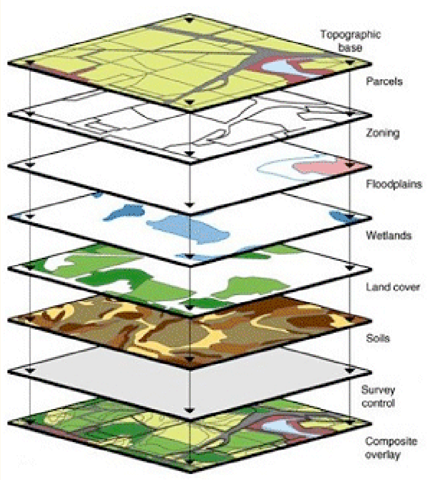
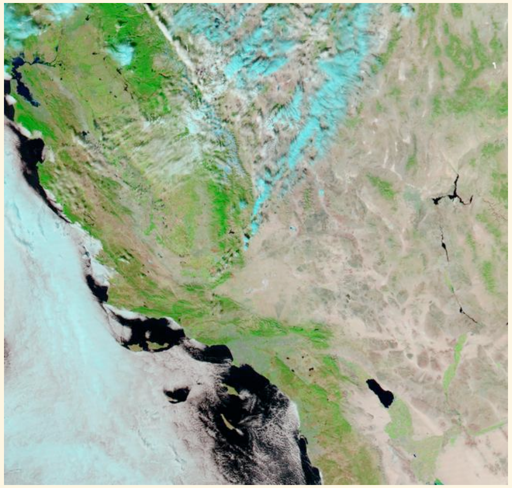
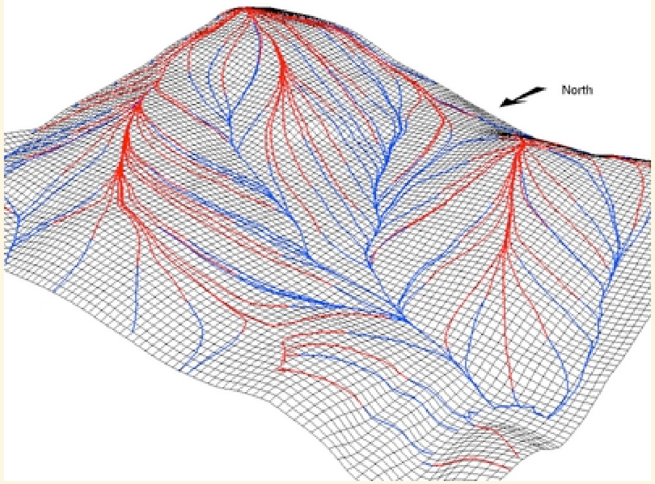
# GIS CONCEPTS

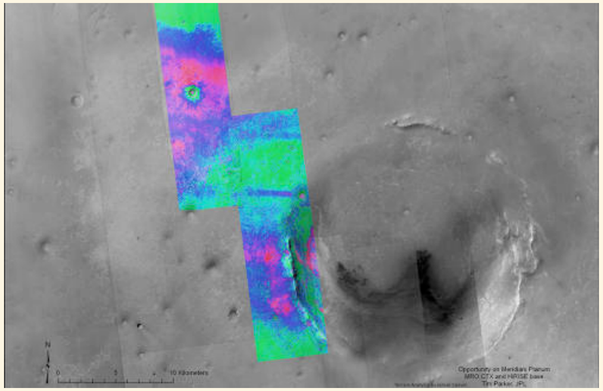

## DAVID ORME

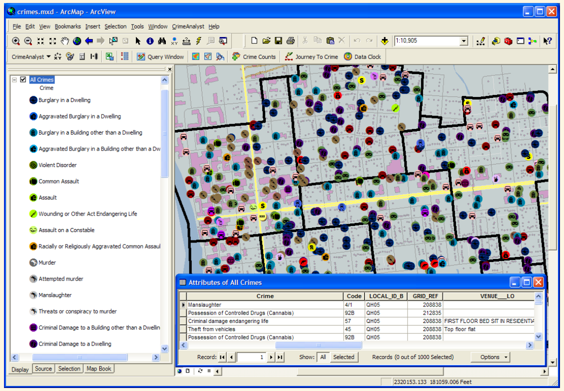
# WHAT IS A GIS?


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




North



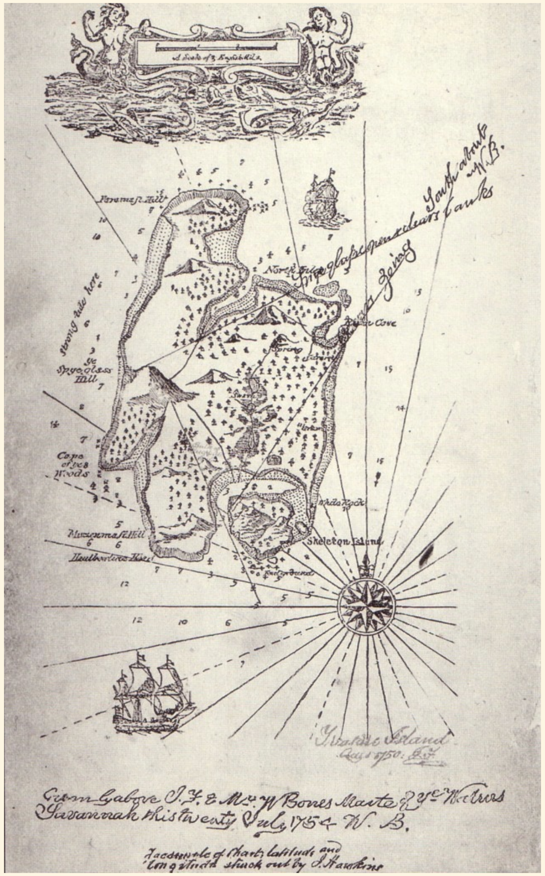

crimes.mxd - ArcMap - ArcView
Attributes of All Crimes

# WHAT IS 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:

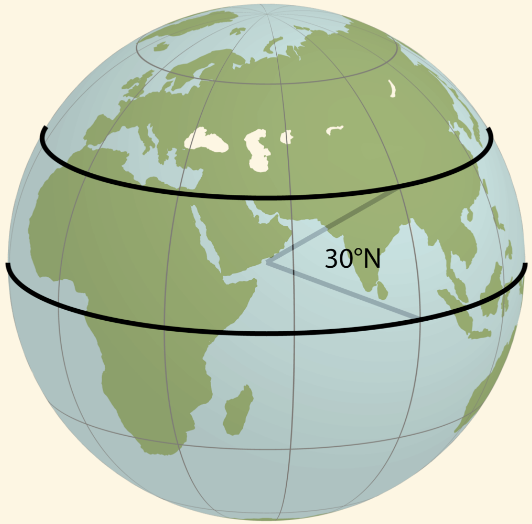
- A set of coordinates
- A known coordinate system

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

# SPHERICAL COORDINATES

## Latitude

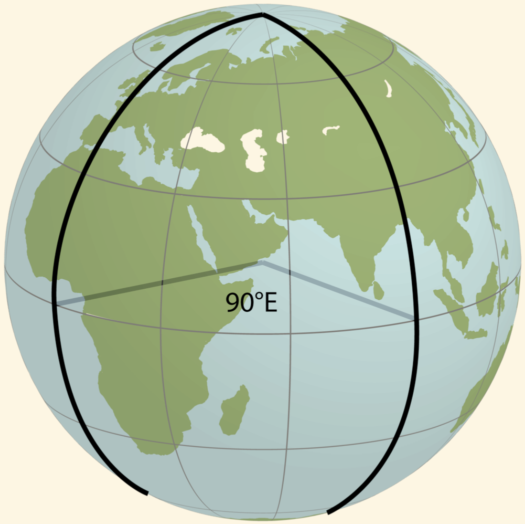
- an angle above or below the equator
- points of equal latitude form a parallel
- distance between parallels is constant*



# SPHERICAL COORDINATES

**Longitude**:

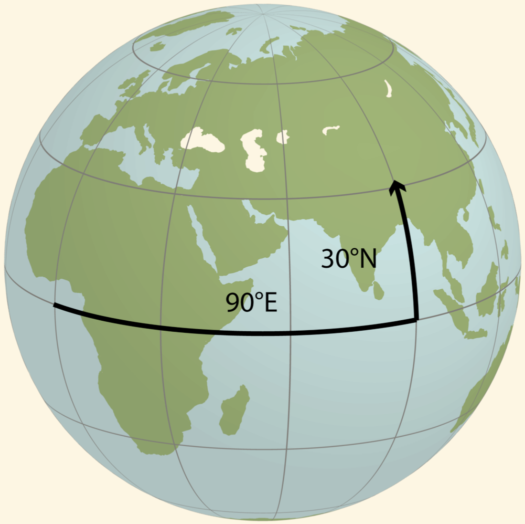
- an angle around the equator
- points of equal longitude form a meridian
- distance between meridians varies



# 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 (c. 5,500 m)



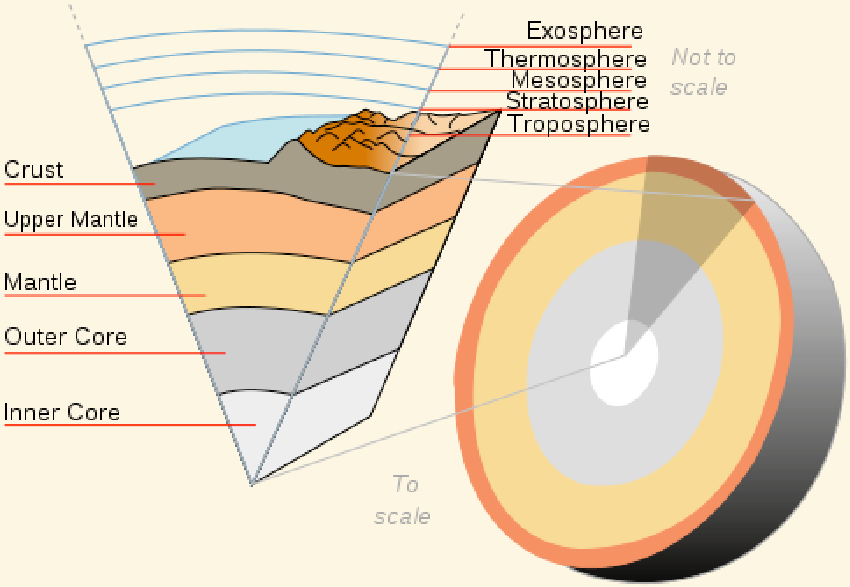
# GEOGRAPHIC COORDINATE SYSTEM

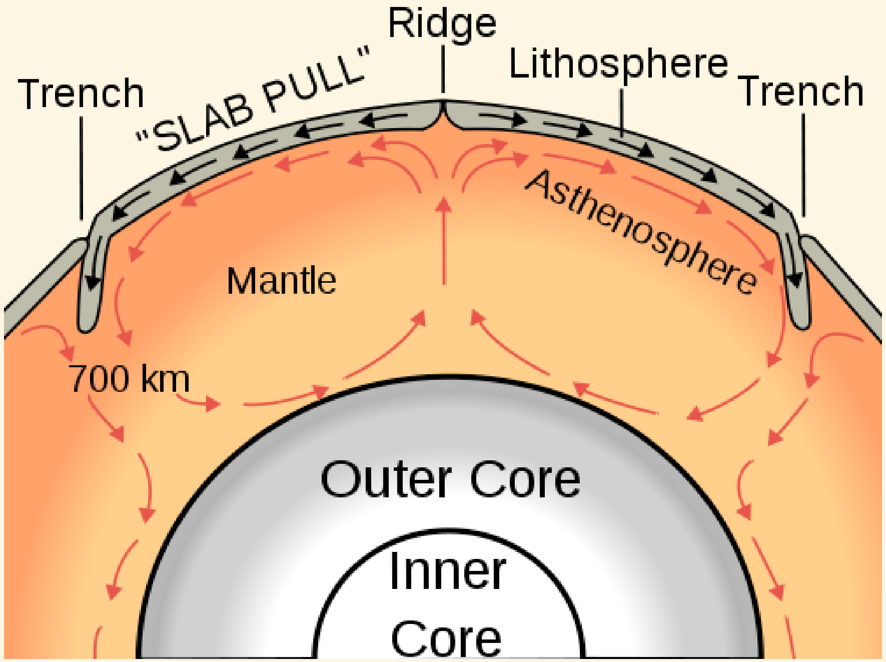
- The Earth is not a sphere (~ 1 in 298 flattening)
- There are **many** reference ellipsoids or datums.

| 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

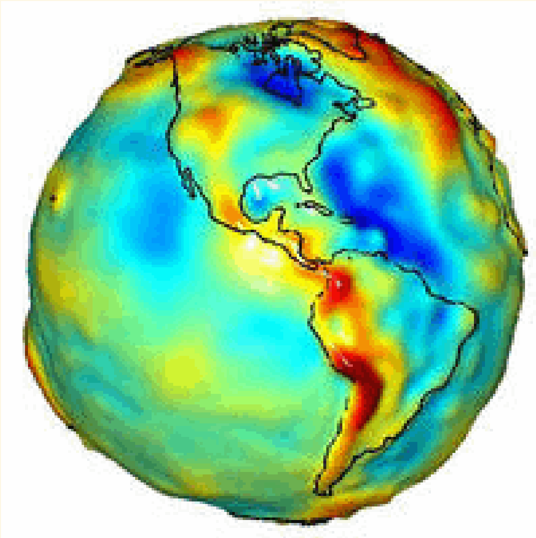


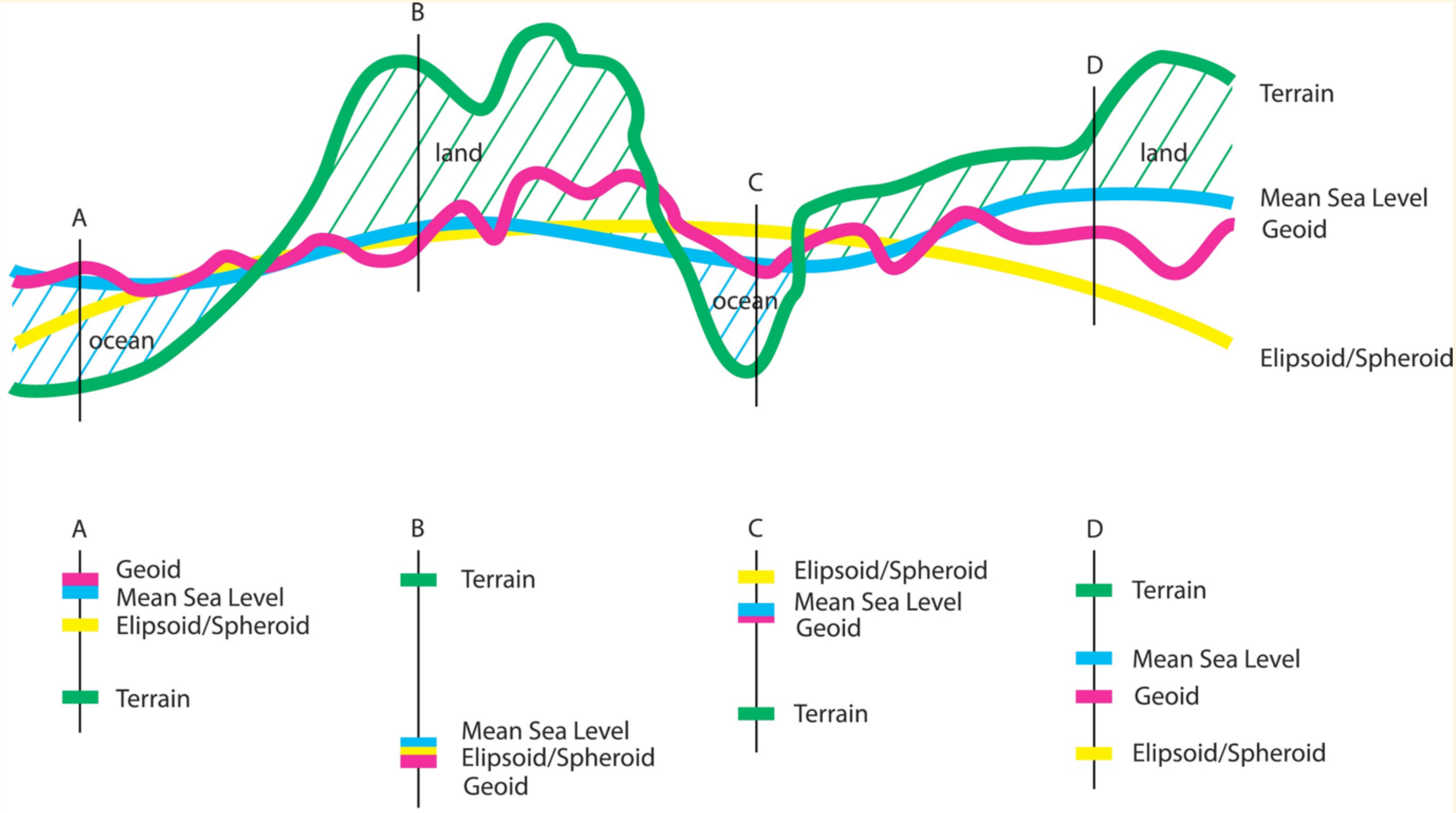
# GEOGRAPHIC COORDINATE SYSTEM

**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

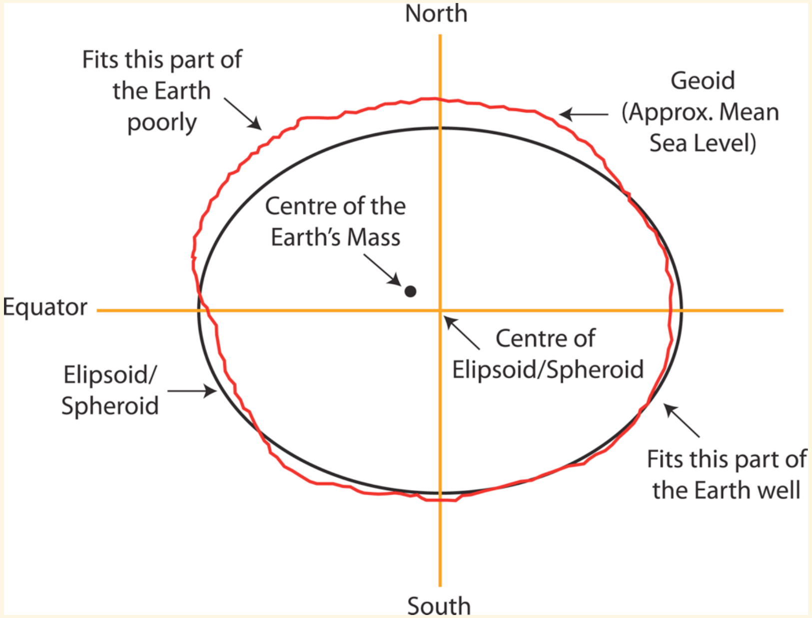


# WGS 84

- 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°0’5.31”E !

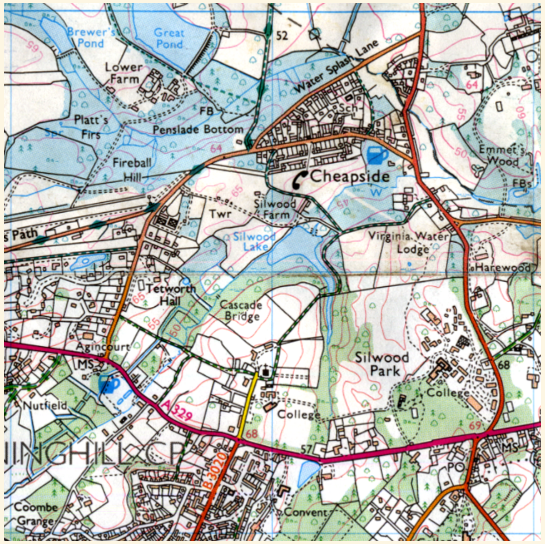
# LOCAL GEOGRAPHIC DATUM

- 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

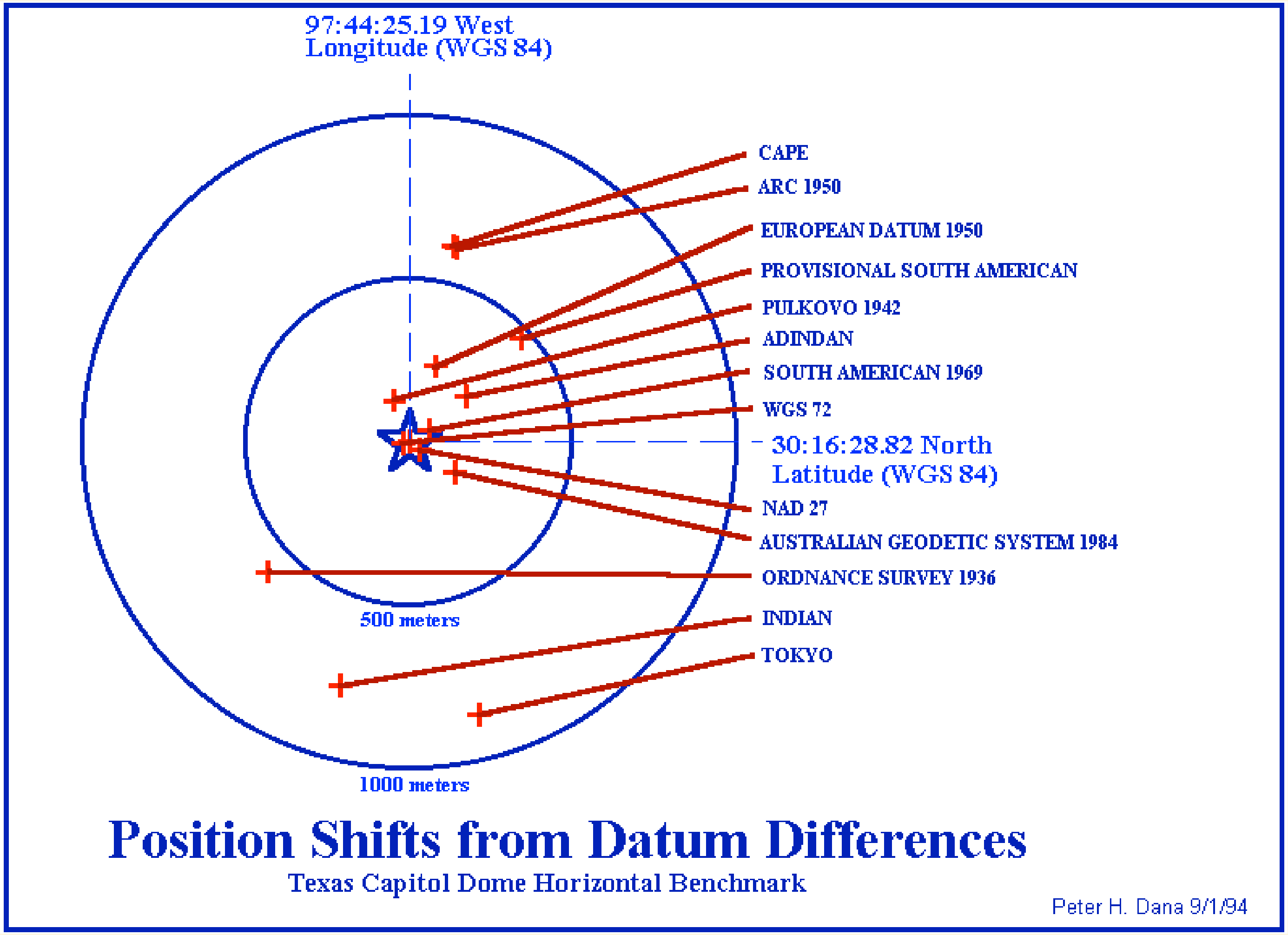


# LOCAL GEOGRAPHIC DATUM

- 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

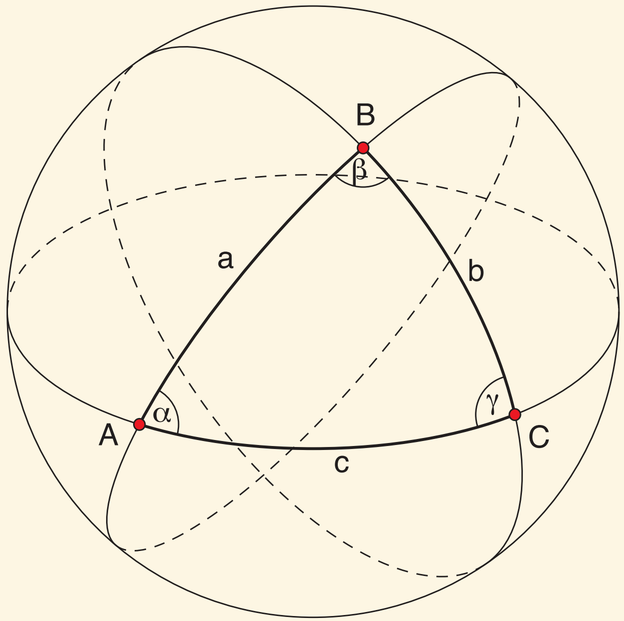


# DATUM SHIFT


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

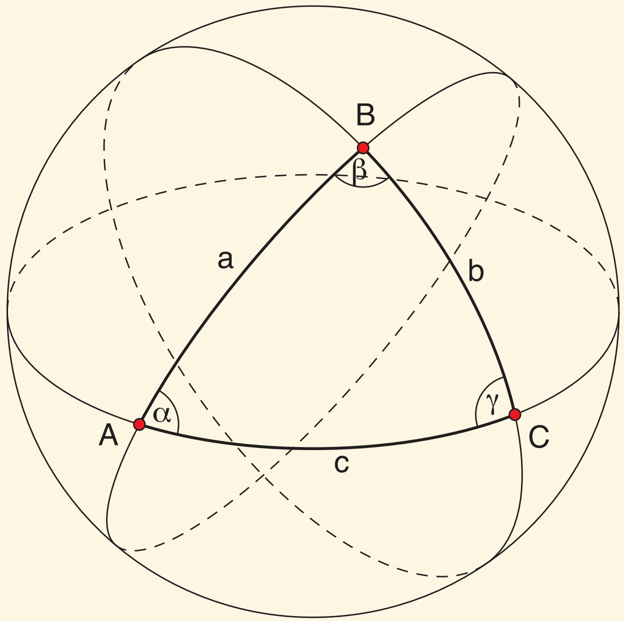
# SPHERICAL GEOMETRY

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



# 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:

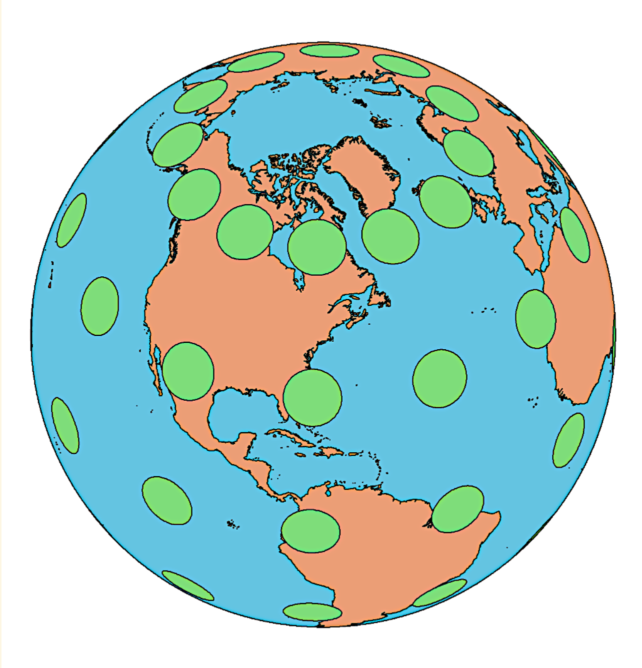
- **Shape**: conformal maps
- **Area**: equal-area maps
- **Distance**: equi-distant maps
- **Direction**: azimuthal maps

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

# PROJECTED COORDINATE SYSTEMS

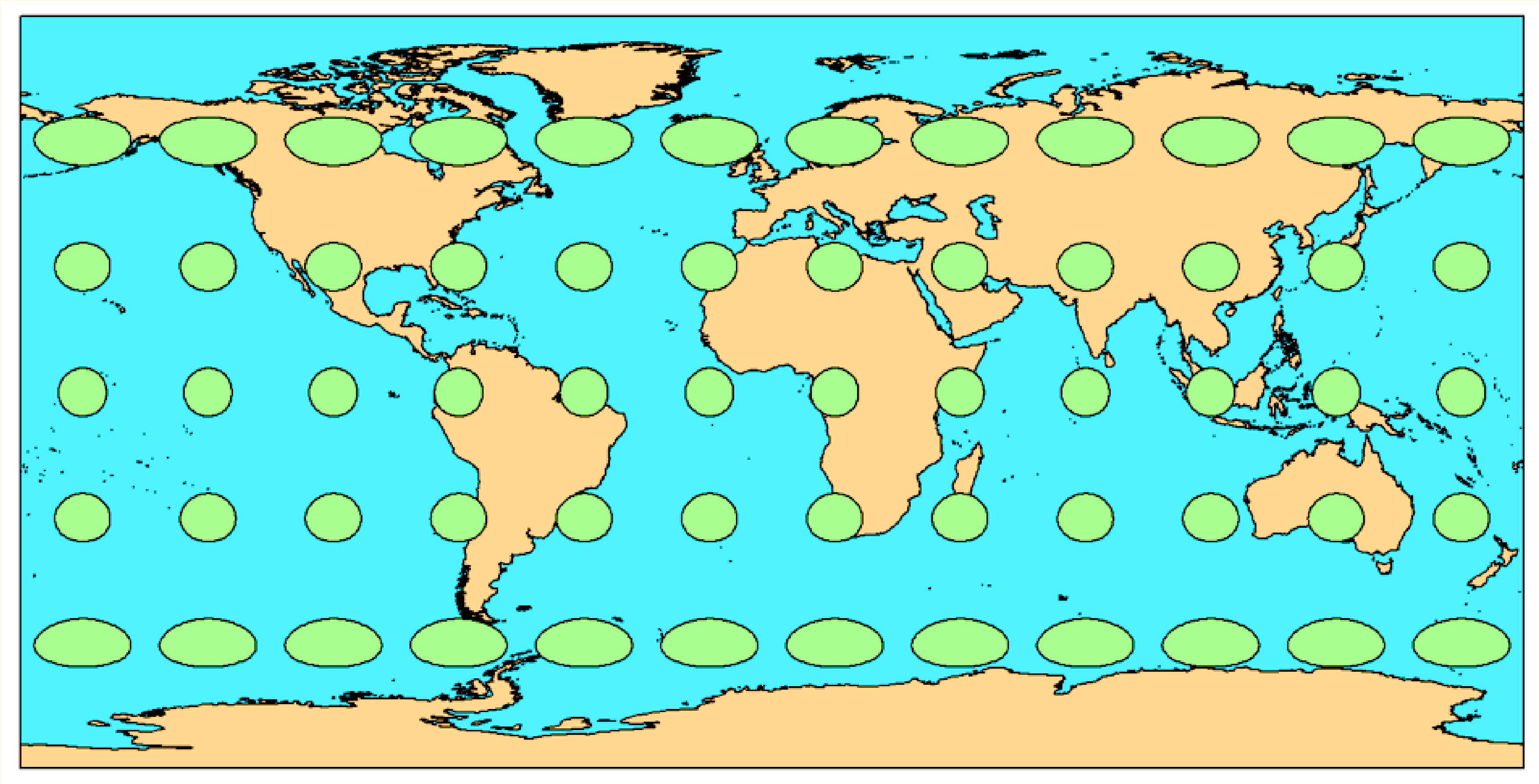
**Tissot indicatrix:**

- 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



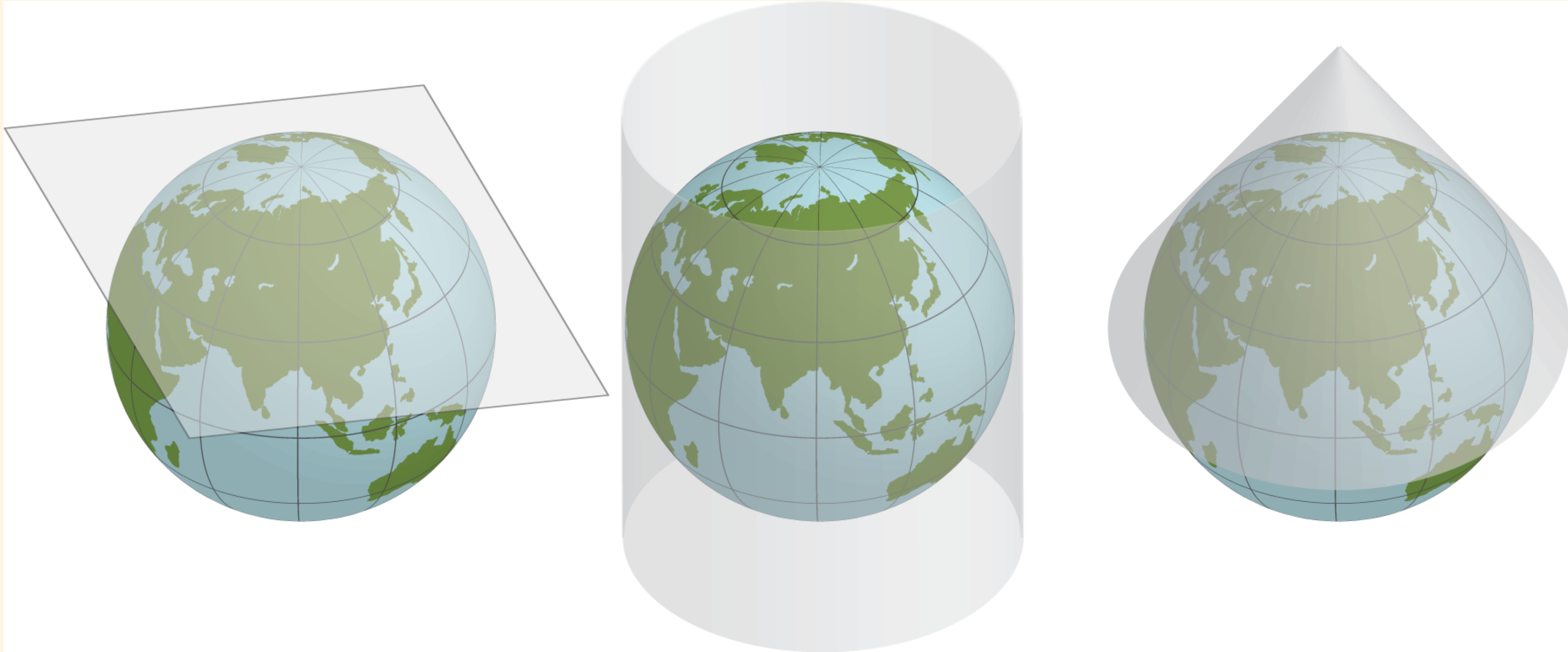
# PROJECTED COORDINATE SYSTEMS

**Equirectangular:** latitude and longitude as X and Y



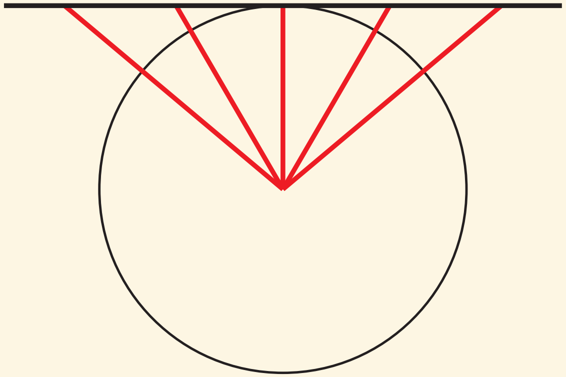
# PROJECTED COORDINATE SYSTEMS

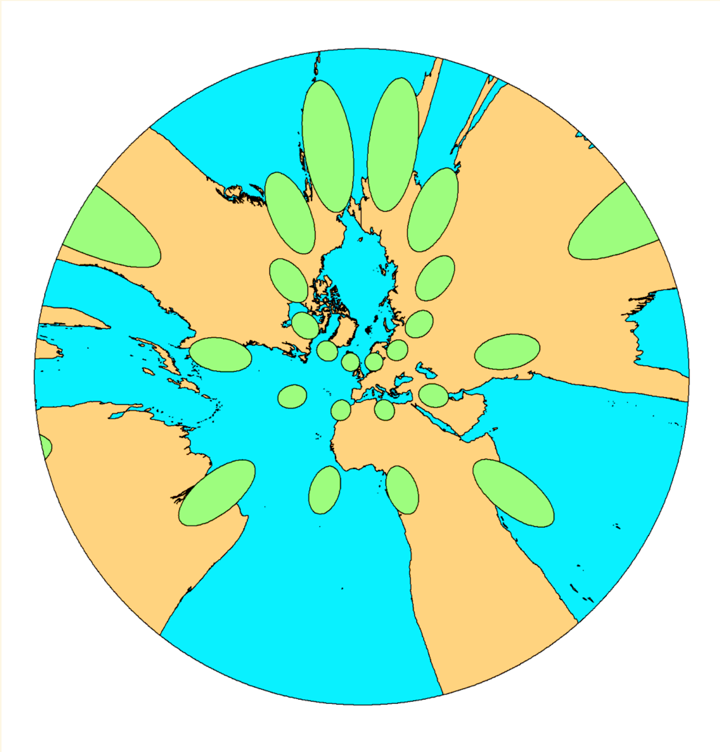
Classification according to mapping to planar surface:



# PROJECTED COORDINATE SYSTEMS

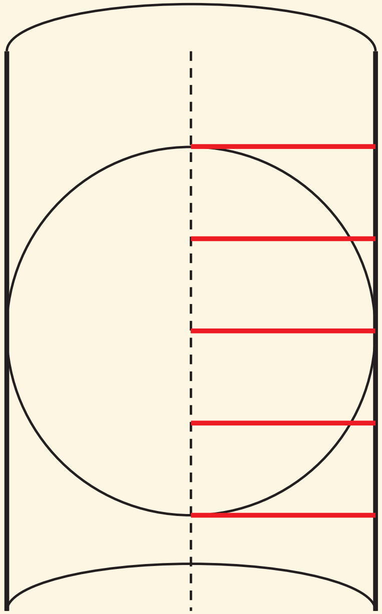
**Gnomonic**: planar, preserves bearings from a single central point, but little else.

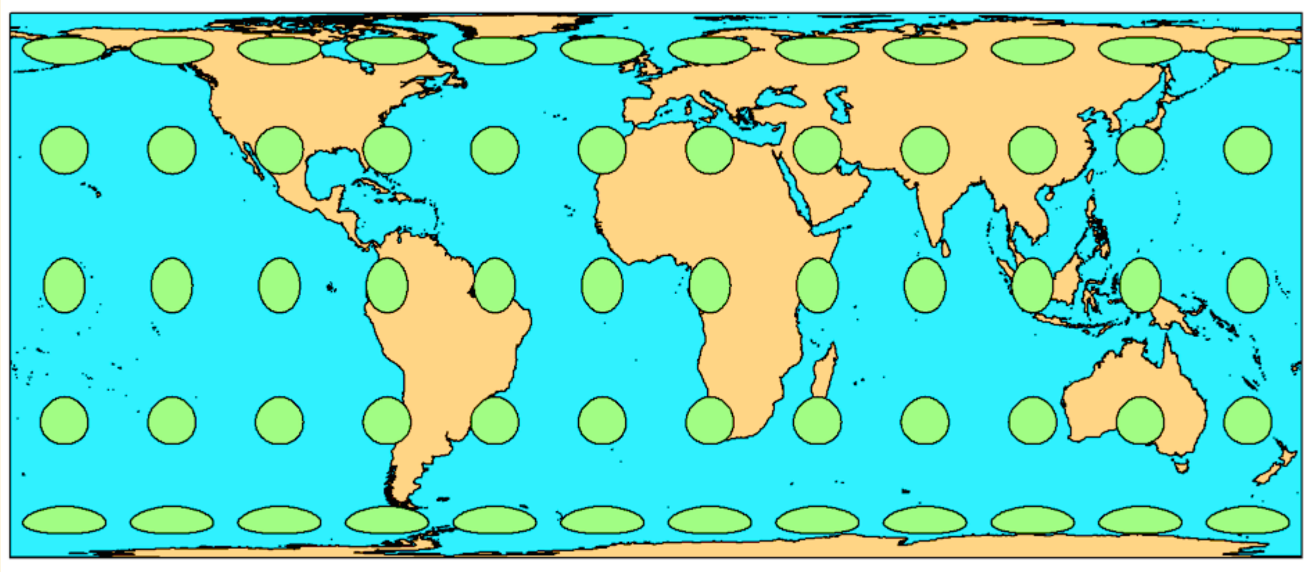




# PROJECTED COORDINATE SYSTEMS

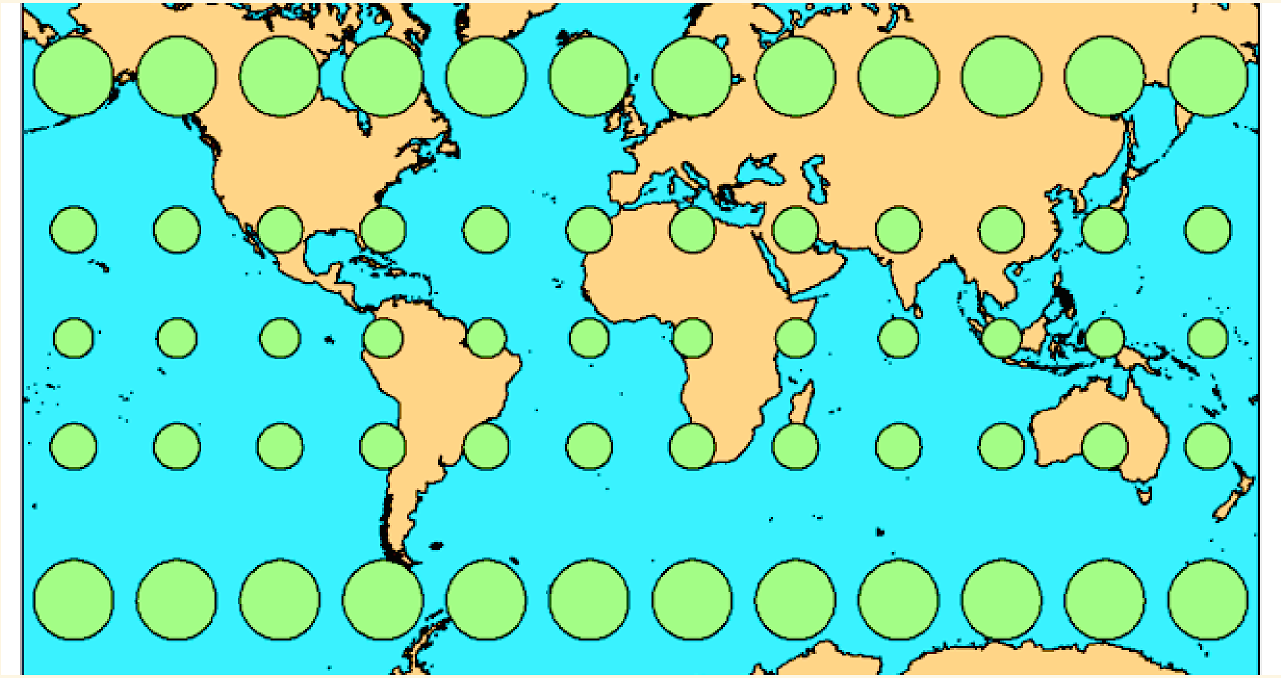
**Cylindrical:** preserves area, not shape





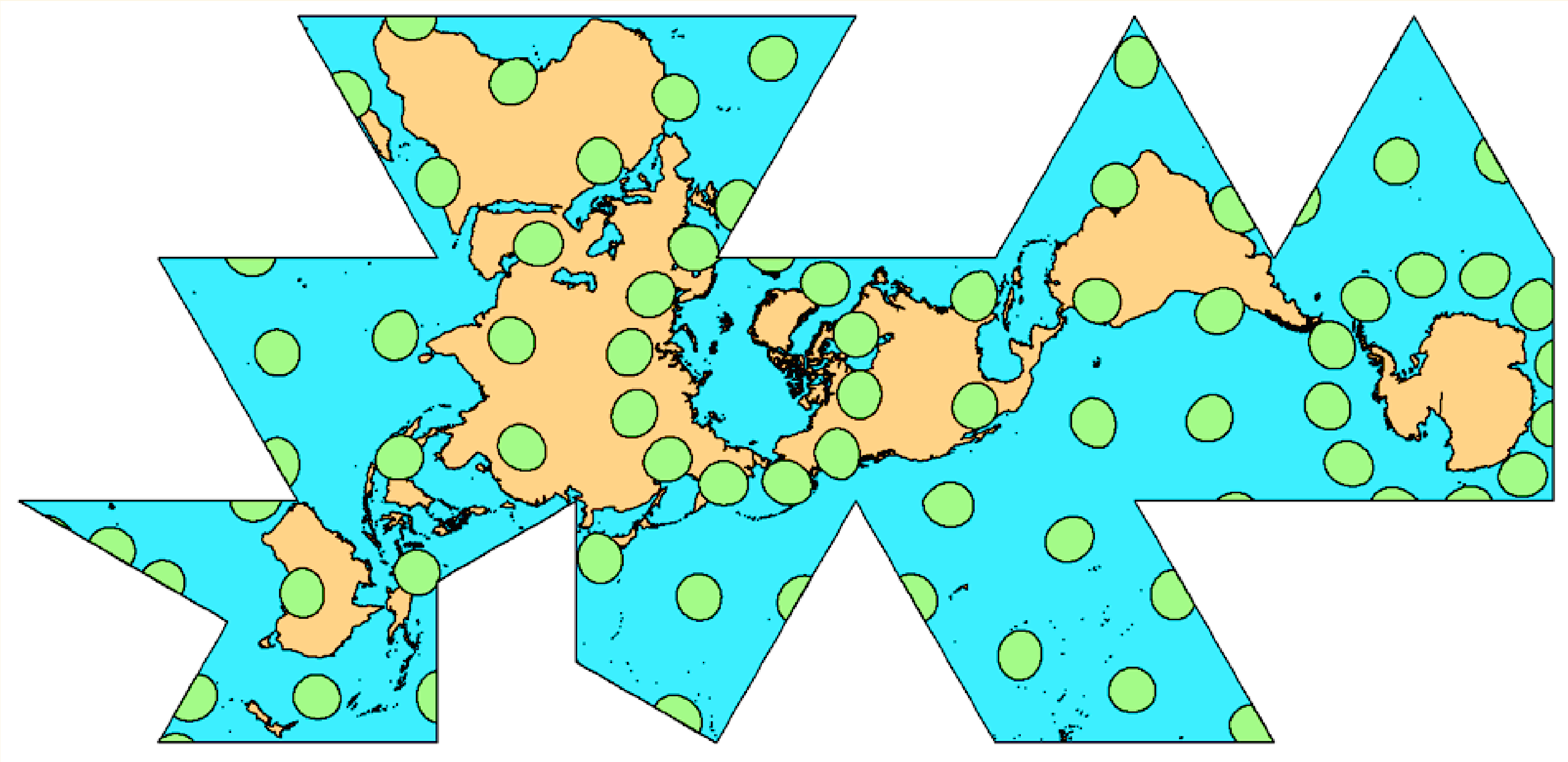
# PROJECTED COORDINATE SYSTEMS

**Mercator**: preserves shape, not scale



# PROJECTED COORDINATE SYSTEMS

**Fuller Dymaxion**: compromise projection



# GEOGRAPHIC DATA

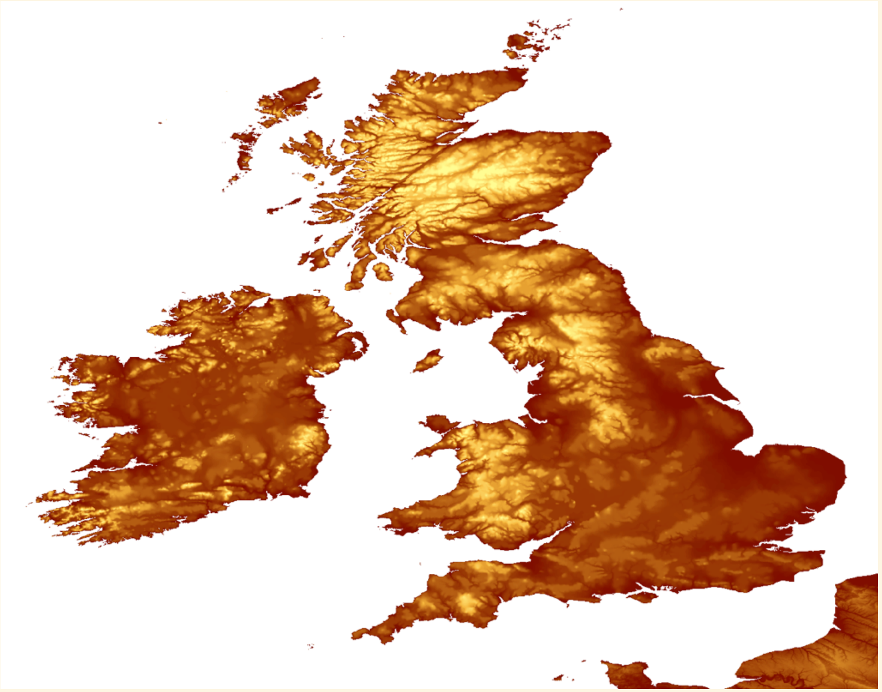
- A **Coordinate system** and:
  - **Vector** data: coordinates of points, lines, polygons
  - **Raster** data
    - grid data
    - satellite and aerial images

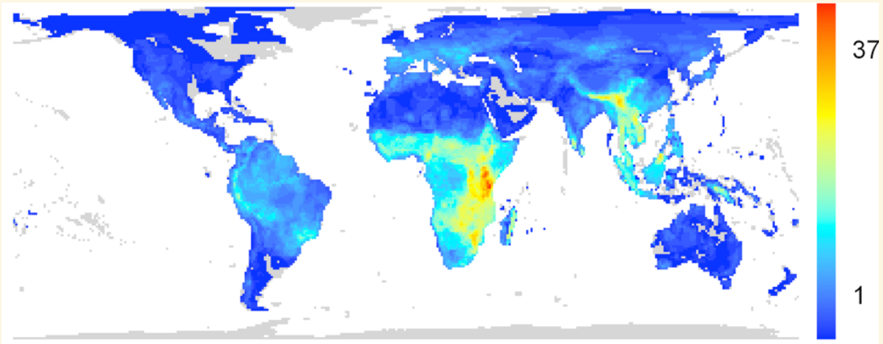
# RASTER DATA

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




37
1

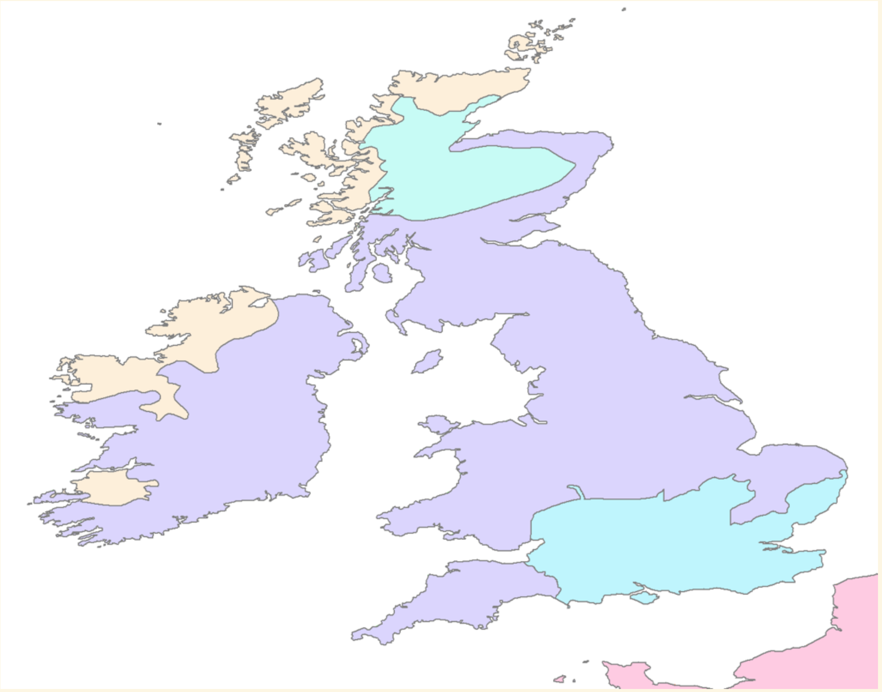

Brewer's Pond
Great Pond
52
Water Splash Lane
Lower Farm
FB
Sch
Platt's Firs
Penslade Bottom
Emmet's Wood
Fireball Hill
Cheapside
FBs
Twr
Silwood Farm
s Path
Silwood Lake
Virginia Water Lodge
Harewood
Tetworth Hall
Cascade Bridge
Agincourt
MS
Silwood Park
College
Nutfield
A329
College
B3020
57
MS
PO
Coombe Grange
Convent

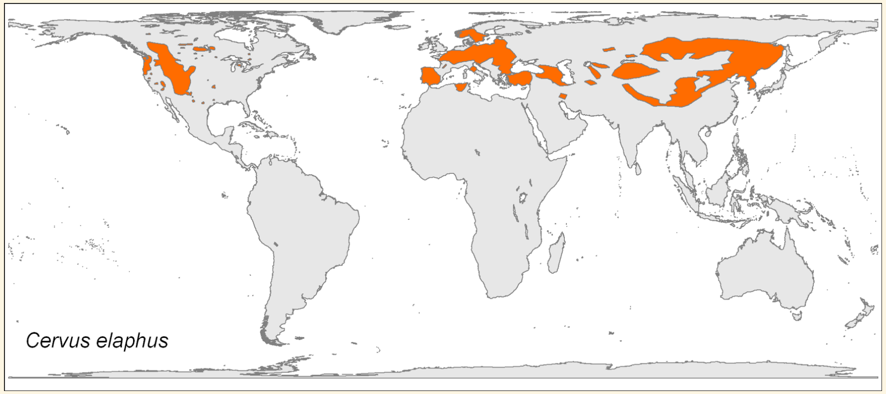
# VECTOR DATA

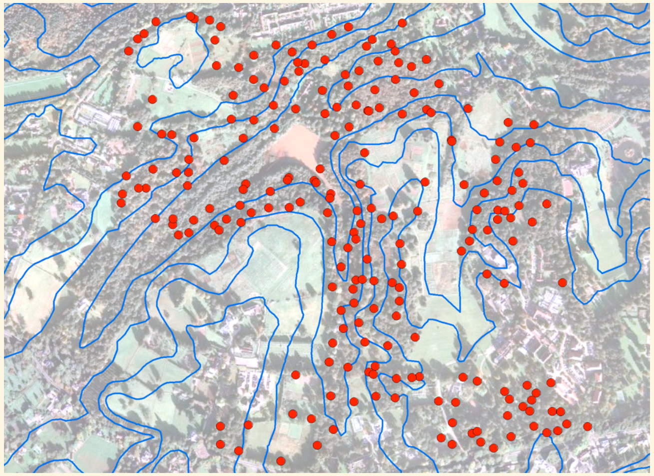
A set of *features*, containing one of:

- 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*