Final Projects - Posters

Printing: Send to Andrew Phillips (andrew.g.phillips@nmt.edu) with the information he needs, listed on webpage: https://nmtearth.com/wide-format-plotter/

Note that you are printing for this class (so you do not need a separate account number)

Timing: Poster session during lab next Monday. We will have poster boards set up in MSEC lobby.

Andrew needs time to print the posters and he will not be available Friday afternoon. He requests getting poster files to him no later than 10 am Friday.

GMT Part 2: Gridding and Data Processing

November 27, 2017

Gridded Data and GMT

- Last week learned how to make simple maps and plots with GMT
- This week – add more functionality by including wider range of data

- Gridded dataset: array of regularly spaced points in space
  - Example: elevation at given latitude and longitude

Gridded Data and GMT

- GMT works with gridded data stored in a binary format (net-CDF) that includes a header followed by data

- Lots of gridded data exists, some within GMT itself
  - earth_relief_05m.grd -- used last week, is bathymetry and topography at 5 arc minutes (~10 km) across the globe (etopo5)
  - Shoreline information (GSHHG)

  (Global Self-consistent, Hierarchical, High-resolution Geography)
  - For US, USGS has higher resolution data available:
  - https://earthexplorer.usgs.gov

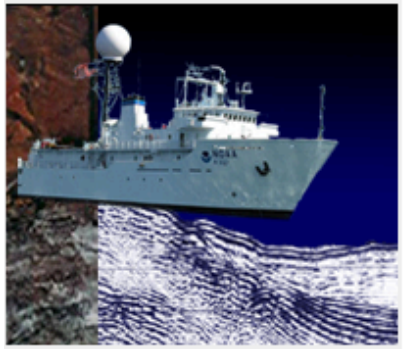
NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Search

NOAA > NESDIS > NCEI (formerly NGDC) > Marine Geology and Geophysics

privacy policy

Marine Geophysics | **Marine Geology** | **Bathymetry**



Contribute Data

Marine Geophysics

Marine Geology

Bathymetry and Relief

U.S. Extended Continental Shelf Project

Frequently Asked Questions

Educational Resources

Marine Geology and Geophysics

World Data Service for Geophysics

Marine Geophysics

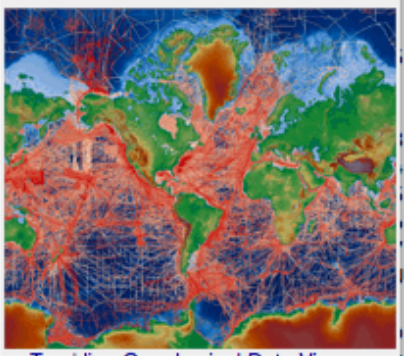
All trackline geophysics
geophysical data viewer
marine and global gravity
passive acoustic data
sediment thickness
seismic reflection
water column sonar

Marine Geology

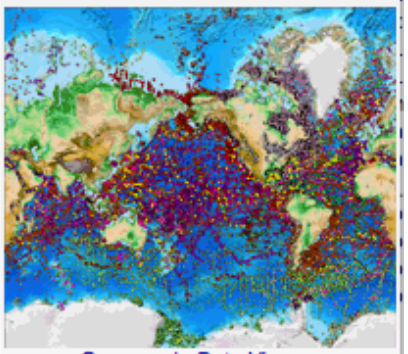
All geosample data
access geosample data
crustal age grids
find geosamples (IMLGS)
NOS seabed descriptions
ocean drilling data

Ocean Depths (Bathymetry) & Relief

All bathymetry & relief
coastal elevation models
create custom grid
ETOPO1, global grids
fishing maps
Great Lakes
hydrographic surveys
IHO DCDB
international ocean mapping
multibeam bathymetry
paleobathymetry
shorelines



Trackline Geophysical Data Viewer



Geosample Data Viewer

Bathymetry Data Viewer

Related Data:
Geomagnetism
Natural Hazards
Tsunami/Tides

https://www.ngdc.noaa.gov/mgg/mggd.html

Can get etopo01 here – 1 minute, so ~2 km

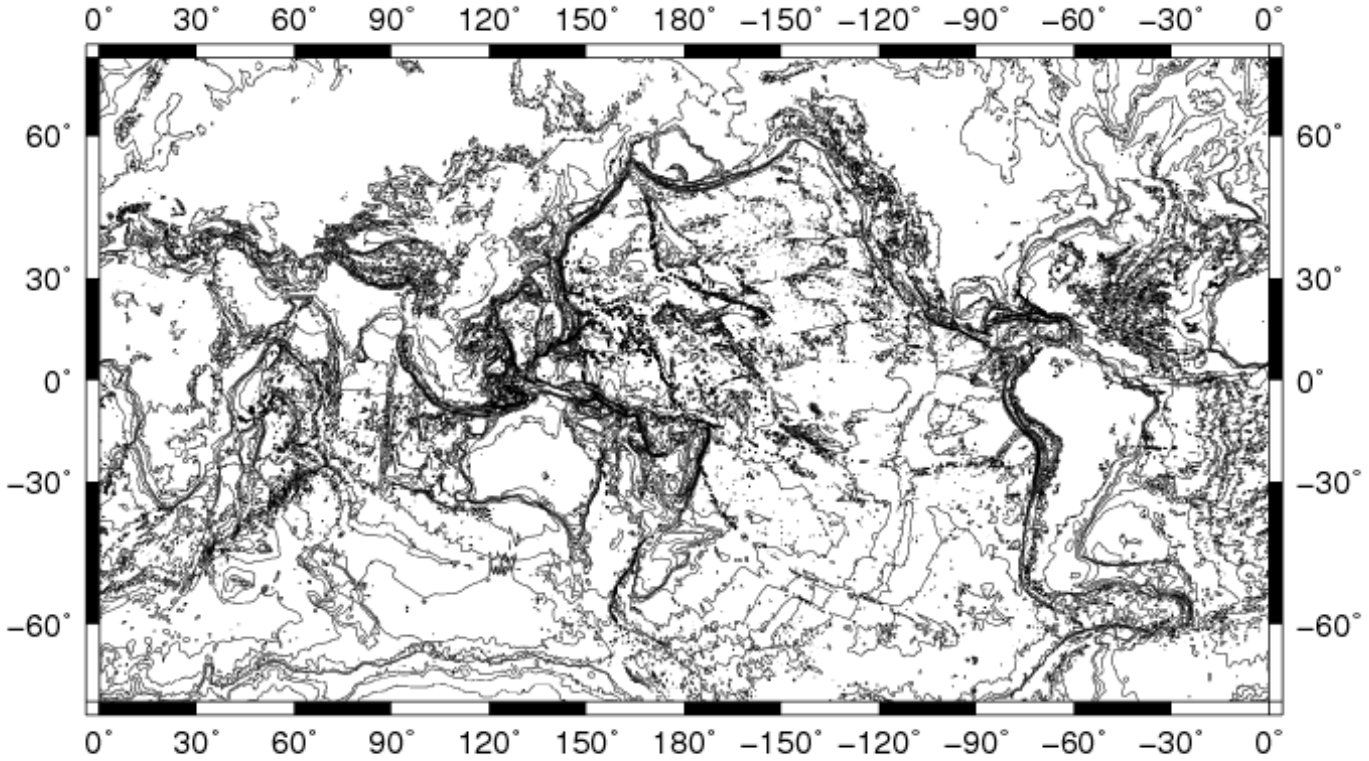
How to display gridded data in GMT

- Can use contouring, make contour maps

```
gmt grdcontour etopo5.grd -R0/360/-70/70 -JM6i -C1000 -P -B30 > global_contour.ps
```

What projection is this?

What are the contour increments?



Using grdcontour

```
gmt grdcontour etopo5.grd –
R0/360/–70/70 –JM6i –C1000 –P –
B30 > global_contour.ps
```

Our example used the very basic required arguments

Many other parameters can be used….

-A# where # defines numbers to annotate

-L limit range (don't draw contours below some low value or above some high value)

grdcontour

grdcontour - Make contour map using a grid

Synopsis

grdcontour *grid* **-C**[+]*cont_int*|*cpt* **-J***parameters* [**-A**[**-**|[+]*annot_int*][/*labelinfo*]] [**-B**[**p**|**s**]*parameters*] [**-D***template*] [**-F**[**l**|**r**]] [**-G**[**d**|**f**|**n**|**l**|**L**|**x**|**X**]*params*] [**-Jz**|**Z***parameters*] [**-K**] [**-L***low/high*] [**-O**] [**-P**] [**-Q***cut*] [**-R***west/east/south/north*[/*zmin*/*zmax*][**+r**]] [**-S***smoothfactor*] [**-T**[**+**|**-**][**+d***gap*[/*length*]][**+l**[*labels*]]] [**-U**[*stamp*]] [**-V**[*level*]] [**-W**[*type*]*pen*][**+c**[**l**|**f**]] [**-X***x_offset*] [**-Y***y_offset*] [**-Z**[**+s** *factor*][**+o***shift*][**+p**]] [**-bo**binary] [**-do**nodata] [**-ho**[*n*]] [**-p**flags] [**-t**transp]

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

Description

grdcontour reads a 2-D grid file and produces a contour map by tracing each contour through the grid. PostScript code is generated and sent to standard output. Various options that affect the plotting are available. Alternatively, the x/y/z positions of the contour lines may be saved to one or more output files (or stdout) and no plot is produced.

Required Arguments

grid

2-D gridded data set to be contoured. (See GRID FILE FORMATS below).

-C[+]*cont_int*

The contours to be drawn may be specified in one of three possible ways:

1. If *cont_int* has the suffix ".cpt" and can be opened as a file, it is assumed to be a CPT. The color boundaries are then used as contour levels. If the CPT has annotation flags in the last column then those contours will be annotated. By default all contours are labeled; use **-A-** to disable all annotations.
2. If *cont_int* is a file but not a CPT, it is expected to contain contour levels in column 1 and a C(ontour) OR A(nnotate) in col 2. The levels marked C (or c) are contoured, the levels marked A (or a) are contoured and annotated. Optionally, a third column may be present and contain the fixed annotation angle for this contour level.
3. If no file is found, then *cont_int* is interpreted as a constant contour interval. However, if prepended with the + sign the *cont_int* is taken as meaning draw that single contour. The **-A** option offers the same possibility so they may be used together to plot a single annotated contour and another single non-annotated contour, as in '… -A+10 -C+5' that plots an annotated 10 contour and an non-annotated 5 contour. If **-A** is set and **-C** is not, then the contour interval is set equal to the specified annotation interval.

If a file is given and **-T** is set, then only contours marked with upper case C or A will have tick-marks. In all cases the contour values have the same units as the grid.

-J*parameters* (more …)

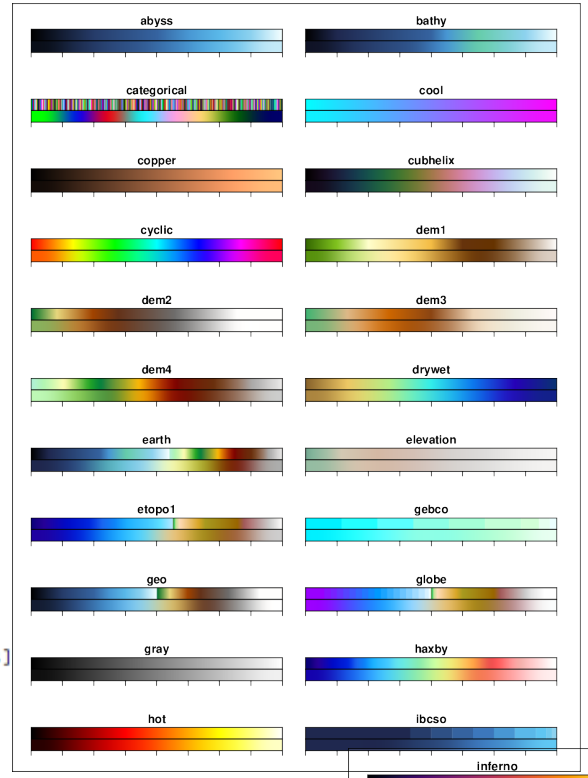
Select map projection.

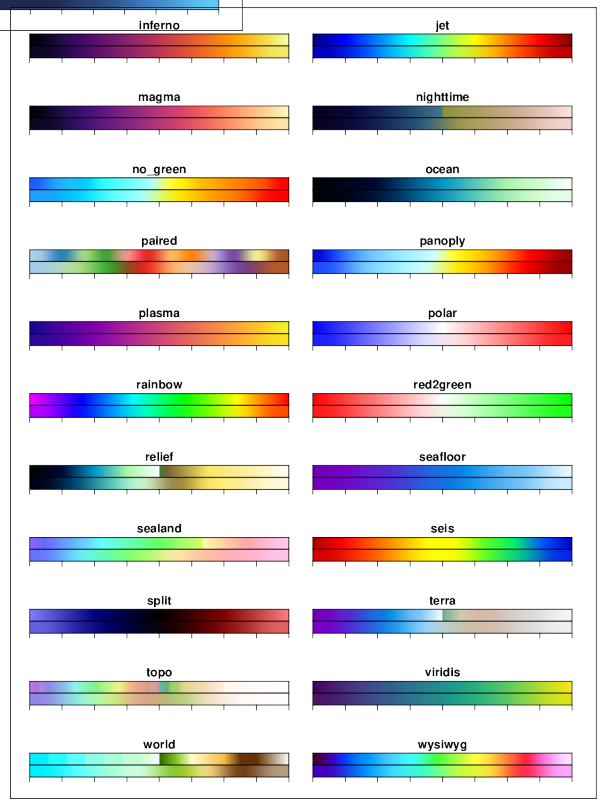
Adding color to gridded datasets

- Instead of contour lines, can plot these datasets with color
- First need to define a color palette table for your dataset (map values to specific colors)
- GMT has tools for this:
  - makecpt
  - grd2cpt

GMT colortables

```
-C Specify a colortable [Default is rainbow]:
   [Notes: R=Default z-range, H=Hinge, C=colormodel]
   ------------------------------------------------------------------------------------
   abyss       : Black/dark blue to lightblue for bathymetry [R=-8000/0, C=RGB]
   bathy       : Like abyss but via aquamarine at mid-depths [R=-8000/0, C=RGB]
   categorical : Color table particularly suitable for categorical data [vRGB]
   cool        : Linear change from blue to magenta [C=RGB]
   copper      : Dark to light copper brown [C=RGB]
   cubhelix    : Intensity colormap via cube helix by Dave Green [C=RGB]
   cyclic      : Cyclic colormap, spans 360 degrees of hue [C=HSV]
   dem1        : Digital Elevation Model (DEM) scale by Thomas Dewez [R=0/800, C=RGB]
   dem2        : Digital Elevation Model (DEM) scale by Dewez/Wessel [R=0/4900, C=RGB]
   dem3        : Digital Elevation Model (DEM) scale by Paul Wessel [R=0/6000, C=RGB]
   dem4        : Digital Elevation Model (DEM) scale for Wikipedia figures [R=0/1500, C=RGB]
   drywet      : Goes from dry to wet colors [C=RGB]
   earth       : Colors for global bathymetry/topography relief [R=-11000/9000, H=0, C=RGB]
   elevation   : Washed-out colors for topography [R=0/7000, C=RGB]
   etopo1      : Colormap used in the ETOPO1 global relief map [R=-11000/8500, H=0, C=RGB]
   gebco       : Colors for GEBCO bathymetric charts [R=-7000/0, C=RGB]
   geo         : Colors for global bathymetry/topography relief [R=-8000/8000, H=0, C=RGB]
   globe       : Colors for global bathymetry/topography relief [R=-10000/10000, H=0, C=RGB]
   gray        : Gray linear ramp from black to white [C=RGB]
   haxby       : Bill Haxby's color scheme for geoid & gravity [C=RGB]
   hot         : Black through red and yellow to white [C=RGB]
   ibcso       : The IBCSO bathymetry colors [R=-12000/0, C=RGB]
   inferno     : New colormap Option B from matplotlib [C=RGB]
   jet         : Dark to light blue, white, yellow and red [C=RGB]
   magma       : New colormap Option A from matplotlib [C=RGB]
   nighttime   : Colors for DMSP-OLS Nighttime Lights Time Series [C=HSV]
   no_green    : For those who hate green [H=0, C=RGB]
   ocean       : White-green-blue bathymetry scale [R=-8000/0, C=RGB]
   paired      : Qualitative color map with 6 pairs of colors [C=RGB]
   panoply     : Default colormap of Panoply [C=RGB]
   plasma      : New colormap Option C from matplotlib [C=RGB]
   polar       : Blue via white to red [H=0, C=RGB]
   rainbow     : Rainbow: magenta-blue-cyan-green-yellow-red [C=HSV]
   red2green   : Polar scale from red to green via white [H=0, C=RGB]
   relief      : Wessel/Martinez colors for topography [R=-8000/+8000, H=0, C=RGB]
   seafloor    : Purple-blue-white bathymetry scale [R=-6000/0, C=RGB]
   sealand     : Smith bathymetry/topography scale [R=-6000/+3000, H=0, C=HSV]
   seis        : R-O-Y-G-B seismic tomography colors [C=RGB]
   split       : Like polar, but via black instead of white [H=0, C=RGB]
   terra       : Colors for global bathymetry/topography relief [R=-7000/7000, H=0, C=RGB]
   topo        : Sandwell/Anderson colors for topography [R=-7000/+7000, H=0, C=HSV]
   viridis     : New colormap Option D from matplotlib [C=RGB]
   world       : Colors for global bathymetry/topography relief [R=-7000/7000, H=0, C=RGB]
   wysiwyg     : 20 well-separated RGB colors [C=RGB]
   ------------------------------------------------------------------------------------
```





makecpt

>>> makecpt **-C**jet **-T**-200/200/25 > colors.cpt

Creates a new file (colors.cpt) that contains colors for each data value between -200 and 200 in increments of 25 using the “jet” colortable

You define the data range to be used

```
-200    0/0/159 -175    0/0/159
-175    0/0/223 -150    0/0/223
-150    0/31.875/255    -125    0/31.875/255
-125    0/95.625/255    -100    0/95.625/255
-100    0/159.38/255    -75     0/159.38/255
-75     0/223.12/255    -50     0/223.12/255
-50     31.875/255/223.12       -25     31.875/255/223.12
-25     95.625/255/159.38       0       95.625/255/159.38
0       159.38/255/95.625       25      159.38/255/95.625
25      223.12/255/31.875       50      223.12/255/31.875
50      255/223.12/0    75      255/223.12/0
75      255/159.38/0    100     255/159.38/0
100     255/95.625/0    125     255/95.625/0
125     255/31.875/0    150     255/31.875/0
150     223/0/0 175     223/0/0
175     159/0/0 200     159/0/0
B       black
F       white
N       127.5
```

grd2cpt

- Make color palette table directly from grid file
- Advantages – you don't need to know bounds of data

gmt grd2cpt etopo5.grd -Crelief > my_etopo5.cpt

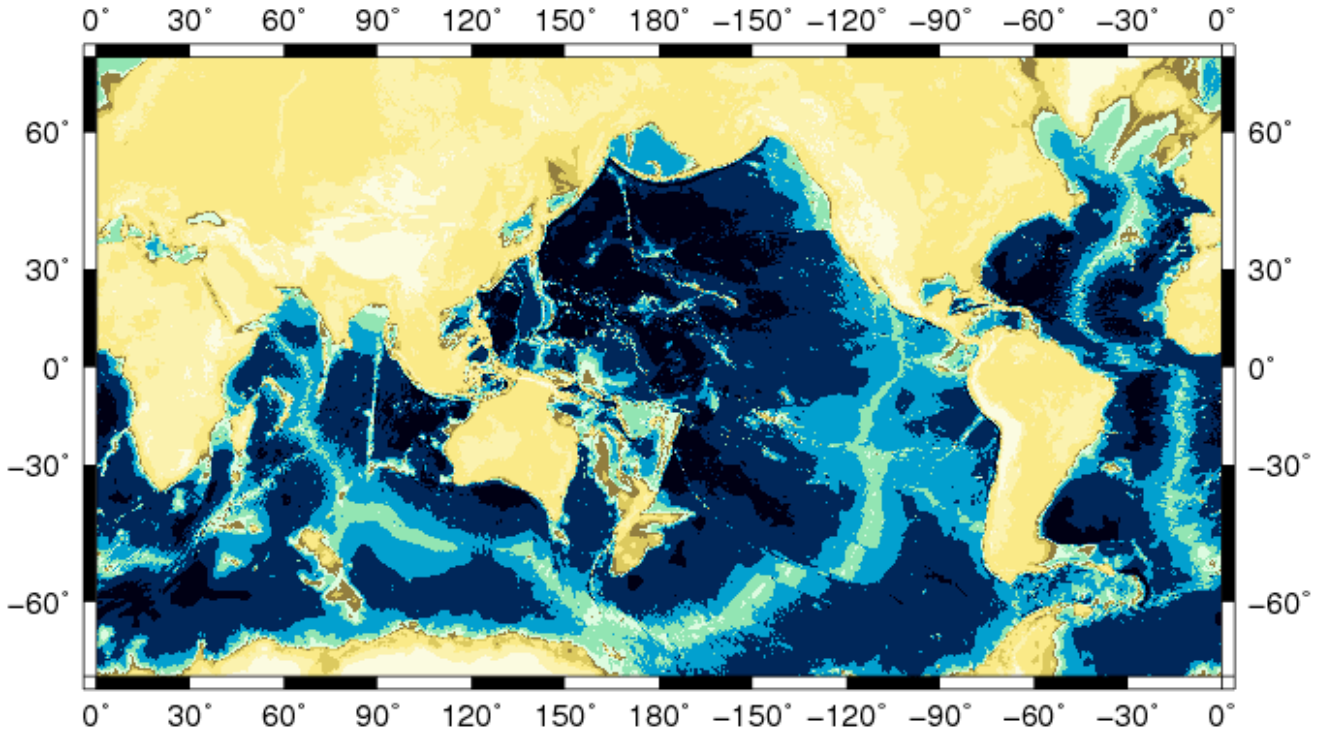
Can set steps (-S), otherwise it will define it's own steps

```
bash-3.2$ gmt grd2cpt etopo5.grd -Crelief
-10741  0/4/20  -5301.51610962  0/4/20
-5301.51610962  0/38/80 -4131.11465258  0/38/80
-4131.11465258  0/150/200       -3287.17285788  0/150/200
-3287.17285788  137.6/225.8/174.4       -2566.05571172  137.6/225.8/174.4
-2566.05571172  218.8/251/219.8 -1892.04485796  218.8/251/219.8
-1892.04485796  135.6/115.6/56  -1218.0340042   135.6/115.6/56
-1218.0340042   218.8/198.8/88  -496.916858044  218.8/198.8/88
-496.916858044  250/234/126     347.02493665    250/234/126
347.02493665    252/241/167     1517.42639369   252/241/167
1517.42639369   253.4/250.2/223.8       7833    253.4/250.2/223.8
B       black
F       white
N       white
```

Back to the map….

- Now have grid file and color map, can use grdimage to plot on the map

gmt grdimage etopo5.grd -R0/360/-70/70 -JM6i -Cmy_etopo5.cpt -B30 -P > etopo5_map.ps



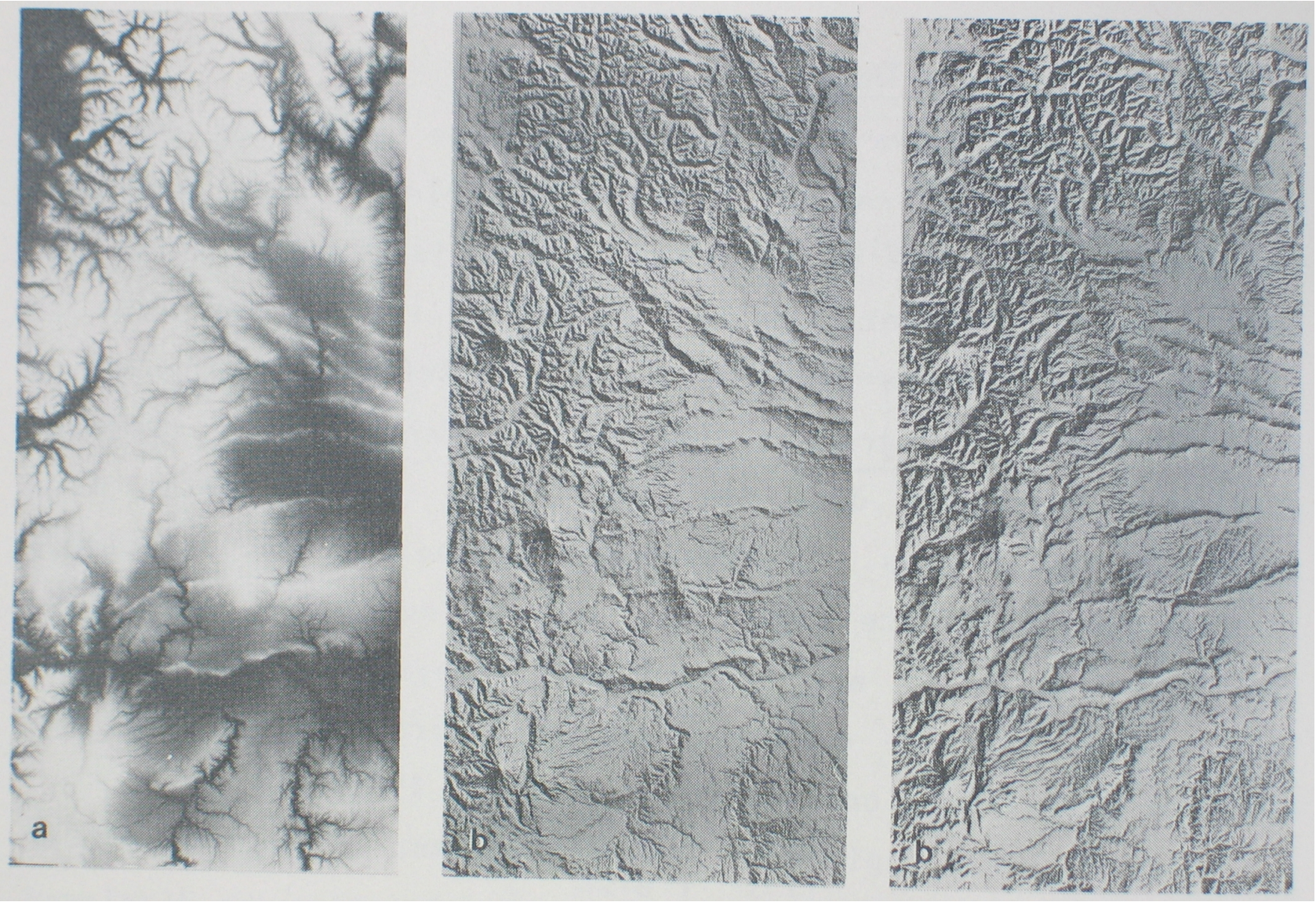
Maybe not best color choice, but easy to modify that

Even better – add shading (illumination)

Illuminated from lower right

Grayscale topo map

Illuminated from upper right



Adding illumination

- Need to use:
  - grdgradient: computes directional derivative in specific direction. Will give output grid file for the directional derivative
    - Use –A to give azimuth of the derivative (-A0 illuminates from the north)
  - grdimage: use as before, but include –I[intensity_file] from the grdgradient

Note that the intensities need to be normalized between (-1,+1). Can check values after grdgradient using

>>> grdinfo filename

And use grdhisteq or grdmath if needed to get within range

Adding other data in GMT

- You might have other data (DEMs for a small research site for example) that you want to include
- These can be converted into netCDF format and then plotted with GMT
- gmt grdraster – tool takes any binary format to netCDF

Other data processing

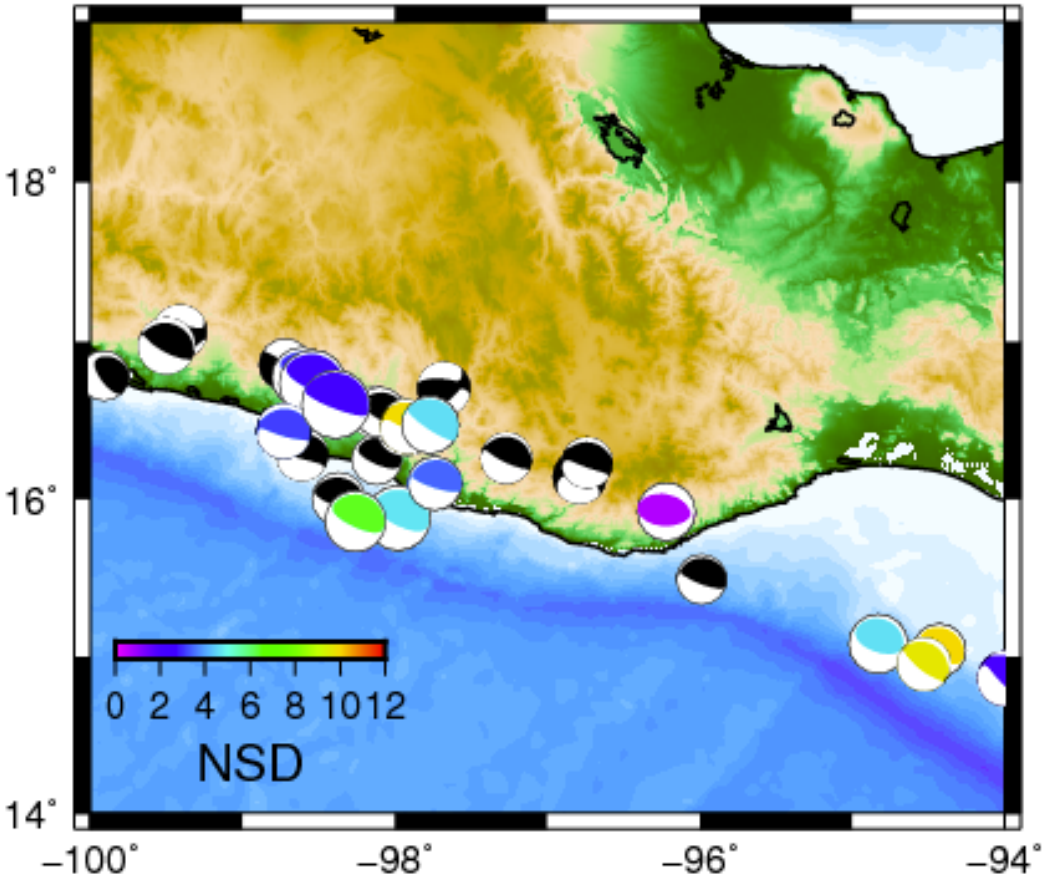
- Fit circles, linear and more advanced trend lines to data
- Can resample and filter data (both 1D and gridded data)
- For gridded data, can also use gmt tools to mask certain areas, limit z-ranges, do math, etc....
  - grdclip, grdedit, grdmask, grdlandmask, grdmath
- Convert data table to 2D grd file (xyz2grd)
- Convert grd file to xyz data table (grd2xyz)

Other GMT tools

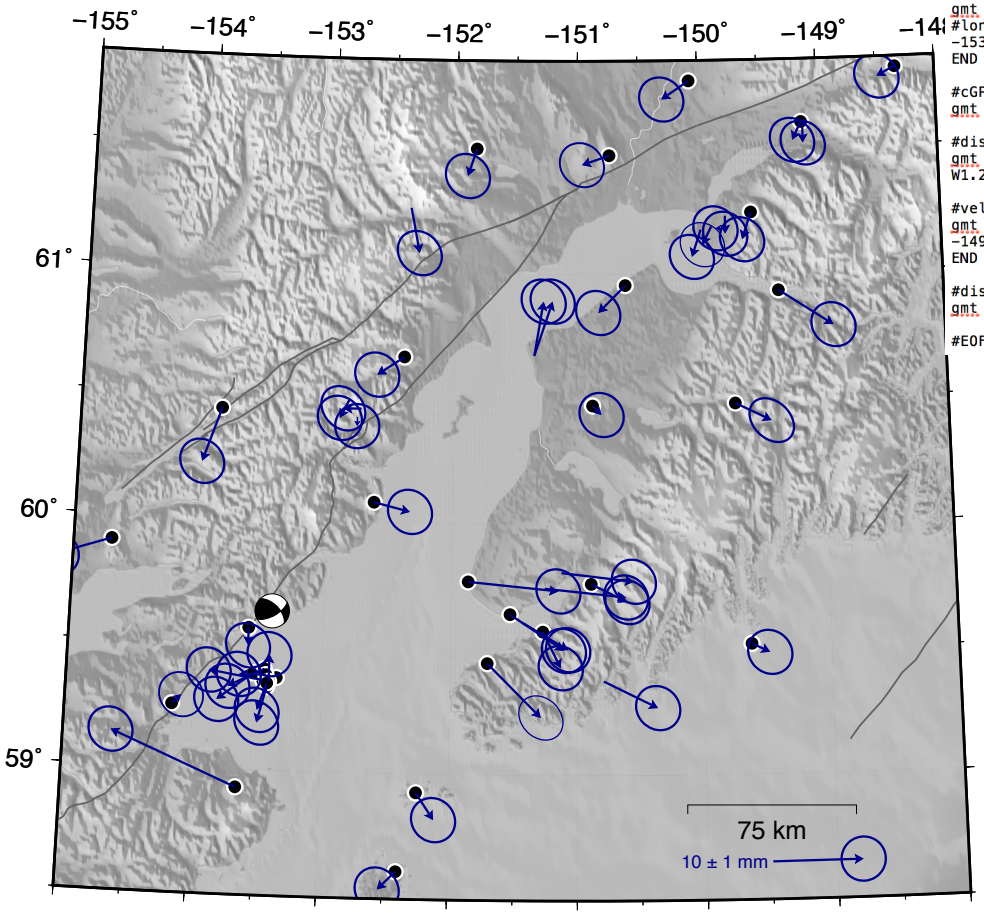
- Lots of other miscellaneous modules available useful to geologists….
- Like psxy but with additional parameters needed
- Plot seismograms
  - pssac – seismograms in SAC format
  - pssegy – plot SEGY data
- Plot velocity vectors (psvelo)
- Plot focal mechanisms (psmeca and pspolar)
  - pscoupe – plot focal mechanisms in cross section

Use of psmeca

```
#!/bin/bash

BATHY=/usr/local/GMT4.4.0/share/mgg

LONMIN=-100
LONMAX=-94
LATMIN=14
LATMAX=19

FILE=mex_cmt.txt
OUTFILE=mexico_class_cmt.ps

#main script
rm $OUTFILE
gmt grdimage $BATHY/ETOPO1_Bed_g_gmt4.grd -Cglobe.cpt -JM4.0i -R$LONMIN/$LONMAX/$LATMIN/$LATMAX -V -P -Y6.0 -K > $OUTFILE
gmt pscoast -R -JM -Bf1a2WSen -Dh -W1 -P -O -K >> $OUTFILE

#plot eq focal mechs
awk '{print $1, $2, $3, $4, $5, $6, $7, $8, $9, $10, $11, $12}' mex_cmt_thrust.txt | gmt psmeca -O -JM -R -Sm0.20i -K -L >> $OUTFILE

awk '{print $1, $2, $3, $4, $5, $6, $7, $8, $9, $10, $11, $12}' mex_cmt_thrust_nsd.txt | gmt psmeca -O -JM -R -Sm0.20i -Znsd.cpt -K -L
>> $OUTFILE

gmt psscale -D.7i/.75i/3/0.20h -B2:NSD: -Cnsd.cpt -O -K >> $OUTFILE

gs $OUTFILE
~
```



Use of psvelo




```
#!/bin/tcsh
|
gmtset PS_MEDIA                      Custom_520x550
gmtset FONT_ANNOT_PRIMARY       14
gmtset MAP_FRAME_TYPE           PLAIN
gmtset FORMAT_GEO_OUT       ddd:mm:ss.xF
gmtset FORMAT_FLOAT_OUT         %.12g
gmtset PS_CHAR_ENCODING         ISOLatin1+

set REGION = "-R-155/-148/58.5/61.85"
set PROJ = "-JL-151/60/59/61/7i"
set GMTDIR = "/Users/roon/work/research/GMT/"
set PRJDIR = "/Users/roon/work/research/projects/iniskin/"

#
set START = "-K $REGION $PROJ -X0.5i -Y.25i"
set CONT  = "-R -J -K -O"
set END   = "-R -J -O"

set VEL_SCALE = 175
set ARROW_SCALE = "5p+a60+e"

set ps = `basename $0 .gmt5`.ps

gmt makecpt -A+0.5 -T-5000/3000/50 -Cgray > topo.cpt

gmt grdimage ${GMTDIR}/topo/etopo1/ETOPO1_Bed_Cook_Inlet_0.1m.grd -I${GMTDIR}/topo/etopo1/ETOPO1_Bed_Cook_Inlet.norm -
Bf0.5a1 -BWNse -Ctopo.cpt $START > $ps
gmt pscoast -Na -Df -Ir/0.5p,white -Na/0.25p,- -W0.75p,darkgray -Slightgray -t40 $CONT >> $ps

#FAULTLINES
gmt psxy $GMTDIR/Alaska_faults.gmtlin -W1p,100 $CONT >> $ps

#EARTHQUAKE FOCAL MECHANISM
gmt psmeca -Sc1.35 -h1 -C $CONT << END >> $ps
#lon       lat    depth str dip slip st dip slip mant  exp plon plat
-153.405 59.636 125   313 59   152   59 66   34    5.929 19   -153.405 59.636
END

#cGPS sites
gmt psxy $PRJDIR/maps/sites.ll -Sc0.115i -: -Gblack -W1.25p,white $CONT >> $ps

#displacements
gmt psvelo $PRJDIR/absolute_displacements/Iniskin.gmtvec -L -A${ARROW_SCALE} -Se${VEL_SCALE}/0.95/0 -Gdarkblue -
W1.25p,darkblue  $CONT >> $ps

#velocity scale
gmt psvelo -Gdarkblue -N -L -A${ARROW_SCALE} -Se${VEL_SCALE}/0.95/10 -W1.25p,darkblue -V  $CONT <<END >> $ps
-149.5 58.65 0.01 0.000 0.001 0.001 0 10 \261 1 mm
END

#distance scale
gmt psbasemap -L-149.5/58.875/60/75 -B $END >> $ps

#EOF
```

Reminders for Next Week

- Print out your poster by Friday morning
- No lecture period on Monday
- Poster boards will be placed in MSEC lobby – be ready to show off your poster during the lab session
- Will also do evaluations for the class on Monday during the poster session.