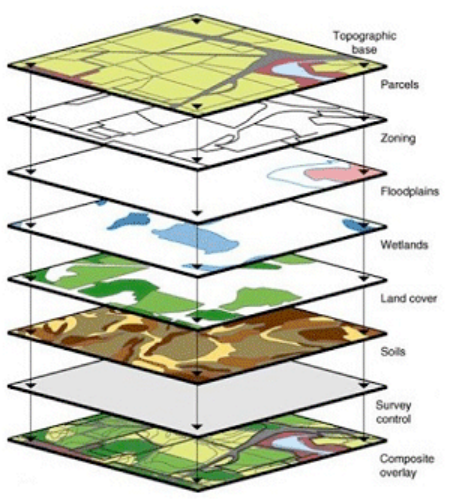
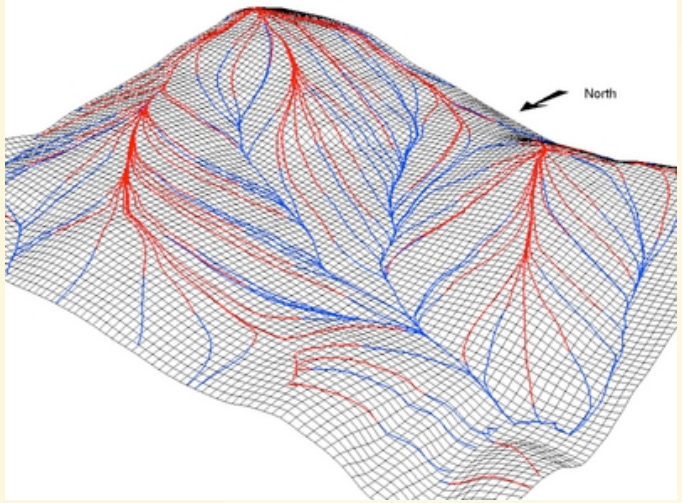
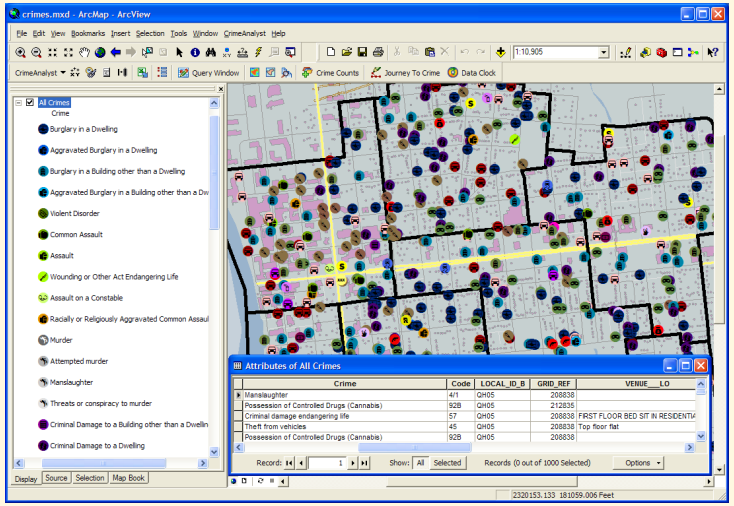
GIS concepts

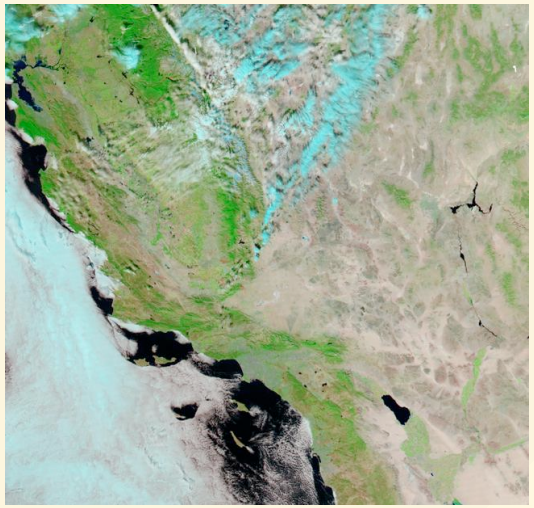
David Orme

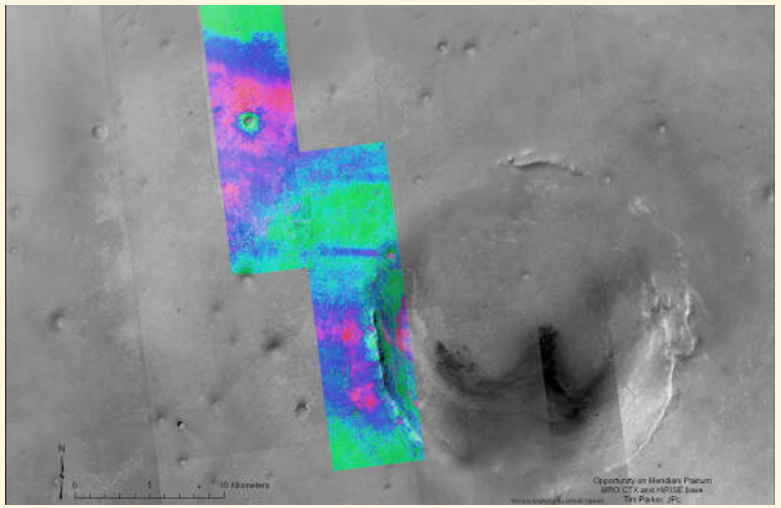
What is a GIS?


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


North


crimes.mxd - ArcMap - ArcView
Attributes of All Crimes





What is geographic information?

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

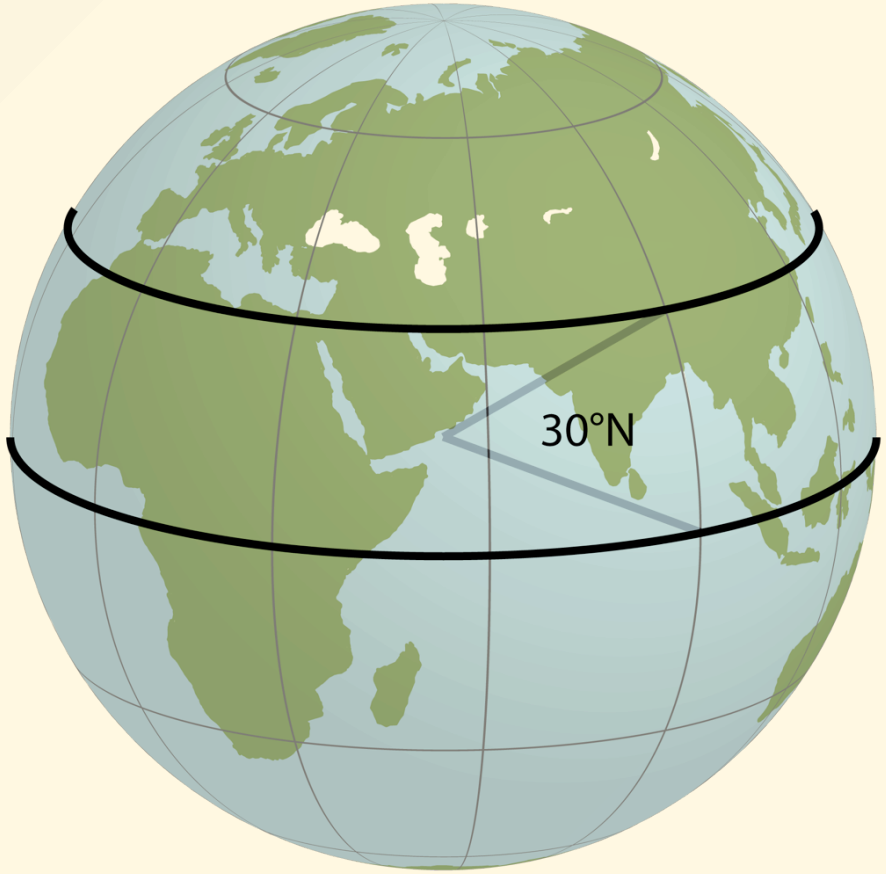
- A set of coordinates
- A known coordinate system

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

Spherical coordinates

Latitude

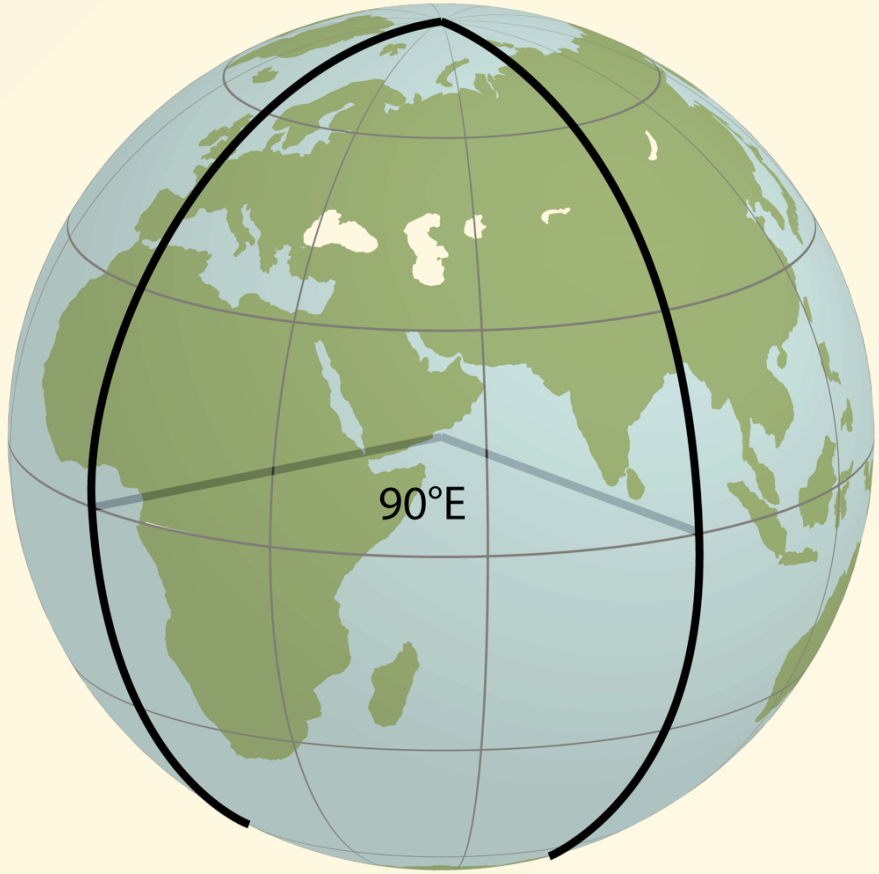
- an angle **above or below** the equator
- points of equal latitude form a **parallel**
- distance between parallels is constant*



Spherical coordinates

Longitude:

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



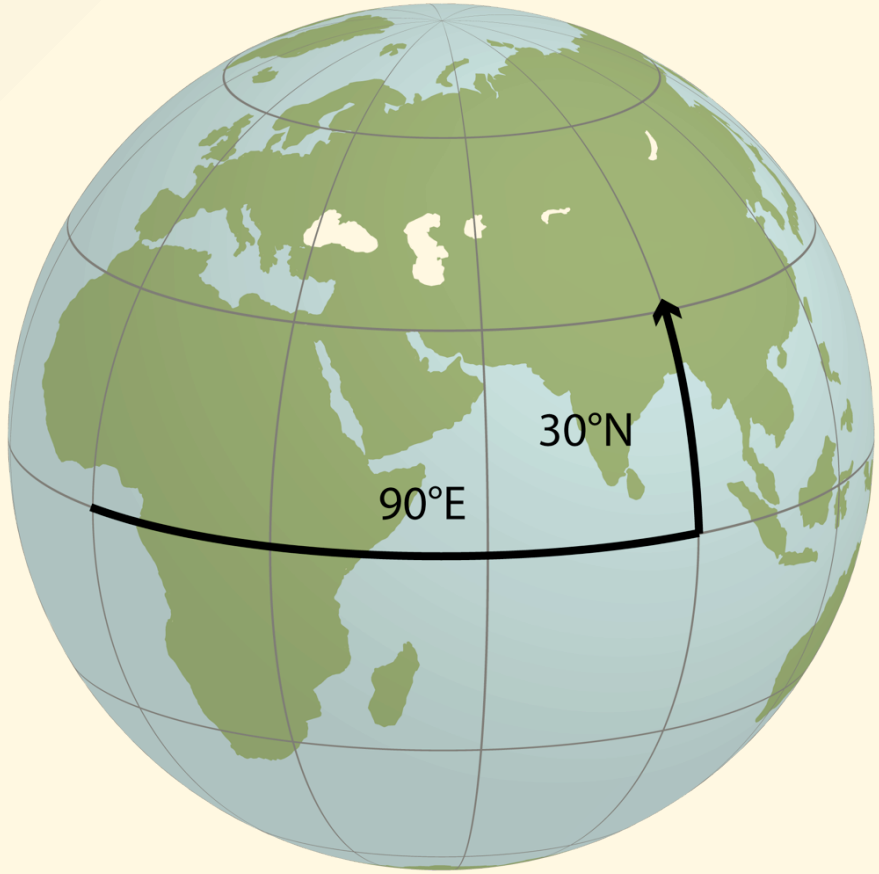
Spherical coordinates

Latitude and longitude:

- 90° 0’ 0” E and 30° 0’ 0” N
- 90.00 E, 30.00 N

3D coordinates

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



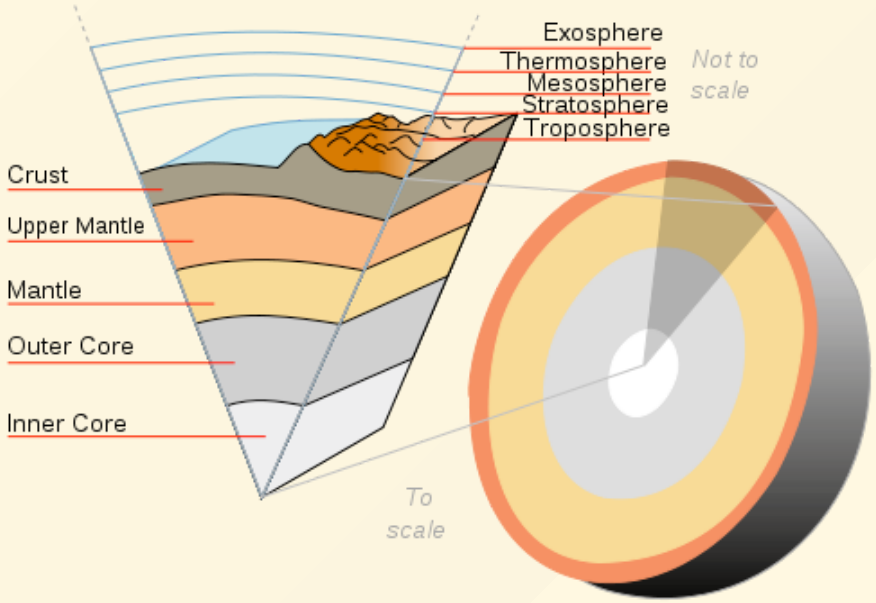
Geographic coordinate system

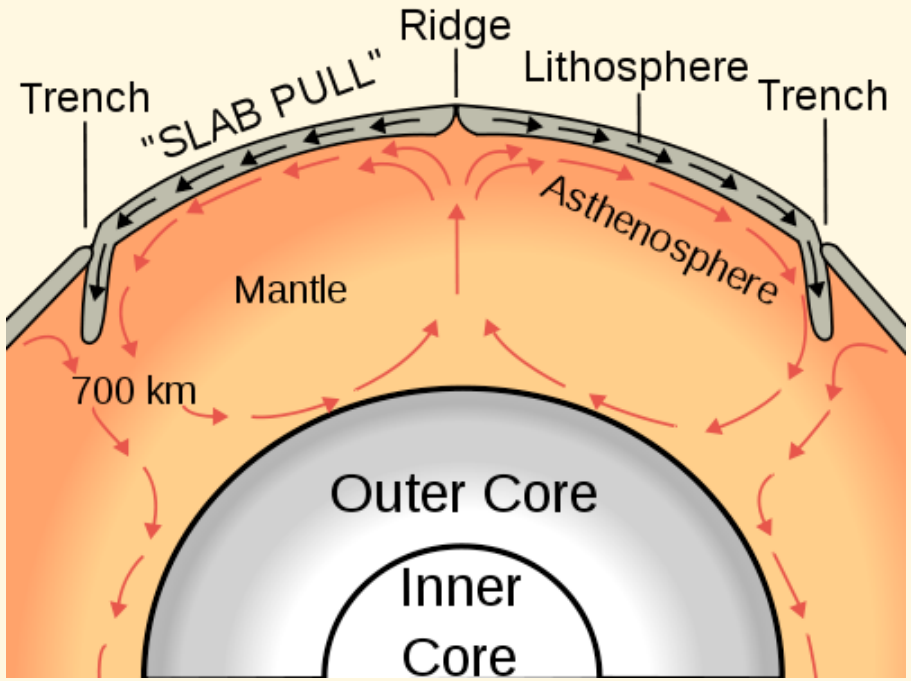
- The Earth is not a sphere (~ 1 in 298 flattening)
- There are **many** reference ellipsoids or datums.

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

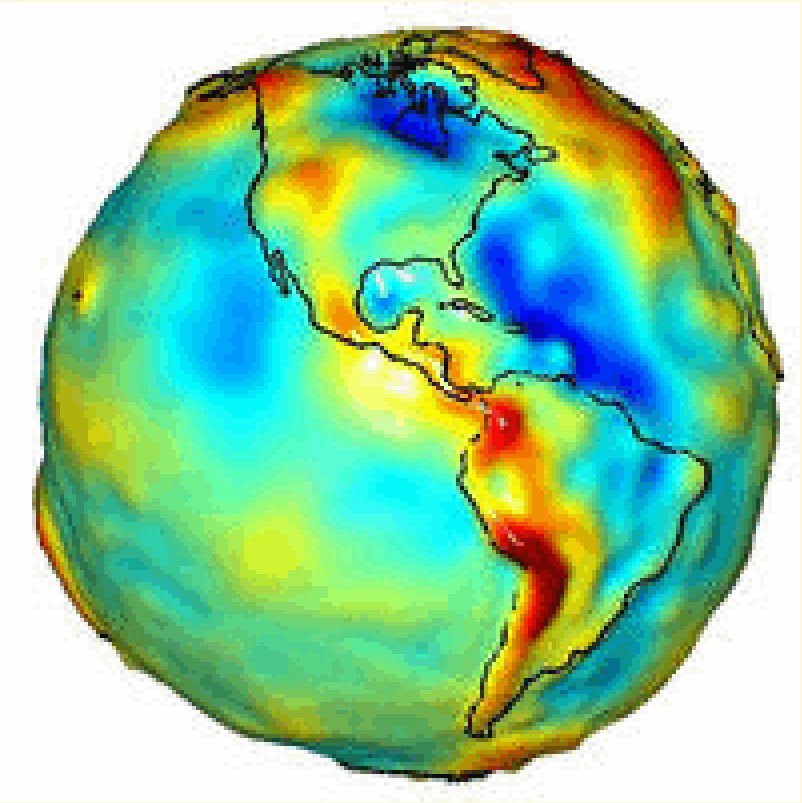




Geographic coordinate system

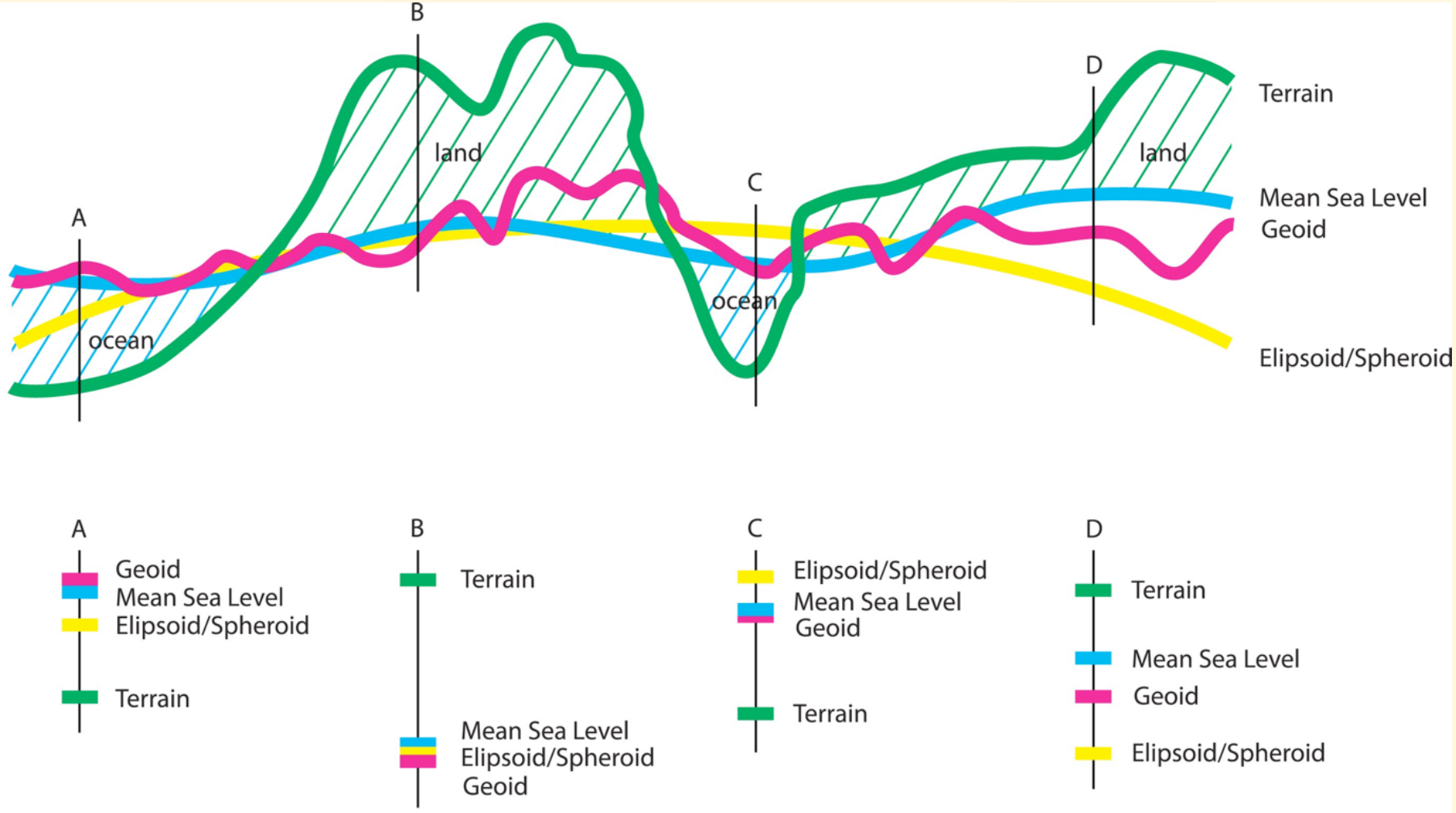
Geoid

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



Notes:

Geographic coordinate system



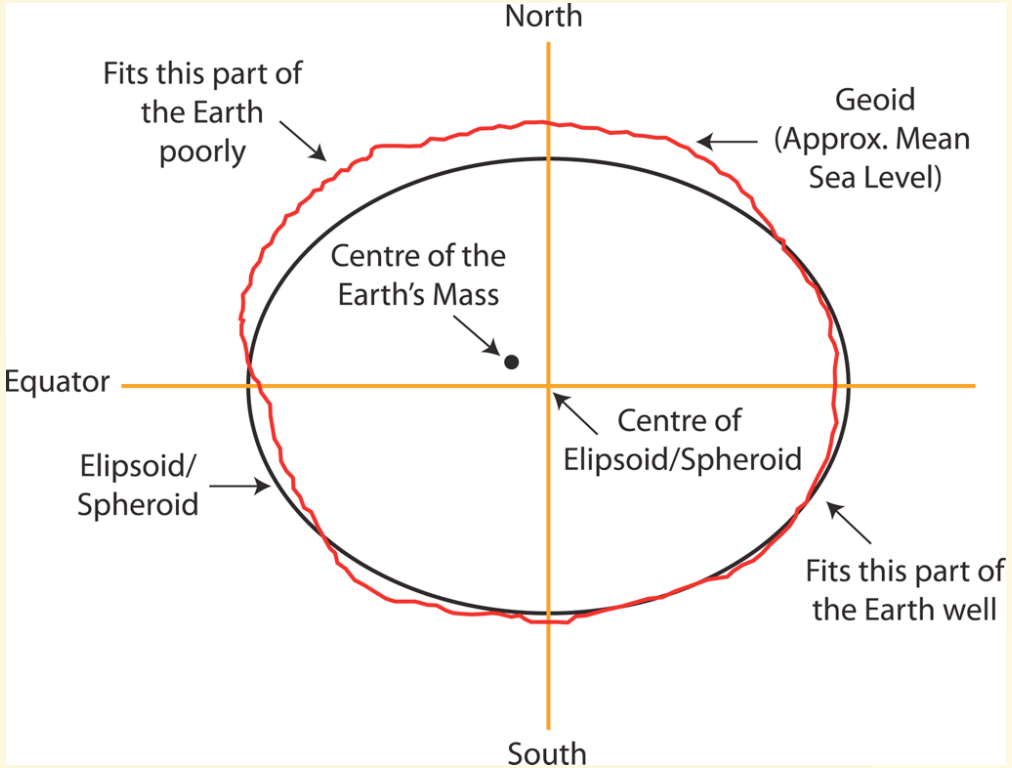
WGS 84

- 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 !

Notes:

Local geographic datum

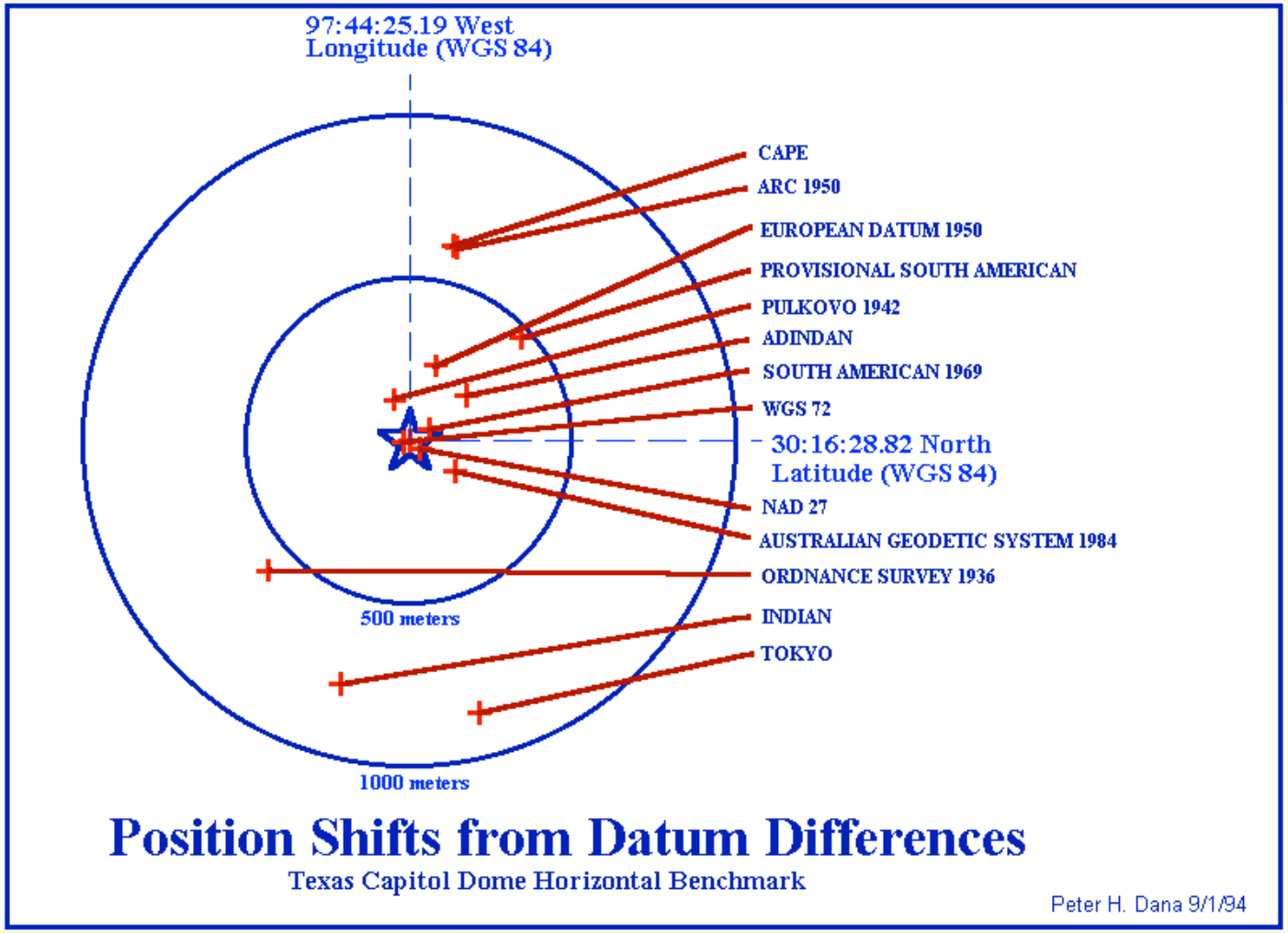
- The fit between a geoid and a datum varies in space
- Global models, like WGS 84, work well on average
- Countries adopt local datum models that fit better locally



Local geographic datum

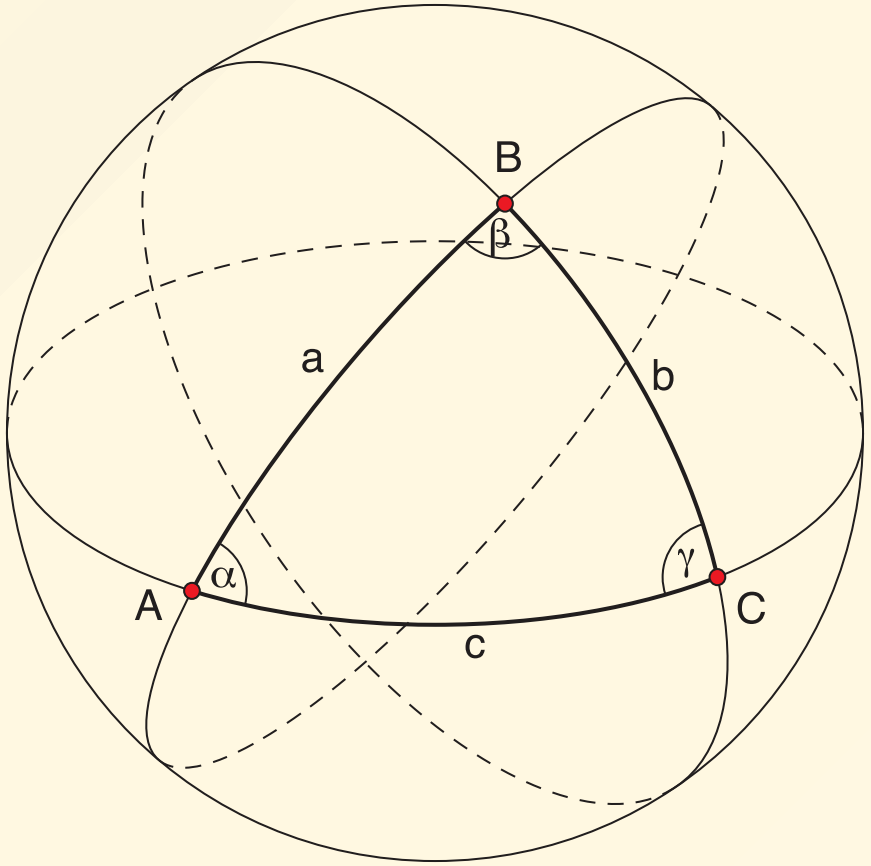
- WGS84
  - -0.639875°W
  - 51.4090°N
- UK uses the **OSGB 36 datum**
  - -0.638331°W
  - 51.4085°N
- The shift varies nationally

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
500 meters
INDIAN
TOKYO
1000 meters
Position Shifts from Datum Differences
Texas Capitol Dome Horizontal Benchmark
Peter H. Dana 9/1/94

Spherical geometry

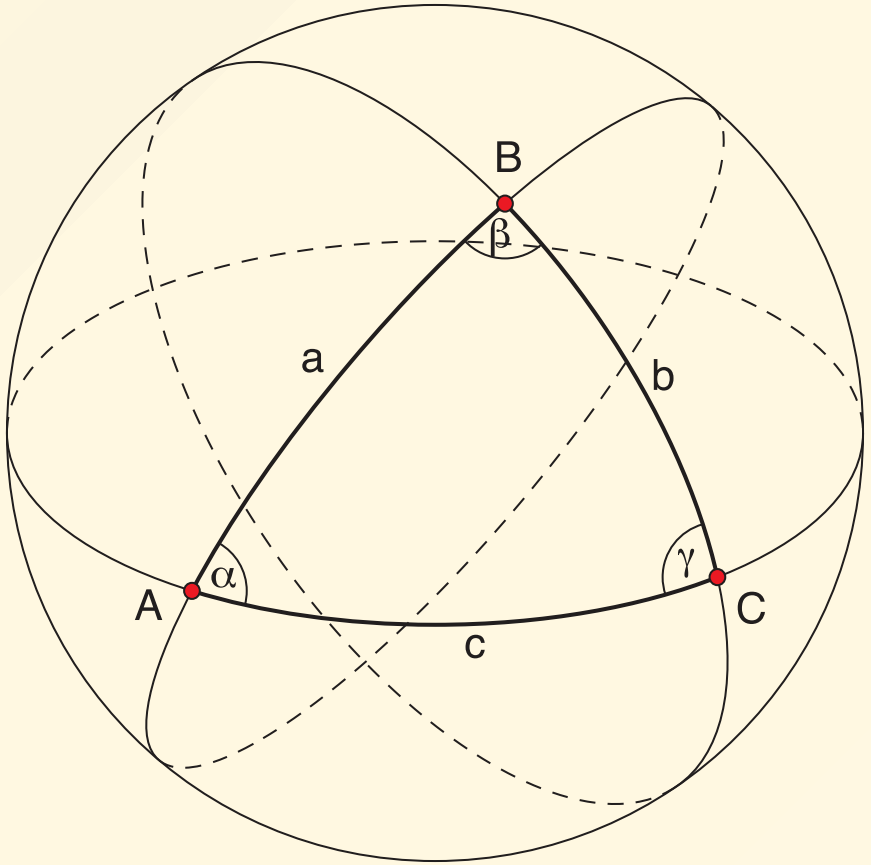
- Great circles
- Spherical ‘triangle’
- **Spherical** geometry:
  - exact and fast
- **Ellipsoidal** geometry:
  - iterative and slow



Notes:

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).

Notes:

Projected coordinate systems

Map projections can preserve:

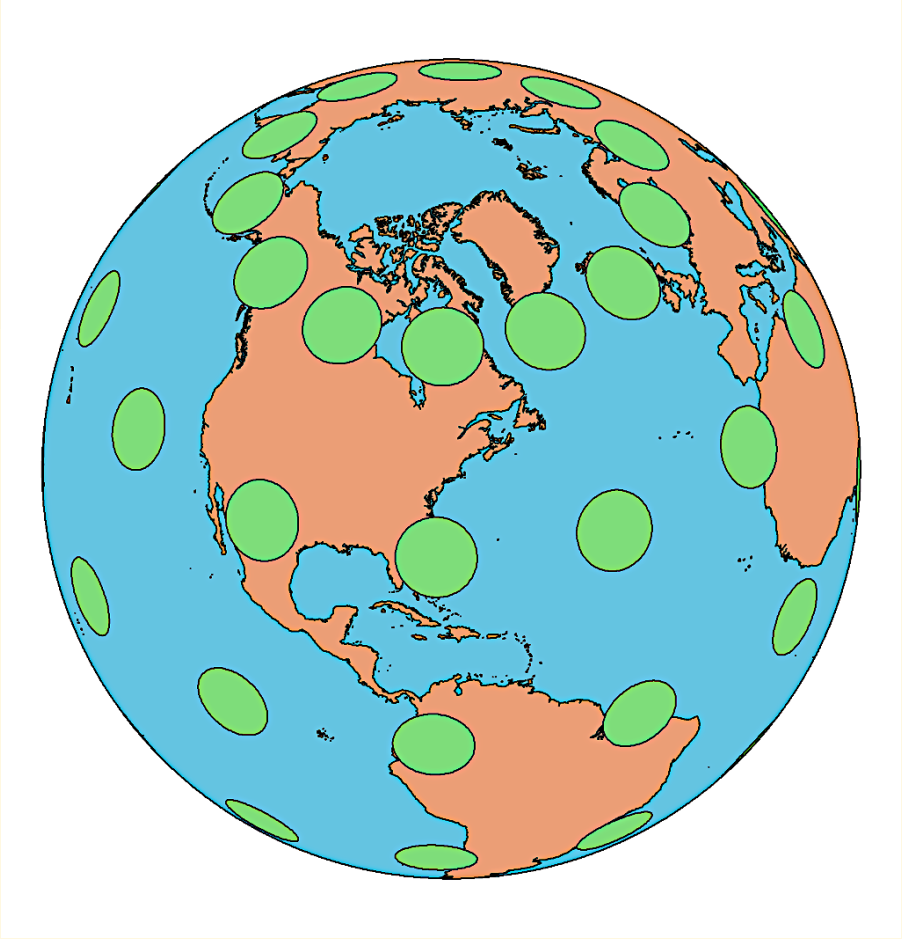
- **Shape**: conformal maps
- **Area**: equal-area maps
- **Distance**: equi-distant maps
- **Direction**: azimuthal maps

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

Projected coordinate systems

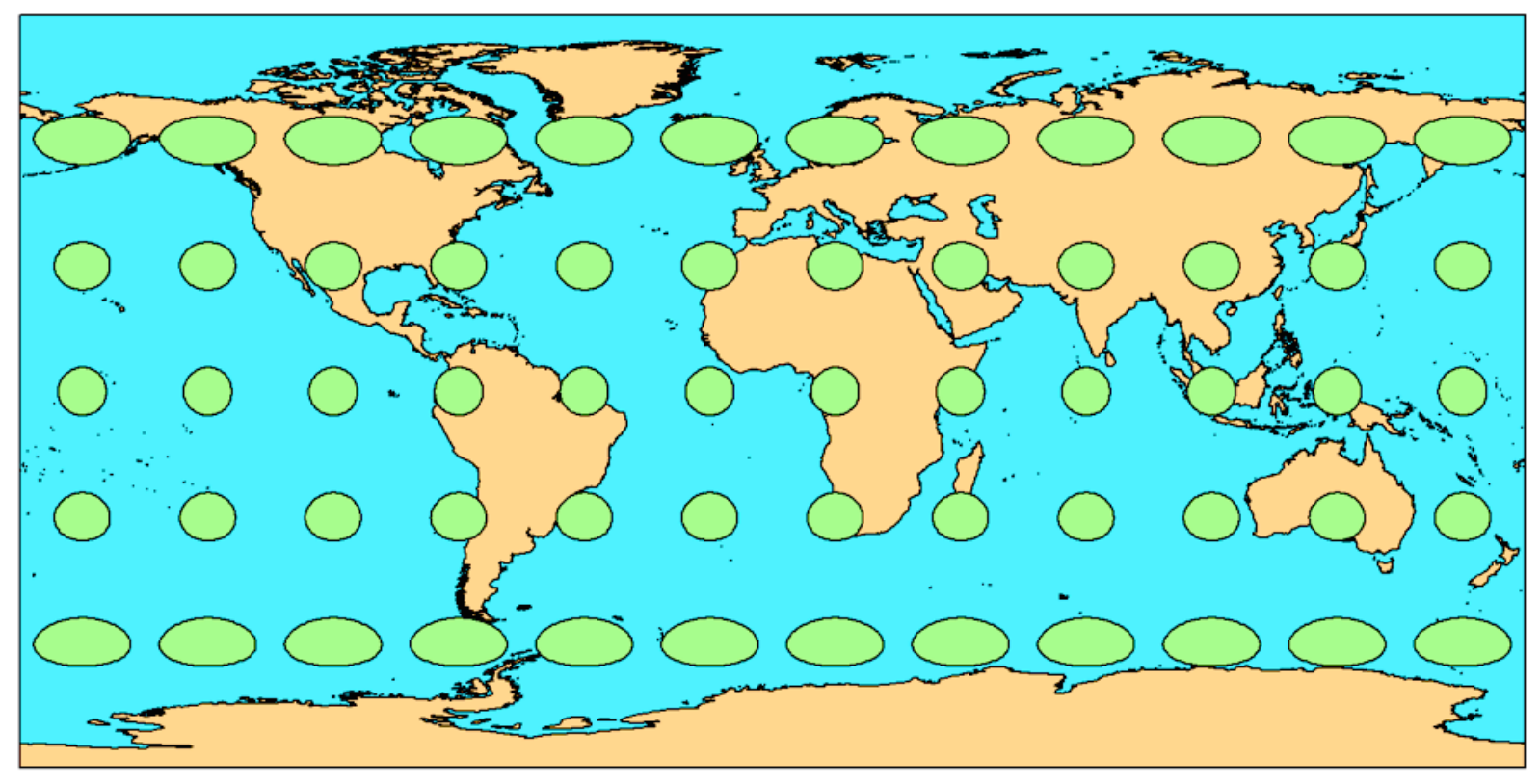
Tissot indicatrix:

- 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



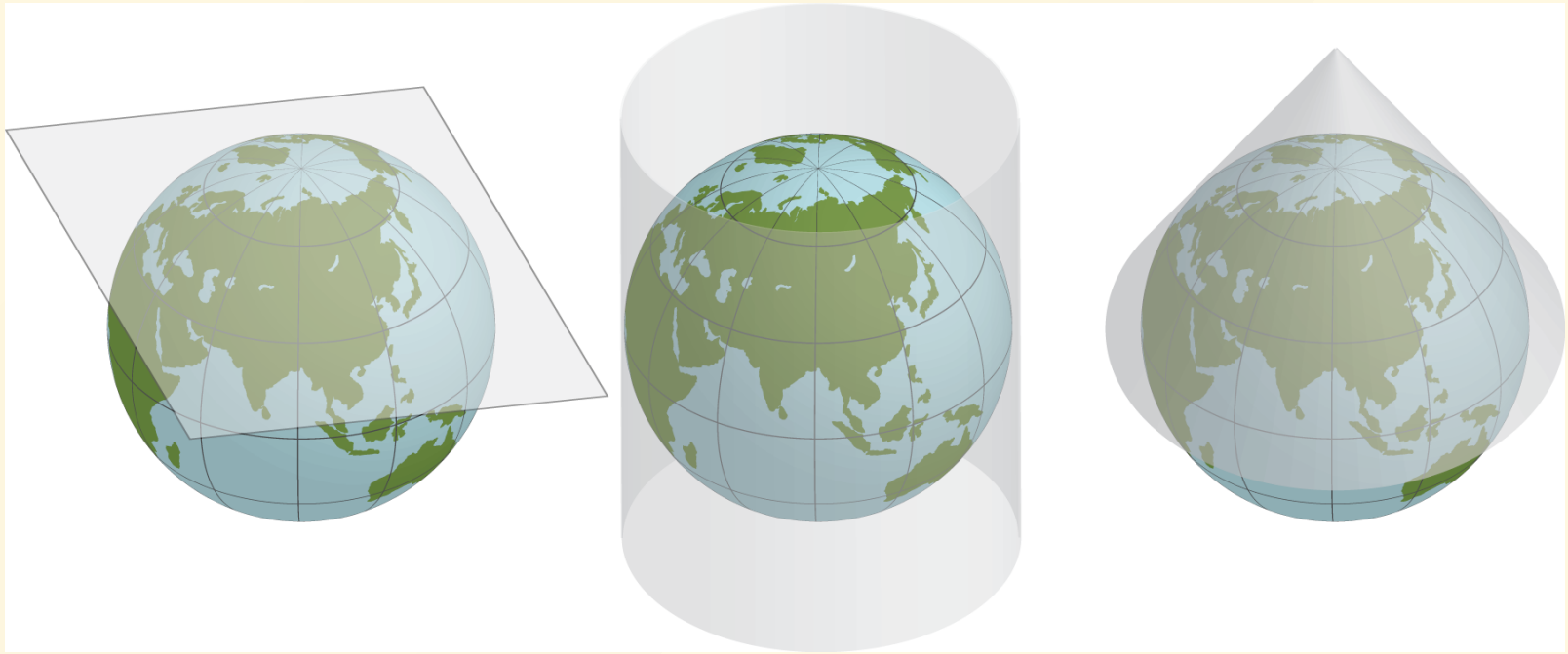
Projected coordinate systems

Equirectangular: latitude and longitude as X and Y



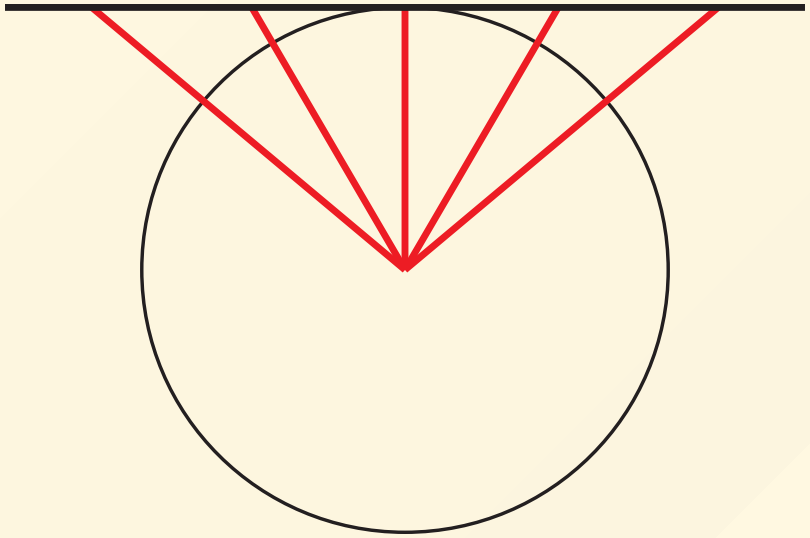
Projected coordinate systems

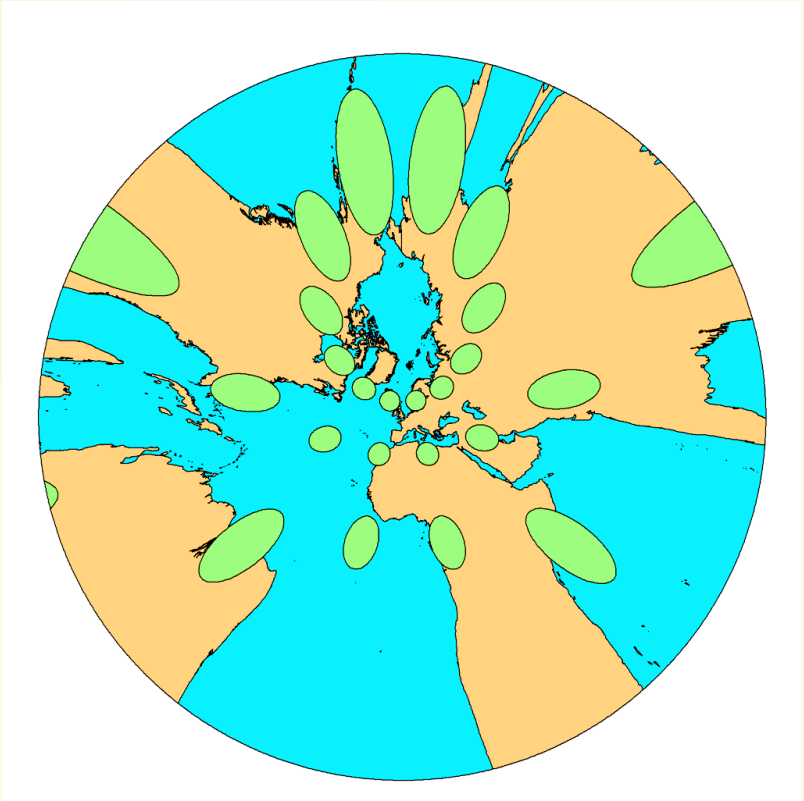
Classification according to mapping to planar surface:



Projected coordinate systems

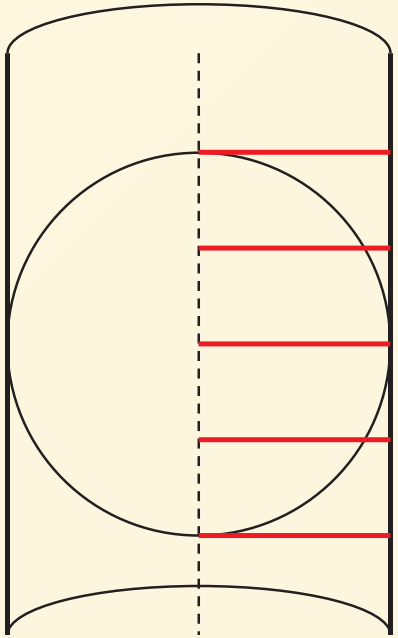
Gnomonic: planar, preserves bearings from a single central point, but little else.

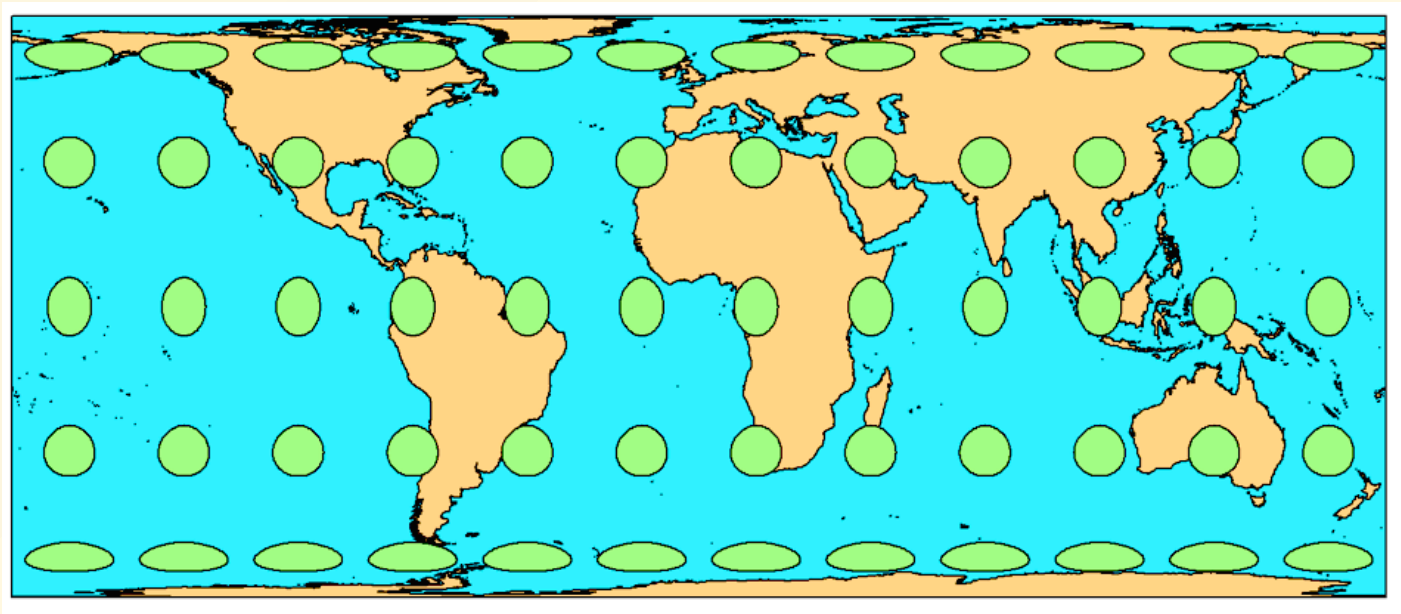




Projected coordinate systems

Cylindrical: preserves area, not shape

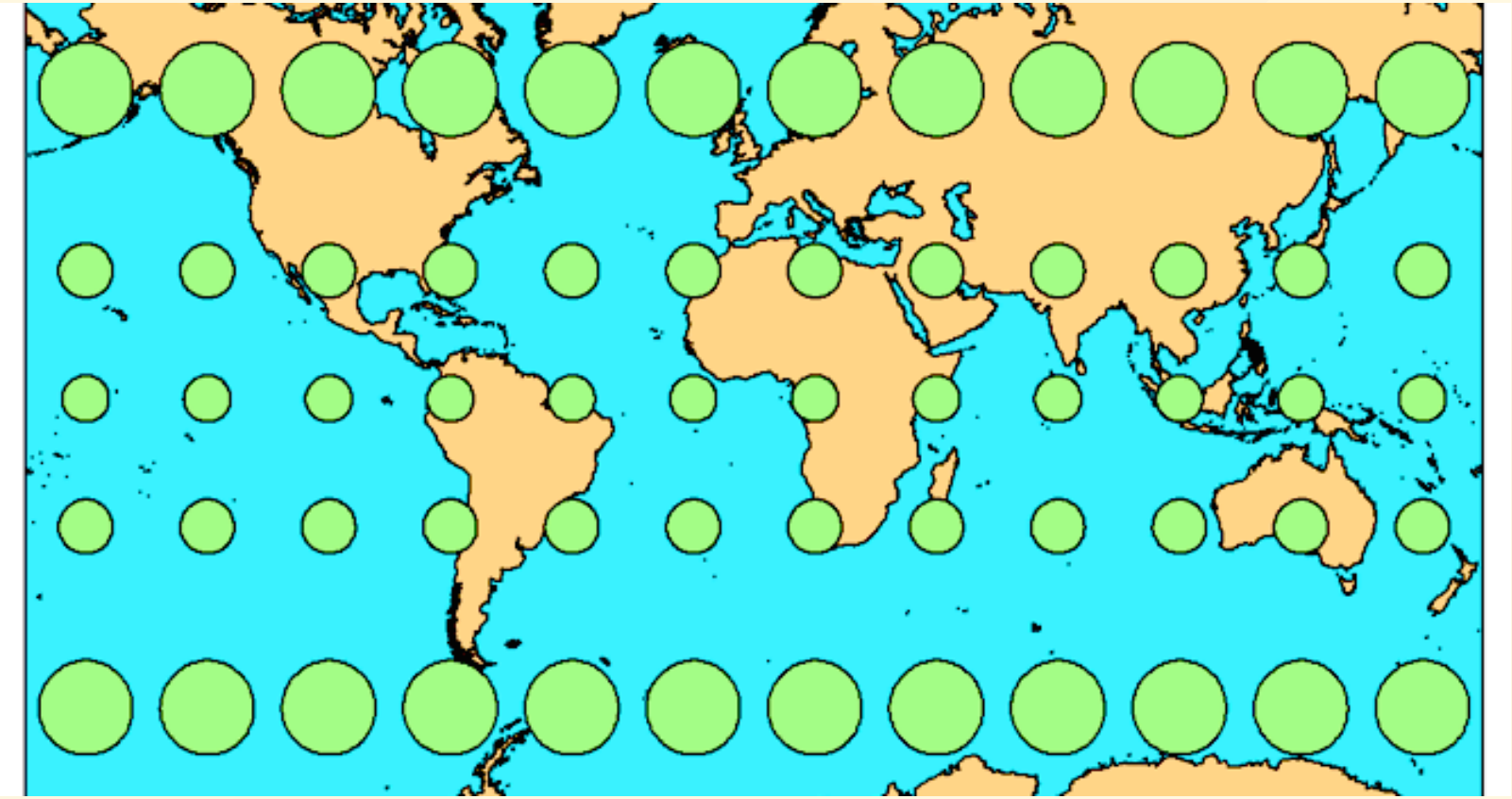




Notes:

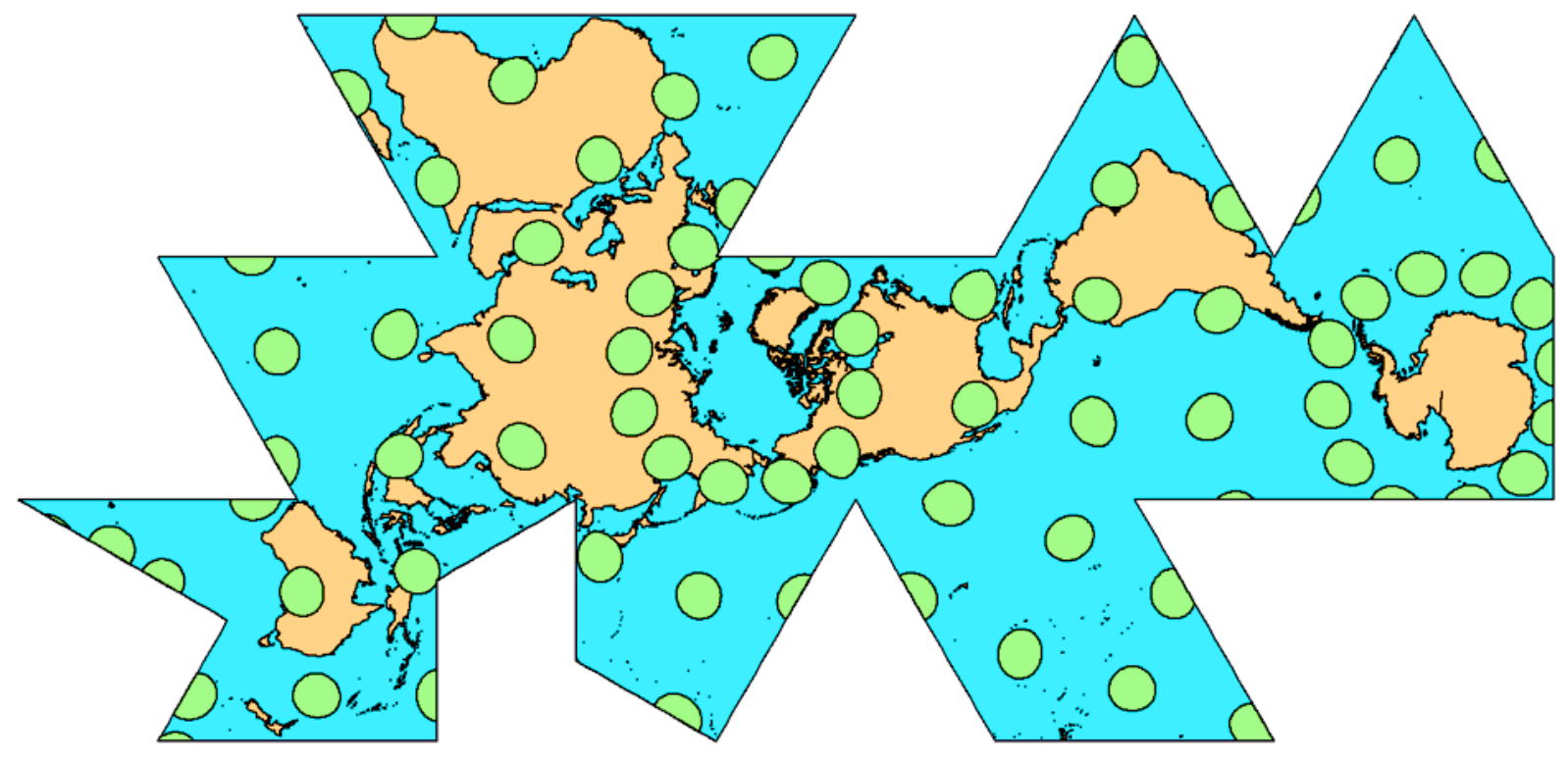
Projected coordinate systems

Mercator: preserves shape, not scale



Projected coordinate systems

Fuller Dymaxion: compromise projection



Geographic data

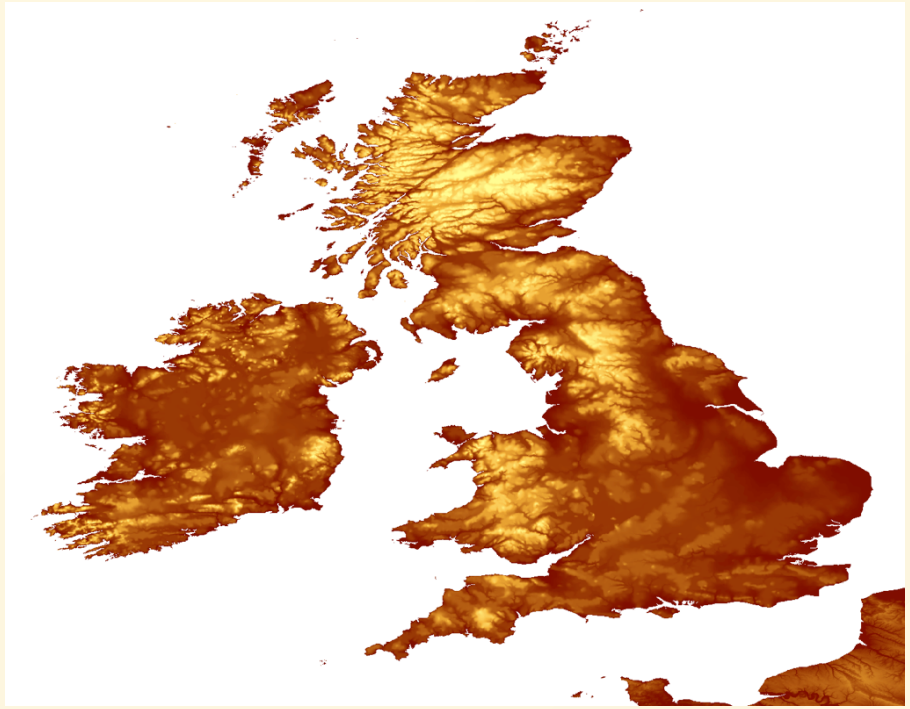
- A **Coordinate system** and:
  - **Vector** data
    - coordinates of points, lines, polygons
  - **Raster** data
    - grid data
    - satellite and aerial images

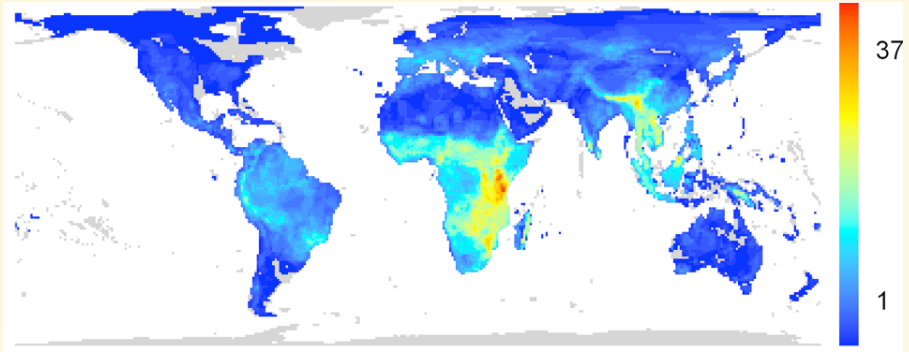
Raster data

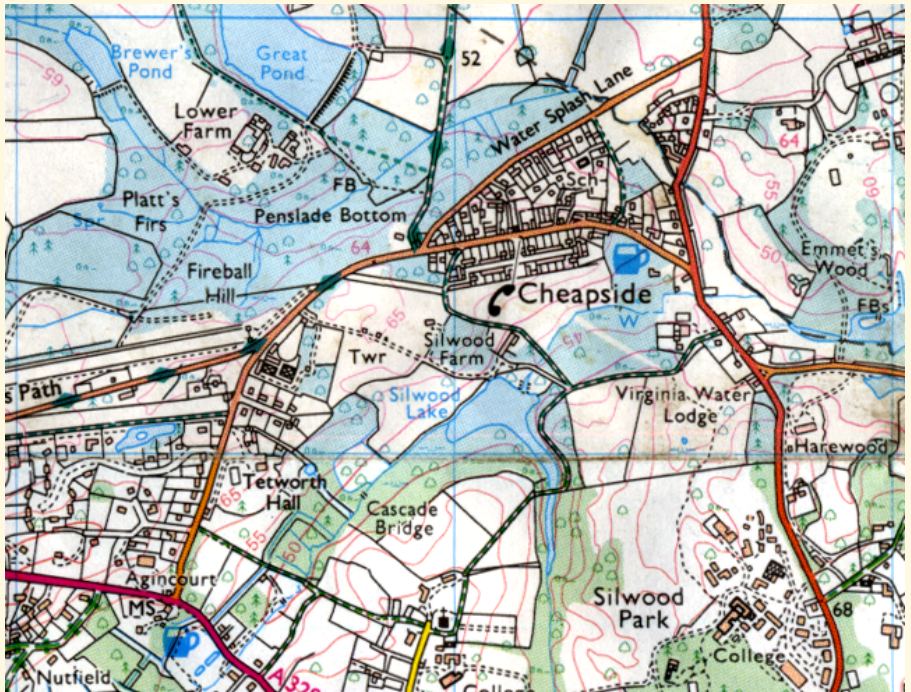
An **image** covering a continuous surface

- 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




37
1

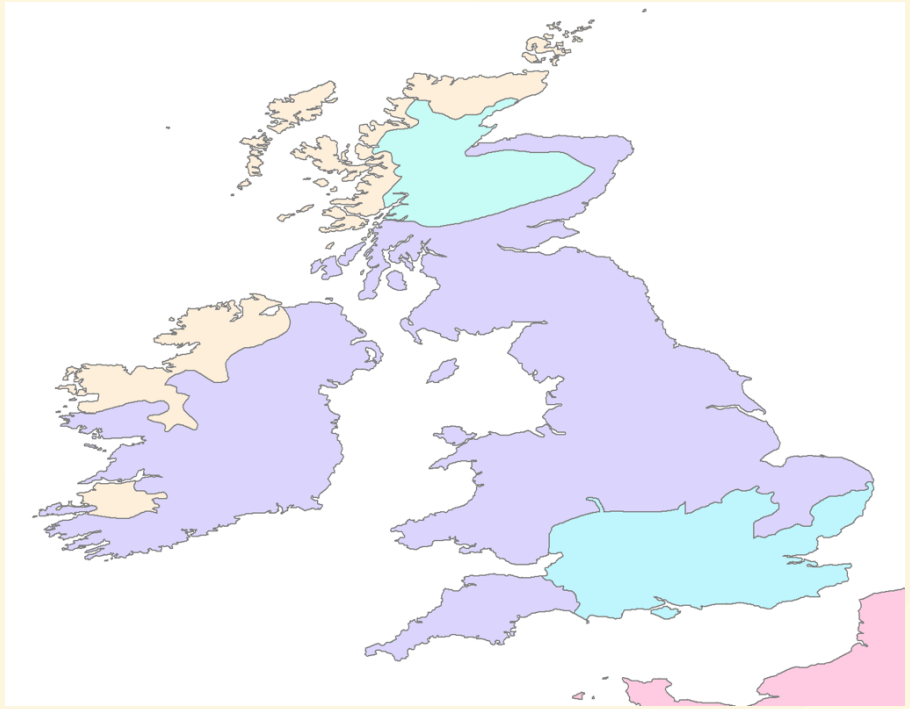

Brewer's Pond
Great Pond
Lower Farm
Platt's Firs
FB
Penslade Bottom
Fireball Hill
52
Water Splash Lane
Sch
Emmet's Wood
FBs
Cheapside
Silwood Farm
Twr
Silwood Lake
Virginia Water
Lodge
Harewood
Tetworth Hall
Cascade Bridge
Agincourt
MS
Silwood Park
College
Nutfield

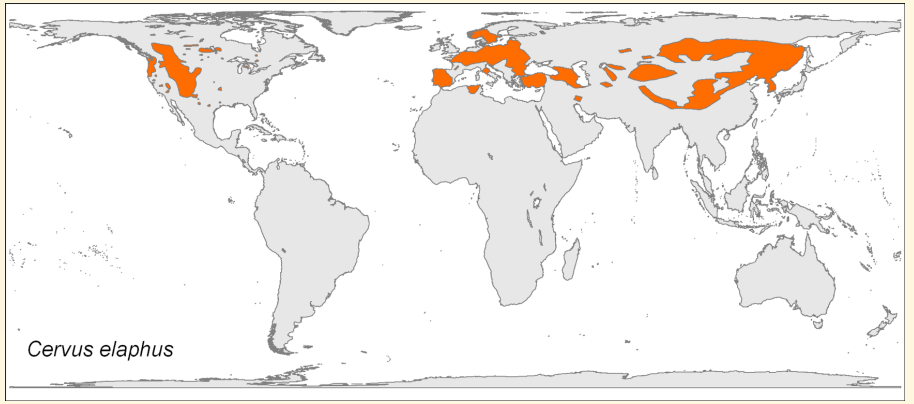
Vector Data

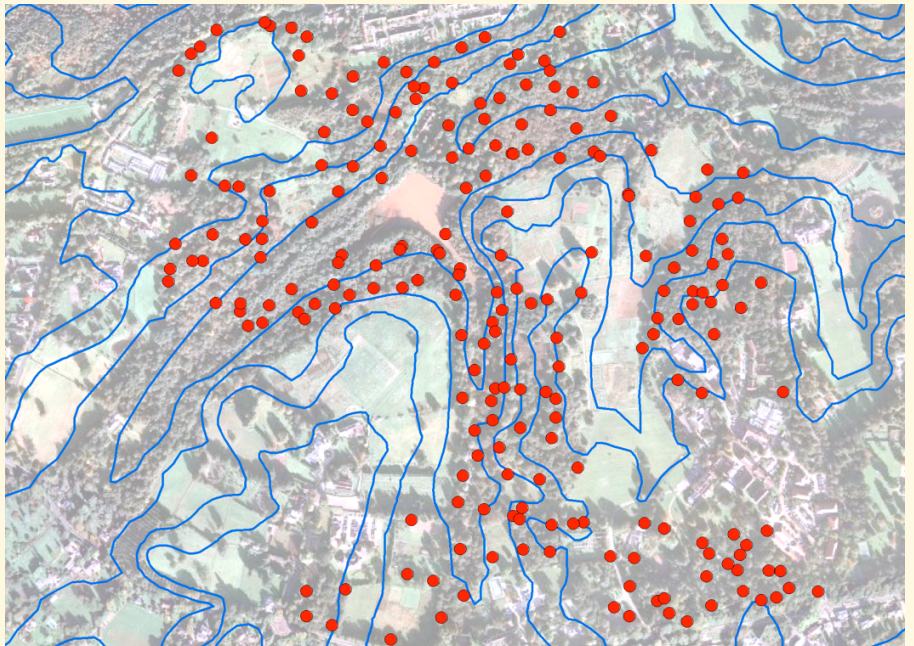
A set of *features*, containing one of:

- 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*