5. GMT Projections

GMT programs that read position data will need to know how to convert the input coordinates to positions on the map. This is achieved by selecting one of several projections. The purpose of this section is to summarize the properties of map projections available in GMT, what parameters define them, and demonstrate how they are used to create simple basemaps. We will mostly be using the *pscoast* command and occasionally *psxy*. (Our illustrations may differ from yours because of different settings in our .gmtdefaults file.) Note that while we will refer to lengths and scales in inches, you may want to use cm as unit instead (see *gmtdefaults* man page).

5.1 Non-map Projections

5.1.1 Linear Projection (–Jx or –JX)

The linear projection comes in three flavors: linear, $\log_{10}$, and power. The projection for the *y*-axis can be set independently from the *x*-axis. We will show examples of all three by first creating dummy data sets using *sample1d* and *nawk* (or *awk*):

```
sample1d -I1 -L << END | nawk '{print $1, sqrt ($1)}' > sqrt.d
0  0
100      0
END
sample1d -I10 -L << END | nawk '{print $1, sqrt ($1)}' > sqrt.d10
0  0
100      0
END
```

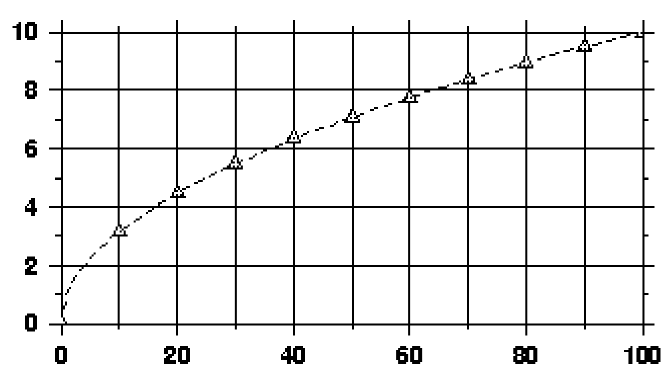
The projection is defined by stating

• scale in inches/unit (**–Jx**) or axis length in inches (**–JX**)

If the *y*-scale or *y*-axis length is different from that of the *x*-axis (which is most often the case), separate the two scales (or lengths) by a slash, e.g., **–Jx**0.1/0.5 or **–JX**8/5.

Linear projection

Selection of this transformation will result in a linear scaling of the input coordinates. Thus, our *y* = sqrt (*x*) data sets will plot as shown below:



The complete commands given to produce this plot were

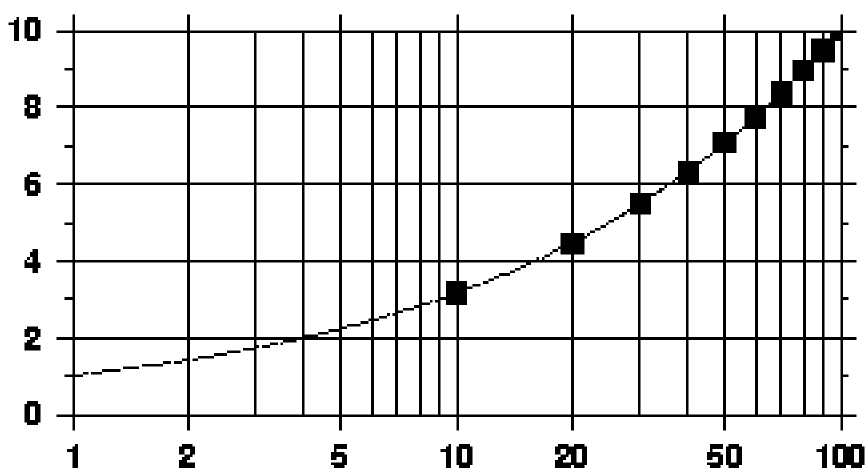
```
psxy -R0/100/0/10 -JX4/2 -Ba20f10g10/a2f1g2WSne -W5t15_15:0 -P -K -X0.5 -Y0.5 sqrt.d >
linear.ps
psxy -R  -JX  -St0.1 -G200 -W -O sqrt.d10 >> linear.ps
```

Normally, the user's *x*-values will increase to the right and the *y*-values will increase upwards. It should be noted that in many situations it is desirable to have the direction of positive coordinates be reversed. For example, when plotting depth on the *y*-axis it makes more sense to have the positive direction downwards. All that is required to reverse the sense of positive direction is to supply a negative scale (or axis length).

Logarithmic projection

The $\log_{10}$ transformation is selected by appending an *l* (lower case L) immediately following the scale (or axis length) value. Hence, to produce a plot in which the *x*-axis is logarithmic (the *y*-axis remains linear), try

```
psxy -R1/100/0/10 -Jx2l/0.2 -B2g3/a2f1g2WSne -W5t5_5:0 -P -K -X0.5 -Y0.5 -H sqrt.d > log.ps
psxy -R  -Jx -Ss0.1 -G0 -W -O -H sqrt.d10 >> log.ps
```

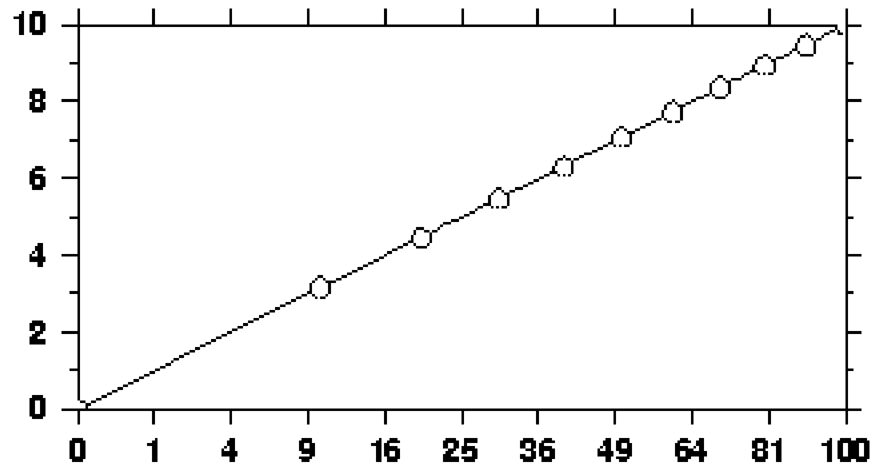


Note that if *x*- and *y*-scaling are different and a $\log_{10}$-$\log_{10}$ plot is desired, the *l* must be appended twice: Once after the *x*-scale (before the /) and once after the *y*-scale.

Power projection

This projection allows us to display x^a versus y^b. While *a* and *b* can be any value, we will select $a = 0.5$ and $b = 1$ which means we will plot *y* versus $\sqrt{x}$. We indicate this scaling by appending a *p* (lower case P) followed by the desired exponent, in our case 0.5. Since $b = 1$ we do not need to specify *p*1 since it is identical to the linear scaling. Thus our command becomes

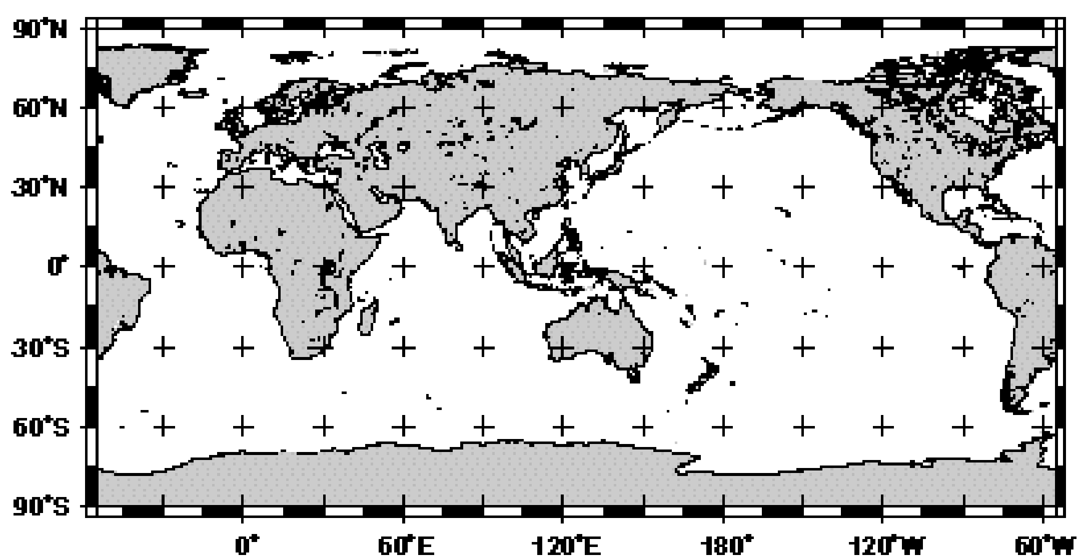
```
psxy -R0/100/0/10 -Jx0.4p0.5/0.2 -Ba1p/a2f1WSne -W5 -P -K -X0.5 -Y0.5 sqrt.d > pow.ps
psxy -R  -Jx  -Sc0.1 -G255 -W -O sqrt.d10 >> pow.ps
```



While these linear projections are primarily designed for generic *x-y* data, it is sometimes necessary to plot geographical data in a linear projection. This poses a problem since longitudes have a 360 degree periodicity. GMT therefore needs to be informed that it has been given geographical data although a linear projection has been chosen. We do so by appending a **d** (for degrees) to the **–Jx** (or **–JX**) option. As an example, we want to plot a crude world map centered on 125˚E. Our command will be

```
gmtset GRID_CROSS_SIZE 0.1 BASEMAP_TYPE FANCY DEGREE_FORMAT 3
pscoast -R-55/305/-90/90 -Jx0.014d -B60g30f15/30g30f15WSen -Dc -G200 -W1 -P -X0.5 -Y0.5 >
degree.ps
```

with the result reproduced below.



5.1.2 Linear Projection with Polar (θ, *r*) Coordinates (–Jp or –JP)

In many applications the data is better described in polar or cylindrical (θ, *r*) coordinates rather than the usual Cartesian coordinates (*x*, *y*). The relationship between the Cartesian and polar coordinates are described by $x = r \cdot \cos\theta$, $y = r \cdot \sin\theta$. The polar transformation is simply defined by providing

- scale in inches/unit (**–Jp**) or full width of plot in inches (**–JP**).

As an example of this projection we will create a gridded data set in polar coordinates $z(\theta, r) = r^2 \cdot \cos(4\theta)$ using *grdmath*, a "Reverse Polish Notation" (RPN) calculator that operates on or creates grdfiles. We could also create the data with *xyz2grd* and the UNIX tool *nawk*: ($0.06981317 = 4 \cdot (360^\circ/2\pi)$); its command line is commented out in the script below.

```
#nawk 'BEGIN {for (theta = 0; theta <= 360; theta += 6) {for (r = 2.0; r <= 4.01; r += 0.1) print
theta, r, cos (0.06981317 * theta) * r * r}}' /dev/null | xyz2grd -R0/360/2/4 -I6/0.1 -Gtest.grd
grdmath -R0/360/2/4 -I6/0.1 X 4 MUL PI MUL 180 DIV COS Y 2 POW MUL = test.grd
grdcontour test.grd -JP4 -B30Ns -P -C2 -S4 -X0.5 -Y0.5 > donut.ps
```

We used *grdcontour* to make a contour map of this data. Because the data file only contains values with $2 \leq r \leq 4$, a donut shaped plot appears below.