# The Earth as a Rotating Planet

# The Shape of the Earth

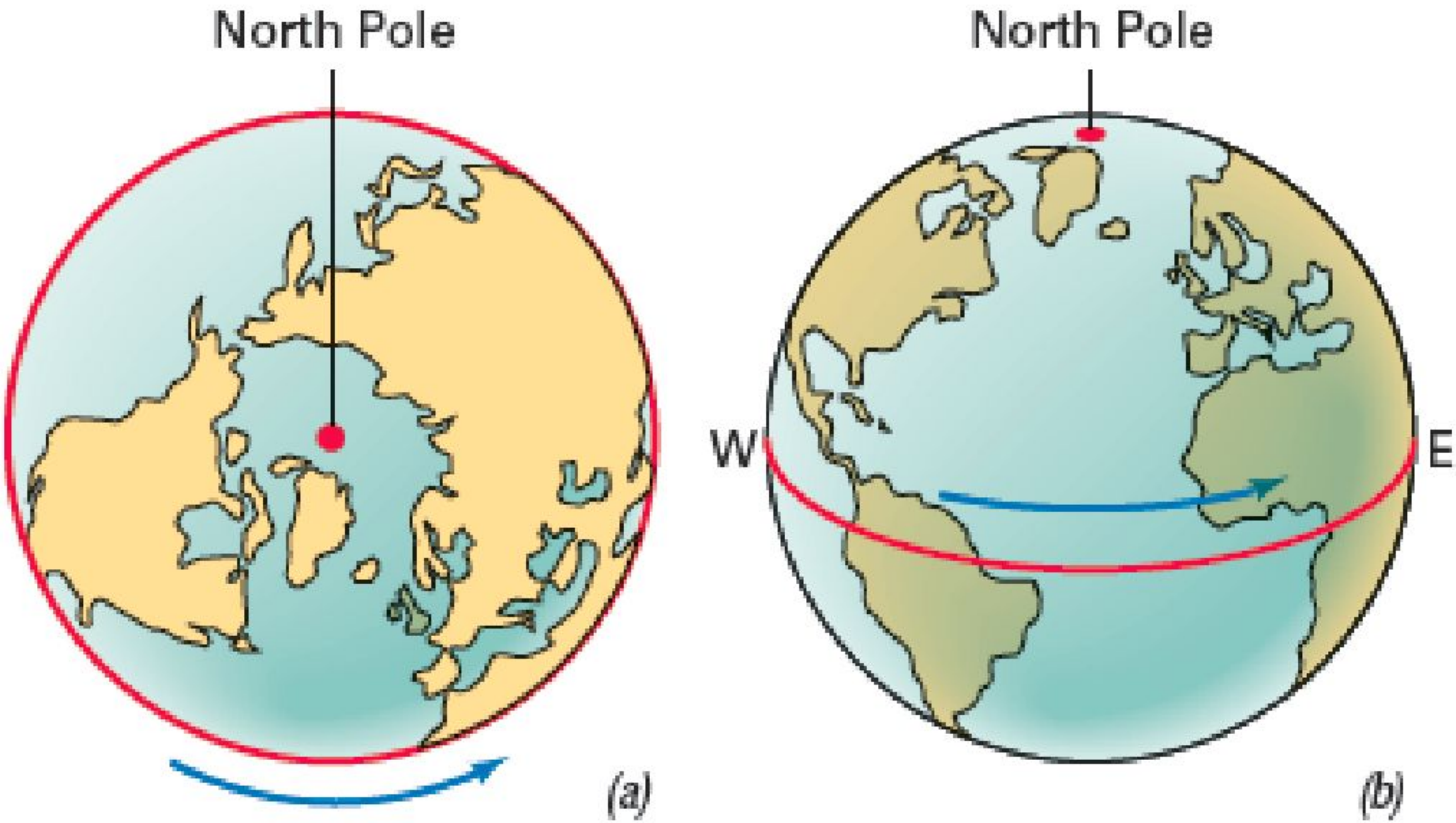
The Earth assumes the shape of an *oblate ellipsoid* because it bulges slightly at the equator (diameter: 12,756 km) and flattens at the poles (diameter 12,714 km), due to centrifugal force of its rotation.

# Earth Rotation

Earth rotation refers to the counter-clockwise turning of the Earth on its axis (imaginary line passing through the centre of the planet and joining the north and south poles).

## Environmental Effects of Earth Rotation

The Earth's rotation causes the *coriolis effect* (winds and ocean currents are deflected to the right of their path in the northern hemisphere; left in the southern hemisphere).




**2.1 DIRECTION OF EARTH ROTATION** The direction of rotation of the Earth can be thought of as (a) counter-clockwise at the North Pole, or (b) eastward (from left to right) at the equator.

# The Geographic Grid

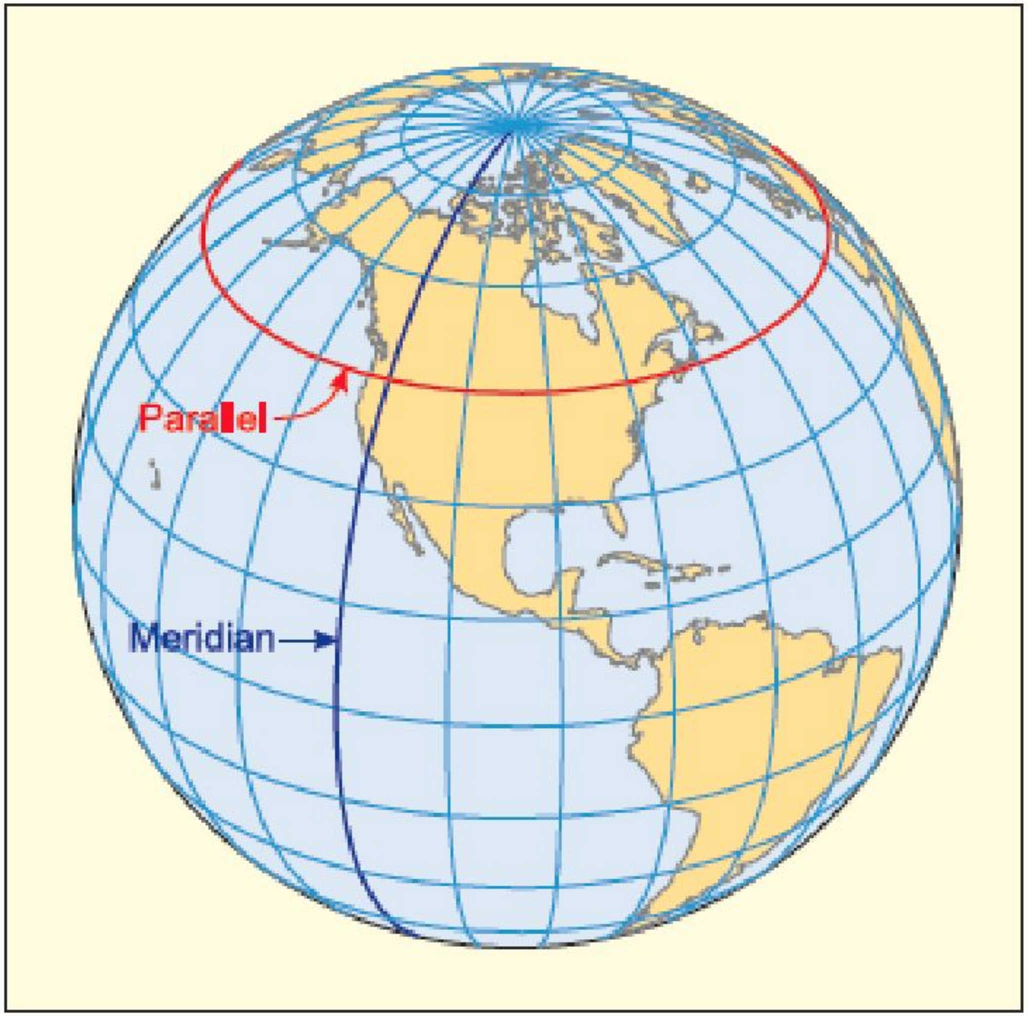
## Parallels and Meridians

The geographic grid is a spherical coordinate system (set of circles called parallels and meridians) used to determine the locations of features on the Earth's surface.

# The Geographic Grid

Parallels are a set of circles arranged perpendicular to the axis of rotation (equator, midway between the north and south poles is the longest parallel).

Meridians are a set of circles at right angles to the parallels.

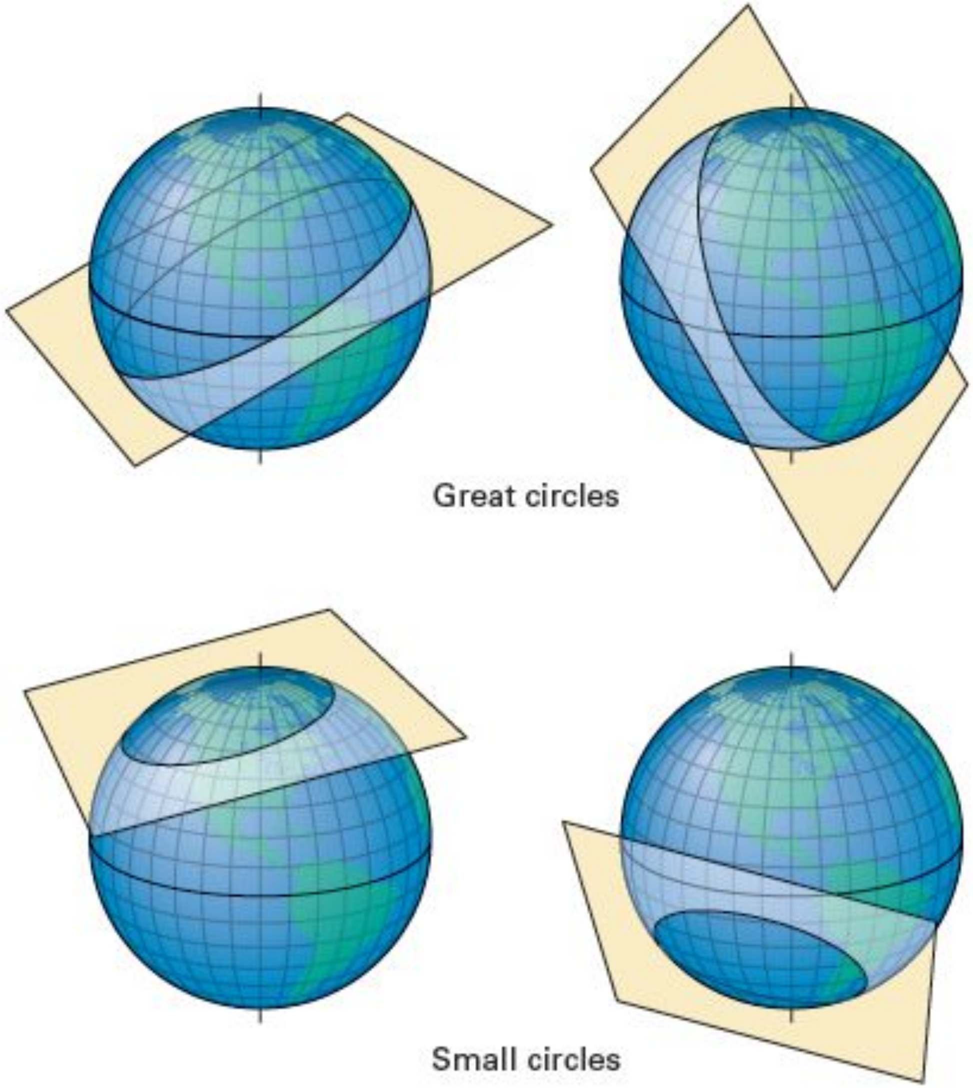



2.2 **PARALLELS AND MERIDIANS** Parallels of latitude divide the globe crosswise into a series of circles arranged perpendicular to the polar axis. Meridians of longitude divide the globe from pole to pole.

# The Geographic Grid

Great circles are constructed so that the plane of intersection with the surface of the sphere passes through the centre of the globe.

With small circles the plane of the intersection passes through the surface of the sphere , but not its centre.




2.3 **GREAT AND SMALL CIRCLES** A great circle is created on the surface of a sphere when the plane of intersection with the surface also passes through the centre of the sphere irrespective of its inclination. Small circles are created when a plane passes through the sphere but does not intersect the centre point.

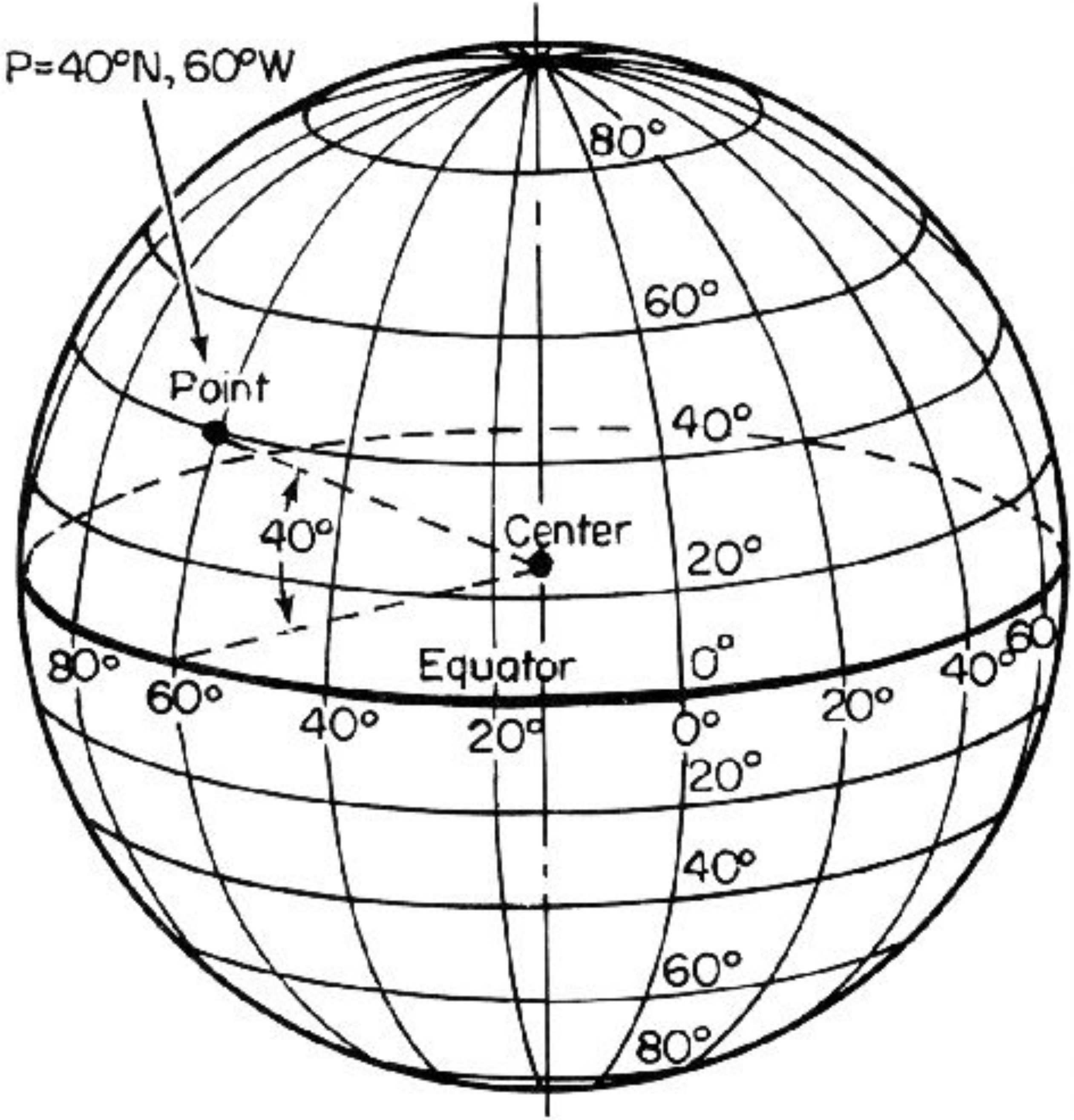
# The Geographic Grid

## Latitude and Longitude

The equator is the only great circle parallel and is given the value of 0º.

Parallels of latitude measure the angular distance north and south of the equator.

In the northern hemisphere, latitude ranges from 0º to 90º N at the North Pole; in the southern hemisphere, latitude increases to 90º S at the South Pole.



P=40°N, 60°W
80°
60°
Point
40°
40°
Center
20°
Equator
0°
80°
60°
40°
20°
0°
20°
40°
60
20°
40°
60°
80°

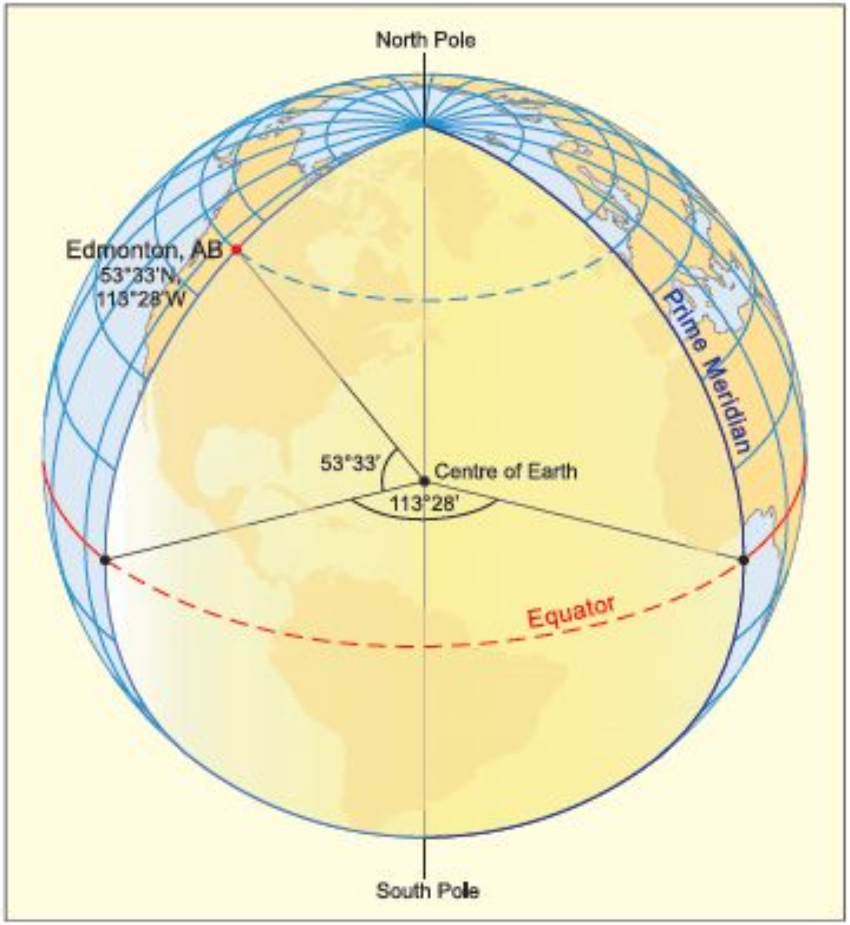
# The Geographic Grid

By international convention the meridian running through the Royal Observatory in Greenwich, England, is used as the prime meridian of the world (commonly the Greenwich meridian; 0º longitude).

Meridians of longitude measure angular distance east and west of the prime meridian (range: from 0º to 180º E or 180º W).

# The Geographic Grid

For greater precision, degrees of latitude and longitude can be subdivided into minutes (1/60 of a degree) and seconds (1/60 of a minute).




**2.5 LATITUDE AND LONGITUDE** The geographic coordinate system of latitude and longitude gives locations of points on Earth's surface as angular distances measured from the centre of the Earth with respect to specified planes of reference. Latitude represents the angular distance north or south of the equator. Longitude is the angular distance east or west of the prime meridian. Thus, Edmonton lies 53º 33′ north of the equator (latitude) and 113º 28′ west of the prime meridian (longitude).

# The Geographic Grid

A Global Positioning System (GPS; 24 satellites at an altitude of 20,200 km) can provide location (latitude and longitude) information to an accuracy of about 10m horizontally and 15 m vertically.

**2.6 GPS RECEIVERS** Latitude and longitude can be rapidly and accurately determined using a hand-held GPS receiver or a unit mounted in a vehicle.

# Map Projections

Because the Earth's shape is nearly spherical, it is impossible to represent it on a flat sheet of paper without distorting the curved surface in some way.

There are various ways to mathematically change the actual geographic grid of curved parallels and meridians into a flat coordinate system (Map Projections).

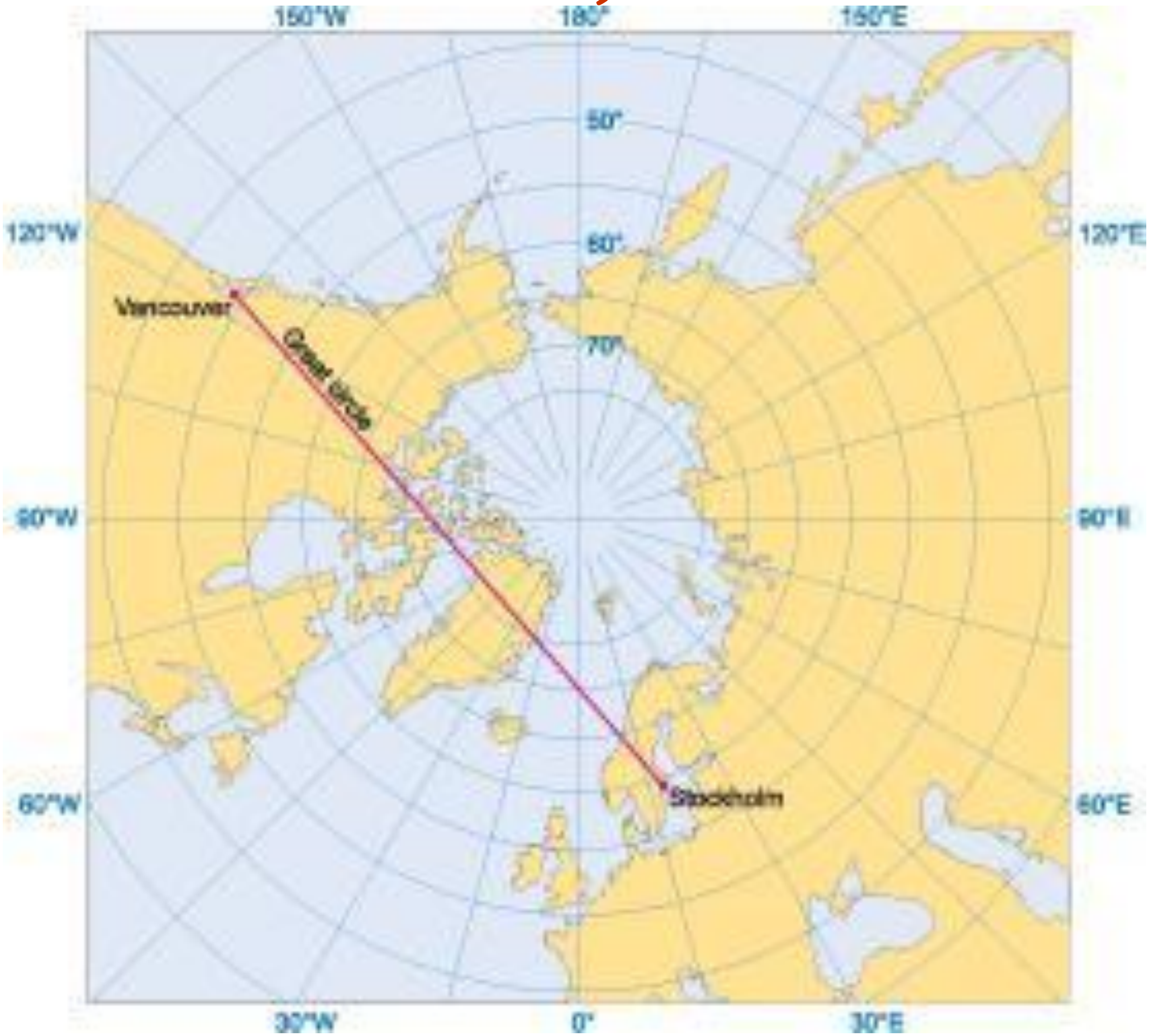
# Map Projections

The polar projection can be centred on either the North or South Pole.

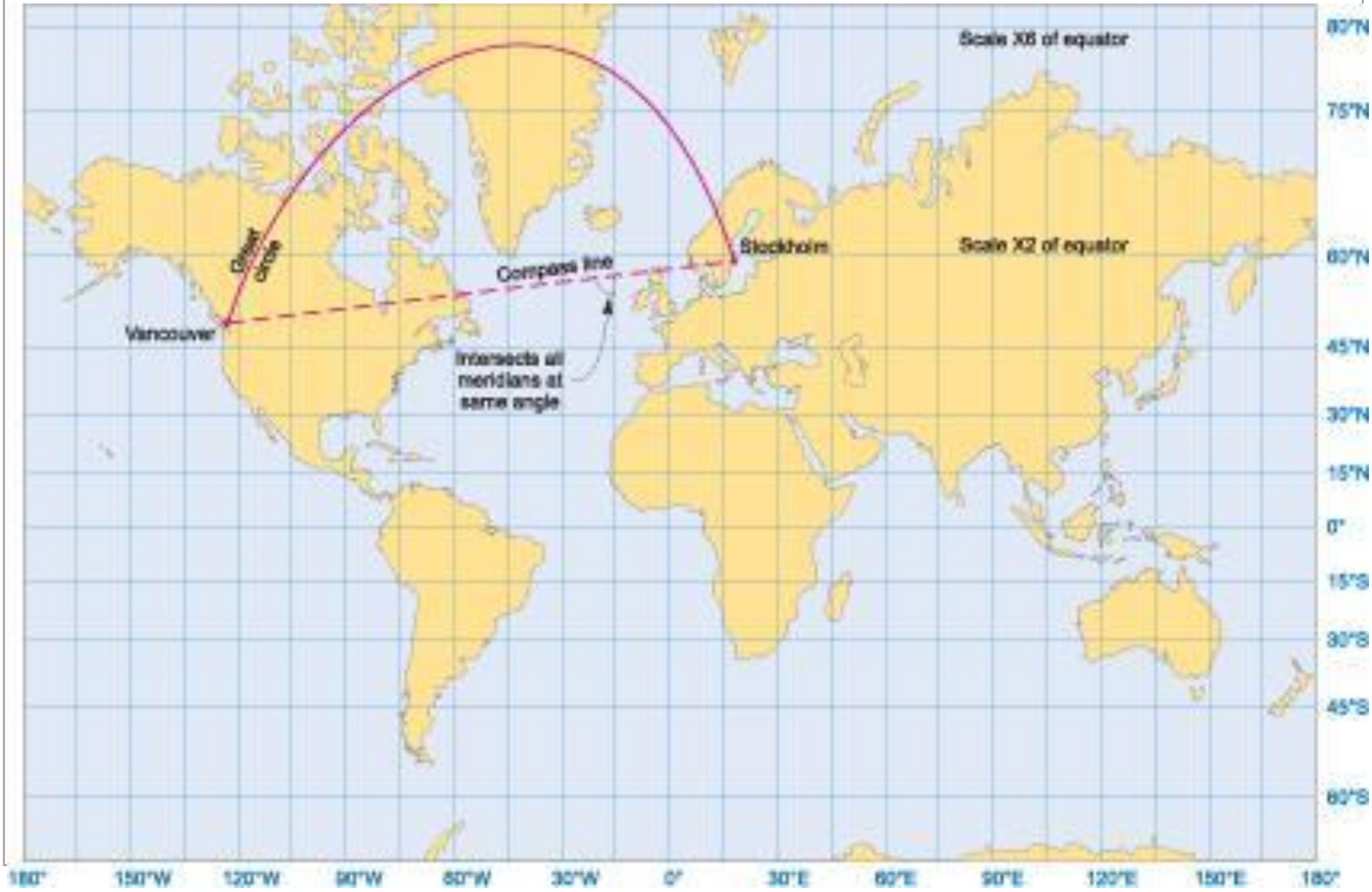
The Mercator projection is a rectangular grid with meridians shown as straight vertical lines, and parallels as straight horizontal lines.

The Goode projection uses two sets of mathematical curves to form its meridians. It uses sine curves between the $40^{th}$ parallels, and beyond the $40^{th}$ parallels, towards the poles, it uses ellipses.

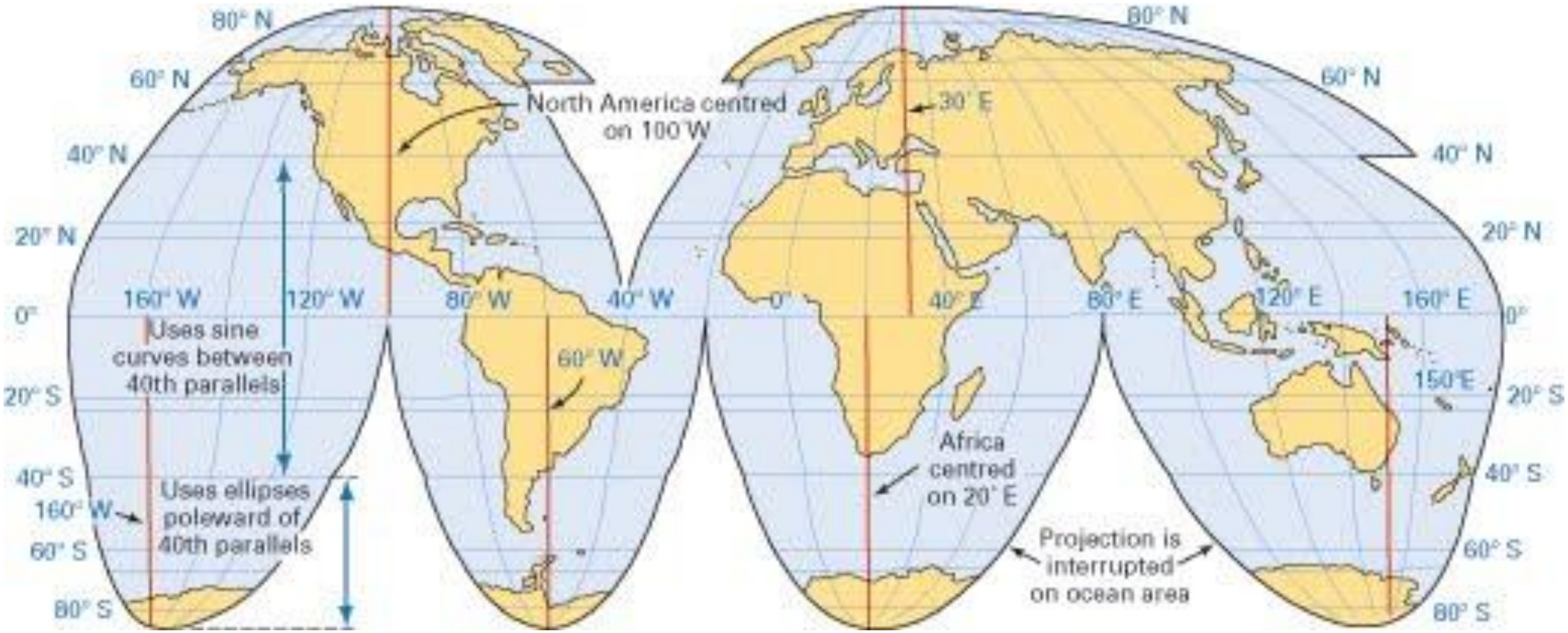
# Polar Projection



# Mercator Projection



# Goode Projection



# Global Time

Global time systems, like map projections, are also derived from the geographic grid, but with the additional component of Earth's rotation.

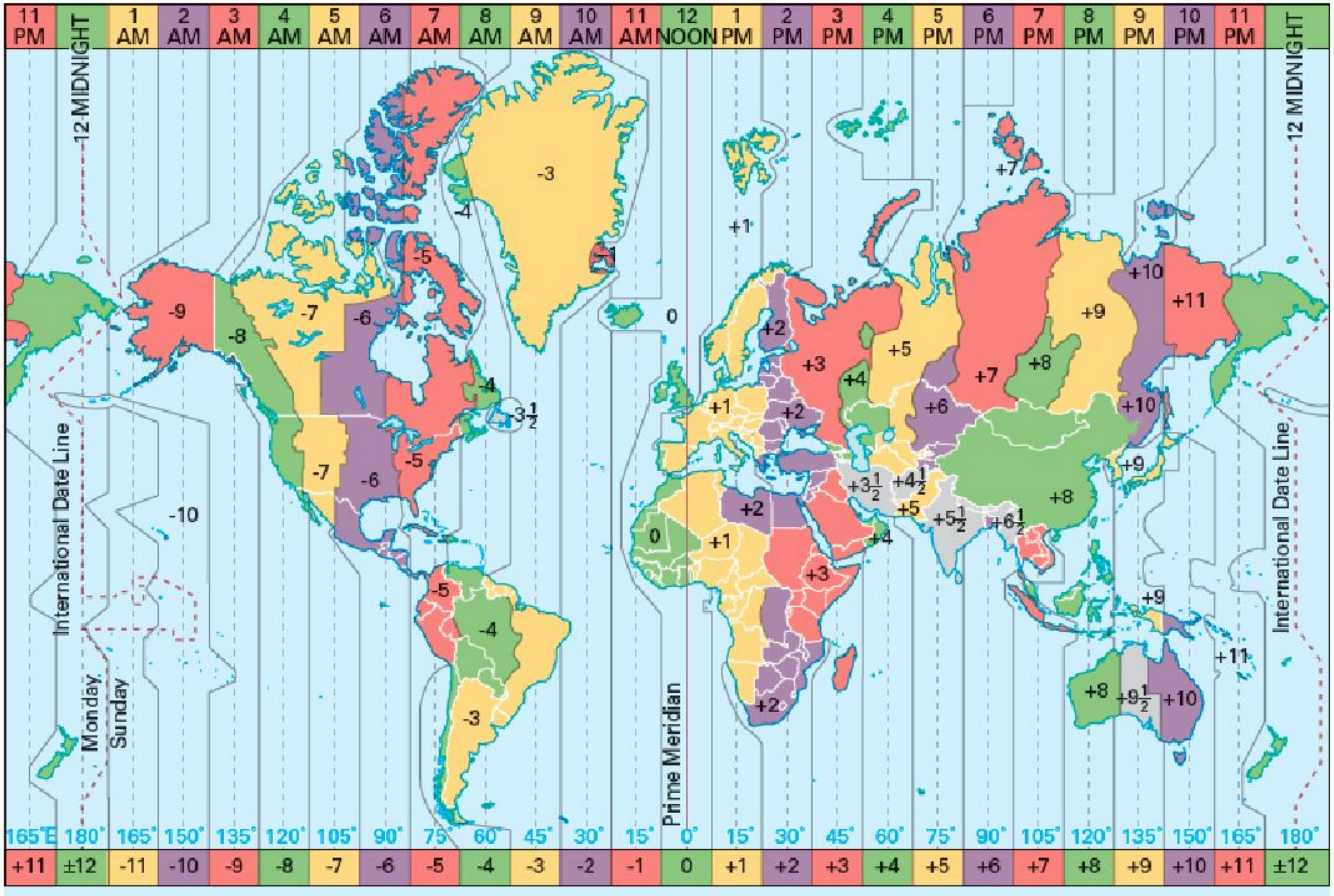
## Standard Time

In the standard time system, the Earth is divided into 24 time zones.

# Global Time

## World Time Zones

Identified according to the number of hours each time zone differs from the time in Greenwich, England (ex. -7 indicates that local time is seven hours behind Greenwich time, +2 indicates that local time is two hours ahead or Greenwich time).




2.10 **TIME ZONES OF THE WORLD** Dashed lines represent 15° meridians, and bold lines represent 7½° meridians. Alternate zones appear in colour. (After U.S. Navy Oceanographic Office.)

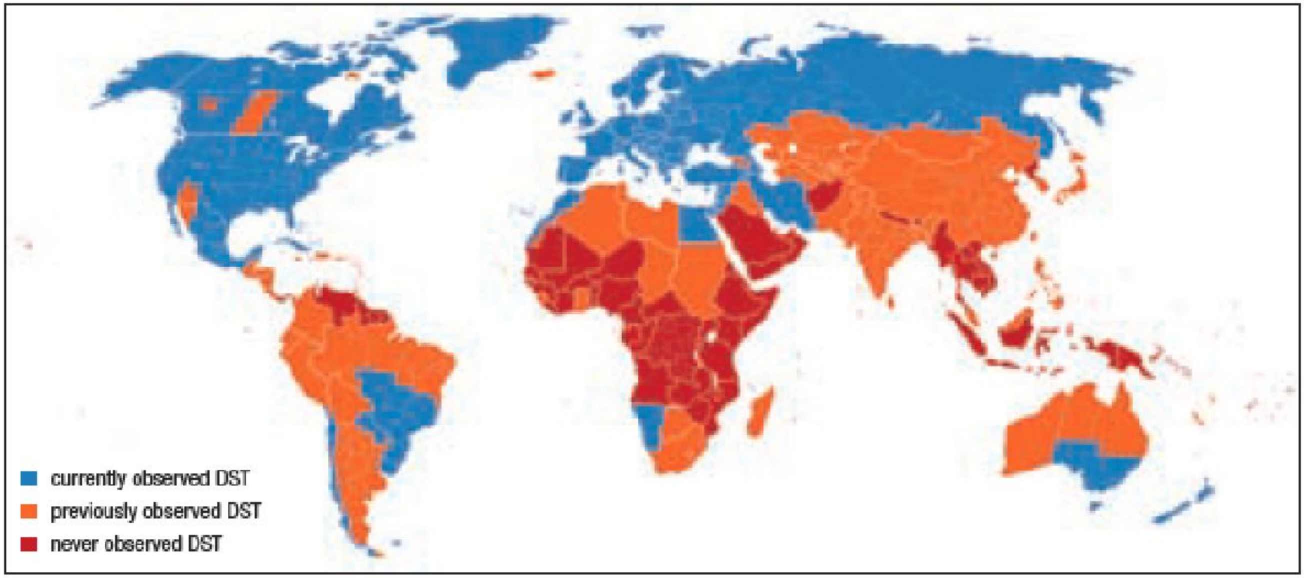
# Global Time

Because of the historical importance of the Greenwich Observatory, world time was traditionally referenced to Greenwich Mean Time (GMT) – recently replaced by Coordinated Universal Time (UTC).

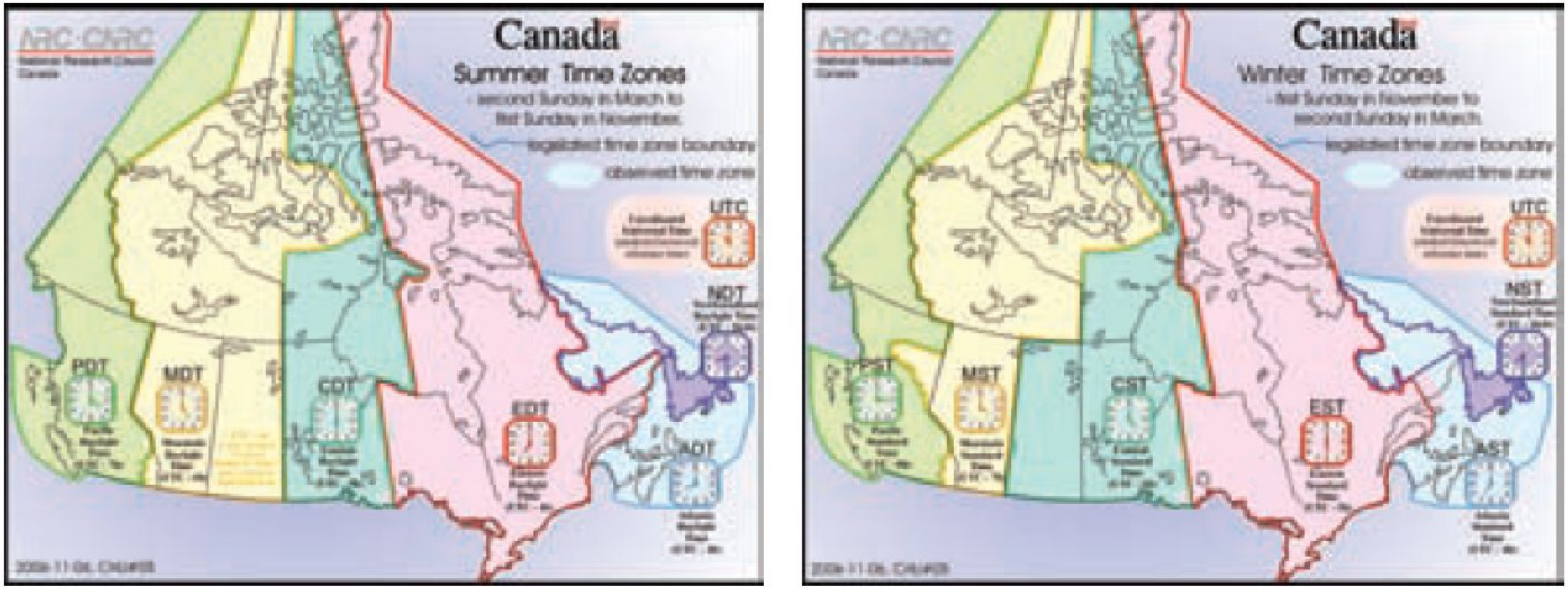
# Global Time

## Daylight Savings Time (DST)

Established by setting all clocks ahead by one hour in the spring to transfer the early morning daylight period to the early evening.




**2.12 DAYLIGHT SAVING TIME** Most industrialized nations in the northern hemisphere have adopted DST; major exceptions are Japan, China, and India. DST is generally not implemented in tropical countries where the period of daylight changes little during the course of the year. (Data from http://www.webexhibits.org/daylightsaving/g.html)




2.11 **TIME ZONES OF CANADA DURING SUMMER AND WINTER** Several time zones do not follow provincial boundaries, and not all places observe Daylight Saving Time, hence the boundaries vary seasonally.

# Global Time

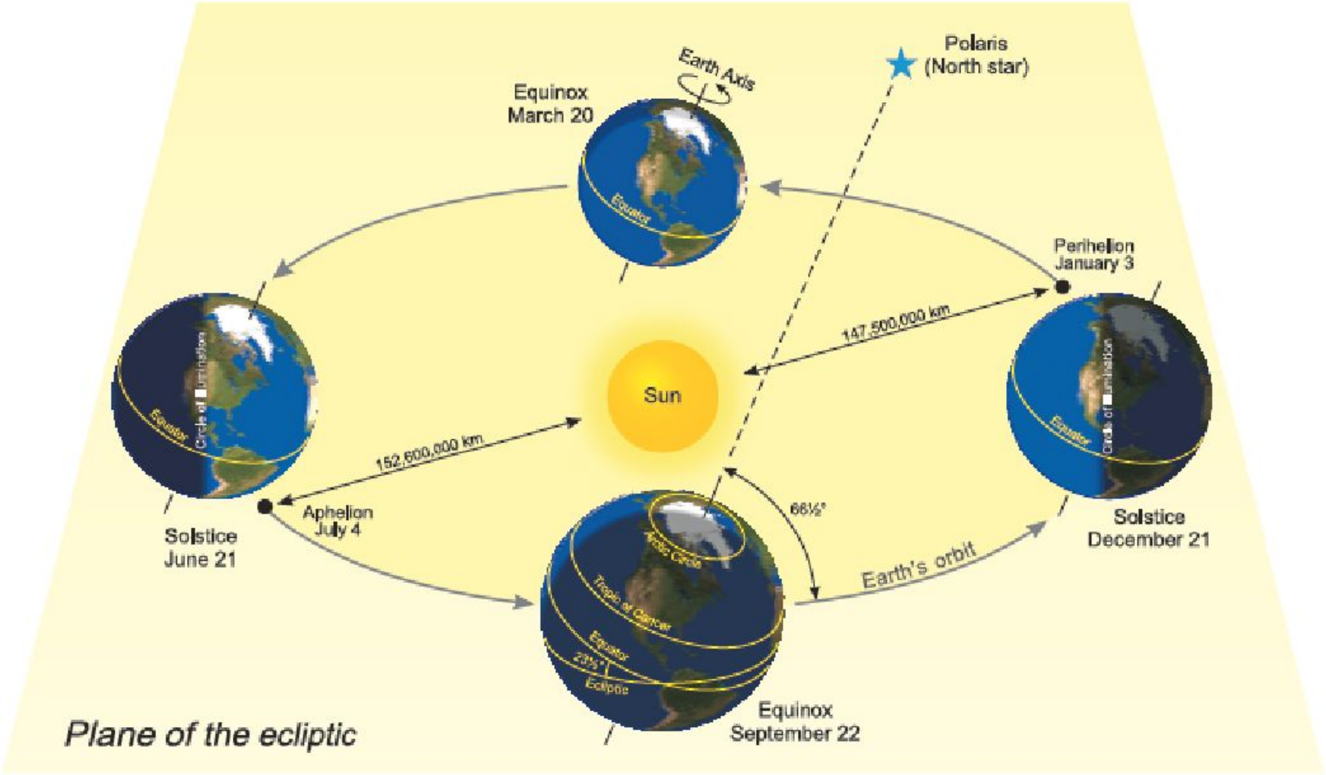
## International Date Line

The 180th meridian serves as the International Date Line; calendars advance by one day when travelling westward across the date line and turn back by one day when travelling eastward across the date line.

# The Earth's Revolution Around the Sun

The orbital motion of the Earth around the sun is termed revolution.

It takes 365.242 days for the Earth to complete one revolution (orbit) around the sun.




2.13 **REVOLUTION OF THE EARTH** Viewed from a point over the North Pole, the Earth both rotates and revolves in a counter-clockwise direction. Earth is closest to the sun at perihelion, and furthest from the sun at aphelion (relative distances are greatly exaggerated). (From *Introduction to Weather and Climate* by O.W. Archibold, John Wiley & Sons Canada, Ltd., 2011.)

# The Earth's Revolution Around the Sun

Because the Earth traces a slightly elliptical orbit around the sun, the distance between them varies by about 3 percent during each revolution.

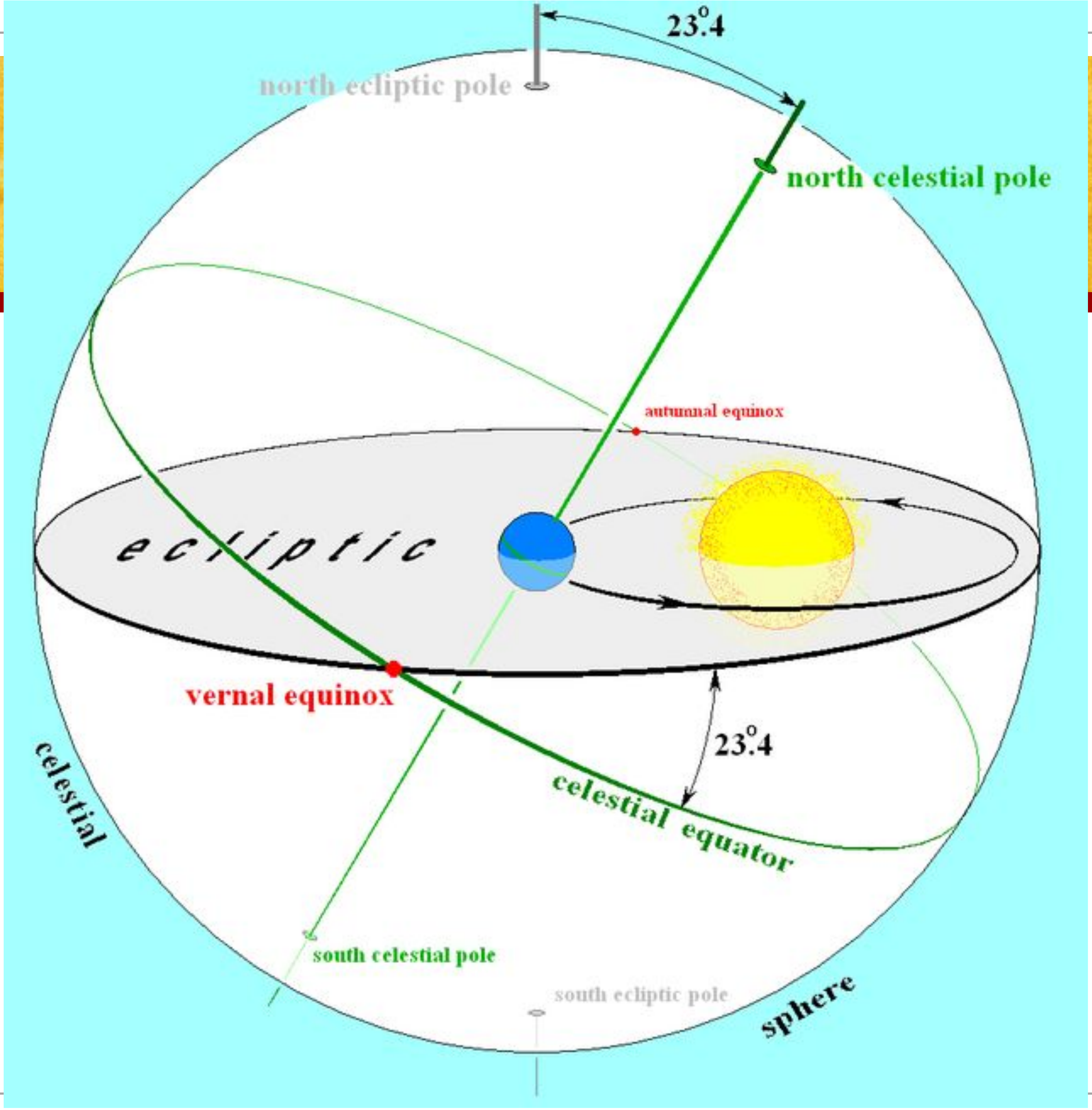
*Perihelion*: when the Earth is nearest the sun (Jan. 3; 147.7 million km).

*Aphelion*: when the Earth is furthest from the sun (July 4; 152.6 million km).

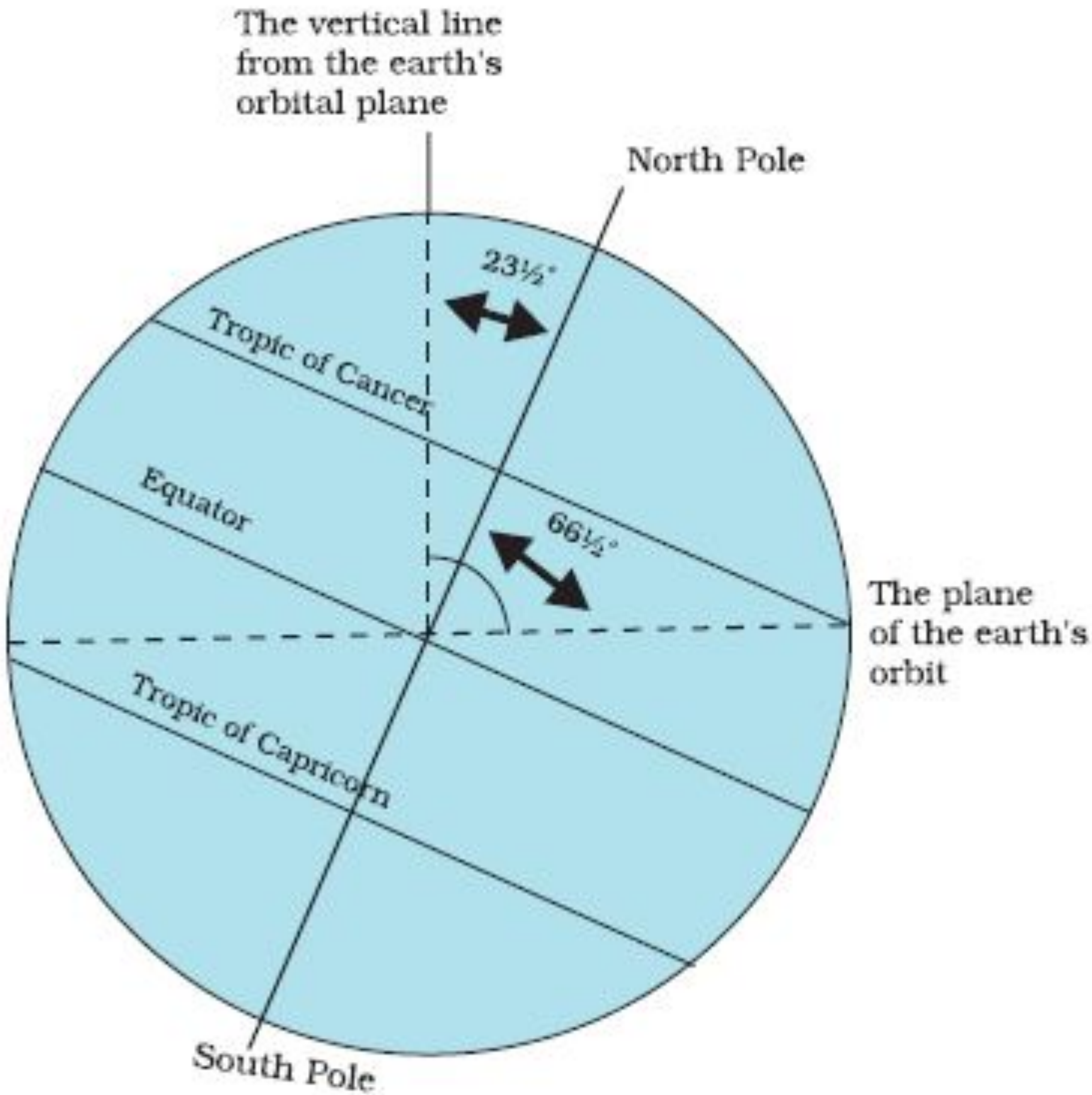
# The Earth's Revolution Around the Sun

## Tilt of the Earth's Axis

The Earth's axis is tilted with respect to the plane of the ecliptic (the plane circumscribed by the Earth's orbit around the sun) by 66.5º.



23°.4
north ecliptic pole
north celestial pole
autumnal equinox
ecliptic
vernal equinox
23°.4
celestial equator
celestial
south celestial pole
south ecliptic pole
sphere


The vertical line from the earth's orbital plane
North Pole
23½°
Tropic of Cancer
Equator
66½°
The plane of the earth's orbit
Tropic of Capricorn
South Pole

# The Earth’s Revolution Around the Sun

## Solstice and Equinox

On or about December 22, the Earth is positioned so that the North Pole is inclined at an angle of 23½º away from the sun, and the South Pole is inclined at the same angle toward the sun (winter or December solstice).

Six months later, on or about June 21, the Earth is at the opposite point in its orbit (summer or June solstice).

# The Earth's Revolution Around the Sun

The equinoxes occur midway between the date of the solstices, and at these times the Earth's axial tilt is neither toward nor away from the sun.

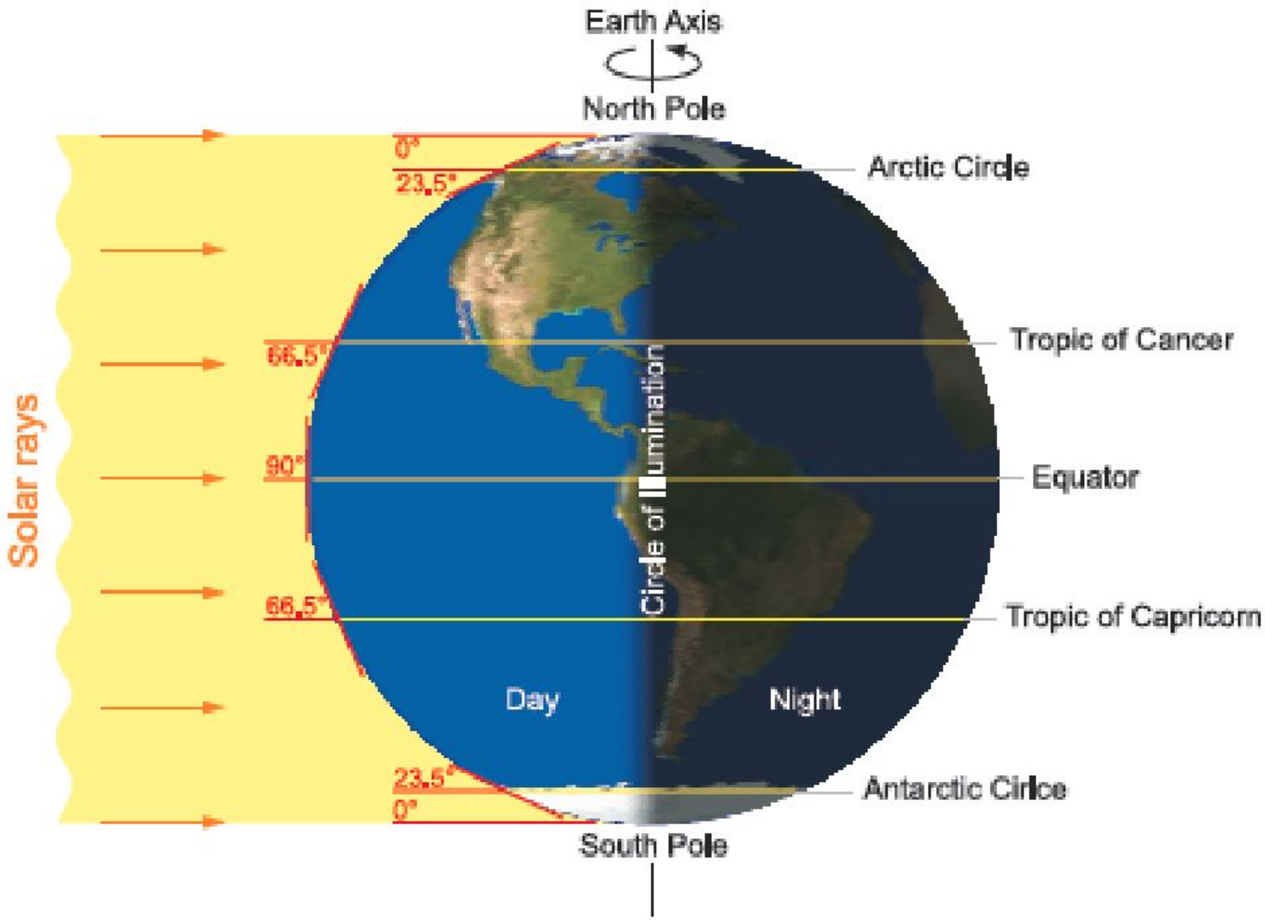
The *vernal equinox* (spring equinox) occurs on or about March 21 and the *autumnal equinox* (fall equinox) on or about September 22.

# The Earth's Revolution Around the Sun

## Equinox Conditions

At the equinoxes the circle of illumination passes through the North and South Poles.

The *subsolar point*, the point on the Earth's surface where the sun at noon is directly overhead, falls on the equator.




2.15 **EQUINOX CONDITIONS** At this time, the Earth's axis of rotation is exactly at right angles to the direction of solar illumination. The subsolar point lies on the equator. The sun's rays are at a tangent with Earth's surface at the poles. (From *Introduction to Weather and Climate* by O.W. Archibold, John Wiley & Sons Canada, Ltd., 2011.)

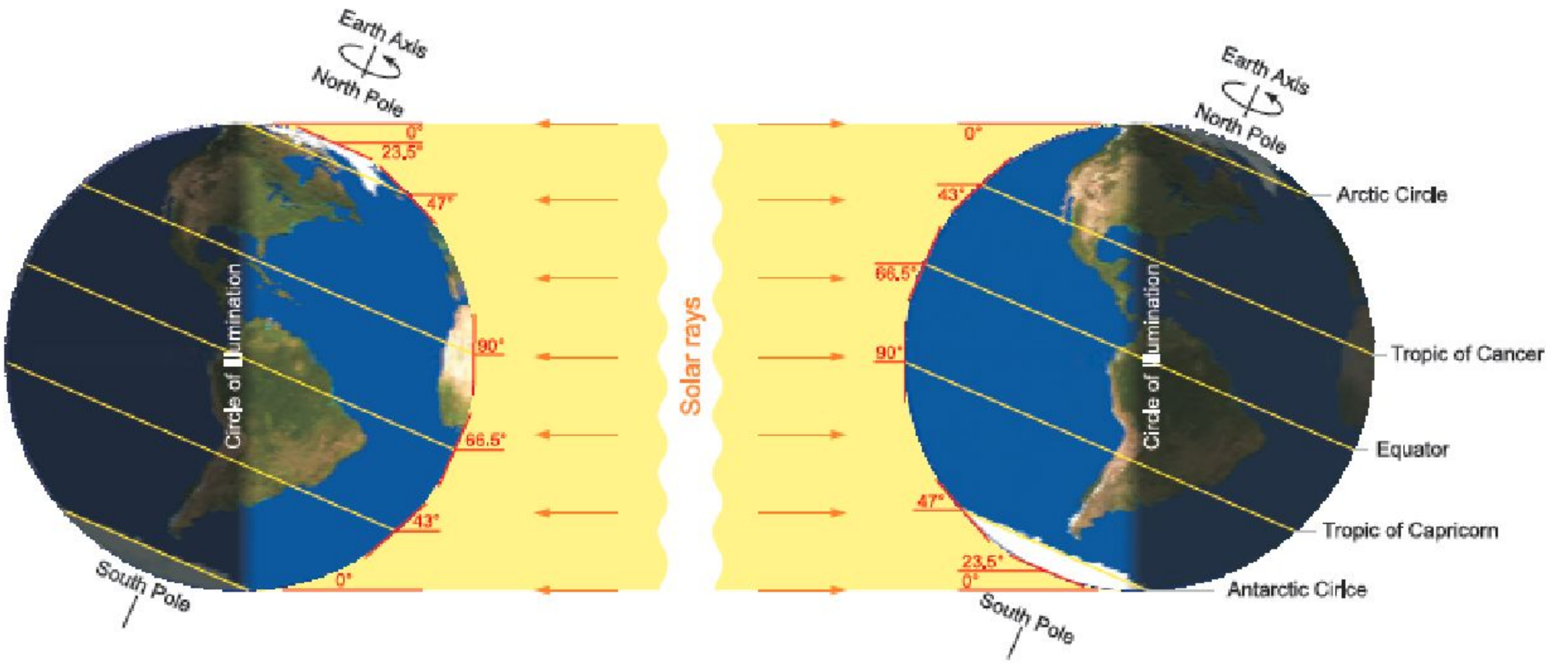
# The Earth's Revolution Around the Sun

## Solstice Conditions

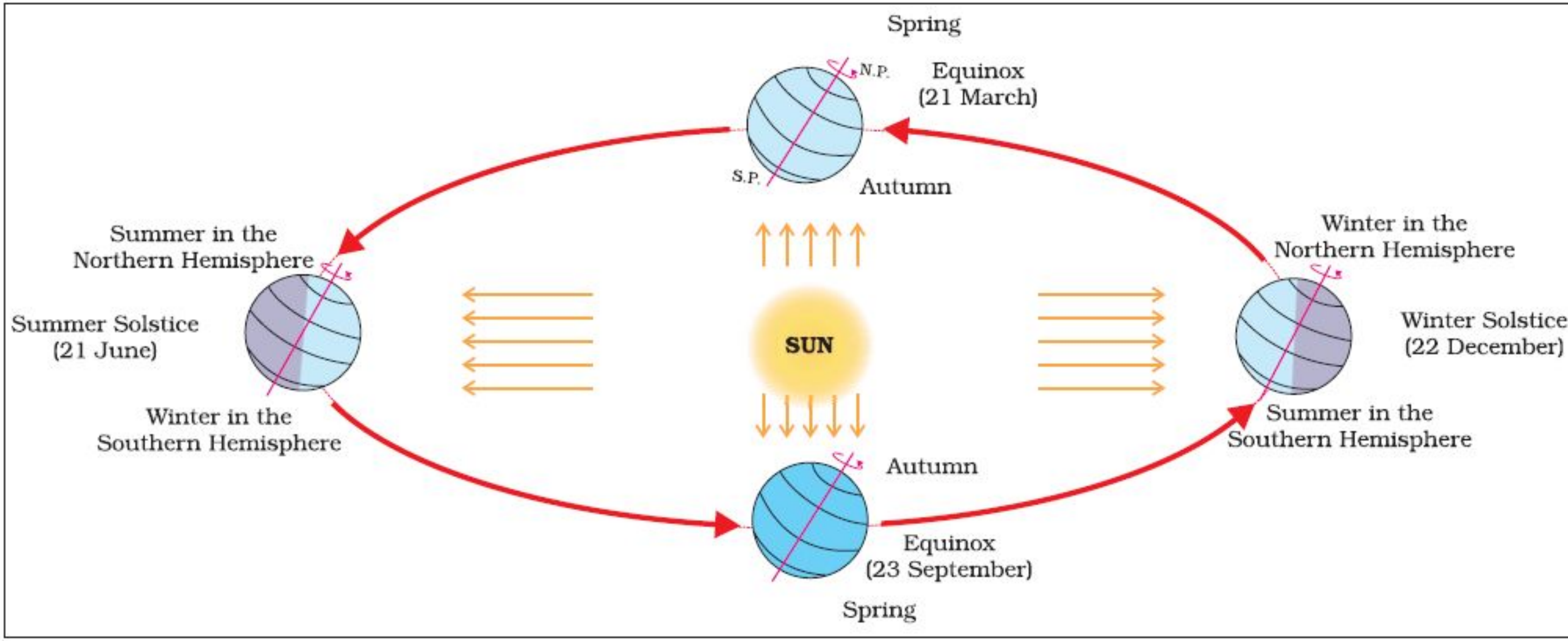
During both the June and December solstices the *circle of illumination* passes from the Arctic Circle (parallel at 66½º N) to the Antarctic Circle (parallel at 66½º S).

June Solstice: the subsolar point is 23½º N (parallel known as the Tropic of Cancer).

December Solstice: the subsolar point is 23½º S (parallel known as the Tropic of Capricorn).



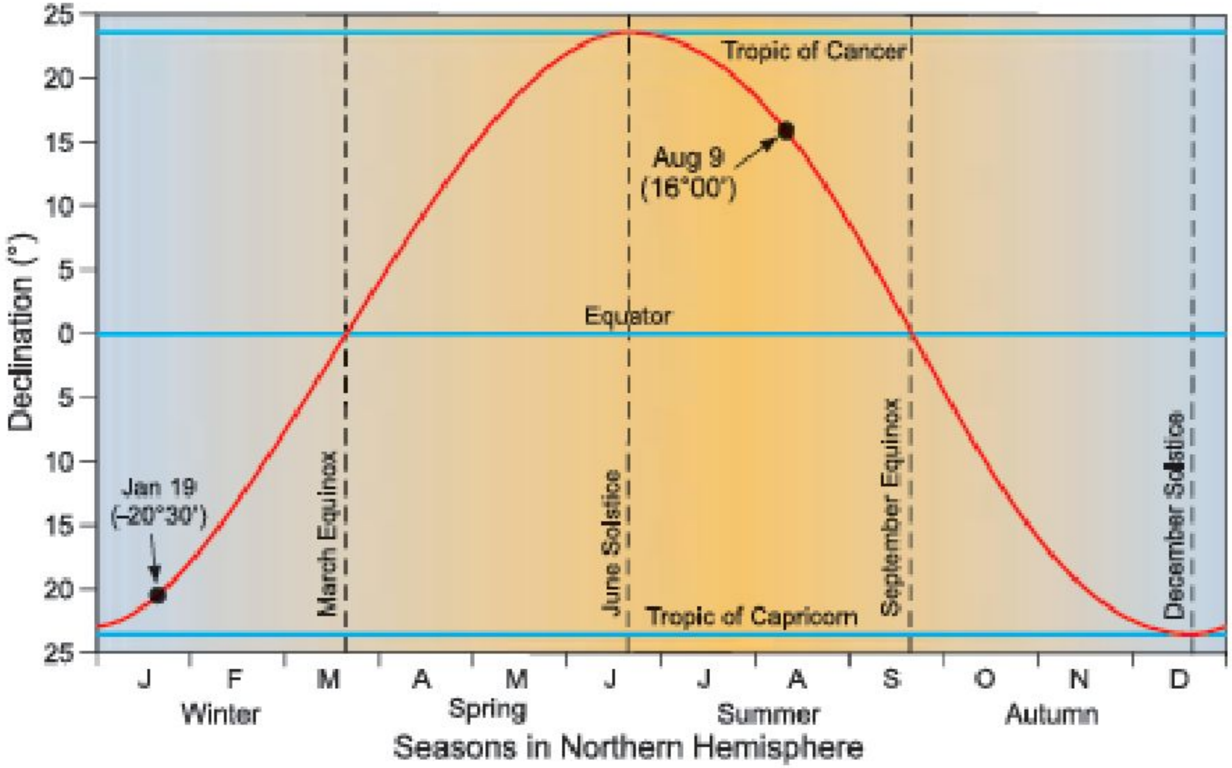

2.16 **SOLSTICE CONDITIONS** Because of the tilt of the Earth's axis, polar regions experience either 24-hour daylight or 24-hour darkness. The subsolar point lies on the Tropic of Cancer (lat. 23½° N) in June (left) and on the Tropic of Capricorn (lat. 23½° S) in December (right). (From *Introduction to Weather and Climate* by O.W. Archibold, John Wiley & Sons Canada, Ltd., 2011.)


Spring
N.P.
Equinox
(21 March)
S.P.
Autumn
Summer in the
Northern Hemisphere
Winter in the
Northern Hemisphere
Summer Solstice
(21 June)
SUN
Winter Solstice
(22 December)
Winter in the
Southern Hemisphere
Summer in the
Southern Hemisphere
Autumn
Equinox
(23 September)
Spring

# The Earth's Revolution Around the Sun

The subsolar point travels northward and southward in its annual cycle between the Tropics of Cancer and Capricorn.

The latitude of the subsolar point is referred to as the sun's declination.




**2.17 SUN'S DECLINATION** The declination of the sun (also referred to as the sun's ephemeris) refers to the latitude where the noon sun is directly overhead (i.e., the zenith angle is 0°). When the subsolar point lies in the northern hemisphere, declination is positive; if it lies in the southern hemisphere, declination is negative.

# The Earth's Revolution Around the Sun

The difference in duration of daylight and darkness increases with latitude.