**tectoplot**

tectoplot is a bash script and some helper scripts that make nice maps and cross sections using GMT, with a focus on making regional seismotectonic maps. This script allows a more exploratory style of analysis of typical geophysical datasets, while also producing publication quality figures in EPS/PDF format, in the reproducible (and free) scripting workflow provided by a UNIX shell and GMT. tectoplot generates intermediate and final datasets that are stored in a temporary data folder, providing an easy way to extract and process data to be used elsewhere.

To take advantage of GMT’s full functionality, tectoplot can run custom scripts in-line during execution, allowing access to the full suite of GMT commands as well as other external commands.

tectoplot incorporates several global plate motion datasets (currently MORVEL56-NNR, GBM, GSRM). The plate motions and plate-boundary kinematics described by these datasets can be used to understand complex tectonic regions. Plate polygons have been sanitized and oriented for these datasets in advance, and plate boundary segment azimuths and relative motions at segment midpoints have been precomputed.

tectoplot can also plot most of the results of TDEFNODE models.

tectoplot has a straightforward swath profile functionality built on top of GMT’s gridtrack module, which will plot and output the 0, 25, 50, 75, and 100% quantiles of cross-profiles. The same procedure can orthogonally project general XYZ data, seismic XYZM data, and focal mechanisms (using pscoupe) onto multi-segment profile lines. The profiles can be automatically shifted in X and Z directions based on the intersection of the profile tracks with an XY polyline, allowing stacking of (for instance) aligned profile data. The swath data and projected XYZ/seismic data are output to files for external use.

tectoplot is designed to work with regional scale datasets in geographic coordinates (geodetic latitude and longitude) and is not tested for projected data or for very small areas of interest.

**OPTIONS**

**REGION**

AOI: -r MINLON MAXLON MINLAT MAXLAT

Global: -r g

Country: -r ID

Lat/Lon arguments are in decimal degrees.

The -r option provides the map data area of interest, which is used to clip grid and other data before plotting, and which commonly coincides with the limits of the map frame. However, projections specified using the -RJ option will not necessarily have map frames that coincide with a rectangular (in geographic coordinates) REGION.

If an alternative projection is not specified using -RJ, the map will use the equidistant cylindrical projection (GMT -JQ) referenced to lon\_min (possibly will update to use lon\_ave instead).

-r g sets the AOI to [-180 180 -90 90]

-r ID uses a 2 character country code to query GMT for a spatial extent, buffered by 1 degree. This will currently cause problems for countries that span the international date line (notably the USA).

**POLYGON AOI** ( -pg|--polygon polygon\_file.xy )

Use an XY polygon to select data instead of the AOI box.

**PROJECTION** (-RJ { -Rarg1 -Jarg2 } )

**GRID** (-B { -Barg1 -Barg2 … } )

The -RJ option sets the region and projection of the map area, using GMT -R and -J command strings. The -B option sets the parameters for plotting the grid, which is plotted the final element plotted on the map and which overlays everything else.

If -B option is not selected, we will use the automatically determined grid from GMT.

|  |  |
| --- | --- |
| tectoplot -RJ { -Rg -JQ0/5i } -B { -Bxafg -Byafg } -a l –-open  plots a global map, in equidistant cylindrical projection centered on Lon=0°, 5 inches wide | A close up of a map  Description automatically generated |
| tectoplot -RJ { -Rg -JG0/10/60/5i } -B { -Bxafg -Byafg } -a l –-open  plots a global map, in orthographic projection centered on Lon=0°, Lat=0°, 5 inches wide | A picture containing building, game, drawing  Description automatically generated |

**COASTLINES** (-a|--coast [[quality]])

Plot GMT coastlines from GHSSG using gmt pscoast. Currently only plots sea-land coasts as lines; should eventually also plot lake/land as well.

Quality levels are:

a – auto, f – full, h – high, i – intermediate, l – low, c – crude

**COAST/SEA FILL** (-ac [[landcolor]] [[seacolor]])

When plotting coastlines, fill the land and sea with the given colors. You can fill only land areas by specifying a single color after -ac.

|  |  |
| --- | --- |
| tectoplot -RJ { -Rg -JG0/10/60/5i } -B { -Bx30afg -By30afg } -a l -ac gray lightblue --open | A close up of a logo  Description automatically generated |

**SEISMICITY** (-z [scale])

Default size: 0.05i

DATA FILE FORMAT: LON LAT DEPTH MAG (…), whitespace separated fields

-117.9565 36.4803333 0.57 3.15 1950-12-30T16:08:52.120Z ci3342445

Depths are positive downward relative to sea level, in km. Magnitudes are MW values, which can be calculated from M0 using A picture containing drawing

Description automatically generated

The scale factor argument provides a constant multiplicative scaling of the symbol size.

By default, seismicity is scaled by magnitude and colored by depth. The transition to blue colors in the default color stretch is controlled by the EQMAXDEPTH parameter (+km downward from sea level). The CPT file is shared with Slab2 seismicity and a few other depth-dependent data types.

The relative size of seismicity can be controlled by setting the SCALEEQS flag to 1 and providing an exponential factor (SEISSTRETCH) and a MW magnitude that will be unaffected by the stretch (SEISSTRETCH\_REFMAG). EQ magnitudes M will be scaled by M^(SEISSTRETCH)/(SEISSTRETCH\_REFMAG^(SEISSTRETCH-1)). This scaling is not reflected in the ouput data files.

The SCALEEQS flag and SEISSTRETCH/SEISSTRETCH\_REFMAG parameters are also seen by the -mprof routine when data are labelled with the > indicator, e.g.:

> /path/to/eqdata.txt 150k -1 -W0.2p,black -C/path/to/cptfile.cpt

When focal mechanisms are being plotted with seismicity, tectoplot will (if REMOVE\_EQUIVS==1) identify equivalent events between the seismicity and the CMT database and remove the seismicity events. This avoids double-plotting of events. The calculation is done using the origin or centroid location, depending on which has been specified as the CMT data source. The cutoff latitude/longitude difference is currently 2° and the allowable difference in time is 5s.

Because the older catalog data has many USGS solutions with fixed depths that are wildly ugly when plotted in cross section, tectoplot will by default remove the most common default depth events from the cross section (REMOVE\_DEFAULTDEPTHS==1), and will plot those events as gray symbols on the map underneath the colored seismicity (REMOVE\_DEFAULTDEPTHS\_WITHPLOT==1).

**TOPOGRAPHY/BATHYMETRY** (-t [[source]])

Plot colored shaded relief derived from [[source]] dataset.

**X-Z PROFILE** (-mprof control\_file width height Xshift Yshift)

**CMT (focal mechanisms)**

tectoplot deploys some scripts that will download GCMT .ndk files and the entire ISC focal mechanism database (which contains many events reported by other institutions than GCMT). However, there are some challenges with the synchronizing the ISC/GCMT database. ISC reports multiple focal mechanisms per event, and includes some (but apparently not all?) GCMT events.

We create a merged focal mechanism database by first discarding any ISC events without nodal plane or magnitude data. We separate CENTROID vs ORIGIN locations and clean the databases separately, because ISC reports CENTROID locations only for some events. We then remove all ISC events for which there is a GCMT equivalent (based on the GCMT data source tag in the ISC database). We then remove events which have multiple ISC sources, leaving only the most prevalent source (largest number of focal mechanisms in the database from that source). We then compare each event with the next event in time from the whole catalog, and remove events that occur within 30 seconds and 0.1° of each other, preferring GCMT over ISC when possible. This generally removes ISC events that are in the GCMT database but had no GCMT equivalent in the ISC database for some reason. We don’t handle triple events.

The resulting database of focal mechanisms is generally cleaned of repeated events. The ID code for the events is the date string in the format yyyy-mm-ddThh:mm:ss which can be directly compared with scraped ANSS event data.

The option to cull equivalent events is set by REMOVE\_EQUIVS=1 (default) and is activated when both CMT and seismic data are plotted. In some areas, the culling can remove ~10% of events and significantly improve the plotting of CMT+seismic data together.

|  |  |
| --- | --- |
|  | tectoplot -r 112 120 -12 -10 -t 10m -z -c GCMT\_ORIGIN --open -setvars { REMOVE\_EQUIVS 0 SEISSTRETCH 4 SCALEEQS 1 SEISSTRETCH\_REFMAG 6 } -o nocull.pdf  GCMT centroid locations avoid overlap of events. |
|  | With culling, 116 events were removed from the seismic catalog. |

tectoplot can currently plot focal mechanisms in two formats: psmeca -Sc (GCMT format, best double couple indicated by nodal plane SDR, Mw) and psmeca -Sm (Moment tensor format, 6 components + mantissa and exponent). The -Sc format is default, and the format can be changed using -setvars {

**PROFILES**

-mprof)

CONTROLFILE WIDTH HEIGHT XOFFSET YOFFSET

: psmeca are projected so that the direction you are looking has the lower x axis values to the left, the higher x axis values to the right, and depth increasing downward.

Profiles are plotted in bare x-z space. If a cross-line is specified in the control file, then the profiles will be shifted in the x direction so that their intersection with the cross line occurs at x=0. If the y-adjust option is set, a constant shift will be added to each profile so that the z value at x=0 is equal to 0.

The profile will be marked on the map according to is specified color, and an inverted triangle will be plotted at each vertex (filled at first vertex). These points are marked above the cross section itself as inverted triangles.

Profiles can address datasets that exist within the temporary data directory, including selected seismicity (eqs.txt) and focal mechanisms (cmt.dat). These particular data files are written after equivalent event removal and size stretching, so the plot on the cross section will match the plotted data on the map.

Other seismicity, XYZ, and focal mechanism data can be specified.

Grids can be sampled either using a single line profile with sampling distance indicated, or using a swath profile method that plots the quantiles of the data and requires swath width, swath spacing, and sub-swath spacing parameters.

The symbology of these datasets is generally indicated in the control file through additional GMT arguments that are fed to the appropriate plotting module (psxy, psmeca, etc).

-sprof)

[LON1] [LAT1] [LON2] [LAT2] WIDTH(k)

A profile plot can be created on the fly using the -sprof command. Specify the coordinates of the profile endpoints and the full profile width as a number ending in k, (e.g. 10k, 150k). IF topography is plotted, a swath profile will be created. IF seismicity or CMT data are plotted, they will also be included in the profile any symbolized using the seismic CPT color scheme. The x and z axes limits will be automatically estimated from the total data plotted. The width, height, and vertical/horizontal offset of the profile plot are the default values.

(NOTE: will implement a SPROF\_MAX\_DEPTH parameter to limit the depth of the profile, set with -setvars { }).

**3D OBLIQUE VIEW**

**-ob [[azimuth °]] [[inclination °]]**

If the -geotiff flag has been specified, use -ob to plot the tiff image in an oblique 3D perspective view from the given azimuth and inclination, with an underlying grid frame floating beneath. The vertical exaggeration will be set by the default -JZ0.5i option.

The output of this command is saved as oblique.ps and oblique.pdf in the temporary folder.

A picture containing table, pair, cake, bed

Description automatically generated

tectoplot -n -r 110 120 -15 -5 -t -tc grayhs.cpt -v BG 70 rescale --open -geotiff -ob 135 25

To implement: Manual specification of vertical exaggeration factor

**TECHNICAL NOTES**

On OSX, filenames on HFS+ filesystems are case insensitive. This causes problems with using filenames as tags for various data (e.g. NB\_1.pldat == nb\_1.pldat). Files will always get overwritten rather than created. This is important for plate models like MORVEL56 with identical plate names nb/NB.