Miscellaneous Projections

The miscellaneous classification is employed for projections not mathematically developed as projections onto a conic surface and which are primarily used for global or hemispherical small scale maps. Except for certain cases with the Lagrange projection, the cartesian origin coincides with λ_0 and $\phi = 0°$, and `+lat_0` is not used with any of the miscellaneous projections.

August Epicycloidal Projection

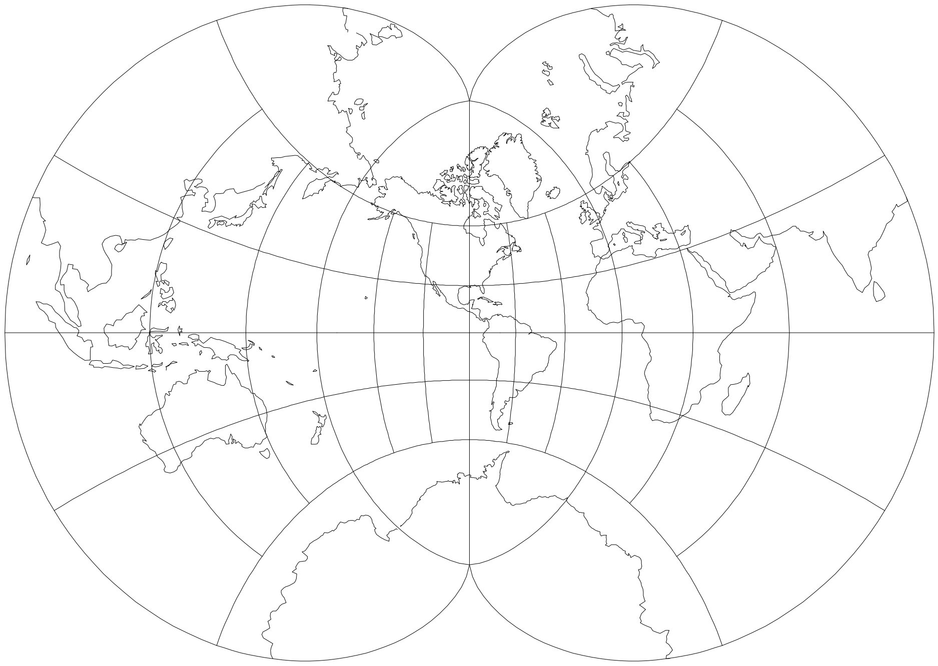

Figure 59: August Epicycloidal projection, with shorelines and 30°graticule. Central Meridian 90° W (`+proj=august +lon_0=90w`).

Classifications: Miscellaneous conformal.

Aliases: August.

Available forms: Forward, spherical projection.

Usage and options: `+proj=august`

Bacon Globular Projection

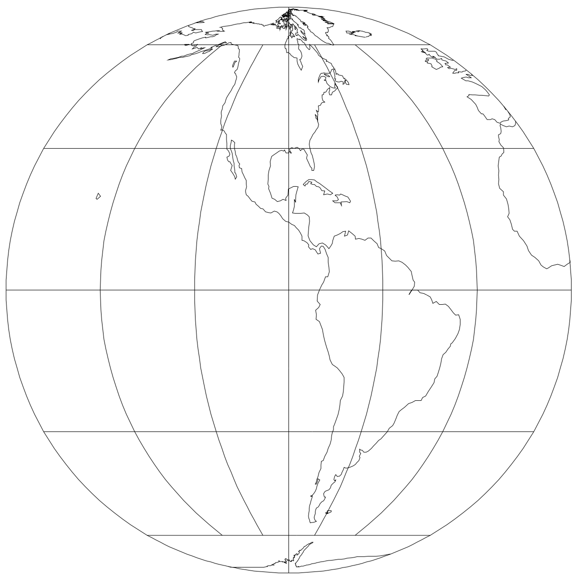

Figure 60: Bacon Globular projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=bacon +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward, spherical projection.

Usage and options: `+proj=bacon`

Nicolosi Globular Projection

Figure 61: Nicolosi Globular projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=nicol +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward, spherical projection.

Usage and options: `+proj=nicol`

Fournier Globular I Projection

Figure 62: Fournier Globular I projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=fourn +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward, spherical projection.

Usage and options: `+proj=fourn`

Apian Globular I Projection

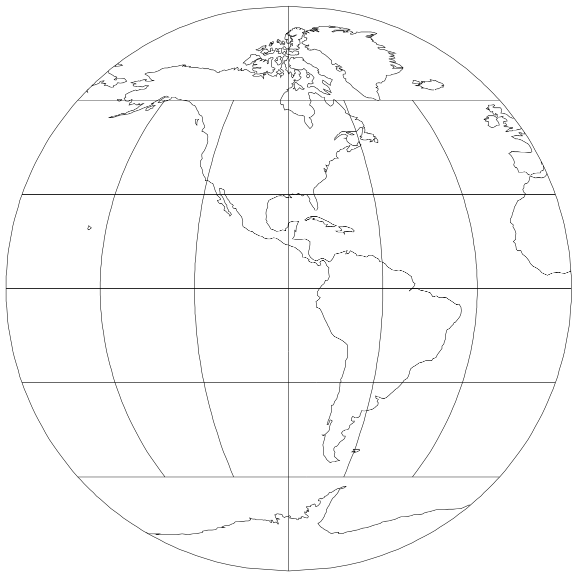

Figure 63: Apian Globular I projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=apian +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward, spherical projection.

Usage and options: `+proj=apian`

Eisenlohr Projection

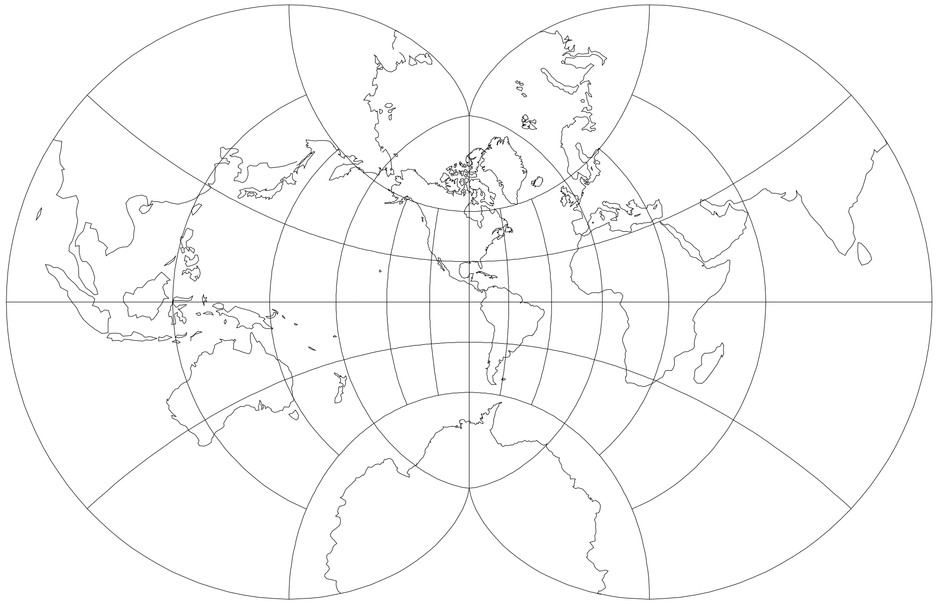

Figure 64: Eisenlohr projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=eisen +lon_0=90w`).

Classifications: Miscellaneous. Conformal.
Available forms: Forward and inverse, spherical projection.
Usage and options: `+proj=eisen`

Ortelius Oval Projection

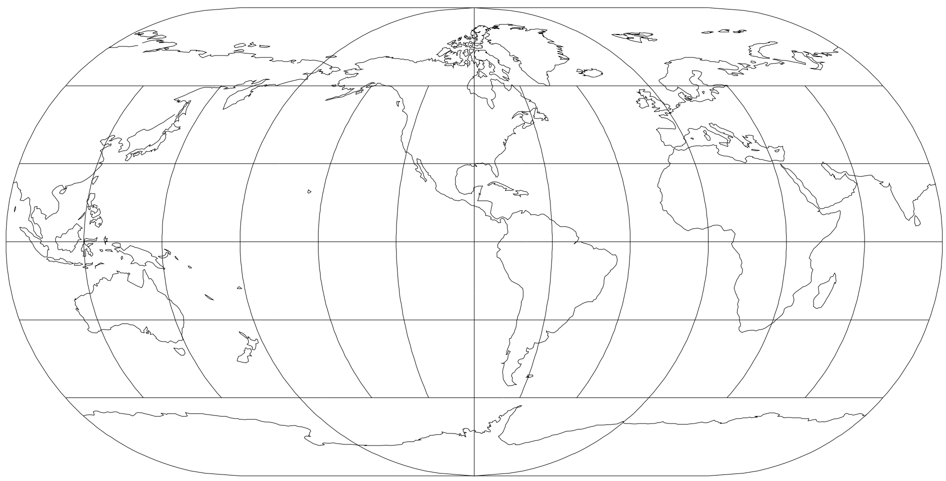

Figure 65: Ortelius Oval projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=ortel +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.
Available forms: Forward, spherical projection.
Usage and options: `+proj=ortel`

Van der Grinten (I) Projection

Figure 66: Van der Grinten I projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=vandg +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward and inverse, spherical projection.

Usage and options: `+proj=vandg`

Van der Grinten II Projection

Figure 67: Van der Grinten II projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=vandg2 +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward, spherical projection.

Usage and options: `+proj=vandg2`

Van der Grinten III Projection

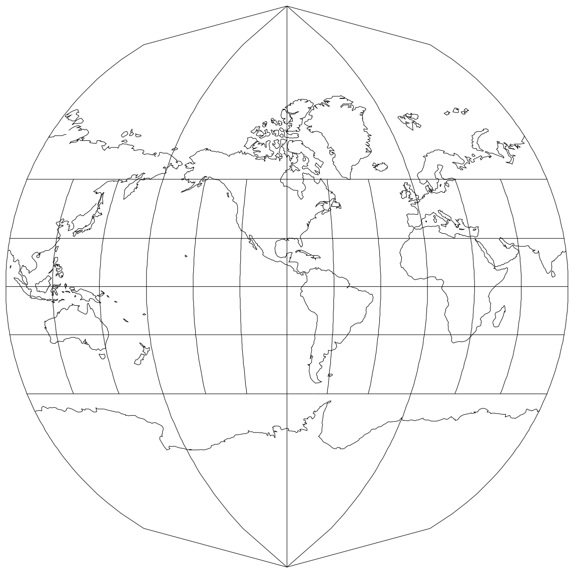

Figure 68: Van der Grinten III projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=vandg3 +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward, spherical projection.

Usage and options: `+proj=vandg3`

Van der Grinten IV Projection

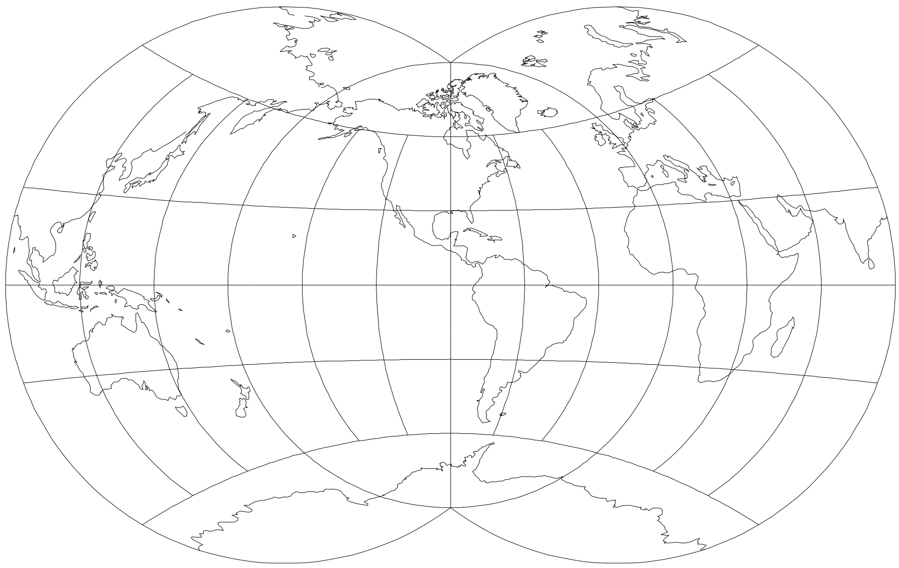

Figure 69: Van der Grinten IV projection, with shorelines and 30° graticule. Central Meridian 90° W (`+proj=vandg4 +lon_0=90w`).

Classifications: Miscellaneous. Neither conformal nor equal area.

Available forms: Forward, spherical projection.

Usage and options: `+proj=vandg4`

Lagrange Projection

Figure 70: Lagrange projection, with shorelines and 30° graticule. Central Meridian 90° W. (`+proj=lagrng +lon_0=90w`)

Classifications: Miscellaneous. Conformal.

Available forms: Forward, spherical projection.

Usage and options: `+proj=lagrng +W=`r `+lat_1=`ϕ_1

The `+W` option provides for specifying the ratio $r = \lambda'/180°$ that defines a circular meridian passing through the poles and $\lambda_0 \pm \lambda'$. Figure 70 shows the default value of $r = 2$, and figures 71 and 72 show respective values of $r = 1$ and $r = 1.4$. Option `+lat_1=`ϕ_1 specifies a parallel that will be a straight line ($\phi_1 = 0$ when not specified) as well as the origin of the y axis. Figure 73 is an example for $\phi_1 = 30°$S.

Figure 71: Lagrange projection, with shorelines and 30° graticule. Central Meridian 90° W. (`+proj=lagrng +lon_0=90w +W=1`)

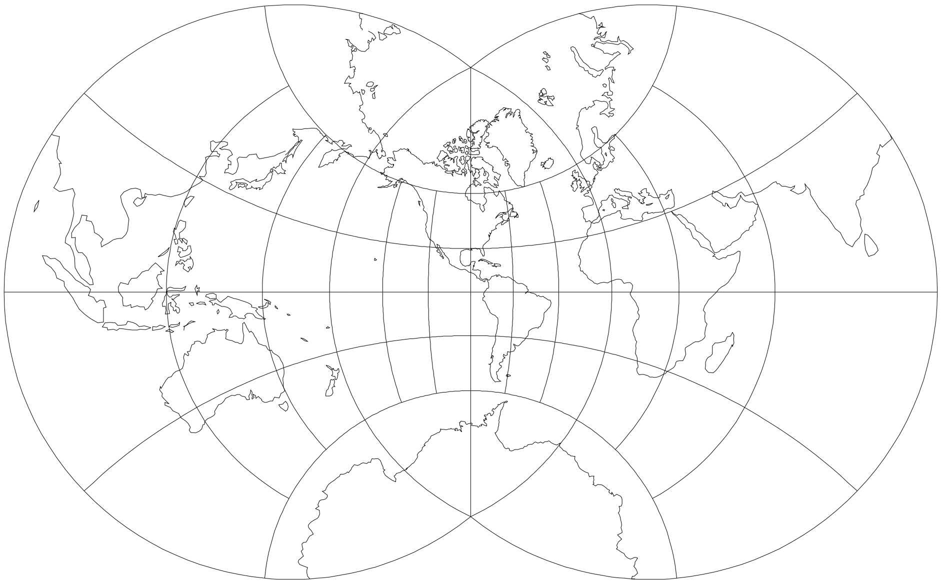

Figure 72: Lagrange projection, with shorelines and 30° graticule. Central Meridian 90° W. (`+proj=lagrng +lon_0=90w +W=1.4`)

Figure 73: Lagrange projection, with shorelines and 30° graticule. Central Meridian 90° W. (`+proj=lagrng +lon_0=90w +lat_1=30s`)

U.S. State Plane Coordinate Systems (SPCS)

Since 1935 each of the United States have defined by State legislative action one or more SPCS zones in terms of datum, geographical extent and cartographic projection parameters relating geographic coordinates to the cartesian coordinates used in land surveying. Mitchell and Simmons (1945, p. 45–47) and Snyder (1988, p. 52–56) provide tables of the cartographic parameters for each of these zones. The North American Datum of 1927 (NAD27) and Clarke 1866 ellipsoid are used for SPCS27 and cartesian units are in "U.S. surveyor feet" with a metric conversion of 1 m $\equiv$ 39.37 in. (versus the International conversion of 1 in. $\equiv$ 2.54 cm).

Subsequent to the use of modern surveying equipment and satellite data, improved positioning information has resulted in establishing a new datum, NAD83, SPCS83 and the GRS80 ellipsoid (Stem, 1989). Several States have also altered their zones and units of the cartesian coordinate system. It is unclear as to the status of NAD83 in each States because of the current transitional period (see Stem, 1989, p. 9) and users should check with local State authorities as to the exact system in current usage.

SPCS Conversion Procedures

Procedures are available to perform forward, `for27` or `for83`, or inverse, `inv27` or `inv83`, conversions for respective SPCS27 or SPCS83. If any of the procedures are executed without run-line arguments the following usage line will be printed:

```
usage: xxxxx state_code [ -M ] [ proj_parameters ] [ file ... ]
```

where `xxxxx` is the procedure name. The `state_code` is a National Geodetic Survey reference number for each of the SPCS zones. If the user does not know the code number, an anotated list can be obtained by executing `nad27` or `nad83` followed by the state's name. For example, to obtain Colorado's SPCS27 zone codes:

```
$ nad27 colo
```

and the following results will appear:

```
# 501:colorado north datum:NAD27
# 502:colorado central datum:NAD27
# 503:colorado south datum:NAD27
```

Colorado's respective North, Central and South zone codes are 501, 502 and 503. A complete list is obtained by executing `nad27` or `nad83` without any run-line argument.

The `-M` options allows cartesian coordinates to be in meters rather than the default surveyor's feet and the `proj_parameters` provides for entering any of program *proj's* hyphen type runline parameters. To select forward transformation to meters with 4 fractional digits then:

```
for27 502 -M -f '%.4f' my.data | ...
```

As an example, using real numbers, the SPCS27 cartesian coordinates for two sites near Boston are to be obtained from their latitude-longitude locations in a file *Boston.harbor*:

```
42d19'40.180"N  70d53'26.214"W # Boston Lighthouse
42d30'19.187"N  70d50'03.052"W # Marblehead Lighthouse
```

Execution of `nad27` determines the zone number:

```
$ nad27 mass
# 2001:massachusetts mainland datum:NAD27
# 2002:massachusetts island datum:NAD27
$ ...
```

And the following determine the SPCS27 coordinates in feet:

```
$ for27 2001 -r -f '%.3f' Boston.harbor
764787.570      484445.491 # Boston Lighthouse
779542.978      549243.661 # Marblehead Lighthouse
$ ...
```

Caveats

A few elements related to SPCS should be emphasized:

- The user must be warned that SPCS coordinates in one datum cannot be directly converted to the alternate datum. For example:

  ```
  inv27 2001 -o my.data.27 | for83 2001 -i >my.data.83
  ```

  is executionally correct, **but it will not produce the correct result!** The change in the datum represents shifts in the coordinates that are not compensated for by *proj* conversions.

- The tables employed by the software discussed in this appendix were adapted from tabular material in the GCTP II distribution tape (Elassal, 1987).

- The author has encountered tabulations of geographic-SPCS values which do not exactly agree with *proj* conversions (differences are in the centimeter range and limited to zones employing the Transverse Mercator projection). But exhaustive testing and improvement of *proj*'s accuracy and the fact that GCTP II agrees with *proj* to within 10^{-3} m or 3×10^{-3} feet suggests that either such tabulations were performed with insufficient precision or alternate algorithms were employed.

Appendix 1—Summary of basic commands

This is a summary of the material contained in the *man*(1) file available from host system as an on-line file or as hard copy from the system administrator.

The following run line control parameters can appear in any order:

`-b` — Special option for binary coordinate data input and output through standard input and standard output. Data is assumed to be in system type *double* floating point words. This option is useful when **proj** is a *son* process and allows bypassing formatting operations.

`-i` — Selects binary input only (see `-b` option).

`-o` — Selects binary output only (see `-b` option).

`-t`*a* — *A* specifies a character employed as the first character to denote a control line to be passed through without processing. This option applicable to ASCII input only. (`#` is the default value).

`-e␣`*string* — *String* is an arbitrary string to be output if an error is detected during data transformations. The default value is the string: `*\t*`. Note that if the options `-b`, `-i` or `-o` are employed, an error is returned as a HUGE value for both return values.

`-c␣`*file* — *File* is the source file name of additional `+` option control data for the projection procedures.

`-r` — This options reverses the order of the expected input from longitude-latitude or x-y to latitude-longitude or y-x.

`-s` — This options reverses the order of the output from x–y or longitude-latitude to y–x or latitude-longitude.

`-m␣`*mult* — The cartesian data may be scaled by the *mult* parameter. When processing data in a forward projection mode the cartesian output values are multiplied by *mult* otherwise the input cartesian values are divided by *mult* before inverse projection. If the first two characters of *mult* are `1/` or `1:` then the reciprocal value of *mult* is employed.

`-f␣`*format* — *Format* is a *printf*(3) format string to control the form of the output values. For inverse projections, the output will be in degrees when this option is employed. If a format is specified for inverse projection the output data will be in decimal degrees. The default format is `%.2f` for forward projection and DMS for inverse.

`-[w|W]`*n* — *N* is the number of significant fractional digits to employ for seconds output (when the option is not specified, `-w3` is assumed). When `-W` is employed the fields will be constant width with leading zeroes.

The `+args` runline arguments are associated with cartographic parameters and usage varies with projection selected and only two are discussed here They may be either entered on the run line where they must be preceeded by the `+` symbol or specified in the file reference by the `-c` option where the `+` prefix is optional. The options are processed in left to right order from the run line followed by processing the entries in the `-c` file. Reentry of an option is ignored with the first occurance assumed to be the desired value.

`+proj=`*name* — is **always** required for selection of the transformation function and where *name* is an acronym for the desired projection. A list of currently available projections and their *names* can be obtained by: `proj +proj=list | more`.

`+ellps=`*acronym* — The `+ellps` option allows selection of standard, predefined ellipsoid figures. For a list of currently available ellipsoid figures and their *acronyms* execute: `proj +ellps=list | more`.

`+inv` — The presence of this option selects the inverse projection mode of operation. It is equivalent to executing program `invproj`.

`+geoc` — Geographic coordinates are to be treated as geocentric.

`+over` — Inhibit reduction of longitude range to within $\pm 180°$ of the central meridian.

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Cartographic Projection Procedures for the UNIX Environment—A User's Manual

by

Gerald I. Evenden[1]

Open-File Report 90–284

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. Use of tradenames is for purposes of identification only and does not constitute endorsement by the U.S. Geological Survey.

May 13, 1990

(Revised August 30, 1991)

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