GE: 2219: CARTOGRAPHY

LECT # 3

Geodesy

Shape of the earth

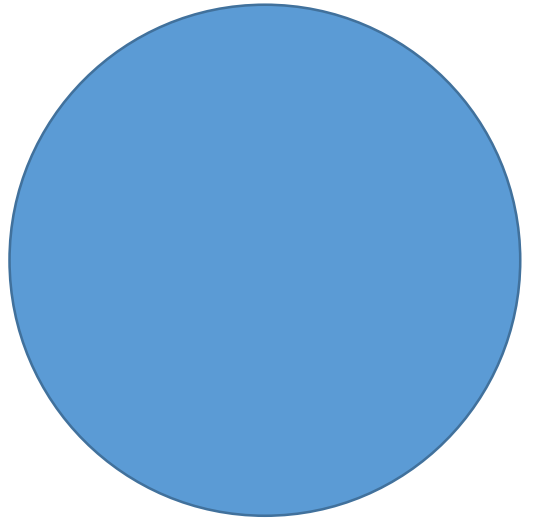
What shape is the Earh ?

a) Flat

b) Round

c) Dodecahedral

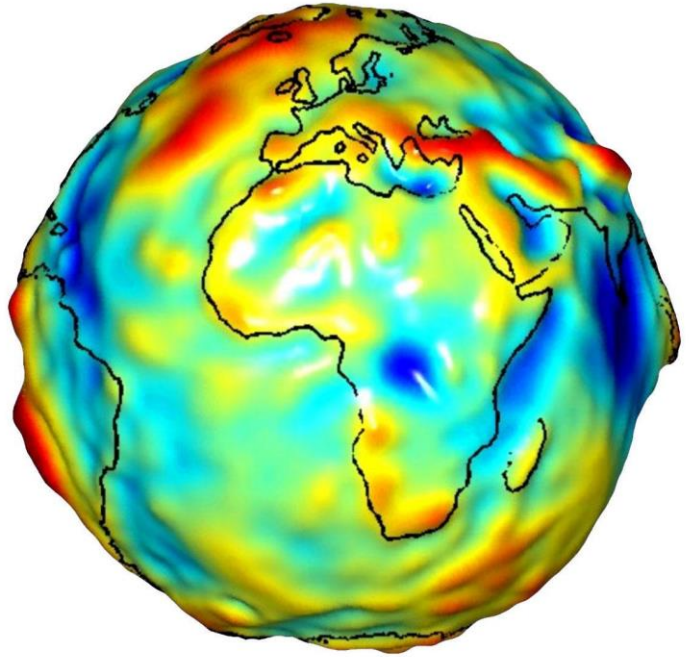
d) Other



How do you know ?

Geodesy

Geodesy is the study of the shape and size of the earth



Geodesy is the Earth science of accurately measuring and understanding Earth's figure, orientation in space, and gravity. The field also incorporates studies of how these properties change over time and equivalent measurements for other planets. (Wikipedia)

Shape of the earth

Accurate shape of the Earth is need to improve:

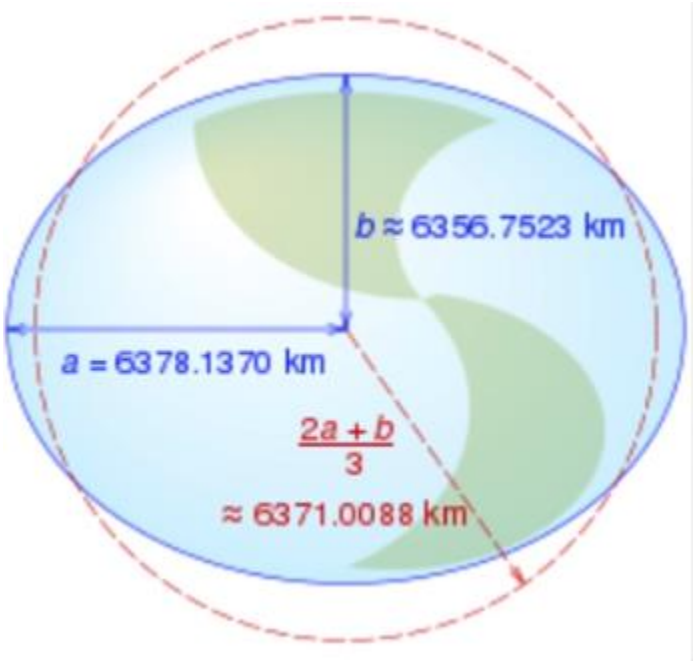
- Accuracy of location measurement (coordinates)
- Accuracy of maps (Charts in atlas)

Understanding of the shape of Earth has evolved over time.

Size of the Earth:

- Eratosthenes (274 BC – 194 BC): Earth circumference 40,250 km.
- Posidonius (135 BC – 51 BC): Earth circumference 38,400 km.
- Another estimate of 28, 960 km was used by Ptolemy to make the world map used until 1500s!
- Sir Isac Newton reasoned the flattening of the Earth based on rotational forces.

Modern Earth:

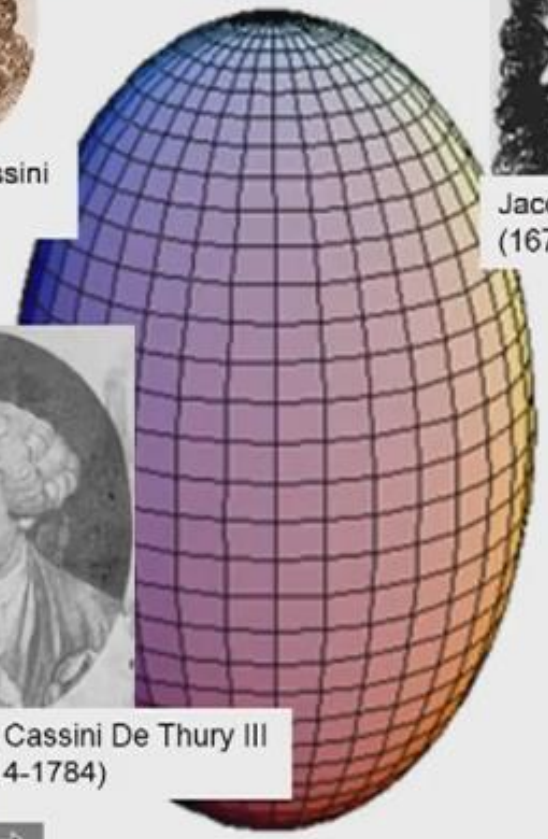


Shape of the Earth – Oblate or Prolate??

Giovanni Cassini
(1625-1712)

Jacques Cassini
(1677-1756)

Cesar-Francois Cassini De Thury III
(1714-1784)



Prolate

Oblate

Shape of the Earth – Oblate or Prolate??

Charles Marie de La Condamine
and Pierre Bouguer
Peru (modern Ecuador) 1735 – 1744
"*Measure of the Earth*" by L.
Ferreiro

Pierre Louis Moreau de Maupertuis
Lapland (modern Finland) 1736 - 1737

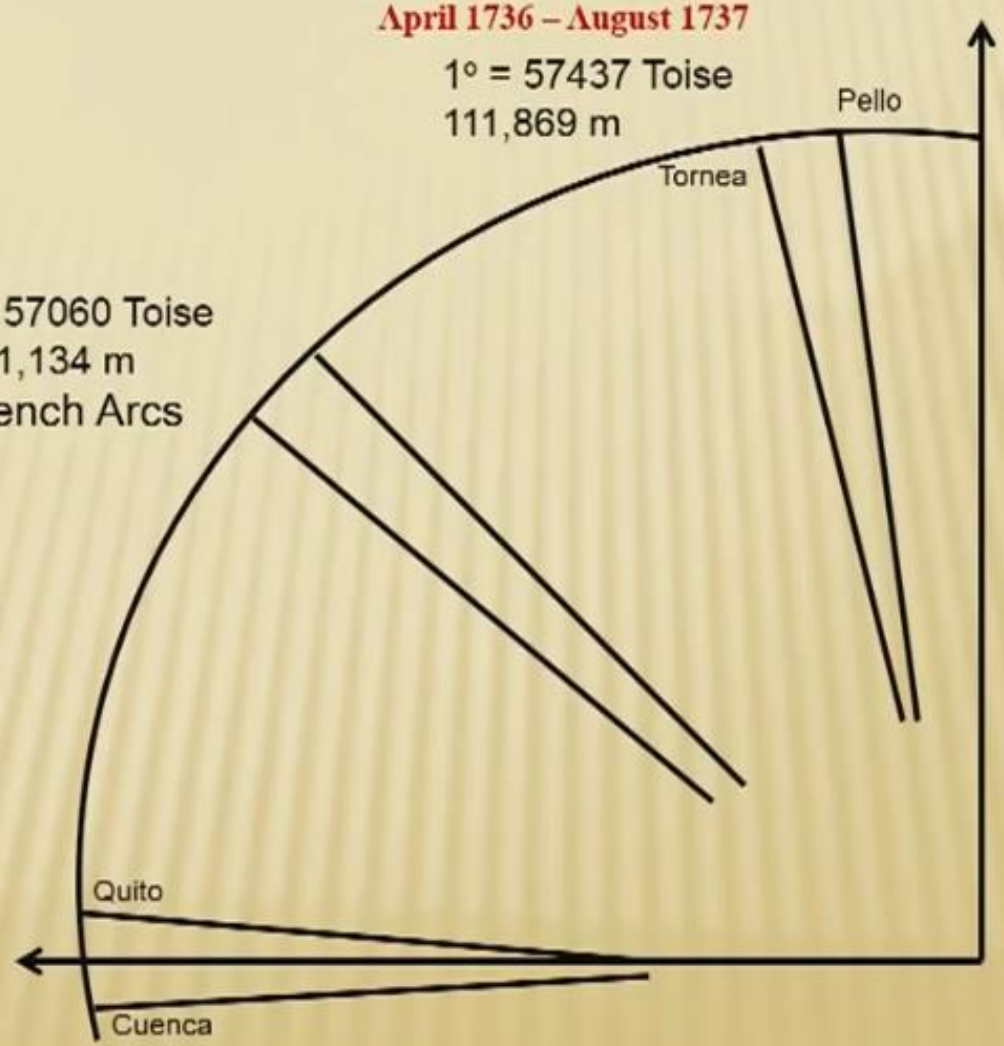
Expeditions of the French Royal Academy of Sciences

LAPLAND – Modern Finland
April 1736 – August 1737

1° = 57437 Toise
111,869 m

1 Toise ~ 1.95 m

1° = 57060 Toise
~ 111,134 m
French Arcs



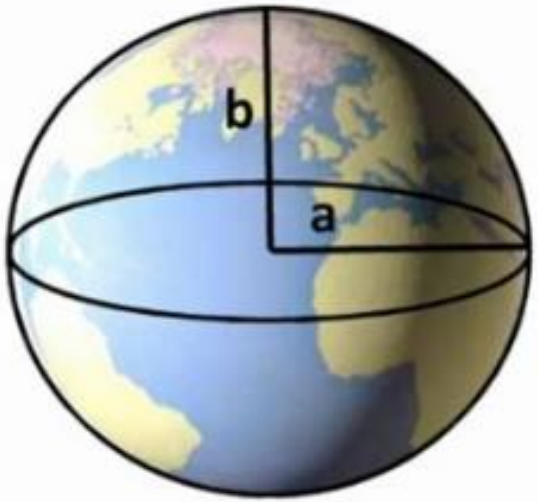
1° = 56753 Toise
110,536 m

PERU – Modern Ecuador
May 1735 – February 1745

Shape of the earth:

Sphere

a = b



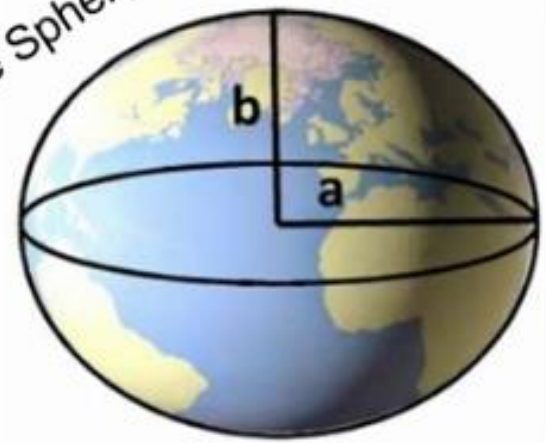
a = Semi major axis

b = Semi minor axis

Ellipsoid

a > b

a.k.a Oblate Spheroid



$\frac{a-b}{a}$ = flattening

Ellipse:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Circle: $x^2 + y^2 = a^2 = b^2$

Official Ellipsoid

- Geodetic surveys are conducted to measure locations on the surface of the Earth.
- Observed locations are used to fit an Ellipsoid to model the the shape of the Earth.
- Each country, continent or other comparably large areas have specific ellipsoid parameters to " Official Ellipsoid"

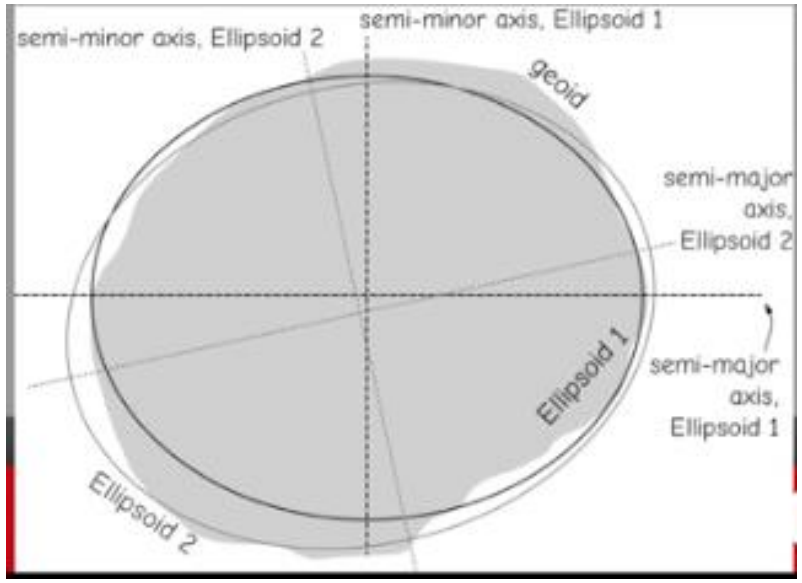
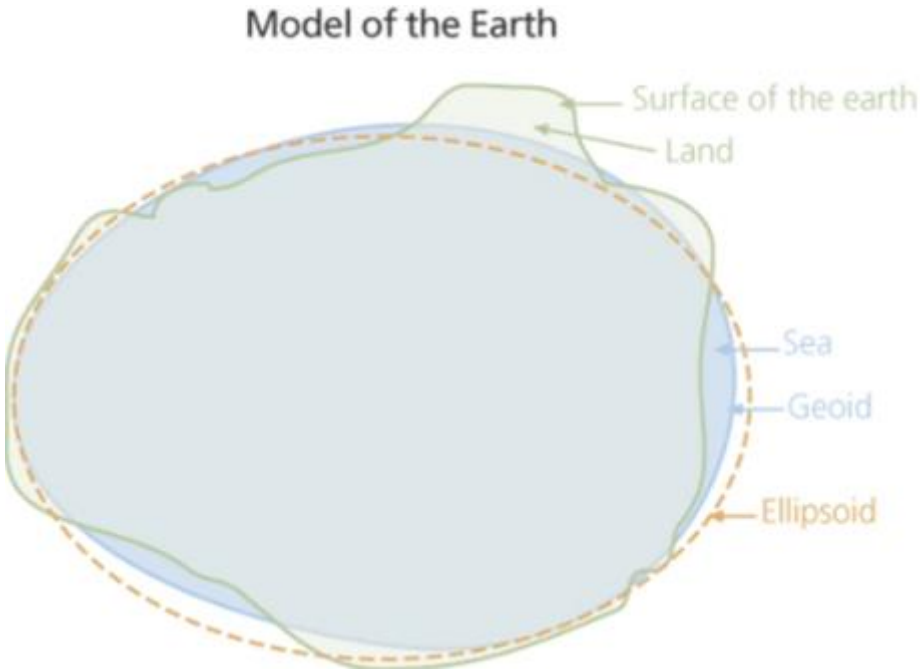


Table 3-1: Official ellipsoids. Radii may be specified more precisely than the 0.1 meter shown here (from Snyder, 1987 and other sources).

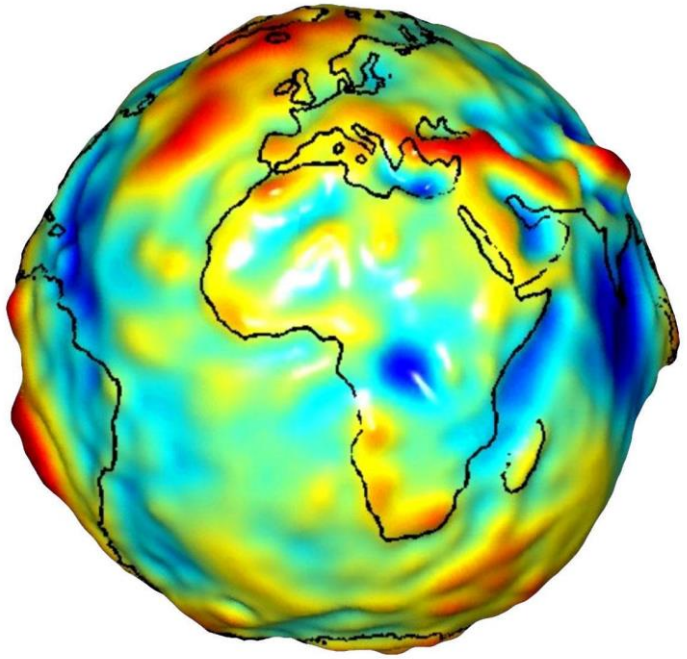
Name	Year	equatorial Radius, a meters	Polar Radius, b meters	Flatten-ing Factor	Users
Airy	1830	6,377,563.4	6,356,256.9	1/299.32	Great Britain
Bessel	1841	6,377,397.2	6,356,079.0	1/299.15	Central Europe, Chile, Indonesia
Clarke	1866	6,378,206.4	6,356,583.8	1/294.98	North America; Philip-pines
Clarke	1880	6,378,249.1	6,356,514.9	1/293.46	Most of Africa; France
Interna-tional	1924	6,378,388.0	6,356,911.9	1/297.00	Much of the world
Australian	1965	6,378,160.0	6,356,774.7	1/298.25	Australia
WGS72	1972	6,378,135.0	6,356,750.5	1/298.26	NASA, U.S. DOD
GRS80	1980	6,378,137.0	6,356,752.3	1/298.26	Worldwide
WGS84	1987 – current	6,378,137.0	6,356,752.3	1/298.26	U.S. DOD, Worldwide

What is the true shape of the Earth?

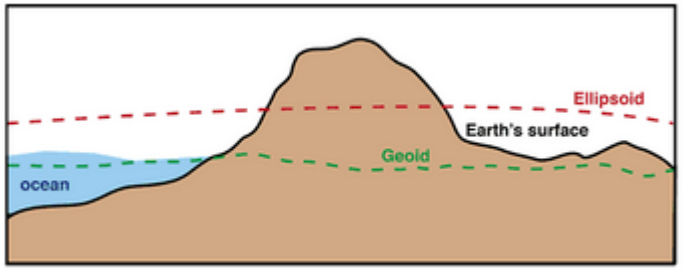
- With its mountains, valleys and plains, the Earth is an irregular body.
- Its surface is difficult to compute across and it is more convenient to use a shape close to sea level
- The true shape of the Earth varies from modeled ellipsoid due to variation in earh density.
- The variations in the Earth density change the gravitational field of the Earth.



Geoid

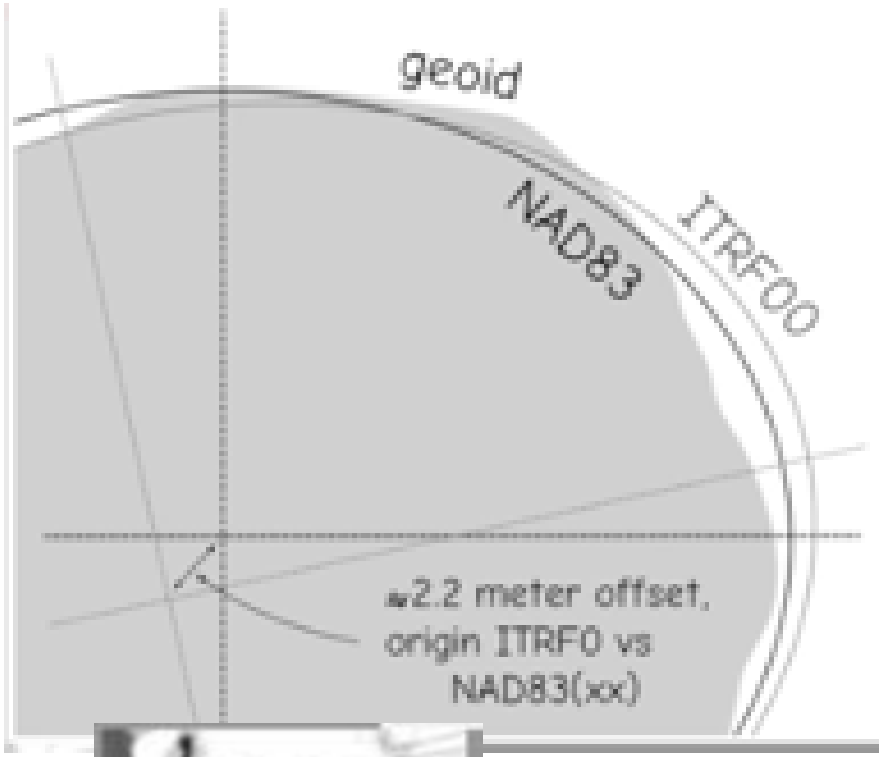


- A geoid is the irregular-shaped “ball” that scientists use to more accurately calculate depths of earthquakes, or any other deep object beneath the earth’s surface.
- The geoid An equipotential surface to which gravity is normal and most closely approximate mean sea level over the entire Earth.
- Geoid is a 3D surface along which the pull of gravity is a specified constant (e.g. $9.81\text{m}/s^2$)..
- World-wide, the difference between the geoid and mean sea level is at the most around 1 m.



Geodetic Datum

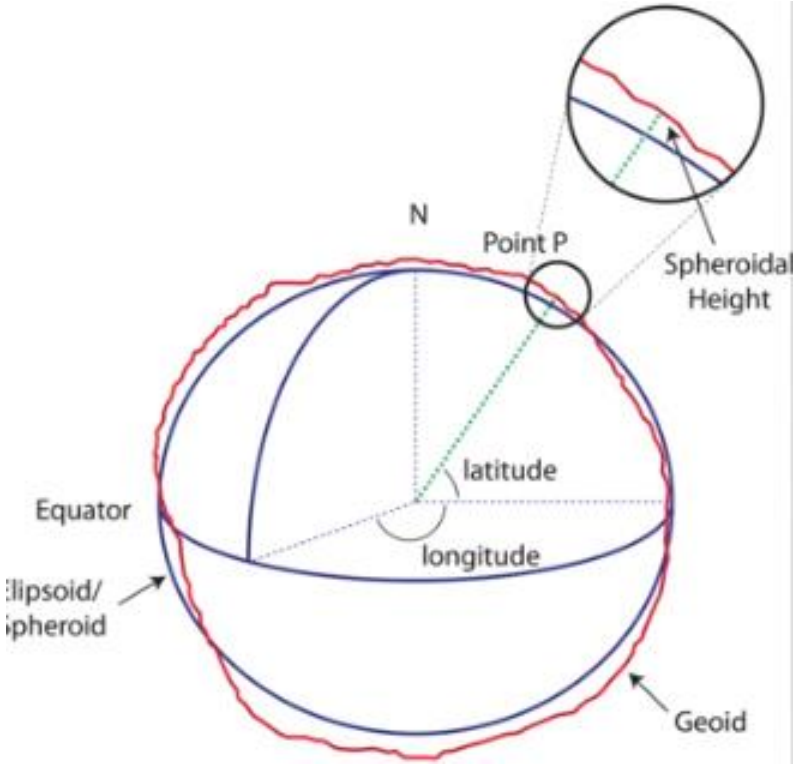
- Datum is a reference point, line or surface (plural of the word “data”).
- Geodetic datum is a reference surface used to locate points on the earth.
- An elipsoid that best fits ground measurements (benchmark points).
- Geodetic datum has eight parameters.
  - Size of the ellipsoid (a and b).
  - Origin of the ellipsoid (x, y, z).
  - Orientation of the ellipsoid (α, β, γ).
- Datum is adjusted as we collect more observational data (now from GPS)




Benchmark

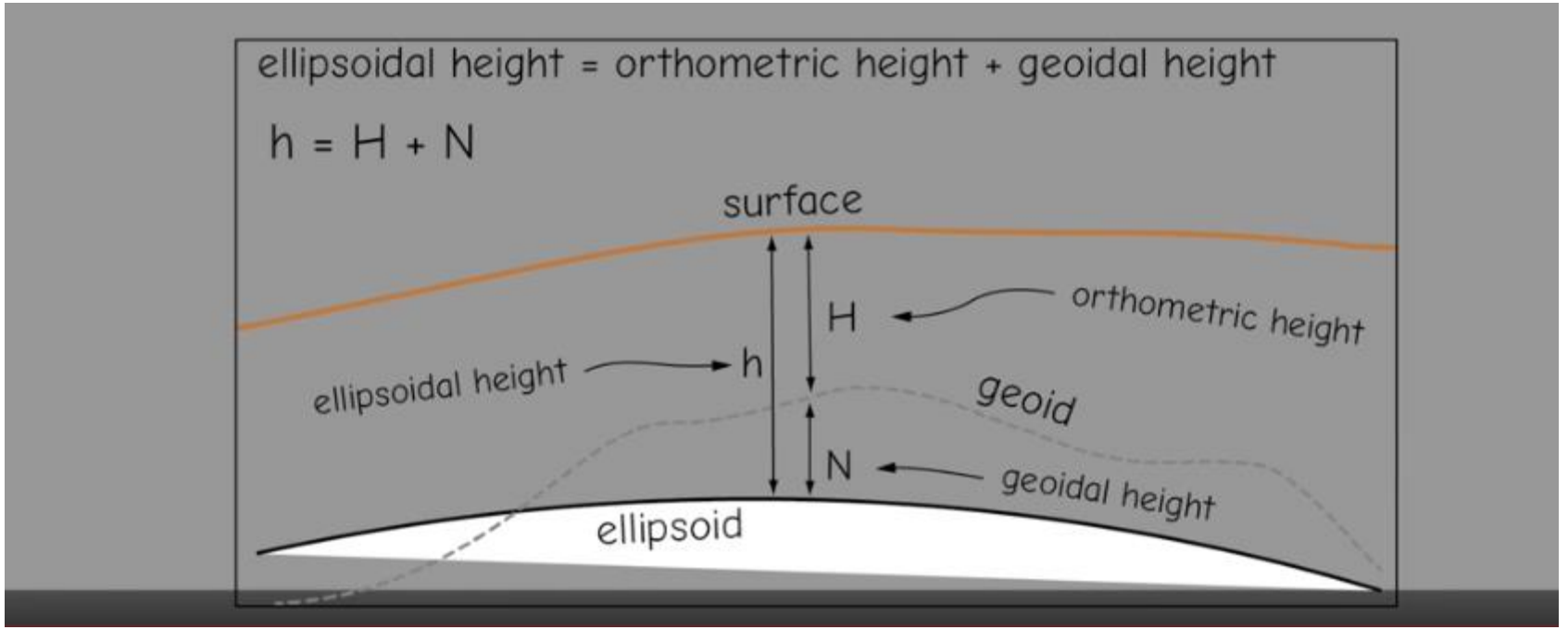
Horizontal datum:

- Horizontal datums precisely specify each location on the Earth's surface in latitude and longitude or other coordinate system.
- Horizontal datum is set by the chosen ellipsoid .
- Coordinate system is overlaid on the ellipsoid.
- Commonly used datums
  - NAD (North American Datum) ... 1927, 1983
  - WGS (World Geodetic Survey) ... 1984 and later
  - ITRS (International Terrestrial Reference Frame)... 1988 and later
  - ITRS is gradually becoming the world standard.



Vertical datum:

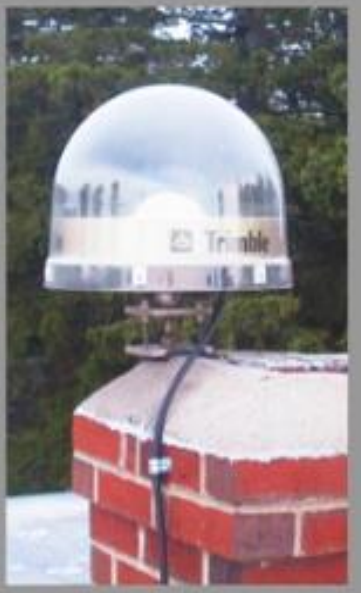
- A vertical datum is used for measuring the elevations of points on the earth's surface. They are used as a reference for specifying land elevations and water depths.
- Both Ellipsoid and geoid are used as a vertical datum

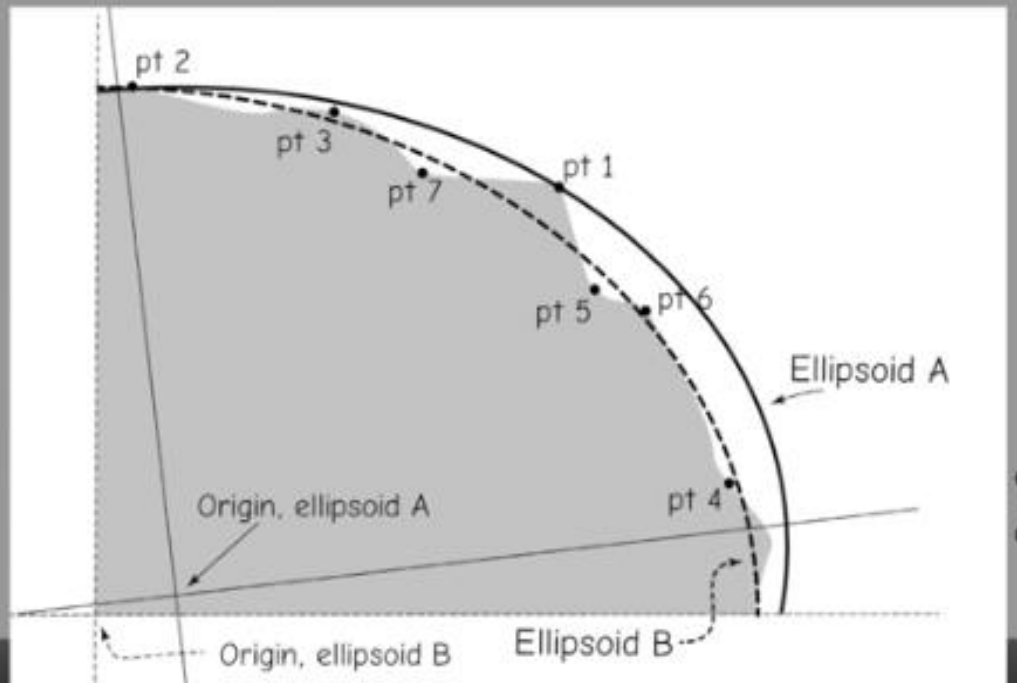


Datum adjustment

- Datum is adjusted as we collect more observational data
- GPS satellite data is used to gradually improve the datum
  - HARN (High Accuracy Reference Network) ... Private Survey
  - CORS (Continuously Operating Reference System) .... Based on GPS satellites

CORS Station



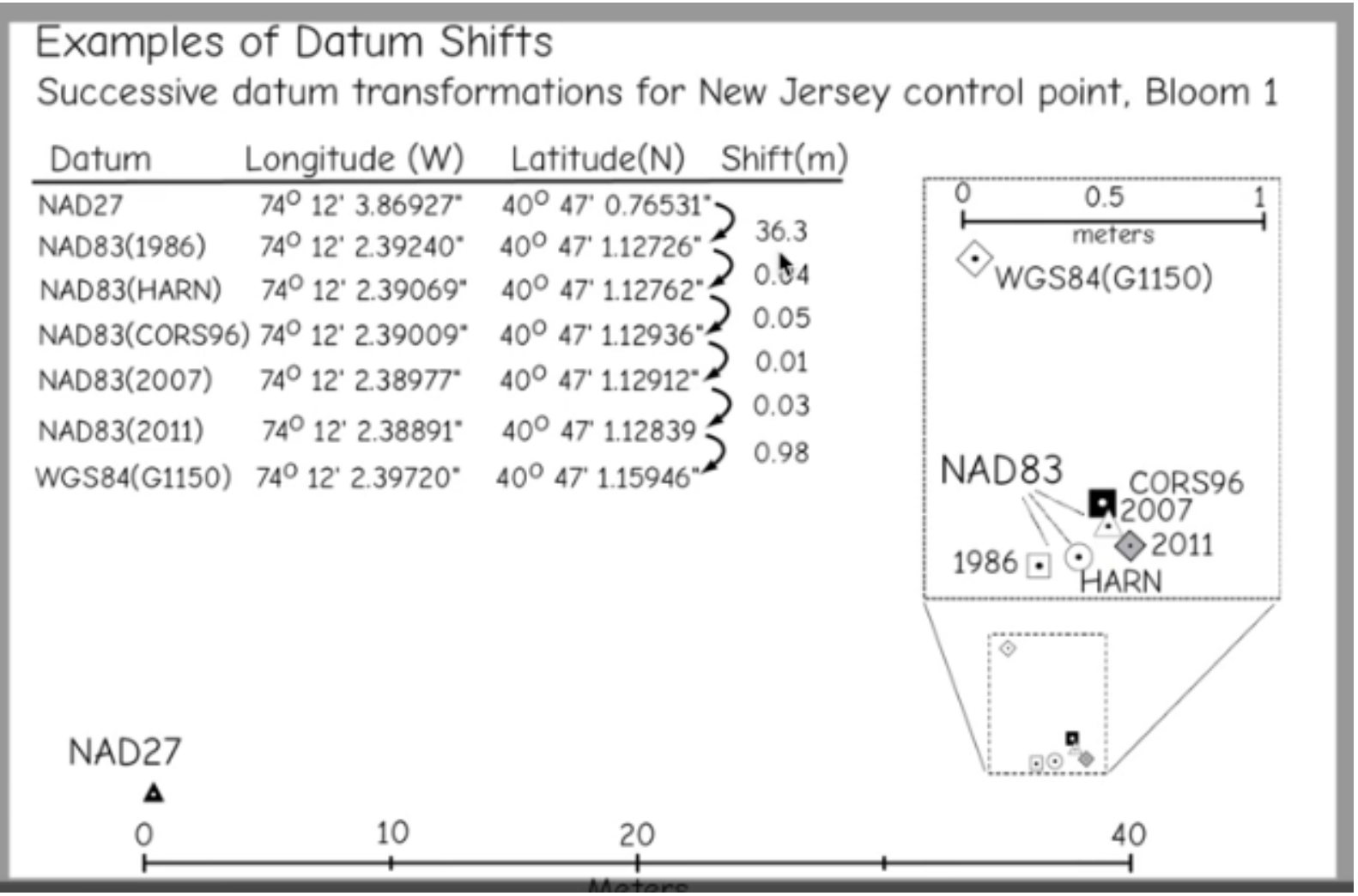


- Ellipsoid A is based on pt 1 and pt 2
- Ellipsoid B is achieved based on additional survey points pt 3 to pt 7

Datum shift

Datum adjustments result in shifting in the coordinates of points in the surface

The point on the surface is not shifted but coordinate system has changed



Summary

https://www.youtube.com/watch?v=WzAYu5eZXr4

THANKS