Earth's shape

The earth is generally viewed as a sphere; however its shape is not as perfect as a sphere in reality. Given below are the models that have attempted to describe the shape of the earth:

Spherical model

Based on a circle, it treats earth as a sphere to make mathematical calculations easier.

Ellipsoid/ Oblate spheroid model

- Based on an ellipse, rotating an ellipse around the semi-minor axis creates an ellipsoid. Latitude, longitude and planar coordinate systems are determined with respect to the ellipsoid.
- Earth is flattened at poles with a bulge at equator and this is attributed to the earth's rotation. Rotation of earth has centrifugal force associated with it, which causes an object to move away from the centre of gravity. The force is greatest at equator causing an outward bulge and thus giving that region a larger circumference

Geoid model

- Describes unique and irregular shape of the earth. The variation in the density of different rock types and irregularities caused by mountain ranges and ocean depths affect the gravity of earth.

- Geoid can be perceived as a sea level surface (where dynamic effects such as tides and waves are excluded) whose irregular shape is attributed to the earth's gravity

- No simple surface such as sphere or spheroid/ellipsoid can model the sea level surface completely so best fit of the spheroid/ellipsoid to the sea level surface is performed.

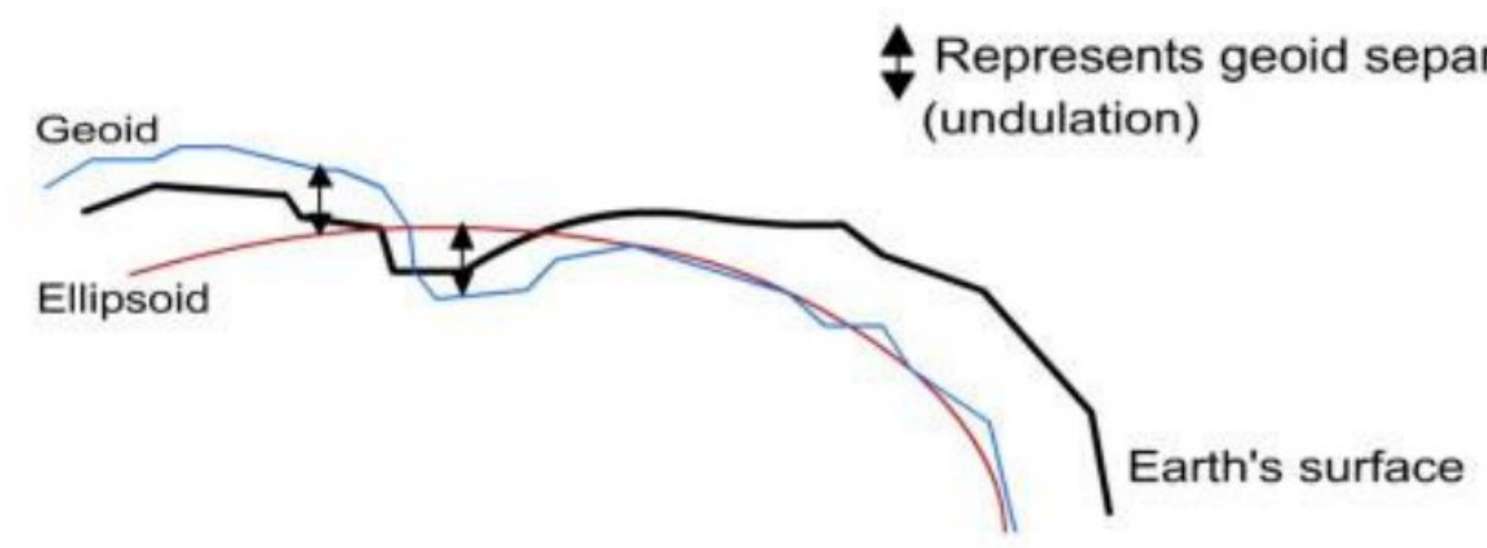

Figure 1: Representation of geoid model

- The geoid differs from the shape of ellipsoid by upto ± 100 m and this difference is known as geoid separation or geoid undulation

- Elevations and contour lines depicted on maps are measured with respect to the geoid

Datums

A datum is a reference point or surface against which measurements are made using models of the shape of the earth.

Vertical Datum : A vertical datum is a reference surface used to measure elevations of the point on earth's surface. It is tidal, based on sea level, or geodetic, based on ellipsoid

The tidal vertical datum takes local mean sea level as reference for height measurement. Mean sea level is the arithmetic mean of the hourly water elevation taken over a specific 19 years cycle which is defined as zero elevation for local area and is close approximation to the geoid (geoid and local mean sea level differ by not more than a couple of meters). As zero elevation defined for one country is not necessarily same for other countries, therefore a number of local vertical datums are defined.

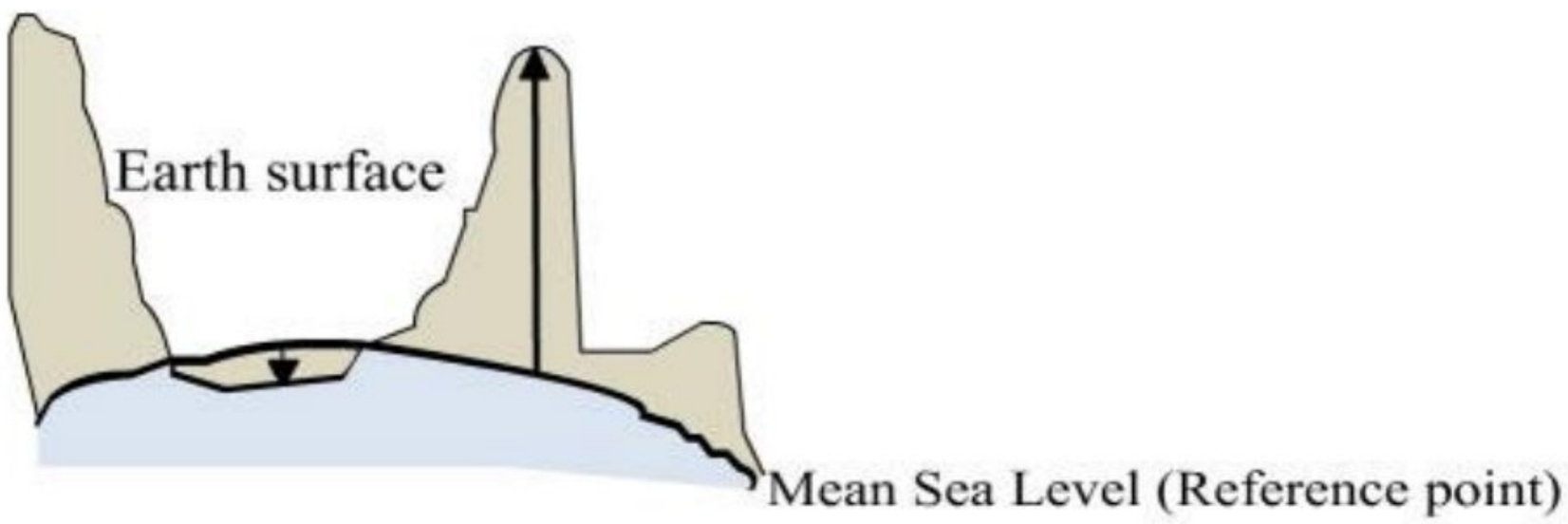

Figure 2 : Vertical Datum

The mean sea level height is also known as orthometric height or geoid height.

The geodetic vertical datum uses ellipsoid as the reference surface. The surface of the ellipsoid is considered to represent zero altitude. Points above the ellipsoid represent positive altitude and points below the surface represent negative altitude. The altitude is also known as ellipsoidal or geodetic height. GPS devices furnish ellipsoidal heights.

The relationship between ellipsoidal height H and geoid height h is given as

$$H = h + N$$

where N refers to the geoid ellipsoid separation.

Horizontal datum : A horizontal or geodetic datum is defined as an ellipsoid which is used as a reference surface for the planimetric measurements on the Earth surface usually expressed in latitudes and longitudes. It can be of two types:

a. Local geodetic datum: The one which best approximates the size and shape of a particular part of earth's sea level surface. The centre of this spheroid doesn't coincide with centre of mass of the earth

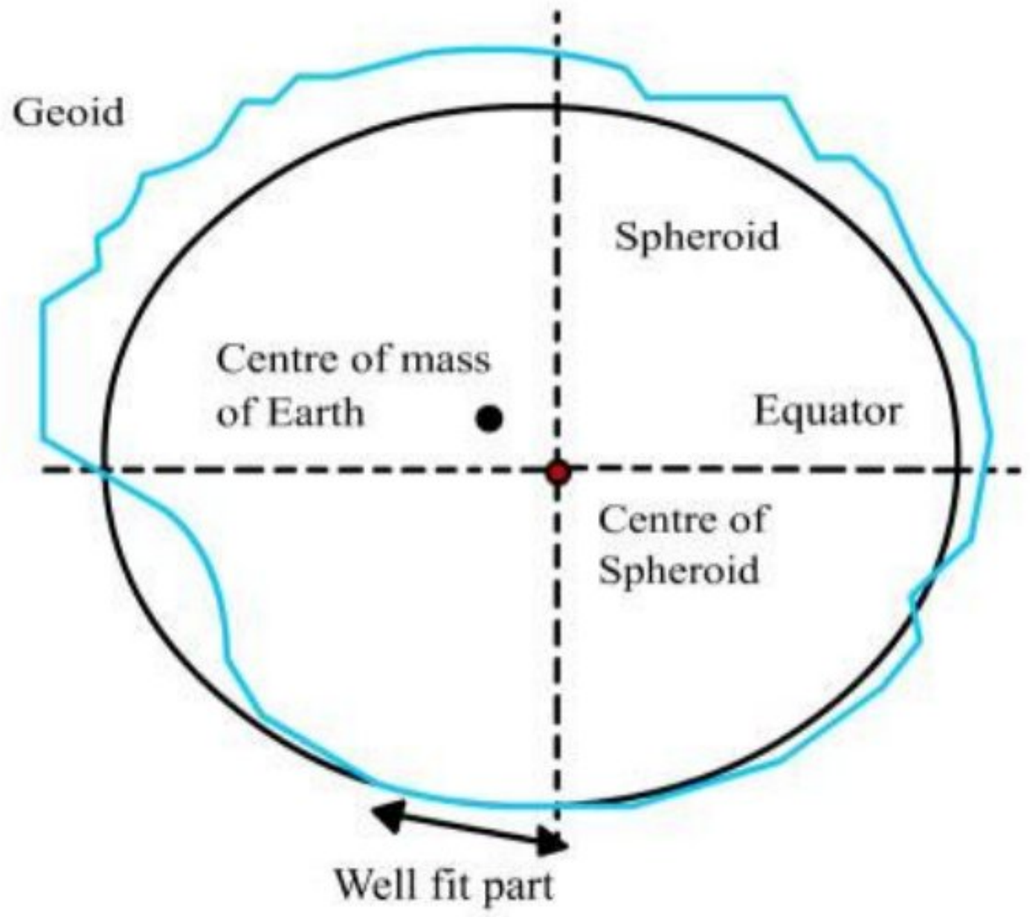

Figure 3: Local geodetic datum

b. Global/Geocentric datum: The one that best approximates the size and shape of the whole earth. The centre of this spheroid coincides with centre of mass of the earth. The US Global Positioning System uses geocentric datum

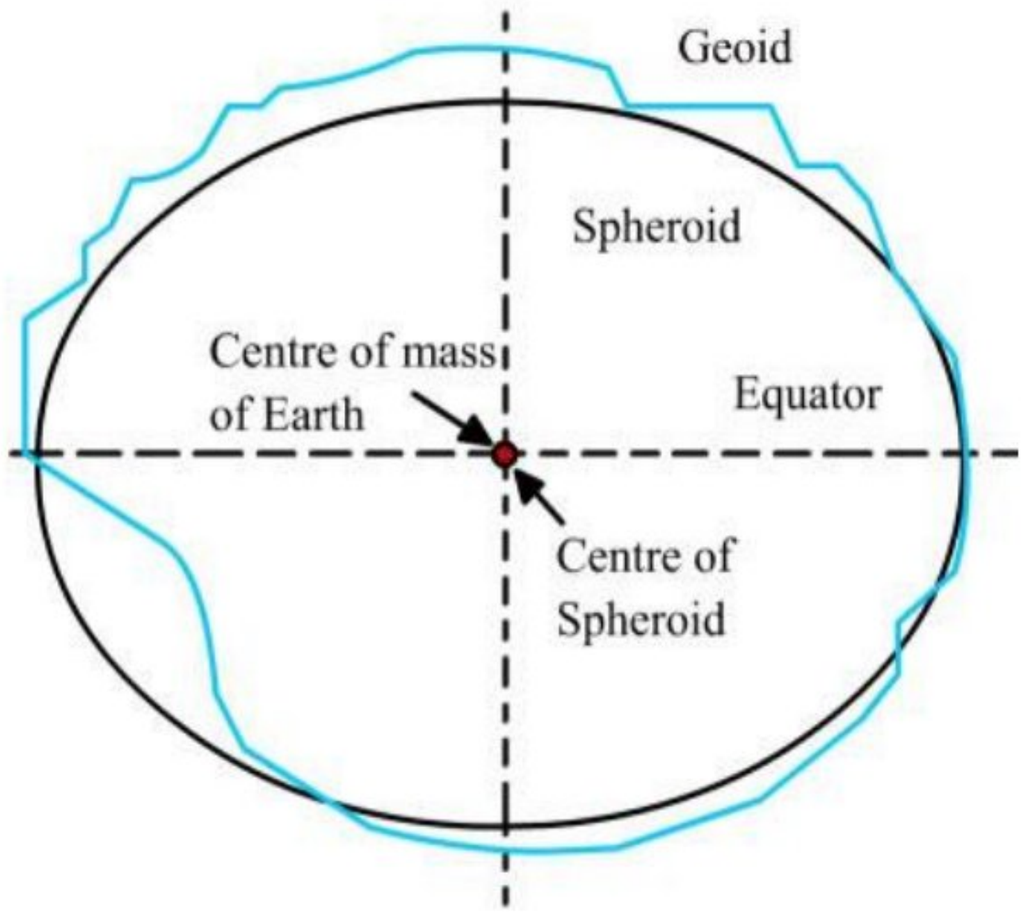

Figure 4: Geocentric datum

The use of local datums results in uneven connectivity of longitudinal and latitudinal lines between different countries/regions. These mismatches were common over hundred meters and created confusion about locating an

area correctly. With the advent of Global Positioning System (GPS) technology this disagreement was no longer acceptable. World-wide datums which are now used in all countries/regions began to be developed.

The datum presently used for GPS is called WGS 84 (World Geodetic System 1984). It consists of a three-dimensional Cartesian coordinate system and an associated ellipsoid. The positions can either be described as XYZ Cartesian coordinates or latitude, longitude and ellipsoid height coordinates. The origin of the datum is the centre of mass of the Earth and it is designed for positioning anywhere on Earth.

Did you know?

The US GPS (Global Positioning System) uses WGS 84 as its datum whereas it's alternative GLONASS (Global Navigation Satellite System), a radio based satellite navigation system operated by Russia uses PZ-90 (Parametrop Zemp 1990) as its datum.