GIS concepts

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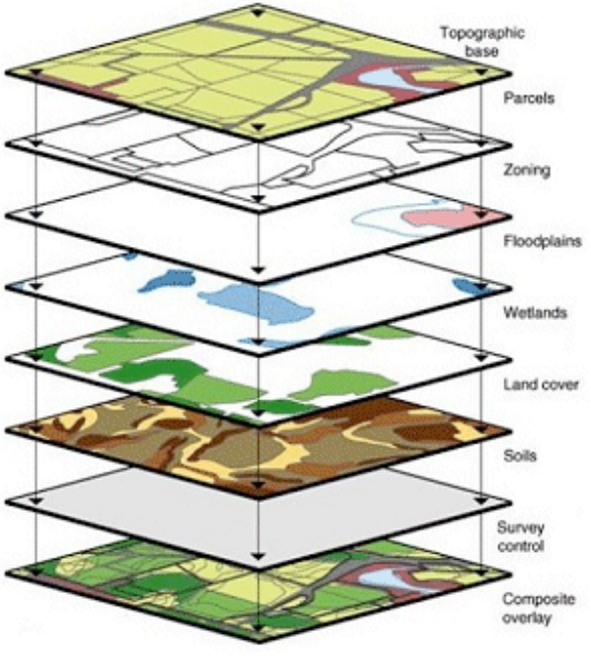
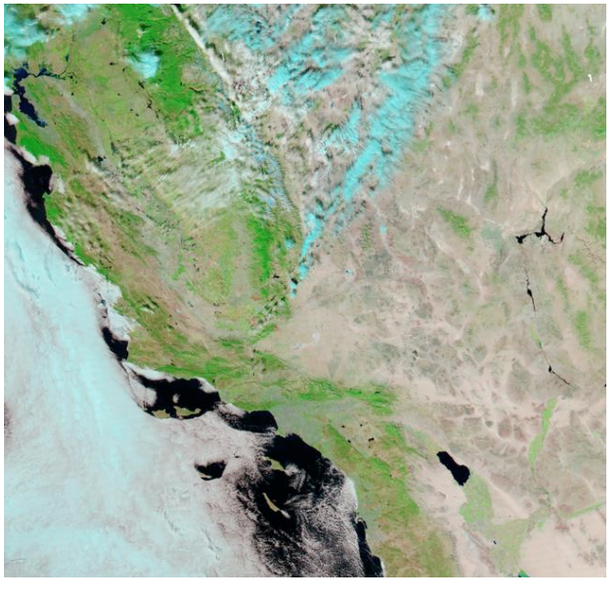
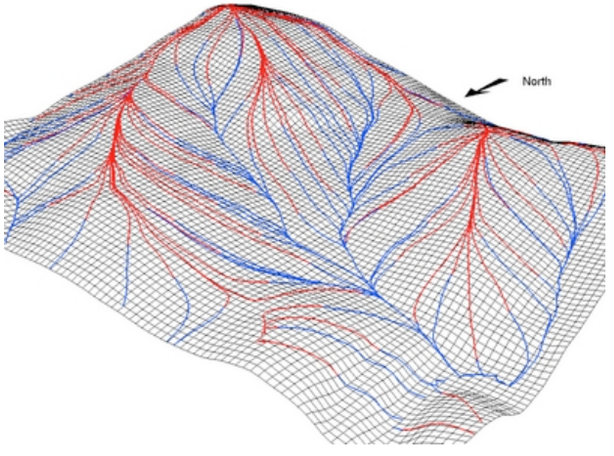
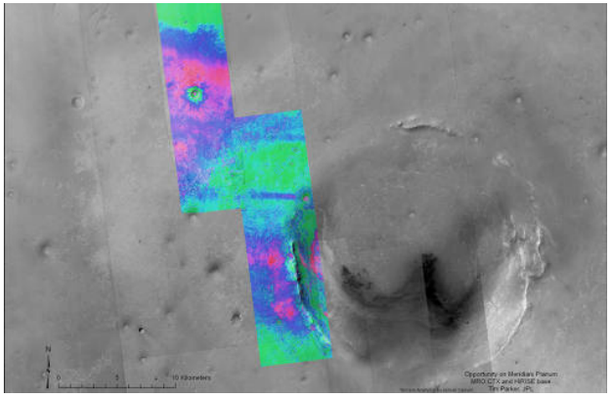
October 23 2016

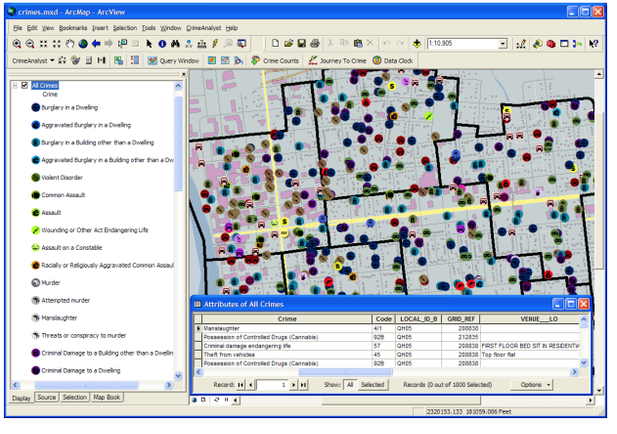
What is a GIS?


Topographic base
Parcels
Zoning
Floodplains
Wetlands
Land cover
Soils
Survey control
Composite overlay




North




crimes.mxd - ArcMap - ArcView
Attributes of All Crimes

What is a GIS?

Many things to many people but at core is any system used for:

- creating,
- storing,
- manipulating,
- analysing and
- presenting geographic information

What is *geographic information*?

Any piece of data that can be located in space, using:

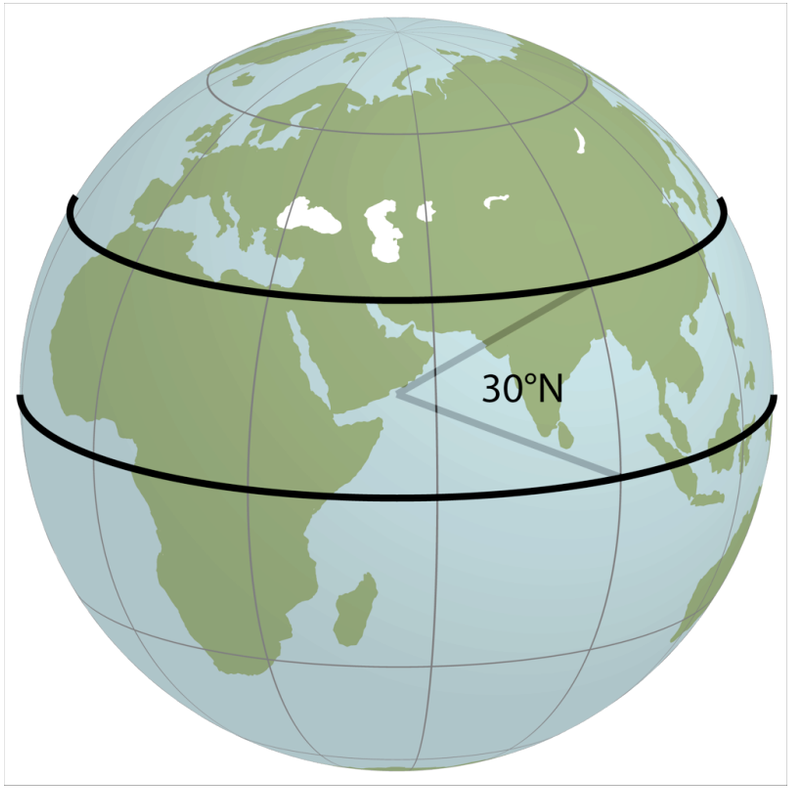
- A set of coordinates
- A known coordinate system

Without **both** of these bits of information, we do not have geographic information!

Spherical coordinates

Latitude:

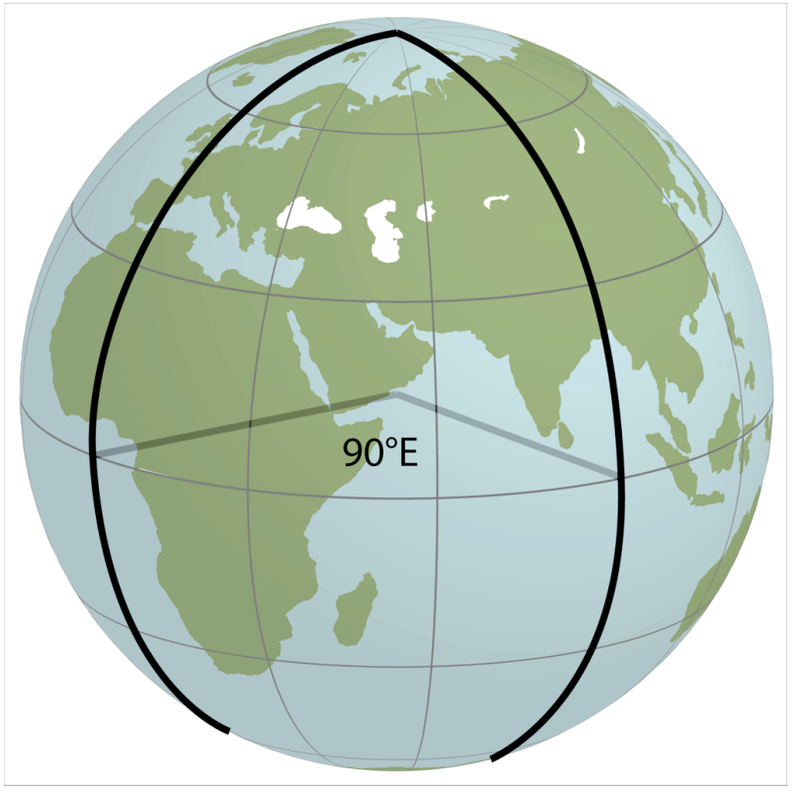
- an angle above or below the equator
- points of equal latitude form a parallel
- distance between parallels is constant*



Spherical coordinates

Longitude:

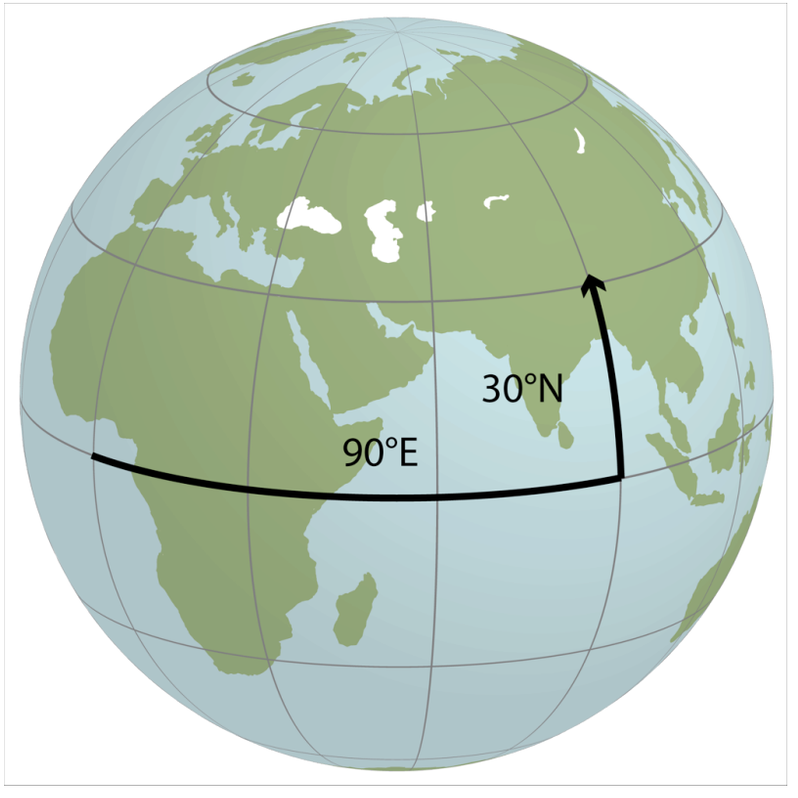
- an angle around the equator
- points of equal longitude form a meridian
- distance between meridians varies



Spherical coordinates

Latitude and longitude

- 90°0’0” E, 30°0’0” N
- 90.00 E, 30.00 N
- Can include height:
- Near Lhasa, Tibet - ~ 5,500m



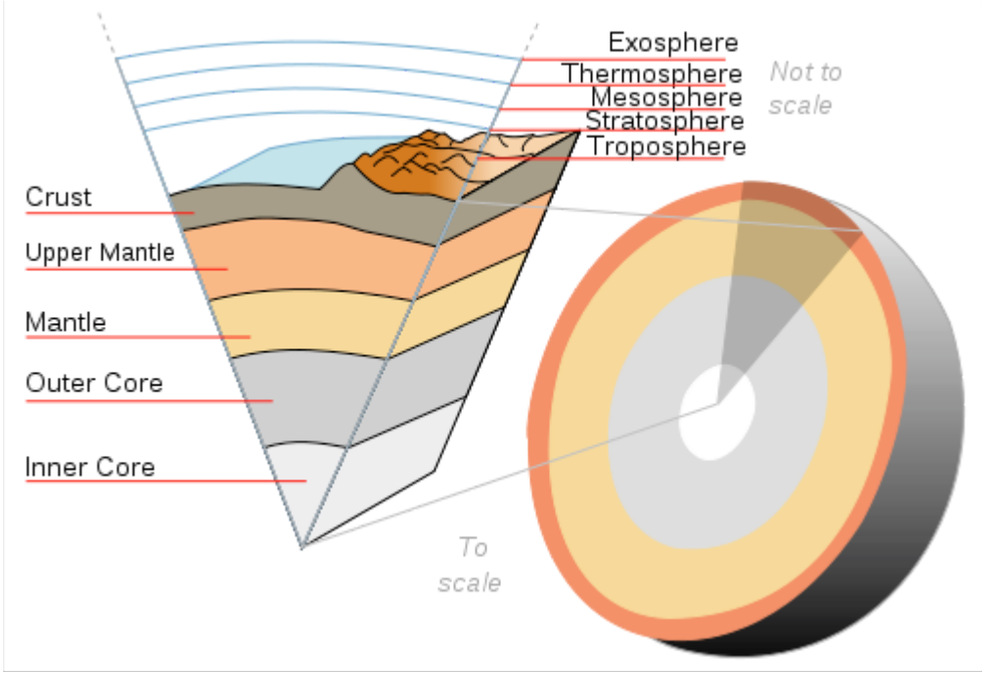
Geographic coordinate system

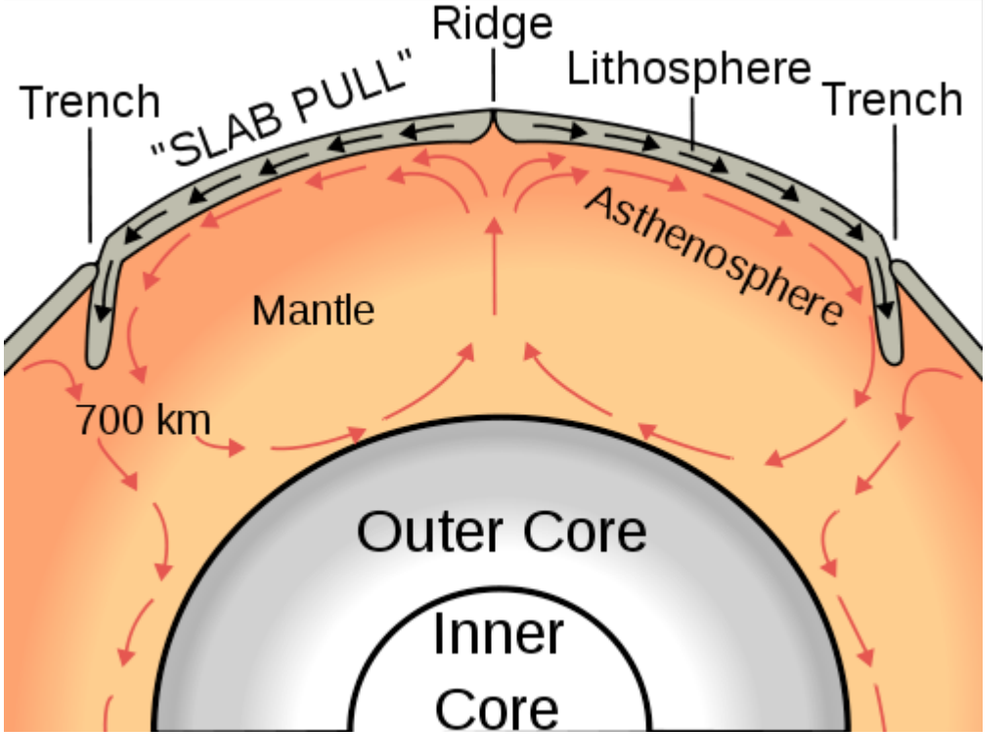
- The Earth is not a sphere
- ~ 1 in 298 flattening
- Estimated reference ellipsoid or datum.

Name	**$r_{equator}$ (m)**	**r_{poles} (m)**
Airy 1830	6,377,563.4	6,356,256.91
Bessel 1841	6,377,397.16	6,356,078.96
Clarke 1866	6,378,206.4	6,356,583.8
International 1924	6,378,388	6,356,911.9
WGS 1984	6,378,137	6,356,752.31

Geographic coordinate system

- Unfortunately, the Earth isn't a ellipsoid either.
- Distribution of mass is uneven and dynamic

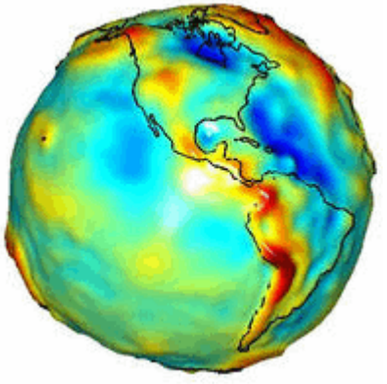




Geographic coordinate system

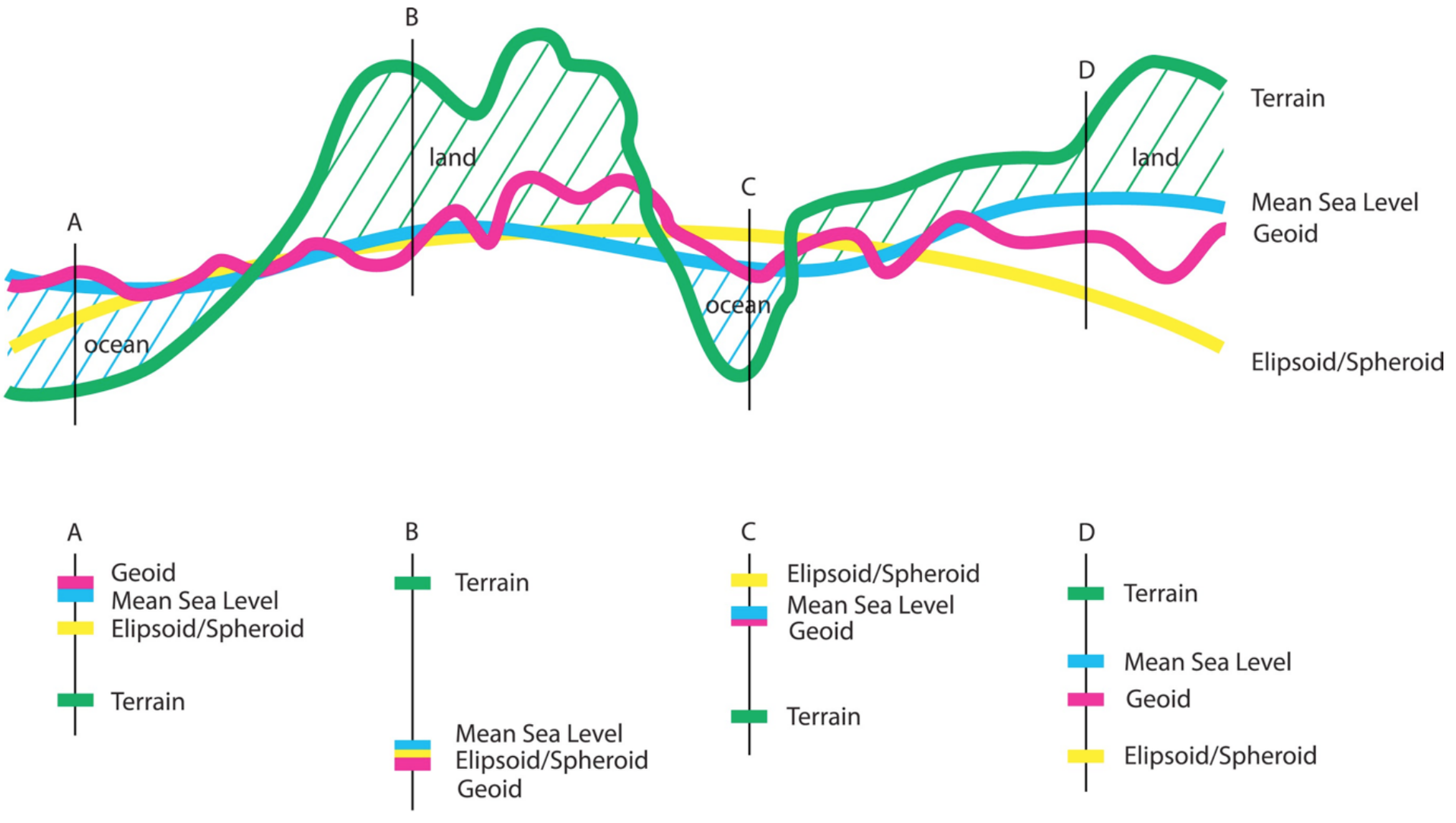
Geoid

- Surface of equalgravitational force
- Up and down are **perpendicular** to the local geoid
- A level surface is **tangent** to the local geoid



Grace Gravity Model 3

Geographic coordinate system

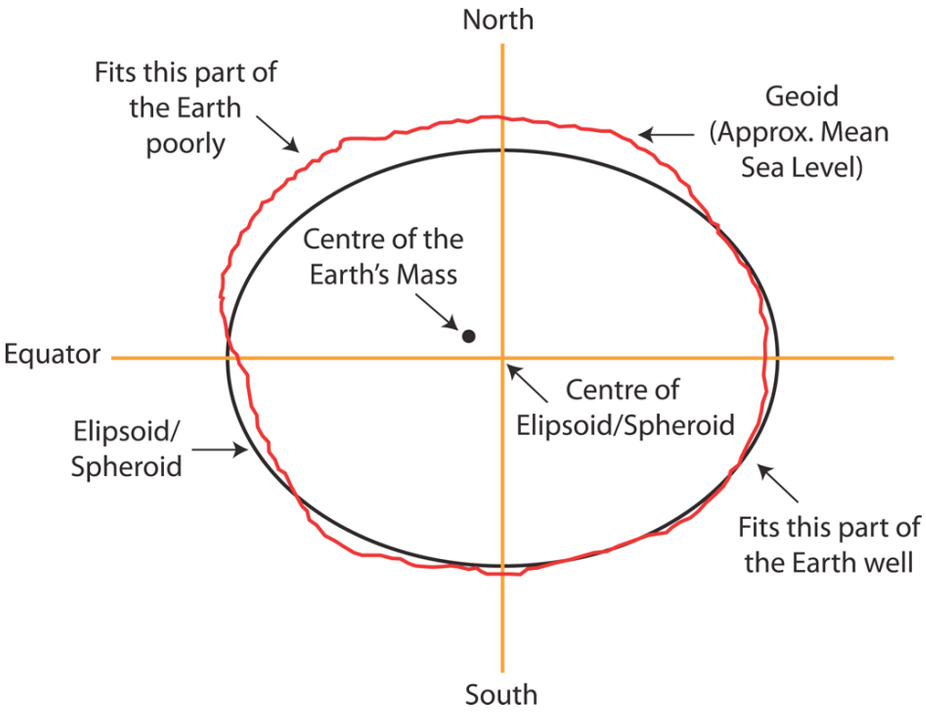


WGS 84

- Combined datum and geoid giving a standard global coordinate system
- Uses modern satellite data to provide ellipsoid measurements and gravity model
- Used by GPS
- Prime meridian: 0°0’5.31”E !

Local geographic datum

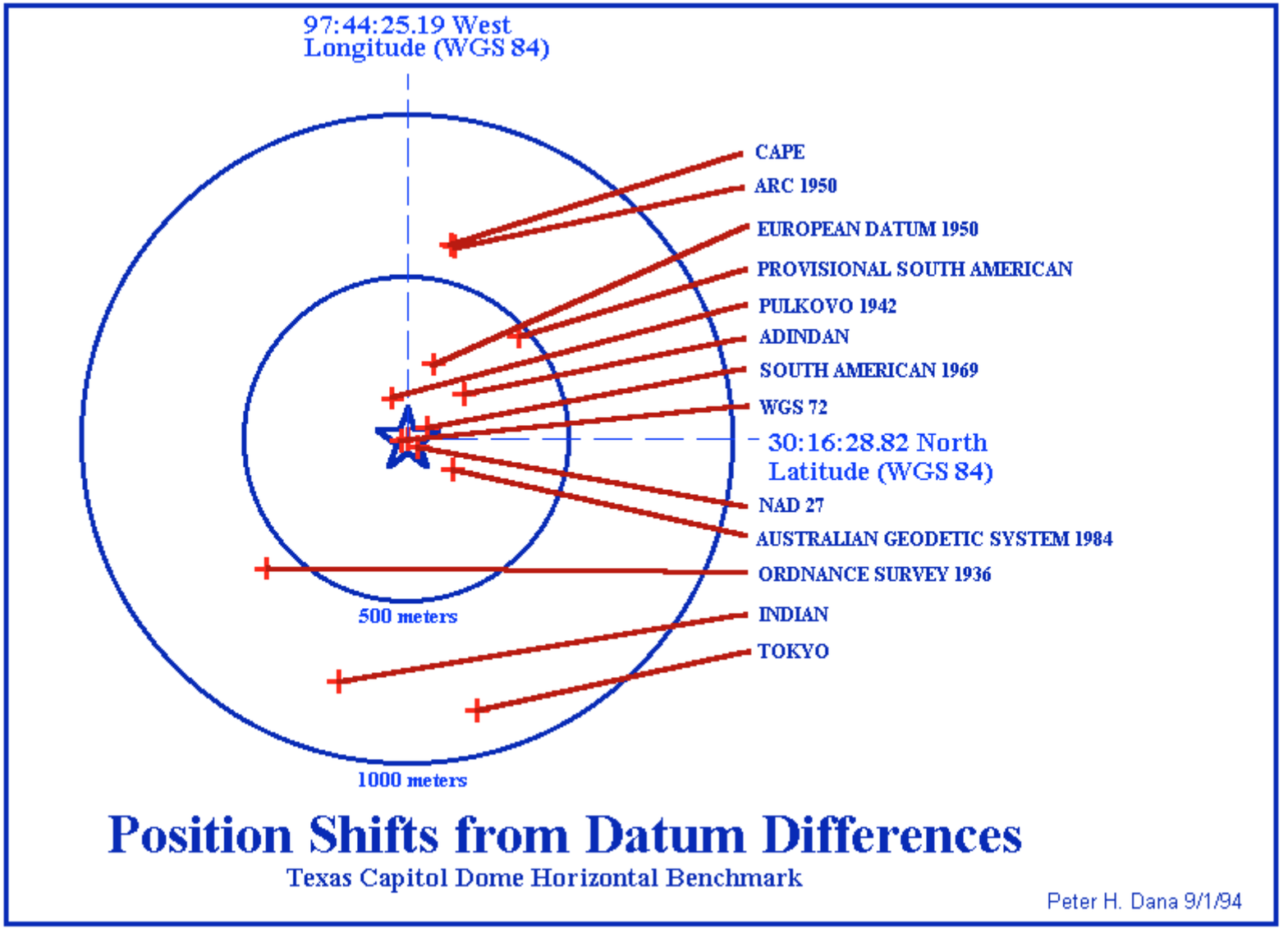
- The fit between a geoid and a datum varies in space
- Global models, like WGS 84, work well on average
- Countries adopt local datum models that fit better locally



Local geographic datum

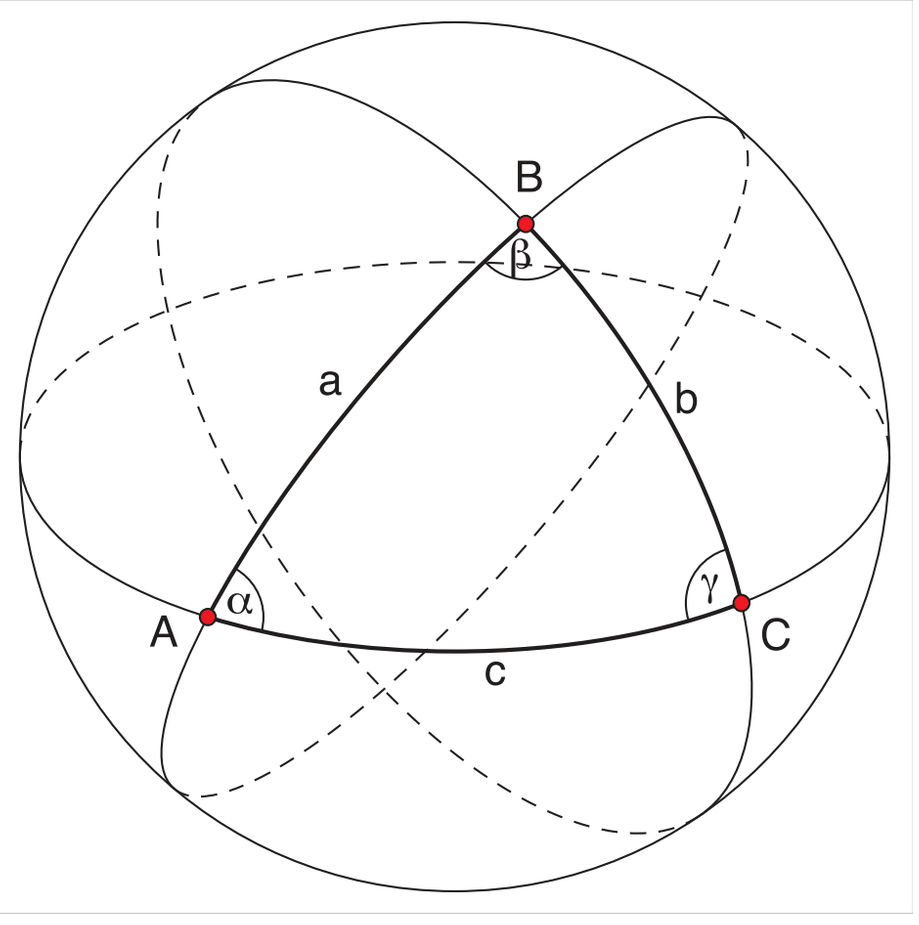
- British National Grid uses the OSGB 36 datum
- Same latitude & longitude + different datum = datum shift
- In Cornwall, a WGS 84 point is ~70 m east and ~ 70 m south of OSGB 36.
- The shift varies nationally

Datum shift


97:44:25.19 West
Longitude (WGS 84)
CAPE
ARC 1950
EUROPEAN DATUM 1950
PROVISIONAL SOUTH AMERICAN
PULKOVO 1942
ADINDAN
SOUTH AMERICAN 1969
WGS 72
30:16:28.82 North
Latitude (WGS 84)
NAD 27
AUSTRALIAN GEODETIC SYSTEM 1984
ORDNANCE SURVEY 1936
INDIAN
TOKYO
500 meters
1000 meters
Position Shifts from Datum Differences
Texas Capitol Dome Horizontal Benchmark
Peter H. Dana 9/1/94

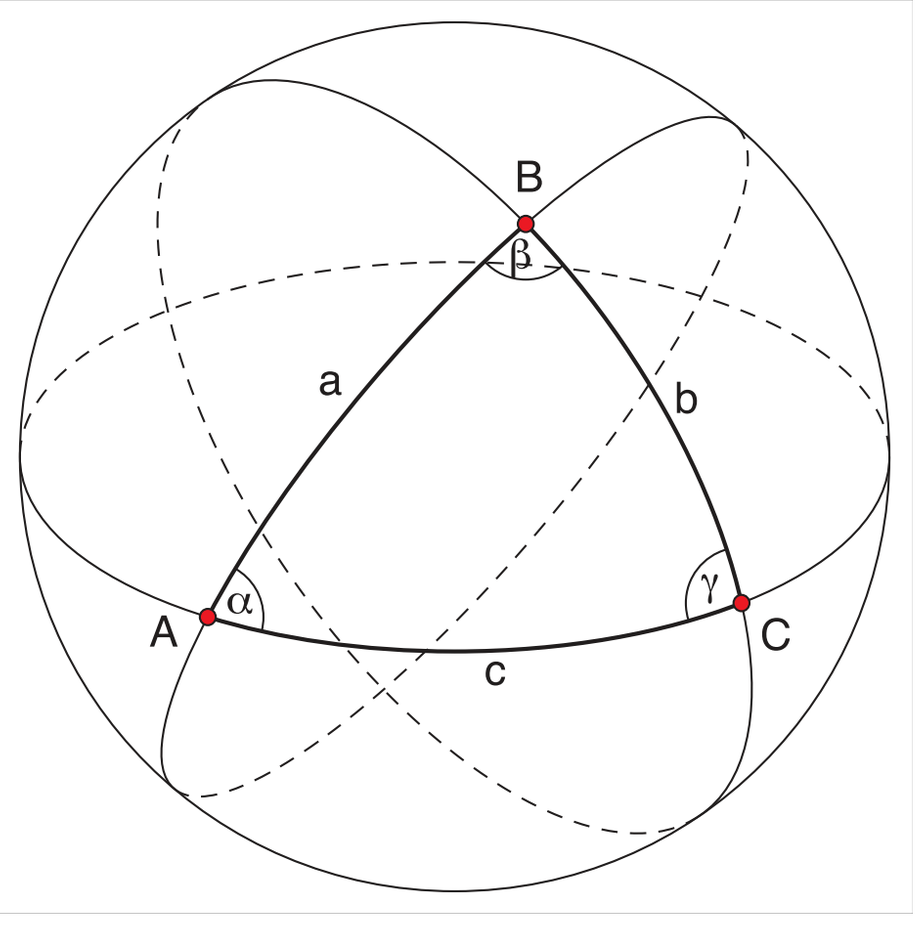
Spherical geometry

- Great circles
- Spherical ‘triangle’
- **Spherical** geometry:
  - exact and fast
- **Ellipsoidal** geometry:
  - iterative and slow



Spherical geometry

- Globes not convenient or easily scalable
- Precise calculations slow
- Not easily useable on flat screen or on paper
- Need a flat representation of space



Projected coordinate systems

- It is impossible to project an spherical surface onto a plane without distortion (Gauss, 1827).
- The ellipsoid surface of the Earth for small distances (~ 10 km) is flat enough for simple purposes but for anything else…

Projected coordinate systems

Map projections can preserve:

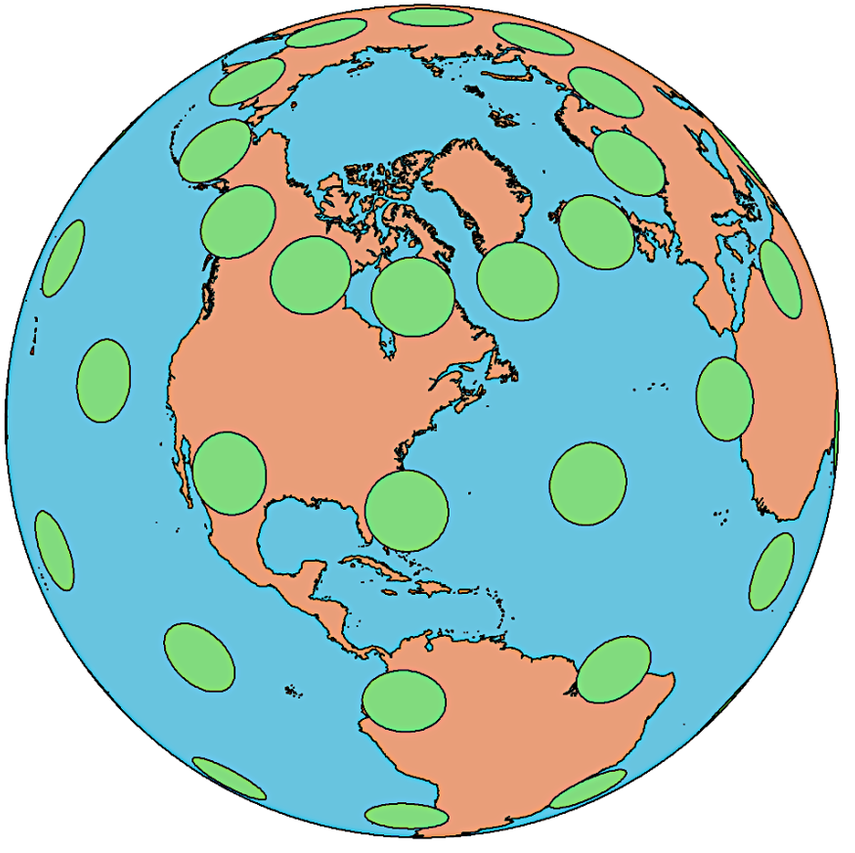
- **Shape**: conformal maps
- **Area**: equal-area maps
- **Distance**: equi-distant maps
- **Direction**: azimuthal maps

But most projected coordinate systems can only preserve **one** of these things.

Projected coordinate systems

Tissot indicatrix:

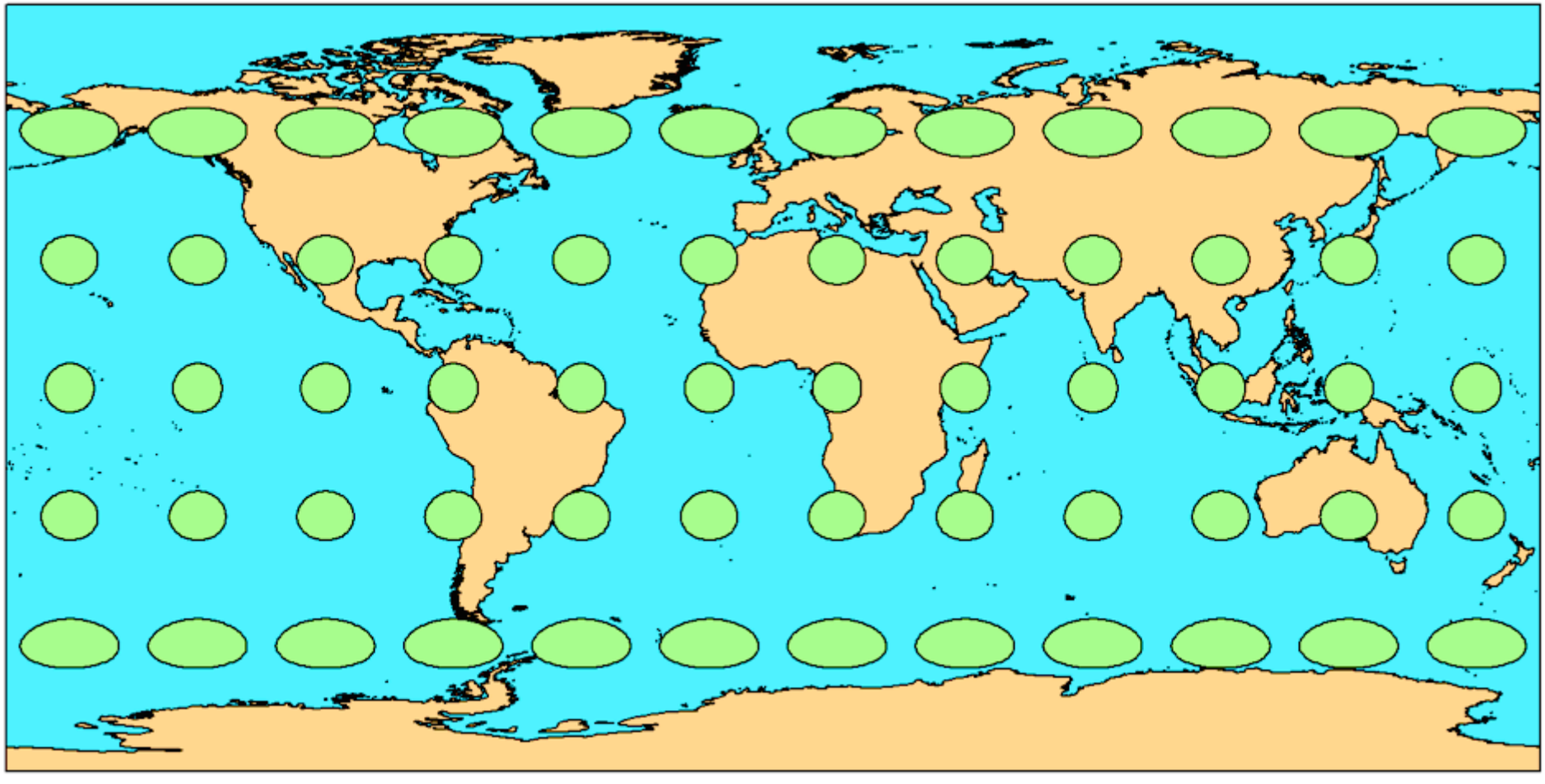
- An circle on the surface of the Earth.
- All points on the edge are equidistant from the center.
- Show distortion of ellipsoid surface on planar projections



Orthographic

Projected coordinate systems

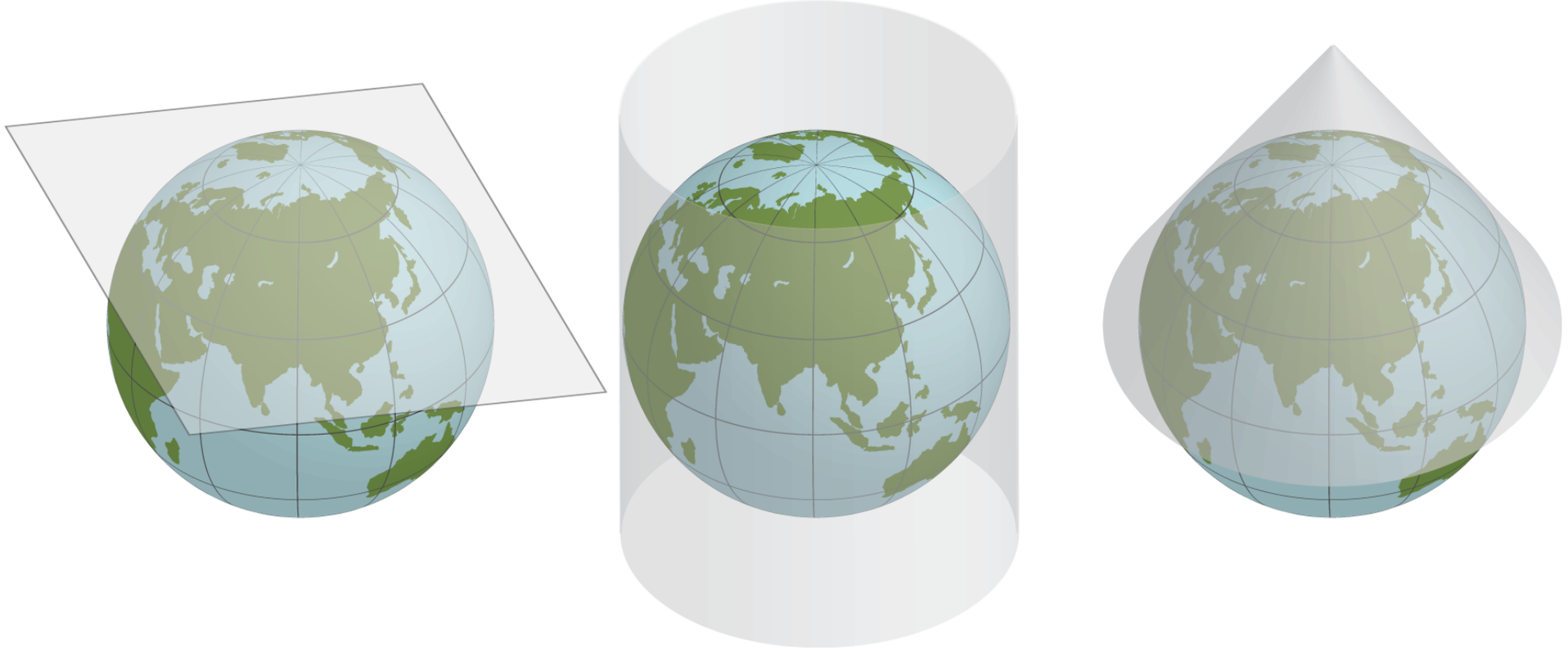
Equirectangular : Treat latitude and longitude as X and Y



Equirectangular

Projected coordinate systems

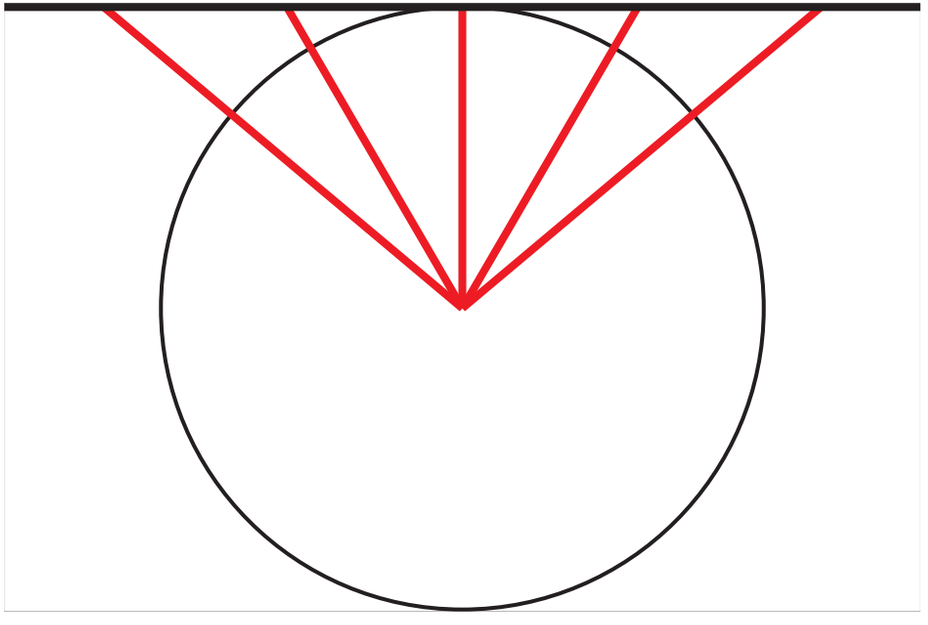
Classification according to mapping to planar surface:

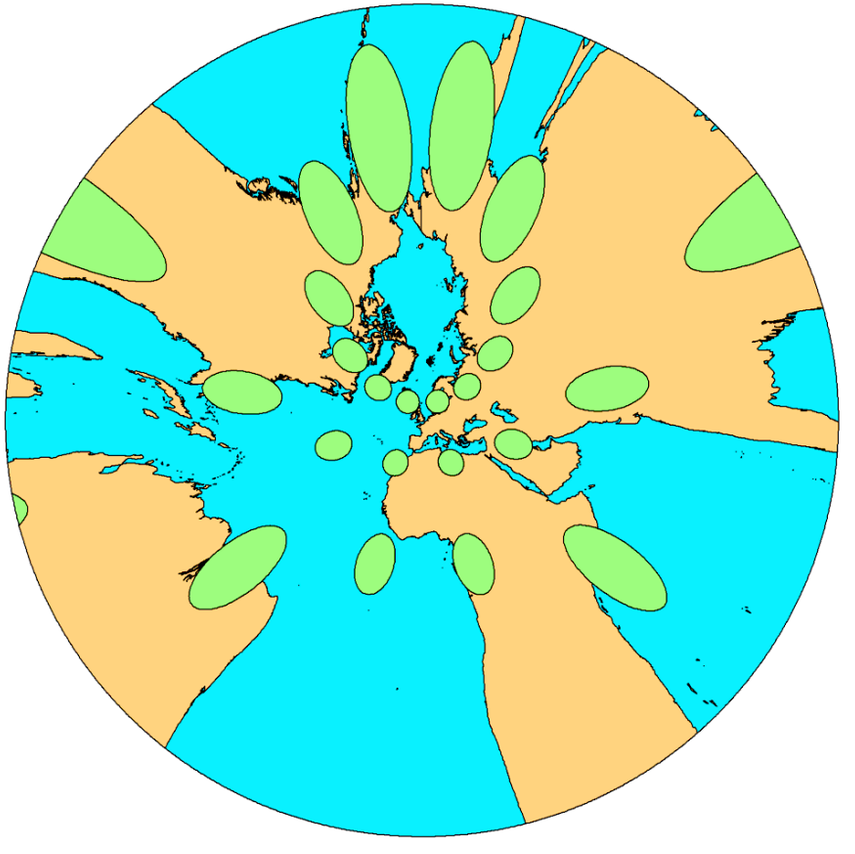


Planar Cylindrical Conical

Projected coordinate systems

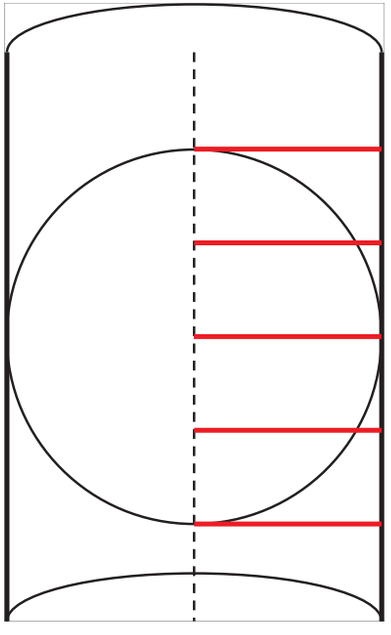
Gnomonic: planar, preserves bearings from a single central point, but little else.

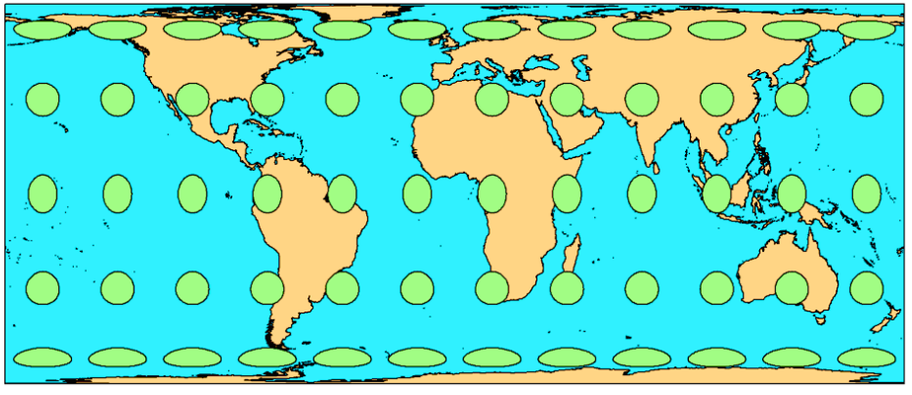




Projected coordinate systems

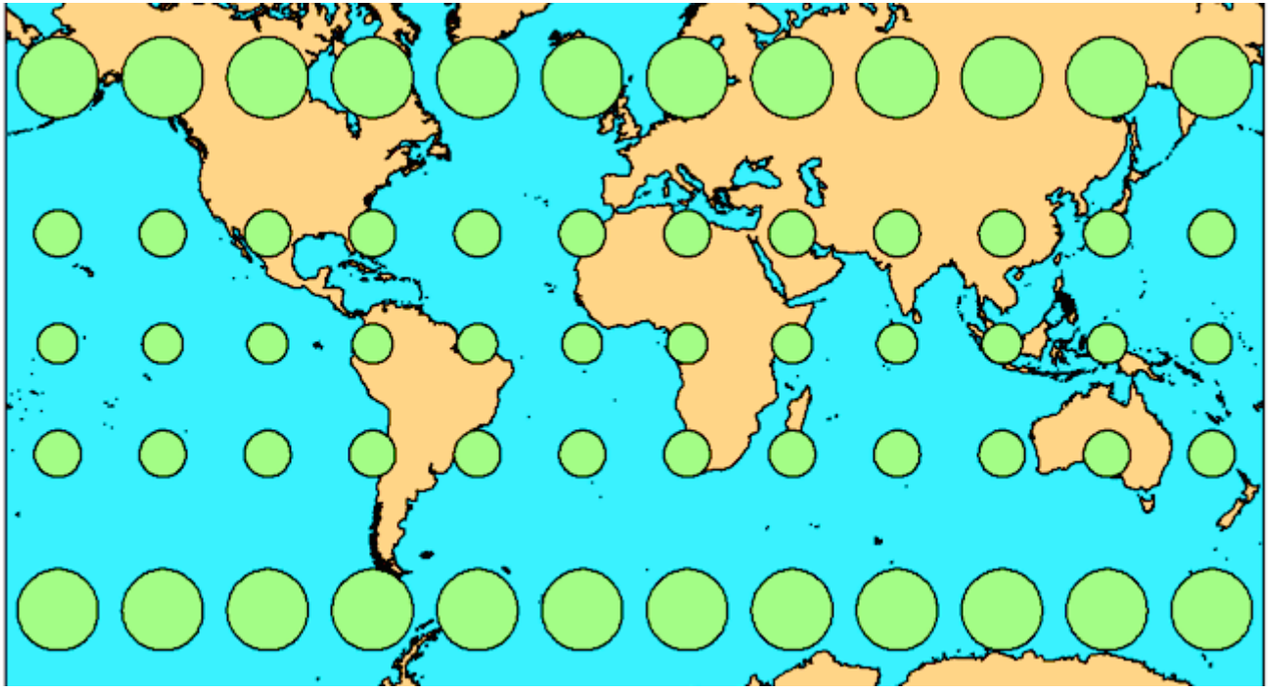
Cylindrical: preserves area, not shape





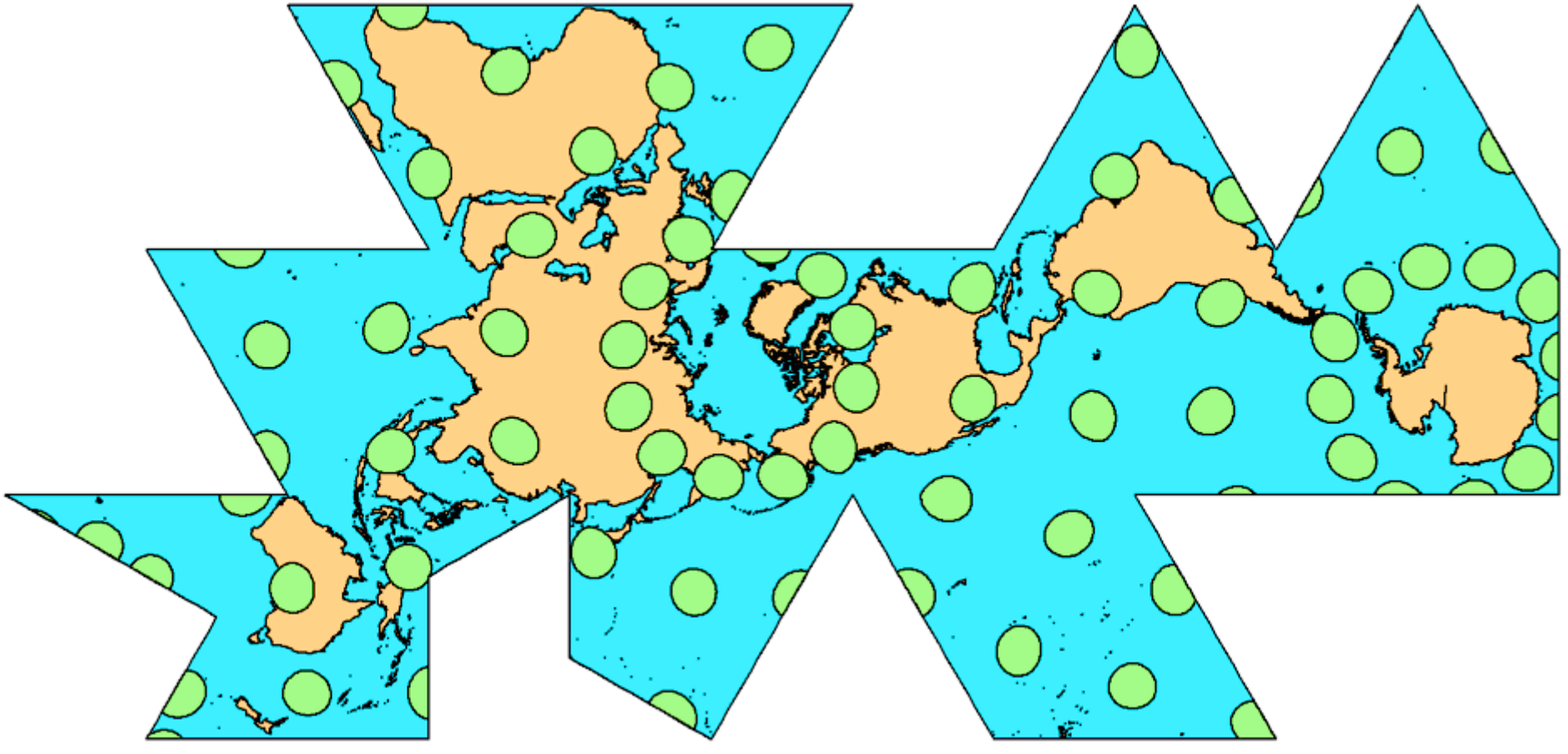
Projected coordinate systems

Mercator: preserves shape, not scale



Projected coordinate systems

Fuller Dymaxion: compromise projection



Geographic data

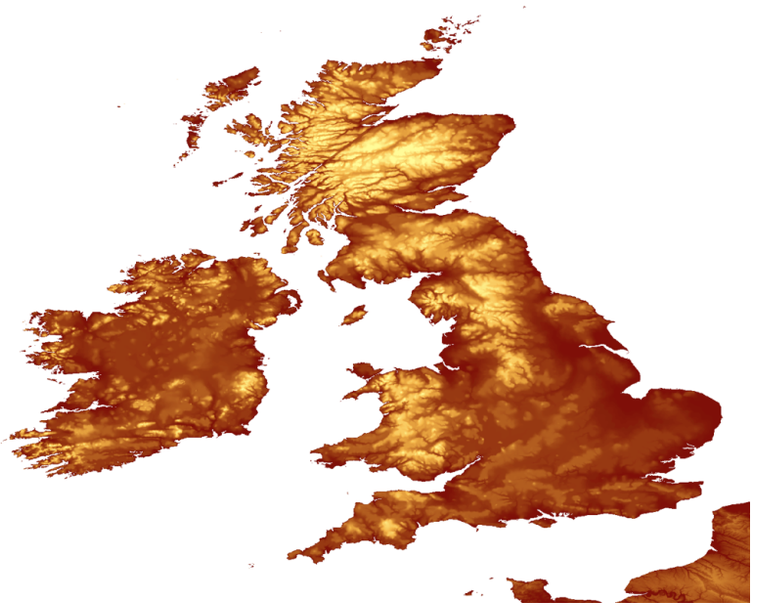
- A **Coordinate system** and:
  - **Vector** data: coordinates of points, lines, polygons
  - **Raster** data
    - grid data
    - satellite and aerial images

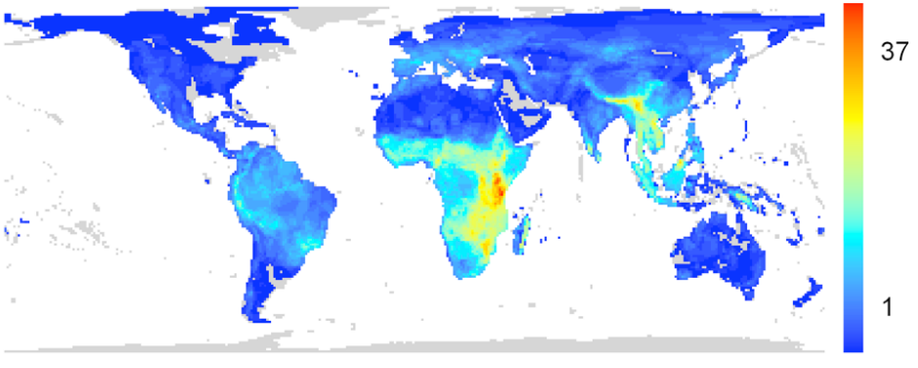
Raster data

An **image** covering a continuous surface

- Made up of individual **pixels**, each with a **value**
  - Categorical: land cover, species presence
  - Continuous: temperature, precipitation
- Has a **resolution** (pixel size)
- Needs **origin** and coordinate system

Raster data




37
1


Brewer's Pond
Great Pond
Lower Farm
Water Splash Lane
Platt's Firs
FB
Penslade Bottom
Sch
Emmet's Wood
Fireball Hill
Cheapside
FBs
Silwood Farm
Twr
Silwood Lake
Virginia Water
Lodge
Harewood
Tetworth Hall
Cascade Bridge
Agincourt
MS
Silwood Park
College
Nutfield
A329
College
B3020
Coombe Grange
Convent
PO
MS

Vector Data

- A set of *features*, containing one of:
  - Individual **points**, or sets of connected points forming **lines** or **polygons**
- Needs a coordinate system
- Coordinates are a precise location, but may have precision or accuracy information
- Features may have an attribute table.

Vector Data