1983) as found at http://www.seismology.harvard.edu/CMTsearch.html. A list of all events in the catalog of the first 60 days of 1998 is included as an example.

Significant earthquakes: Dunbar et al. (1997) have compiled a list of significant earthquakes starting 2000 B.C., their catalog is accesible at http://www.ngdc.noaa.gov/seg/hazard/sigintro.html. After quoting all lines without data by inserting a hash sign ("# "), the format produced by this engine can be read directly into (A)GIS. (Internally, all that

(A)GIS does is to use awk to check if lines are quoted and for exporting of the relevant columns.) (A)GIS plots only earthquakes that have a magnitude assigned, you might want to change the relevant `awk` lines in `agis_plotting.tcl`.

PDE earthquakes: The United States Geological Survey keeps different hypocenter catalogs at the National Earthquake Information Center (`http://wwwneic.cr.usgs.gov/neis/epic/epic_global.html`). The "Screen File Format" can be read by (A)GIS.

Custom "xys" files: (A)GIS can plot two custom ASCII data files specified by the user. They have to be in a columnar format similar to the polygon data described above and need at least longitude, latitude and some size value for every line (hence "xys"). If you have x and y coordinates only, modify the plotting routine or create an `xys` file yourself with the help of an awk one-liner:

```
awk '{if($1!="")print($1,$2,1)}' old_xy.dat > new_xys.dat
```

You can now plot your data from the `new_xys.dat` file and use the multiplying factor as the standard size of the symbols (see also sec. 6.2).

Technical details how these files are handled are explained later in the text and in the comments found in `agis_plotting.tcl`.

6 Usage of (A)GIS

In the following I assume that you have a running version of (A)GIS. The usage will be explained by going through all menu points that show up at the start-up screen. The basic idea of (A)GIS is to use GUI facilities to select important plotting parameters, produce a GMT script and run it from within the program. When this is done successfully, the produced postscript code is converted to a GIF image and then displayed. By doing this, it is easy to create a basic script that can then be modified for more complex applications when the limits of (A)GIS are reached.

The menu list is divided into five pull down menues, `File/Plot`, `Datasets`, `Parameters`, `Scripting Options` and `GMT man pages` as well as two buttons, `Map it!` and `Quit`.

6.1 Menu `File/Plot`

This menue takes care of the main file handling and general input/output functions of (A)GIS. The first item, `Create PS ...`, leads to the identical action as the `Mapit!` button, that is:

- a GMT script is created and executed;
- if a postscript file was created, this is converted into a GIF;
- the GIF map display underneath the menu bar is updated.

The next three items allow the user to create a postscript file only or individually display the postscript. This might be helpful if you have trouble installing a PS-to-GIF converter. The

filenames used for this process default to `/tmp/agis_$USER_tmp.ps` and `/tmp/agis_$USER_tmp.gif` (again, this can be changed in `agis_configure.tcl` or `agis_siteconfig.tcl`). "`$USER`" is replaced by the UNIX user name to avoid conflicts with write permissions if more than one user operates (A)GIS on a single machine. If the produced map files are to be kept, the user can either copy them to another place by hand or use the following two items in the menu list, `Save PS file` and `Save GIF file`.

`Load` and `Save parameters` use a file to dump almost all (A)GIS parameter settings so that a session can be restarted at a later time without having to redo all the fine tuning. (A)GIS comes with four example parameter files (`example?.dat`) that can be loaded to experiment with the software.

6.2 Menu `Datasets`

The first item in the `Datasets` menu leads to the raster data choice dialog where the files to choose from are those described in sec. 5. The same holds true for the polygon datasets of the second item. In contrast to the raster data sets, polygon sets can be plotted on top of each other. Future versions of (A)GIS will allow multiple layers of raster data as well.

The next part of the `Datasets` menu lets the user choose the custom GMT grd-file he wants to plot, whereas `Change ... file` in the next three lines modify the respective custom polygon data files.

The polygon menu comes with the option of plotting two user defined data sets as mentioned above. The following two items in the menu list bring up two identical dialogs where the names of the custom `xys` files, the columns for latitude, longitude and size as well as a magnification factors for the size can be specified. Internally, all data sets are of course handled by a trivial `awk` script that can be viewed in the GMT script file or in the source code, that is `agis_plotting.tcl`.

6.3 Menu `Parameters`

This longest menu is used to set all the parameters for the GMT script. It is this step in the map production process where were the graphical user interface can be hopefully most helpful.

Item `Region` This item brings up the region selection dialog. Where the eastern, northern etc. boundaries are self-explaining, the "Center of map projection" is needed for whole earth viewing projections. Clicking on "The whole thing!" expands the geographical boundaries as far as possible for the checked projection. ""Square" it" attempts to make a square-like map by setting the difference between the boundaries equal. "Center focus in region" sets the center of map projection values to the averages of the boundaries.

Item `Projection` The projection order chosen for the dialog box follows the GMT manual (`http://www.soest.hawaii.edu/wessel/gmt/gmt_doc.html`) closely. Projections themselves are explained briefly in the `pscoast` man page. The last check-box, "custom projection", allows the user to specify the projection with the magnification factor in the GMT format explicitly.

This might be needed since formatting is not perfectly done by (A)GIS and not all GMT projections are implemented. Some of the projections adjust the geographic region to be plotted as suitable.

Items for `pscoast` The next three items deal with pscoast. A small subset of the polygon data that can be plotted by this routine are mentioned in the `Pscoast polygon selection` list. The next item allows changing the color of the land and sea coverage, while the last pscoast item is responsible for changing some linewidths.

Raster data set items Toggle the automatically provided legends for the gravity, age, geoid and topography data sets on and off and select the subset grid resolution. If the value you choose (in arc minutes) is smaller than the minimum value supported by the specific data set, (A)GIS increases the value again. There will be a warning when a larger number of data points are about to be processed. Keep in mind that small machines might have a hard time if the resolution is too high and/or the map size is too big. "Change colormap" lets the user choose a colormap other than the ones used automatically when a predefined raster data file is selected. If you change the raster data set to one of the predefined ones after choosing your own colormap, you have to reenter the selection. Use "Shade raster data" to toggle the shading that is done for topographic and gravity datasets using `grdgradient`.

Polygon data set items The next three menu items change what they say, `Symbols...`, `Sizes...` and `Color` of the polygon data. Sizes are in fractions of the mapwidth and get multiplied by another factor with the size column of the `xys` data. The symbols types that are implemented are, again, only a subset of what GMT can do. Linewidth changing only works for the plate boundaries and the rivers and national boundaries of pscoast so far. Name tags can be switched on and off for hot-spots and volcano data sets.

Items for map grid line and frames `Gridlines` and `Frame annotation` are on/off switches. By default, the gridlines are twice as densely spaced as the outer annotation intervals along the map frame. Change this in `agis_plotting.tcl`, if you like. The mapscale the user can switch on and off is positioned in the lower left corner of the map and calculated to be correct at center latitudes.

Miscellaneous plotting items Add a title to the plot and change the page size and orientation here. Don't expect perfect results in terms of title placement or centering of the final map on the produced postscript file. Reasonable results should be achievable with the built in functions of (A)GIS, while final copies will surely need some hands-on modification of the GMT script.

6.4 Menu `Scripting options`

The first item, `Show GMT script`, shows the file that is created and executed by (A)GIS to get GMT to produce the postscript file we are viewing. This is intended to do two things: Show the inexperienced user what can be done (in addition to the introduction in the GMT manual) and give the experienced user a fast tool to get to a start script for more complicated applications. This file is called `$HOME/agis_parameters.dat` by default. `Add stuff to the pscoast line` lets the user add additional commands to the last `pscoast` command of the script file without having to exit from (A)GIS and run the script independently. The file presented by `Show script errors` contains the stderr output of the GMT commands invoked and should be helpful for debugging. By default, GMT is "verbose".

6.5 Menu `GMT man pages`

This menu list is intended to provide fast access to the GMT man pages for reference. At the time of the first call, a temporary file is created from the `man` command and afterwards displayed every time the user selects the same command man page again.

Finally, the two buttons on the right hand side of the menu bar do what they say.

7 Examples

The following examples were produced by running (A)GIS with the full data sets as described above. They can be reproduced if the data is available locally by loading the parameters file given in the distribution.

Hypocenters from the NEIC dataset Figure 1 shows the map of `example1.ps` from the (A)GIS distribution, the whole Earth in the Mollweide projection. ETOPO5 in 60 arc minute resolution is the ground raster layer. All hypocenters of the USGS/NEIC dataset from 1973 – 1997 with magnitude greater than five and NUVEL1 plate boundaries are superimposed. Load `example1.dat` to produce this plot. To reduce the size of this documentation, the postscript file is not exactly that produced by (A)GIS but a converted GIF with lower resolution.

Smith & Sandwell/GTOPO30 topography Figure 2 of example number two shows a part of the Indian ocean and the Indian subcontinent. It was produced using the Smith & Sandwell/GTOPO30 dataset in full resolution and has the pscoast shoreline data in high resolution superimposed. The original map has fascinating detail that might be lost in this reproduction.

Sea-floor age of Müller et al. Example 3 as resp-resented by Fig. 3 and the files `example3.ps` and `example3.dat` shows the North Atlantic region sea-floor age data coverage together with plate boundaries (Stereographic projection).

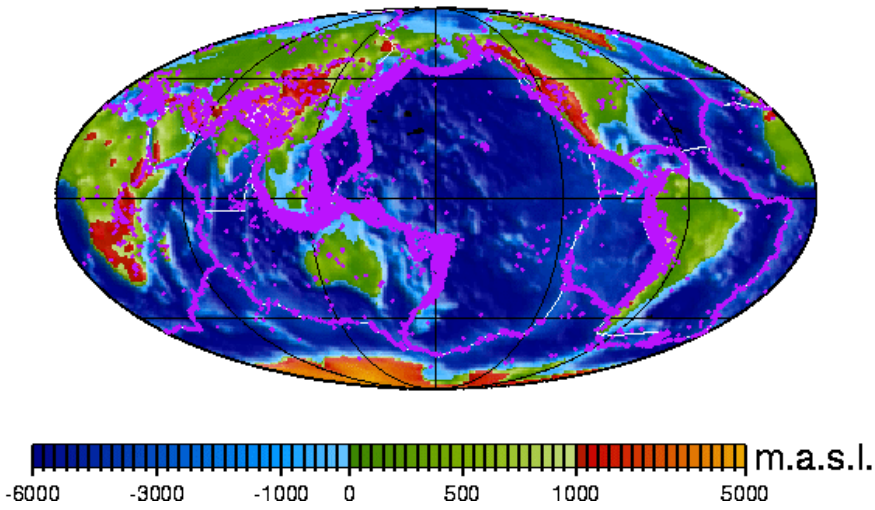

Figure 1: ETOPO5, NUVEL1 plate boundaries and PDE hypocenter distribution as of `example1.ps`, resolution reduced. Data from DeMets et al. (1990); NOAA (1988); USGS/NEIC (1998).

Gravity anomalies from Sandwell and Smith (1997) The last example (`example4.*`) of Fig. 4 shows gravity anomalies in the Indian ocean.

8 Conclusion

The (A)GIS software package was programmed in a modular way. Every routine is commented, so it should be fairly easy to modify the code and add extensions to the software. If you do so, that's fine, but please do not call it (A)GIS when you distribute it and make reference to the original software. Please keep in mind that while GMT offers a large number of interesting and useful mapping options and (A)GIS tries to make use of them, (A)GIS can't be as flexible as GMT. In addition, it is pretty hard to test every single combination of what-might-go-wrong-if. Hence, (A)GIS can be expected to fail to produce useful maps under certain circumstances. Of course, the software is provided as is, no guarantee whatsoever is given and no responsibility for possible damage is taken.

Hopefully, (A)GIS demonstrates what can be done nowadays that great geophysical data sets and mapping software is available. If (A)GIS helps in making the research work of earth scientists easier, the mission is accomplished.

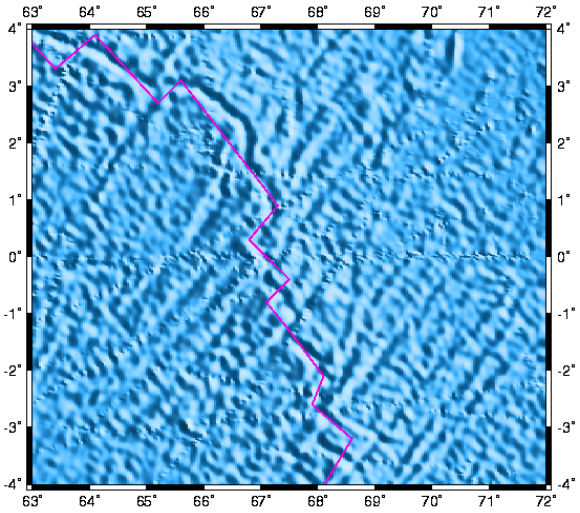

Figure 2: A part of the Carlsberg ridge in the Indian Ocean as of `example2.ps`, parameters can be loaded from `example2.dat`. The original file has extremely high resolution and was quite big. The reduced image shown here was shrunk to 81dpi using `xv`. Bathymetry data is from Smith and Sandwell (1997), plate boundary from DeMets et al. (1990), scale is the same than in Fig. 1.

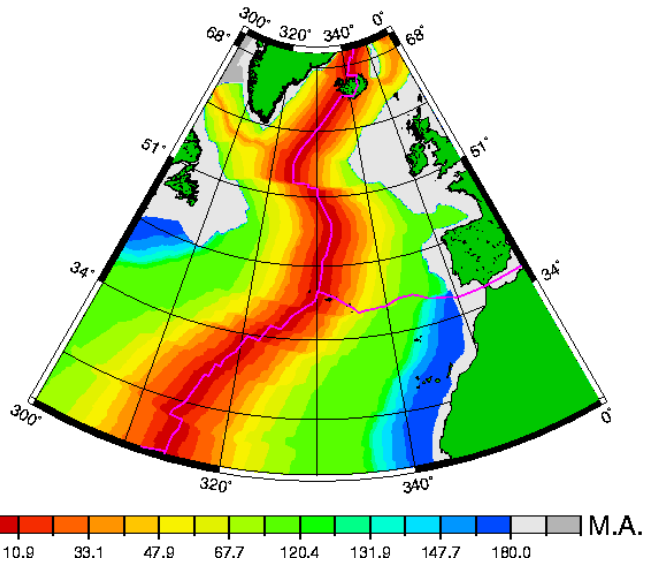

Figure 3: Sea-floor age of Müller et al. (1997) and plates from DeMets et al. (1990).

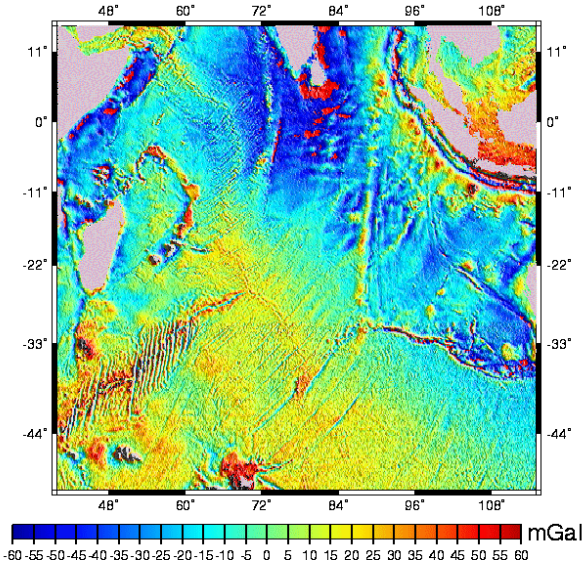

Figure 4: Free-air gravity anomalies in a part of the Indian ocean from Sandwell and Smith (1997). Dominant features are the Carlsberg, Southwest Indian and Southeast Indian ridges, the Bengal fan and the Ninety-east ridge. Resolution was restricted to 10 instead of 2 arc minutes.

References

DeMets, C., Gordon, R. G., Argus, D. F., and Stein, S. (1990). Current plate motions. *Geophys. J. Int.*, 101:425–478.

Dunbar, P. K., Lockridge, P. A., and Whitewide, L. S. (1997). *Catalog of Significant Earthquakes 2150 B.C.–1991 A.D.* Report SE-49. National Geophysical Data Center, Boulder, Colorado.

Dziewonski, A. and Woodhouse, J. (1983). Studies of the seismic source using normal-mode theory. In Kanamori, H. and Boschi, E., editors, *Earthquakes: observation, theory, and interpretation: notes from the International School of Physics "Enrico Fermi" (1982: Varenna, Italy)*, pages 45–137. North-Holland Publ. Co., Amsterdam.

EDC (1996). *Global 30 Arc Second Elevation Data Set*. EROS Data Center, Sioux Falls, South Dakota.

Gilly, D. (1994). *UNIX in a Nutshell*. O'Reilly & Associates, Inc., Cambridge.

Müller, D., Roest, W. R., Royer, J.-Y., Gahagan, L. M., and Sclater, J. G. (1997). Digital isochrons of the world's ocean floor. *J. Geophys. Res.*, 102:3211–3214.

NOAA (1988). *Data Announcement 88-MGG-02, Digital relief of the Surface of the Earth*. National Geophysical Data Center, Boulder, Colorado.

Ousterhout, J. K. (1993). *TCL and the TK Toolkit*. Addison-Wesley.

Rapp, R. H., Wang, Y. M., and Pavlis, N. (1991). The ohio state 1991 geopotential and sea surface topography harmonic coefficient models. Rep. 410, Dept. of Geod. Sci. and Surv., Ohio State University, Columbus, Ohio.

Sandwell, D. T. and Smith, W. H. F. (1997). Marine gravity anomaly from Geosat and ERS 1 satellite altimetry. *J. Geophys. Res.*, 102:10039–10050.

Simkin, T. and Siebert, L. (1994). *Volcanoes of the World*. Geoscience Press, Tucson, Arizona, 2nd edition.

Smith, W. H. F. and Sandwell, D. T. (1997). Global seafloor topography from satellite altimetry and ship depth soundings. *Science*, 277:195–196.

Steinberger, B. (1998). Plumes in a convecting mantle: Models and observations for individual hotspots. *J. Geophys. Res.* submitted.

USGS/NEIC (1998). *National Earthquake Information Center, World Data Center A for Seismology. Global Earthquake Search*. United States Geological Survey, National Earthquake Information Center, `http://wwwneic.cr.usgs.gov/neis/epic/epic_global.html`.

Wessel, P. and Smith, W. H. F. (1991). Free software helps map and display data. *EOS Trans. AGU*, 72:445–446.

Wessel, P. and Smith, W. H. F. (1995). New version of the Generic Mapping Tools released. *EOS Trans. AGU*, 76:329.

A Technical details

A.1 Organization of the (A)GIS software

After unpacking the `agis_v0.5.tar` file the directory should look something like this

```
> ls -F
01_02-98.cmt                    agis_menus.tcl
COPYING                         agis_parameters.tcl
COPYRIGHT                       agis_plotting.tcl
README                          colormaps/
agis*                           example1.dat
agis.tcl                        example1.ps.gz
agis_configure.tcl              example2.dat
agis_datasets.tcl               example2.ps.gz
agis_def.gif                    example3.dat
agis_gmtdefaults                example3.ps.gz
agis_helper_checkfile*          example4.dat
agis_helper_create_man_page*    example4.ps.gz
agis_helper_handle_gmtdefaults* hotspots.dat
agis_helper_rmtmp_silent*       manual.ps
agis_init.tcl                   nuvel.yx
agis_iomisc.tcl                 volcanoes.dat
```

where the `colormaps` directory contains the color tables for GMT.

```
> ls
col.00.cpt        col.11.cpt        col.22.cpt        col.33.cpt
col.01.cpt        col.12.cpt        col.23.cpt        col.34.cpt
col.02.cpt        col.13.cpt        col.24.cpt        col.35.cpt
col.03.cpt        col.14.cpt        col.25.cpt        col.36.cpt
col.04.cpt        col.15.cpt        col.26.cpt        col.37.cpt
col.05.cpt        col.16.cpt        col.27.cpt        geoid.cpt
col.06.cpt        col.17.cpt        col.28.cpt        gravity.cpt
col.07.cpt        col.18.cpt        col.29.cpt        seafloor_age.cpt
col.08.cpt        col.19.cpt        col.30.cpt        seafloor_age2.cpt
col.09.cpt        col.20.cpt        col.31.cpt        topo.cpt
col.10.cpt        col.21.cpt        col.32.cpt
```

The files in this distribution can be classified as follows:

Copyright: `COPYING` and `COPYRIGHT` deal with legal issues. (A)GIS is distributed under the GNU public license, see the file `COPYING`.

The `agis` file: A `ksh` script that is used to check if the environment variable `$agis_root` and `wish` is available at the places (A)GIS is looking. If all is fine, `wish` is invoked with `agis.tcl`. `agis_def.gif` is the start-up screen.

Tcl files: All files with the `tcl` extension contain the tcl code that runs (A)GIS. `agis.tcl` is the main file, it contains `source` commands and builds up some frames. `agis_configure.tcl` has all global variables and the default settings for plotting whereas `agis_init.tcl` handles the startup sequence. The file `agis_menu.tcl` holds the definition for the main menu line and the procedures found in `agis_datasets.tcl`, `agis_parameters.tcl` and `agis_plotting.tcl` correspond roughly to all possible actions in the individual pull-down menus. Finally, `agis_iomisc.tcl` contains most of the input/output routines and some additional tcl procedures.

All of these files should be fairly well commented so that I won't go into any detail here.

`agis_helper_` files These contain small `ksh` scripts that are called by (A)GIS' tcl routines and handle more operating system based processes. Most of them could be integrated into the main tcl code but it seemed more transparent for possible porting to other operating systems to keep them external.

`example.dat` and `.ps`: The `dat` files contain the parameter dump that was created with (A)GIS after the examples presented in sec. 7 were produced. The postscript files are packed with `gzip` and correspond to the shrinked figures in this manual and are not identical to the real postscript files produced (they were too big to be included in the distribution).

The file `manual.ps` is this manual, `nuvel.yx` is the modified plate boundary polygon file after DeMets et al. (1990) and `01_02-98.cmt` contains the Harvard CMT double couple fault plane solution for the first 60 days of 1998.

Colormaps: The `colormaps` directory contains the colormaps that are used by (A)GIS to map the default datasets. `col.00.cpt` through `col.35.cpt` are colormaps which span the data range from $-1 \ldots 1$.

B Modifying (A)GIS

(A)GIS may be freely modified and distributed as long as modified version are not called (A)GIS. There are plenty of easy possible future enhancements one could think of, for instance interactive design of colormaps, support of more complicated user data sets and multiple layers of raster data. When this extensions become available, they will be included in future versions. Some common modification (as opposed to extension or enhancement) tasks are described below:

Using other path names for the locally available data sets. This is easily done when its still the same format than the supported raster and polygon data sets, just change the pathnames in `agis_configure.tcl` or in your `agis_siteconfig.tcl` file.

Including new raster data sets. Make sure that the data is in one of the formats that can be read by `grdraster`, `img2latlongrd` or `grdimage` itself. Then include a new global path variable and raster data settings in `agis_configure.tcl`/`agis_siteconfig.tcl` as was done for instance for the gravity data. Next, include a new point in the menu in the `agis_menus.tcl` file after the old ones that lets you choose your new data file instead of the old ones. Last, add some new plotting commands in `agis_plotting.tcl`. With some familiarity with UNIX and GMT this should be easily done by "cut-and-paste" with the default data sets as examples.

Including new polygon data sets. In principle, this works the same way than for raster data with the exception that polygon data can be multi-layer and you need to introduce another global variable in `agis_configure.tcl`. How to do this should be evident when the custom xys files 1 and 2 are taken as an example.

Last resort. Contact Thorsten Becker (`becker@eps.harvard.edu`) or Alexander Braun (`braun@em.uni-frankfurt.de`).