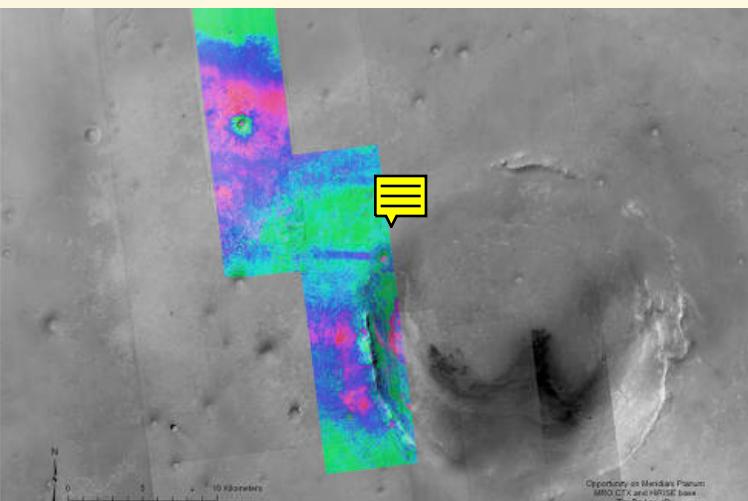
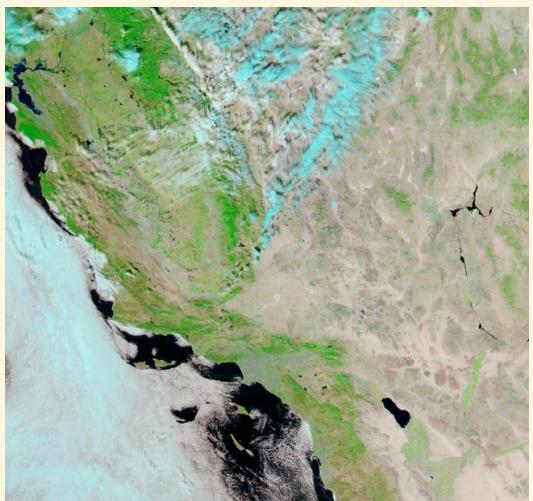
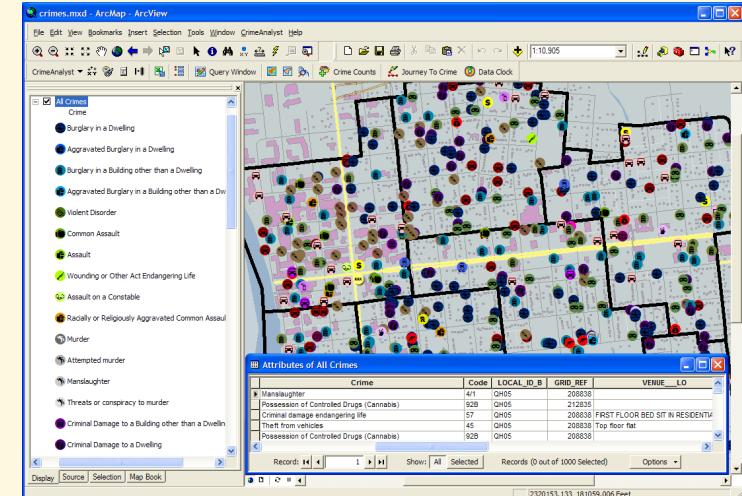
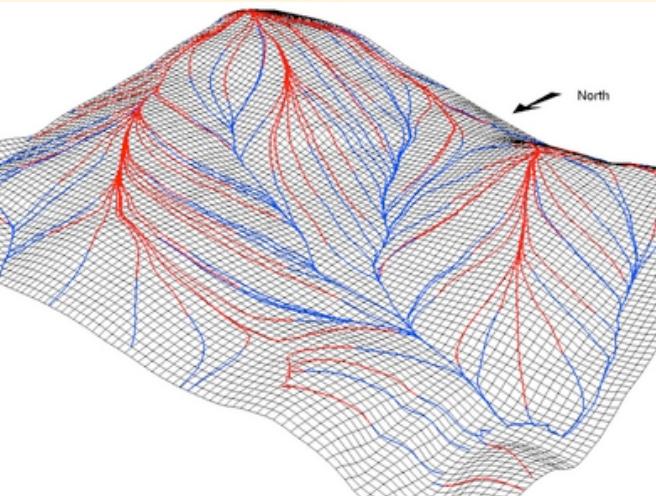
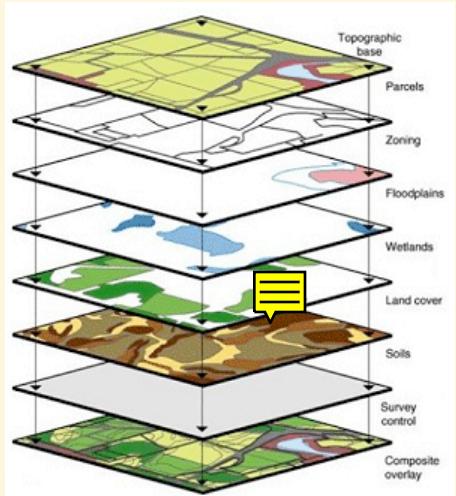


GIS concepts

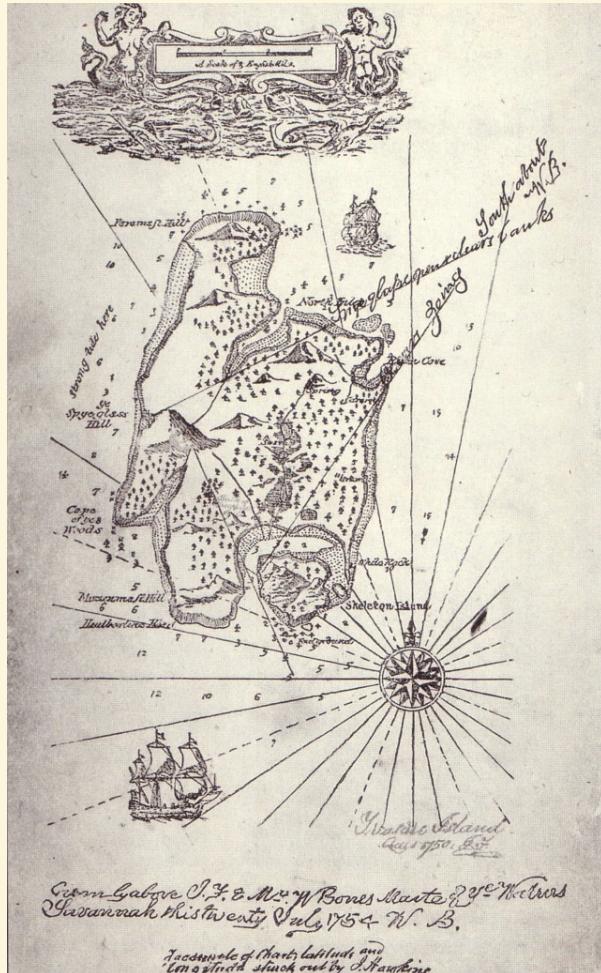
David Orme



What is a GIS?



What is geographic information?



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

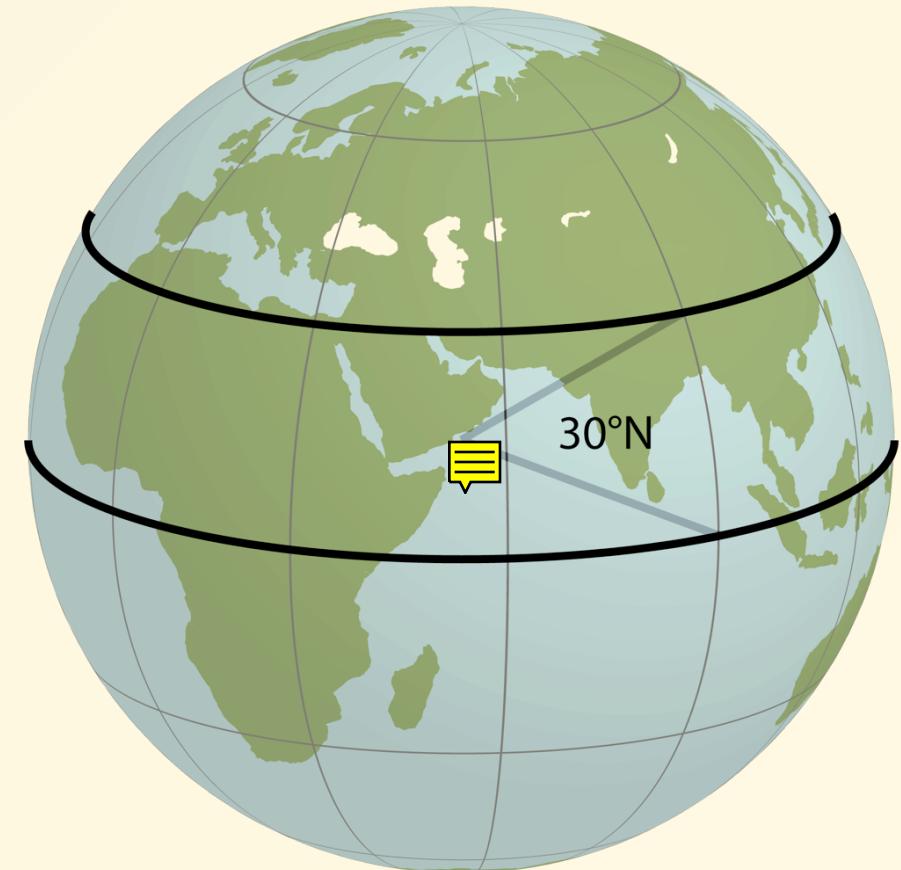
- A set of coordinates
- A known coordinate system

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

Spherical coordinates

Latitude

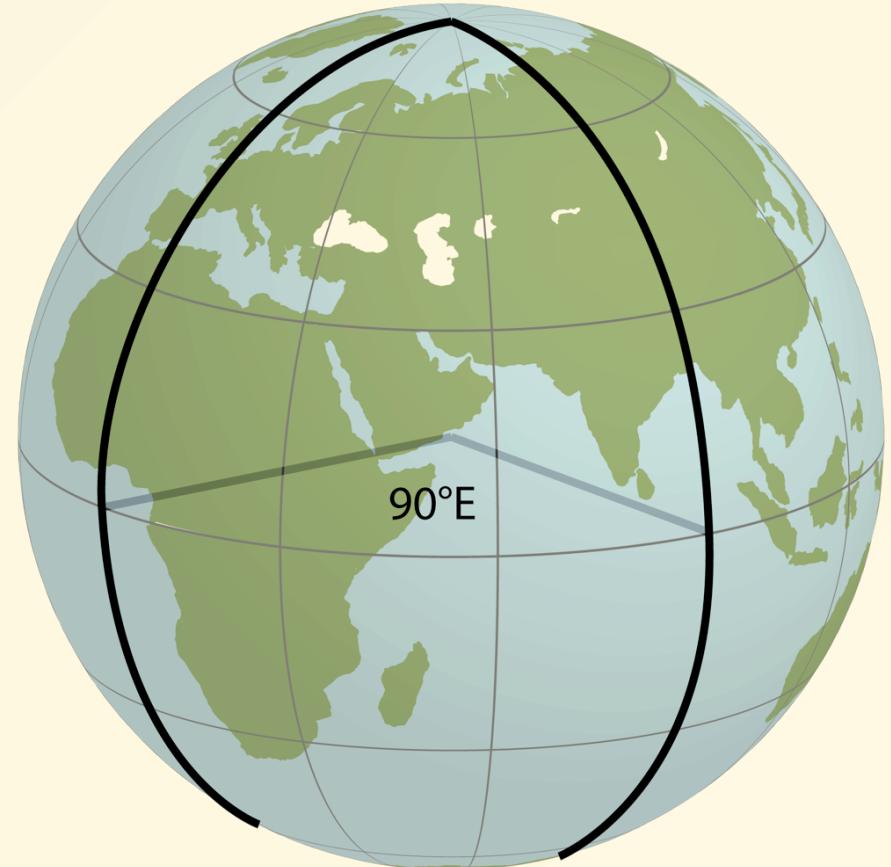
- an angle **above or below** the equator
- points of equal latitude form a **parallel**
- distance between parallels is constant*



Spherical coordinates

Longitude:

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



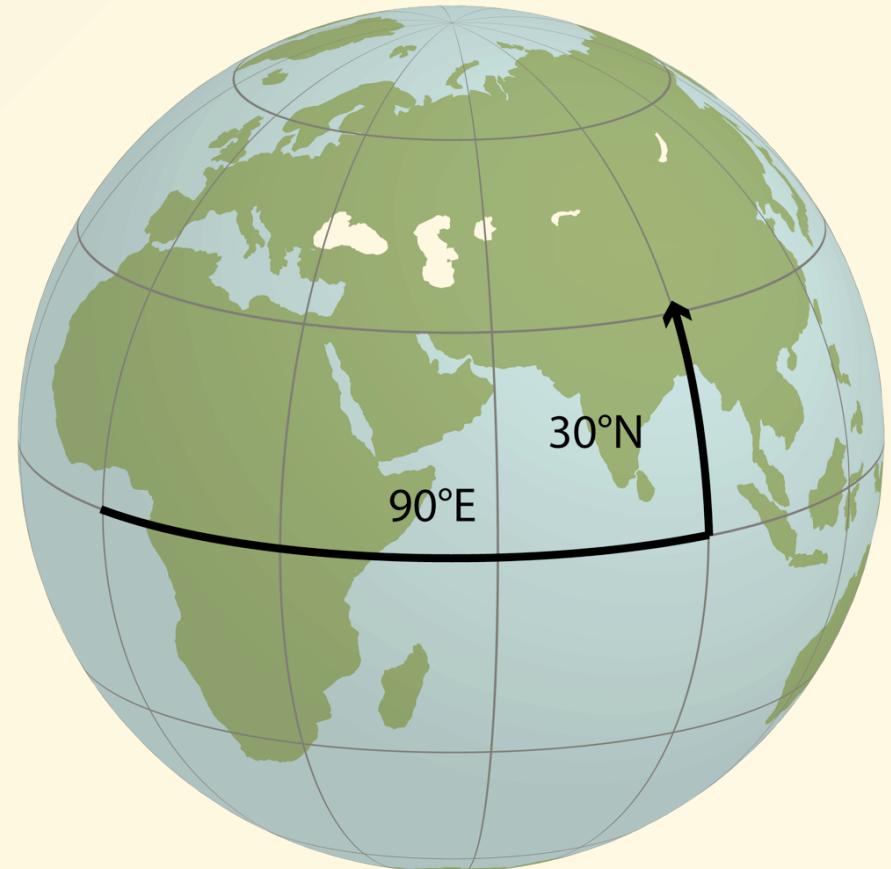
Spherical coordinates

Latitude and longitude:

- $90^\circ 0' 0''$ E and $30^\circ 0' 0''$ N
- 90.00 E, 30.00 N

3D coordinates

- Can include height
- In Tibet: 5,500 m
- Height above what?



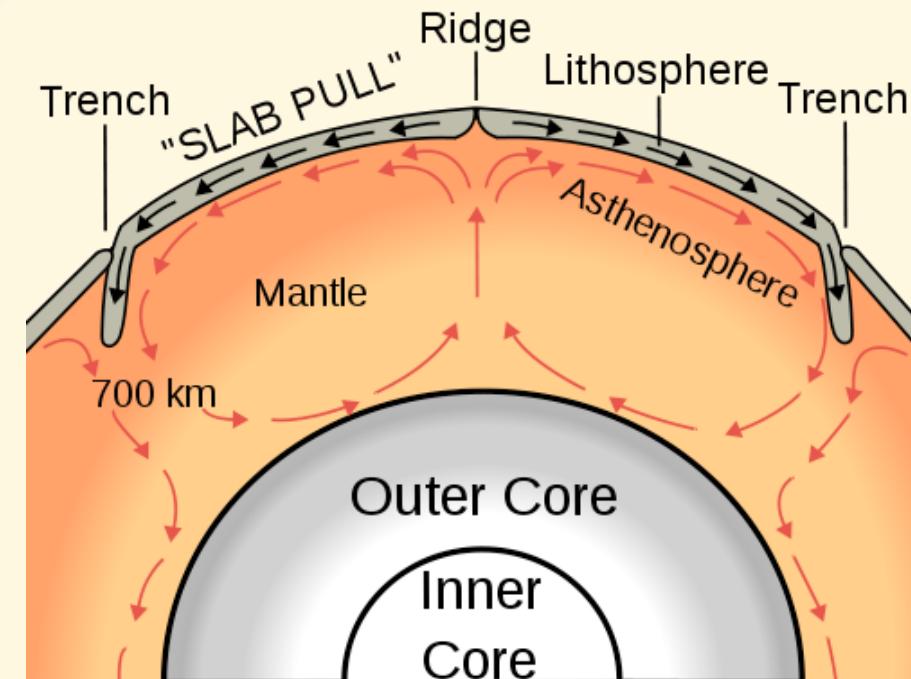
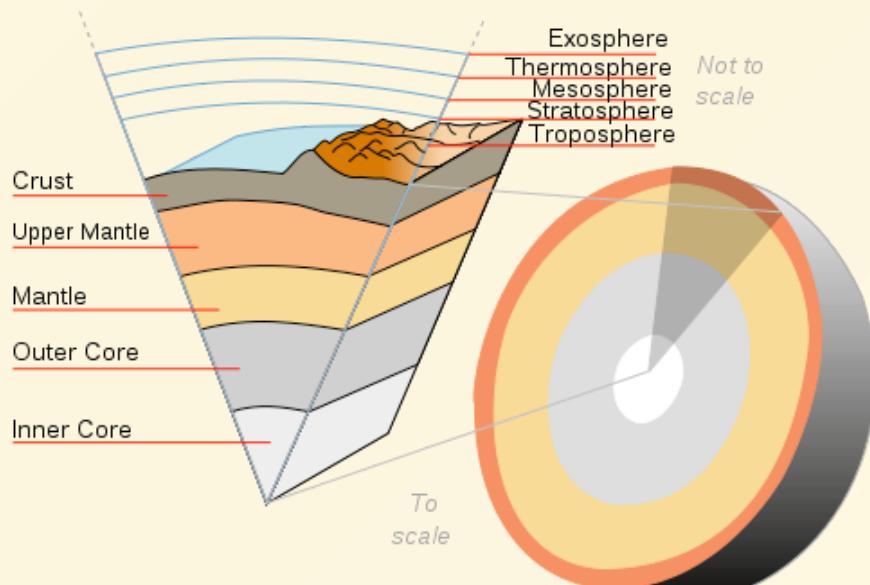
Geographic coordinate system

- The Earth is not a sphere (~ 1 in 298 flattening)
- There are **many** reference ellipsoids or datums.

Name	r _{equator} (m)	r _{poles} (m)
Airy 1830	6,377,563.4	6,356,256.91
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

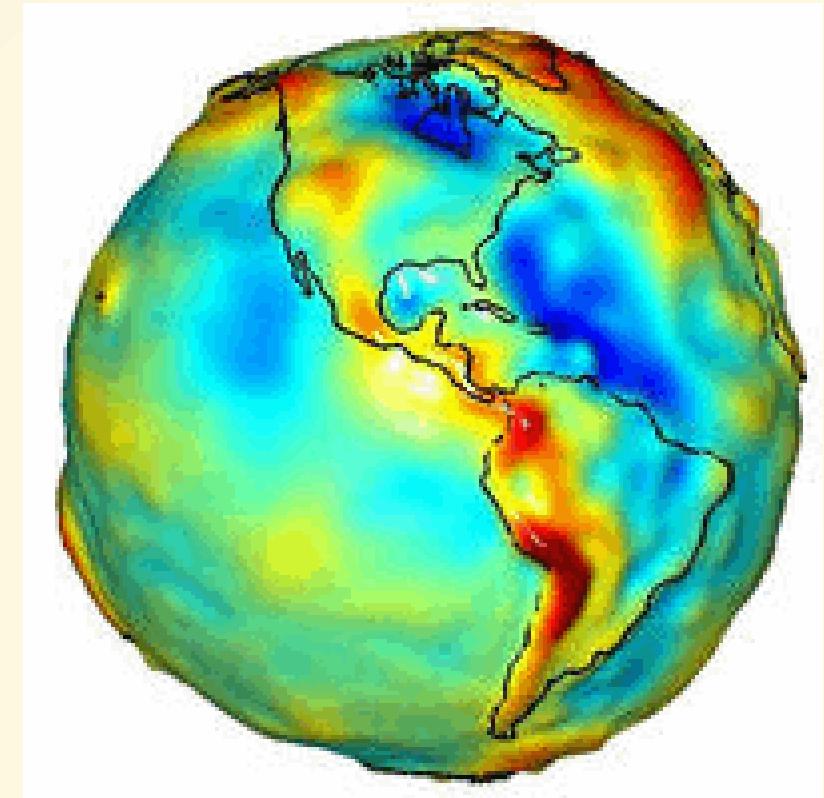
- Unfortunately, the Earth isn't a ellipsoid either.
- Distribution of mass is uneven and dynamic



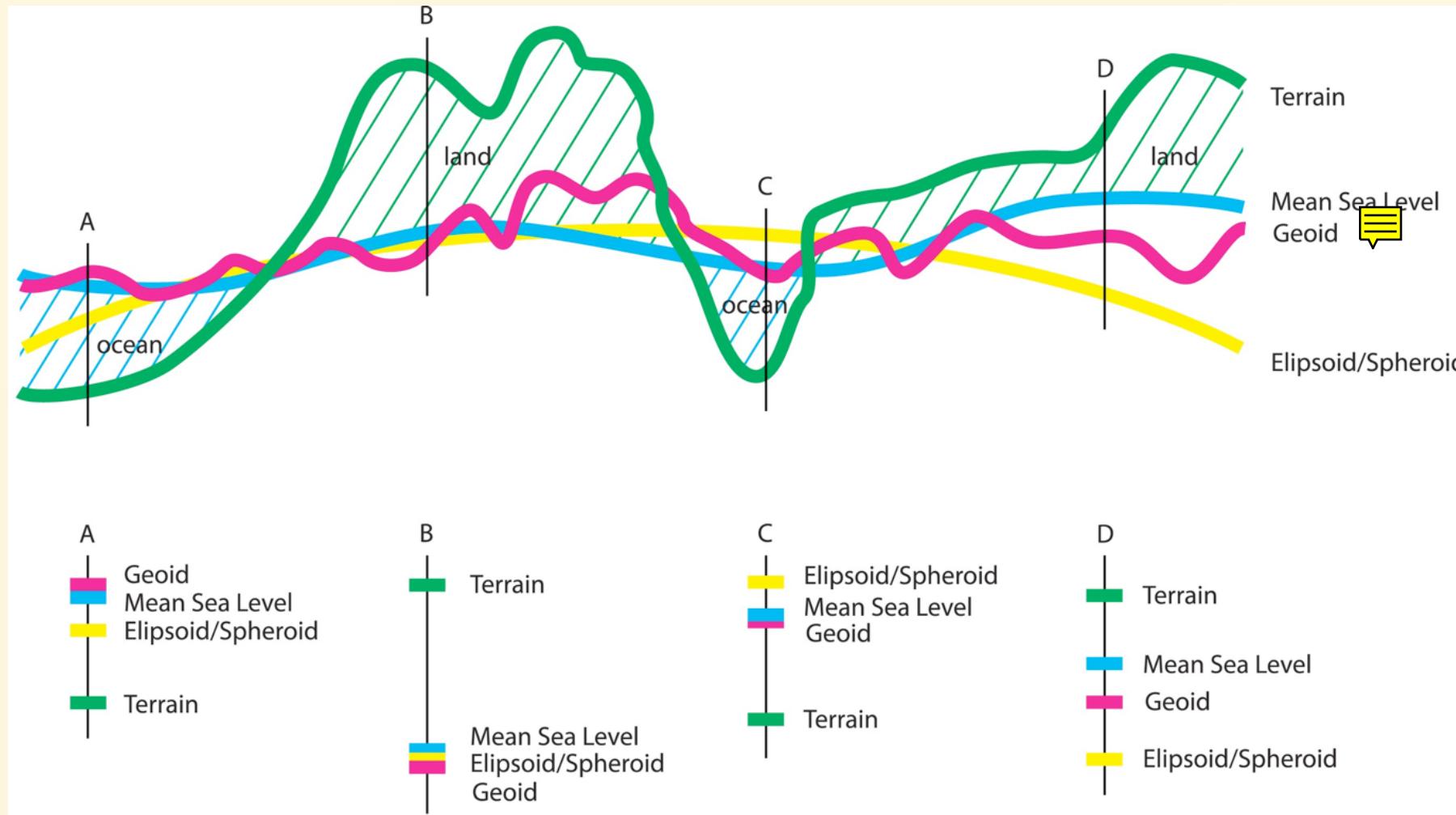
Geographic coordinate system

Geoid

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



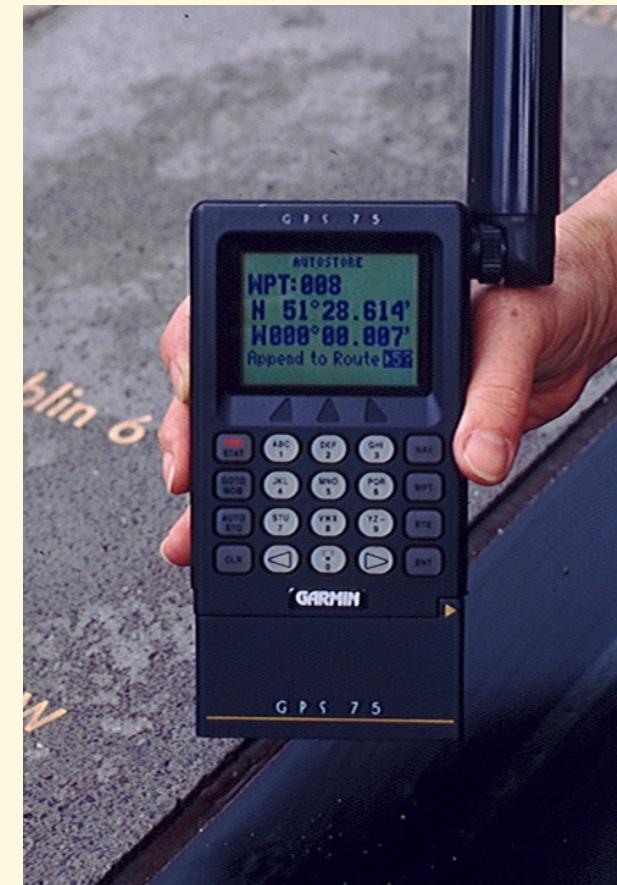
Geographic coordinate system



WGS 84

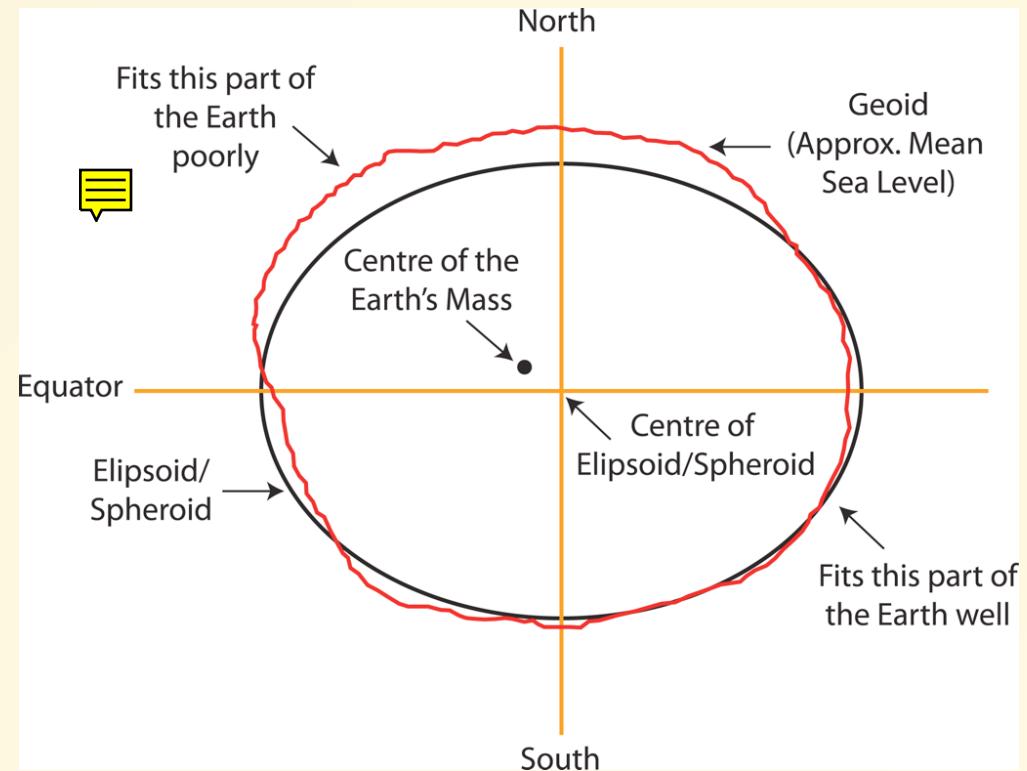


- Combined datum and geoid giving a standard global coordinate system
- Uses modern satellite data to provide ellipsoid measurements and gravity model
- Used by GPS
- Prime meridian: $0^{\circ}0'5.31''E$!



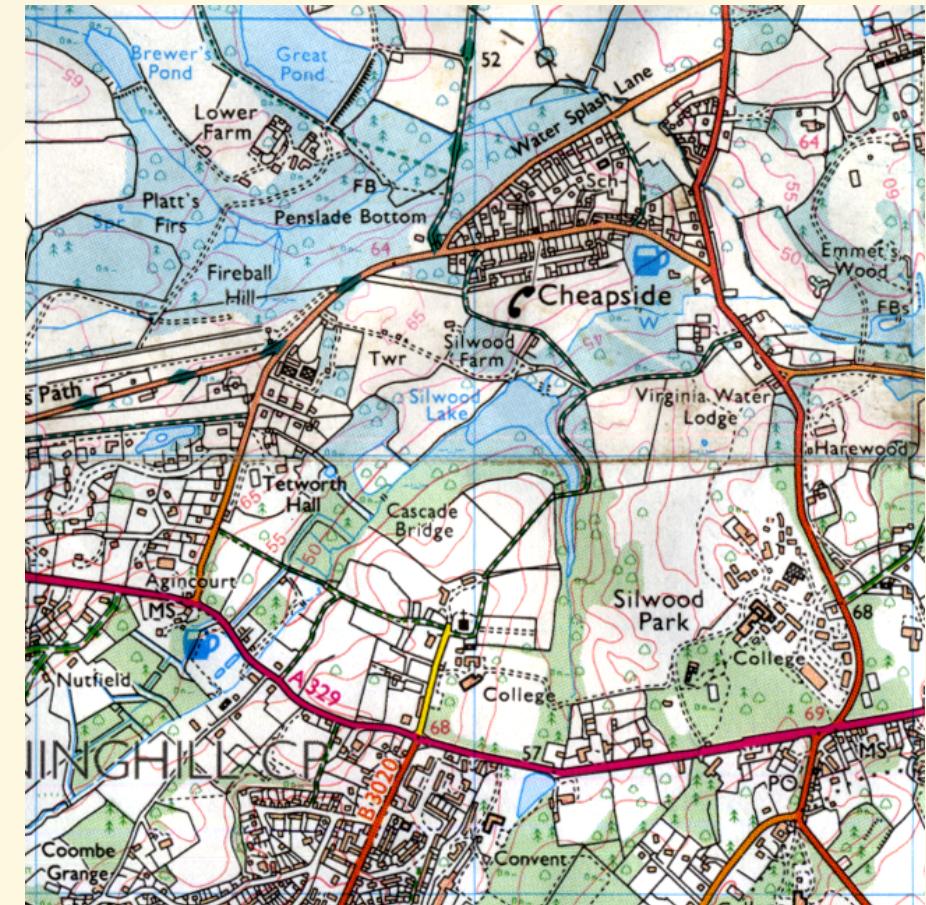
Local geographic datum

- 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

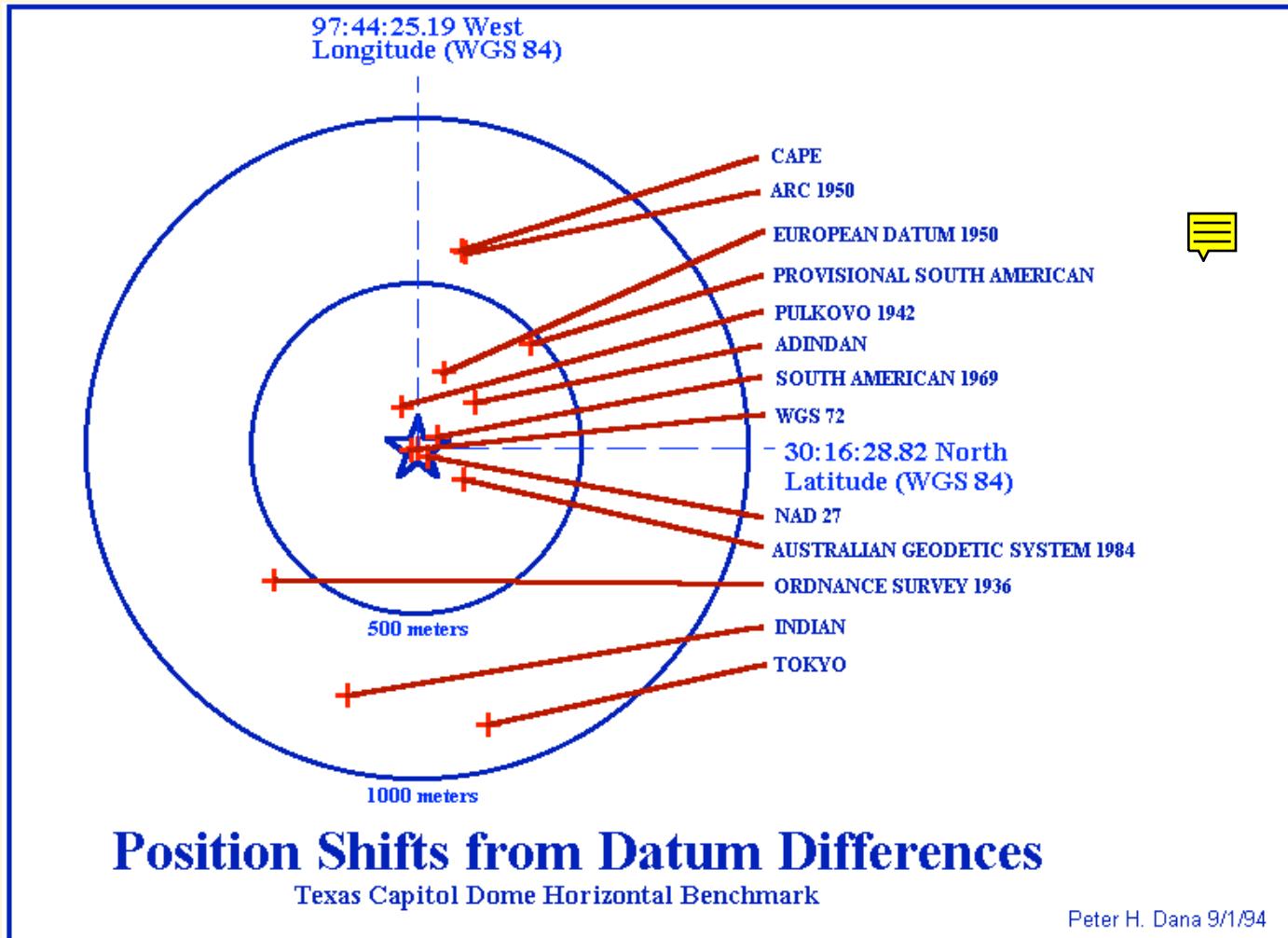


Local geographic datum

- WGS84
 - $-0.639875^{\circ}\text{W}$
 - 51.4090°N
- UK uses the **OSGB 36 datum**
 - $-0.638331^{\circ}\text{W}$
 - 51.4085°N
- The shift varies nationally

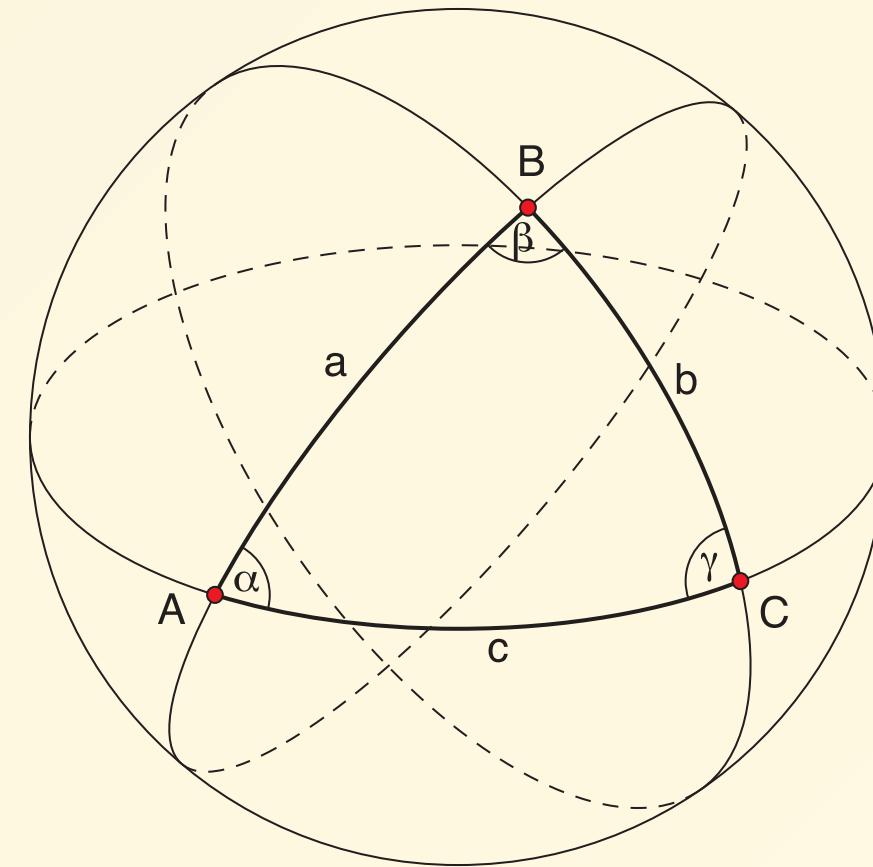


Datum shift



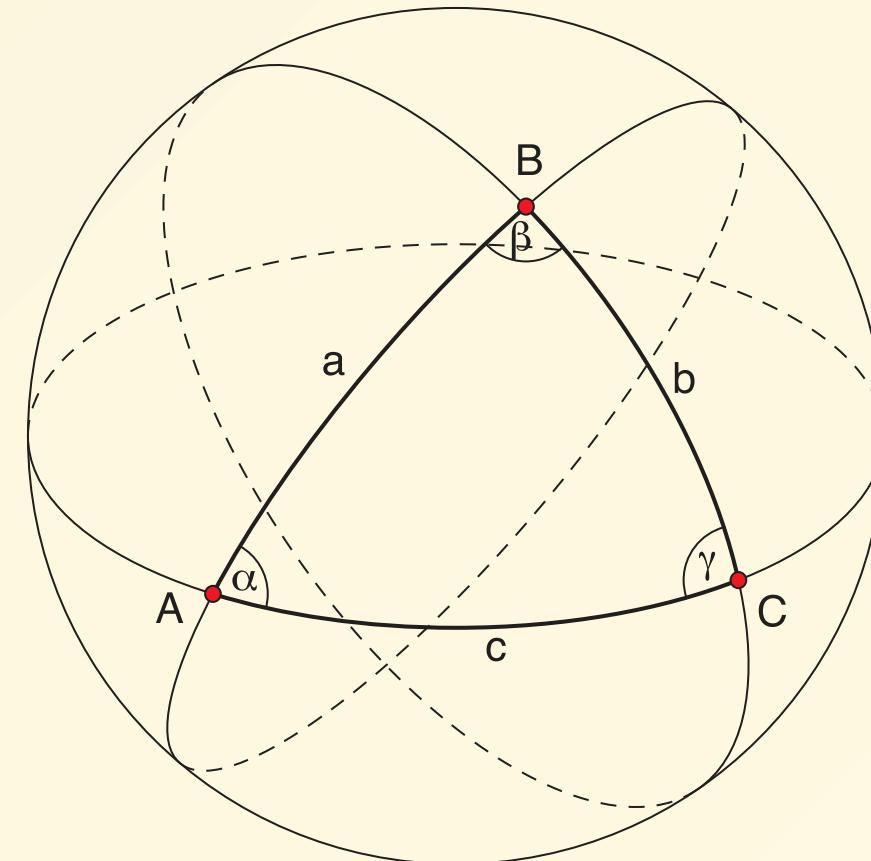
Spherical geometry

- 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).

”



Projected coordinate systems

Map projections can preserve:

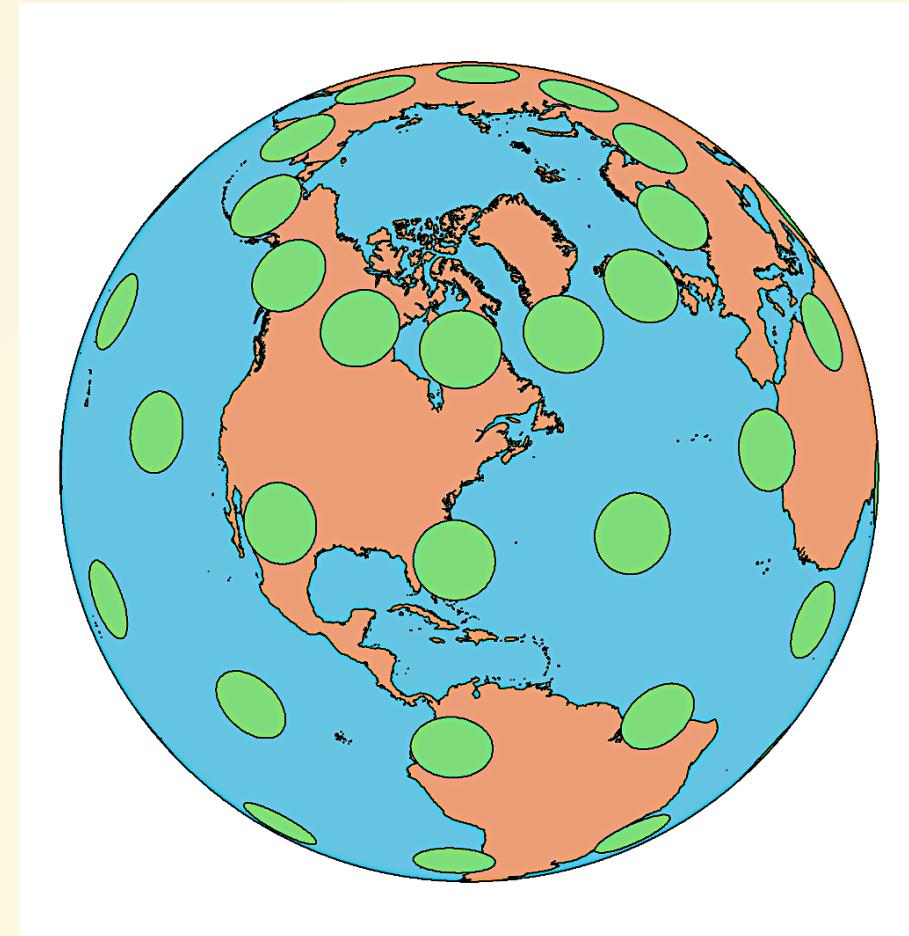
- **Shape**: conformal maps
- **Area**: equal-area maps
- **Distance**: equi-distant maps
- **Direction**: azimuthal maps

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

Projected coordinate systems

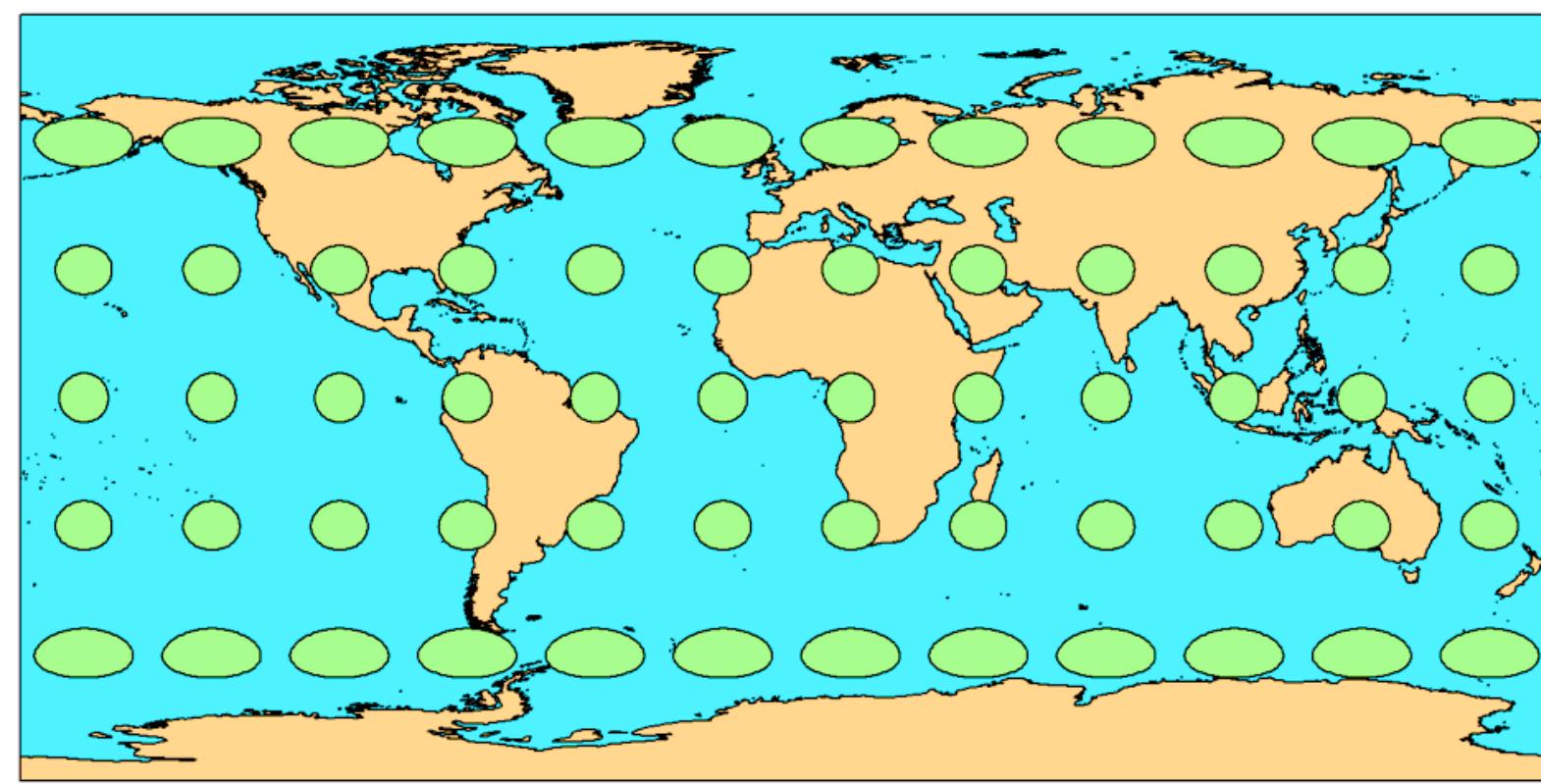
Tissot indicatrix:

- 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



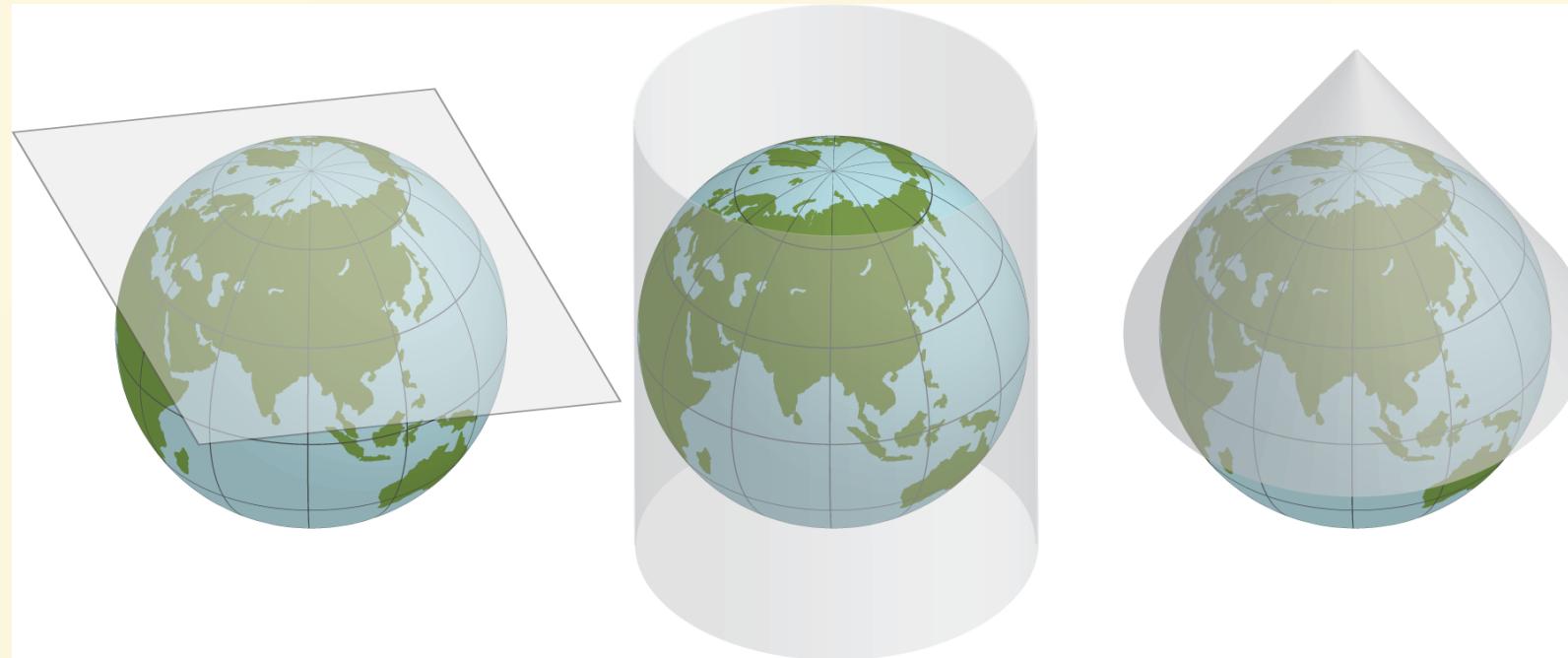
Projected coordinate systems

Equirectangular: latitude and longitude as X and Y



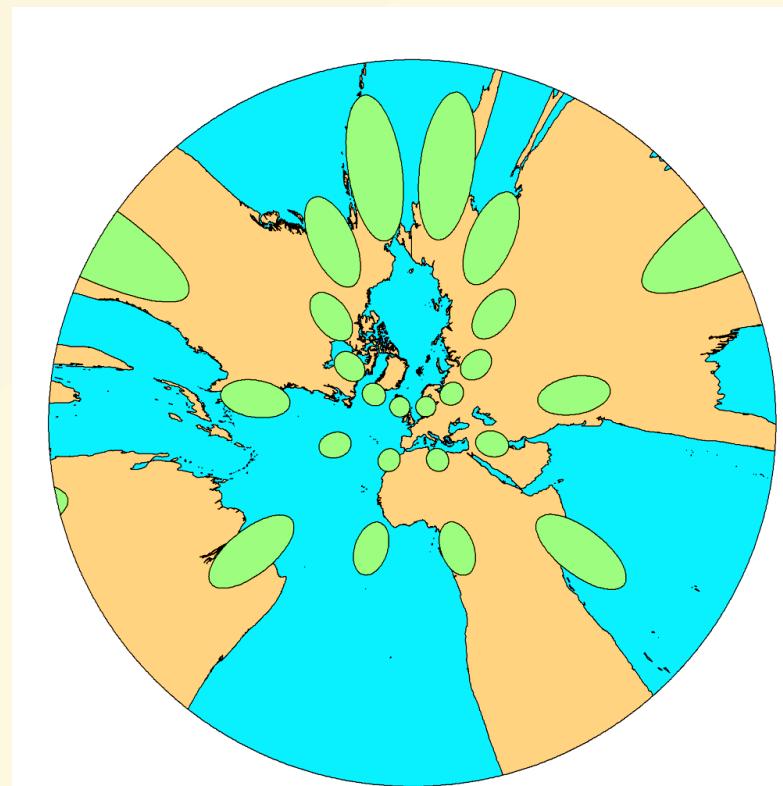
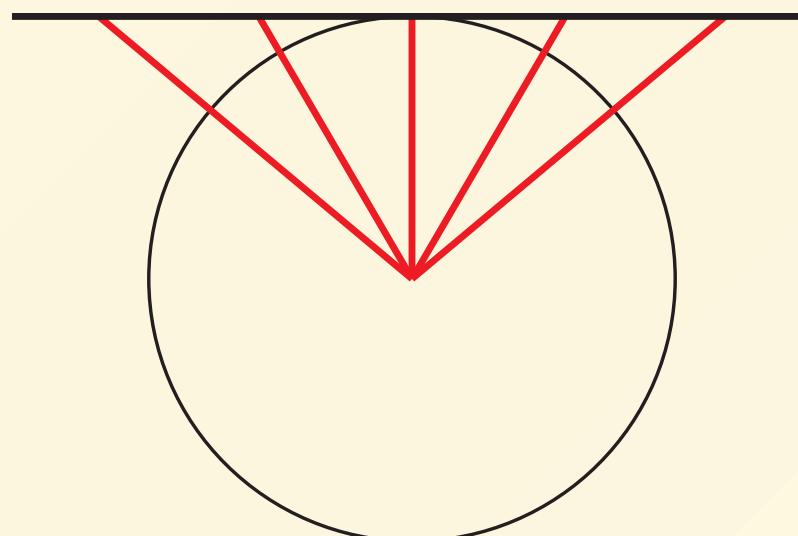
Projected coordinate systems

Classification according to mapping to planar surface:



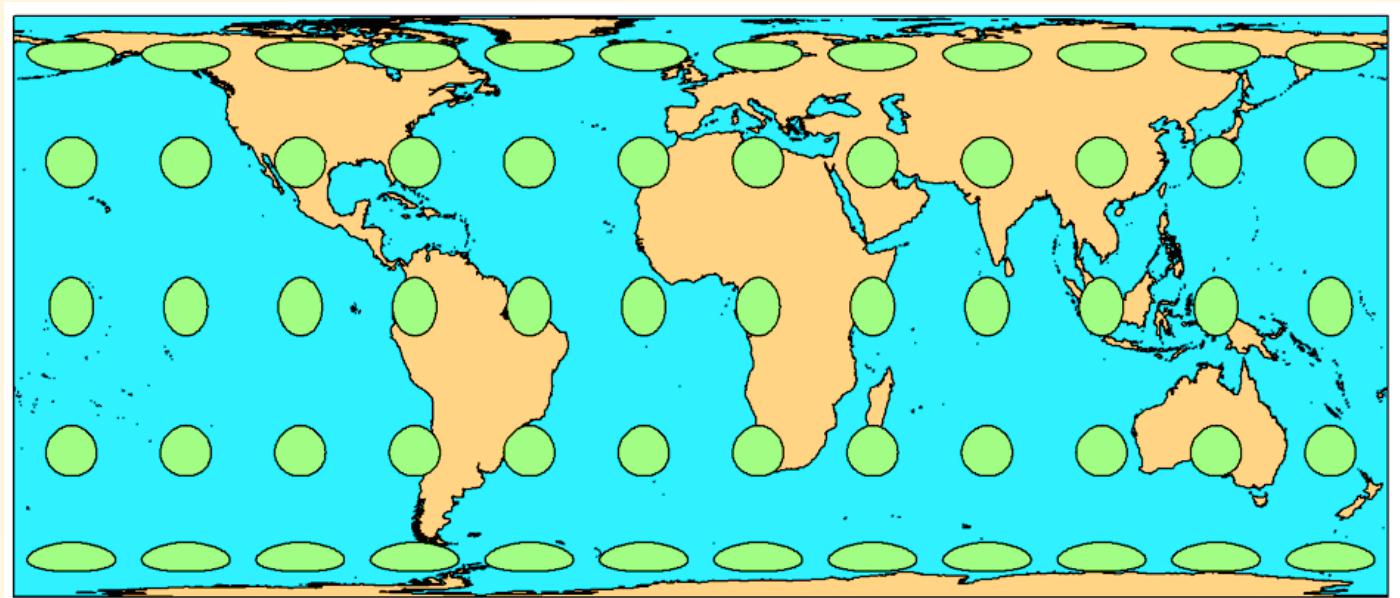
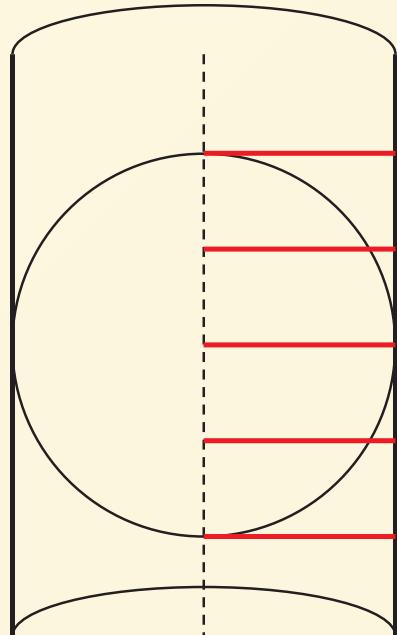
Projected coordinate systems

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



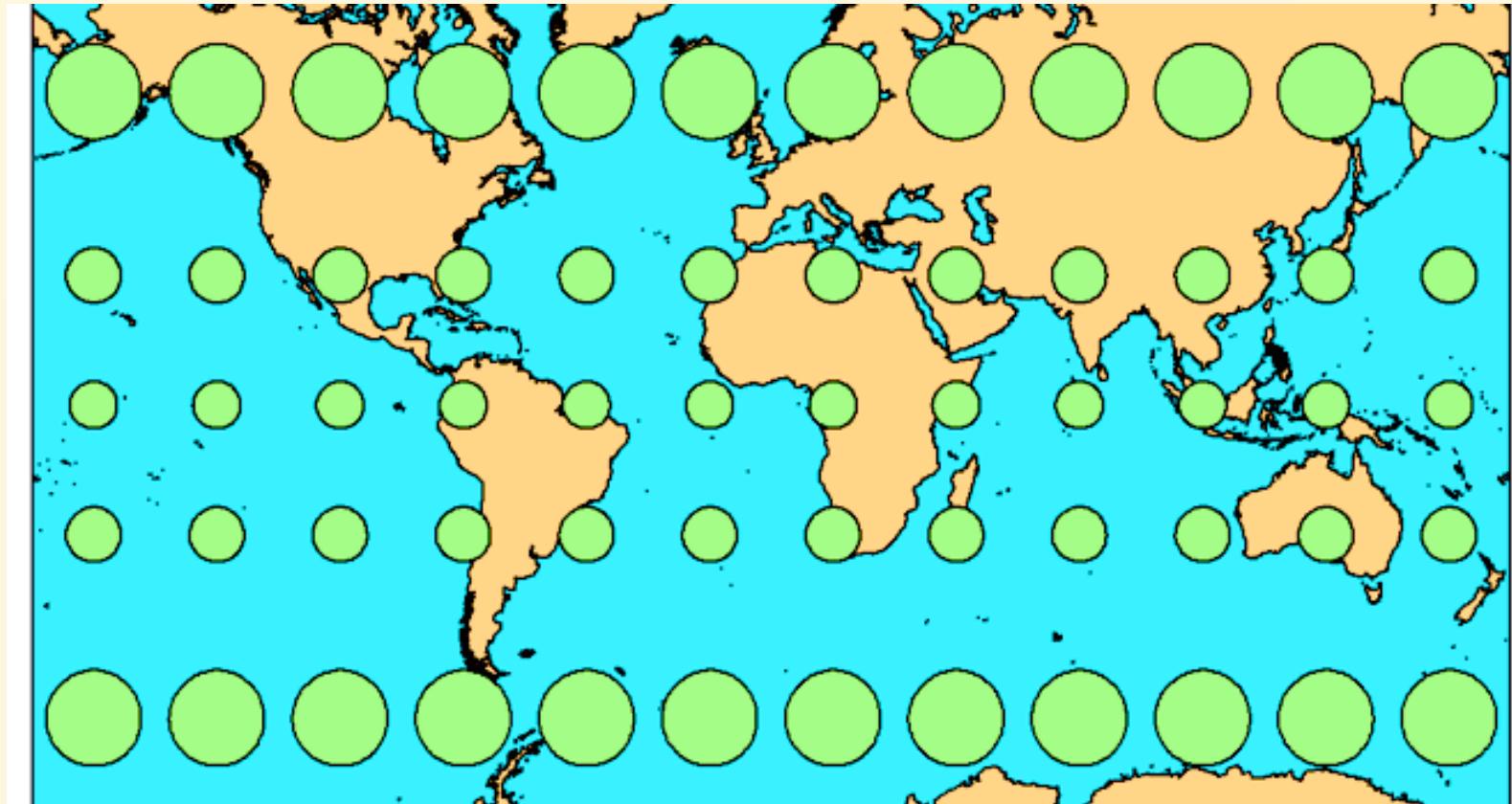
Projected coordinate systems

Cylindrical: preserves area, not shape



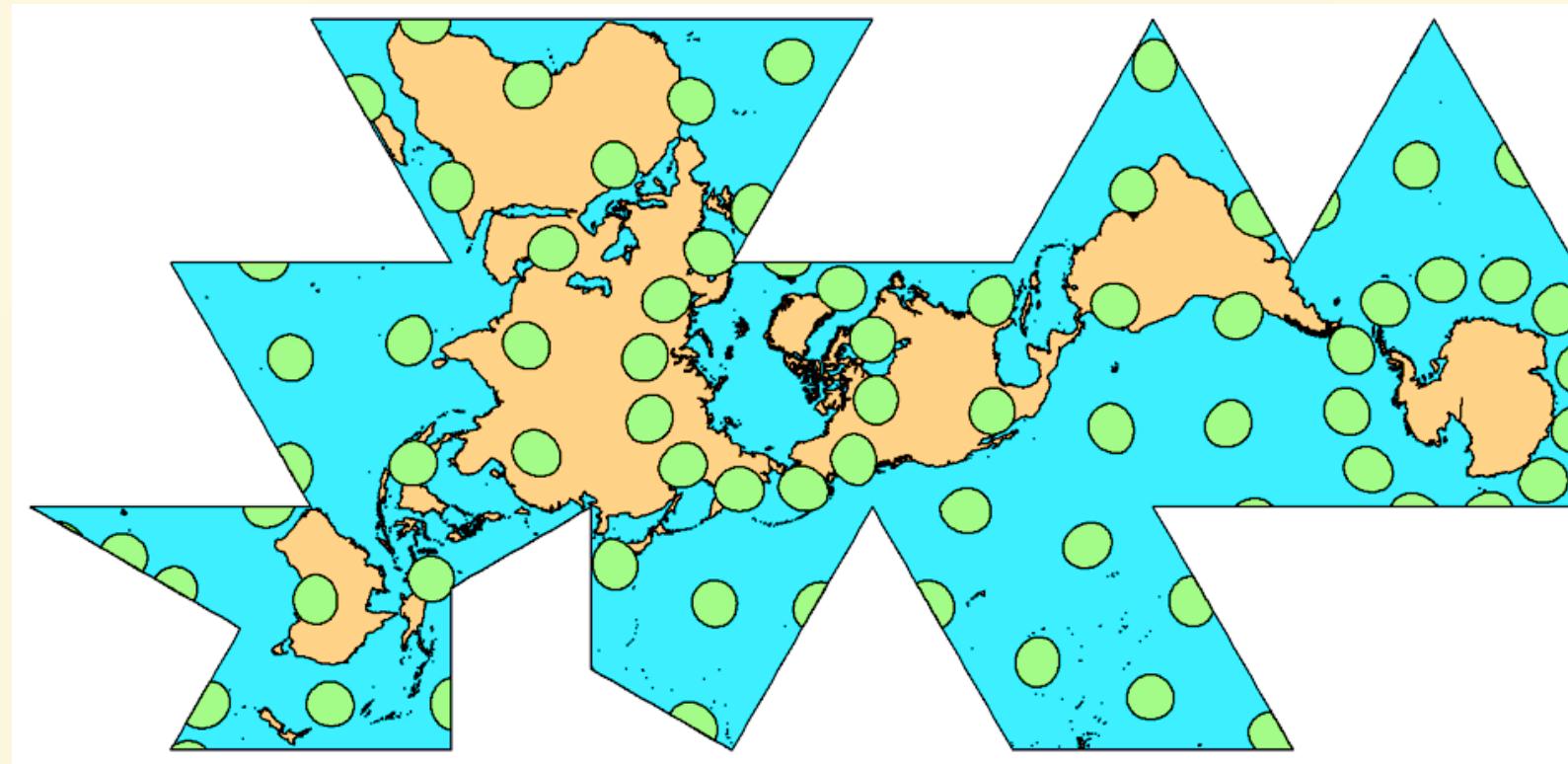
Projected coordinate systems

Mercator: preserves shape, not scale



Projected coordinate systems

Fuller Dymaxion: compromise projection



Geographic data

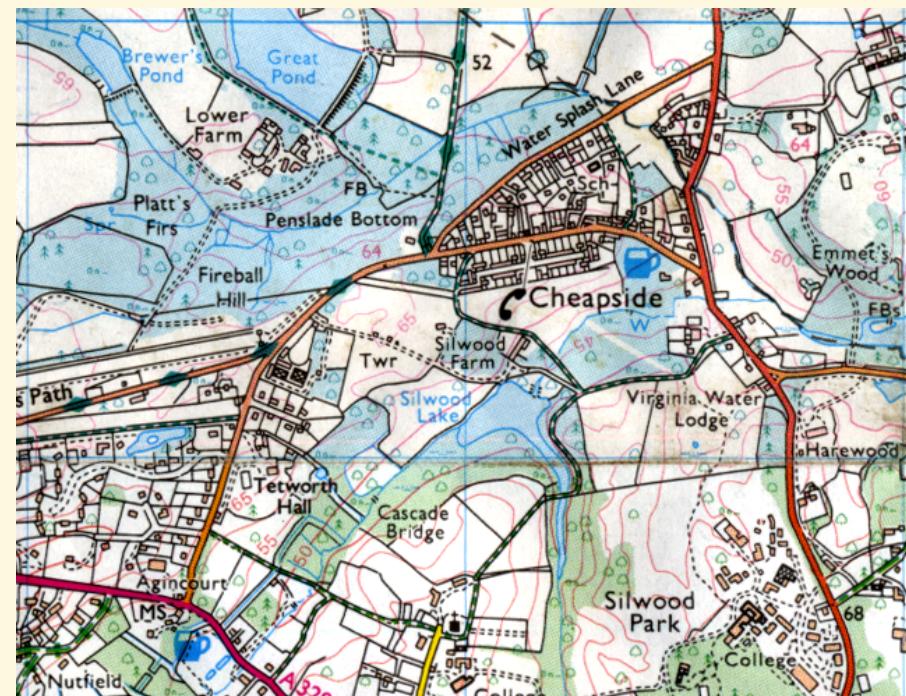
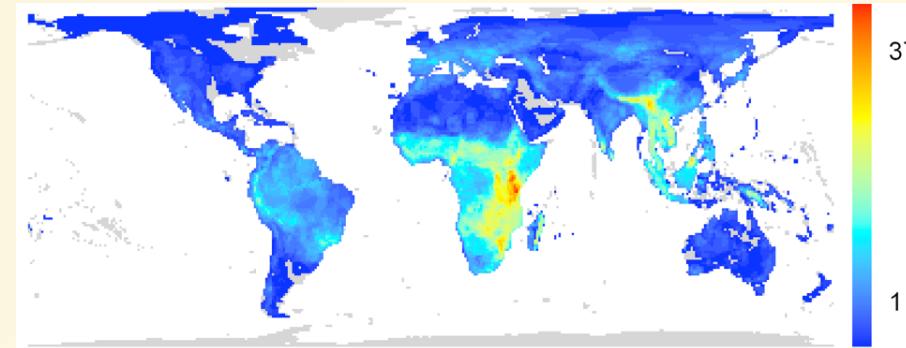
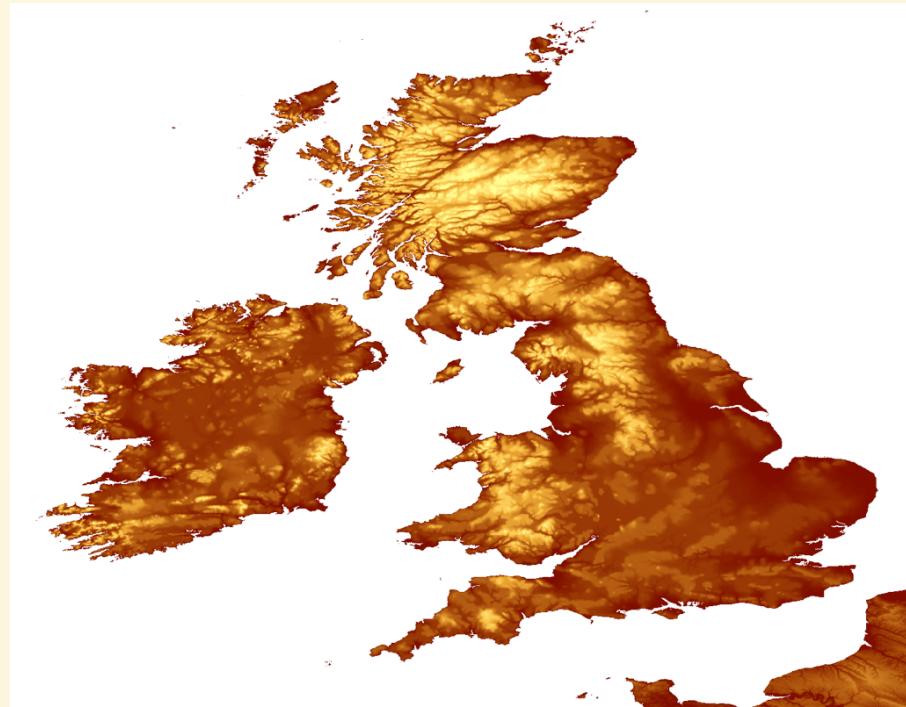
- A **Coordinate system** and:
 - **Vector** data
 - coordinates of points, lines, polygons
 - **Raster** data
 - grid data
 - satellite and aerial images

Raster data

An **image** covering a continuous surface

- 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

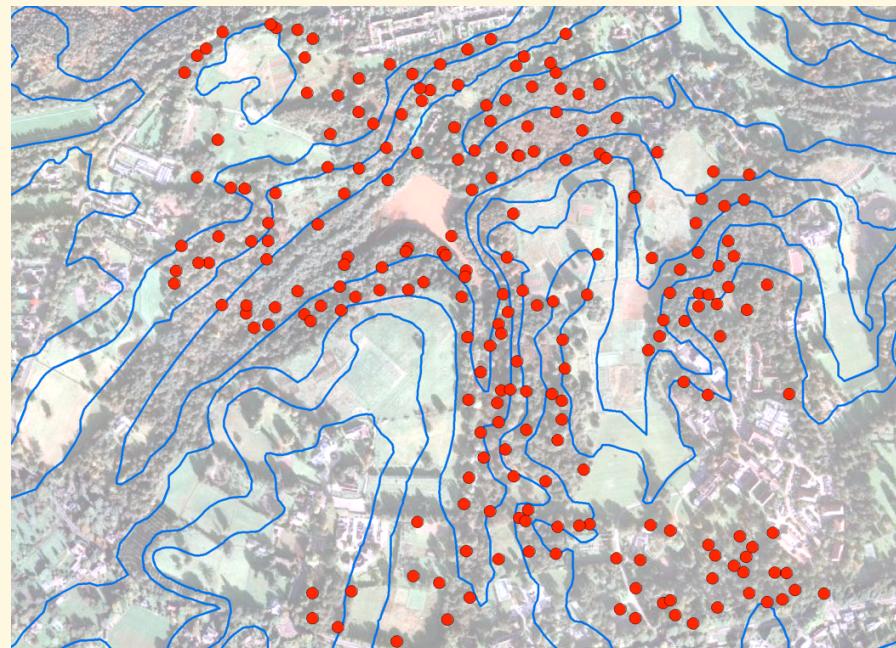
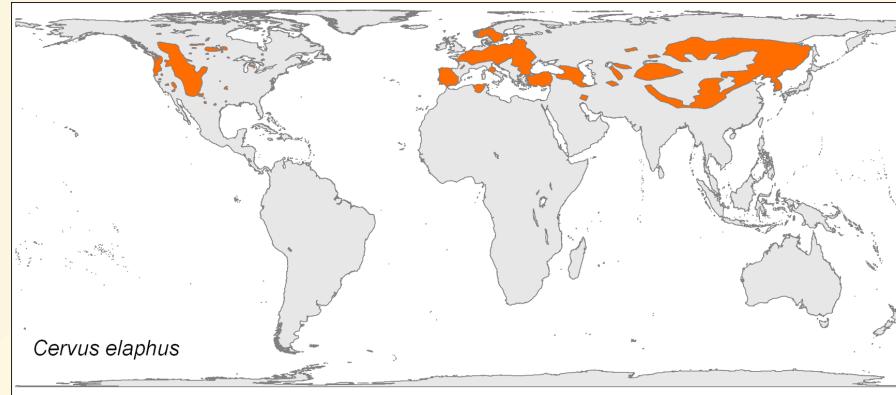
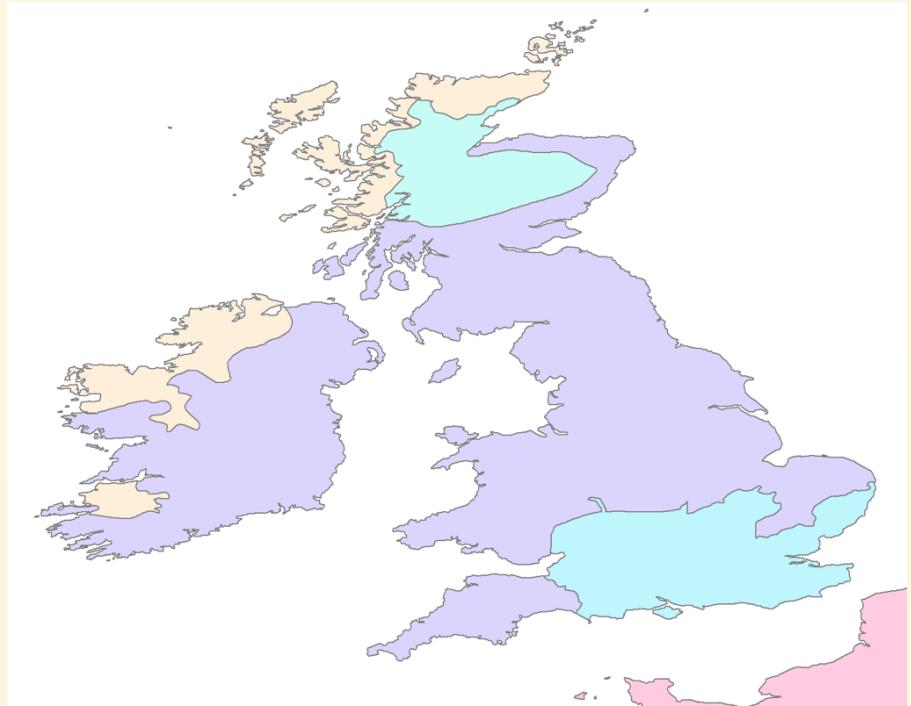


Vector Data

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



Data comparison

Raster

- Fixed grid
- One value per pixel per bands
- Often multiple stacked bands
- Attribute tables for *values* (VAT)

Vector

- Features with arbitrary shapes
- Attribute tables for *features*