1. Prefaces

1.1 Preface to version 3.1

GMT 3.1 is a major upgrade of the Generic Mapping Tools. However, most of the improvements are "under the hood", not readily visible to the user. The primary purpose of the present release is to ensure complete portability of GMT to as many hardware platforms as possible. To accomplish that goal we made three fundamental changes to the GMT source code:

1. All GMT source code strictly follows the ANSI C standard.
2. All GMT source code is POSIX compliant.
3. Architecture-independent files are read and written with netCDF 3.

Since the release of GMT 3.0 we have seen more 64-bit operating systems and a steady evolution of netCDF to accomodate such systems. GMT 3.0 has therefore become harder and harder to install and it was time for a significant upgrade. GMT 3.1 is now highly portable and has been installed and tested under Solaris, HP Unix, SGI Irix, Linux, MkLinuk, OSF, Ultrix, and Win32. The GMT package also is Y2K compliant.

Although portability has been our main concern, GMT 3.1 also delivers several new features and programs. Among the most significant offerings are:

1. Two new map projections (Gnomonic and Miller).
2. 90 built-in bit and hachure patterns and a new mechanism for color patterns. **–Gp|P** now accepts pattern *dpi* rather than block building *size*; *dpi* = 0 uses default dpi.
3. Full support for native binary table input/output for all programs that read tables.
4. Shorthand mechanism for 5 alternative 2-D grid formats via .gmt_io file.
5. Four new programs: *blockmode* for block-averaging by mode estimates, *gmtconvert* to translate between native binary and ASCII table formats, *gmtselect* to select subsets of table data based on multiple spatial criteria, and *grdvolume* for calculating volumes under surfaces within a specified contour. One supplemental program, *psimage*, has been revised and incorporated into the main GMT while another, *psmegaplot*, has been relegated to the supplemental archive.
6. Boundary condition options for several grid-generating or manipulating programs.
7. Improved *PostScript* BoundingBox implementation.
8. Numerous bug fixes (seae CHANGES for deltails).
9. More examples.
10. A new GMT map-making tutorial book and short-course.

In addition, several programs have more functionality thanks to new options. For example, *pscoast* can now set up clip paths based on the coastlines or dump an ASCII table rather than drawing them, and *psxy* and *psxyz* can read symbol codes from the input data. The following is a summary of new capabilities:

Program	Changes
blockmedian	**–Q** returns median *z* and the (*x*,*y*) at that value.
grd2xyz	**–S** suppresses nodes that equal NaN **–Z** extended to specify arbitrary binary output file formats
grdcontour	**–N** sets label unit, **–Z** optionally takes an offset
grdgradient	**–L** sets the boundary conditions at edges
grdinfo	**–C** formats output for easy parsing
grdmask	**–H** added
grdsample	**–L** sets the boundary conditions at edges

grdtrack	**–S** suppresses output that equal NaN, also **–L** as above
grdview	**–L** sets the boundary conditions at edges
makecpt	**–I** option to reverse grayramp
minmax	**–C** formats output for easy parsing
nearneighbor	**–L** sets the boundary conditions at edges
project	**–M** multisegment option. Also handles any number of input colums
pscoast	**–M** to dump ASCII coastline file, **–Gc** and **–Sc** to create clip paths
pscontour	**–L** to draw network triangles
pshistogram	**–L** to draw transparent histogram
psmask	**–F** option for pixel registration
psscale	**–E** to extend scale with fore- and back-ground colors
pstext	**–D** to translate basepoint after map projection
psxy[z]	**–SE** plots ellipses given axes in km (and thus replaces ellipse scripts) **–S** without symbol makes program read last column as symbol type
sample1d	**–A**, **–C**, and **–L** become **–Fa**|**c**|**l** but is backward compatible.
xyz2grd	**–Z** extended to specify arbitrary binary input file formats
–JM and **–Jm**	Optional forms are **–JM***lon*/*lat*/*width* and **–Jm***lon*/*lat*/*scale*

Speaking of *pscoast*, the coastline and political boundaries data bases have undergone modest changes and will continue to do so as we obtain better data. Several bugs have been fixed, and new political borders have been added (but not all).

While fixing inconsistencies and enhancing the GMT programs we do occasionally get into a situation which was best resolved by renaming a command line option. We do not like to do so since it introduces incompatibilities between versions of GMT; however, sometimes this is neccesary in order to fix a bug (as in *grdclip* and *grdpaste* below). This has in particular been used to ensure that the common command line options are unique and that some others have the same meaning in as many programs as possible. This is a list of incompatibilities between GMT 3.0 and 3.1, revise any GMT shell scripts accordingly:

Program	Change
grdclip.c	**–A** and **–B** have been replaced by **–Sa** and **–Sb**; the **–B** interfered with the usual meaning of **–B**.
grdpaste.c	Same problem; introduced **–Sa** and **–Sb.**
grdview.c	**–D** no longer an option; **–M** and **–W** follow *grdcontour* syntax and are set by –**Wc** and –**Wm**.
nearneighbor.c	–**M** is replaced by –**S***radius***k** as in *psmask*
project.c	–**M** becomes the multisegment flag as usual; old –**M** replaced by –**Q**.
psclip.c	–**S** becomes –**C**, and –**O** must now explicitly be set.
psmask.c	–**S** and –**C** have reversed roles to match *psclip*; –**M** is replaced by –**S***radius***k**.
psxy[z].c	–**L** only needed to close polygons; –**W**[*pen*] determines outlines.

In addition, no programs have the old option **–F** to change the color of the map frame. We did this to free up this option for future enhancements since the effect easily can be obtained via **gmtset** BASEMAP_FRAME_RGB r/g/b.

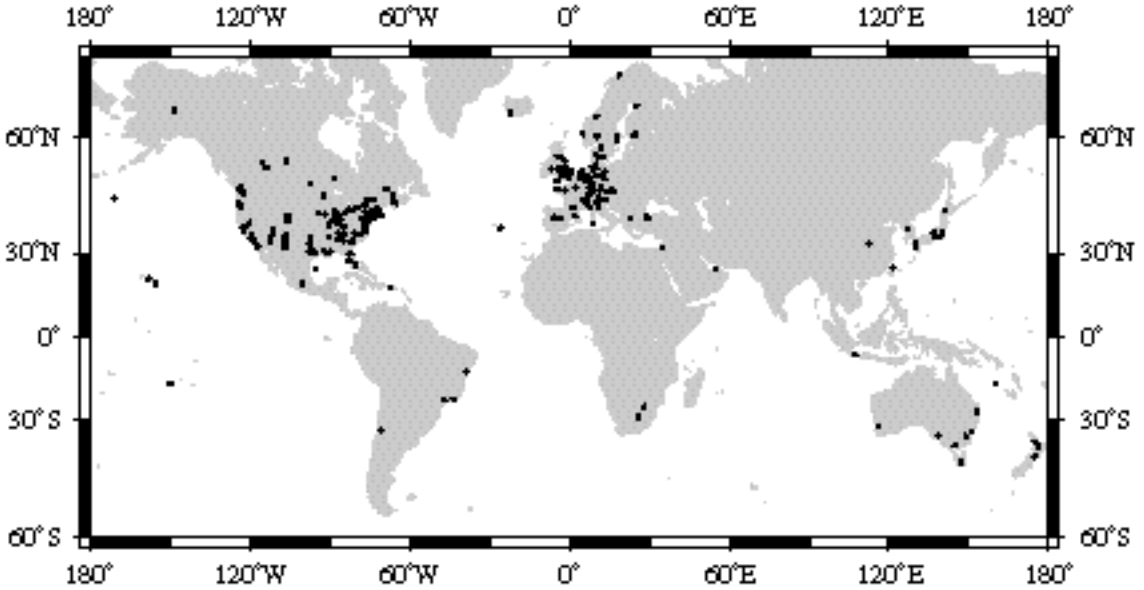
We have received many bug reports regarding GMT 3.0 and we have attempted to correct as many problems as we have had time for. Some of you may be disappointed in finding that GMT 3.1 still has a bug you reported to us. Part of our difficulty lies in the fact that GMT 3.1 has changed significantly since 3.0 so that it is not always easy to verify that a problem has been fixed or is still with us. Thus, while not bug-free, GMT 3.1

provides a more stable platform allowing easier verification and termination of bugs. We encourage you to discover (or rediscover) bugs and bring them to our attention.

Finally, we would like to thank those of you who continue to contributed ideas, bug reports, and advice since version 3.0. We appreciate your input, and believe version 3.1 reflects many of the suggestions you have provided.

1.2 Preface to version 3.0

As of January 1995 it appears that around 5000 scientists and engineers worldwide are using GMT in their work. This estimate is based on ftp traffic over the last few years. Most users of GMT are geoscientists, but there are apparently no limits to the kind of applications that may benefit from GMT: We know GMT is used in medical research, engineering, physics, mathematics, social and biological sciences, and by geographers, fisheries institutes, oil companies, and a wide range of government agencies.



A subset of all GMT users obtained by an electronic survey in October 1994. The circles represent approximately 200 separate institutions with more than 1600 GMT users combined.

The present version 3.0 represents a significant improvement over earlier releases. The most visible change is the inclusion of a high-resolution coastline data base which will allow the generation of small-scale, detailed maps of high quality and accuracy (see Appendix K for more details). In addition, we have added three more map projections, six new programs, modified and added new options to others, and killed numerous bugs. The file CHANGES on the tar archive has all the details; here are some highlights:

· Customizable grdfile i/o.

This allows the user to supply his/her own read/write kernels, link these with GMT during installation, and be able to use GMT programs directly with the user's data files. This mechanism also speeds up many operations by letting the user select a format that allows piping instead of saving the results of intermediate steps to temporary files (as is necessary with the netCDF format). In addition to the default netCDF-based gridfile format, GMT comes equipped with 3 additional formats:

- binary 4-byte floating points with leading grdheader (See Appendix B for formats)
- binary 2-byte short integers with leading grdheader

- Sun 8-bit standard rasterfile (colormap ignored).

The file gmt_customio.c contains information on how to add more formats. We anticipate that formats of general interest will be developed by enterprising users and forwarded to us for possible inclusion in later GMT releases.

· Binary i/o option for several i/o intensive programs.

Several programs typically read and/or write large amounts of data These include blockmean, blockmedian, grd2xyz, nearneighbor, splitxyz, surface, and xyz2grd. These programs are often used to decimate vast quantities of data, but much of the processing time can be spent on the ASCII-binary conversion during read and write. A new **–b** option allows these programs to do their i/o in native binary format (single or double precision).

· 4+ new map projections.

We have included the Robinson pseudo-cylindrical projection (adopted by the National Geographic Society), the Eckert VI equal area projection, the Plate Carré equidistant cylindrical projection, and a generic cylindrical equal area projection. The latter accepts an arbitrary standard latitude: Set to 0˚, 30˚, 37.4˚, or 45˚ you obtain the Lambert, Behrmann, Trystan-Edwards, and Peters (Gall) cylindrical projections, respectively. Furthermore, we have generalized the sinusoidal projection. The interrupted map on the cover page is a superposition of three sinusoidal plots that are offset horizontally.

· 6 new programs.

Programs have been added to address several important tasks:

grd2cpt	Creates a color palette table based on a grdfile
grdlandmask	Creates "wet-dry" mask grdfile from shoreline data base
grdreformat	Converts between various grid formats
grdvector	Draws vector field plots for gridded files.
pscontour	Contouring of raw xyz data (by triangulation)
triangulate	Optimal Delaunay triangulation and gridding of xyz-data

· Simpler map projection option **–J***.

All projections may now be specified with upper or lower case modifier *: Lower case works as before (it expects map scale), while upper case expects map width. This makes it much easier to fit a plot on the page. E.g., **–Jm**5 will generate a Mercator map in which 1˚ of longitude equals 5 inches (or cm, depending on your choice of units), while **–JM**5 will make a map that is 5 inches (or cm) wide regardless of region selected (in both cases, the height will of course depend on region).

All projections now accept arbitrary regions in the **–R** option (in earlier versions there were some projections that implicitly assumed a global map **–R**0/360/-90/90).

· Improved syntax checking.

All GMT programs now have extensive syntax checking and give shorter and more meaningful error messages. It is only when no arguments are provided that the entire usage message will be echoed.

· Better SI support

During installation of GMT you may choose to use SI units as your default (basically, it means that plot sizes are measured in cm instead of inch). This will modify the source code to show the SI default values and produce man pages using SI units. However, you can always override the defaults by modifying your .gmtdefaults file.

· Operational changes.

A few modifications of command arguments have taken place. If you have developed shell-scripts with GMT commands you may need to edit these accordingly:

- The **-#** option (for multiple plot copies) has been replaced by **-c** to avoid problems in cshell scripts (# is the start of a comment in cshells).
- The optional 'r' suffix in **–J** has been moved to the **–R** option.
- *grdmath* is now a general-purpose Reverse Polish Notation (RPN) calculator for grd-files. Hence, the order of the arguments is different.
- The *+file* mechanism to read alternative .gmtcommands files has been changed to apply to alternative .gmtdefaults files. This is more useful since one can now use this mechanism to select different default settings for different output devices (e.g., slidemakers, laserwriters, camera-ready journal formats, etc.).
- 2-D interpolations are now done as bicubic or bilinear interpolation (Taylor expansion is gone).
- Option **–T** in *grdview* (to smooth contours) has been renamed **–S** to match the usage in *grdcontour*.
- *psxy* now clips polygons that exceed the map region correctly
- The improved **–U**[*/x0/y0/*][*label*] option now allows you to specify where you want the timestamp to appear relative to the lower-left corner of the current plot (not page). This would override the default location (-0.75, -0.75) (inches) or (-2,2 cm).

· Several programs have received additional options.

- grdcontour	Added **–M** to create a single multisegment file when using **–D**.
	–C will accept a cpt file if the name ends in ".cpt"
- grdmath	Added hypot, r_squared, min, and max operators
- nearneighbor	Added option **–W** for weighted data input
- psbasemap	Added option **–L** to draw map scale
- pscoast	Added option **–L** to draw map scale and **–I** to draw rivers
- pshistogram	Added **–S** to draw stair-step diagram
- pstext	Added option **–N** to not clip text at boundaries
- pswiggle	Added option **–S** to draw z scale
- psxy	Added **–Sl** option to plot an arbitrary letter or string
	Added option **–N** to not clip symbols at boundaries
- psxyz	Added option **–N** to not clip symbols at boundaries

The documentation (this book plus all manual pages) has been updated to reflect these changes. Two new appendices (J, K) discussing the finer points of filtering and the development of the high-resolution coastline data base have been added.

Finally, we would like to thank those of you who have contributed ideas, bug reports, and advice since version 2.1. We continue to appreciate your input, and believe version 3.0 reflects many of the suggestions you have provided.

1.3. Preface to version 2.1

Since GMT was announced in EOS in October 1991 we have seen more than 1000 ftp requests for the software, and received about 200 registration forms. The large number of new users resulted in many discoveries of bugs and "features" in the programs. Many of these bugs were fixed and the tar distribution was updated accordingly, resulting in versions 2.0.1 and 2.0.2. After the last release (2.0.2), enough modifications have taken place to warrant the update of the documentation and manual pages. In addition to [hopefully] killing most of the bugs, many programs have been equipped with new features. The most significant changes from 2.0 to 2.1 are:

- More map projections. We have added the Albers conic equal area, Cassini cylindrical, Orthographic, Azimuthal equidistant, Hammer equal area, Interrupted sinusoidal, and Winkler projections, bringing the number of map projections to 15.
- 3-D plotting. Most plotting programs will now accept viewpoint and vertical scale information, making it possible to plot perspective-view versions of most plots.
- Coastline data have been reformatted and are now stored using netcdf. This improves the portability of GMT and reduces the size of the distribution archive.

Specific minor enhancements to individual programs can be found in the manual pages. The documentation has been augmented to include a detailed section on the syntax of each of the map projections, including examples. An appendix (C) explaining how to convert GMT *PostScript* output to a Macintosh Encapsulated *PostScript* File (EPSF) also has been added.

Finally, we would like to thank those of you who have contributed ideas, bug reports, and advice since the first release. GMT 2.1 is a much better product than 2.0, but there are still several shortcomings that we hope to address in future releases. We are working on including a high-resolution coastline data base, more map projections, and time-series capabilities (recognizing misc. time formats at the data input/output stage, providing time axis annotation, etc.), just to name a few. As usual, information about these improvements will be announced to registered users by electronic mail.

1.4. Preface to version 2.0

When GMT was released at Lamont-Doherty Earth Observatory in the summer of 1988 it quickly became the standard data manipulation and plotting package which Lamont-Doherty scientists used to massage data and generate camera-ready maps and diagrams. Shortly afterwards color capabilities were added, and color maps and illustrations could easily be viewed under *NeWS*[1] on the SUN workstations, slides could be shot off the screen, and screendumps sent to various color hardcopy devices. Mostly by word of mouth, the number of GMT users among individuals and institutions elsewhere grew to include major research centers both in Europe and the U.S. The system proved easy to use, was general enough so that no matter what data you had, it could be manipulated and plotted, and it produced *PostScript*[2] output which could easily be edited to include custom enhancements. By keeping data files in the ASCII format, most trivial tasks of formatting and processing would be handled by *UNIX* utilities such as *awk, grep, cut, paste, sed,* etc.

GMT has undergone several modifications since its incarnation more than three years ago. The number of map projections available has doubled and now includes Mercator, Oblique Mercator, UTM, Stereographic, Lambert's conformal conic, Lambert's azimuthal

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[1] *NeWS* is a trademark of SUN Microsystems, Inc.

[2] *PostScript* is a trademark of Adobe Systems Inc.

equal-area, and Mollweide equal-area projections. In addition, non-map projections like $\log_{10}(x)$ and x^{α} have been added to the standard linear projection.

The plotting library **pslib** and the map drawing library **gmtlib** have been completely rewritten, resulting in higher quality graphics and more control over details. The *PostScript* macros defined in **pslib** have been optimized, resulting in smaller output files and shorter execution times.

A major new feature is the concept of the .gmtdefaults file. In this file, which will reside in the user's home directory, we find more than 50 parameters including the pen-thicknesses, font-types, and colors to use for maps, which ellipsoid to employ in the map projections, and what units to operate in (cm, inch, or meter). All of these can be set individually by the user, thus customizing GMT defaults to produce the desired results without excessive command line arguments when running individual programs or having to edit the *PostScript* files at a later stage.

In order to make the operation of GMT programs more efficient, the notion of a command history has been implemented. The history remembers the previous standardized command line arguments used with any GMT program and allows the user to use a shorthand when the same argument is needed. This information is stored in a file called .gmtcommands which is maintained in the current directory. Thus more than one .gmtcommands file can exist at the same time.

Finally, the format used for storing 2-D gridded data sets has been changed. The new format is based on the XDR architecture-independent data representation as implemented in the netCDF software package available from NCAR (See Appendix D for how to obtain the necessary code). The advantages of using this new format are many; here we will just mention scanline orientation and the ability to transfer your binary gridded data sets from one type of computer to another which may not have the same way of representing floating point numbers.

With all these enhancements, GMT now supports most accepted standards of today's computing environments: *UNIX*, *PostScript*, ASCII tables, and XDR binary file protocol. We hope the new version 2.0 of GMT will enhance your productivity and make data manipulation and presentation a little bit easier. Should you have any suggestions to future enhancements and modification, we would like to hear from you. Please send your comments to gmt@soest.hawaii.edu.