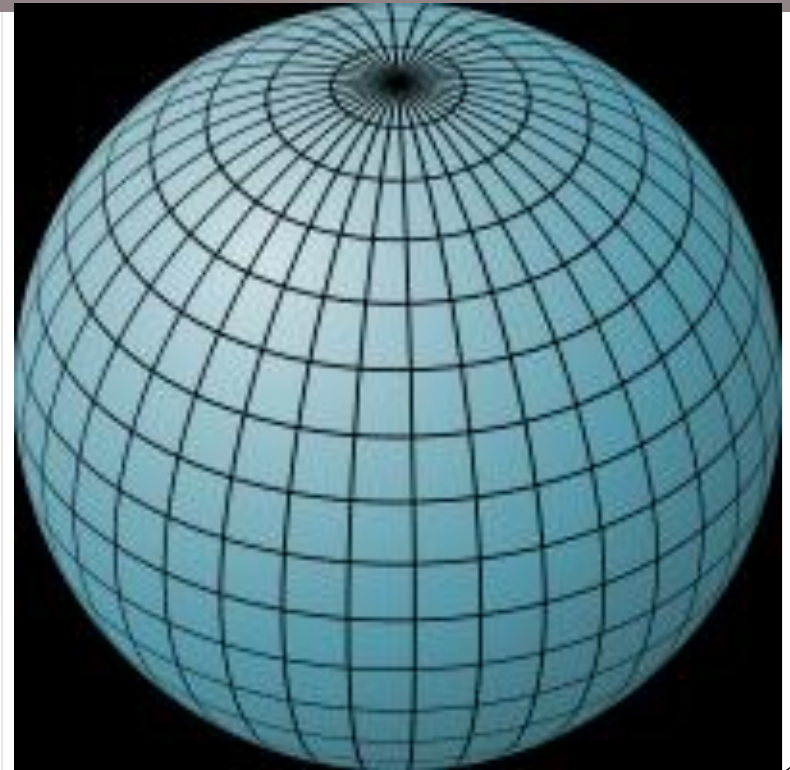
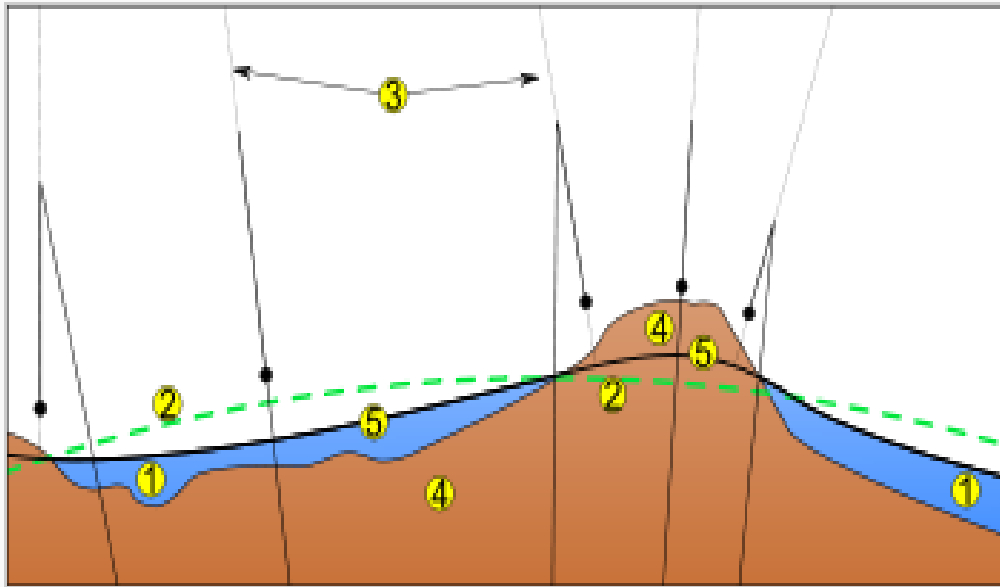


LATITUDE AND LONGITUDE

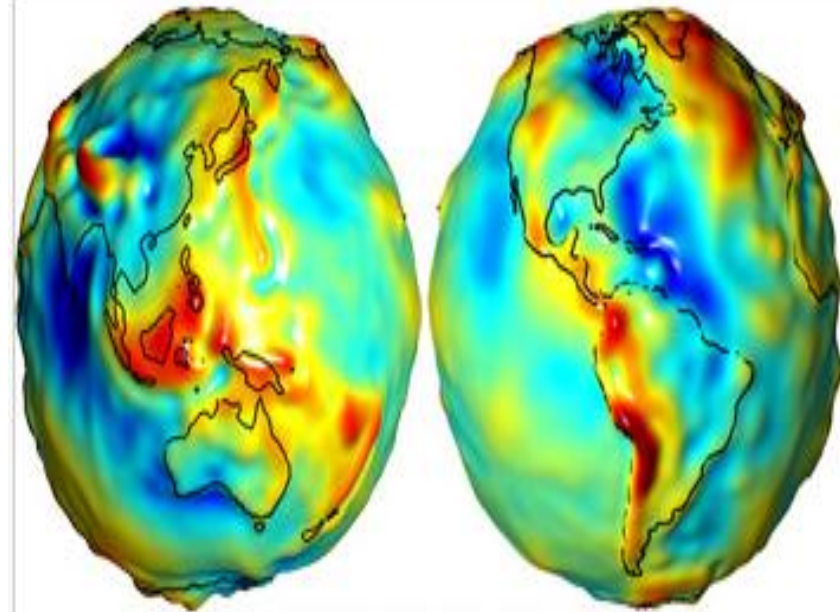


Shape of the Earth

- The Earth is **not a sphere**,
- but an irregular shape approximating a **biaxial ellipsoid**.
- It is nearly spherical, but has an equatorial bulge making the radius at the equator about **0.3% larger than the radius measured through the poles**.
- Though early navigators thought of the sea as a flat surface that could be used as a **vertical datum**, this is far from reality.
- The Earth has a series of layers of equal **potential energy** within its **gravitational field**.
- Height is a measurement at right angles to this surface, roughly toward the centre of the Earth, but local variations make the **equipotential layers irregular** (though roughly ellipsoidal).
- The choice of which layer to use for defining **height is arbitrary**.
- The reference height we have chosen is the one closest to the average height of the world's oceans. This is called the **geoid**.



1. Ocean
2. Reference ellipsoid
3. Local plumb line
4. Continent
5. Geoid



Earth's Gravity Field Anomalies (milligals)

-50 -40 -30 -20 -10 0 10 20 30 40 50

Three-dimensional visualization of geoid undulations, using units of gravity.

- The **geoid** is that **equipotential surface** which would coincide with the mean ocean surface of the Earth, if the oceans and atmosphere were in equilibrium, at rest relative to the rotating Earth, and extended through the continents (such as with very narrow canals). **C.F. Gauss**, first described it

- "mathematical figure of the Earth", a smooth but highly irregular surface that corresponds not to the actual surface of the Earth's crust, but to a surface which can only be known through extensive gravitational measurements and calculations.

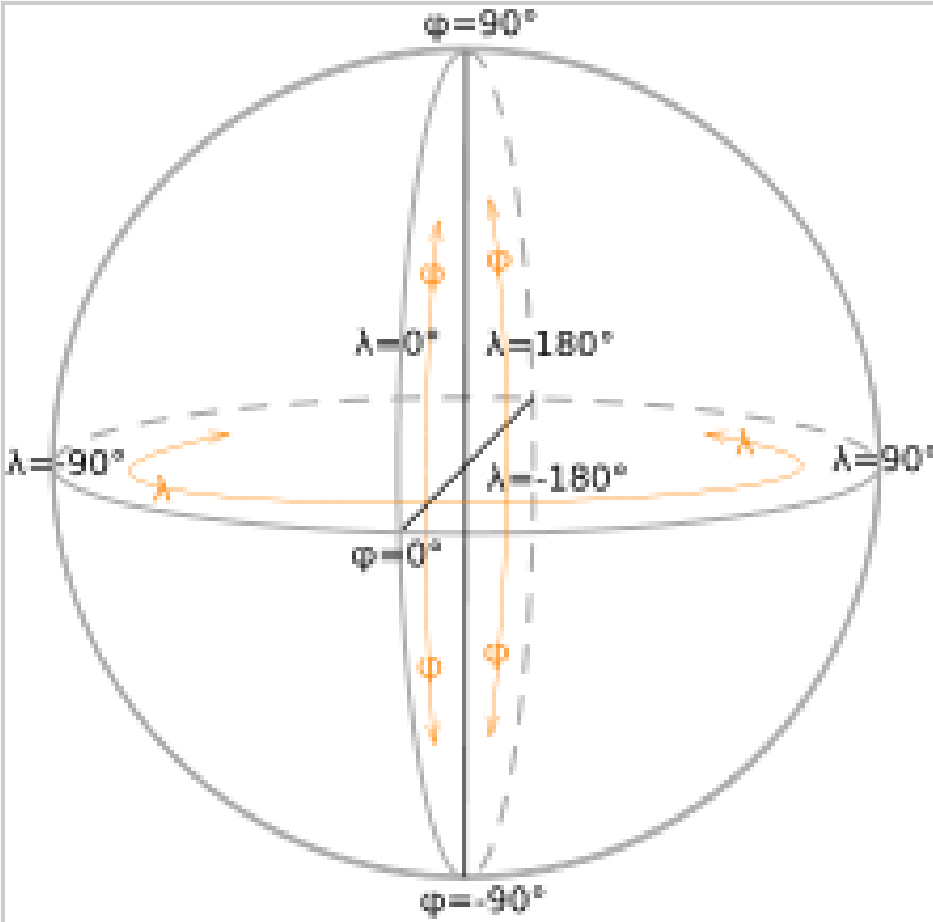
Geographic coordinate system

- A **geographic coordinate system** is a coordinate system that enables every location on the Earth to be specified by a set of numbers and/or letters.
- The coordinates are often chosen such that:
 - one of the numbers represent **vertical position**, and
 - two or three of the numbers represent **horizontal position**.
- A common choice of coordinates is **latitude, longitude and elevation**.

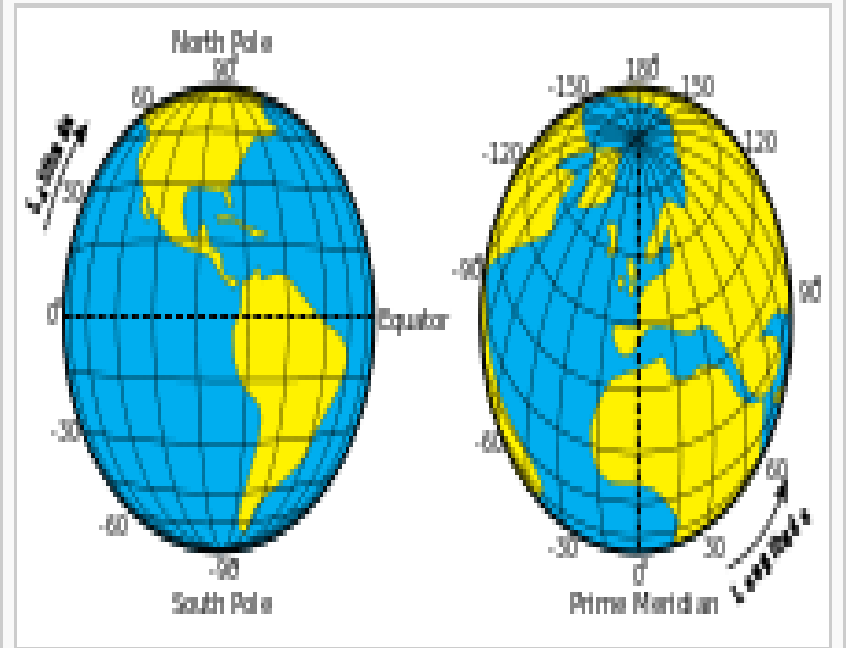
Latitude

- In geography, **latitude** is a geographic coordinate that specifies the north-south position of a point on the Earth's surface.
- Lines of constant latitude, or **parallels**, run east–west as circles parallel to the equator.
- Latitude is an angle which ranges from 0° at the Equator to 90° (North or South) at the poles.
- Latitude is used together with longitude to specify the precise location of features on the surface of the Earth.

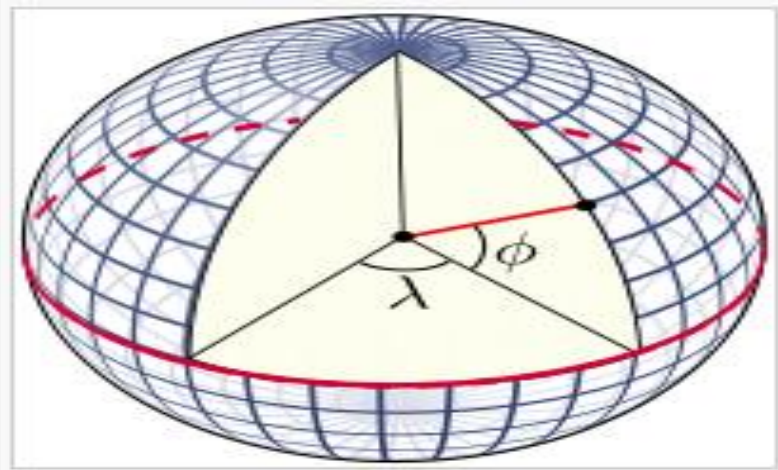
- The latitude (abbreviation: **Lat., ϕ , or phi**) of a point on the Earth's surface is the angle between the:
 - equatorial plane and
 - a line that passes through that point and is **normal to the surface** of a reference ellipsoid which approximates the shape of the Earth.
- This line passes a **few kilometers away** from the center of the Earth except at the poles and the equator where it **passes through Earth's center**.
- Lines joining points of the same latitude trace circles on the surface of the Earth called **parallels**, as they are **parallel to the equator** and to each other.
- The north pole is 90° N; the south pole is 90° S.
- The 0° parallel of latitude is designated the equator, the fundamental plane of all geographic coordinate systems.
- The equator divides the globe into **Northern** and **Southern Hemispheres**.



Latitude phi (φ) and Longitude lambda (λ)



Latitude and Longitude of the Earth



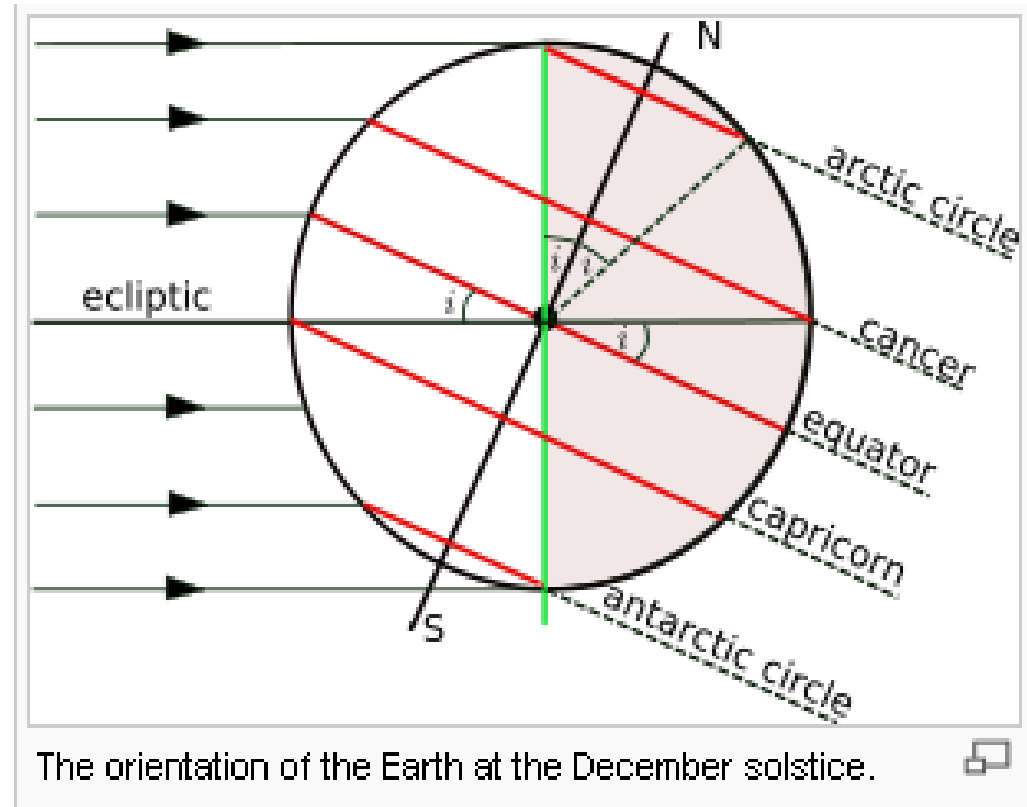
A perspective view of the Earth showing how latitude (φ) and longitude (λ) are defined on a spherical model. The graticule spacing is 10 degrees.

Named latitudes

- Besides the equator, four other parallels are of significance:

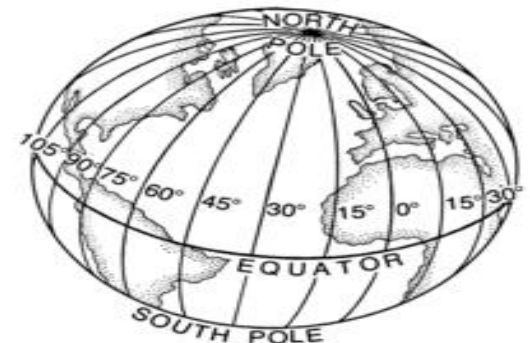
- The plane of the Earth's orbit about the sun is called the ecliptic.
- The plane perpendicular to the rotation axis of the Earth is the equatorial plane.
- The angle between the ecliptic and the equatorial plane is called the inclination of the ecliptic, denoted by i in the figure.
- The current value of this angle is $23^\circ 26' 21''$.
- It is also called the **axial tilt** of the Earth since it is equal to the angle between the axis of rotation and the normal to the ecliptic.

Arctic Circle: $66^\circ 33' 39''$ N
Tropic of Cancer $23^\circ 26' 21''$ N
Tropic of Capricorn $23^\circ 26' 21''$ S
Antarctic Circle $66^\circ 33' 39''$ S



Longitude

- The Longitude (abbreviation: **Long.**, λ , or **lambda**) of a point on the Earth's surface is the angle:
 - east or west from a reference meridian to
 - another meridian that passes through that point.
- All meridians are **halves** of **great ellipses** (often improperly called **great circles**), which converge at the north and south poles.
- **Prime Meridian:** A line passing near the **Royal Observatory, Greenwich** (near **London in the UK**) has been chosen as the international zero-longitude reference line.



- Places to the east are in the eastern hemisphere, and places to the west are in the western hemisphere.
- The **antipodal** meridian of Greenwich is both 180°W and 180°E . The **zero/zero point** is located in the Gulf of Guinea about 625 km south of Tema, Ghana.

Antipodes :

- The antipodes of any place on the Earth is the place that is **diametrically opposite it**, so a **line drawn from the one to the other** passes through the centre of the **Earth** and **forms a true diameter**.
- The antipodes of any place on Earth are distant from it by 180° of **longitude** and as many degrees to **the north of the equator as the original is to the south (or vice versa)**;
- in other words, the **latitudes are numerically equal**, but **one is north and the other south**.
- **Noon** at the one place is **midnight** at the other.
- the **longest day** at one point corresponds to the **shortest day** at the other

- The combination of these two components specifies the position of any location on the planet, but does not consider **altitude** nor **depth**.

- *conjugate graticule* :

This latitude/longitude "**webbing**" is known as the *conjugate graticule*.

- *conjugate diameter*:

In defining an **ellipse**, the short (vertical) diameter is known as the *conjugate diameter*,

- *transverse diameter* :

the long (horizontal) diameter—perpendicular, or "transverse", to the conjugate—is the *transverse diameter*.

- *polar axis & equatorial axis*

With a **sphere or ellipsoid**, the conjugate diameter is known as the *polar axis* and the transverse as the *equatorial axis*.

- The graticule perspective is based on this designation: As the longitudinal rings — geographically defined, all great circles — converge at the poles, it is the poles that the **conjugate graticule** is defined.

- *oblique graticule*

If the polar vertex is "pulled down" 90° , so that the vertex is on the equator, or transverse diameter, then it becomes the **transverse graticule**, upon which all spherical trigonometry is ultimately based (if the longitudinal vertex is between the poles and equator, then it is considered an *oblique graticule*).

- An ellipse is a smooth closed curve which is symmetric about its horizontal and vertical axes