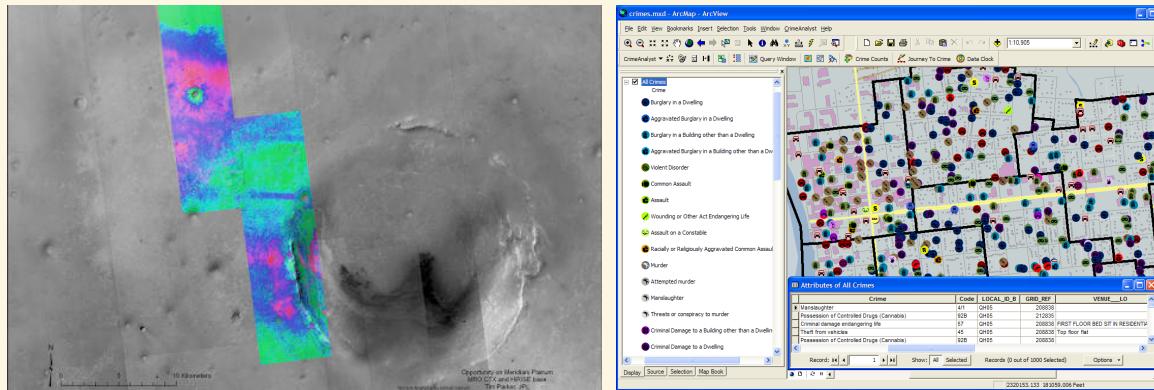
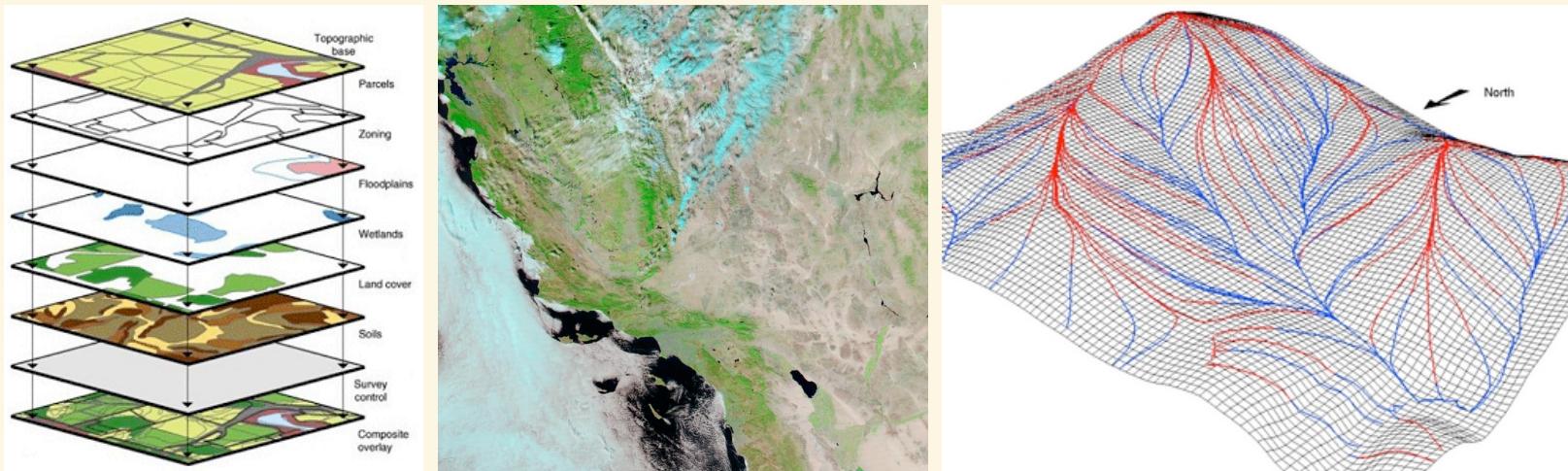


GIS CONCEPTS

DAVID ORME

WHAT IS A GIS?

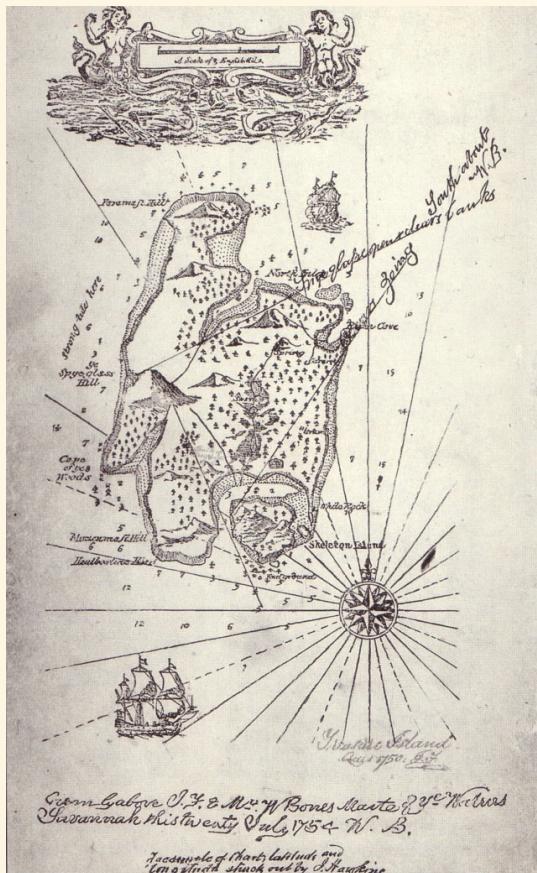


WHAT IS A GIS?

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:

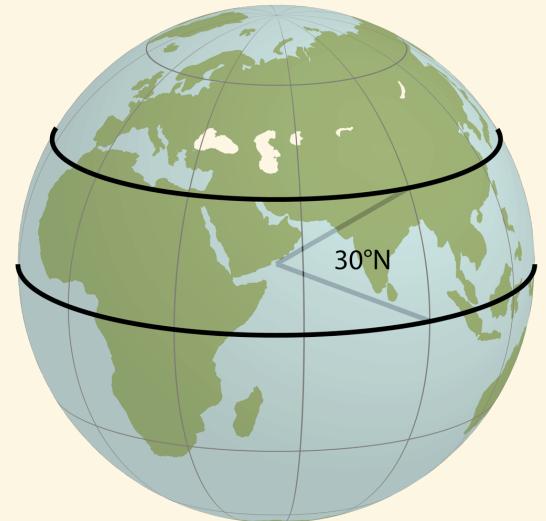
- A set of coordinates
- A known coordinate system

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

SPHERICAL COORDINATES

Latitude

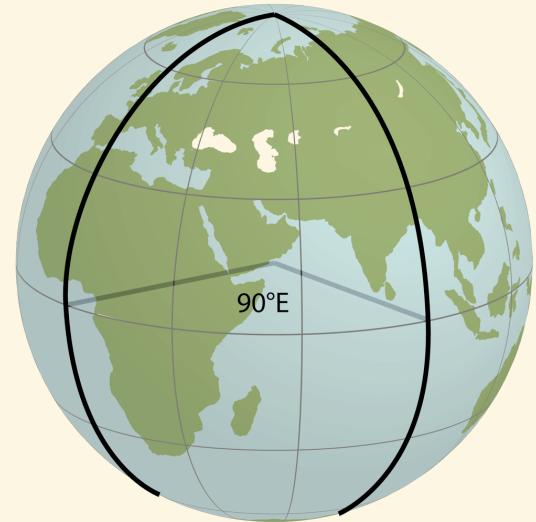
- an angle above or below the equator
- points of equal latitude form a parallel
- distance between parallels is constant*



SPHERICAL COORDINATES

Longitude:

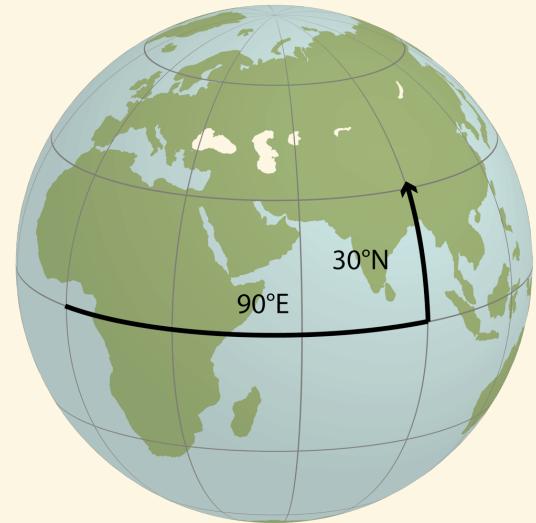
- an angle around the equator
- points of equal longitude form a meridian
- distance between meridians varies



SPHERICAL COORDINATES

Latitude and longitude:

- $90^{\circ}0'0''$ E, $30^{\circ}0'0''$ N
- 90.00 E, 30.00 N
- Can include height:
- Near Lhasa, Tibet (c. 5,500 m)



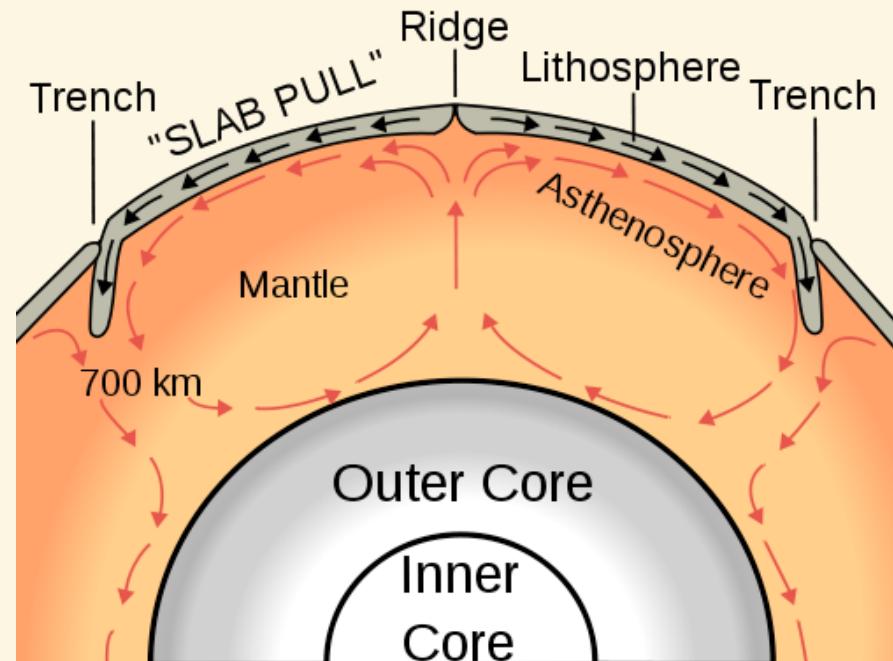
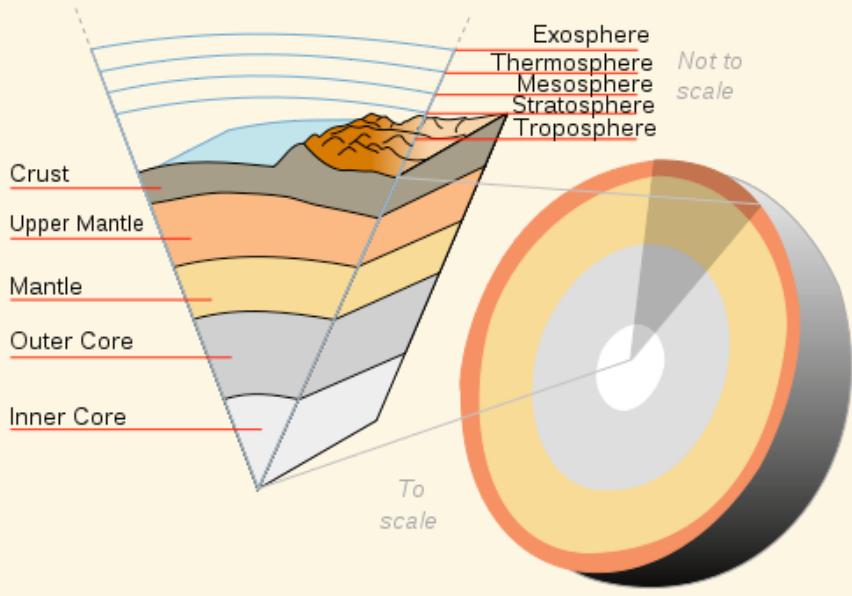
GEOGRAPHIC COORDINATE SYSTEM

- 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

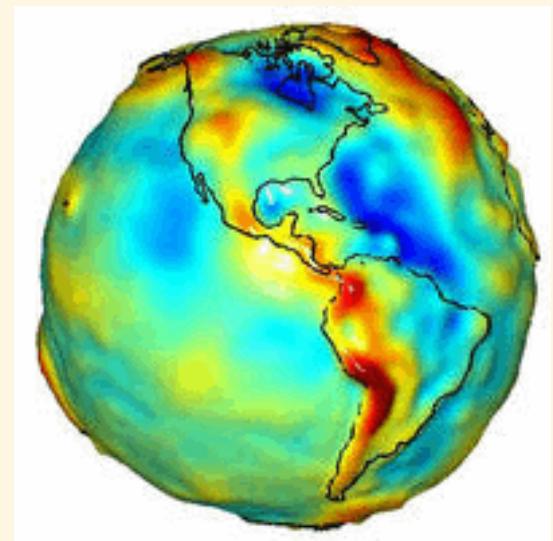
- Unfortunately, the Earth isn't a ellipsoid either.
- Distribution of mass is uneven and dynamic



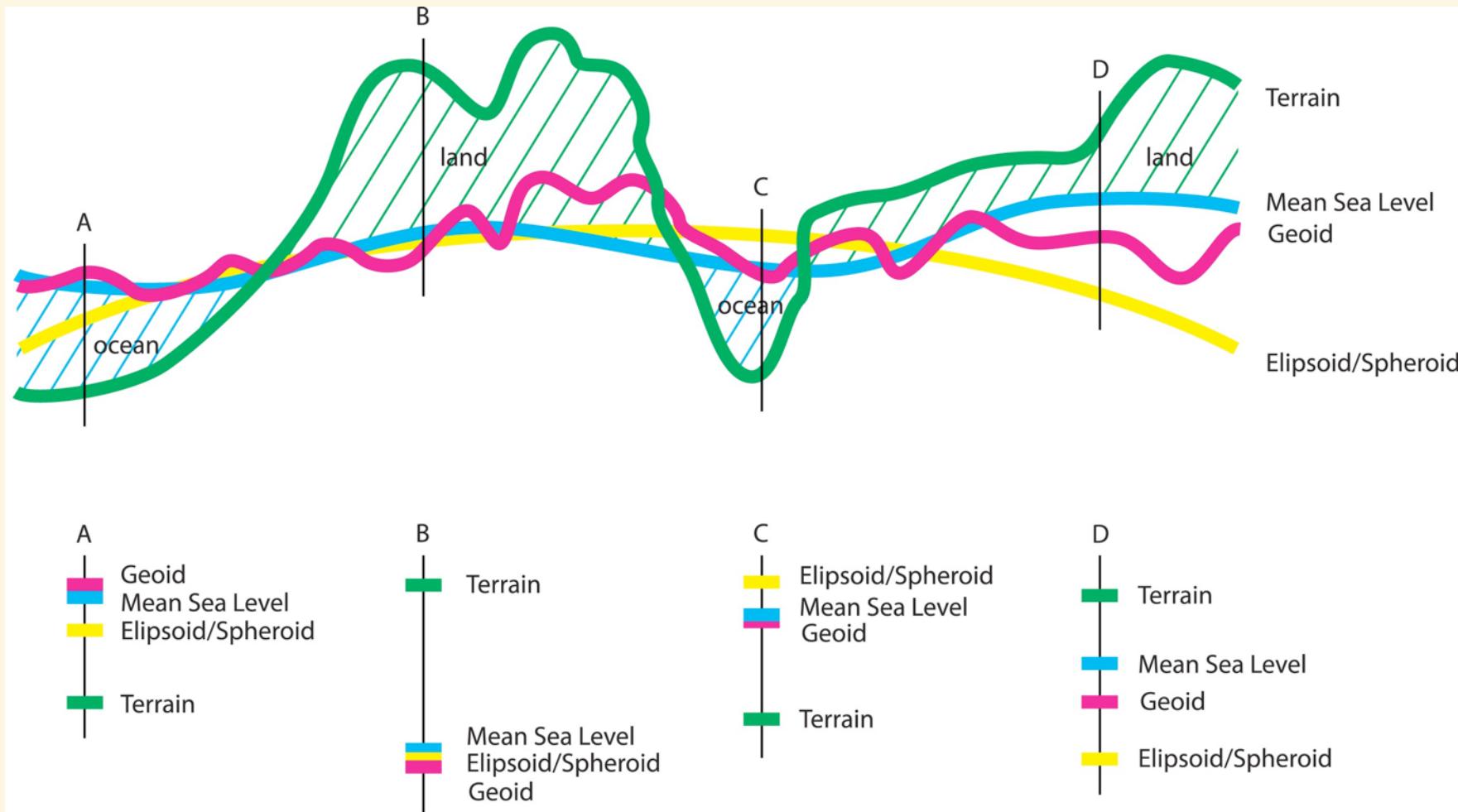
GEOGRAPHIC COORDINATE SYSTEM

Geoid

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

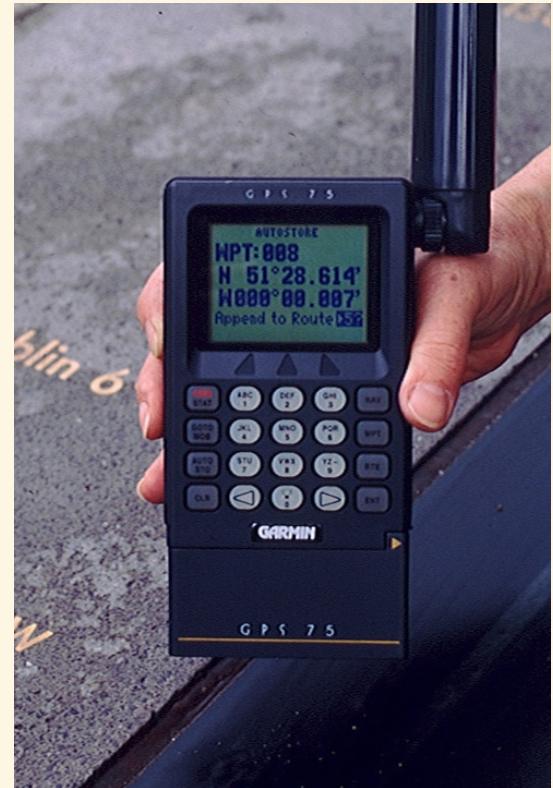


GEOGRAPHIC COORDINATE SYSTEM



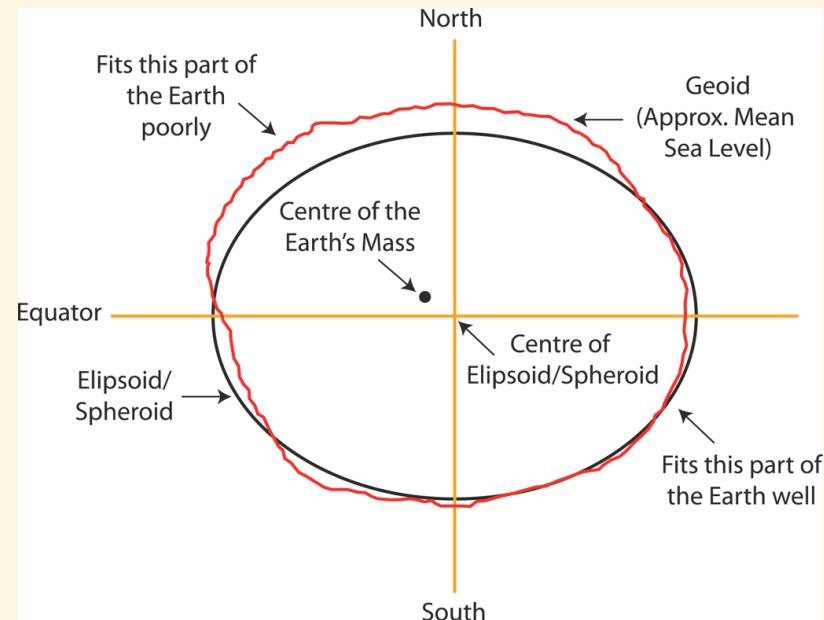
WGS 84

- 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: $0^{\circ}0'5.31''E$!



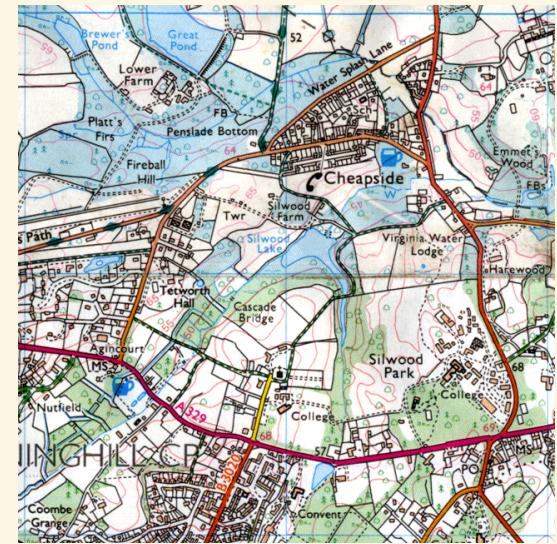
LOCAL GEOGRAPHIC DATUM

- 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

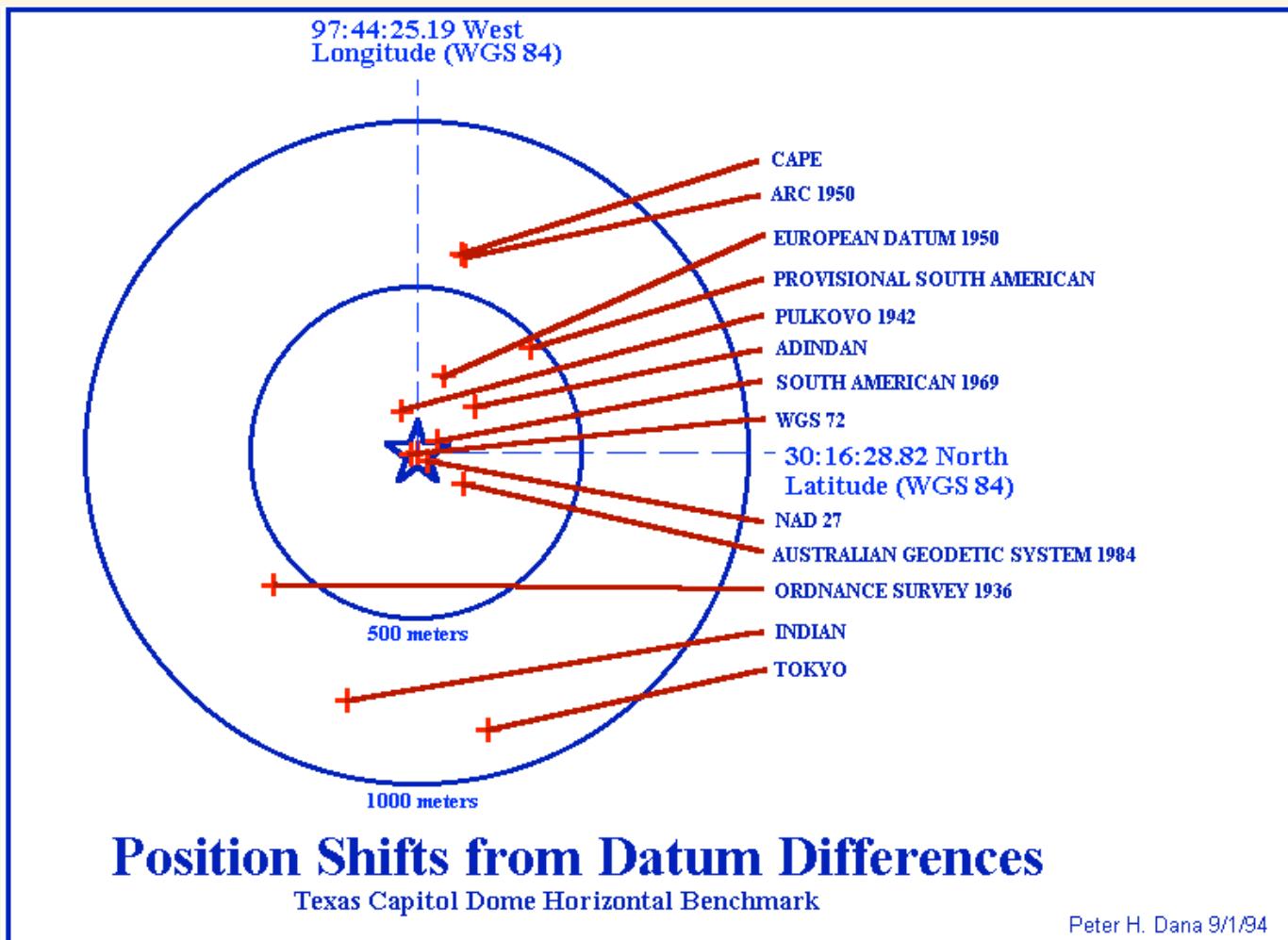


LOCAL GEOGRAPHIC DATUM

- 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

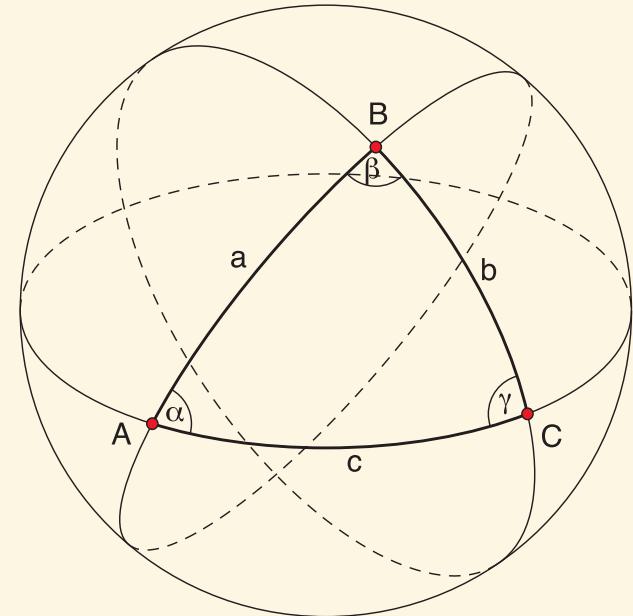


DATUM SHIFT



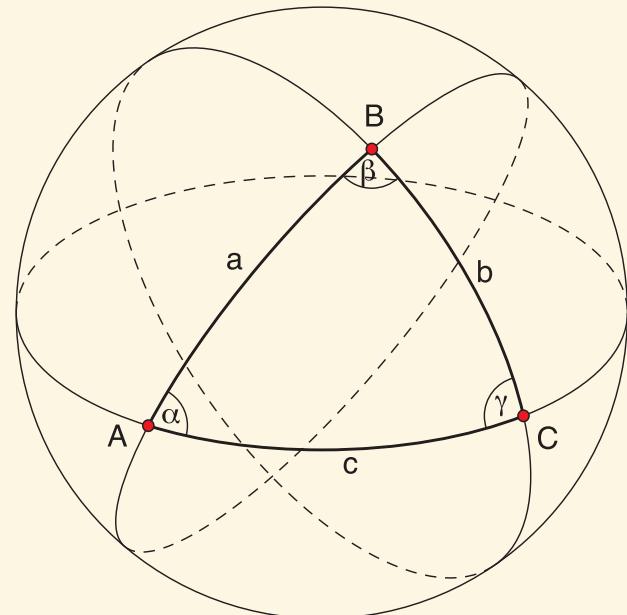
SPHERICAL GEOMETRY

- 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:

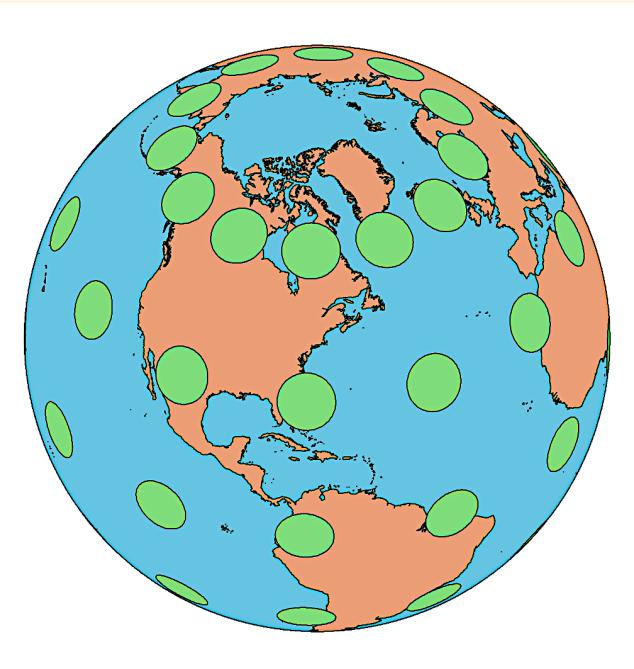
- **Shape:** conformal maps
- **Area:** equal-area maps
- **Distance:** equi-distant maps
- **Direction:** azimuthal maps

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

PROJECTED COORDINATE SYSTEMS

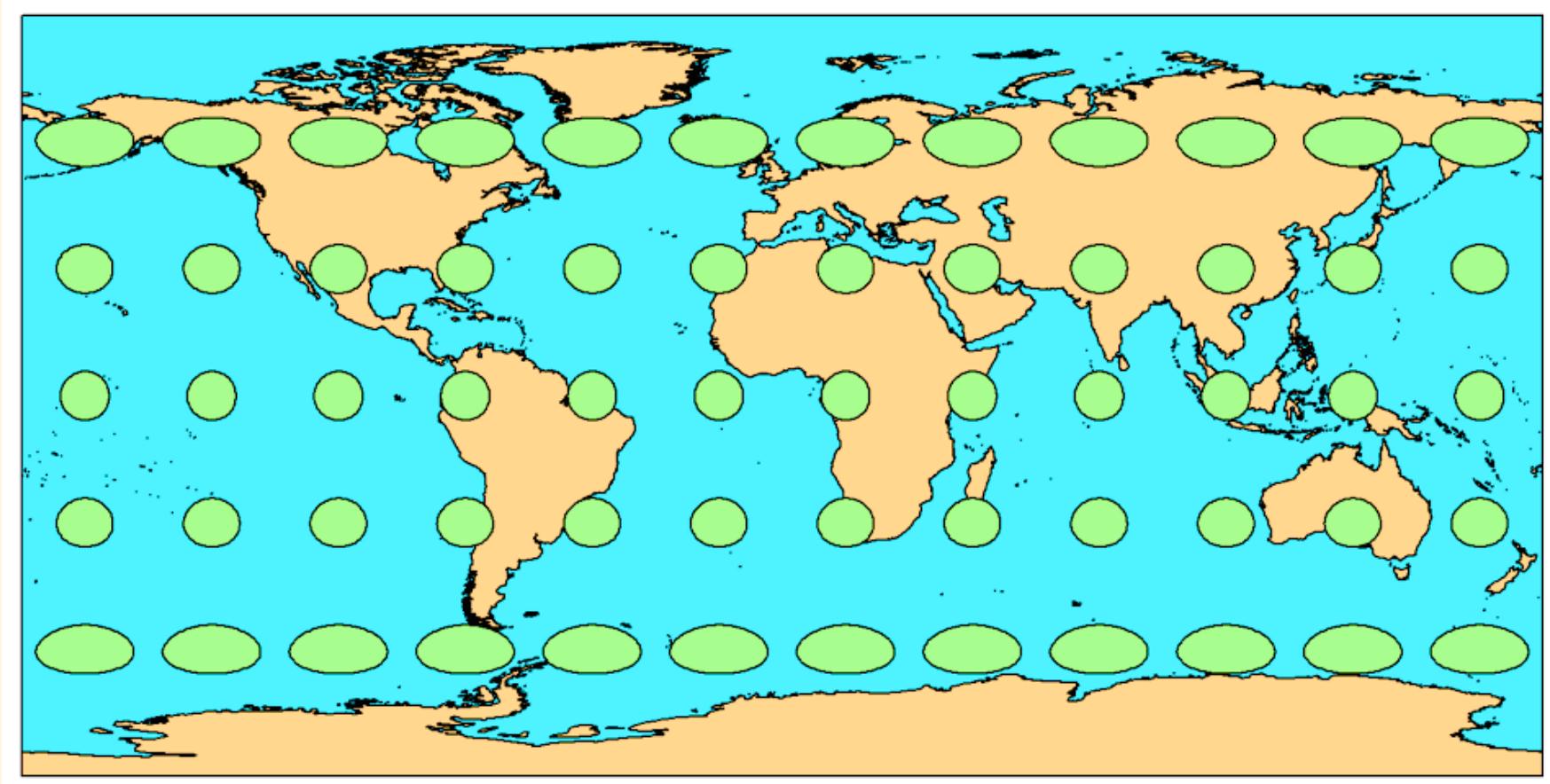
Tissot indicatrix:

- 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



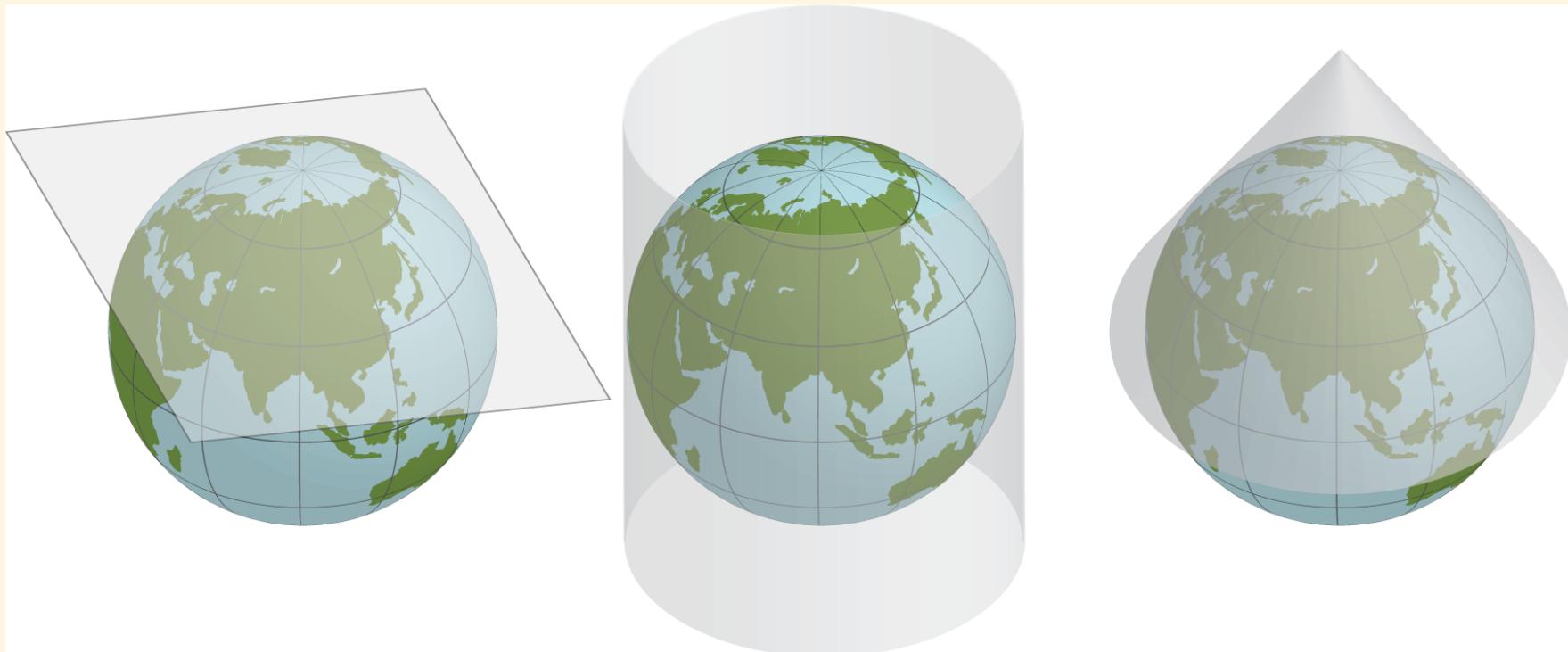
PROJECTED COORDINATE SYSTEMS

Equirectangular: latitude and longitude as X and Y



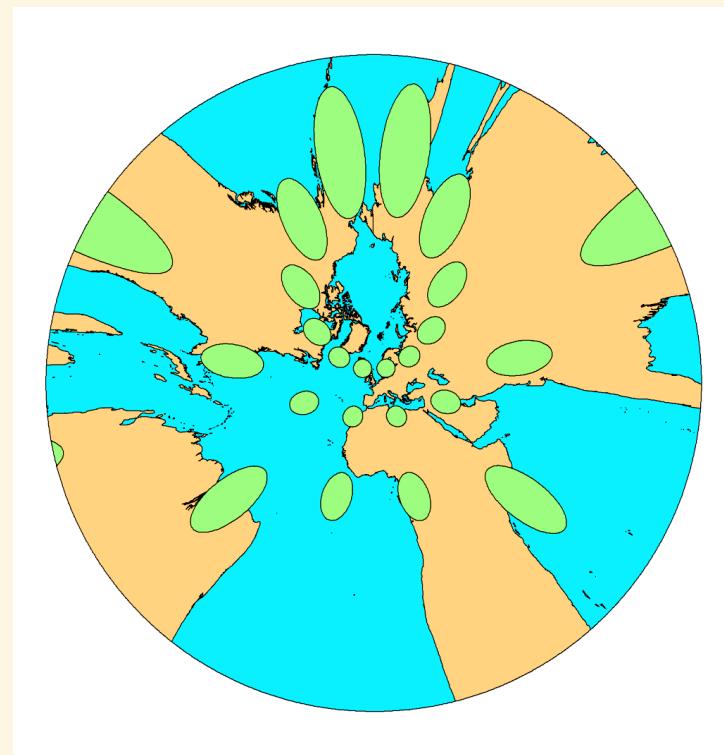
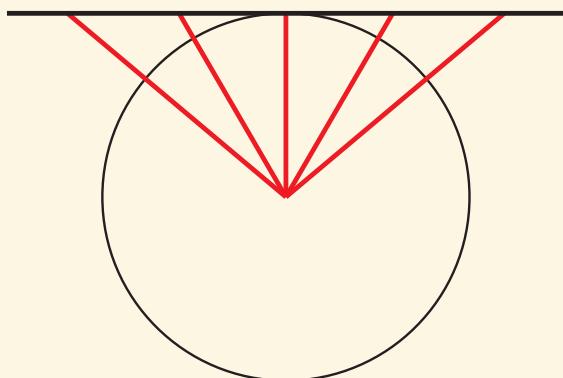
PROJECTED COORDINATE SYSTEMS

Classification according to mapping to planar surface:



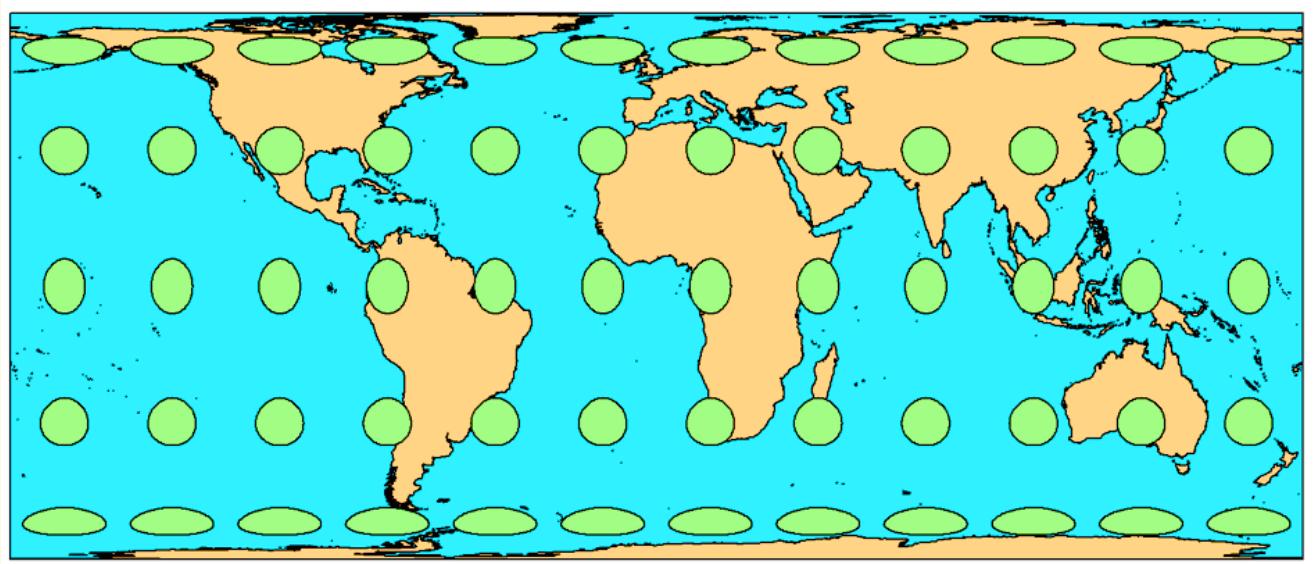
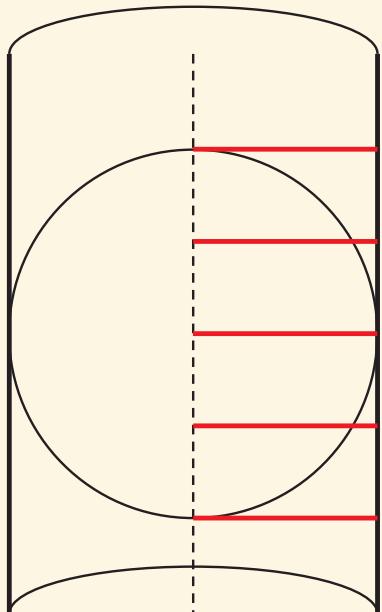
PROJECTED COORDINATE SYSTEMS

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



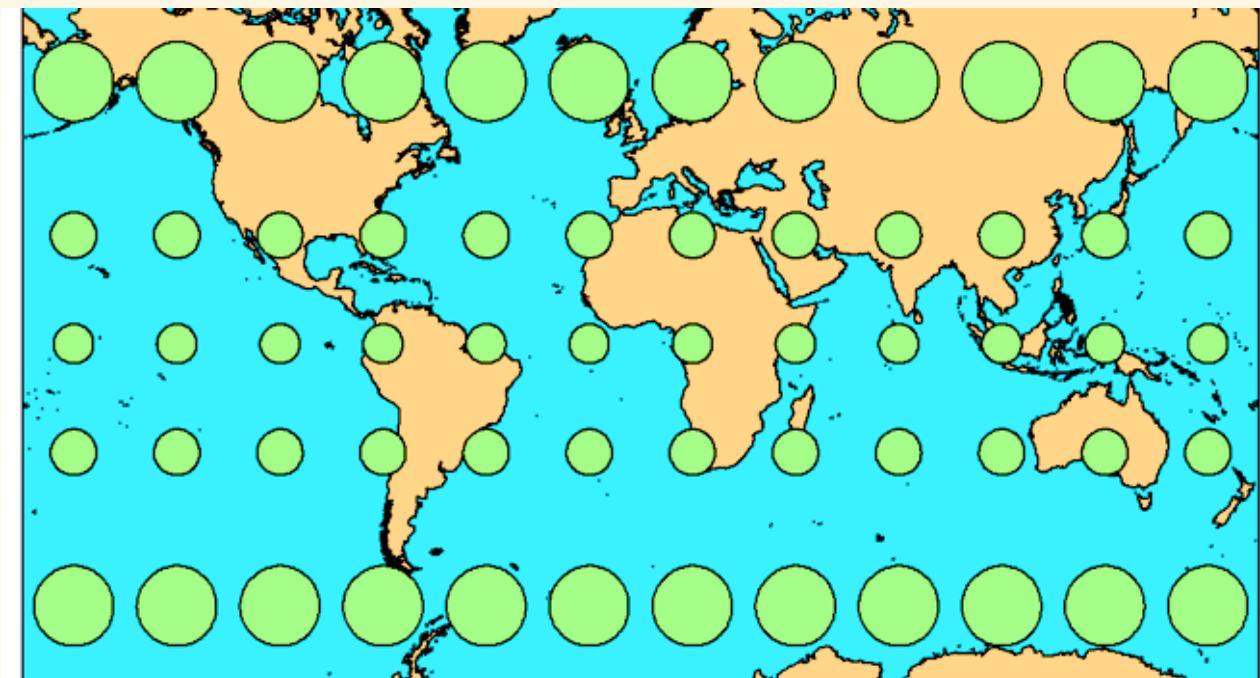
PROJECTED COORDINATE SYSTEMS

Cylindrical: preserves area, not shape



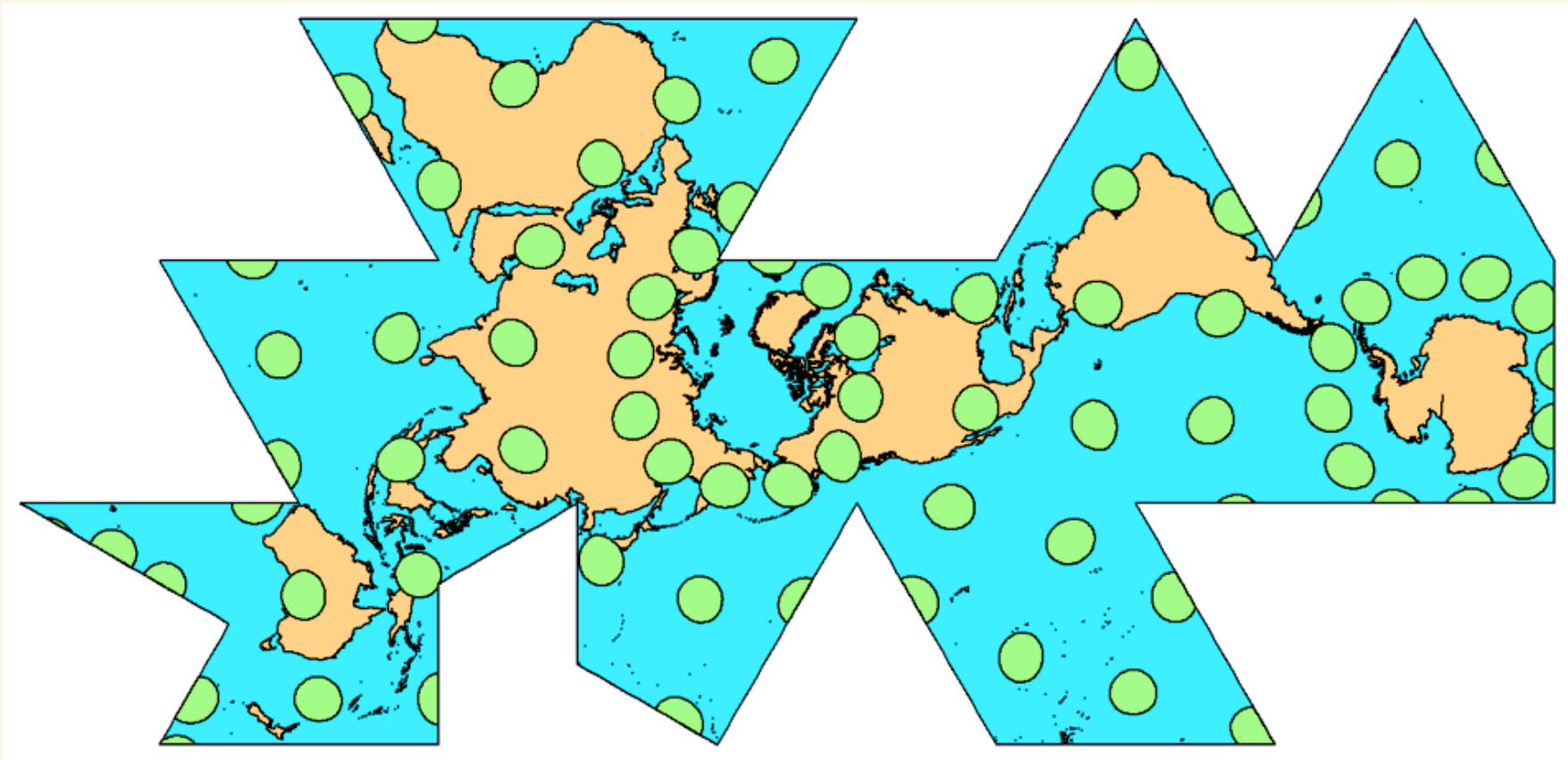
PROJECTED COORDINATE SYSTEMS

Mercator: preserves shape, not scale



PROJECTED COORDINATE SYSTEMS

Fuller Dymaxion: compromise projection



GEOGRAPHIC DATA

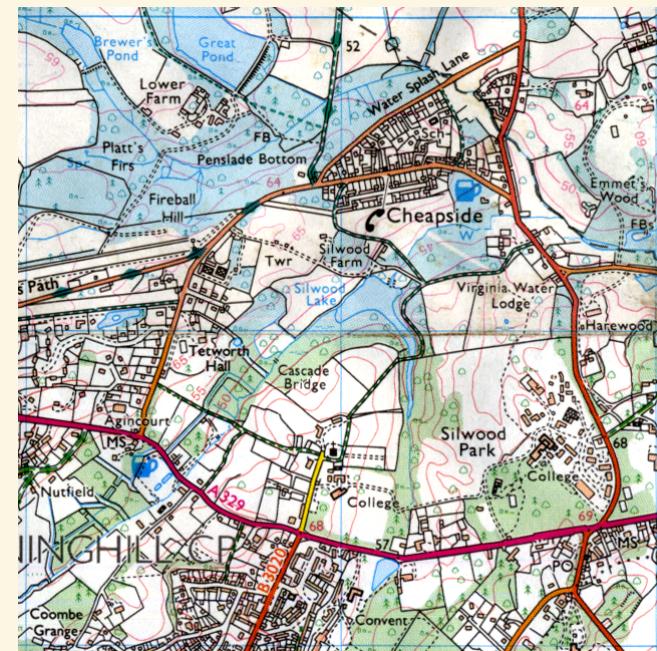
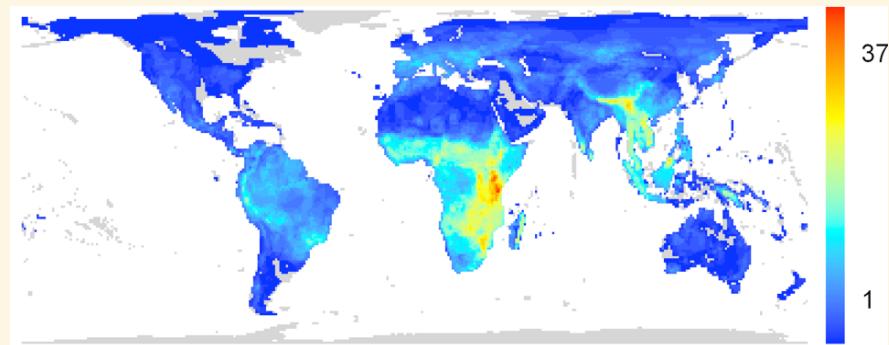
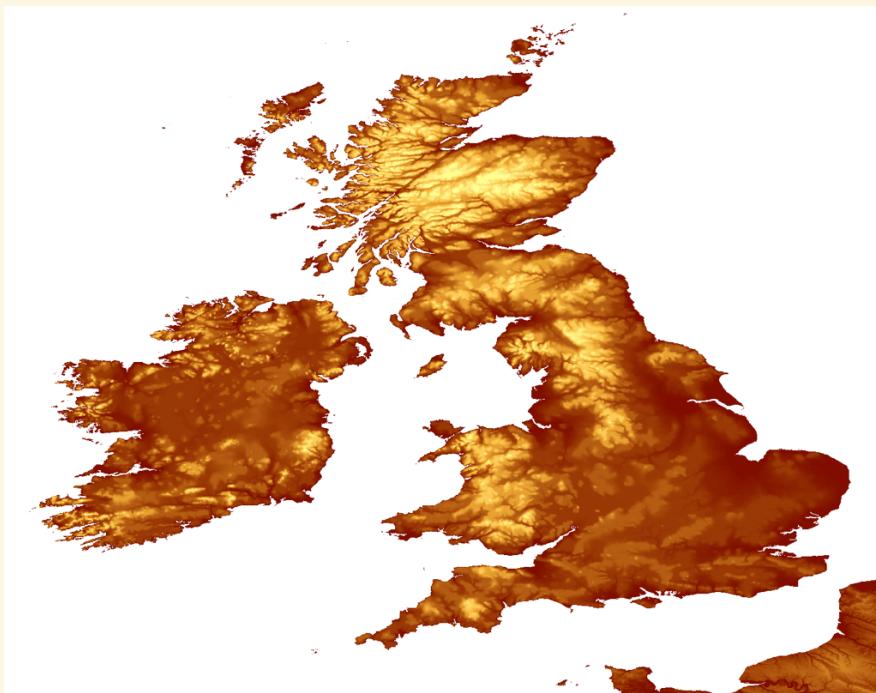
- A Coordinate system and:
 - **Vector** data: coordinates of points, lines, polygons
 - **Raster** data
 - grid data
 - satellite and aerial images

RASTER DATA

An **image** covering a continuous surface

- 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

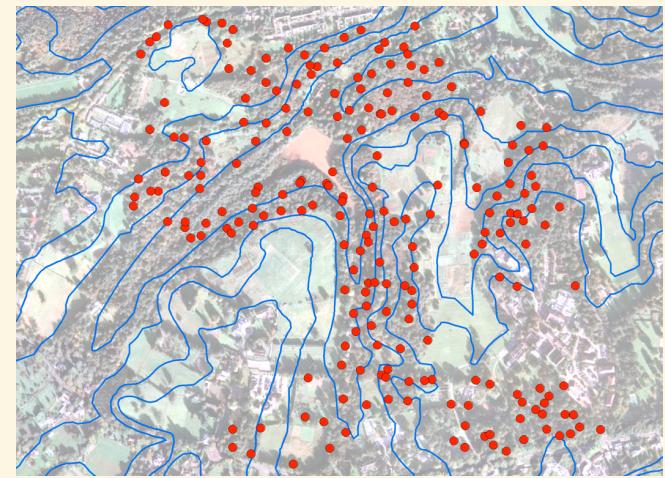
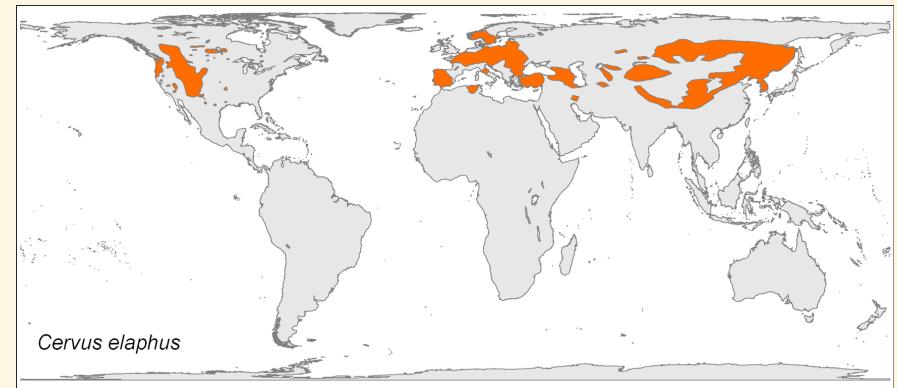
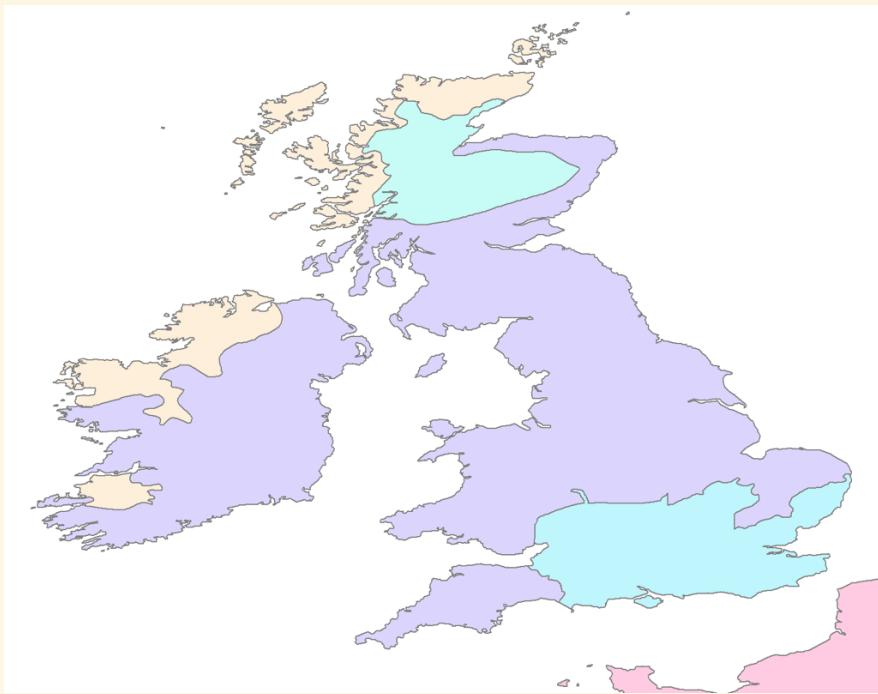


VECTOR DATA

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*