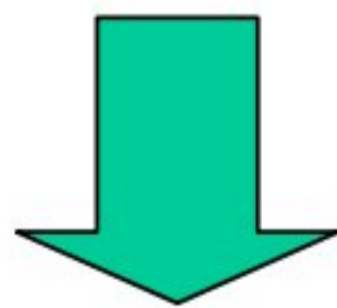


What is a Map?

Definition of Maps:

- A graphic depiction on a flat medium of all or part of a geographic realm in which real world features have been replaced with symbols in their correct spatial location **at a reduced scale.**
- To map is to transform information from one form to another --- Mathematics



• Earth surface $\xrightarrow{\text{map}}$ Paper --- Geography

Models of the Earth

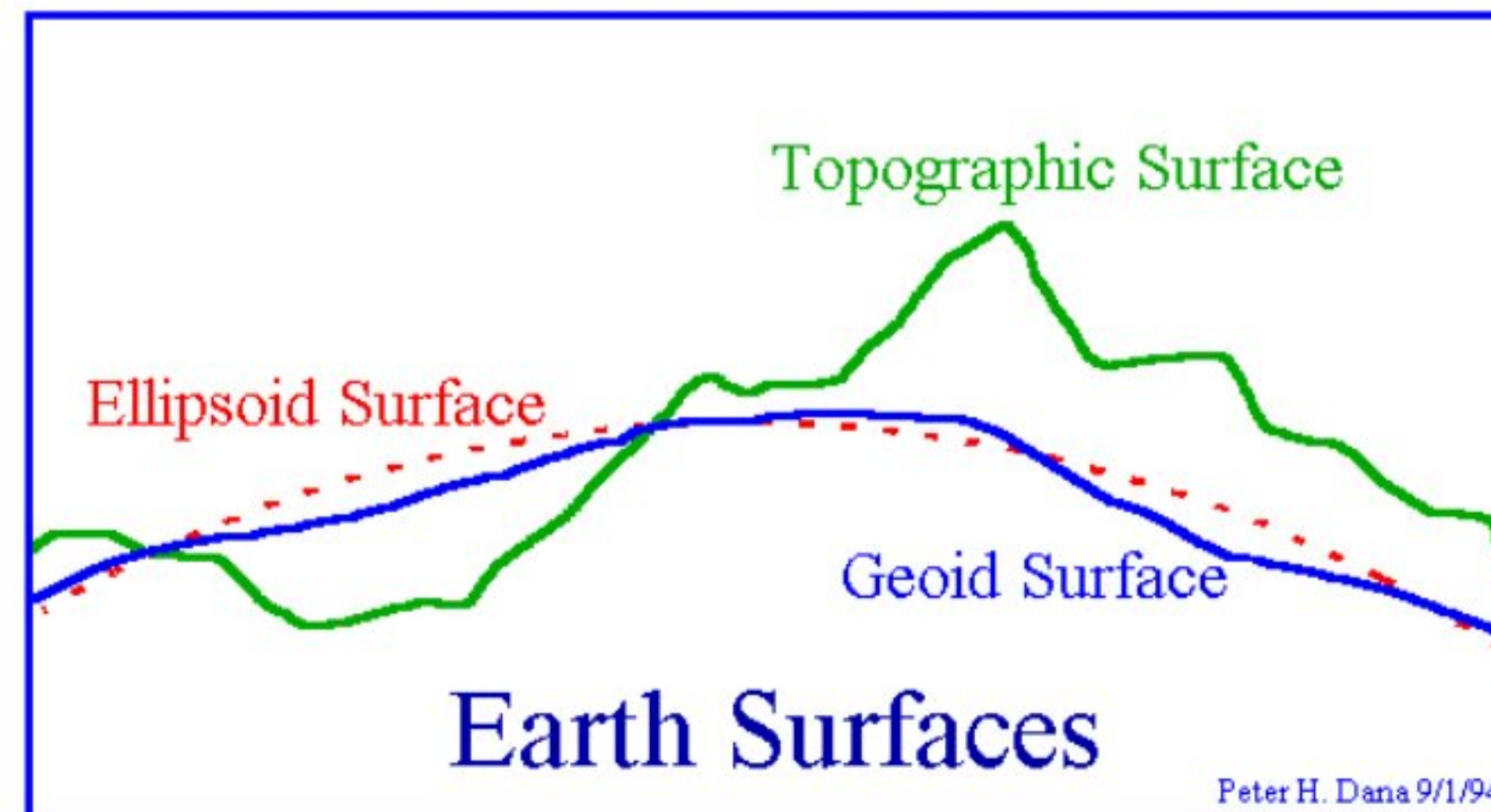
A Sphere



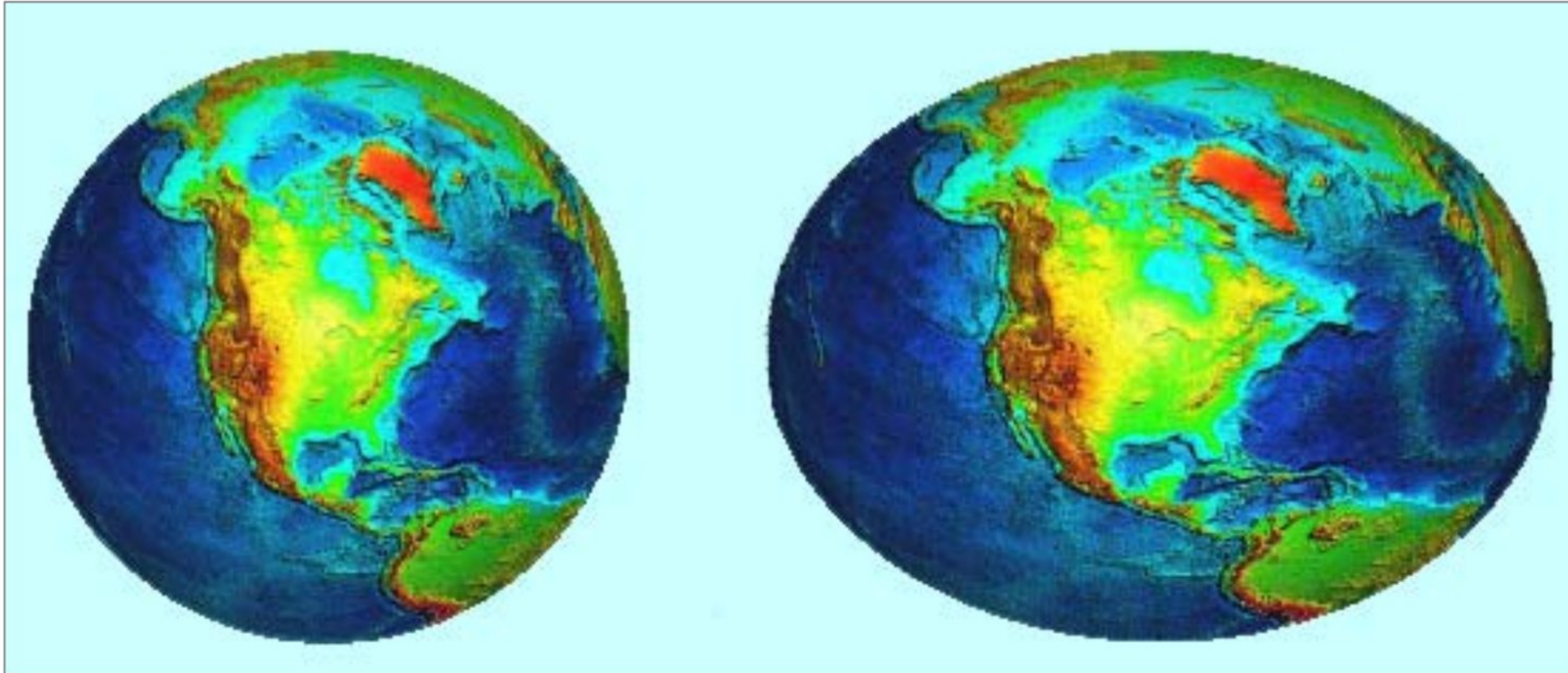
An Ellipsoid



A Geoid



Earth Shape: Sphere and Ellipsoid



Pole to pole distance: 39,939,593.9 meters

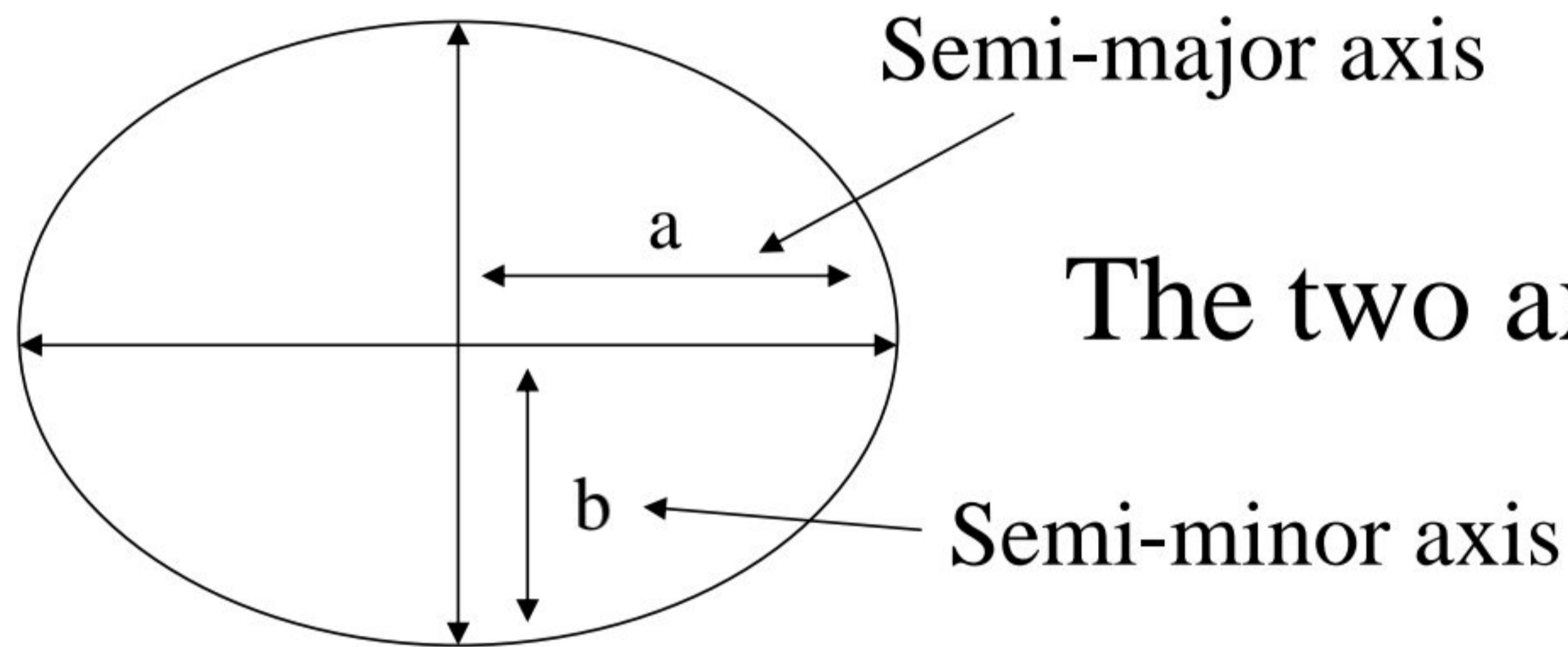
Around the Equator distance: 40,075,452.7 meters

Earth Shape: Sphere and Ellipsoid

- The sphere is about **40 million meters** in circumference.
- An **ellipsoid** is an ellipse rotated in three dimensions about its shorter axis.
- The earth's ellipsoid is only **1/297** off from a sphere.
- Many ellipsoids have been **measured**, and **maps based on each**. Examples are WGS84 and GRS80.

Ellipticity of the Earth

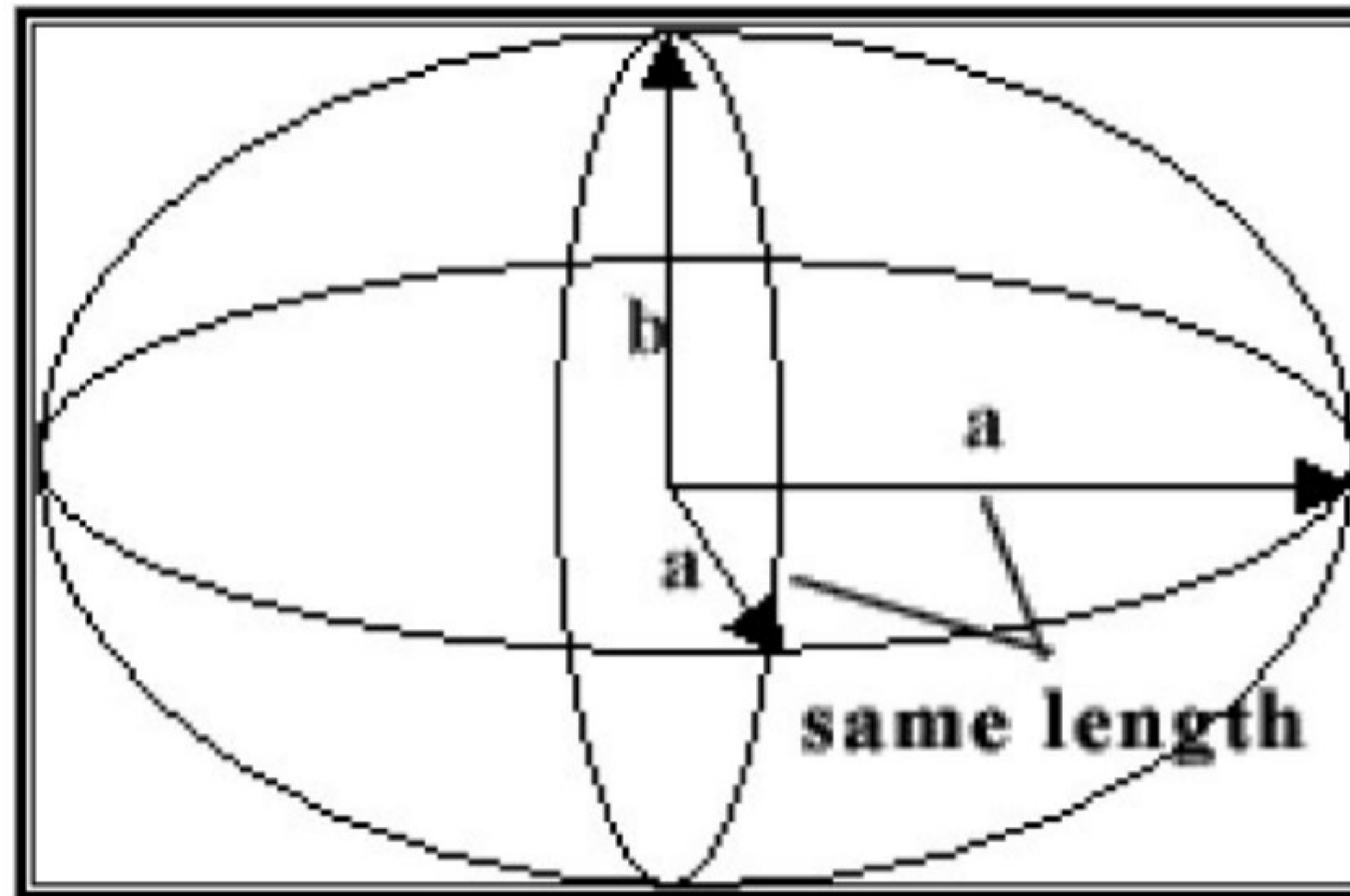
- **How far** is the **Earth** from being a perfect sphere?



The two axes of an ellipsoid

- Using these two axes' lengths we can calculate the **ellipticity** (flattening) of an ellipsoid, with $f = 0$ being a perfect sphere and $f = 1$ being a straight line

Ellipticity of the Earth

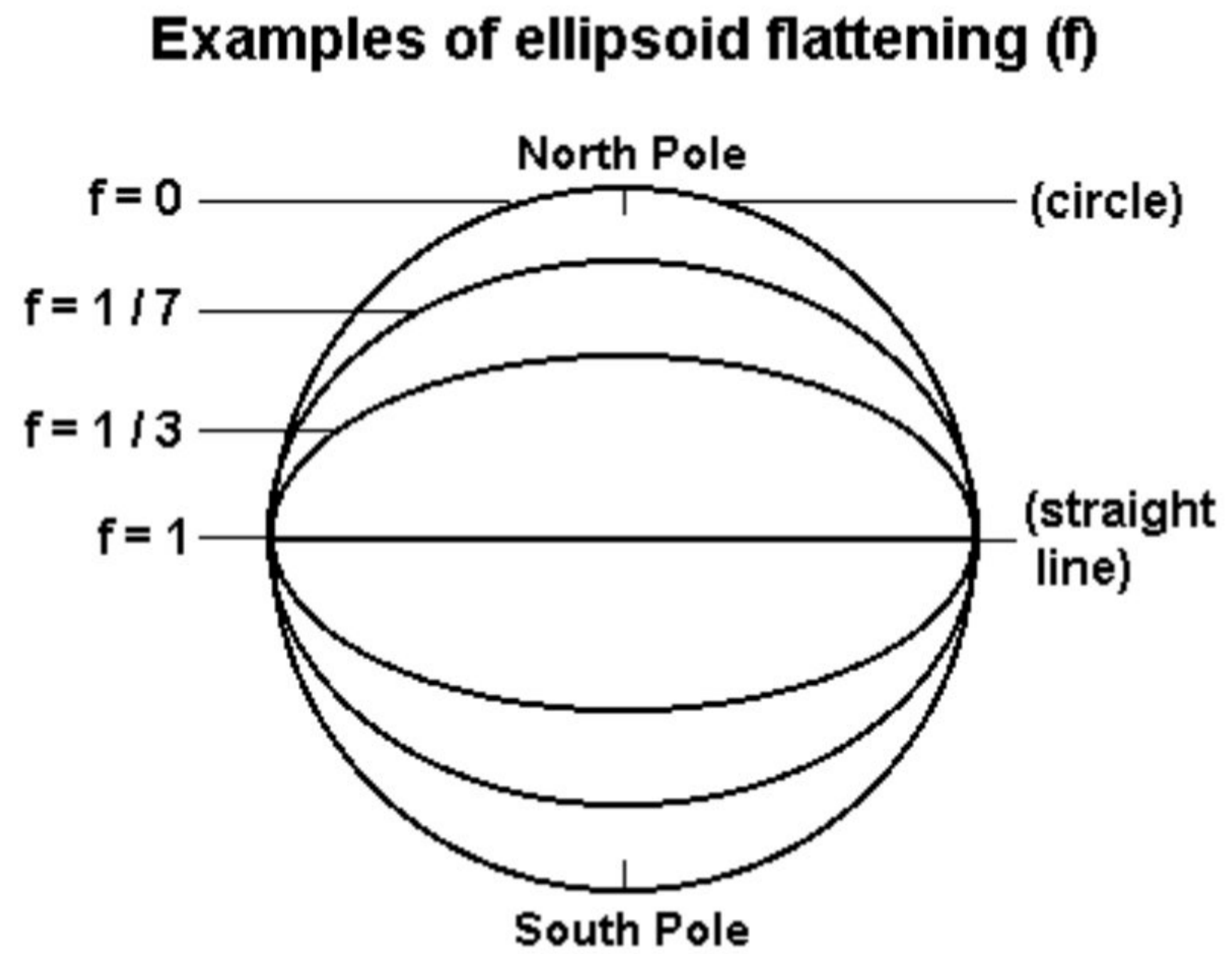


- a = semi-major axis
- b = semi-minor axis
- $f = [(a - b) / a] = \text{flattening}$

Ellipticity of the Earth

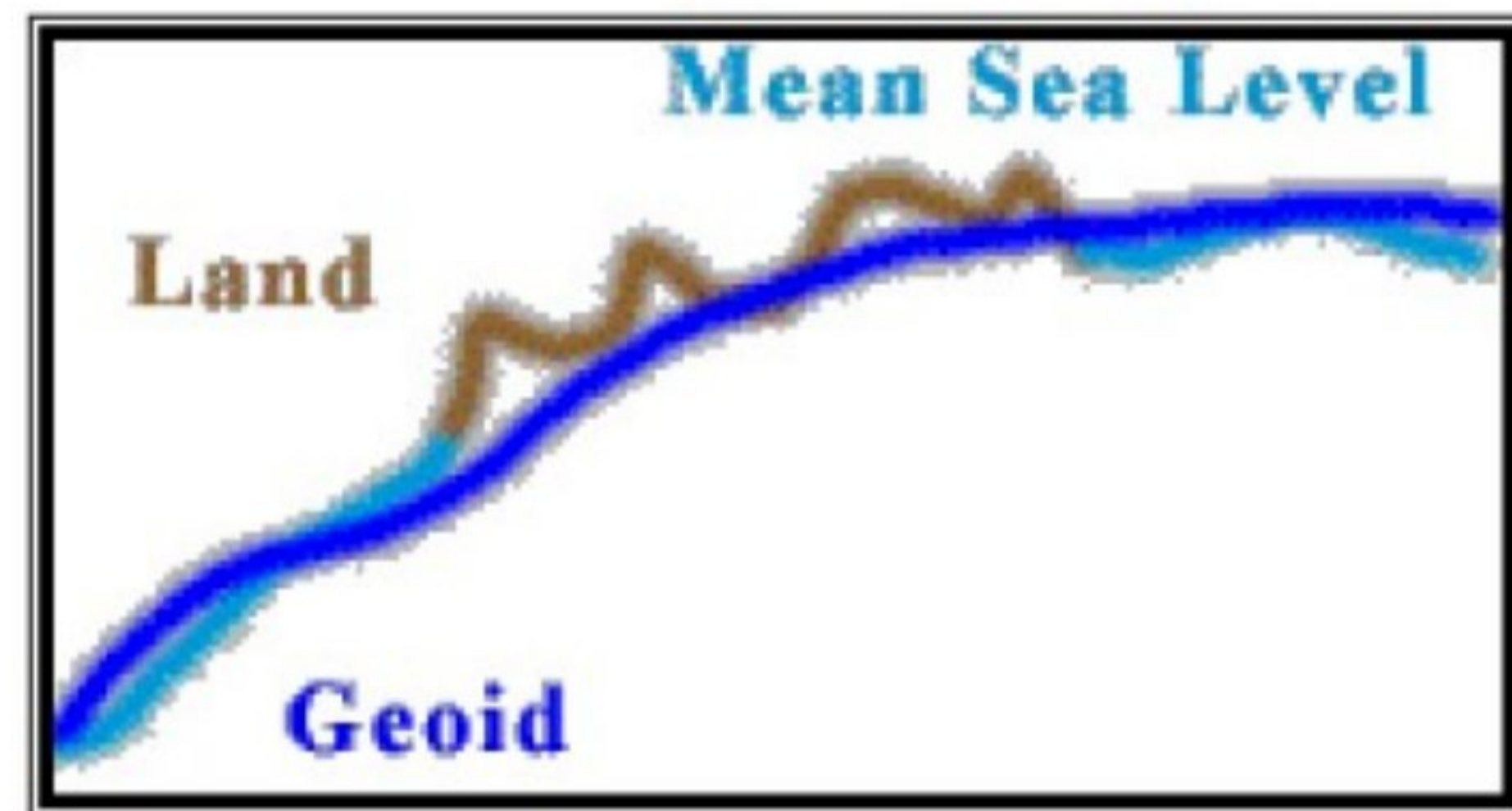
- **Newton** estimated the Earth's ellipticity to be about $f = 1/300$
- **Modern satellite technology** gives an $f = 1/298$ (~ 0.003357)

↑
These small values of f tell us that the Earth is very close to being a sphere, but not close enough to ignore its ellipticity if we want to accurately locate features on the Earth



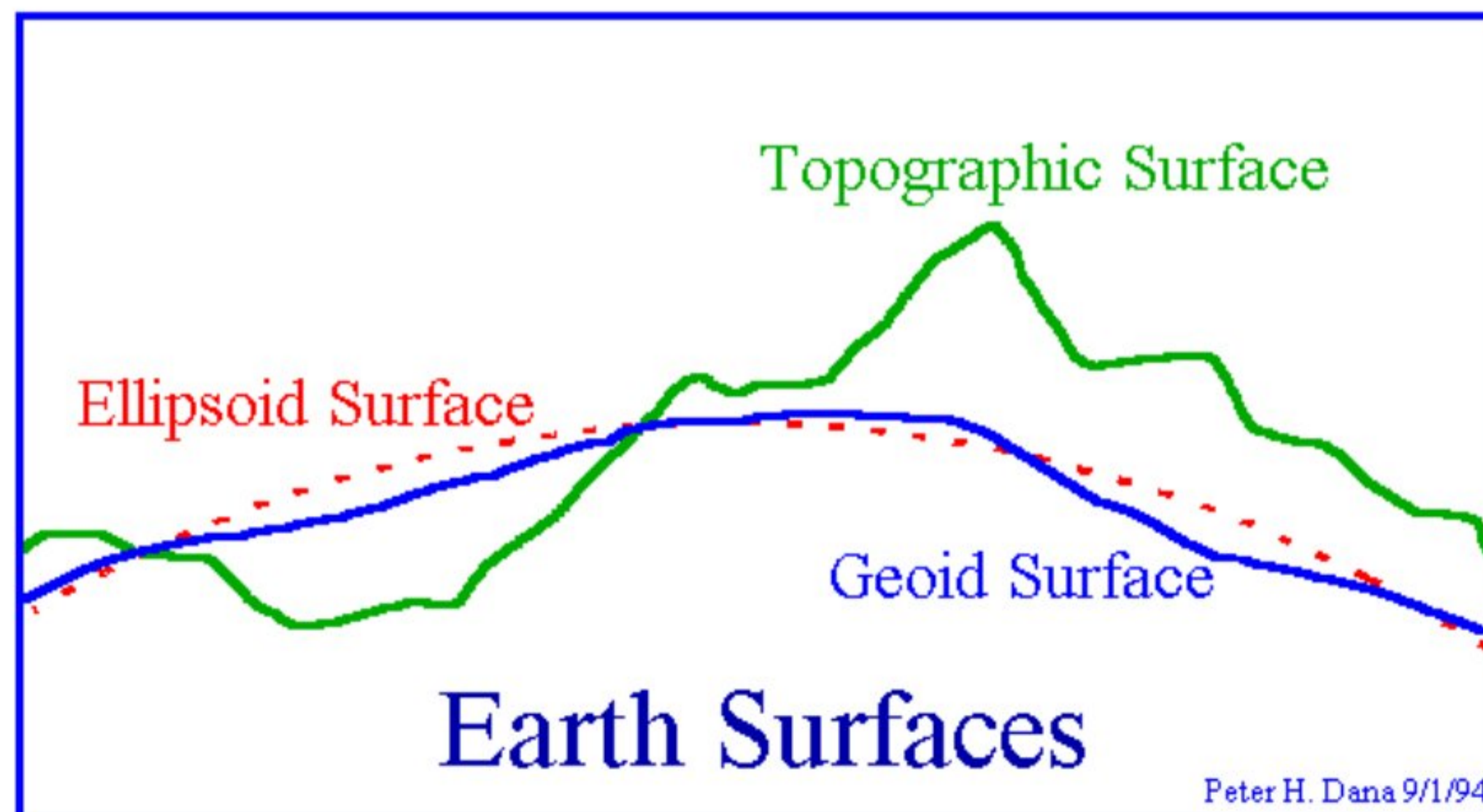
The Earth as a Geoid

- Rather than using a regular shape like an ellipsoid, we can create a **more complex** model that takes into account the **Earth's irregularities**
- The only thing shaped like the Earth is the Earth itself, thus the term **Geoid**, meaning “Earth like”
- Its **shape** is based on the Earth's gravity field, correcting for the centrifugal force of the earth's rotation.



The Earth as Geoid

- **Geoid** → The surface on which gravity is the same as its strength at mean sea level
- **Geodesy** is the science of measuring the size and shape of the earth and its gravitational and magnetic fields.



Geodetic Datum

- In order to manage the complexities of the shape of a geoid model of the Earth, we use something called a **geodetic datum**
- **Datum** -- *n.* (dat - m) \ any numerical or geometric quantity which serves as a reference or base for other quantities
- A geodetic datum is used as a **reference base** for mapping
- It can be **horizontal or vertical**
- It is always tied to a **reference ellipsoid**

Datums

- An ellipsoid gives the **base elevation** for mapping, called a **datum**.
 - North American Datum 1927 (NAD27)
 - North American Datum 1983 (NAD83)
- Particular datums are **based on specific spheroids**:
 - NAD27 is based on the Clarke 1866 spheroid
 - NAD83 is based on the GRS_1980 spheroid
- **Conversions** between datums are called **transformations**

Earth Models and Datums

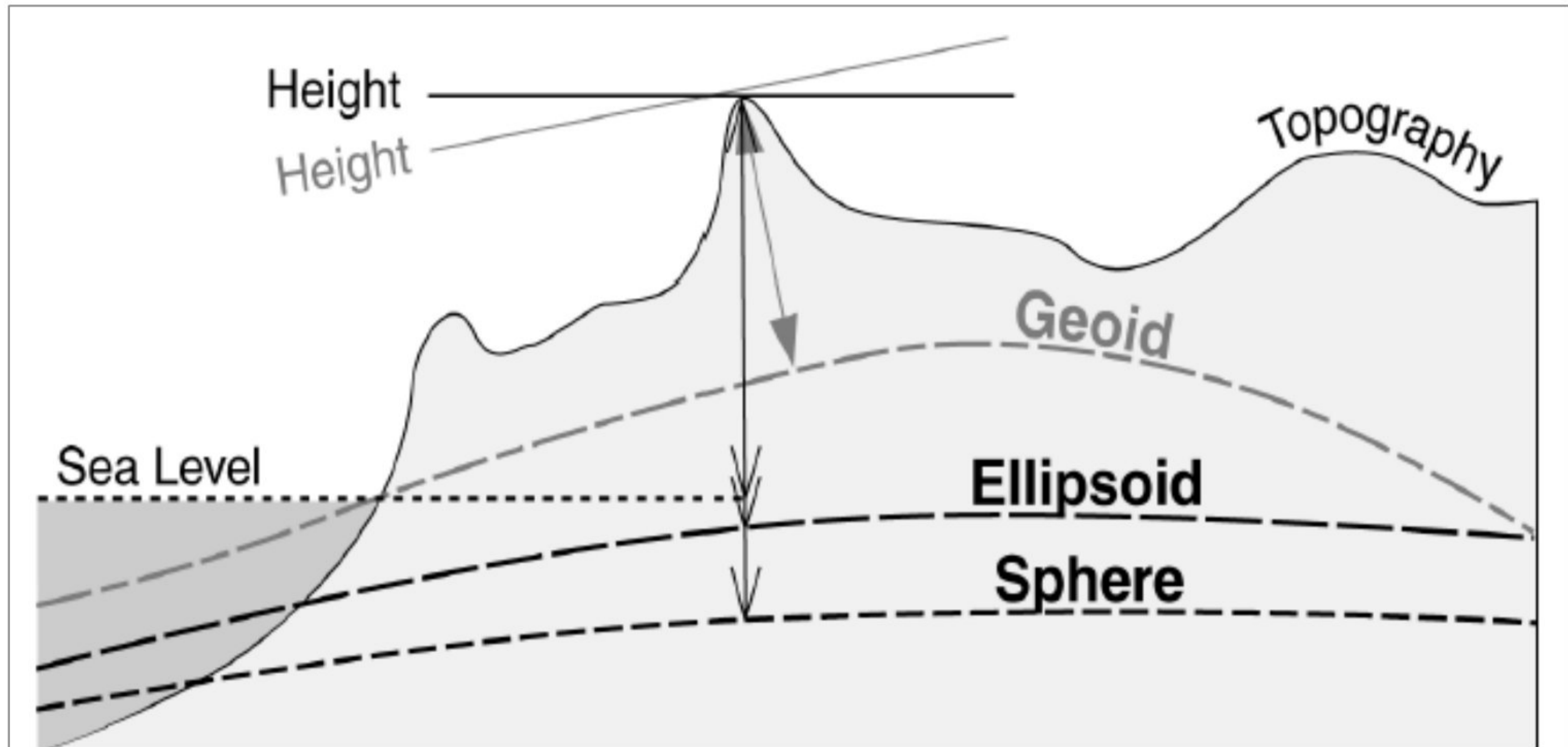
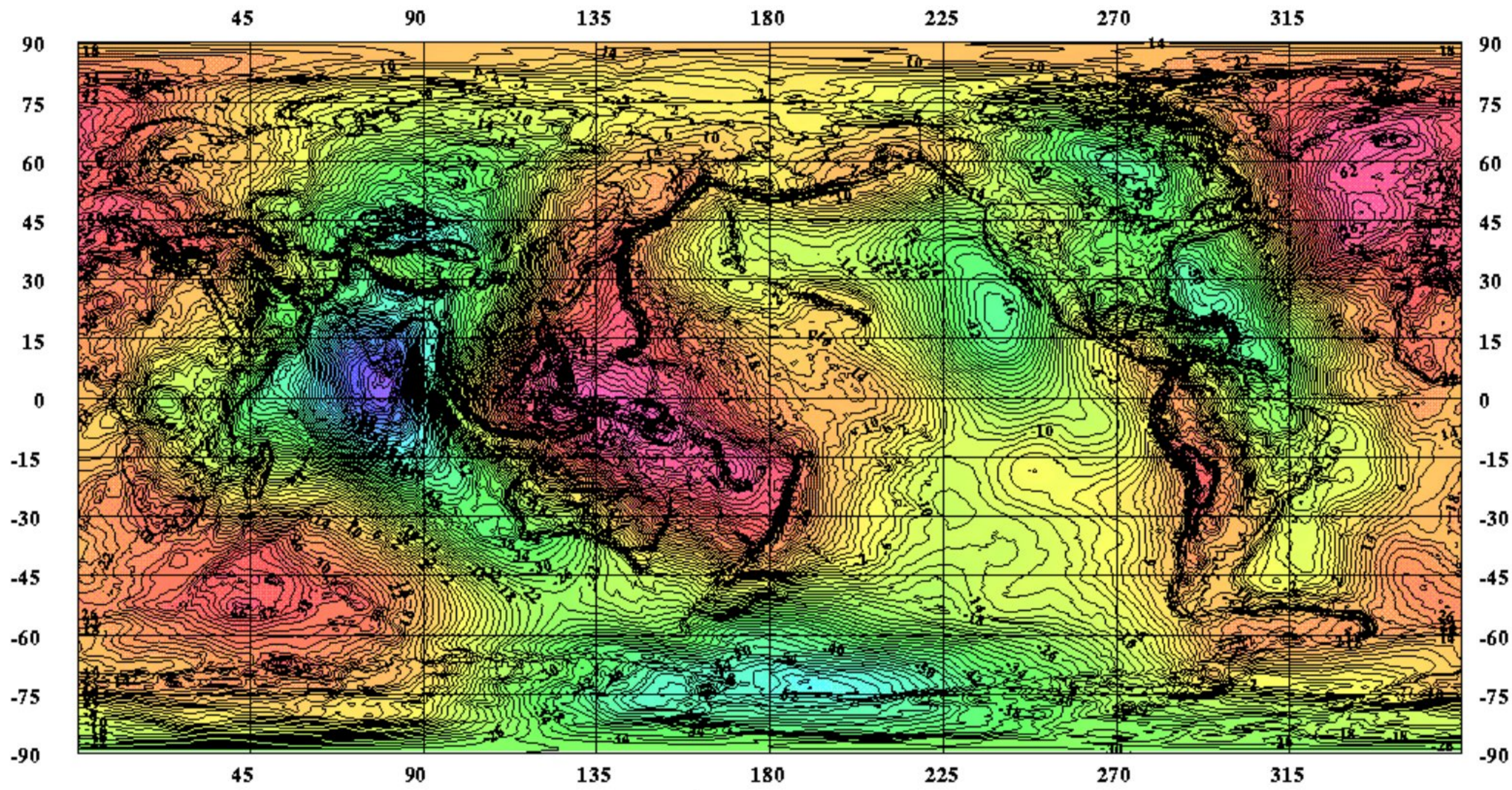


Figure 2.4 Elevations defined with reference to a sphere, ellipsoid, geoid, or local sea level will all be different. Even locations as latitude and longitude will vary somewhat. When linking field data such as GPS with a GIS, the user must know what base to use.

Geoid



EGM96 15 MINUTE GEOID CI = 2 Meters

-105.0  85.0 Meter