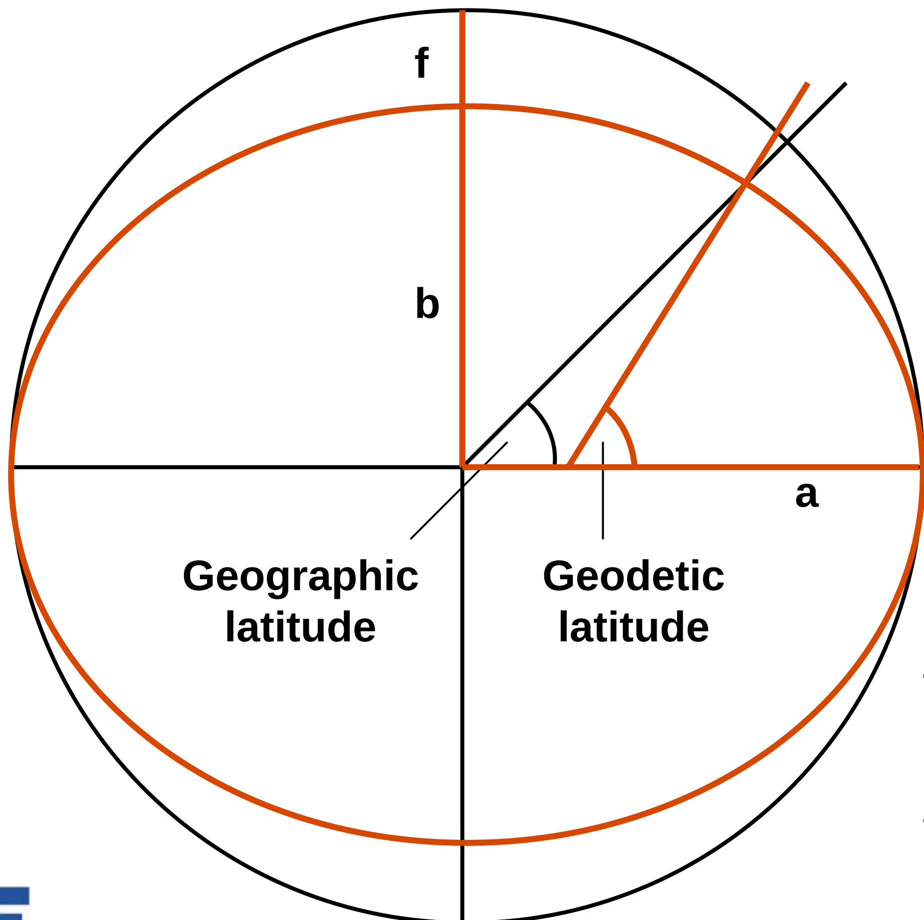
Map projections

Rüdiger Gens

Coordinate systems

Geographic coordinates



a: semi-major axis

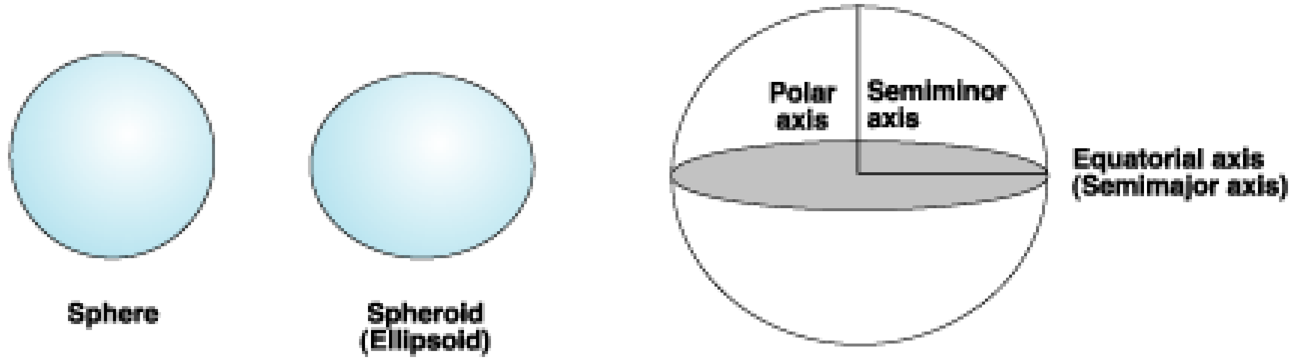
b: semi-minor axis

f: flattening = (a-b)/a
Expresses as a fraction
1/f = about 300

– geographical coordinates imply spherical Earth model

– geodetic coordinates imply ellipsoidal Earth model

Sphere versus spheroid



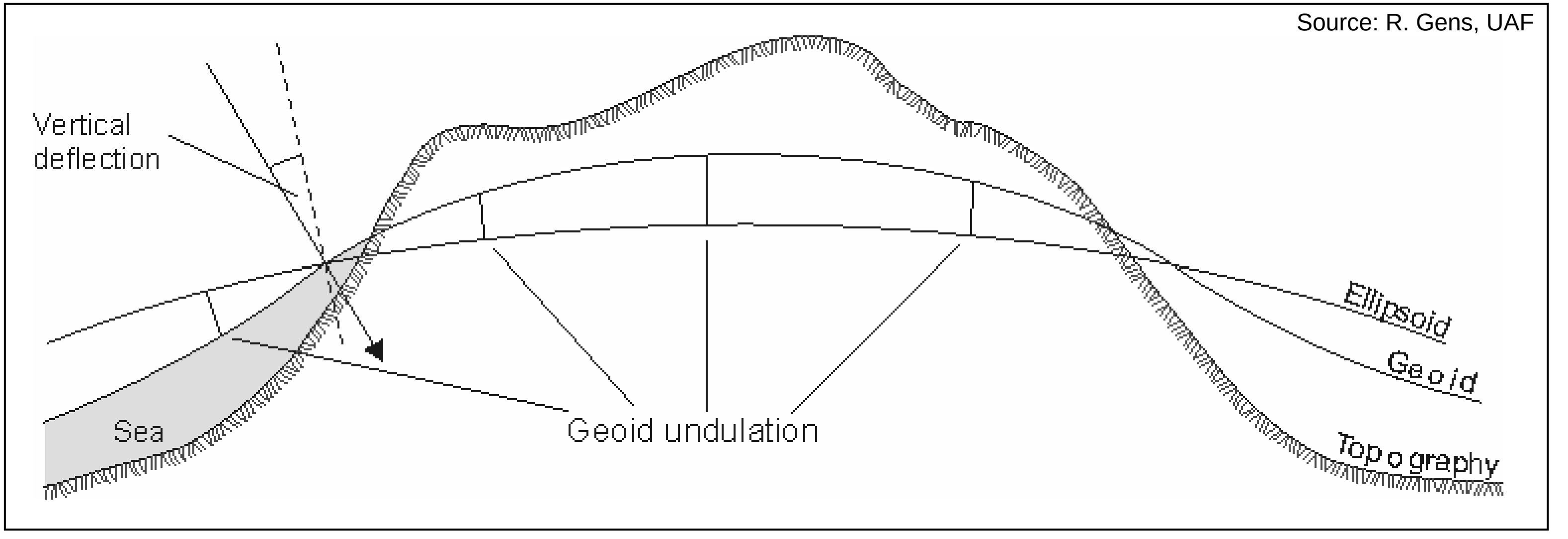
Source: ArcGIS help file

- assumption that the earth is a sphere is possible for small-scale maps (smaller than 1:5000000)
- to maintain accuracy for larger-scale maps (scales of 1: 1000000 or larger) a spheroid is necessary

Common Spheroids

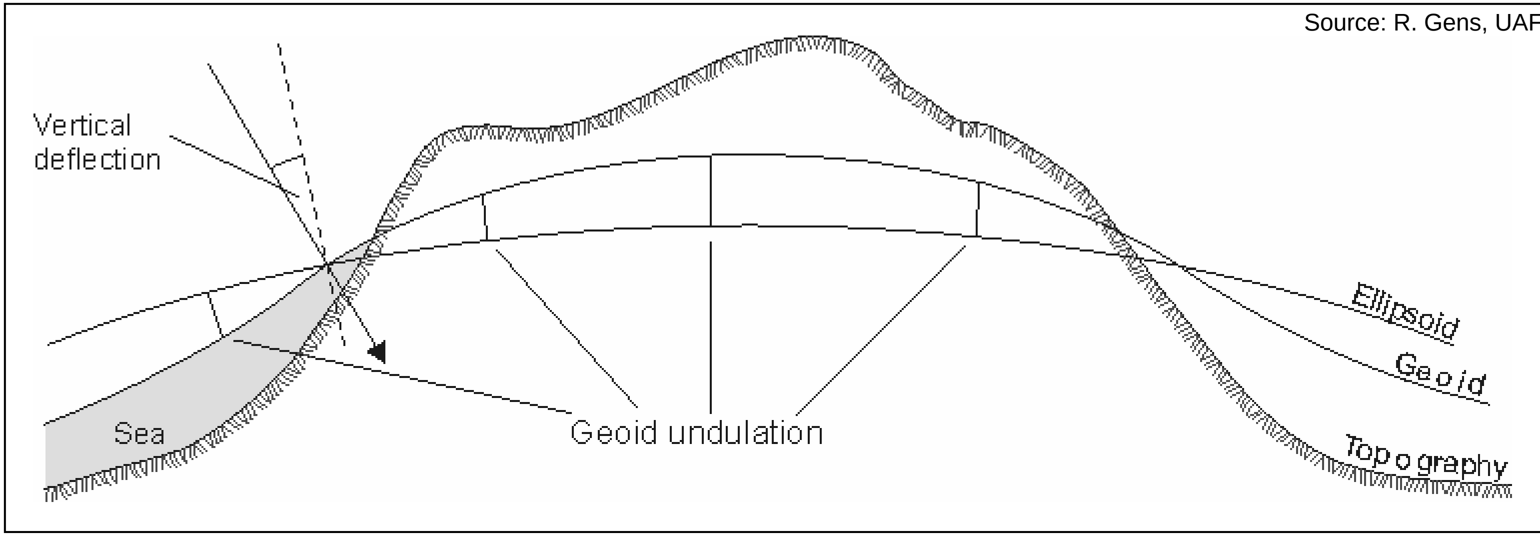
- Bessel 1841
- Clarke 1866, Clarke 1880
- GEM 6, GEM 10C
- GRS 1967, GRS 1980
- International 1924, International 1967
- WGS 72, WGS 84

Reference surfaces



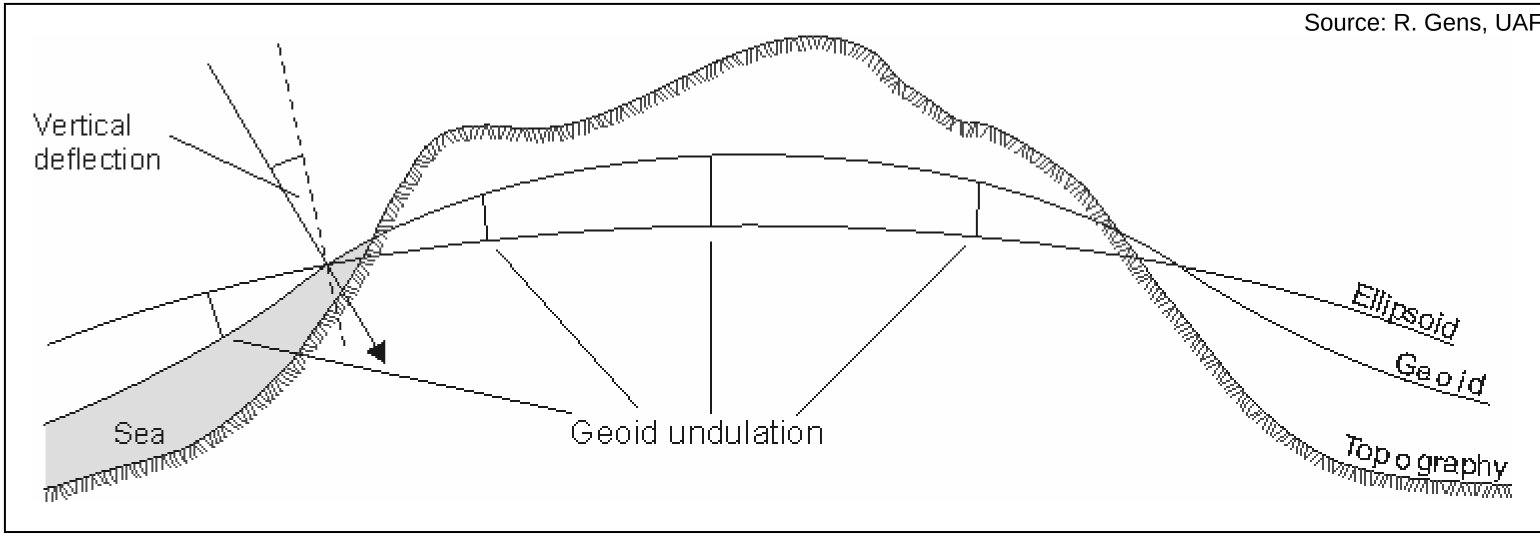
- three reference surfaces
  - topography
  - geoid
  - ellipsoid

Reference surfaces



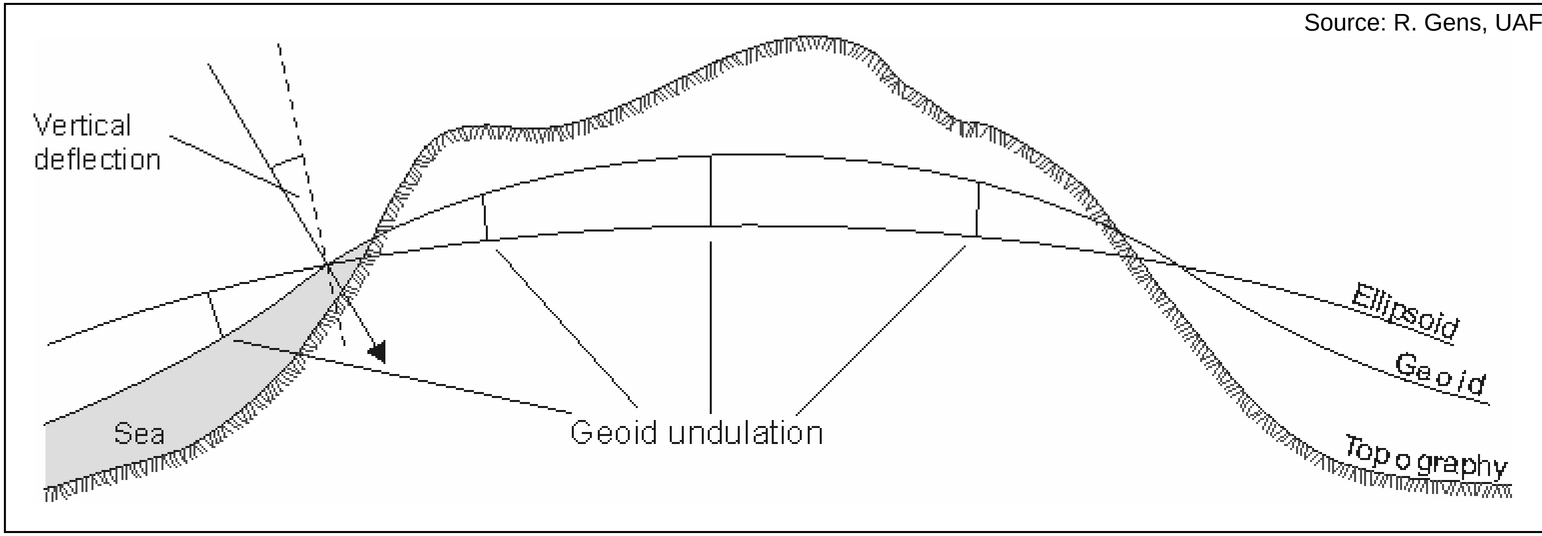
- *topography* represents the physical surface of the Earth

Reference surfaces



- *geoid* defined as level surface of gravity field with best fit to mean sea level
  - maximum difference between geoid and mean sea level about 1 m

Reference surfaces

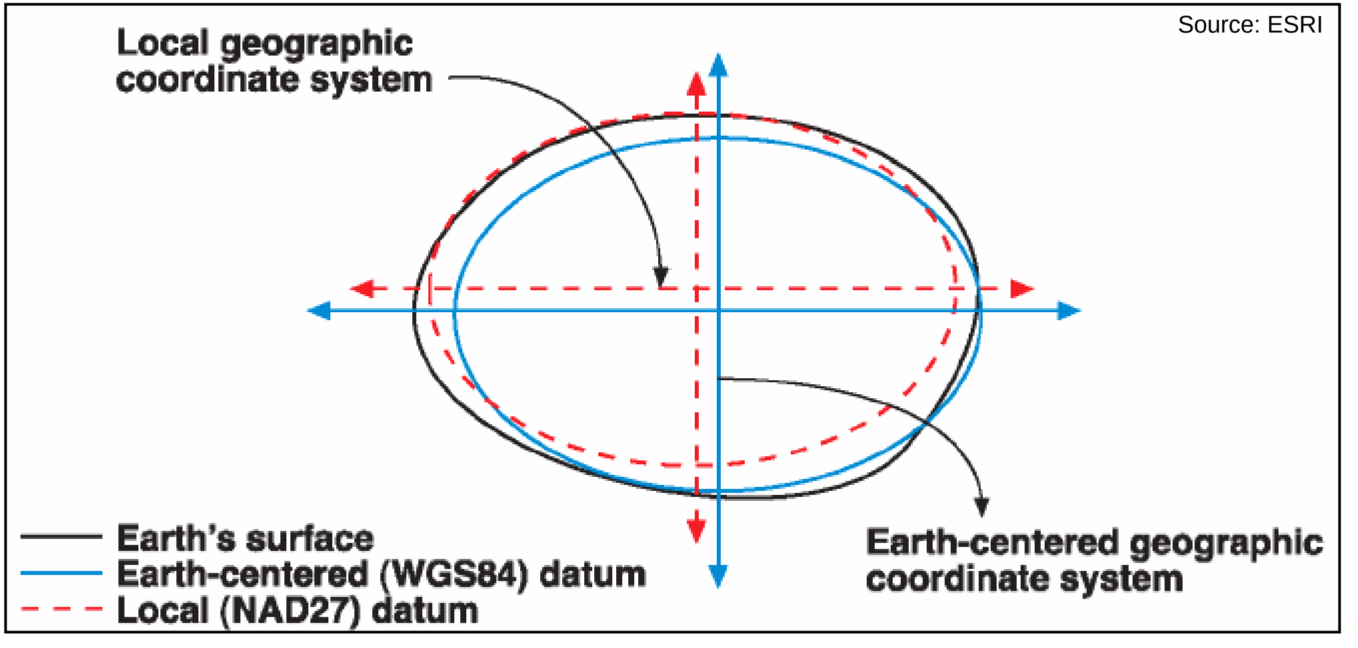


- *ellipsoid* defines mathematical surface approximating the physical reality while simplifying the geometry

Map projections

Datum

- describes the relationship between a particular local ellipsoid and a global geodetic reference system (e.g. WGS84)
- local datum defines the best fit to the Earth's surface for particular area (e.g. NAD27)



Common Datums

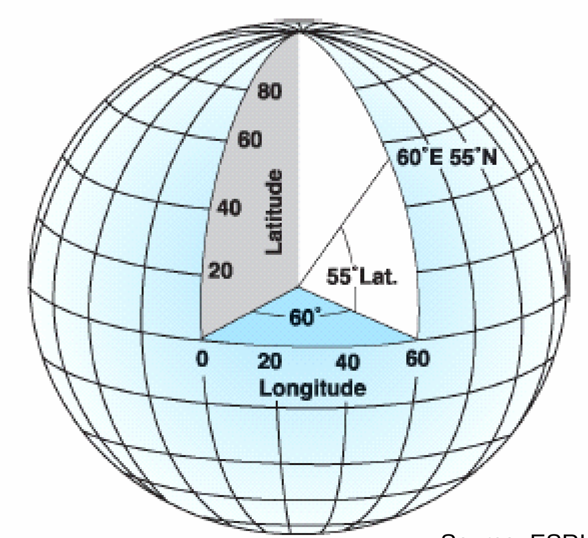
- World Geodetic System 1972 (WGS 72)
- World Geodetic System 1984 (WGS 84)
- North American Datum 1927 (NAD 27)
- North American Datum 1983 (NAD 83)
- European Datum 1950 (ED 50)
- South American Datum 1969 (SAD 69)

Datum

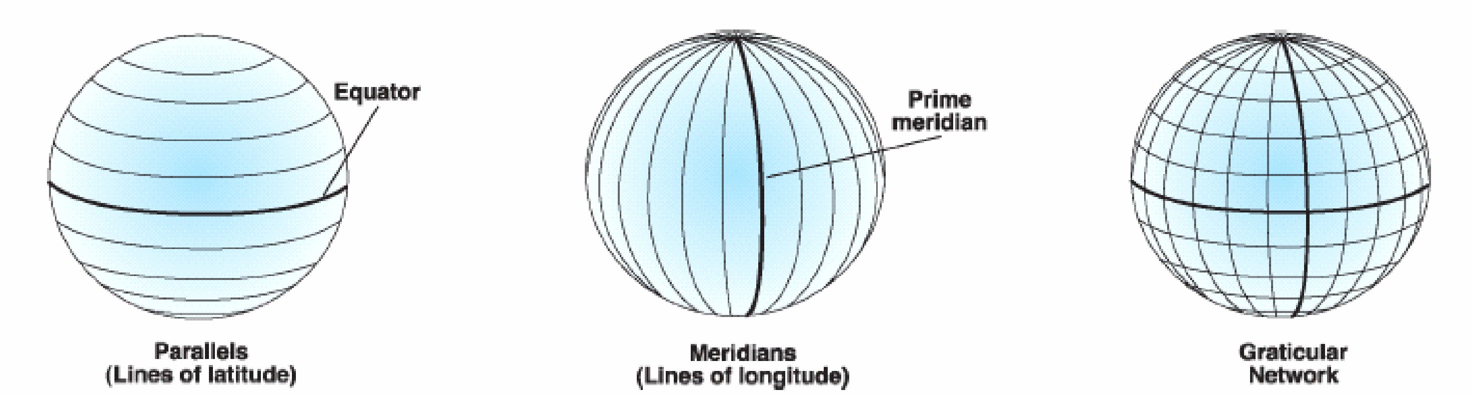
- datum
  - describes the relationship between a particular local ellipsoid and a global geodetic reference system
- coordinate system
  - shape and size given by the ellipsoid
  - position given by the fixing of the origin
  - *fixing of the origin* defines a datum

Geographic coordinate system

- A point is referenced by its *longitude* and *latitude* values
- Longitude and latitude are angles measured from the earth's center to a point on the earth's surface



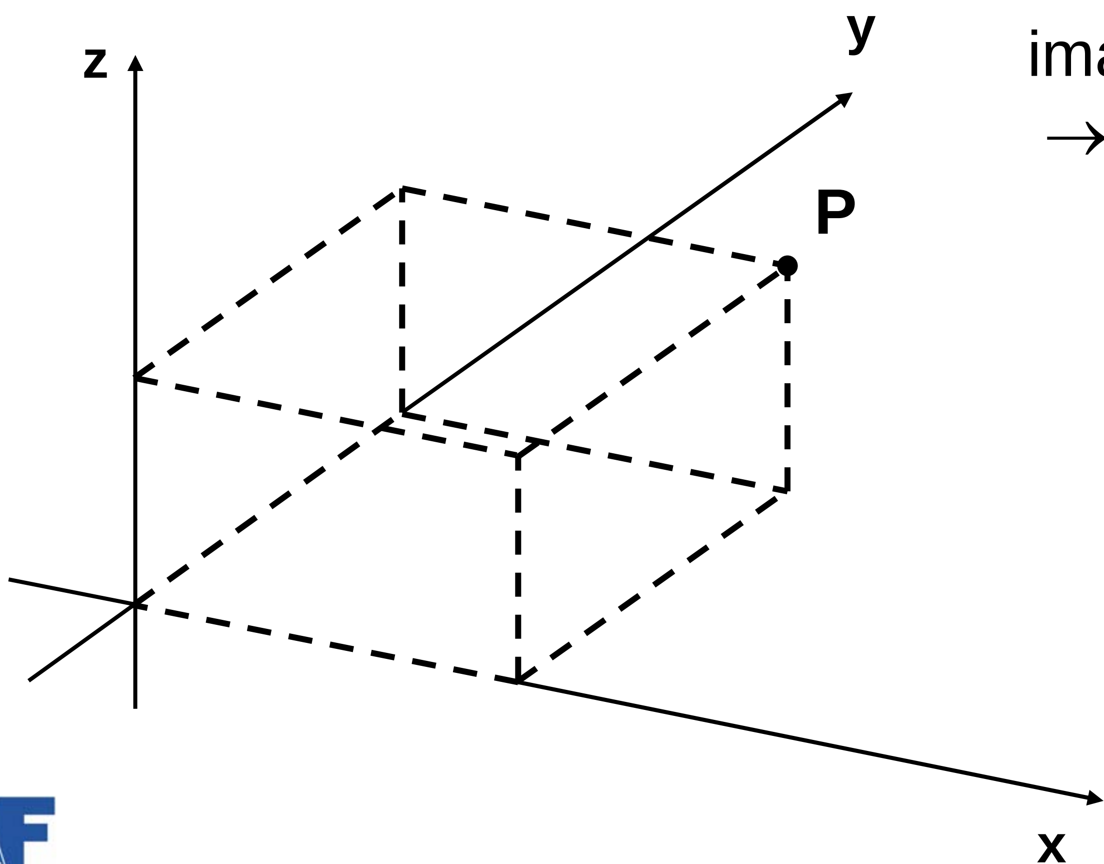
Source: ESRI



Source: ESRI

Coordinate systems

Cartesian coordinates



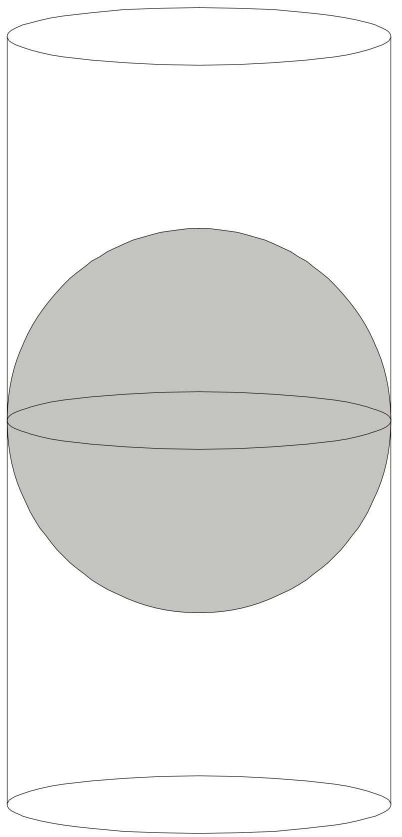
- geodetic coordinates inappropriate for satellite imagery
  → cartesian coordinates

Map projections

- problem of mapping *three-dimensional* coordinates related to a particular datum on a flat surface
  - maps are *two-dimensional*
  - impossible to convert spheroid into flat plane without distortions of shape, area, distance, or direction

$\rightarrow$ map projections

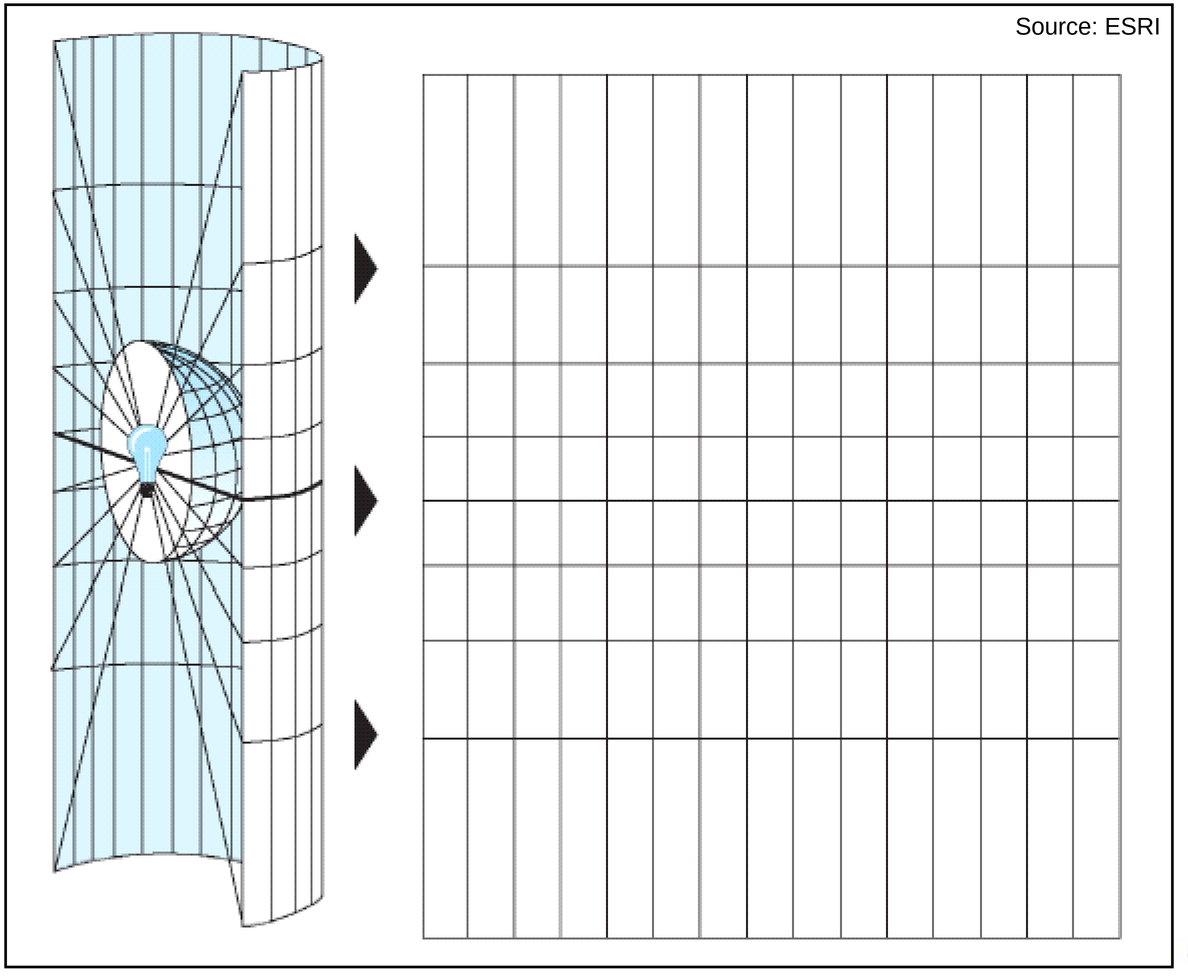
Cylindrical projections



- cylinder that has its entire circumference tangent to the Earth's surface along a great circle (e.g. equator)

Cylindrical projections

- The map projection has distorted the graticule (data near the poles is stretched)



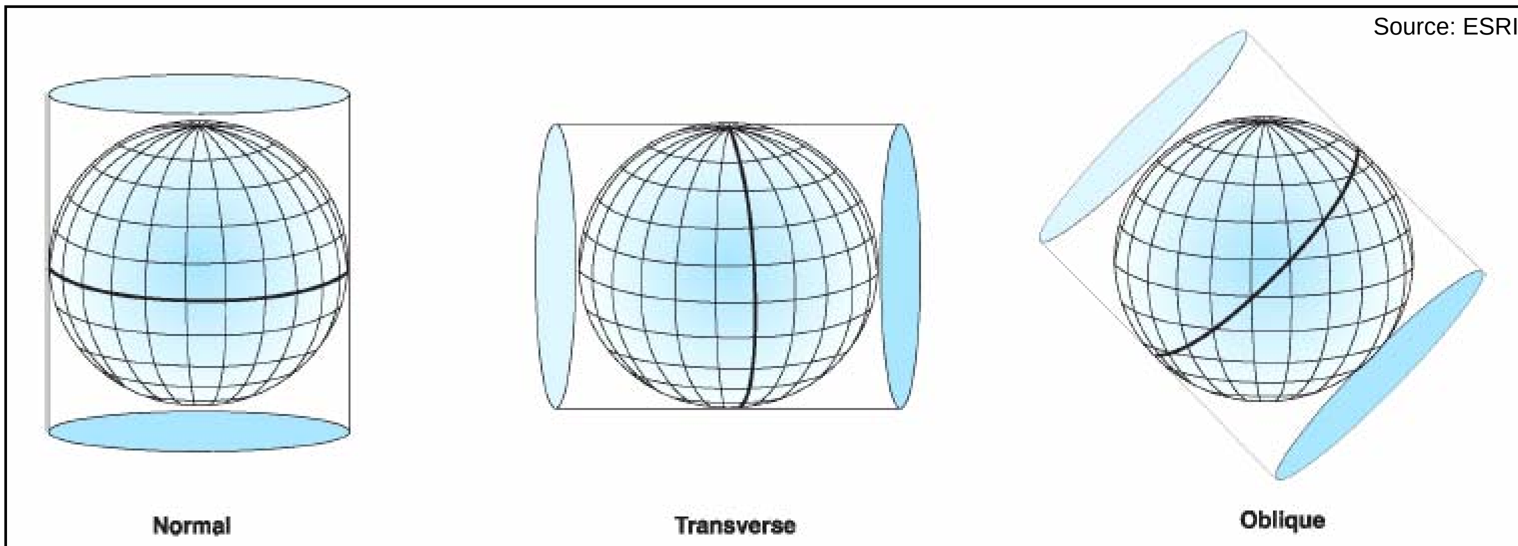
Map projections

So..

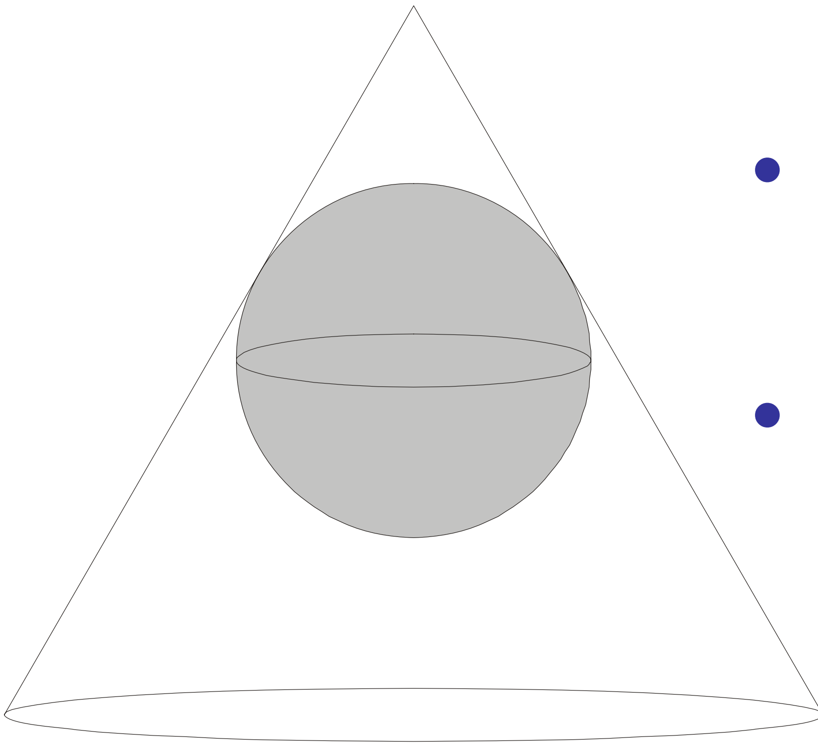
- Where would you use a cylindrical projection?
- And why?

Cylindrical: Examples

- Mercator projection
- Transverse Mercator projection
- Oblique Mercator projection



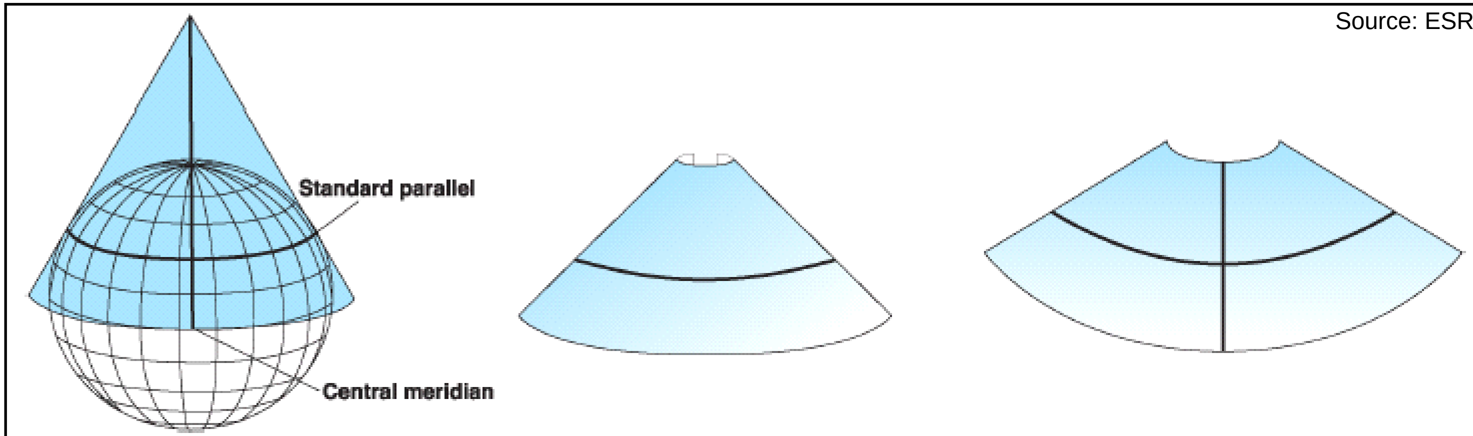
Conic projections



- Simplest conic projection is tangent to the surface along a small circle (called standard parallel)
- The meridians are projected onto the conical surface, meeting at the apex
- Parallel lines of latitude are projected onto the cone as rings.

Conic projections

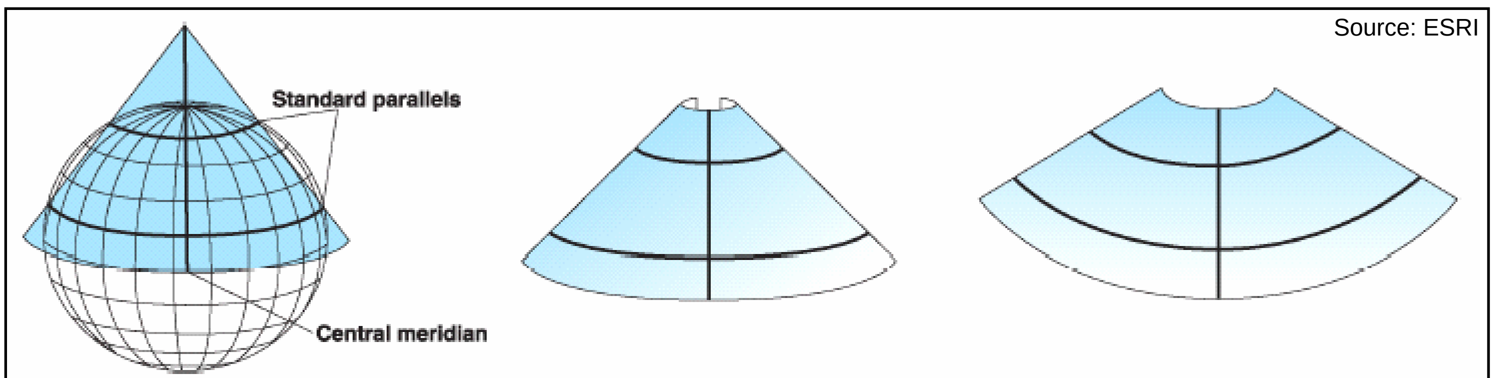
- further you get from the standard parallel, the more distortion increases.



Source: ESRI

Conic projections

- secant projection: a more complex conic projection
- contact the global surface at two locations
- defined by two standard parallels
- less overall distortion than a tangent projection



Map projections

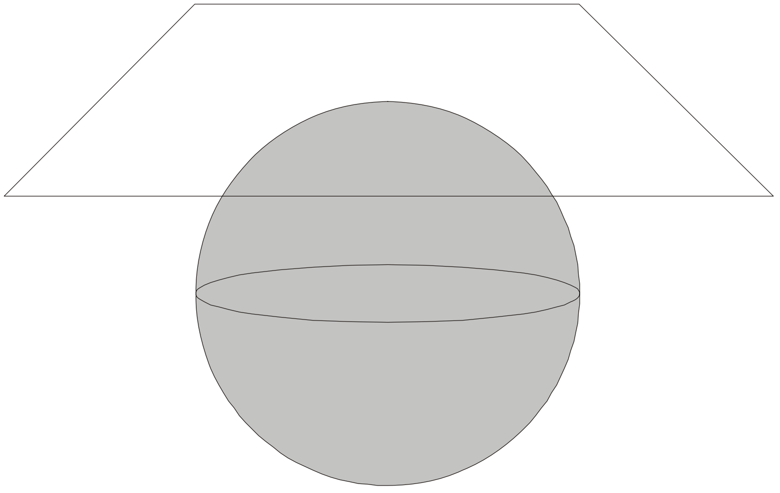
So..

- Where would you use a conic projection?
- And why?

Conic: Examples

- Conic projection with two standard parallels
- Lambert Conformal Conic projection (preserves angles)
- Albers Conic Equal-Area projection (preserves areas)

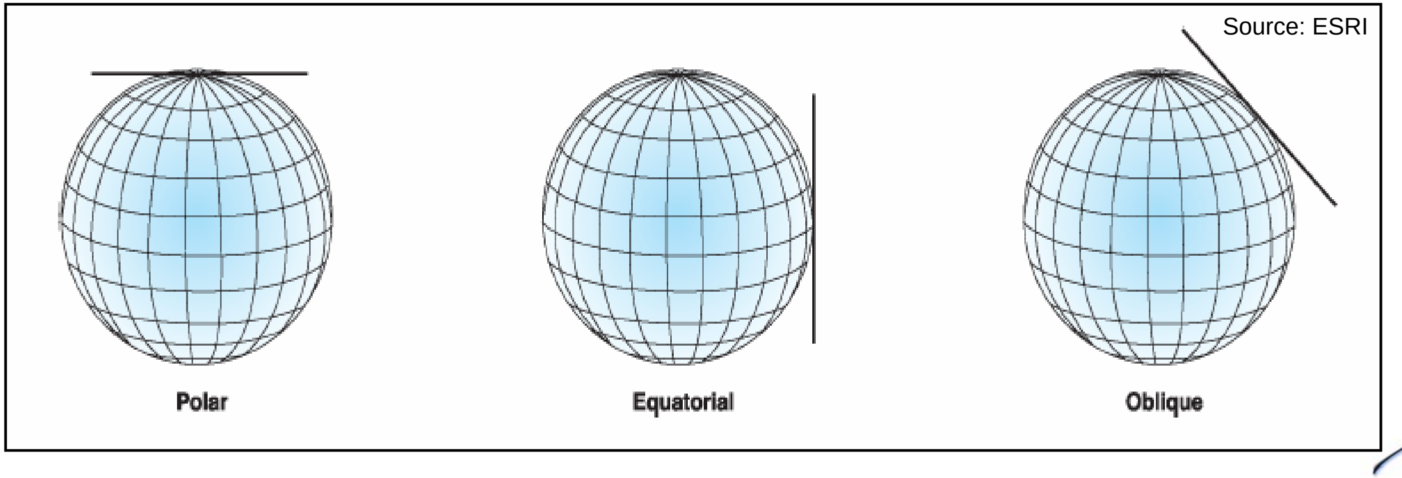
Azimuthal (Planar) projections



- projecting positions directly to a plane tangent to the Earth's surface

Azimuthal (Planar) projections

- Point of contact specifies the aspect and is the focus of the projection.
- The focus is identified by a central longitude and a central latitude.
- Possible aspects are *polar*, *equatorial*, and *oblique*



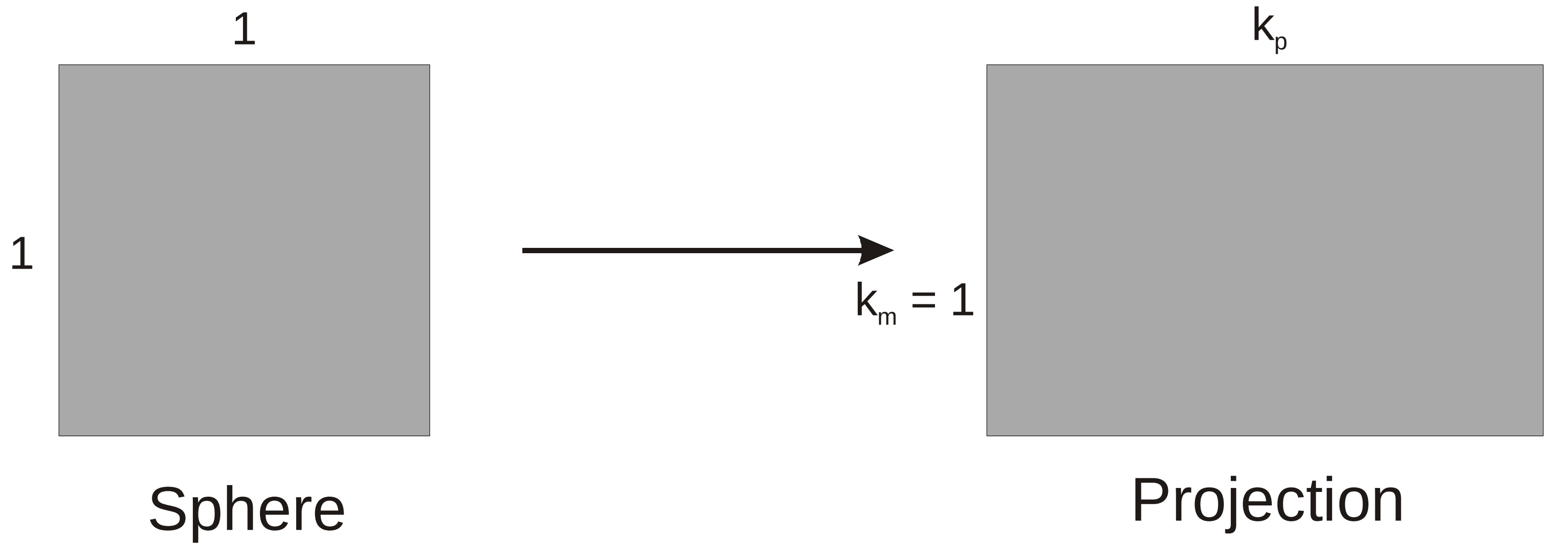
So..

- Where would you use a azimuthal projection?
- And why?

Azimuthal (Planar) projections

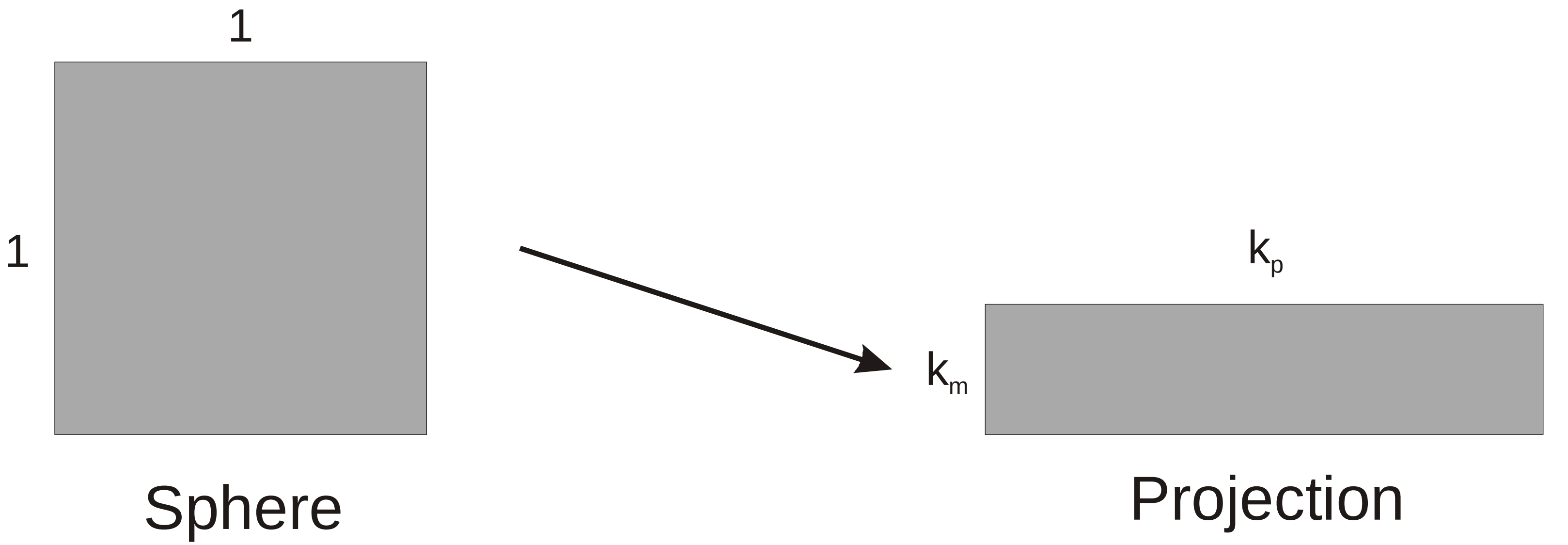
- Lambert Azimuthal Equal-Area projection
- Stereographic (conformal) projection

Equidistant projections



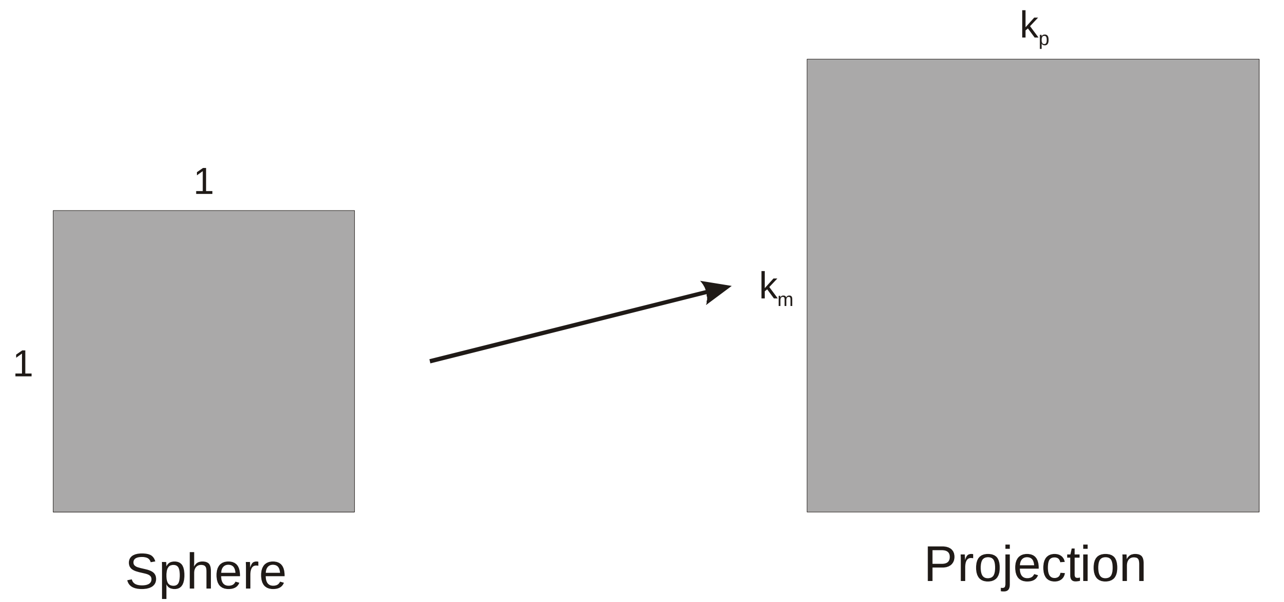
- scale factor along a meridian (line of equal longitude) is equal to 1
- shape and area of square are distorted

Equal-area projections



- equal areas are represented by the same map area regardless of where they occur

Conformal projections



- angles on a conformal map are the same as measured on the Earth's surface
- meridians intersect parallels at right angles

Summary

- map purpose
  - for distribution maps: equal area
  - for navigation: projections that show azimuths or angles properly
- size of area
  - some projections are better suited for East-West extent, others for North-South
  - for small areas the projection is relatively unimportant
  - for large areas the projection is very important