GMT

Generic Mapping Tools or
Gravity, Magnetics and Topography

Lecture #1

Mapping and Plotting with GMT

GMT 4.5.1

- Began as a set of subroutines to write Postscript commands
- Grew with Paul's and Walter's Ph.D. Theses
- Encompassed map projections (30!)
- Data Analysis
- Cross-Over Errors

Paul Wessel, our hero

GMT resources

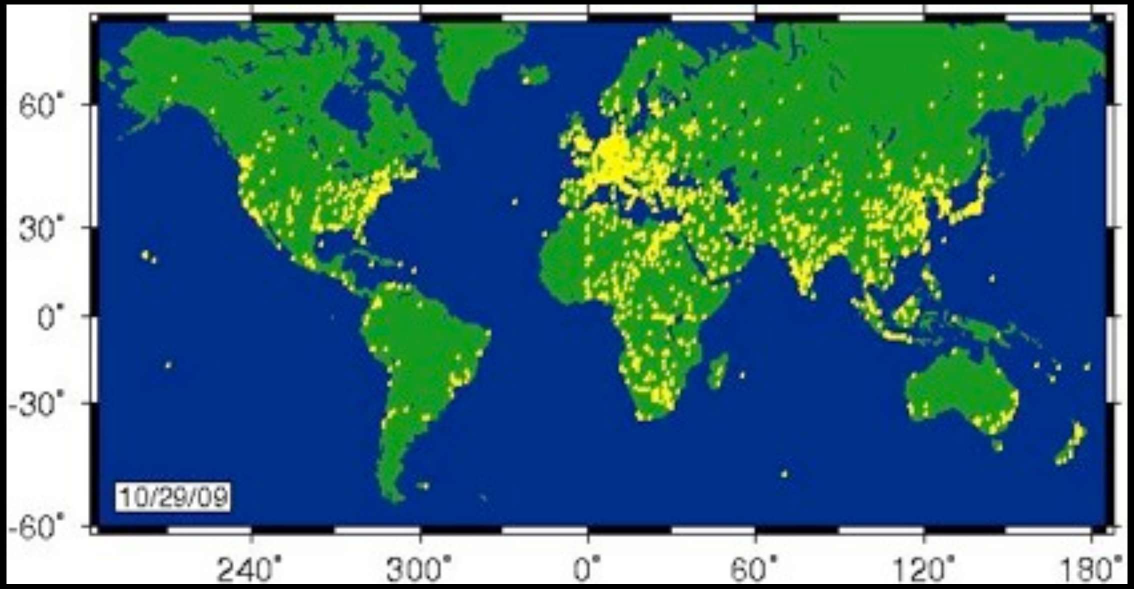
- Web site - gmt.soest.hawaii.edu
- User Group
- Open source project
- Windows, OS X, Unix and OS/2
- Extensive documentation (html and pdf)
- Examples and “cookbook”
- Ancillary data sets included (eg. coastlines)

Postscript

- Vector graphic language
- Rasterizes for output to various devices
- Scale set by dots-per-inch (dpi)
- Typically 300-1200

How does GMT work?

- Scripted language for vector graphics
- Facilitates automated plotting
- Relates graphic space to the data space
- Sequential commands create a plot or map

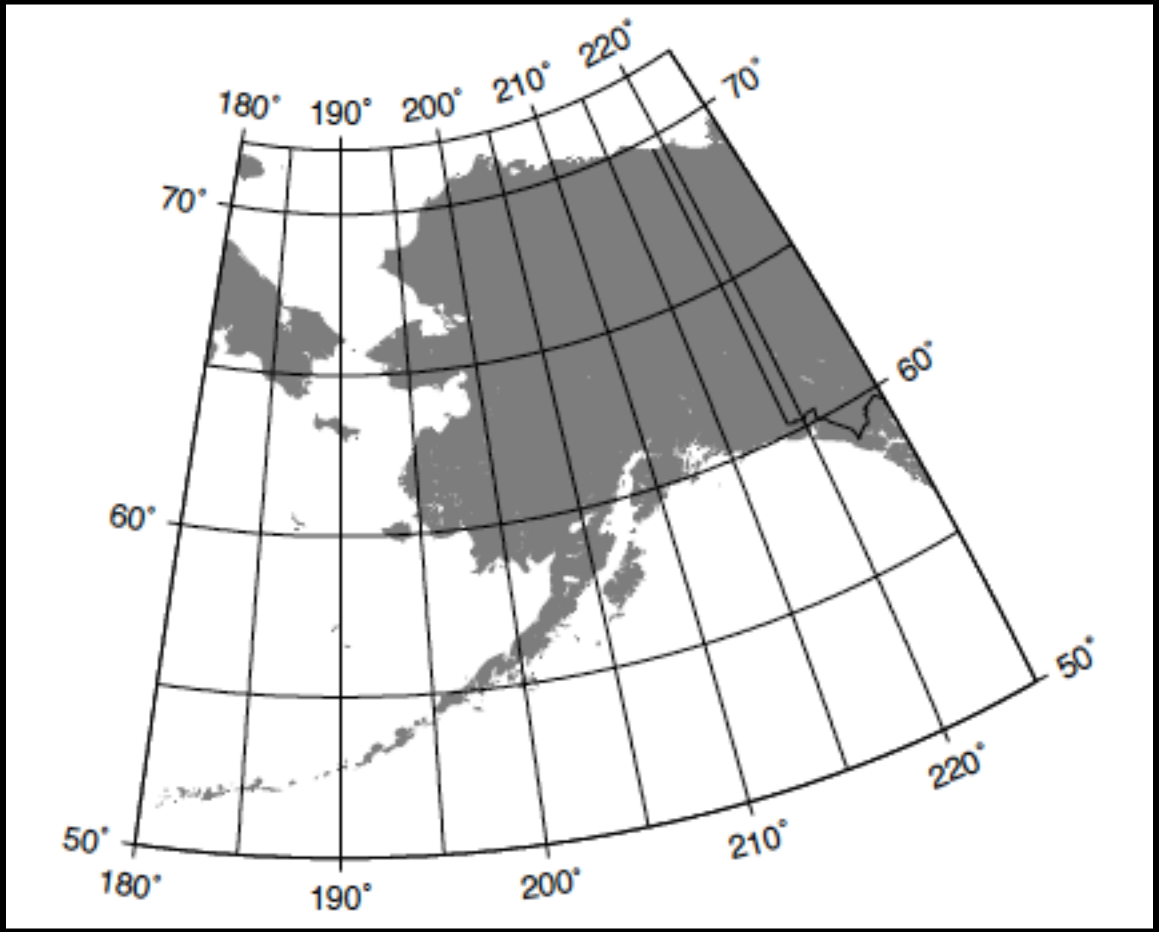


Graphic Programs

- **grdcontour** Contouring of 2-D gridded data
- grdimage Produce images from 2-D gridded datar
- grdvector Plot vector fields from 2-D gridded data
- grdview 3-D perspective imaging of 2-D gridded data
- **psbasemap** Create a basemap frame
- psclip Use polygon files as clipping paths
- **pscoast** Plot coastlines, filled continents, rivers, and political borders
- pscontour Direct contouring or imaging of xyz-data by triangulation
- pshistogram Plot a histogram
- psimage Plot Sun rasterfiles on a map
- pslegend Plot legend on a map
- psmask Create overlay to mask specified regions of a map
- psrose Plot sector or rose diagrams
- psscale Plot grayscale or colorscale
- **pstext** Plot textstrings
- pswiggle Draw anomalies along track
- **psxy** Plot symbols, polygons, and lines in 2-D
- psxyz Plot symbols, polygons, and lines in 3-D

Create a simple plot

```
pscoast -Jc190/68/0.50 -R180/225/50/72 -Di -N1 -G125 -Bg5a10 > Alaska.ps
```



The 17 standardized **GMT** command line switches

-B Defines tickmarks, annotations, and labels for basemaps and axes

-H Specifies that input/output tables have header record(s)

-J Selects a map projection or coordinate transformation

-K Allows more plot code to be appended to this plot later

-O Allows this plot code to be appended to an existing plot

-P Selects Portrait plot orientation [Default is landscape]

-R Defines the extent of the map/plot region

-U Plots a time-stamp, by default in the lower left corner of page

-V Selects verbose operation; reporting on progress

-X Sets the *x*-coordinate for the plot origin on the page

-Y Sets the *y*-coordinate for the plot origin on the page

-b Selects binary input and/or output

-c Specifies the number of plot copies

-f Specifies the data format on a per column basis

-g Identify data gaps based on supplied criteria

-m Specifies data in multiple segment format

-: Assumes input geographic data are (*lat,lon*) and not (*lon,lat*)

Command line on 1st plot

```
pscoast -Jc190/68/0.50 -R180/225/50/72 -Di -N1 -G125 -Bg5a10 > test.ps
```

-Jc specifies the Cassini projection, centered at 190
longitude, 68 latitude and scale at 0.50 inches per map unit

-R defines the map area in WESN form

-Di says to use the intermediate resolution coastline

-N1 says to plot international boundaries

-G says to fill the continents with a medium gray

-Bg5a10 says to put a grid on the map at every 5 map units and annotate it every 10 map units

It looks easy, but...

-B Sets map boundary annotation and tickmark intervals. The format of *tickinfo* is [p|s]*xinfo*[/*yinfo*[/*zinfo*]][:."Title":][W|w][E|e][S|s][N|n][Z|z[+]]. The leading p [Default] or s selects the primary or secondary annotation information. Each of the *?info* segments are textstrings of the form *info*[:"Axis label":][:="prefix":][:,"unit label":]. The *info* string is made up of one or more concatenated substrings of the form [which]*stride*[+-*phase*][u]. The optional which can be either a for annotation tick spacing [Default], f for frame tick spacing, and g for gridline spacing. If frame interval is not set, it is assumed to be the same as annotation interval. *stride* is the desired stride interval. The optional *phase* shifts the annotation interval by that amount. The optional u indicates the unit of the *stride* and can be any of Y (year, plot with 4 digits), y (year, plot with 2 digits), O (month, plot using PLOT_DATE_FORMAT), o (month, plot with 2 digits), U (ISO week, plot using PLOT_DATE_FORMAT), u (ISO week, plot using 2 digits), r (Gregorian week, 7-day stride from start of week TIME_WEEK_START), K (ISO weekday, plot name of day), D (date, plot using PLOT_DATE_FORMAT), d (day, plot day of month 0-31 or year 1-366, via PLOT_DATE_FORMAT), R (day, same as d, aligned with TIME_WEEK_START), H (hour, plot using PLOT_CLOCK_FORMAT), h (hour, plot with 2 digits), M (minute, plot using PLOT_CLOCK_FORMAT), m (minute, plot with 2 digits), C (second, plot using PLOT_CLOCK_FORMAT), c (second, plot with 2 digits). Note for geographic axes m and c instead mean arc minutes and arc seconds. All entities that are language-specific are under control by TIME_LANGUAGE. To specify separate x and y ticks, separate the substrings that apply to the x and y axes with a slash [/] (If a 3-D basemap is selected with −E and −Jz, a third substring pertaining to the vertical axis may be appended.) For linear/log/power projections (−Jx|X): Labels for each axis can be added by surrounding them with colons (:). If the first character in the label is a period, then the label is used as plot title; if it is a comma (,) then the label is appended to each annotation; if it is an equal sign (=) the the prefix is prepended to each annotation (start label/prefix with - to avoid space between annotation and item); else it is the axis label. If the label consists of more than one word, enclose the entire label in double quotes (e.g., :"my label":). If you need to use a colon (:) as part of your label you must specify it using its octal code (\072).By default, all 4 boundaries are plotted (referred to as W, E, S, N). To change the default, append the code for only those axes you want (e.g., WS for standard lower-left x- and y-axis system). Upper case (e.g., W) means draw axis/tickmarks AND annotate it, whereas lower case (e.g., w) will only draw axis/tickmarks. (If a 3-D basemap is selected with −E and −Jz, append Z or z to control the appearance of the vertical axis. Append + to draw the outline of the cube defined by −R. Note that for 3-D views the title, if given, will be suppressed.)
For non-geographical projections: Give negative scale (in −Jx) or axis length (in −JX) to change the direction of increasing coordinates (i.e., to make the y-axis positive down). For log10 axes: Annotations can be specified in one of three ways: (1) *stride* can be 1, 2, 3, or -*n*. Annotations will then occur at 1, 1−2−5, or 1−2−3−4−...−9, respectively; for -*n* we annotate every *n*'t magnitude. This option can also be used for the frame and grid intervals. (2) An l is appended to the *tickinfo* string. Then, log10 of the tick value is plotted at every integer log10 value. (3) A p is appended to the *tickinfo* string. Then, annotations appear as 10 raised to log10 of the tick value. For power axes: Annotations can be specified in one of two ways: (1) *stride* sets the regular annotation interval. (2) A p is appended to the *tickinfo* string. Then, the annotation interval is expected to be in transformed units, but the annotation value will be plotted as untransformed units. E.g., if *stride* = 1 and *power* = 0.5 (i.e., sqrt), then equidistant annotations labeled 1−4−9... will appear.
These GMT parameters can affect the appearance of the map boundary: ANNOT_MIN_ANGLE, ANNOT_MIN_SPACING, ANNOT_FONT_PRIMARY, ANNOT_FONT_SECONDARY, ANNOT_FONT_SIZE_PRIMARY, ANNOT_FONT_SIZE_SECONDARY, ANNOT_OFFSET_PRIMARY, ANNOT_OFFSET_SECONDARY, BASEMAP_AXES, BASEMAP_FRAME_RGB, BASEMAP_TYPE, DEGREE_FORMAT, FRAME_PEN, FRAME_WIDTH, GRID_CROSS_SIZE_PRIMARY, GRID_PEN_PRIMARY, GRID_CROSS_SIZE_SECONDARY, GRID_PEN_SECONDARY, HEADER_FONT, HEADER_FONT_SIZE, LABEL_FONT, LABEL_FONT_SIZE, LINE_STEP, OBLIQUE_ANNOTATION, PLOT_CLOCK_FORMAT, PLOT_DATE_FORMAT, TIME_FORMAT_PRIMARY, TIME_FORMAT_SECONDARY, TIME_LANGUAGE, TIME_WEEK_START, TICK_LENGTH, TICK_PEN, and Y_AXIS_TYPE; see the gmtdefaults man page for details.

gmtdefaults

```
gmtset `cat $workingdir/gmt.plot.parameters` D_FORMAT %.0f MEASURE_UNIT inch

gmtset D_FORMAT %.6f
```

USE gmtdefaults -D to see default settings
USE gmtdefaults -L to see your current settings

Try it again with a script

create with text editor

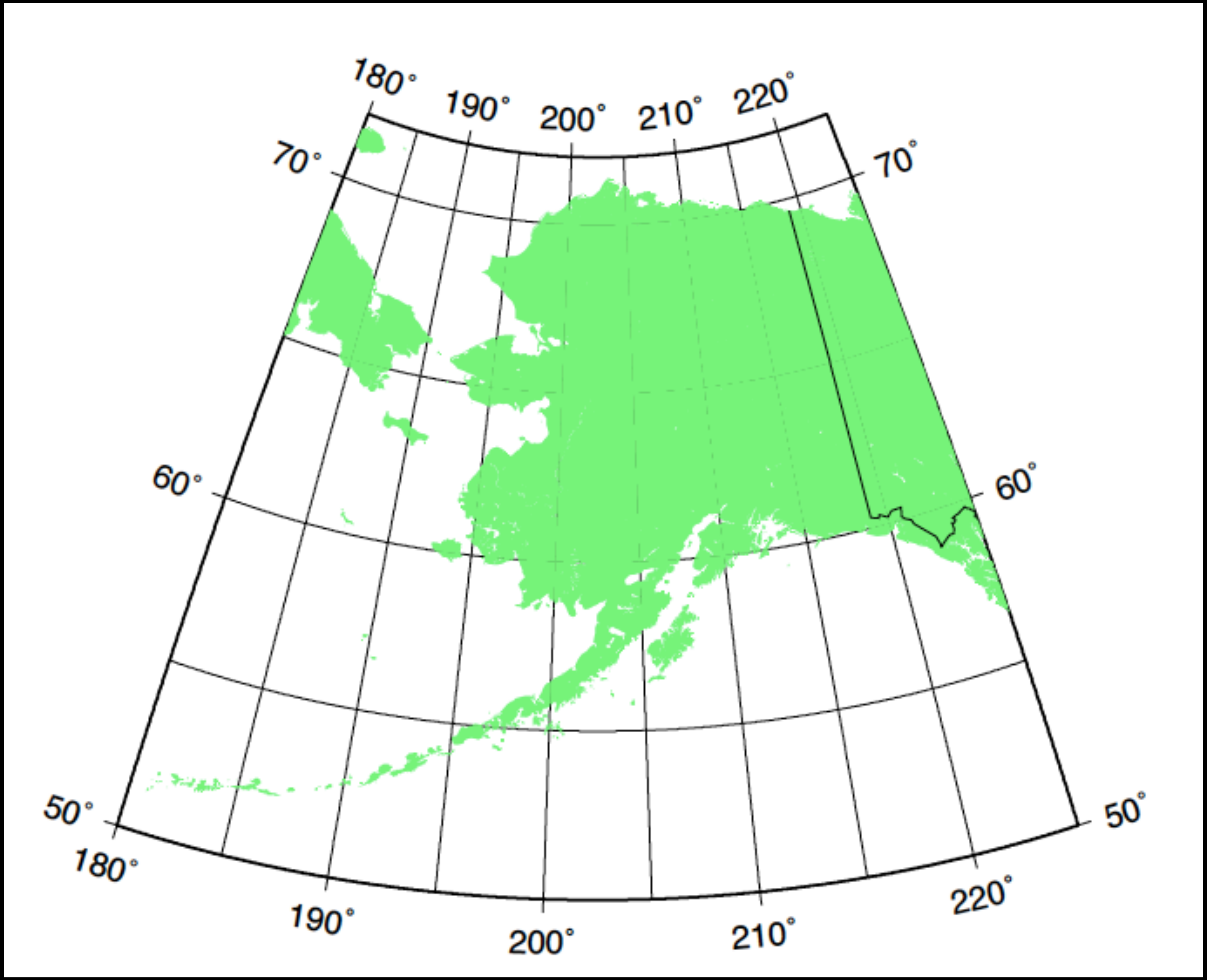
“chmod +x” to make it executable

```
#!/bin/csh
# plot a Cassini projected map of Alaska with a user-defined scale

set workingdir = `pwd`
gmtset `cat $workingdir/gmt.plot.parameters`

set scale = $1

set w_lon = 180
set e_lon = 225
set s_lat = 50
set n_lat = 72

set map_box = -R$w_lon/$e_lon/$s_lat/$n_lat
set filename = alaska.ps

set pro_lon = `echo $w_lon $e_lon | awk '{printf"%.2f",($1+$2)/2.0}'`
set pro_lat = `echo $n_lat $s_lat | awk '{printf"%.2f",($1+$2)/2.0}'`

set map_pro = -Jc$pro_lon/$pro_lat/$scale
```

the commands

```
psbasemap $map_pro $map_box -Bg5a10 -K -P > $filename

pscoast $map_pro $map_box -Di -N1 -G125/255/125 -O >>
$filename
```

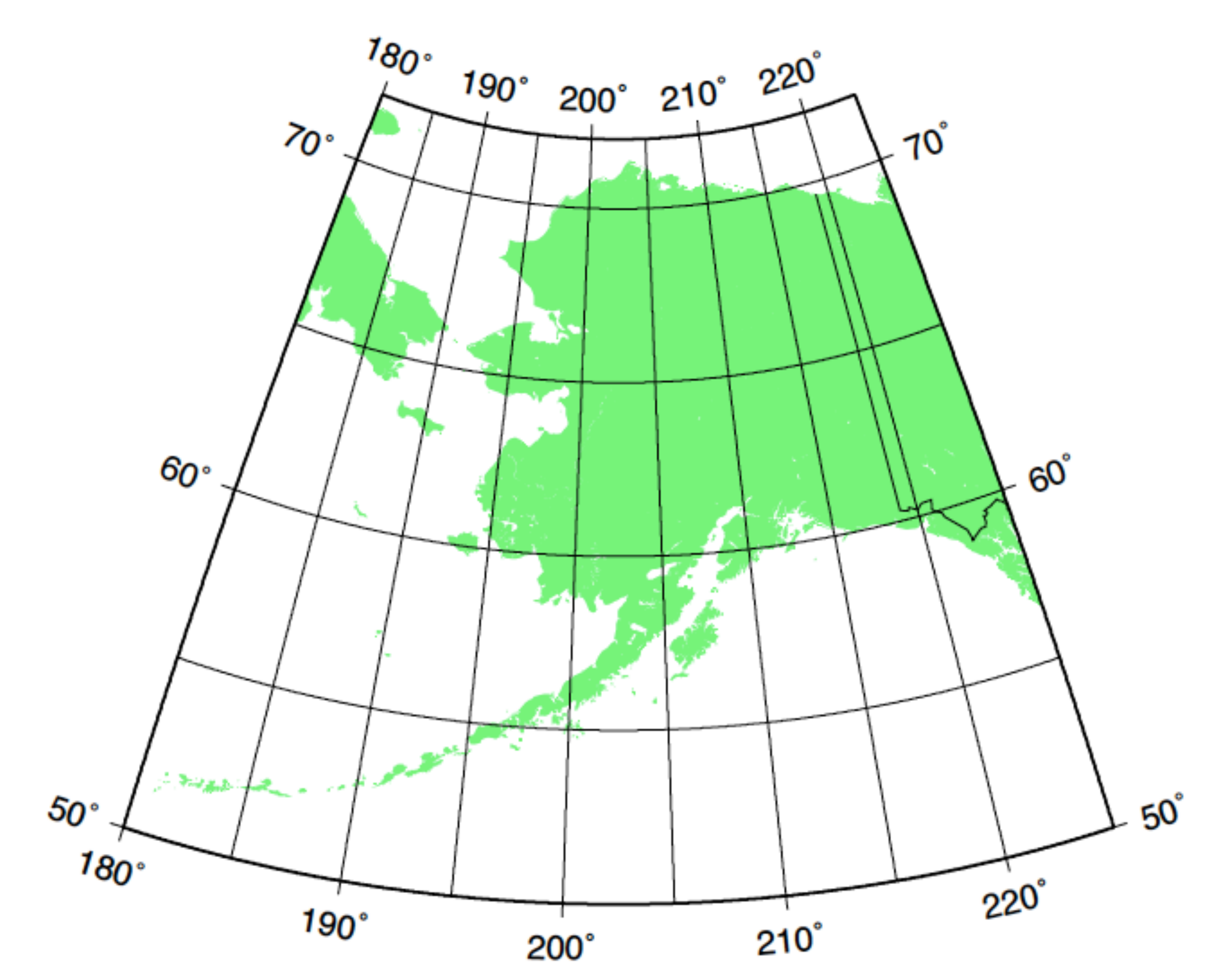
the map.....



sequence is important

```
pscoast $map_pro $map_box -Di -N1 -G125/255/125 -K -P > $filename

psbasemap $map_pro $map_box -Bg5a10 -O >> $filename
```

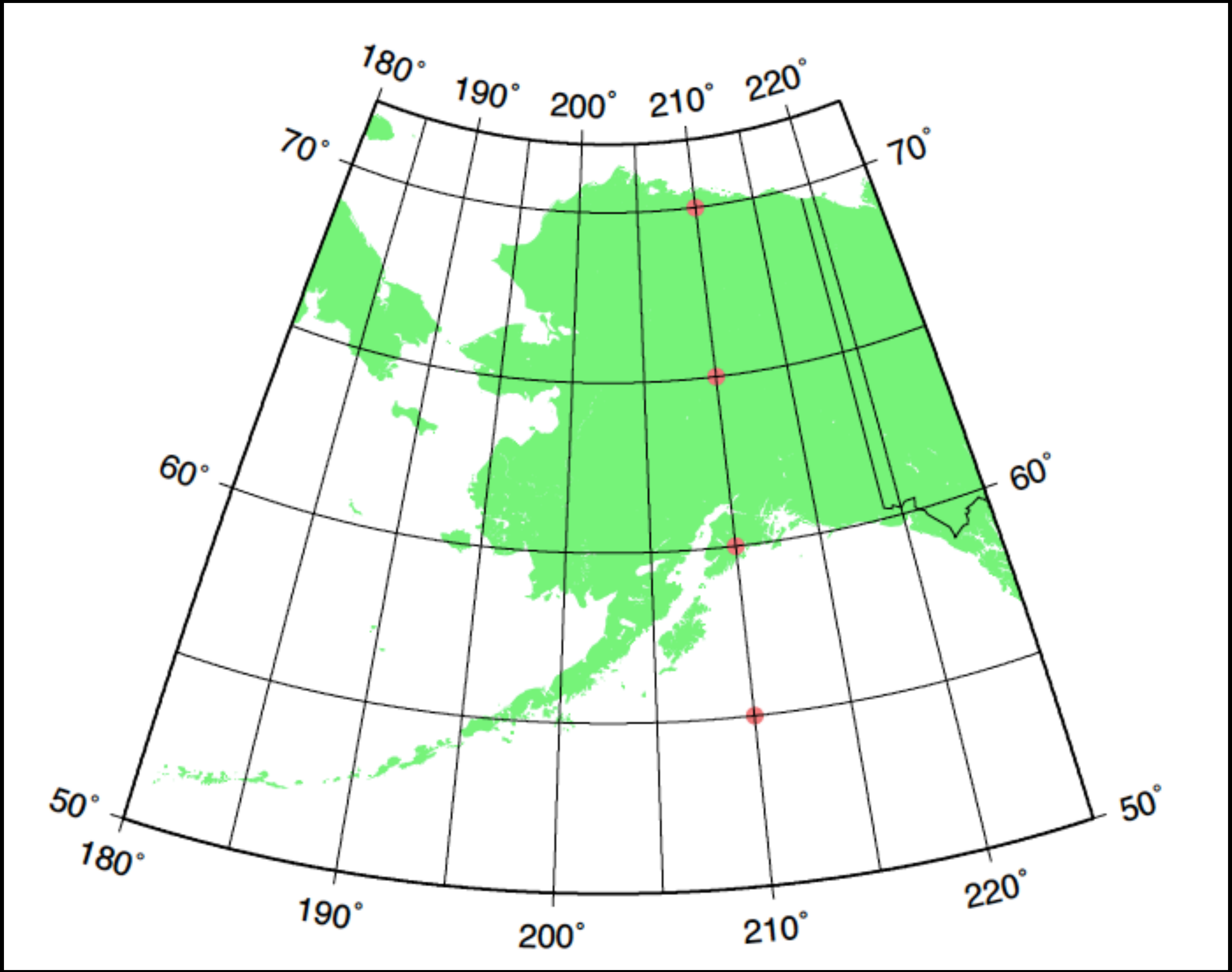
a somewhat different map



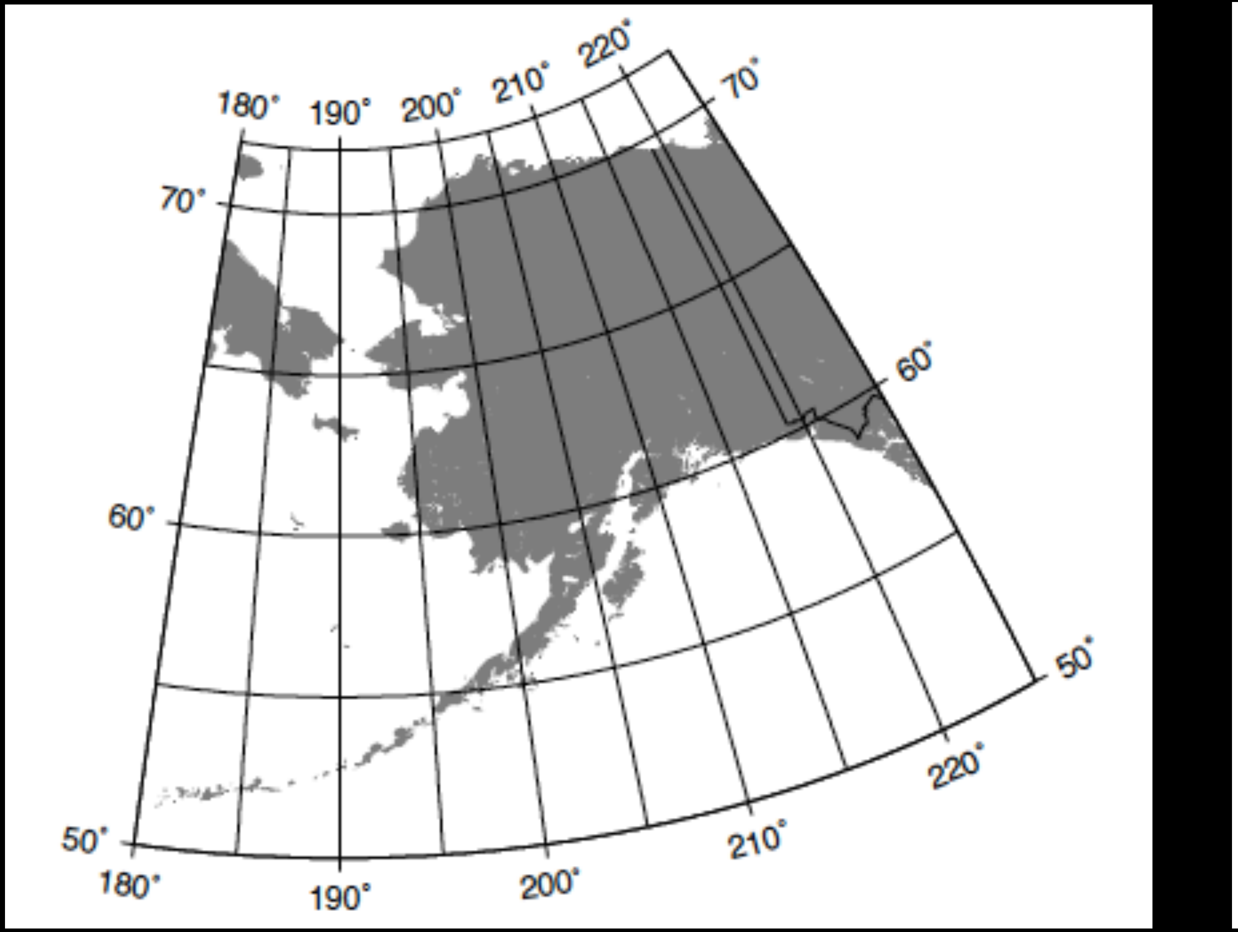
add some data points?

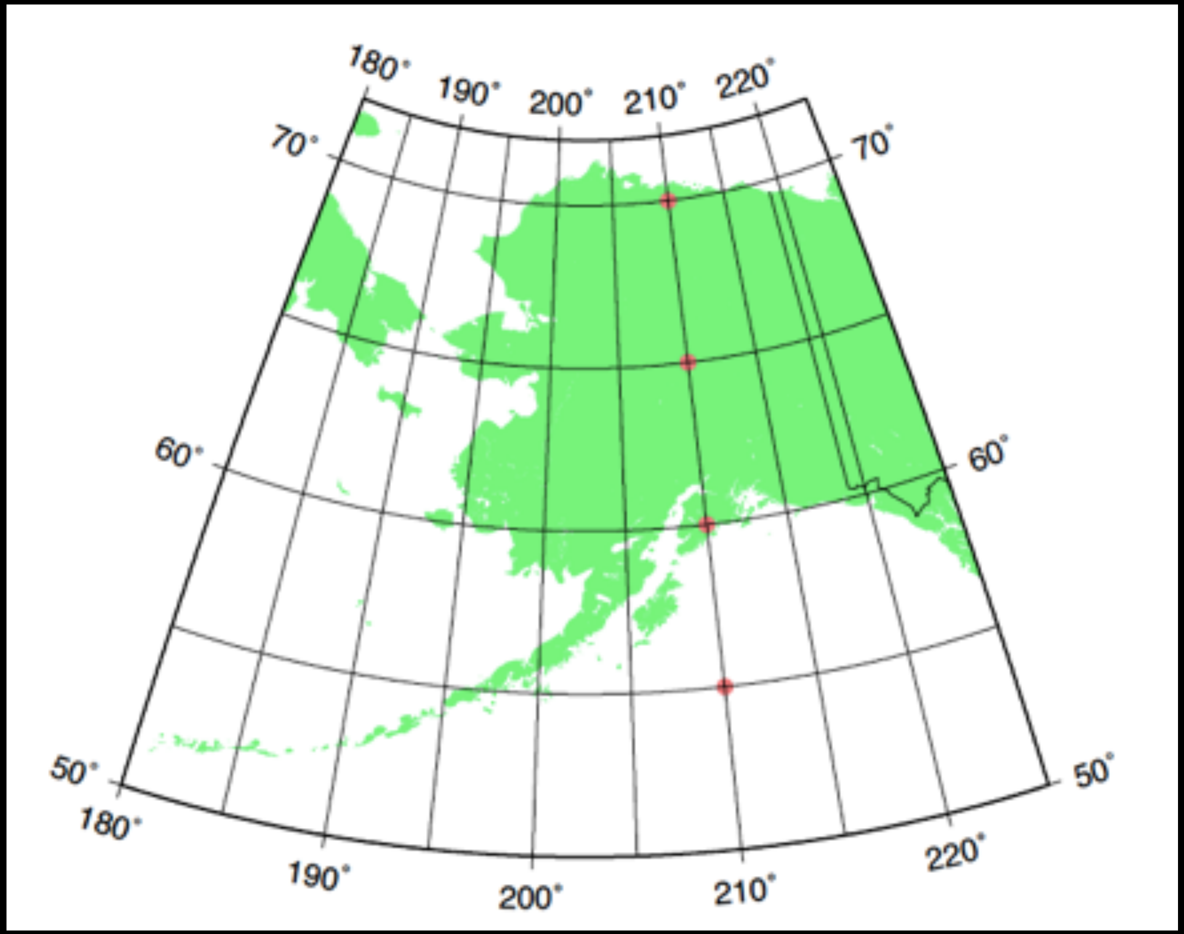
```
pscoast $map_pro $map_box -Di -N1 -G125/255/125 -K -P > $filename

psxy $map_pro $map_box -Sc0.25 -G255/125/125 -K -O >> $filename << END
210 70
210 65
210 60
210 55
END

psbasemap $map_pro $map_box -Bg5a10 -O >> $filename
```

map with data points



so where did we go?





what are -K and -O?

-O suppresses the header, which defines a number of aliases to make a more compact file

```
%!PS-Adobe-3.0
%%BoundingBox: 0 0 595 842
%%Title: GMT v4.2.0 Document from pscoast
%%Creator: GMT
%%For: bernardcoakley
%%DocumentNeededResources: font Helvetica
%%CreationDate: Thu Oct 29 06:47:11 2009
%%LanguageLevel: 1
%%DocumentData: Clean7Bit
%%Orientation: Portrait
%%Pages: 1
%%EndComments

%%BeginProlog
250 dict begin
/A /setgray load def
/B /setdash load def
/C /setrgbcolor load def
/D /rlineto load def
/E {dup stringwidth pop} bind def
/F /fill load def
```

-K suppresses the trailer

a lot of text Postscript precedes these last few lines;

```
1 0 D
 S
%%PageTrailer
S -0 -0 T 4.16667 4.16667 scale 0 A
showpage

%%Trailer

end
%%EOF
```

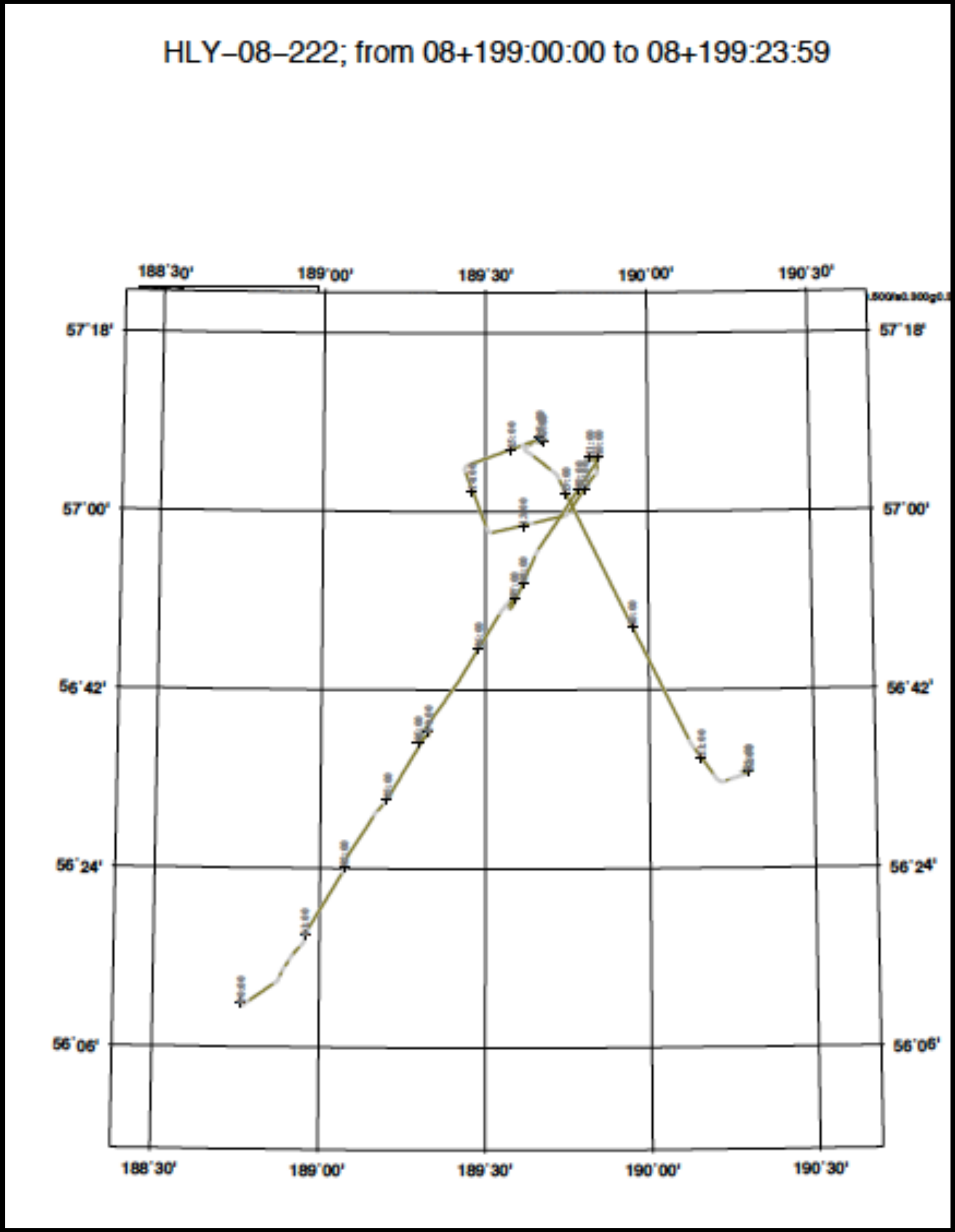
The simplest state uses neither -K or -O and results in a complete plot with both header and trailer.

By using -K and -O we can use GMT commands in series to create a single plot.

most common errors in GMT scripts

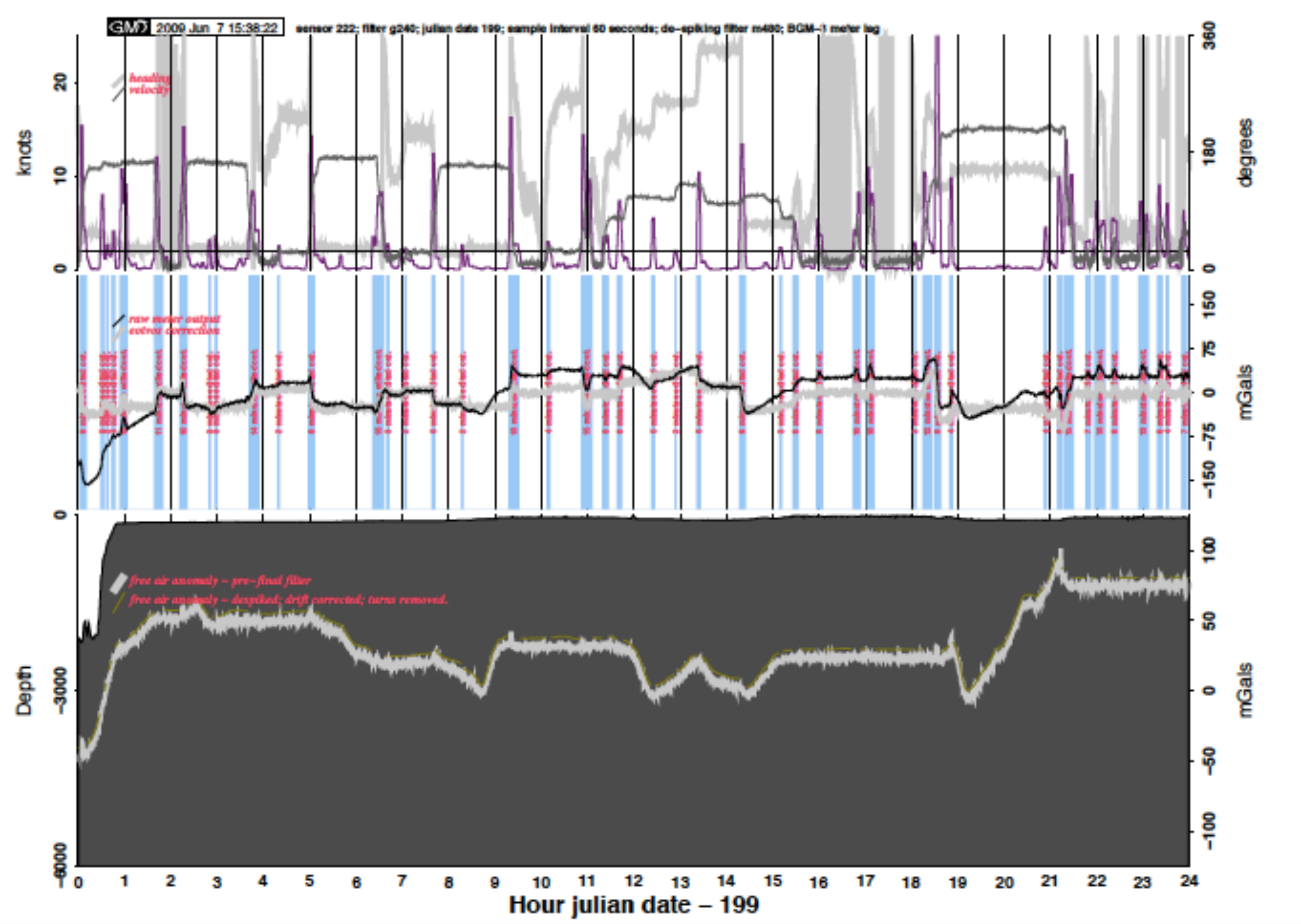
- misuse of -K and -O options
- using “>” instead of “>>” as a redirect
- not specifying -R or -J correctly
- incorrect sequencing of commands
- trying to plot incorrectly scaled data
- trying the write the whole script at once

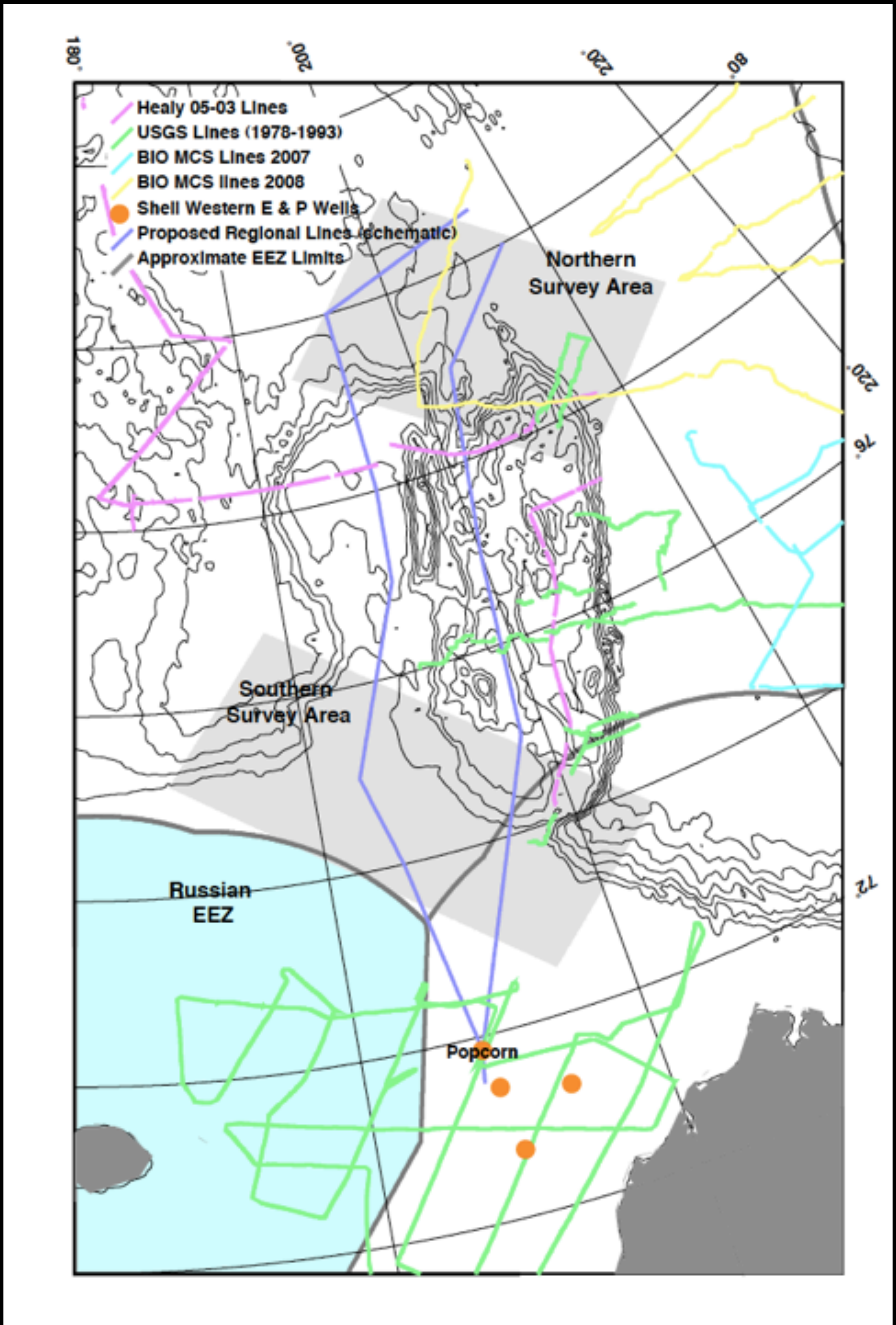
USCGC Ship track



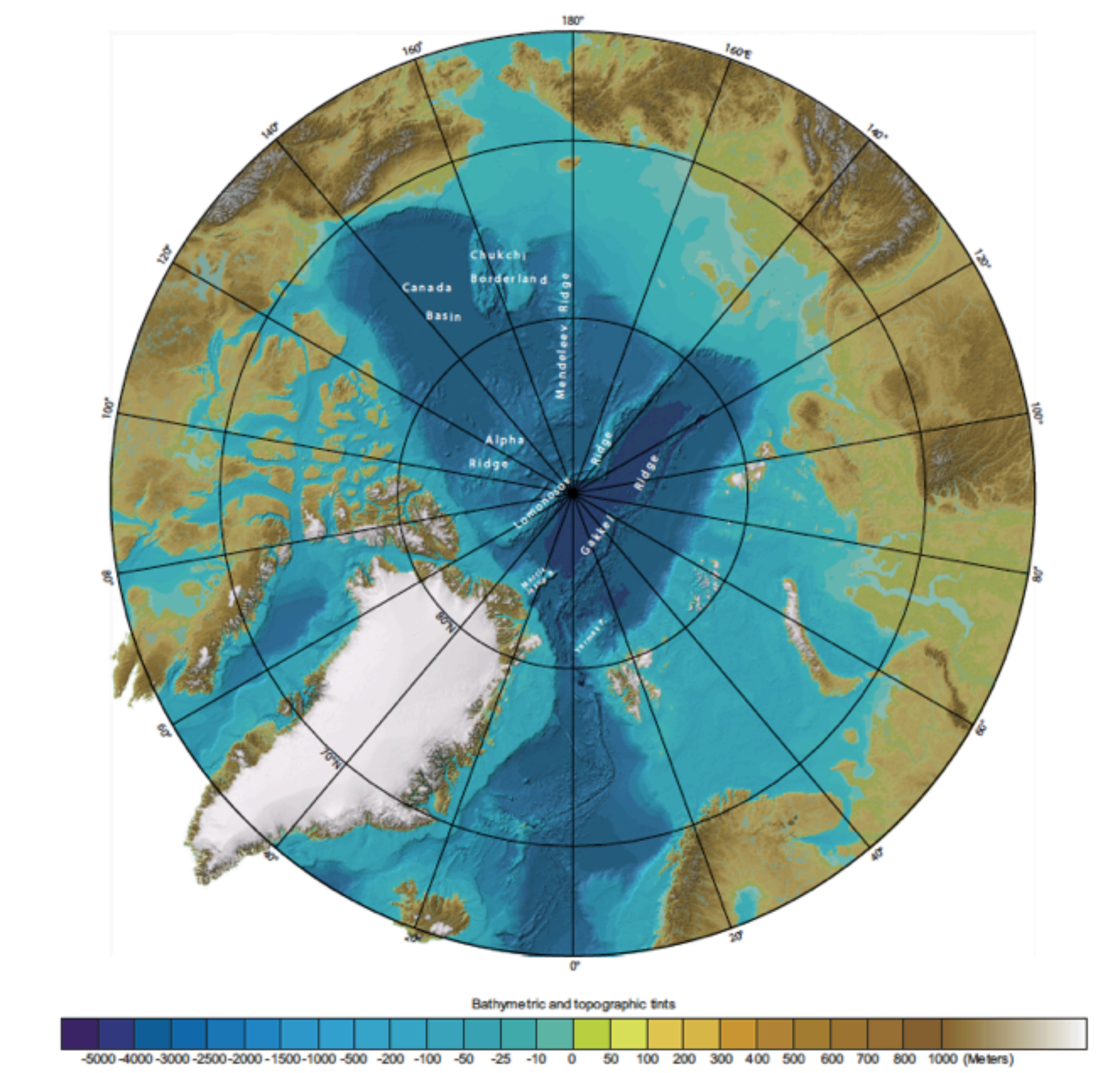
HLY–08–222; from 08+199:00:00 to 08+199:23:59

Gravity data from USCGC Healy




180°
200°
220°
80°
220°
76°
72°
Healy 05-03 Lines
USGS Lines (1978-1993)
BIO MCS Lines 2007
BIO MCS lines 2008
Shell Western E & P Wells
Proposed Regional Lines (schematic)
Approximate EEZ Limits
Northern Survey Area
Southern Survey Area
Russian EEZ
Popcorn

some people are really good at this...



Assignment -

Write a script to plot some data on a map.

Write a 2nd script to do an x, y plot of the same data.

suggestion - use awk to scale or select column data for your plots

Next time, data analysis
and gridding, a lot of gridding with GMT