

# Map projections and distortions

VIS 2129

# Map projection resources

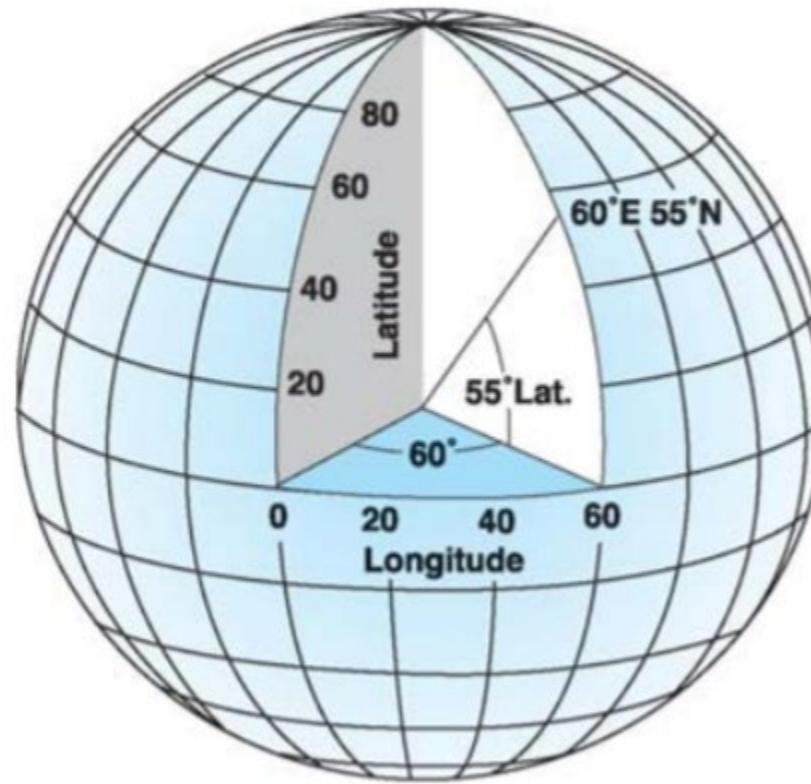
- [\*Understanding Map Projections\*](#) (ESRI 2000)
- PROJ documentation (especially <https://proj.org/usage/projections.html>)
- [spatialreference.org](http://spatialreference.org)



All models are wrong, but some  
are useful.

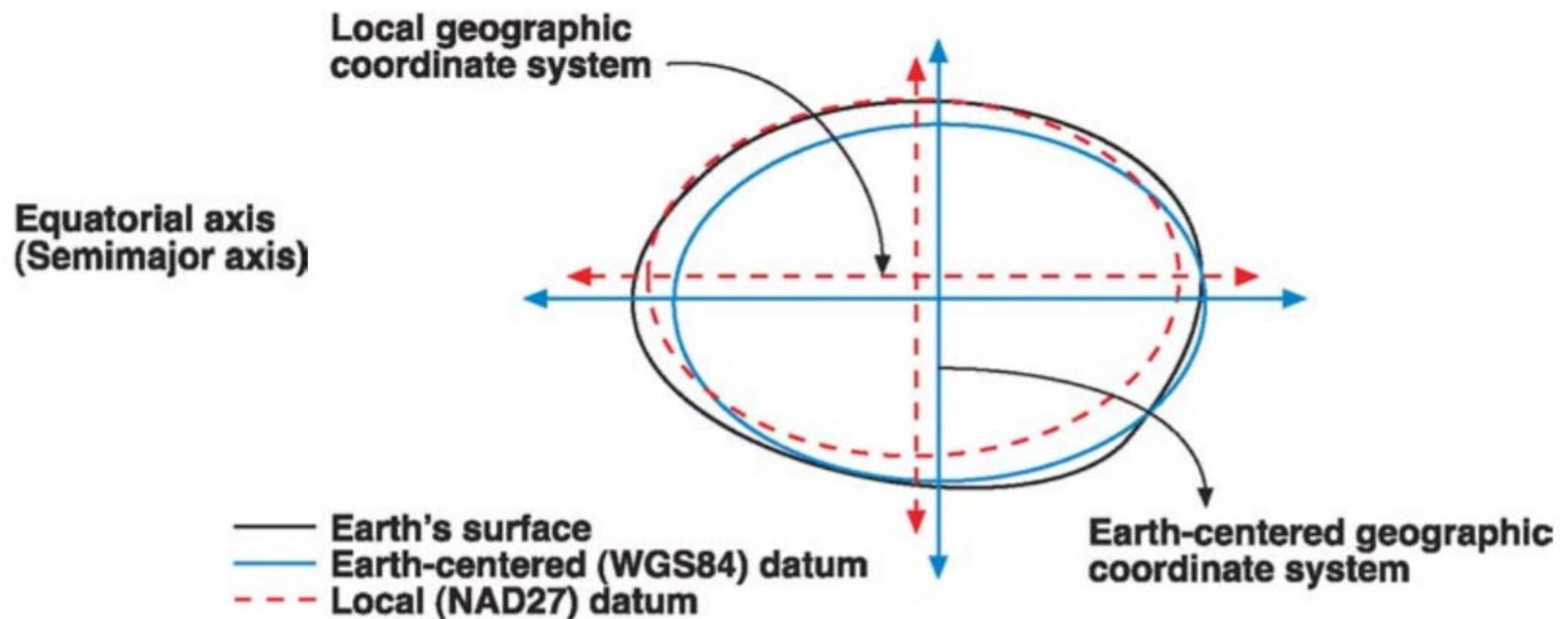
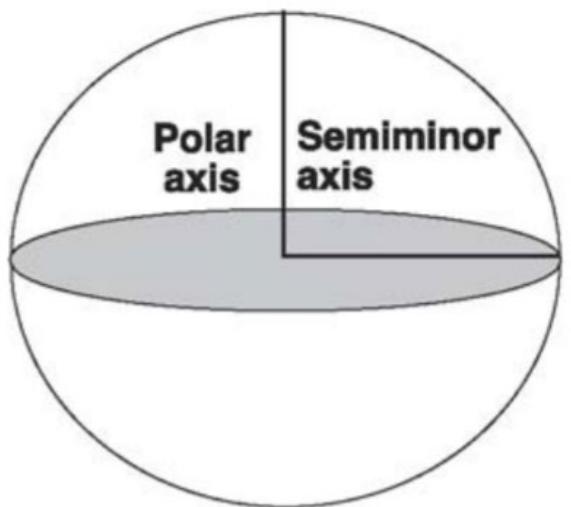
- George Box

# Geographic Coordinate Systems



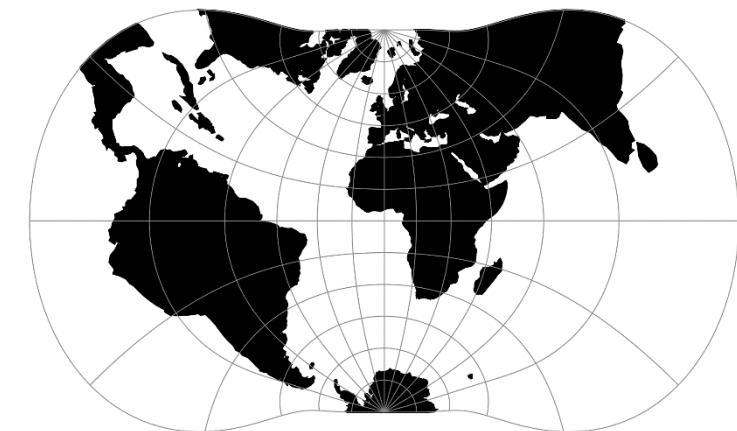
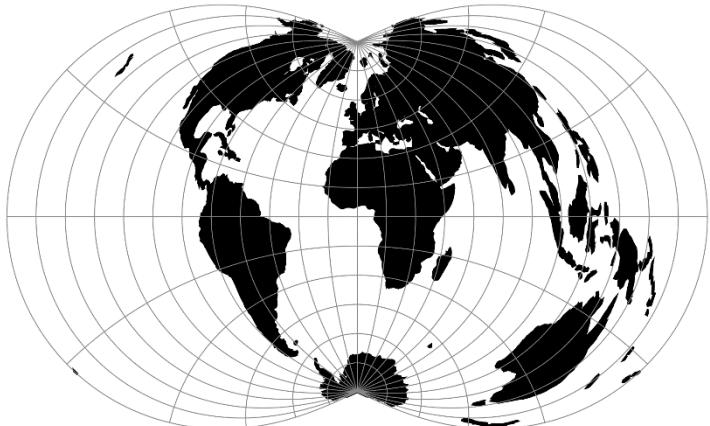
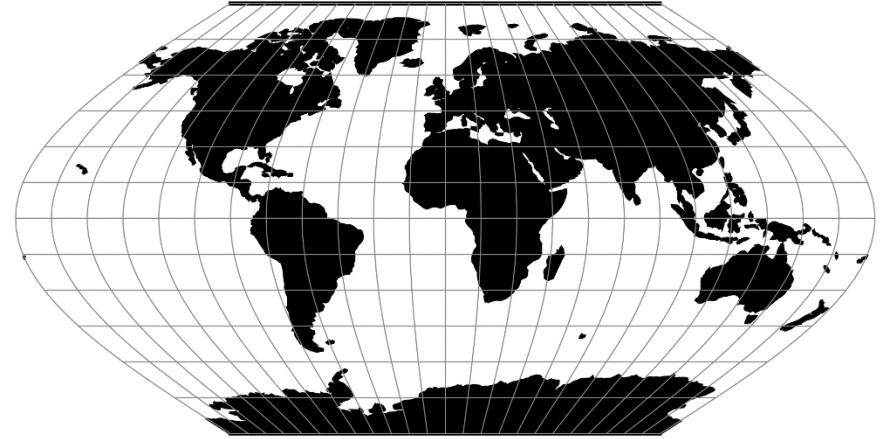
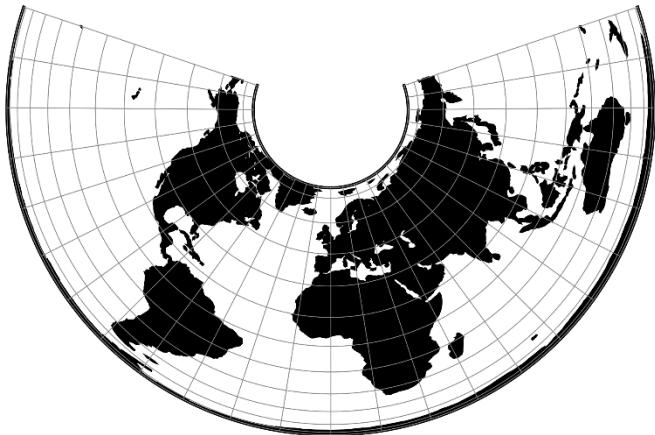
# The earth is not a perfect sphere...

It isn't even symmetrical.

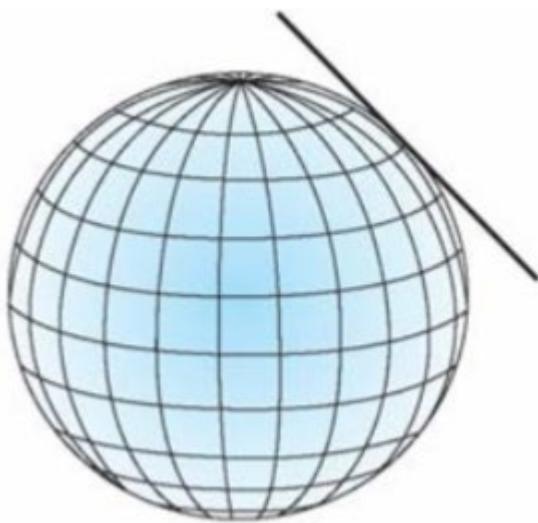


Questions?

# Projected coordinate systems



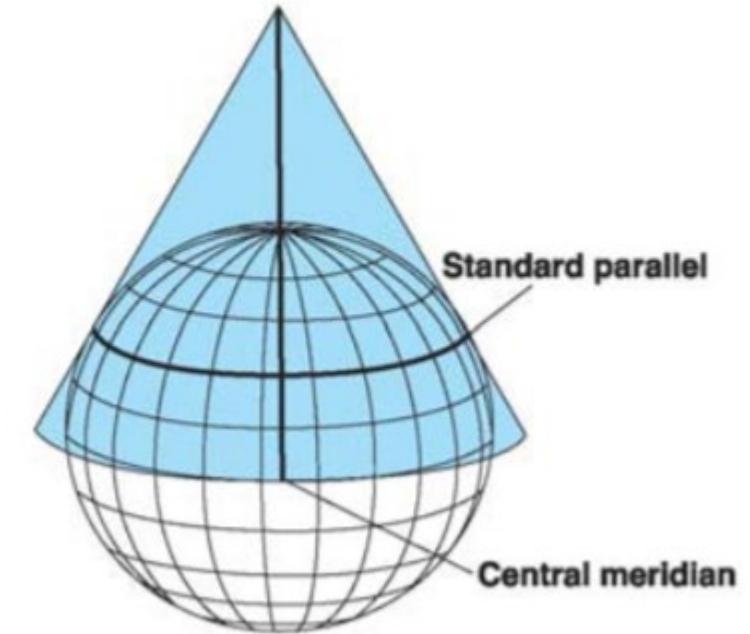
# Basic types of projections



Planar



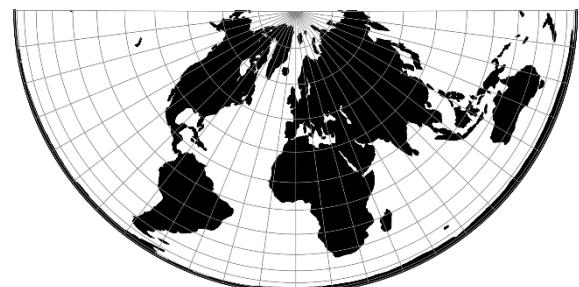
Cylindrical



Conic

# Distortions in projected coordinate systems

Area (Equal area projections)

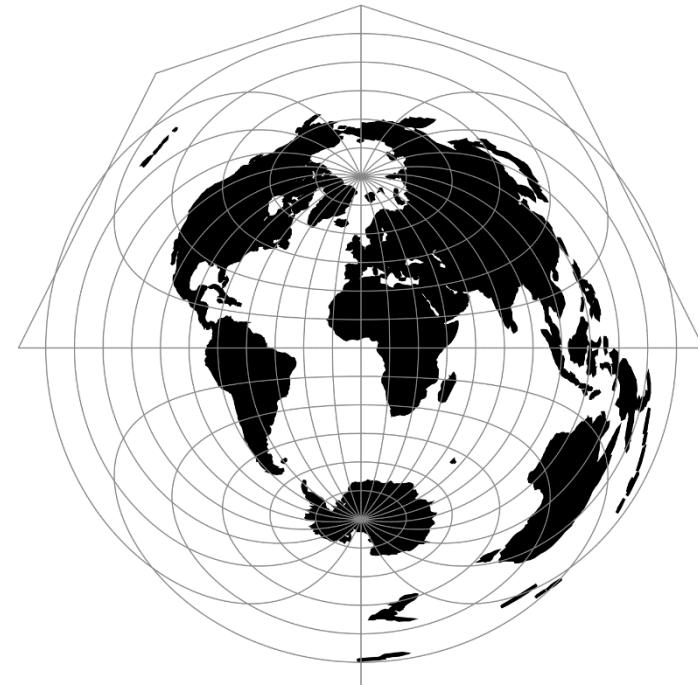


Shape (Conformal projections)



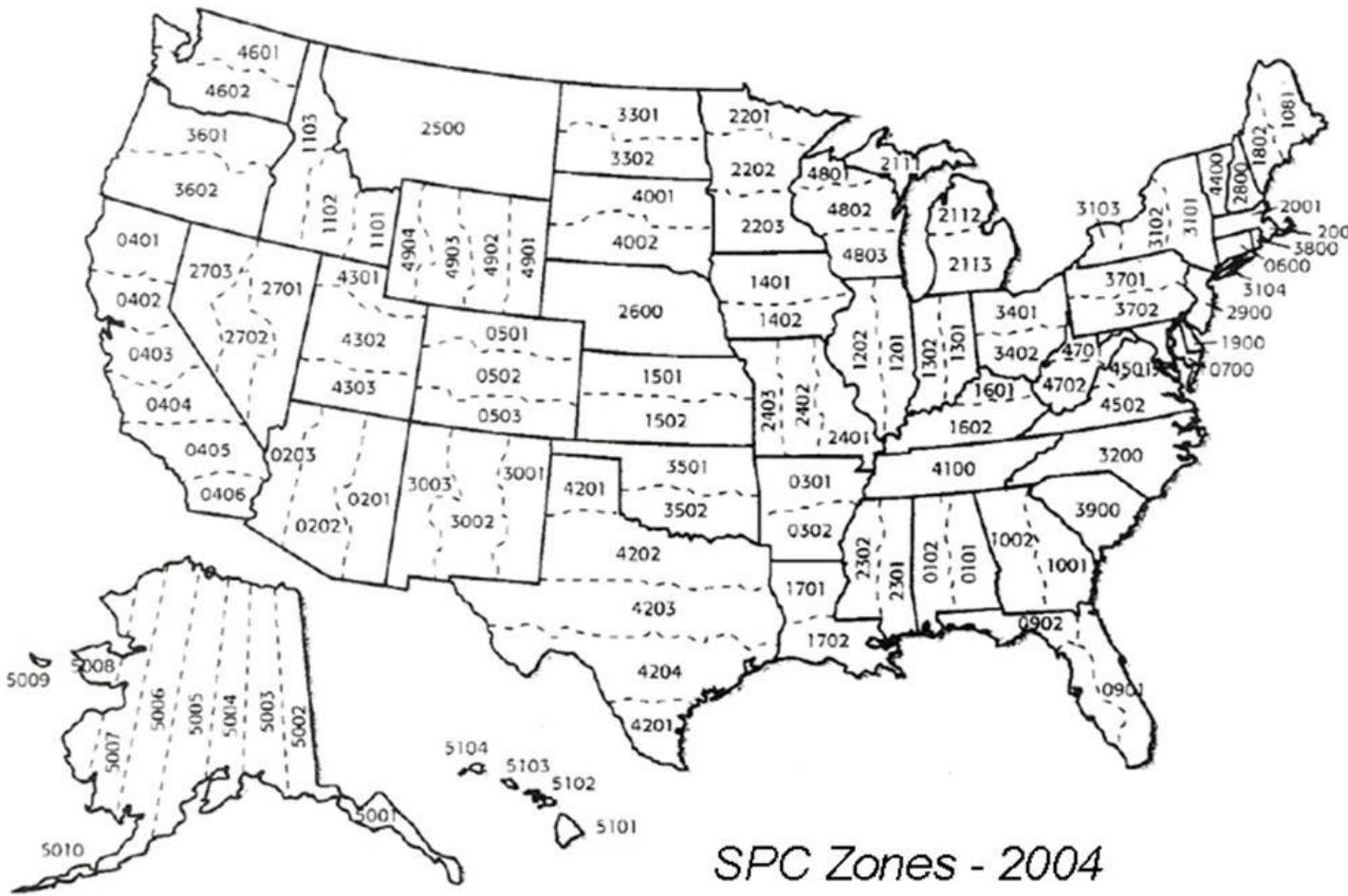
Direction (True-direction projections)

Distance (Equidistant projections)



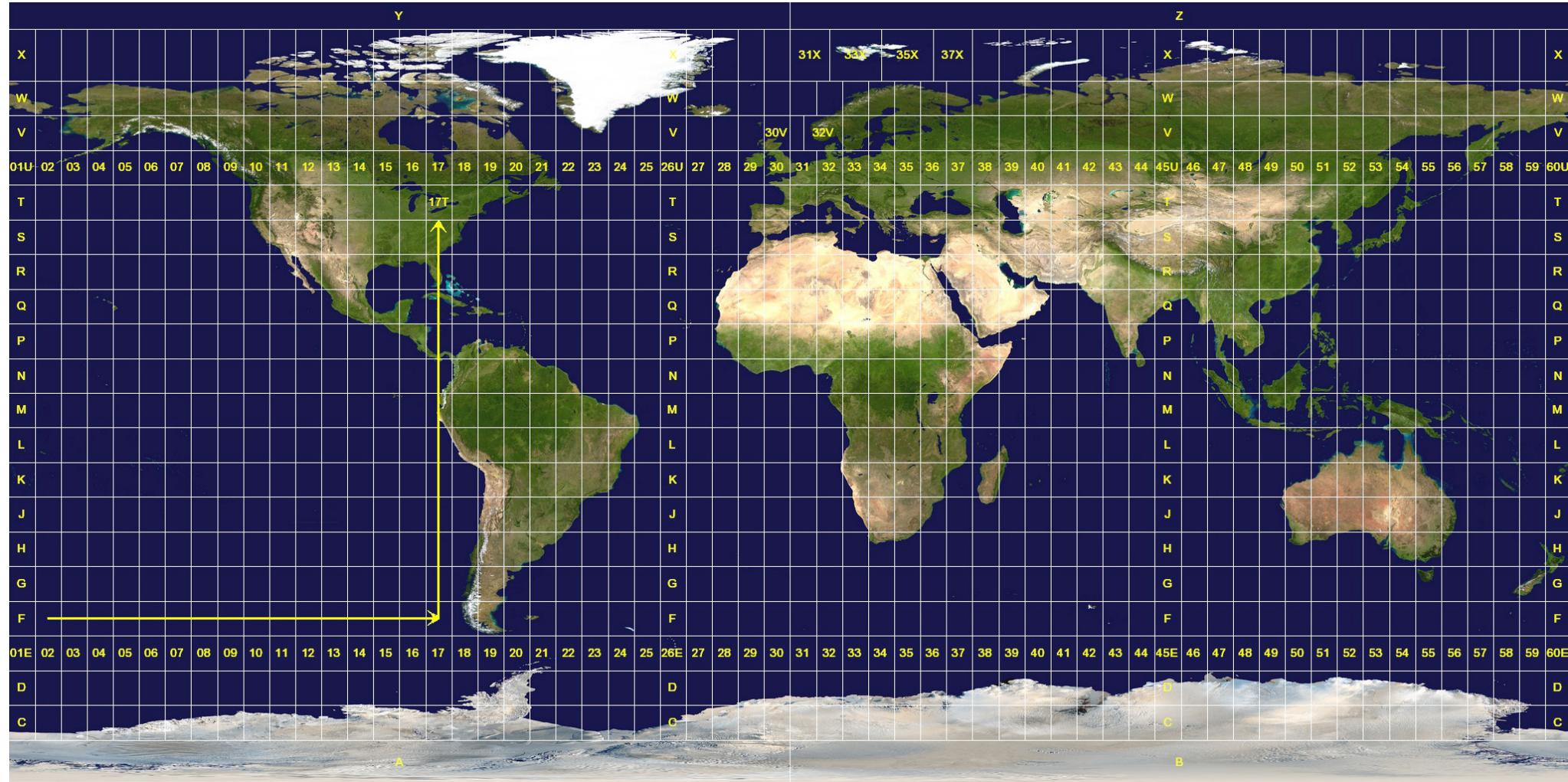
# Questions?

# State Plane Coordinate systems



Usually **Lambert Conformal Conic** (for long east-west zones) or **Transverse Mercator** (for long north-south zones)

# Universal Transverse Mercator (UTM)

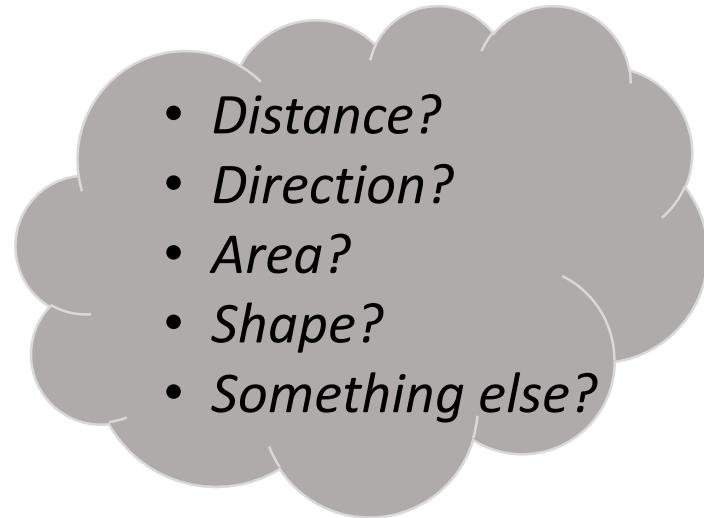


Questions?

## If your goal is to create a useful map, consider:

For maps with each of the uses listed on the right, what (if anything):

- Should you distort?
- Can you distort?
- Should you show as accurately as possible?



## A map showing

- Election results by state
- Lines on a subway transit system
- Bicycle routes
- Navigation routes across the ocean
- Walking routes (posted to a sign/kiosk)
- Areas of a coastal state that are vulnerable to sea-level rise

The rest of this mostly applies to  
those working in R...

# Recommendation

- Search for the appropriate coordinate reference system on [spatialreference.org](http://spatialreference.org)

The screenshot shows a web browser window for the spatialreference.org website. The title bar reads "Home -- Spatial Reference". The address bar shows the URL "spatialreference.org". Below the address bar, there are icons for "Apps" and "SelectorGadget: poi...". The main content area features a map of the United States with the text "Spatial Reference" and "welcome". Below the map are navigation links: "Home", "Upload Your Own", "List user-contributed references", and "List all references". There is also a search bar with a "Search" button. A large section titled "Find your references in any number of formats!" contains a bulleted list of options: "See Existing EPSG Codes: [4326](#), [2805](#)", "Upload your own Projection as [WKT](#), [proj4](#), etc.", "Browse a list: 

- [4362 EPSG references](#)
- [447 ESRI references](#)
- [2380 IAU2000 references](#)
- [2717 spatialreference.org references](#)

". To the right, a sidebar titled "Recent Uploads" lists several entries: "SR-ORG:9221: Pakistan1", "SR-ORG:9220: BINHTHUAN", "SR-ORG:9219: Test Projection Arizona Custom", "SR-ORG:9218: a", and "SR-ORG:9217: ETRS89 / SSBKP". Another sidebar titled "Recently Viewed" lists "NAD27 / UTM zone 19N, 3718 views, 0 comments" and "NAD83 / California zone 2 (ftUS) 8429 views, 0 comments".

**Spatial Reference** welcome

Home | Upload Your Own | List user-contributed references | List all references

Search

**Find your references in any number of formats!**

- See Existing EPSG Codes: [4326](#), [2805](#)
- [Upload your own Projection as WKT, proj4, etc.](#)
- Browse a list:
  - [4362 EPSG references](#)
  - [447 ESRI references](#)
  - [2380 IAU2000 references](#)
  - [2717 spatialreference.org references](#)

**Recent Uploads**

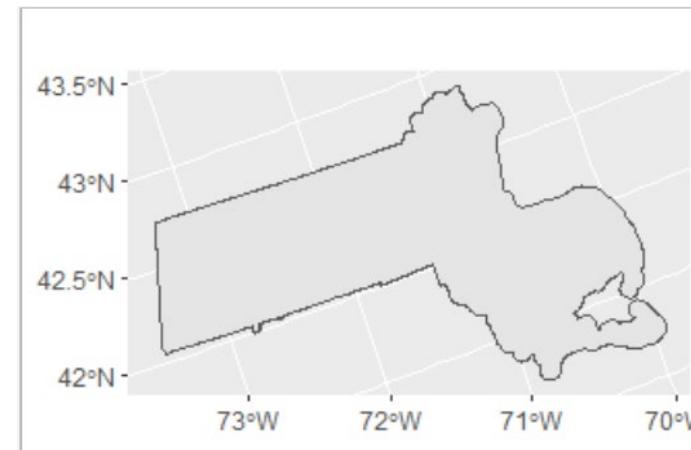
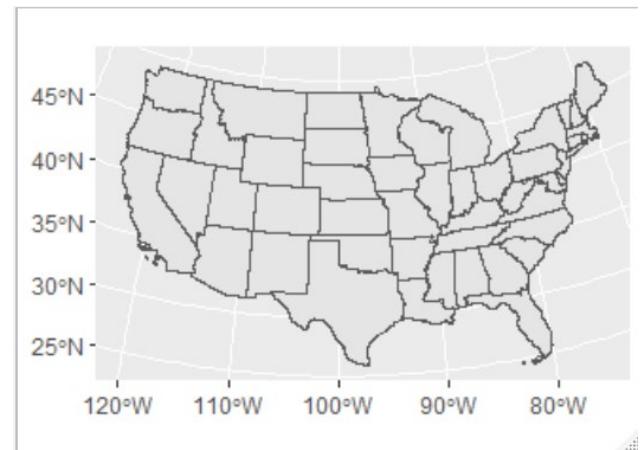
- [SR-ORG:9221: Pakistan1](#)
- [SR-ORG:9220: BINHTHUAN](#)
- [SR-ORG:9219: Test Projection Arizona Custom](#)
- [SR-ORG:9218: a](#)
- [SR-ORG:9217: ETRS89 / SSBKP](#)

**Recently Viewed**

- [NAD27 / UTM zone 19N](#), 3718 views, 0 comments
- [NAD83 / California zone 2 \(ftUS\)](#) 8429 views, 0 comments

# Projections in R (PROJ notation)

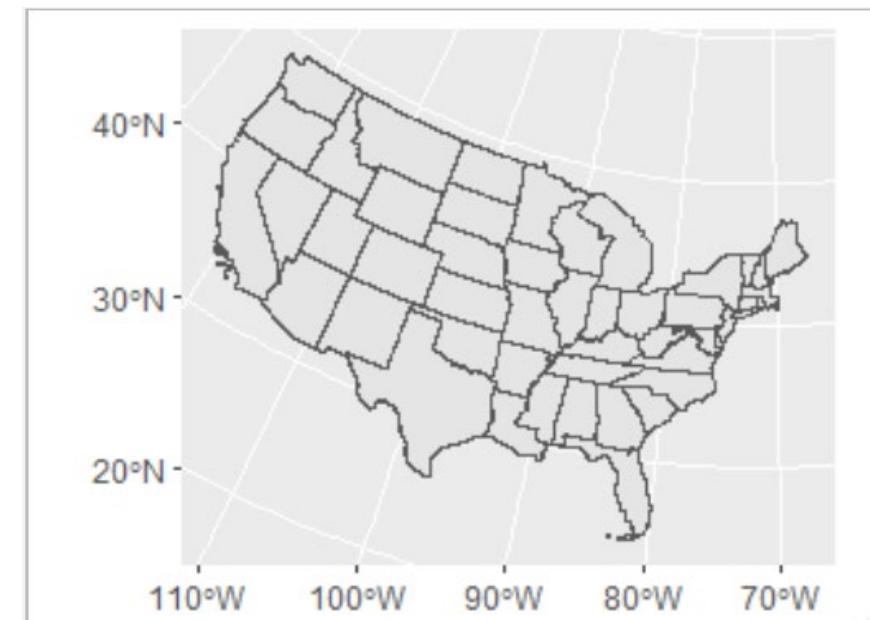
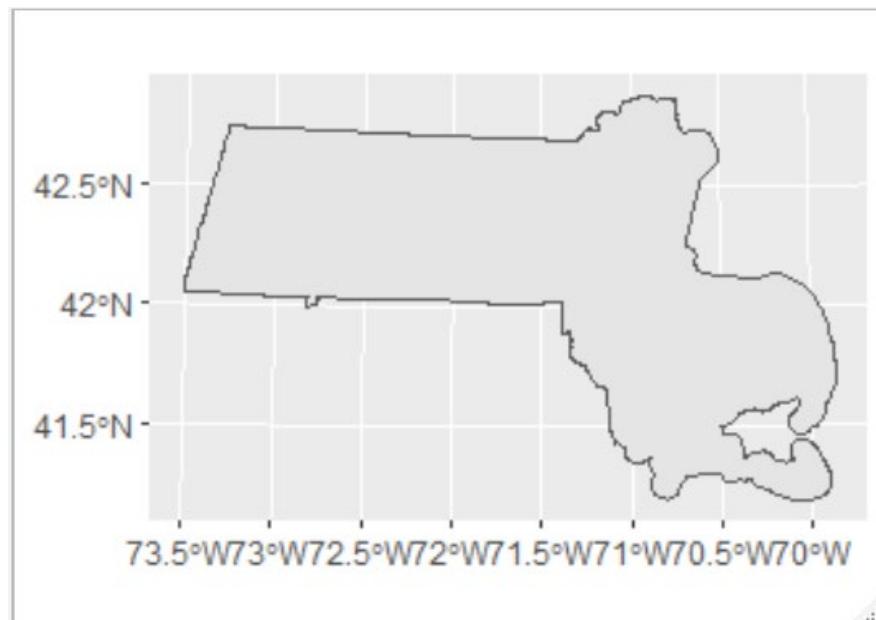
```
states48 %>%  
  st_transform(  
    "+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs") %>%  
  ggplot() +  
  geom_sf()  
  
MA %>%  
  st_transform(  
    "+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs") %>%  
  ggplot() +  
  geom_sf()
```



# Projections in R (PROJ notation)

```
MA %>%  
  st_transform(  
    " +proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs ") %>%  
  ggplot() +  
  geom_sf()
```

```
states48 %>%  
  st_transform(  
    " +proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs ") %>%  
  ggplot() +  
  geom_sf()
```



```
+proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs
```

```
+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs
```

```
+proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs
```

+proj=lcc

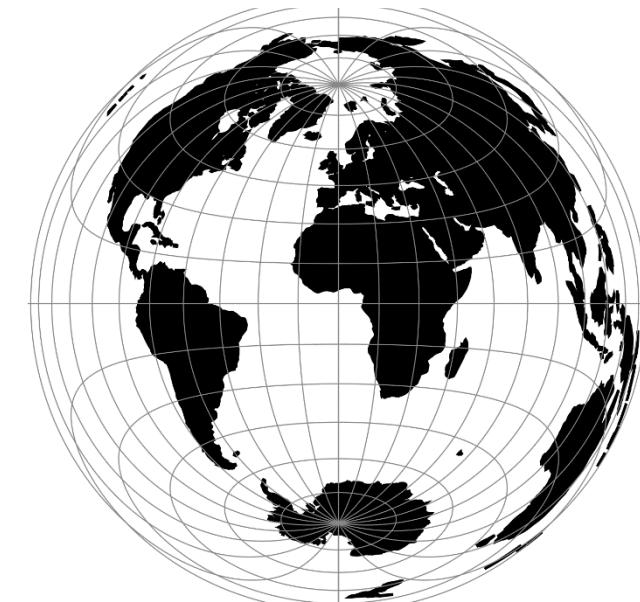
Lambert Conformal Conic projection.



```
+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +units=m +no_defs
```

+proj=laea

Lambert Azimuthal Equal Area projection

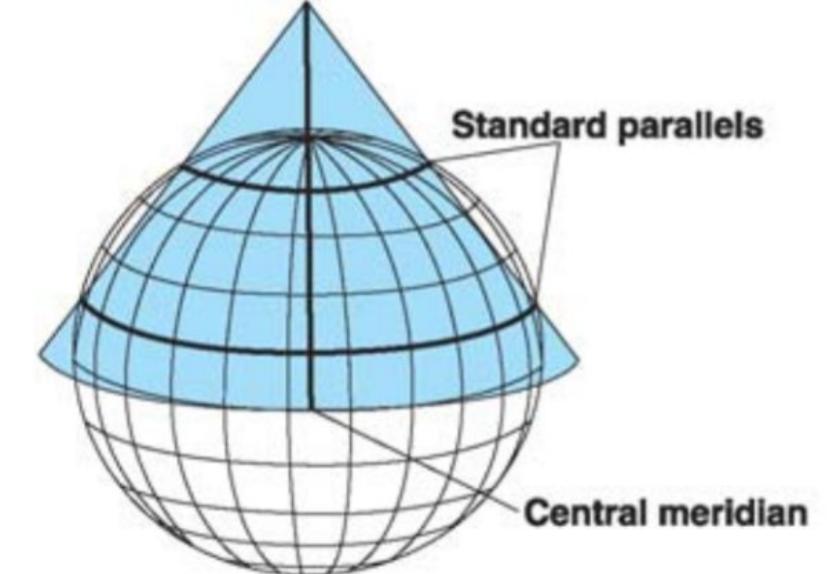


See <https://proj.org/operations/projections/index.html> for a list of 142 possible projections to choose from, with details about each.

```
+proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs
```

+ lat\_1=42.6833 +lat\_2=41.7167

Standard parallels are at  $42.6833^\circ$  and  $41.7167^\circ$



```
+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs
```

No standard parallels, plane is tangent at a single point



```
+proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs
```

+lat\_0=41 +lon\_0=-71.5

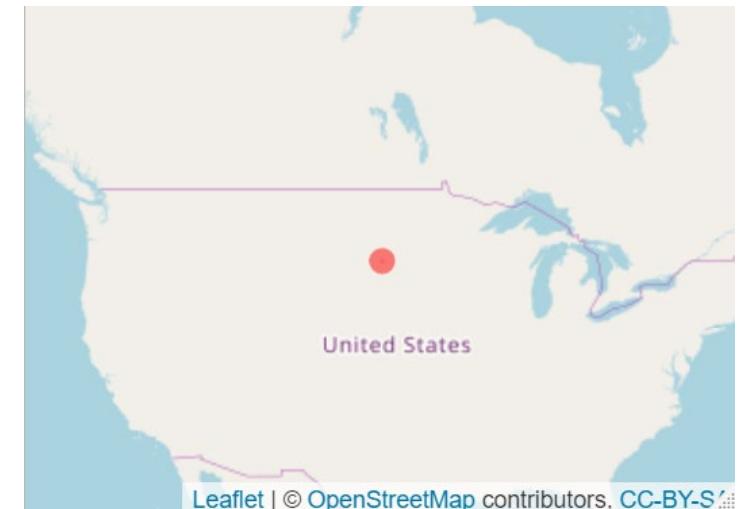
Projection centered at  $41^{\circ}$  latitude,  $-71.5^{\circ}$  longitude



```
+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs
```

+lat\_0=45 +lon\_0=-100

Projection centered at  $45^{\circ}$  latitude,  $-100^{\circ}$  longitude



```
+proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs
```

**+x\_0=200000 +y\_0=750000 +units=m**

Move the origin from the central meridian / equator to a  
Point south west of Massachusetts, and express units in meters.

```
+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs
```

Coordinates still expressed as latitude/longitude

```
+proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs
```

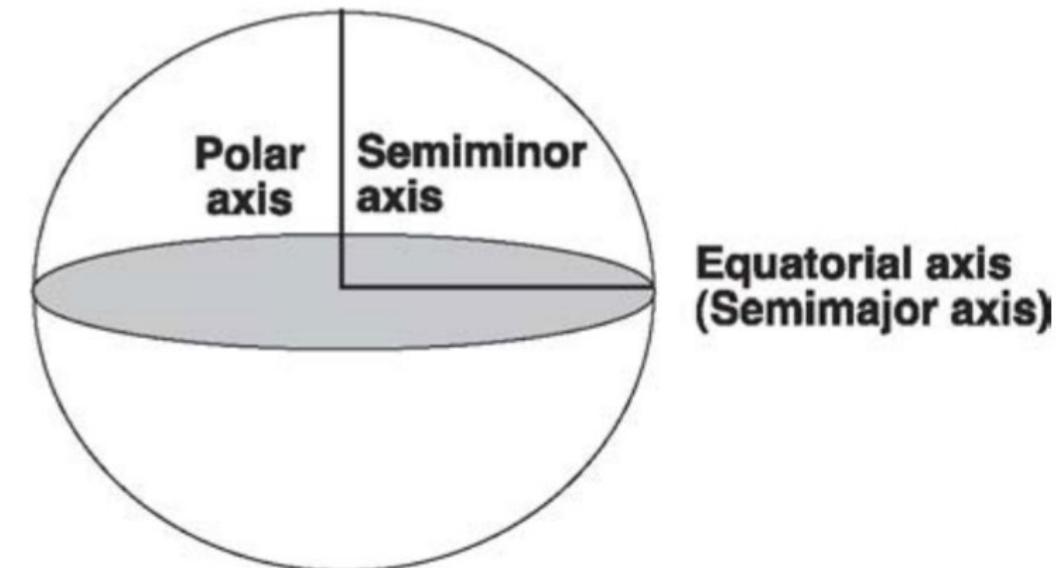
+ellps=GRS80

Use the standard spheroid for the Geodetic Reference System of 1980  
(major radius is 6,378,137 meters, minor radius is 6,356,752 meters)

```
+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs
```

+ a=6370997 +b=6370997

Use spheroid with a major radius of 6,370,997 meters, minor radius of 6,370,997 meters



```
+proj=lcc +lat_1=42.6833 +lat_2=41.7167 +lat_0=41 +lon_0=-71.5 +x_0=200000 +y_0=750000 +units=m +ellps=GRS80 +datum=NAD83 +no_defs
```

+datum=NAD83

Shift the center of the spheroid to be more accurate for North America  
(North American Datum of 1983).

```
+proj=laea +lat_0=45 +lon_0=-100 +a=6370997 +b=6370997 +no_defs
```

Earth-centered datum

