5.4 Cylindrical Projections

5.4.1 Mercator Projection (–Jm or –JM)

Probably the most famous of the various map projections, the Mercator projection takes its name from Mercator who presented it in 1569. It is a cylindrical, conformal projection with no distortion along the equator. A major navigational feature of the projection is that a line of constant azimuth is straight. Such a line is called a rhumb line or *loxodrome*. Thus, to sail from one point to another one only had to connect the points with a straight line, determine the azimuth of the line, and keep this constant course for the entire voyage†. The Mercator projection has been used extensively for world maps in which the distortion towards the polar regions grows rather large, thus incorrectly giving the impression that, for example, Greenland is larger than South America. In reality, the latter is about eight times the size of Greenland. Also, the Former Soviet Union looks much bigger than Africa or South America. One may wonder whether this illusion has had any influence on U.S. foreign policy.

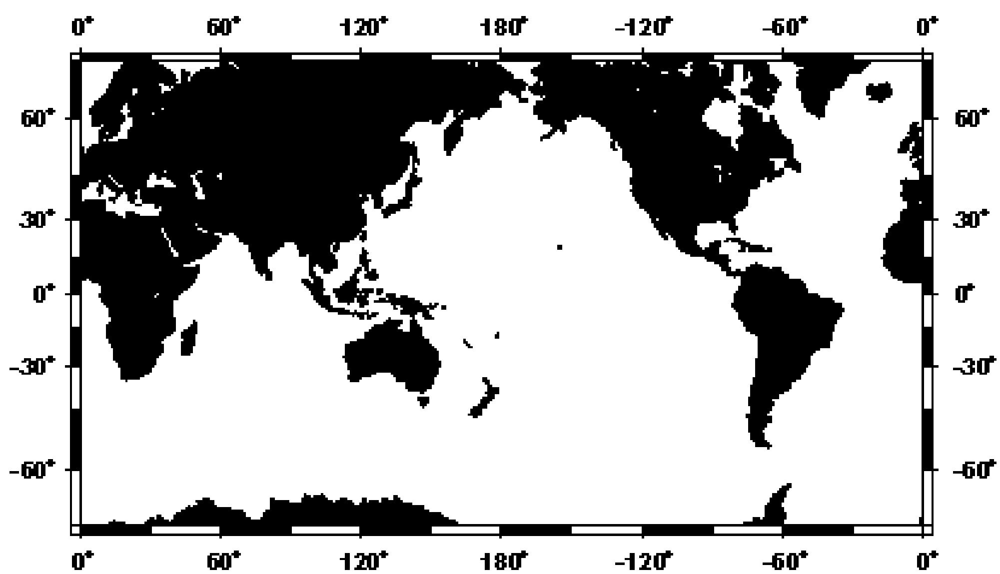
In the regular Mercator projection, the cylinder touches the globe along the equator. Other orientations like vertical and oblique give rise to the Transverse and Oblique Mercator projections, respectively. We will discuss these generalizations following the regular Mercator projection.

The regular Mercator projection requires a minimum of parameters. To use it in GMT programs you supply this information (the first two items are optional and have defaults):

- Central meridian [Middle of your map]
- Standard parallel for true scale [Equator]
- Scale along the equator in inch/degree or 1:xxxxx (**–Jm**), or map width (**–JM**)

Our example presents a world map at a scale of 0.0135 inch pr degree which will give a map 4.86 inch wide. It was created with the command:

```
pscoast -R0/360/-70/70 -Jm1.35e-2 -Ba60f30/a30f15 -Dc -A5000 -G0 -P -X0.5 -Y0.5 >
mercator.ps
```



† This is, however, not the shortest distance. It is given by the great circle connecting the two points.

While this example is centered on the Dateline, one can easily choose another configuration with the -R option. A map centered on Greenwich would specify the region with -R-180/180/-70/70.

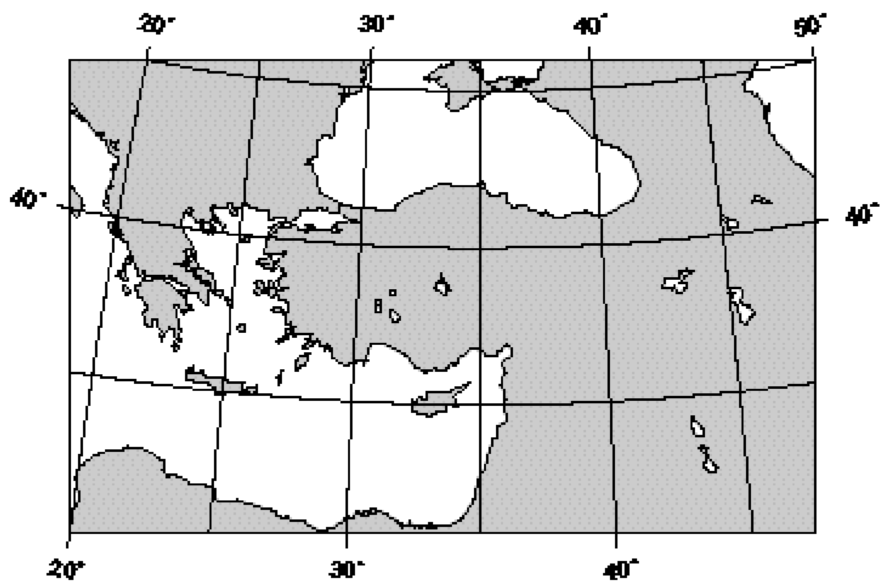
5.4.2 Transverse (–Jt or –JT) & Universal Transverse Mercator UTM (–Ju or –JU)

The transverse Mercator was invented by Lambert in 1772. In this projection the cylinder touches a meridian along which there is no distortion. The distortion increases away from the central meridian and goes to infinity at 90˚ from center. The central meridian, each meridian 90˚ away from the center, and equator are straight lines; other parallels and meridians are complex curves. The projection is defined by specifying

- The central meridian
- Scale along the equator in inch/degree or 1:xxxxx (**–Jt**), or map width (**–JT**)

Our example shows a transverse Mercator map of south-east Europe and the Middle East with 35˚E as the central meridian:

```
pscoast -R20/30/50/45r -Jt35/0.18 -B10g5 -Dl -A250 -G200 -W1 -P -X0.5 -Y0.3 > tm.ps
```



A particular subset of the transverse Mercator is the Universal Transverse Mercator (UTM) which was adopted by the US Army for large-scale military maps. Here, the globe is divided into 60 zones between 84˚S and 84˚N, most of which are 6˚ wide. Each of these UTM zones have their unique central meridian. GMT implements both the transverse Mercator and the UTM projection. When selecting UTM you must specify

- UTM zone (1-60). Use negative value for zones in the southern hemisphere
- Scale along the equator in inch/degree or 1:xxxxx (**–Ju**), or map width (**–JU**)

In order to minimize the distortion in any given zone, a scale factor of 0.9996 has been factored into the formulae. The scale only varies by 1 part in 1,000 from true scale at equator.

5.4.3 Oblique Mercator (–Jo or –JO)

Oblique configurations of the cylinder give rise to the oblique Mercator projection. It is particularly useful when mapping regions of large lateral extent in an oblique direction. Both parallels and meridians are complex curves. The projection was developed in the early 1900s by several workers. Several parameters must be provided to define the projection. GMT offers three different definitions:

Definition 1 (option **–Joa or –JOa**):

- Longitude and latitude of projection center
- azimuth of the oblique equator
- scale in inch/degree or 1:xxxxx along oblique equator (**–Joa**), or map width (**–JOa**)

Definition 2 (option **–Job or –JOb**):

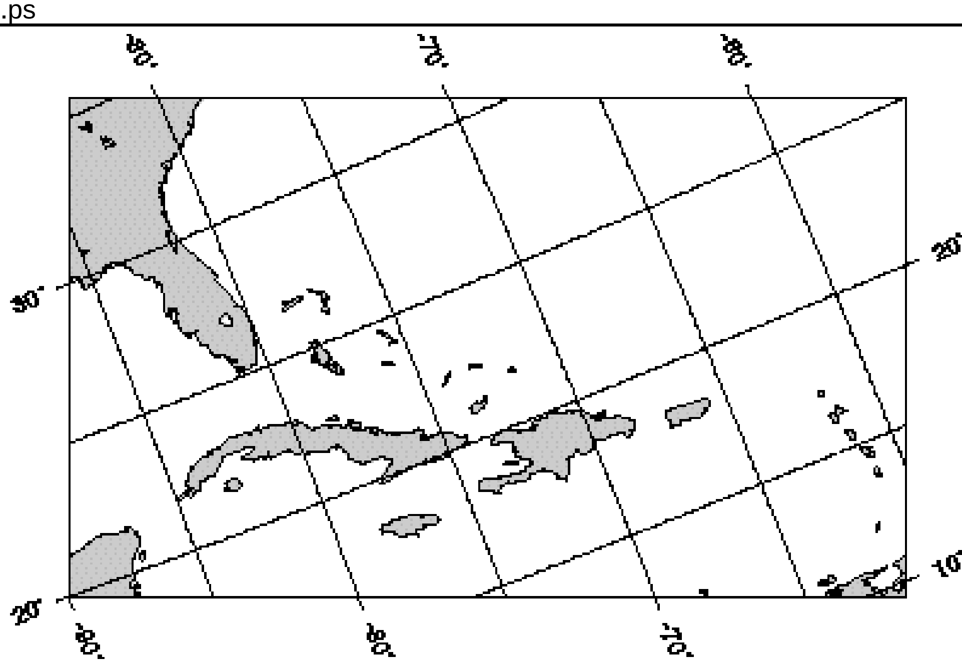
- Longitude and latitude of projection center
- Longitude and latitude of second point on oblique equator
- scale in inch/degree or 1:xxxxx along oblique equator (**–Job**), or map width (**–JOb**)

Definition 3 (option **–Joc or –JOc**):

- Longitude and latitude of projection center
- Longitude and latitude of projection pole
- scale in inch/degree or 1:xxxxx along oblique equator (**–Joc**), or map width (**–JOc**)

Our example was produced by the command

```
pscoast -R270/20/305/25r -Joc280/25.5/22/69/4.8 -B10g5 -Dl -A250 -G200 -W1 -P -X0.4 -Y0.4 >
oblique.ps
```



It uses definition 3 for an oblique view of some Caribbean islands. Note that we define our region using the rectangular system described earlier. If we do not append an 'r' to the **–R** string then the information provided with the **–R** option is assumed to be oblique degrees about the projection center rather than the usual geographic coordinates.

This interpretation is chosen since in general the parallels and meridians are not very suitable as map boundaries.

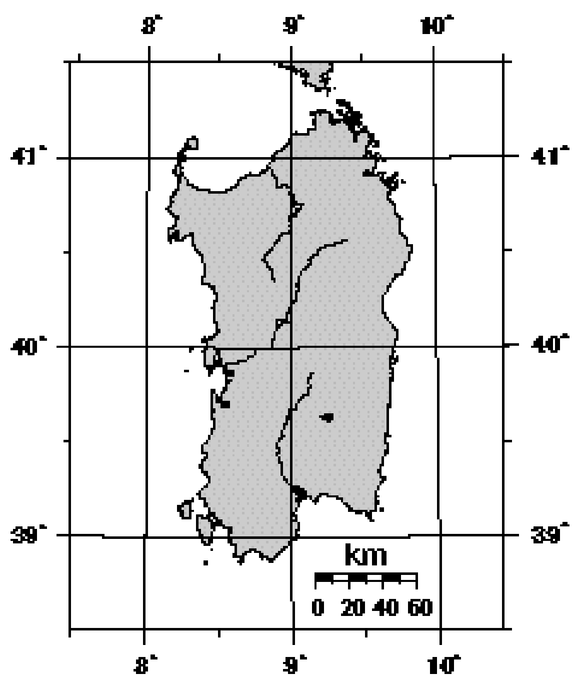
5.4.4 Cassini Cylindrical Projection (–Jc or –JC)

This cylindrical projection was developed in 1745 by C. F. Cassini for the survey of France. It is occasionally called Cassini-Soldner since the latter provided the more accurate mathematical analysis that led to the development of the ellipsoidal formulae. The projection is neither conformal nor equal-area, and behaves as a compromise between the two end-members. The distortion is zero along the central meridian. It is best suited for mapping regions of north-south extent. The central meridian, each meridian 90˚ away, and equator are straight lines; all other meridians and parallels are complex curves. The requirements to define this projection are:

- Longitude and latitude of central point
- Scale in inch/degree or as 1:xxxxx (**–Jc**), or map width (**–JC**)

A detailed map of the island of Sardinia centered on the 8˚45'E meridian using the Cassini projection can be obtained by running the command:

```
pscoast -R7:30/38:30/10:30/41:30r -JC8.75/40/2.5 -B1g1f30m -Dh -Lf9.5/38.8/40/60  -G200 -W1 -Ia/1 -P -X0.4 -Y0.3 > cassini.ps
```



As with the previous projections, the user can choose between a rectangular boundary (used here) or a geographical (WESN) boundary.

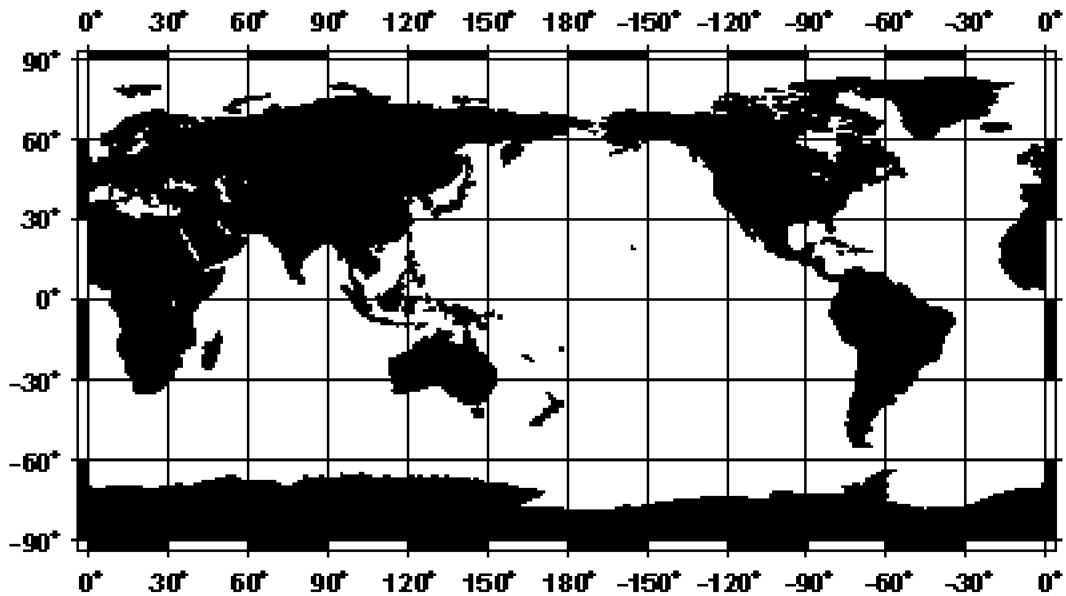
5.4.5 Equidistant Cylindrical Projection (–Jq or –JQ)

This simple cylindrical projection is really a linear scaling of longitudes and latitudes (if you desire a different scaling for one of the axes you must choose the linear projection **–Jx** and append **d** for degrees (see section 5.1.1).) It is also known as the Plate Carrée projection. All meridians and parallels are straight lines. The requirements to define this projection are:

- The central meridian
- Scale in inch/degree or as 1:xxxxx (**–Jq**), or map width (**–JQ**)

A world map centered on the dateline using this projection can be obtained by running the command:

```
pscoast -R0/360/-90/90 -JQ180/5 -B30g30 -Dc -A5000 -G0 -P -X0.5 -Y0.3 > cyl_eqdist.ps
```



5.4.6 General Cylindrical Projections (–Jy or –JY)

This cylindrical projection is actually several projections, depending on what latitude is selected as the standard parallel. However, they are all equal area and hence non-conformal. All meridians and parallels are straight lines. The requirements to define this projection are:

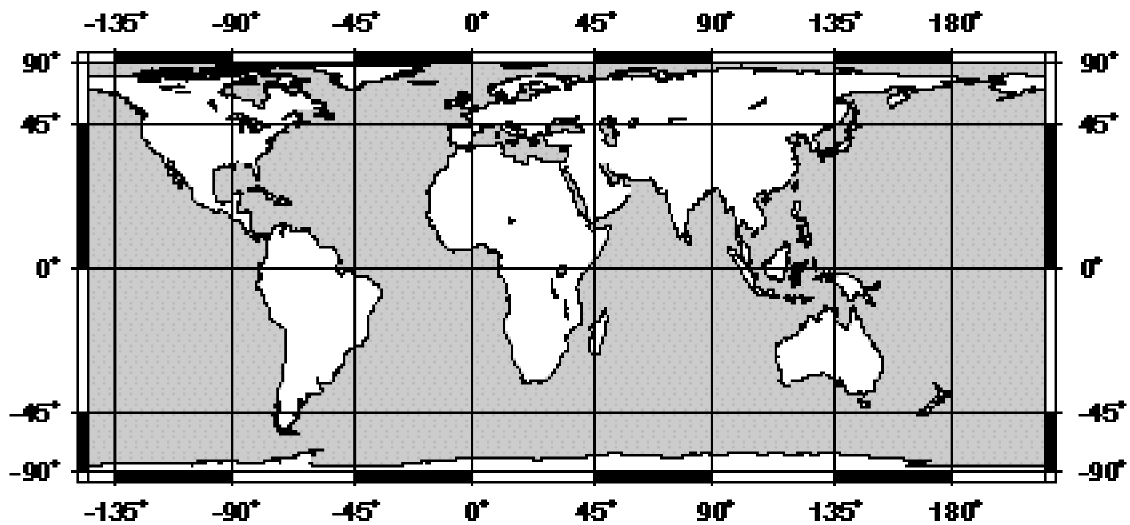
- The central meridian
- The standard parallel
- Scale in inch/degree or as 1:xxxxx (**–Jy**), or map width (**–JY**)

While you may choose any value for the standard parallel and obtain your own personal projection, there are four choices of standard parallels that result in known (or named) projections. These are

Projection name:	Standard parallel:
Lambert	0˚
Behrman	30˚
Trystan-Edwards	37˚24' (= 37.4˚)
Peters (Gall)	45˚

For instance, a world map centered on the 35˚E meridian using the Behrman projection can be obtained by running the command:

```
pscoast -R0/360/-90/90 -JY35/30/5 -B45g45 -Dc -A10000 -S200 -W1 -P -X0.5 -Y0.3 >
behrman.ps
```



As one can see there is considerable distortion at high latitudes since the poles map into lines.

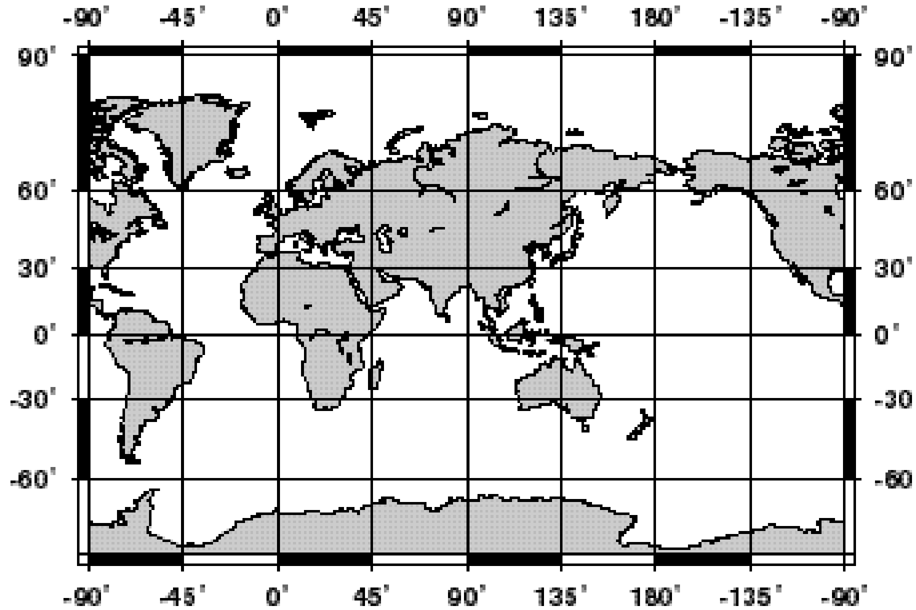
5.4.7 Miller Cylindrical Projections (–Jj or –JJ)

This cylindrical projection, presented by O. M. Miller of the American Geographic Society in 1942, is neither equal nor conformal. All meridians and parallels are straight lines. The projection was designed to be a compromise between Mercator and other cylindrical projections. Specifically, Miller spaced the parallels by using Mercator's formula with 0.8 times the actual latitude, thus avoiding the singular poles; the result was then divided by 0.8. There is only a spherical form for this projection. The requirements to define this projection are:

- The central meridian
- The standard parallel
- Scale in inch/degree or as 1:xxxxx (**–Jj**), or map width (**–JJ**)

For instance, a world map centered on the 90˚E meridian at a map scale of 1: 400,000,000 can be obtained as follows:

```
pscoast -R0/360/-80/90 -Jj90/1:400000000 -B45g45/30g30 -Dc -A10000 -G200 -W1 -P -X0.5 -
Y0.3 > 5.4.7.ps
```


-90˚ -45˚ 0˚ 45˚ 90˚ 135˚ 180˚ -135˚ -90˚
90˚
60˚
30˚
0˚
-30˚
-60˚