

Earth' Latitude and Longitude

The Earth' geographic coordinate system is based on the Earth's axis of rotation and the plane of the Equator. It consists of an imaginary grid of lines running east-west (lines of latitude = parallels) and north-south (lines of longitude = meridians). The system was first devised by Hipparchus (190-120 BC) for measuring distances.

The Latitude:

- The **Authalic Latitude** is based on a spherical earth.
 - i. Latitude is measured in angular degrees from the equator (0°) to the poles (90°).
 - ii. A point north (south) of the equator is labeled, e.g., 25° N (67° S).
 - iii. The most popular coordinate system divides each $^\circ$ (degree) of latitude into $60'$ (minutes), which is subdivided into $60''$ (seconds).

- The **Geodetic Latitude** is based on an ellipsoidal earth.
 - i. The ellipsoidal approach is a more realistic representation of the earth because of the polar flattening.
 - ii. There are different models used to describe the ellipsoidal earth (e.g., WGS 84)).
 - iii. The length of parallels of latitudes decrease from the equator to the poles.
 - The length of 1° of latitude is not constant, but the same for the northern and the southern hemisphere
 - Mathematically easy:
 - a) $\text{length}(\text{parallel of latitude } \varphi) = \cos\varphi * \text{length}(\text{equator})$
 - b) $\text{length}(1^\circ \text{ at latitude } \varphi) = \cos\varphi * \text{length}(\text{equator})/360$
 - Mathematically more exact:

$$\text{latlen} = m_1 + (m_2 * \cos(2\varphi)) + (m_3 * \cos(4\varphi)) + (m_4 * \cos(6\varphi))$$
 with $m_1 = 111132.92$, $m_2 = -559.82$, $m_3 = 1.175$, $m_4 = -0.0023$

Latitude ($^\circ$)	1° of Latitude (km)	$1'$ of Latitude (km)	$1''$ of Latitude (m)
0	110.574	1.843	30.715
10	110.608	1.843	30.724
20	110.704	1.845	30.751
30	110.852	1.848	30.792
40	111.035	1.851	30.843
50	111.229	1.854	30.897
60	111.412	1.857	30.948
70	111.562	1.859	30.989
80	111.660	1.861	31.017
90	111.694	1.862	31.026

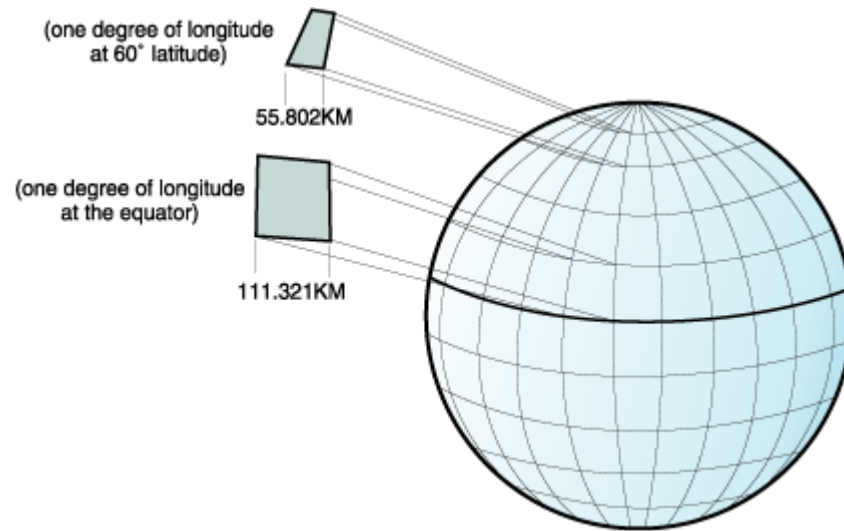
- iv. Since the length difference of 1° (1') of latitude varies only by 1.12 km (19 m), the **standard value of 111.325 km** (1.855 km) **for 1° (1') of latitude** can be used.

The Longitude:

- The longitude defines the position of a point west or east of the prime meridian (0°) which passes through the old Royal Observatory in Greenwich, Great Britain, England.
 - i. Longitudes are measured in angular degrees from the prime meridian (0°) to either west or east, up to 180° W or 180° E, respectively.
 - ii. Each ° (degree) of longitude is divided into 60' (minutes), which is subdivided into 60" (seconds).
 - iii. The meridians converge at the poles. Therefore, the distance of one degree longitude varies upon where it is measured; it decreases to the poles.
 - Mathematically easy:
 - a) For a spherical Earth (approximation):
 $\text{length}(1^\circ \text{ of longitude at latitude } \varphi) = 111.325 \cdot \cos \varphi$
 - b) For an ellipsoidal Earth:
 $\text{length}(1^\circ \text{ of long at latitude } \varphi) = (111.320 + 0.373 \sin^2 \varphi) \cos \varphi$
 - Mathematically more precise:
 $\text{longlen} = (n_1 * \cos \varphi) + (n_2 * \cos(3\varphi)) + (n_3 * \cos(5\varphi))$
 with $n_1 = 111412.84$, $n_2 = -93.5$, $n_3 = 0.118$

Latitude (°)	1° of Longitude (km)	1' of Longitude (km)	1" of Longitude (m)
0	111.319	1.855	30.92
10	109.639	1.827	30.45
20	104.647	1.744	29.07
30	96.486	1.608	26.80
40	85.394	1.423	23.72
50	71.696	1.195	19.92
60	55.800	0.930	15.50
70	38.187	0.636	10.61
80	19.393	0.323	5.39
90	0.00	0.000	0.00

- For a spherical Earth:



- For a spherical Earth, each meridian of longitude would have the length of one-half of the circumference.
 - All degrees have the same length: $\text{length}(1^\circ) = \text{circumference}/360$.
- For an ellipsoidal Earth, the equatorial circumference does not equal that of the meridians.