GEOS 436 / 636
Programming and Automation for Geoscientists

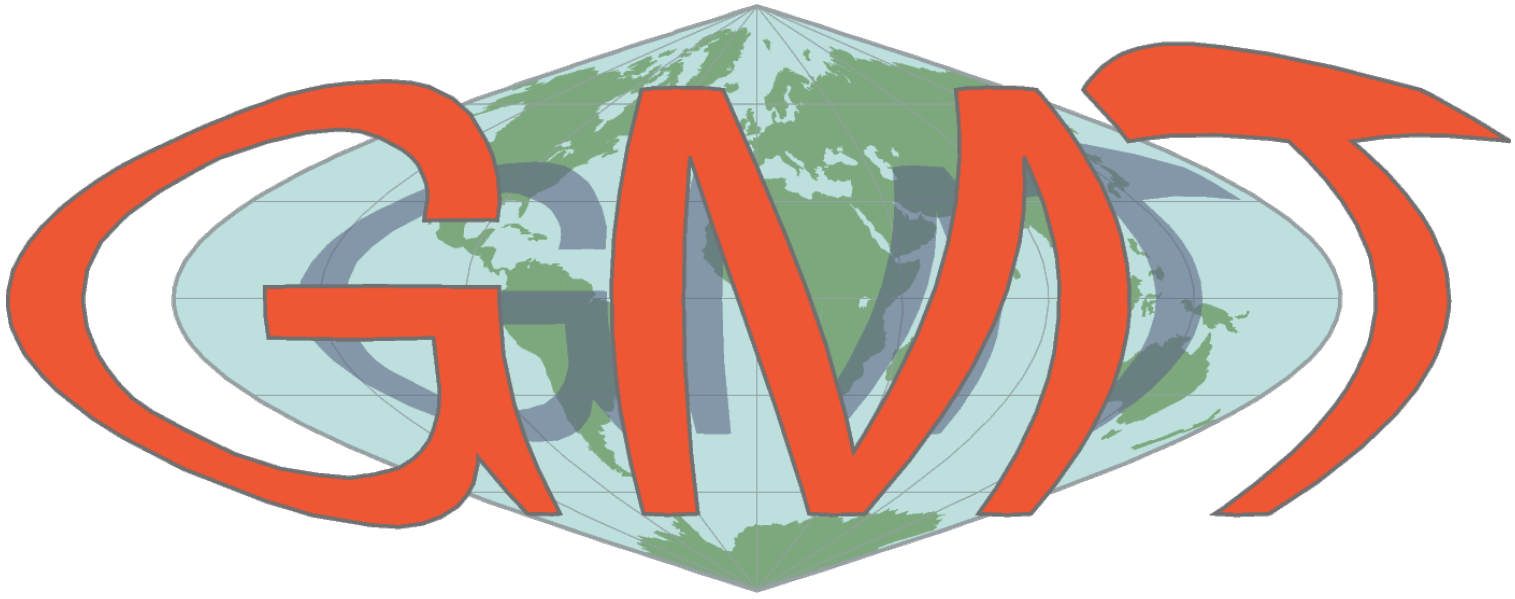
– Week 13: Generic Mapping Tools II –

Ronni Grapenthin
rgrapenthin@alaska.edu
Elvey 413B
x7682

How to automate making publication-quality:

- maps,
- x-y plots,
- animations

using world class base data sets while having maximum flexibility regarding layout of your product?



THE GENERIC MAPPING TOOLS

https://www.generic-mapping-tools.org

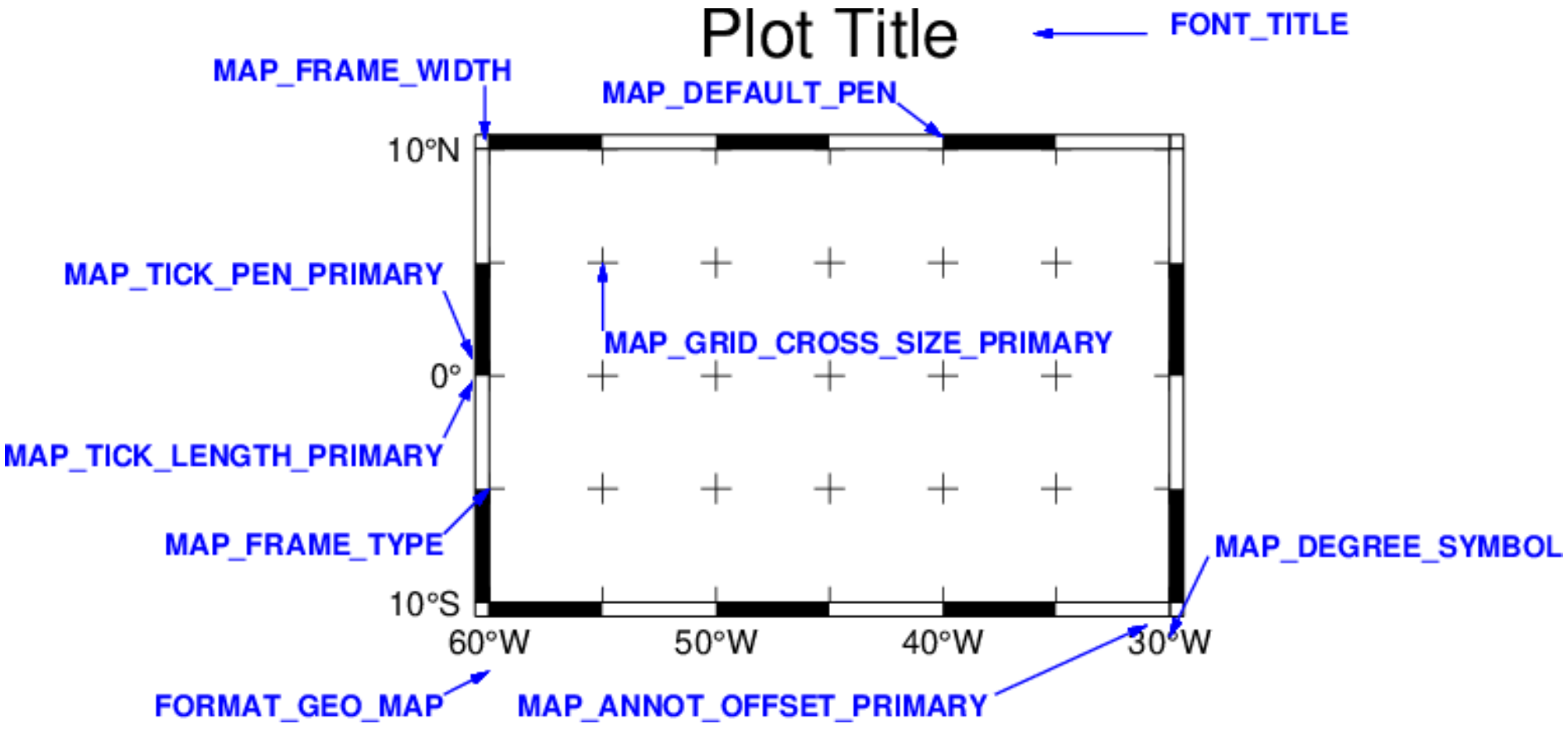
Changing `gmtdefaults`

Last time:

```
gmt set MAP_FRAME_TYPE plain
```

What other parameters are there?

Changing `gmtdefaults`



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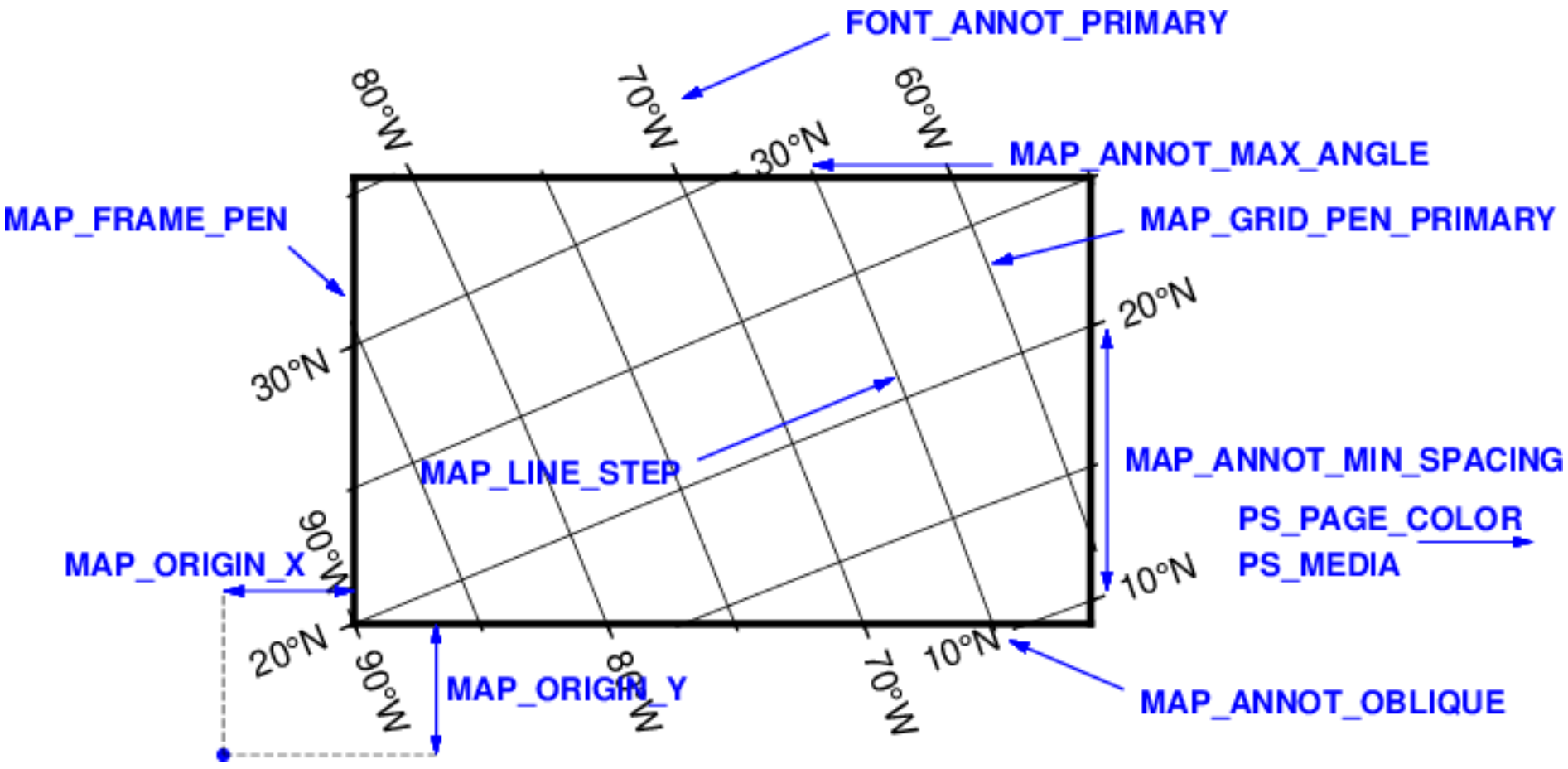
Changing `gmtdefaults`



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Changing `gmtdefaults`

Basic Syntax:

```
gmt set PARAMETER1 value1 PARAMETER2 value2 ...
```

- Use in shell script or on command line
- Changes defaults temporarily (session)
- Can be called many times
- Can be called to set values for a few commands and then reset them later.
- See `https://docs.generic-mapping-tools.org/latest/gmt.conf.html` for full list or parameters.

Changing `gmtdefaults`

Another example

```
gmt set FONT_ANNOT_PRIMARY 12p,Helvetica MAP_GRID_CROSS_SIZE_PRIMARY 0.1i
```

Grids

- We used GMT's mechanism to download a topo grid for Mt. St. Helens
- Downloaded to netCDF files (for 1 s resolution) in
  `~/.gmt/server/earth/earth_relief/earth_relief_01s_g/`
- netCDF is special format to combine data and meta data
- We can inspect this with `gmt grdinfo`

Grids

```
gmt grdinfo N46W122.earth_relief_01s_g.nc
```

```
(pag_gmt) jovyan@jupyter-rgrapentihn:~/.gmt/server/earth/earth_relief/earth_relief_01s_g$ gmt grdinfo N46W122.earth_relief_01s_g.nc
N46W122.earth_relief_01s_g.nc: Title: Produced by grdconvert
N46W122.earth_relief_01s_g.nc: Command: grdconvert /home/jovyan/.gmt/server/earth/earth_relief/earth_relief_01s_g/N46W122.earth_relief_01s
_g.jp2 -G/home/jovyan/.gmt/server/earth/earth_relief/earth_relief_01s_g/N46W122.earth_relief_01s_g.nc=ns -fg -Vq --IO_NC4_DEFLATION_LEVEL=
9 --GMT_HISTORY=false
N46W122.earth_relief_01s_g.nc: Remark:
N46W122.earth_relief_01s_g.nc: Gridline node registration used [Geographic grid]
N46W122.earth_relief_01s_g.nc: Grid file format: ns = GMT netCDF format (16-bit integer), CF-1.7
N46W122.earth_relief_01s_g.nc: x_min: -122 x_max: -121 x_inc: 0.000277777777778 (1 sec) name: longitude n_columns: 3601
N46W122.earth_relief_01s_g.nc: y_min: 46 y_max: 47 y_inc: 0.000277777777778 (1 sec) name: latitude n_rows: 3601
N46W122.earth_relief_01s_g.nc: z_min: 262 z_max: 4384 name: z
N46W122.earth_relief_01s_g.nc: scale_factor: 1 add_offset: 0
N46W122.earth_relief_01s_g.nc: format: netCDF-4 chunk_size: 129,129 shuffle: on deflation_level: 9
GEOGCS["unknown",
    DATUM["WGS_1984",
        SPHEROID["WGS 84",6378137,298.257223563,
            AUTHORITY["EPSG","7030"]],
        AUTHORITY["EPSG","6326"]],
    PRIMEM["Greenwich",0,
        AUTHORITY["EPSG","8901"]],
    UNIT["degree",0.0174532925199433,
        AUTHORITY["EPSG","9122"]],
    AXIS["Longitude",EAST],
    AXIS["Latitude",NORTH]]
```

Why have data on grids?

- Provides regular spacing
- Easy to contour
- Easy quantitative analysis
- Consistent representation of data
- Saves disk space (store two coordinates, x and y increments, and data values)

Contouring gridded data sets

- Use `grdcontour` on `.grd, .nc` files
- Produces contour map by tracing each contour through 2D grid
- Could also save x,y,z positions of contour lines to output files
- . . . has many options, most useful ones:

Option	Purpose
-A*annot_int*	Annotation interval and attributes
-C*cont_int*	Contour interval
-G*gap*	Controls placement of contour annotations
-L*low/high*	Only draw contours within the *low* to *high* range
-Q*cut*	Do not draw contours with fewer than *cut* points
-S*smooth*	Resample contours *smooth* times per grid cell increment
-T[**+**|**-**][**+d***gap*[*/length*]][**+l**[*labels*]]	Draw tick-marks in downhill
	direction for innermost closed contours. Add tick spacing
	and length, and characters to plot at the center of closed contours
-W[**a**|**c**]*pen*	Set contour and annotation pens
-Z[**+s***factor*][**+o***offset*]	Subtract *offset* and multiply data by *factor* prior to processing

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Contouring Mt. St. Helens example

```
#grdcut the region of interest from earth relief data set
gmt grdcut @earth_relief_01s -R-122.4/-121.95/46.0/46.33 -Gsthelens.nc -V
```

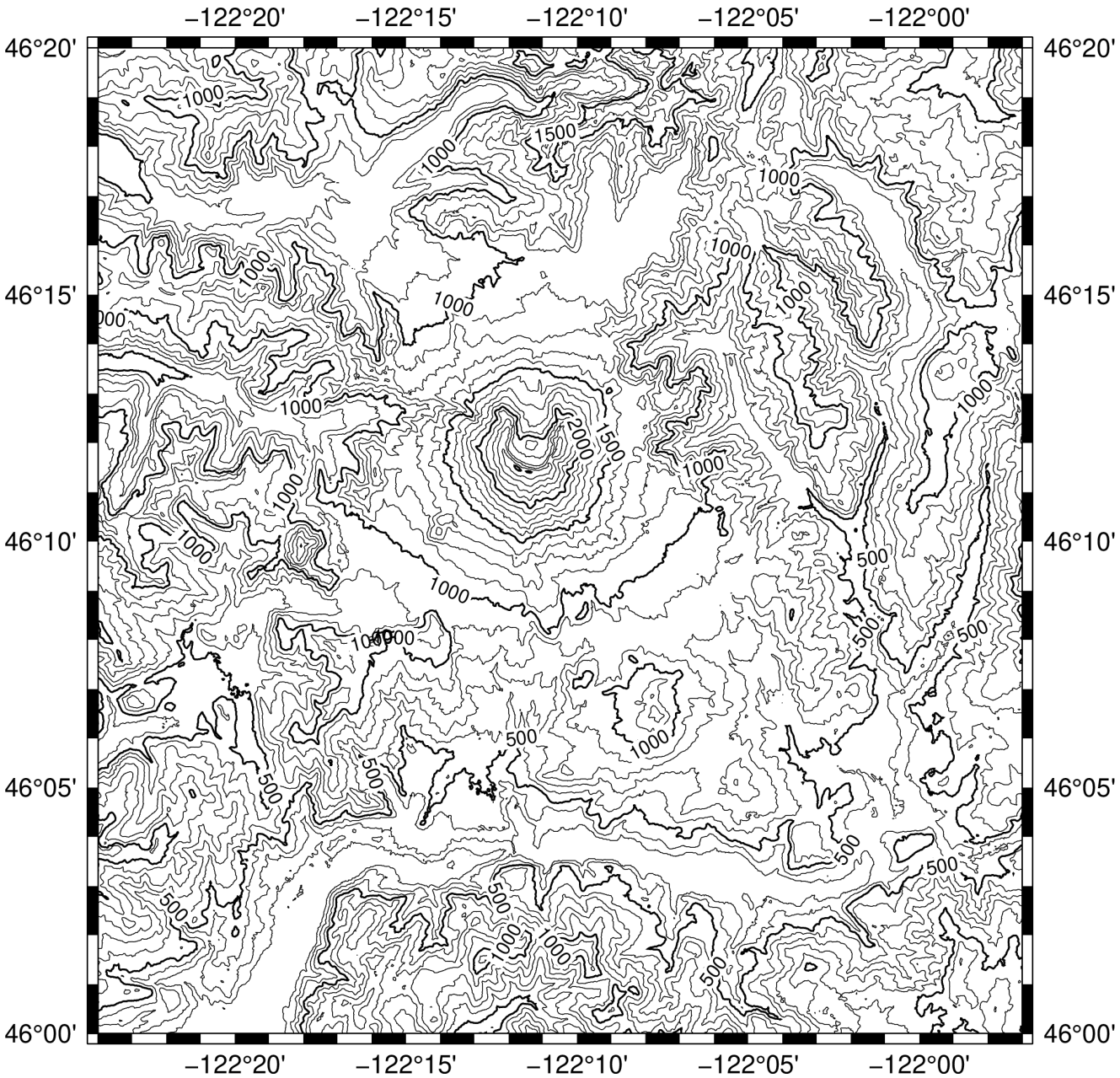
```
(pag_gmt) jovyan@jupyter-rgrapentihn:~$ gmt grdinfo sthelens.nc
sthelens.nc: Title: Produced by grdcut
sthelens.nc: Command: grdcut @earth_relief_01s_g/ -R-122.4/-121.95/46.0/46.33 -Gsthelens.nc -V
sthelens.nc: Remark:
sthelens.nc: Gridline node registration used [Geographic grid]
sthelens.nc: Grid file format: nf = GMT netCDF format (32-bit float), CF-1.7
sthelens.nc: x_min: -122.4 x_max: -121.95 x_inc: 0.000277777777778 (1 sec) name: longitude n_columns: 1621
sthelens.nc: y_min: 46 y_max: 46.3333333333 y_inc: 0.000277777777778 (1 sec) name: latitude n_rows: 1201
sthelens.nc: z_min: 139 z_max: 2525 name: z
sthelens.nc: scale_factor: 1 add_offset: 0
sthelens.nc: format: netCDF-4 chunk_size: 136,134 shuffle: on deflation_level: 3
```

Contouring Mt. St. Helens example

```
#grdcut the region of interest from earth relief data set
gmt grdcontour sthelens.nc -JM6i -C100 -A500 -B -png sthelens_contour

#can also use earth_relief directly
gmt grdcontour @earth_relief_01s -R-122.4/-121.95/46.0/46.33 -JM6i -C100 -
```

Contouring Mt. St. Helens example



Don't have a `.grd` file ...

Use `xyz2grd`

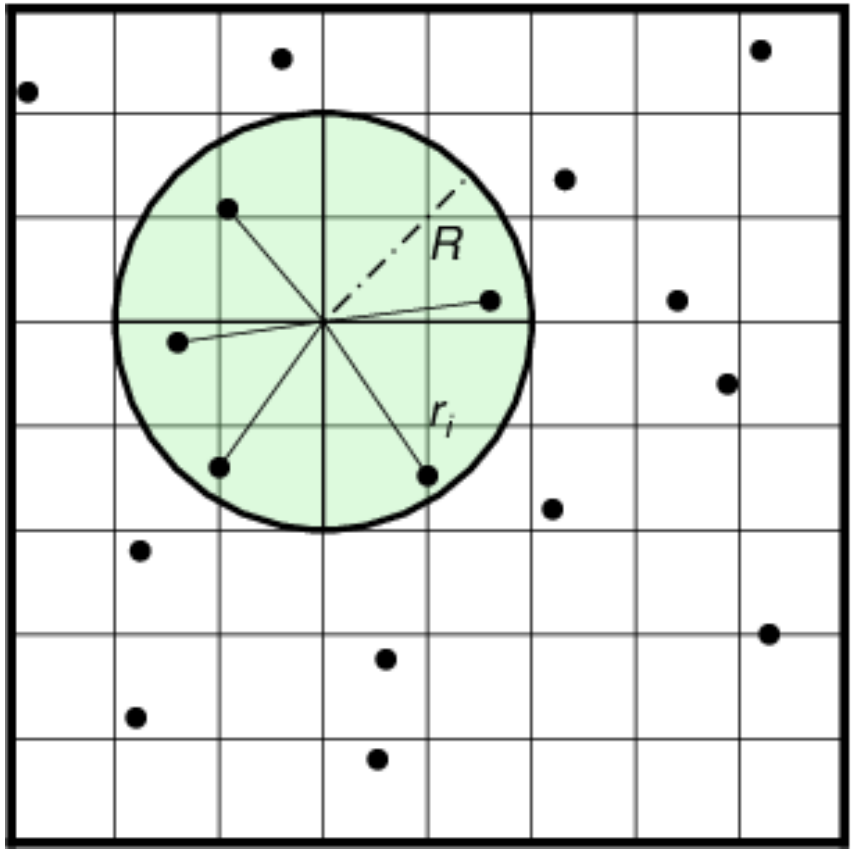
- Converts z-table or xyz-table to regular grid file
- Reports if nodes are lacking data
- Fills such nodes with user-specified value or NaN
- Nodes with multiple values will be set to mean
- Does **not** grid the data, just reformat!

Gridding of arbitrarily spaced data

- Requires interpolation onto regular grid (called “gridding”)
- All gridding modules in GMT must specify gridding domain (region, increment; -R, -I) and output grid filename (-G)

Nearest Neighbor Gridding: `nearneighbor`

- Preferred for high data density
- Simple nearest neighbor averaging, weighted by distance from node
- Local procedure: only considers data inside search radius (-S) around output grid node



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Other gridding methods

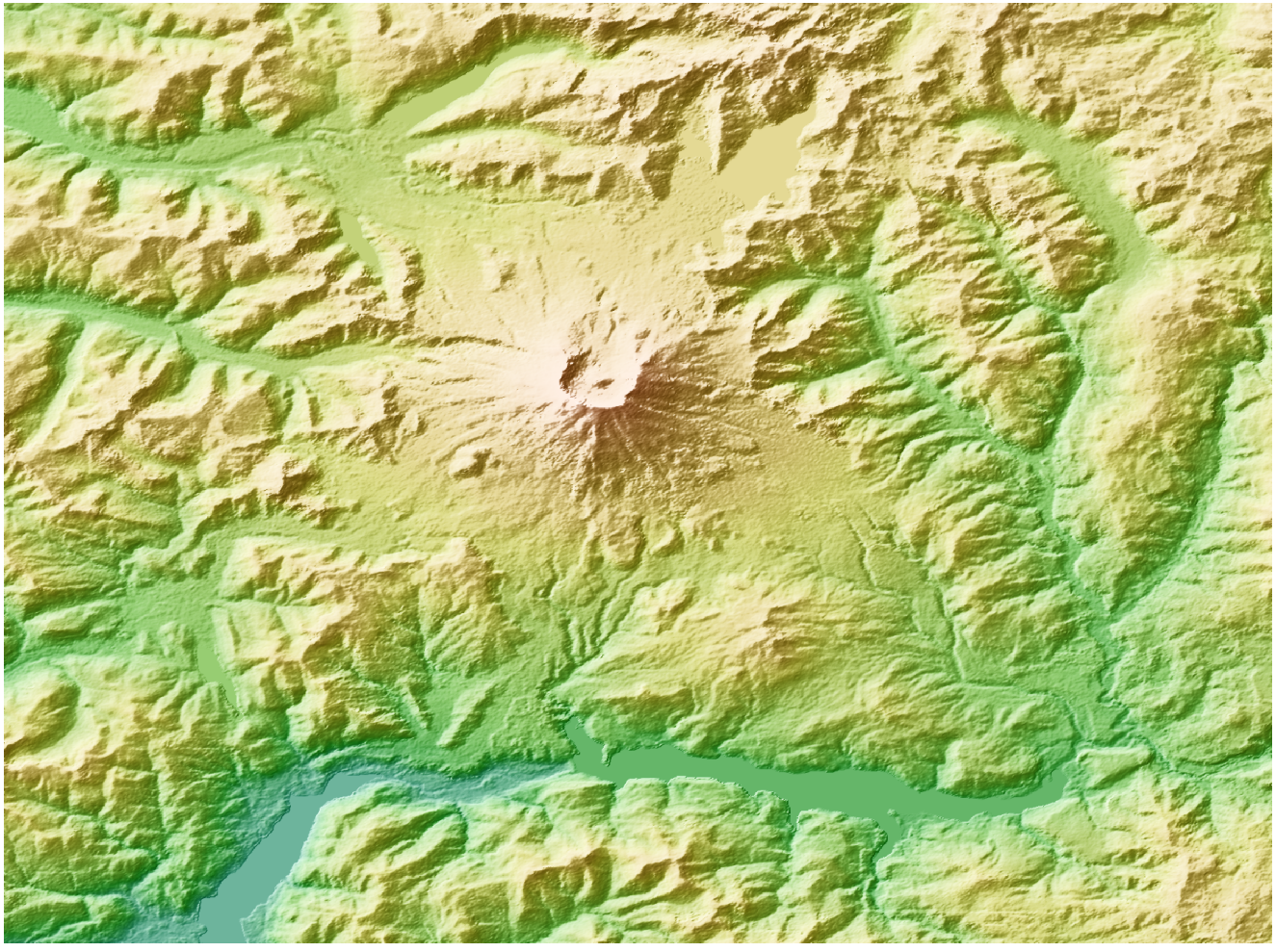
- `surface` - Splines in tension: global procedure; try to force thin elastic plate to go through all data points
- `sphinterpolate` - Spherical gridding in tension of data on a sphere
- `triangulate` - Delaunay triangulation or Voronoi partitioning and gridding of Cartesian data

Adding Color `grdimage`

various options to get a pallete to use with `-C`

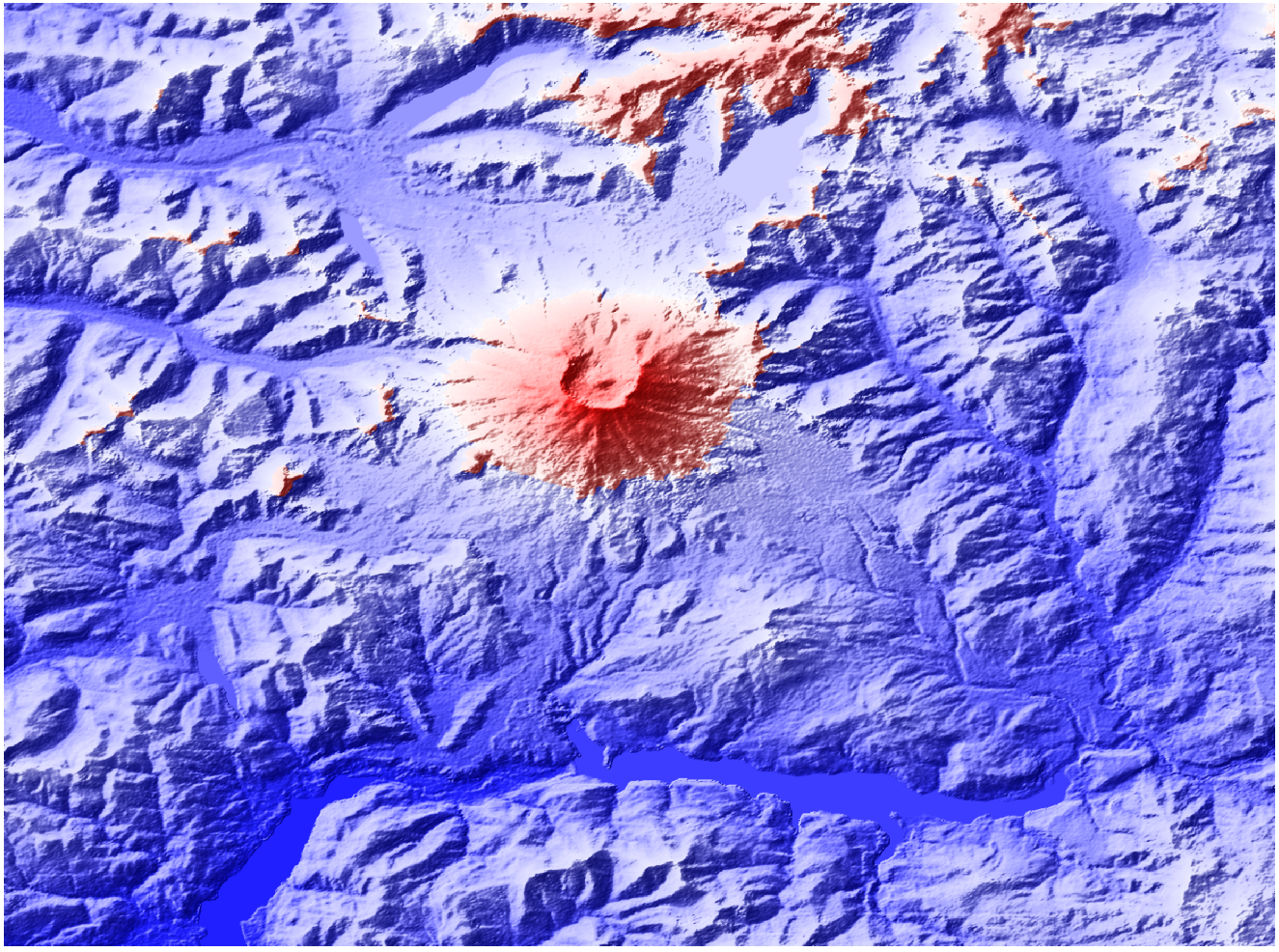
- use built-in color palette name with `-C`, see `https://docs.generic-mapping-tools.org/latest/cookbook/cpts.html#of-colors-and-color-legends` automatically scaled to grid's z-range
- use `makecpt` to generate color palette table (saved to session default cpt), can set transparency,
  - Make cpt with values from -200 to 200 with discrete color change every 25; use polar blue-white-red colortable
  - `gmt makecpt -Cpolar -T-200/200/25 > colors.cpt`
- use `grd2cpt` to make color palette table from one or more grids (e.g., when desired symmetric around zero use `-Sh|l|m|u`
- `-A` flag enables transparency

Mt. St. Helens `gridimage`



```
gmt makecpt -T0/5000/10 -Z -Ctopo > sthelens.cpt
gmt grdimage sthelens.nc -Csthelens.cpt -png sthelens_grid -I
```

Mt. St. Helens `gridimage`



```
gmt makecpt -T0/2600/10 -Z -Cpolar > sthelens.cpt
gmt grdimage sthelens.nc -Csthelens.cpt -png sthelens_grid -I
```

(color palettes can be misleading)

Grid Operations

grd2cpt	Make linear or histogram-equalized color palette table from grid
grdclip	Clip the range of grid values
grdedit	Modify header or content of a grid
grdfft	Mathematical operations on grids in the spectral domain
grdfill	Interpolate across holes in a grid
grdgradient	Compute directional gradients from a grid
grdhisteq	Perform histogram equalization for a grid
grdlandmask	Create a "wet-dry" mask grid from shoreline data base
grdmask	Create mask grid from polygons or point coverage
grdmath	Reverse Polish Notation (RPN) calculator for grids (element by element)
grdmix	Blending and transforming grids and images
grdvolume	Calculate grid volume and area constrained by a contour

https://www.generic-mapping-tools.org

For Ternary Enthusiasts

ternary

Plot data on ternary diagrams

Synopsis

gmt ternary [*table*] [**-JX***width*] [**-R***amin/amax/bmin/bmax/cmin/cmax*] [**-B**[**p**|**s**]*parameters*] [**-C***cpt*] [**-G***fill*] [**-L***a/b/c*] [**-M**] [**-N**] [**-S**[*symbol*][*size*]] [**-U**[*stamp*]] [**-V**[*level*]] [**-W**[*pen*][*attr*]] [**-X**[**a**|**c**|**f**|**r**][*xshift*]] [**-Y**[**a**|**c**|**f**|**r**][*yshift*]] [**-bi**binary] [**-di**nodata] [**-e**regexp] [**-f**flags] [**-g**gaps] [**-h**headers] [**-i**flags] [**-p**flags] [**-qi**flags] [**-t**transp] [**-:**[**i**|**o**]] [**--PAR**=*value*]

Note: No space is allowed between the option flag and the associated arguments.

Description

Reads (*a*,*b*,*c*[,*z*]) records from *table* [or standard input] and plots symbols at those locations on a ternary diagram. If a symbol is selected and no symbol size given, then we will interpret the fourth column of the input data as symbol size. Symbols whose *size* is <= 0 are skipped. If no symbols are specified then the symbol code (see **-S** below) must be present as last column in the input.

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For Ternary Enthusiasts

```
gmt begin ternary_map png
gmt makecpt -Cturbo -T0/80/10
gmt ternary @ternary.txt -R0/100/0/100/0/100 -JX6i \
    -Sc0.1c -C -LWater/Air/Limestone \
    -Baafg+l"Water component"+u" %" \
    -Bbafg+l"Air component"+u" %" \
    -Bcagf+l"Limestone component"+u" %" \
    -B+givory+t"Example data from MATLAB Central"
gmt end
```

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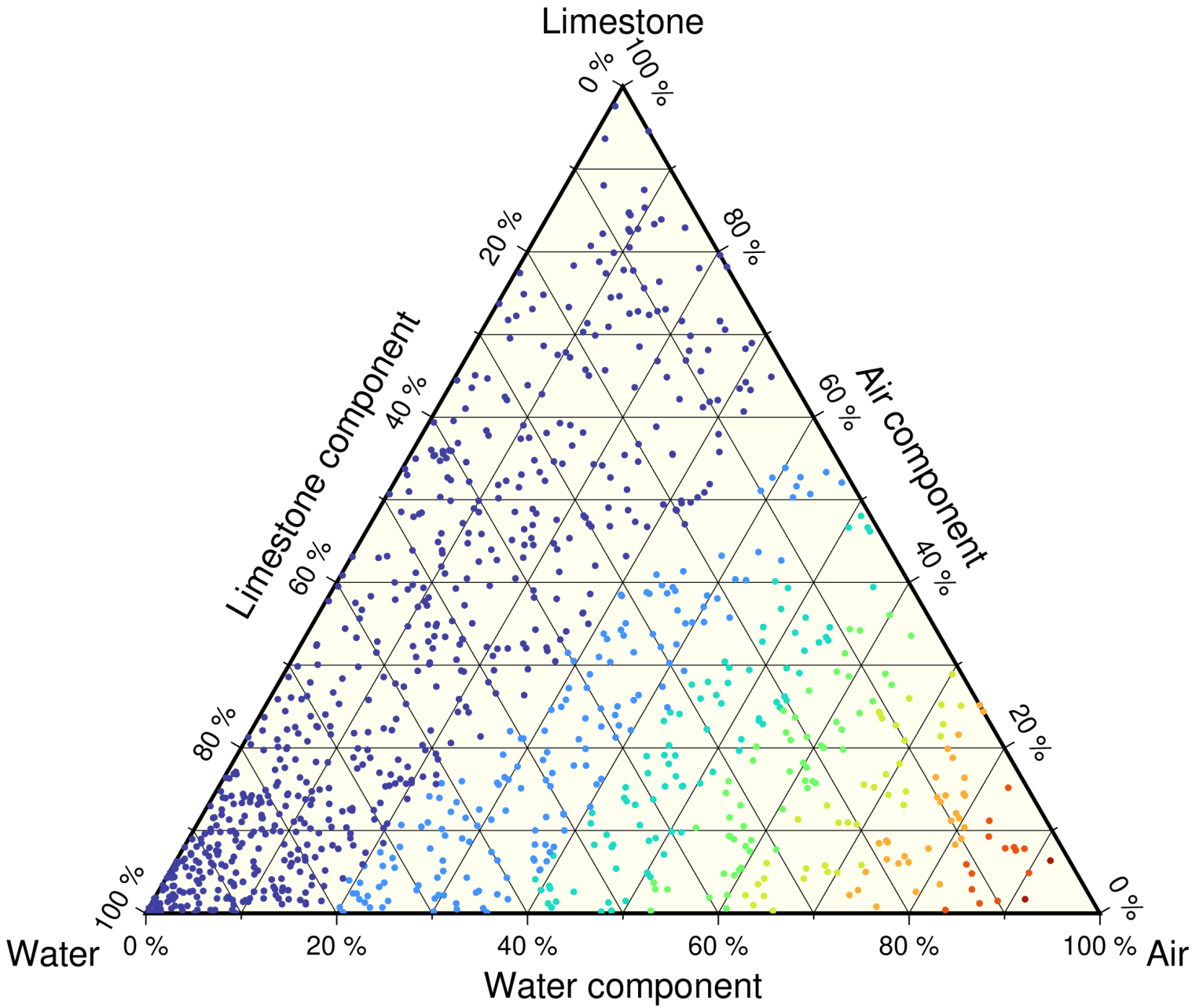
Example data from MATLAB Central



. . . so much more

Core Modules

- basemap
- batch
- begin
- blockmean
- blockmedian
- blockmode
- clear
- clip
- coast
- colorbar
- contour
- dimfilter
- docs
- end
- events
- figure
- filter1d
- fitcircle
- gmt2kml
- gmtconnect
- gmtconvert
- gmtdefaults
- grdgdal
- gmtget
- gmtinfo
- gmtlogo
- gmtmath
- gmtregress
- gmtselect
- gmtset
- gmtsimplify
- gmtspatial
- gmtvector
- gmtwhich
- grd2cpt
- grd2kml
- grd2xyz
- grdblend
- grdclip
- grdcontour
- grdconvert
- grdcut
- grdedit
- grdfft
- grdfill
- grdfilter
- grdgradient
- grdhisteq
- grdimage
- grdinfo
- grdinterpolate
- grdlandmask
- grdmask
- grdmath
- grdmix
- grdpaste
- grdproject
- grdsample
- grdtrack
- grdtrend
- grdvector
- grdview
- grdvolume
- greenspline
- histogram
- image
- inset
- kml2gmt
- legend
- makecpt
- mapproject
- mask
- movie
- nearneighbor
- plot
- plot3d
- project
- psconvert
- rose
- sample1d
- solar
- spectrum1d
- sph2grd
- sphdistance
- sphinterpolate
- sphtriangulate
- splitxyz
- subplot
- surface
- ternary
- text
- trend1d
- trend2d
- triangulate
- wiggle
- xyz2grd

Supplemental Modules

- earthtide
- gpsgridder
- velo
- gshhg
- img2grd
- mgd77convert
- mgd77header
- mgd77info
- mgd77list
- mgd77magref
- mgd77manage
- mgd77path
- mgd77sniffer
- mgd77track
- gmtflexure
- gmtgravmag3d
- gravfft
- grdflexure
- grdgravmag3d
- grdredpol
- grdseamount
- talwani2d
- talwani3d
- segy2grd
- segy
- segyz
- coupe
- meca
- polar
- sac
- backtracker
- gmtpmodeler
- grdpmodeler
- grdrotater
- grdspotter
- hotspotter
- originater
- polespotter
- rotconverter
- rotsmoother
- x2sys_binlist
- x2sys_cross
- x2sys_datalist
- x2sys_get
- x2sys_init
- x2sys_list
- x2sys_merge
- x2sys_put
- x2sys_report
- x2sys_solve

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