

Debre Berhan University



College of Social Science and Humanities

Department of Geography and Environmental Studies

Geography of Ethiopia and the Horn

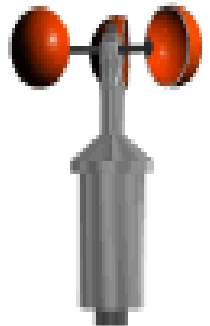


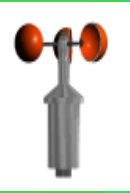
CHAPTER FIVE

THE CLIMATE OF ETHIOPIA AND THE HORN

By: Ayele Behaylu (Assistant Professor)

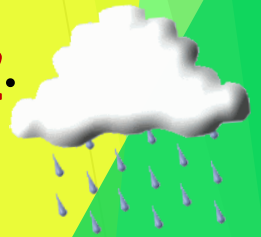
December, 2019





5.1. Introduction

- ⇒ Ethiopia as a large country in the Horn of Africa, is characterized by a *wide variety* of *altitudinal ranges* and *diverse climatic* conditions.
- ⇒ In addition, because of its closeness to the *equator* and the **Indian Ocean**, the country is subjected to *large temporal and spatial variations* in elements of weather and climate.
- ⇒ The climate of Ethiopia is therefore mainly controlled by the seasonal migration of the *Intertropical Convergence Zone* (ITCZ) and associated atmospheric circulations as well as by the complex *topography of the country*.





- Weather is the instantaneous or current state of the atmosphere composing temperature, atmospheric pressure, humidity, wind speed and direction, cloudiness and precipitation.
- ⇒ Weather parameters are measured using various instruments.
 - ⇒ In general, the weather that impacts the surface of the Earth and those that live on the surface takes place in the troposphere.
 - ⇒ **Climate** refers the state of the atmosphere over long time periods, decades and more.
 - ⇒ It is the composite of daily weather conditions recorded for long periods of time.
 - ⇒ Climate also takes into account the extremes or variations that may occur beyond the average conditions.





⇒ Hence, in this chapter, climate of Ethiopia and the Horn will explicitly be discussed.

⇒ *Elements and controls of weather and climate, spatiotemporal patterns of weather and climate, agroecological zones, climate and its implication on Ethiopian biophysical and socio-economic aspects, and climate change* will be the major sub sections of this chapter.





5.2. Elements and Controls of Weather and Climate

- ▶ *What elements do you consider to define weather condition of your locality?*
 - All weather conditions may be traced to the effect of the Sun on the Earth.
 - Most changes in weather involve large scale horizontal motion of air which is called *wind*.
 - Weather is expressed by a combination of several elements.
 - Here are lists of major elements and controls of weather and climate.
 - The climate of a region is ultimately determined by the *radiation*, its *distribution and temporal fluctuations*.
 - The long-term state of the atmosphere is a function of a *variety of interacting elements*.
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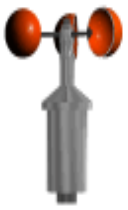
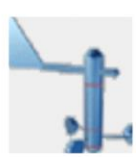


Table 5.1. Elements and controls of weather and climate

Elements	Controls
1. Temperature	1 Latitude/angle of the Sun
2. Precipitation and humidity	2 Land and water distribution
3. Winds and air pressure	3 Winds and air pressure
	4 Altitude and mountain barriers
	5 Ocean currents





5.2.1. Controls of Weather and Climate

- ▶ *What do you think is the source of summer rainfall in Ethiopia? Have you ever noticed varying lengths of days and nights by seasons? What do you think is the reason behind?*
- The climate of any particular location on earth is determined by a combination of many interacting factors.
- These include latitude, elevation, nearby water, ocean currents, topography, vegetation, and prevailing winds.
- Moreover, the *global climate system* and any changes that occur within it also influence local climate.



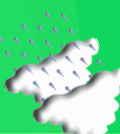
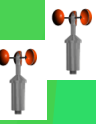
- Hotness or coldness, rainy or cloudiness, sunniness, windiness or calmness, of air you are feeling on the daily base in your current location are expressions of **weather**.
- Now the question one should inquire here is what determines the variations in weather and climate between places and seasons.
- Hence, these determining factors are called controls of weather and climate or climatic controls.
- Some of the **major controls** are discussed below.





a. Latitude

- Latitude is the distance of a location from the equator.
- The sun shines directly on equator for more hours during the year than anywhere else.
- As you move further *away from the equator towards* the *poles*, *less solar insolation* is received during the year and the *temperature* become *colder*.
- Ethiopia's latitudinal location has bearings on its temperature.



- *Latitudinal location of Ethiopia and the Horn* resulted in;
- *high average temperatures*,
 - *high daily* and *small annual ranges of temperature*,
 - *no significant variation* in *length of day* and *night* between *summer* and *winter*.



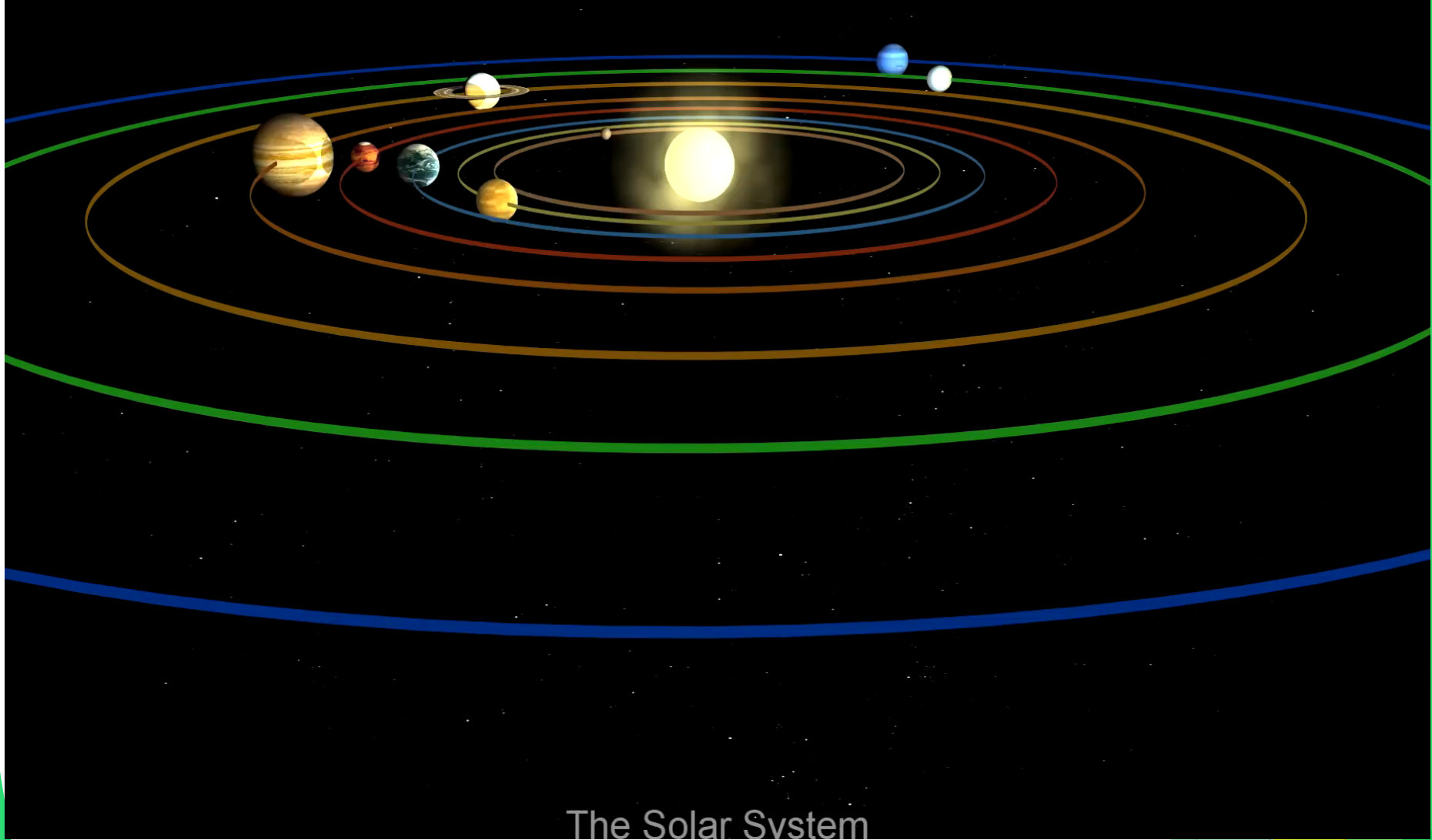


b. Inclination of the Earth's Axis

- The earth's rotation axis makes an angle of about $66 \frac{1}{2}^{\circ}$ with the plane of its orbit around the sun, or about **$23 \frac{1}{2}^{\circ}$** from the perpendicular to the ecliptic plane.
- This inclination determines the ***location*** of the ***Tropics of Cancer, Capricorn*** and the ***Arctic and Antarctic Circles***.
- As the earth revolves around the sun, this inclination produces a ***change in the directness of the sun's rays***; which in ***turn causes the directness of the sun and differences in length of day and seasons***.

Earth's inclination





The Solar System

Space and Astronomy Teaching Resources

Rotation & Revolution of Earth 1.1.mp4

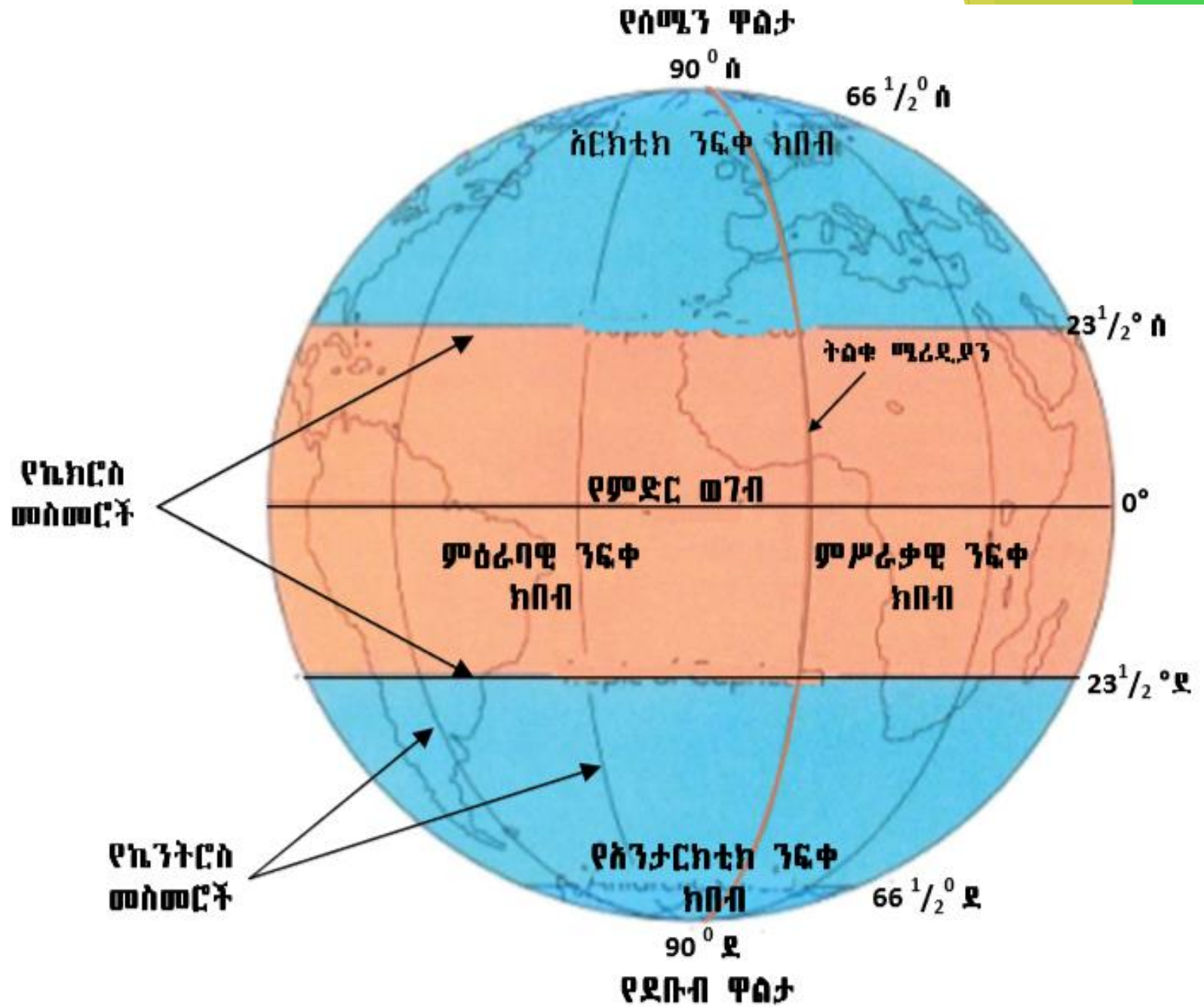
Solar System Video.mp4

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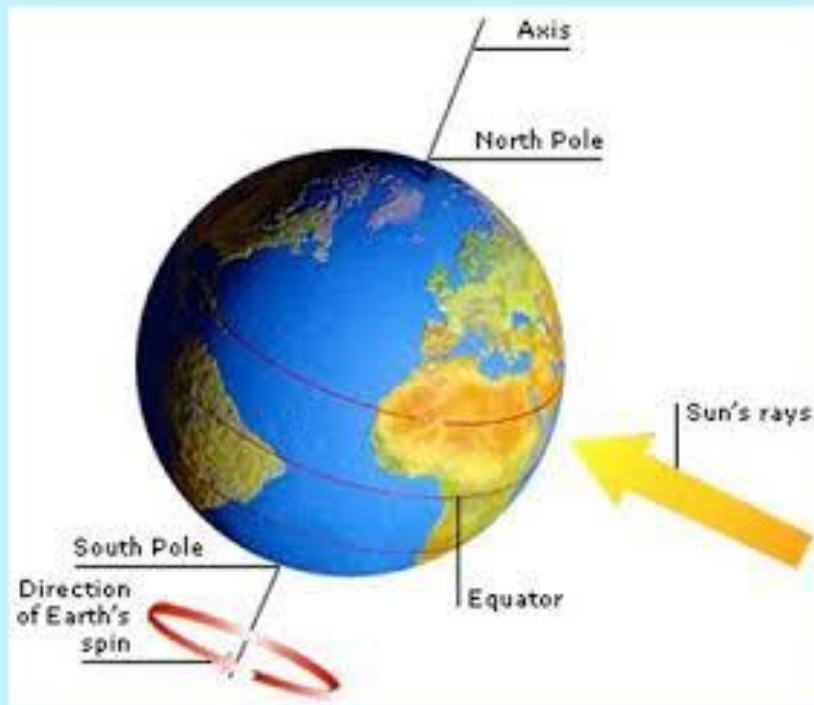
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Earth's Axis Is Tilted



- The tilt is always in the same direction, even as Earth rotates around the sun, so part of the year it points toward the sun, and part of the year it points away from the sun.

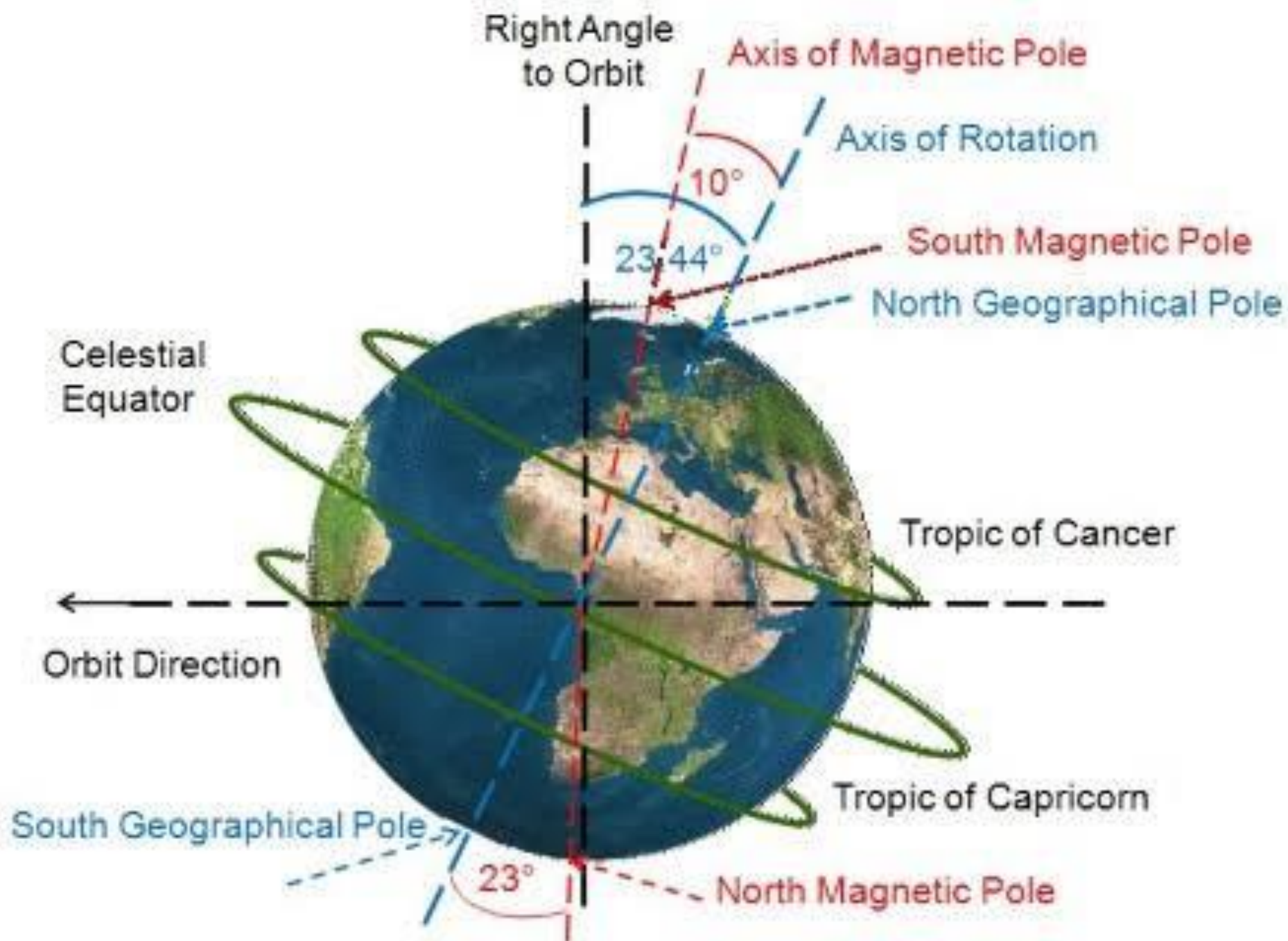




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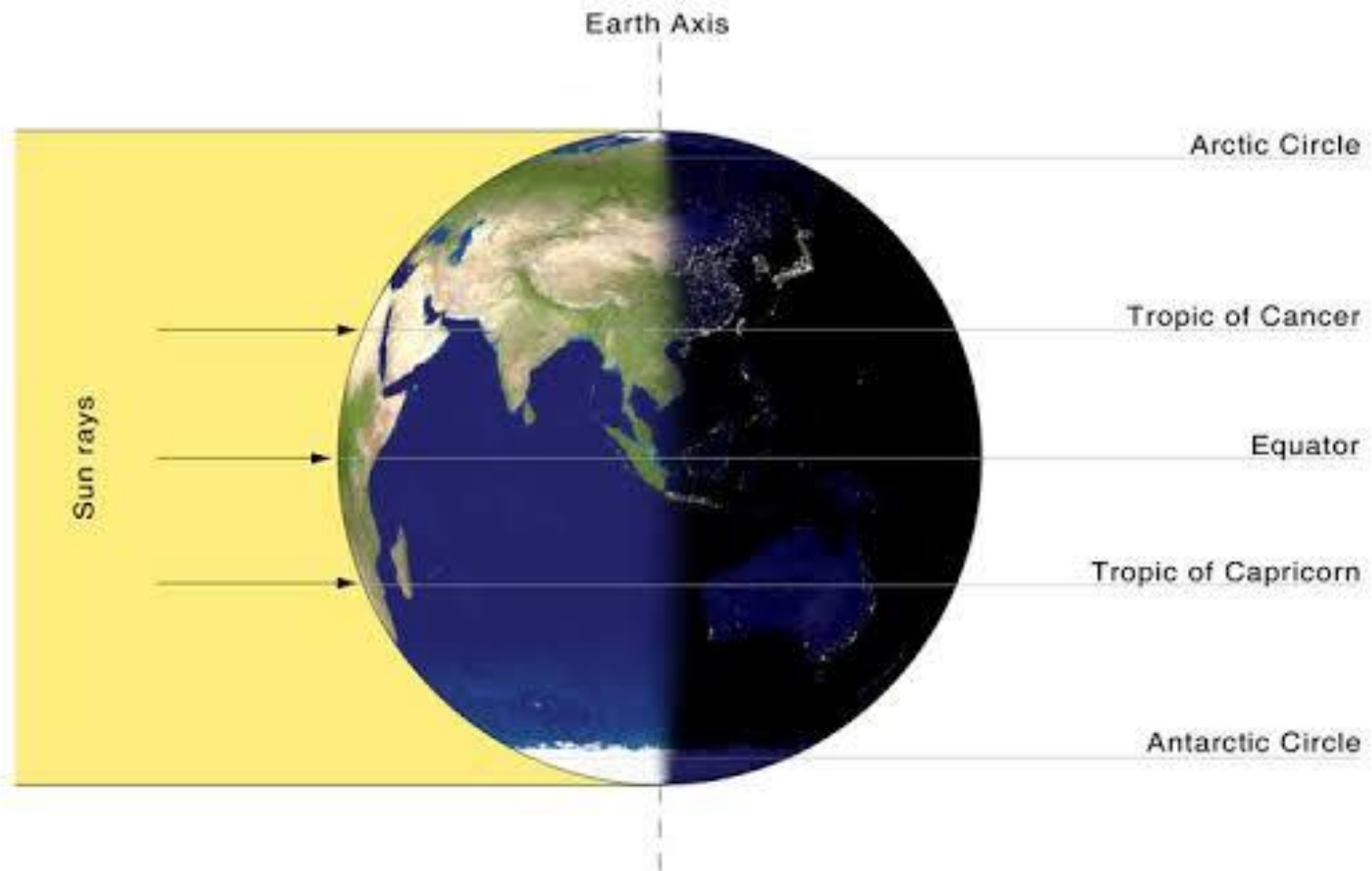
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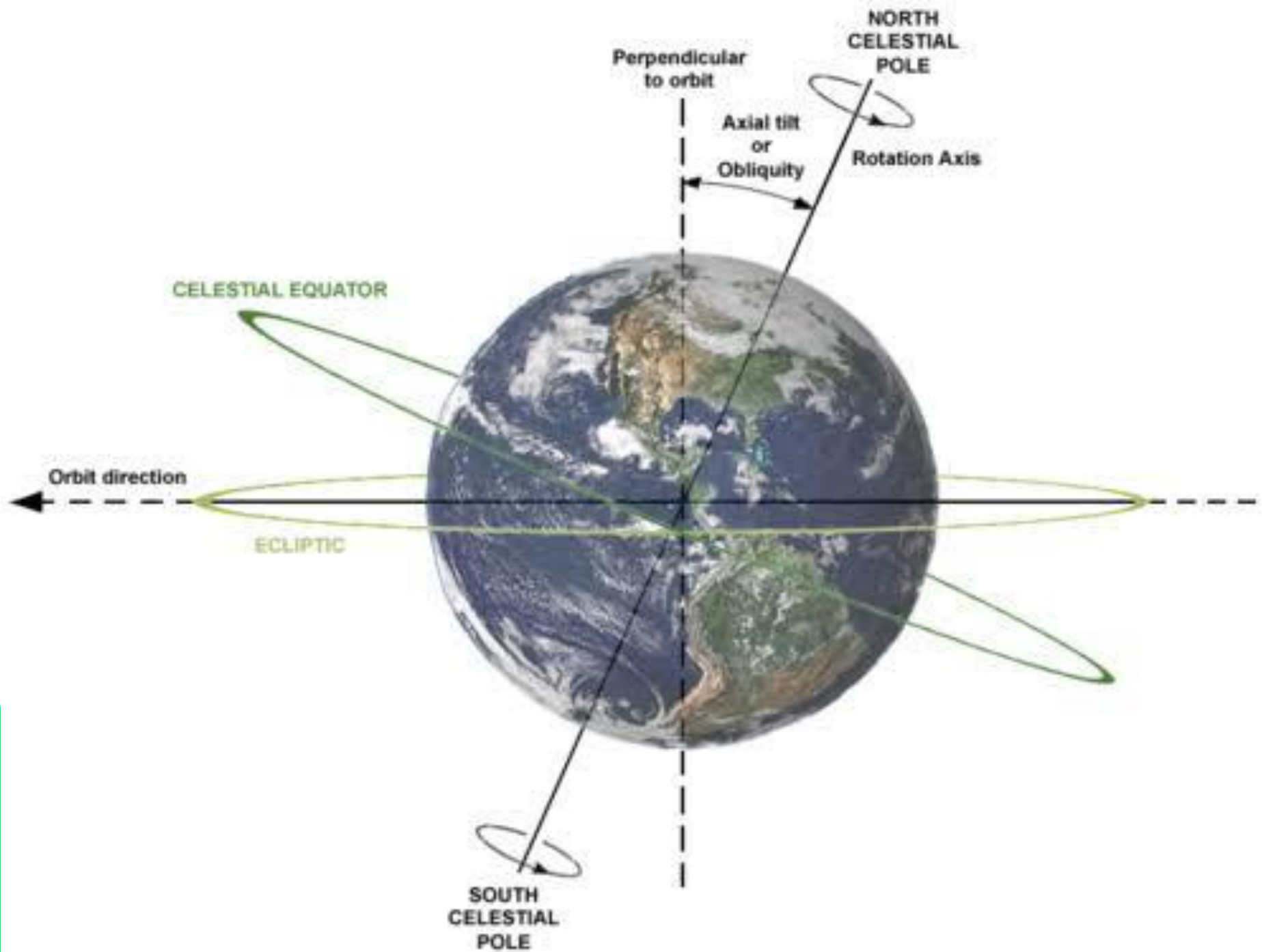




If Earth had NO Inclination (tilt)

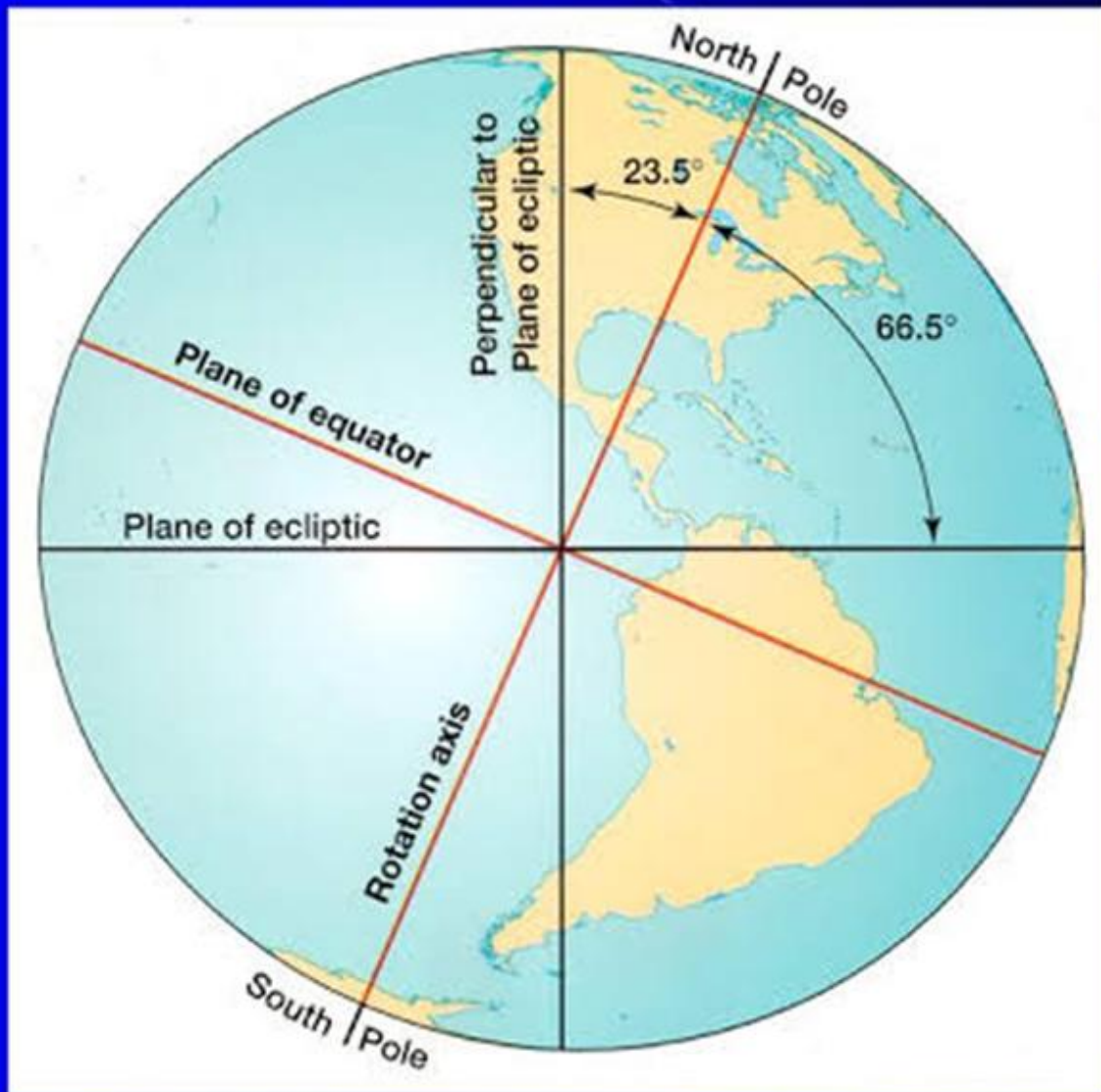
If Earth had NO tilt, then there would be no seasons throughout the year & each day would be an equinox (12 hours of light & 12 hours of night)

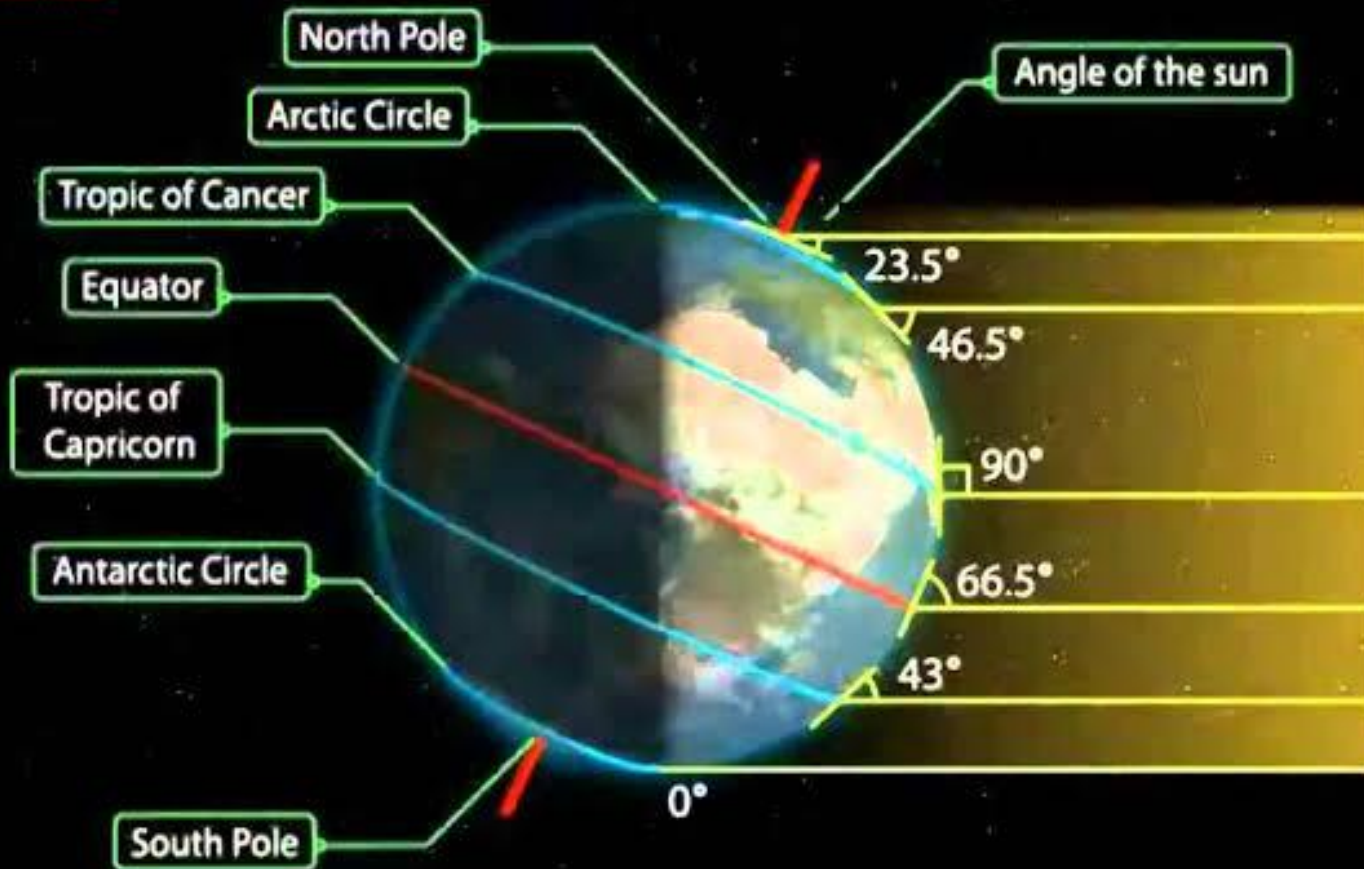




Earth's Revolution Around the Sun

Inclination of Earth's Axis

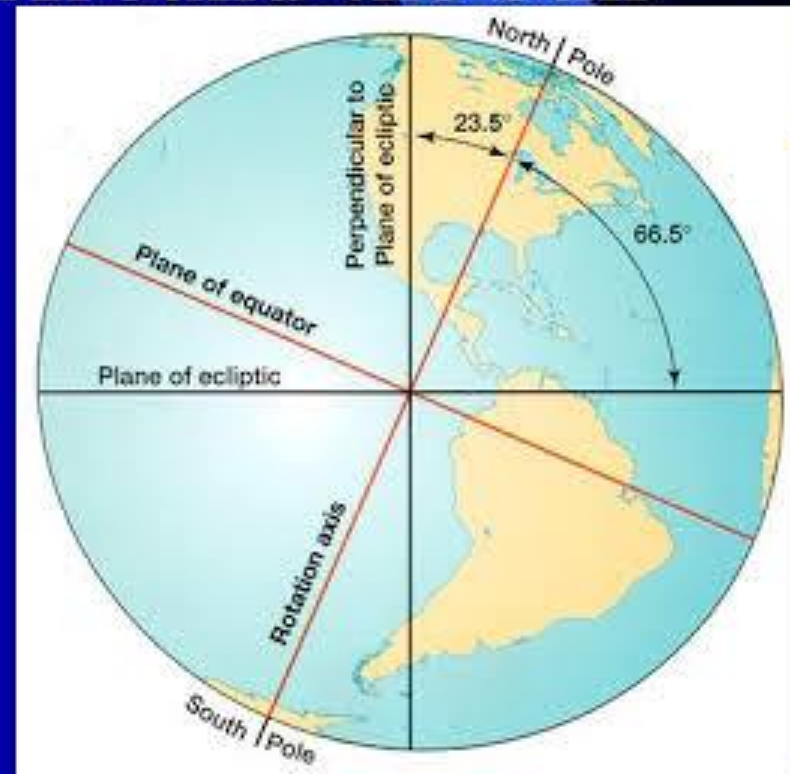




Earth-Sun Relations and The Seasons

Movements of the Earth

- Two main types of Earth's movements:
 - Earth's Rotation on its Axis
 - Earth's Revolution Around the Sun
- Inclination of Earth's axis during Earth's movement



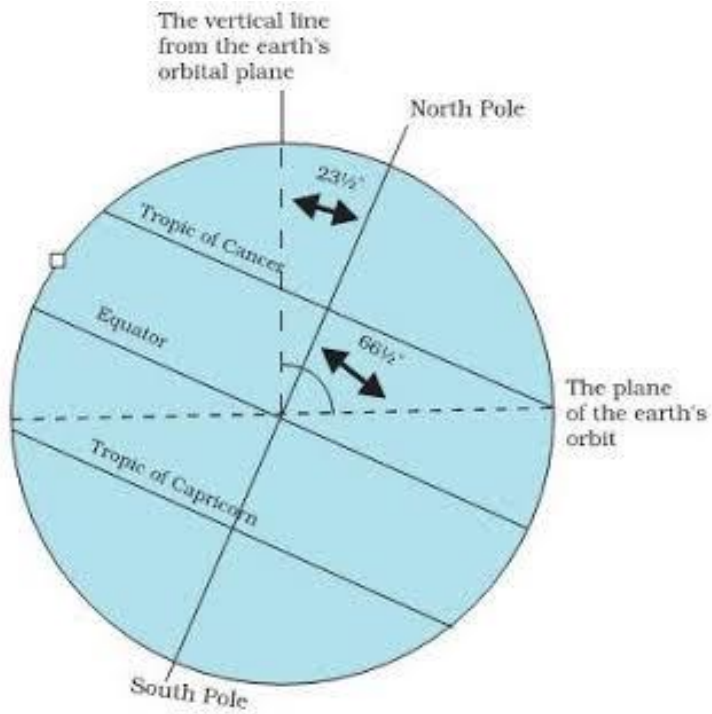


Figure 3.1 : Inclination of the Earth's axis and the orbital plane

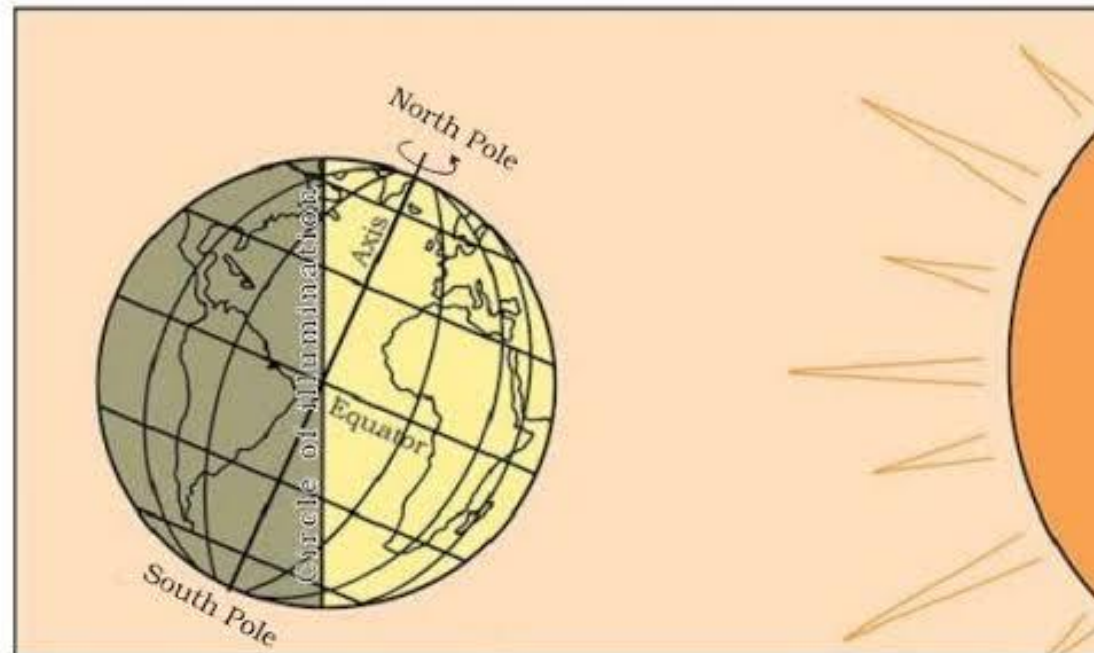
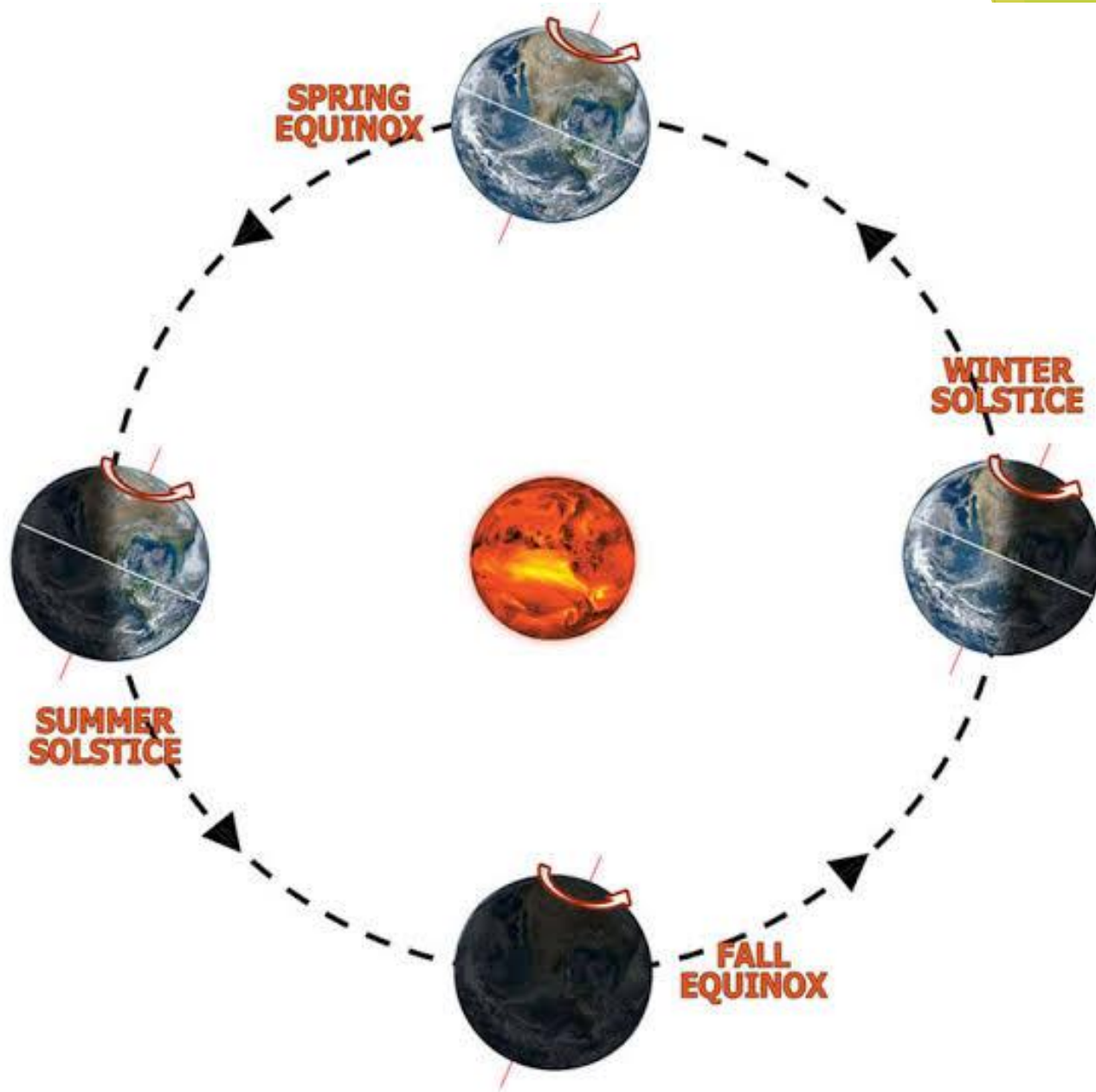
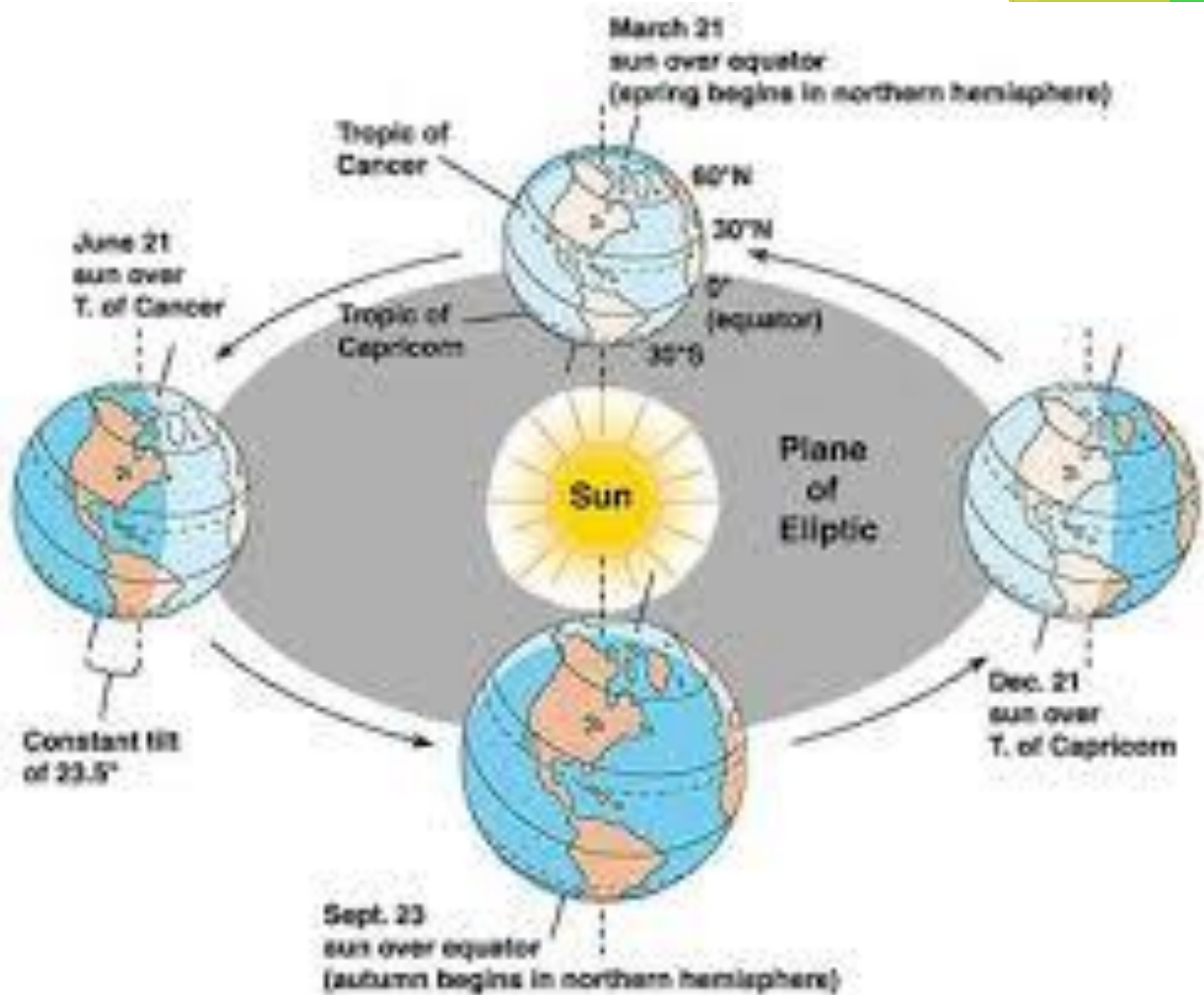


Figure 3.2 : Day and Night on the Earth due to rotation





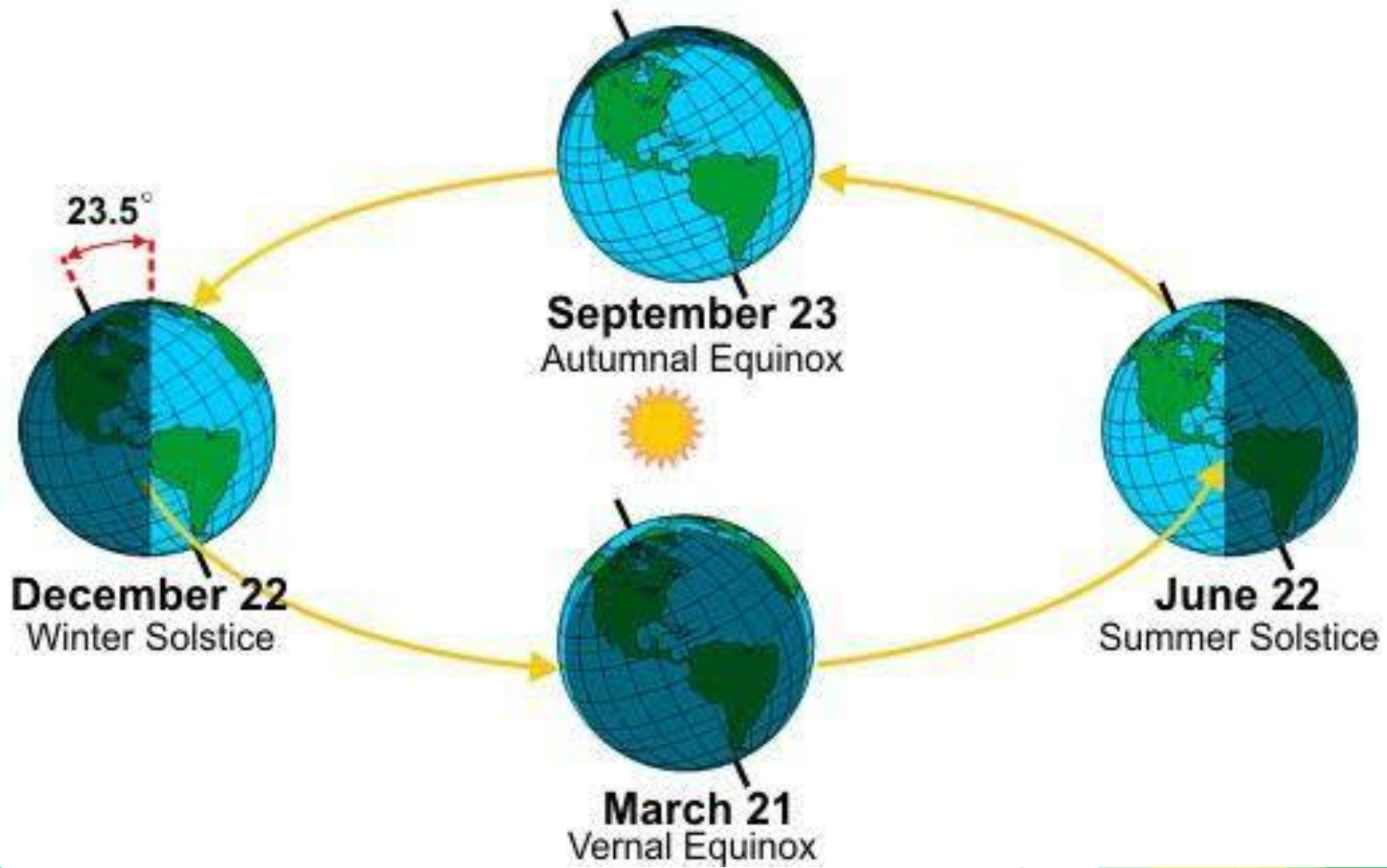
Equinoxes and Solstices

An equinox is one of the two days each year when there is an equal amount of daylight and nighttime hours.



- *An equinox* is the *instant* of *time* when the *sun strikes* the *plane* of the *Earth's equator*.
- During this passage the length of *day* and *night* are *equal*.
- Moreover, revolution of the earth along its orbit, the *inclination of its axis* from the *plane of that orbit*, and the constant position (parallelism) of the axis causes seasonal changes in the **daylight** and **darkness** periods.
- *Equinox* appears *twice a year*.
- Let's see *two major equinoxes*;

- *The Vernal (spring) equinox*: is the day when the point of *verticality of sun's rays crosses* the *equator northwards*.
- This *equinox experiences in Northern Hemisphere* when the sun is *exactly above the equator*.
- During this period, the *length of day and night are equal*.
- *Vernal (spring) equinox marks the beginning of spring season*.
- *March 21* marks the *offset* of the *vernal equinox*.



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በሰን መጋቢት

15 ቀን (march 21)

በጊ ታኅሣስ 15
ቀን (Dec.22)

ክረምት 15 ቀን
(June 21)

መስከረም 15
(September 22)

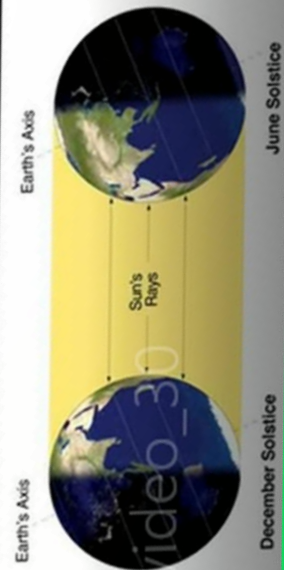


- The **Autumn equinox**: appears to happen when the *sun crosses equator giving approximately equal length between day and night.*
- It appears to happen when the visible sun moves south across the celestial equator on *23rd of September.*
- It marks the *beginning of Autumn season.*

► **Solstice** is an event when the *overhead sun* appears to **cross northern or southern points** relative to the *celestial equator* resulting in *unequal length of days* and *nights* in the hemispheres.

► Both *hemispheres* during this event has either the *most* or *least sunlight* of the year.

A solstice is when the sun reaches its greatest distance north or south of the equator

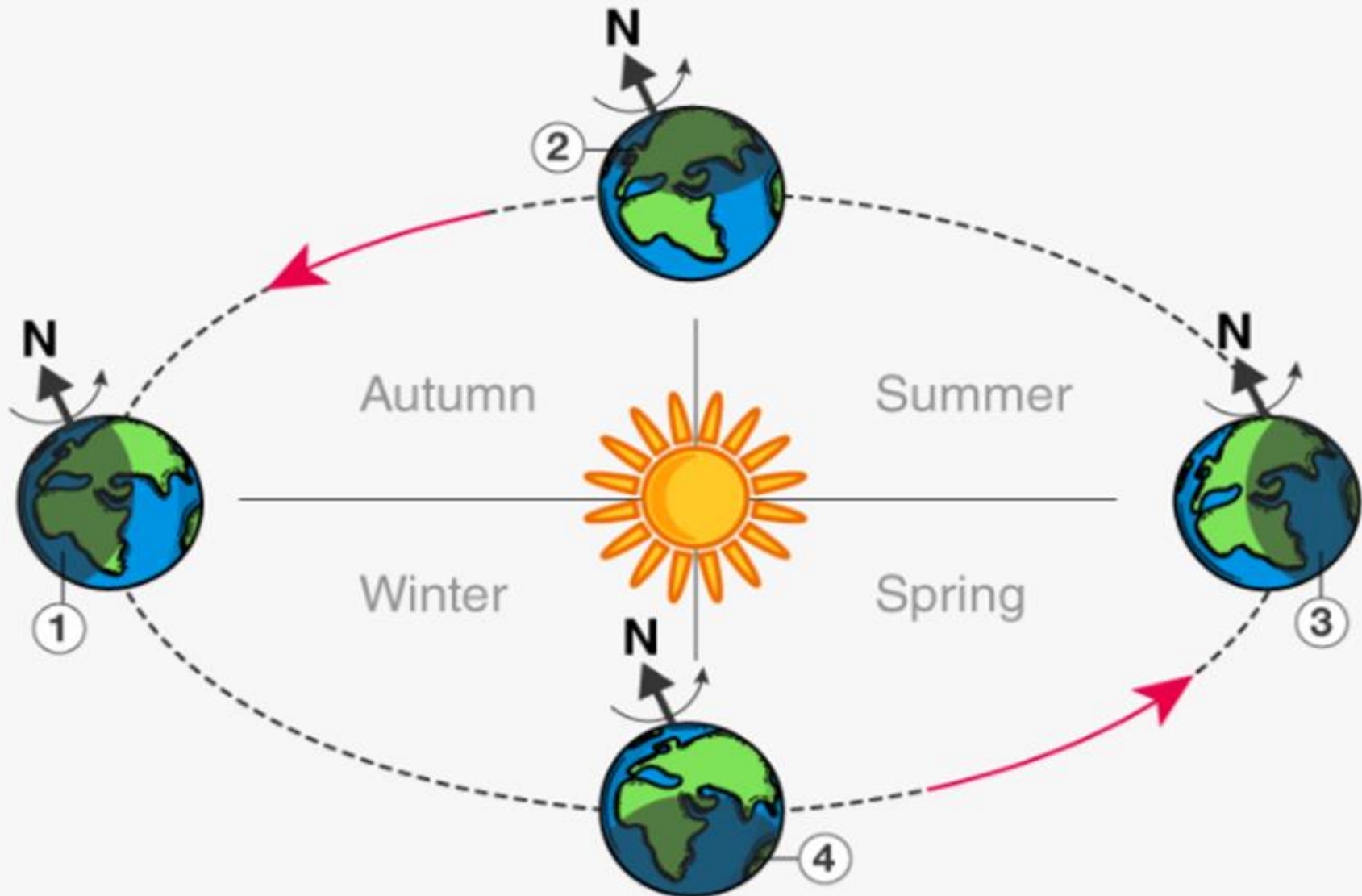


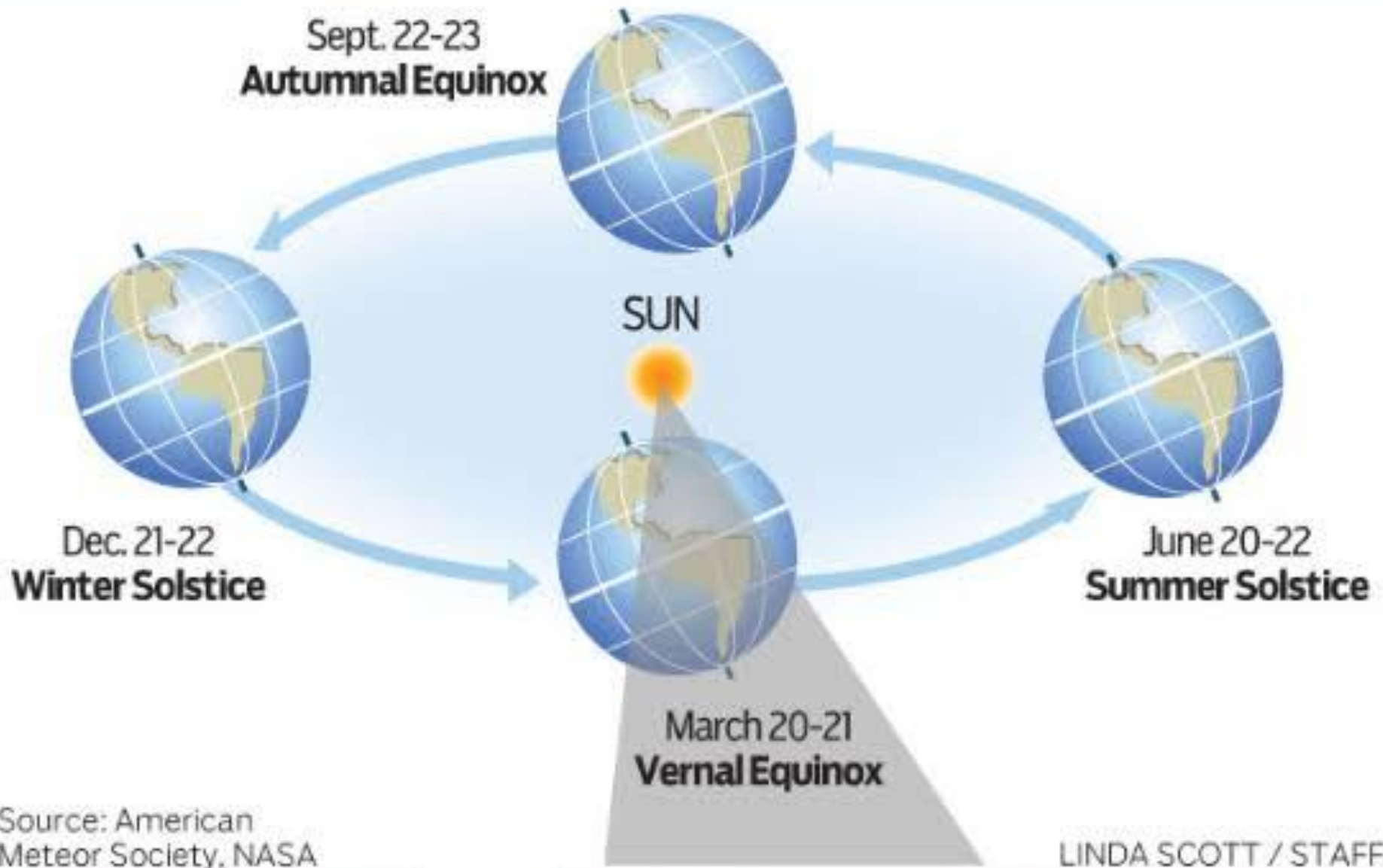
- ✚ **The summer Solstice:** on June 21st , the *northern hemisphere has maximum tilt towards the sun* experiencing longest daylight of the year.
- ✚ It is the *astronomical first day of summer* in the *Northern Hemisphere*.
- ✚ The *sun* is at its *highest position* in the *noonday sky*, directly above *23 ½* in the *Tropic of Cancer*.

The winter solstice: 22nd of December is the day when the *maximum southward inclination* is attained in the *Southern Hemisphere*.

In this event the *sun travels shortest length* causing *longest night* and *shortest daylight* in the *Northern Hemisphere*, it occurs when the sun is directly over the *Tropic of Capricorn*, which is located at $23\frac{1}{2}^{\circ}$ south of the *equator*.

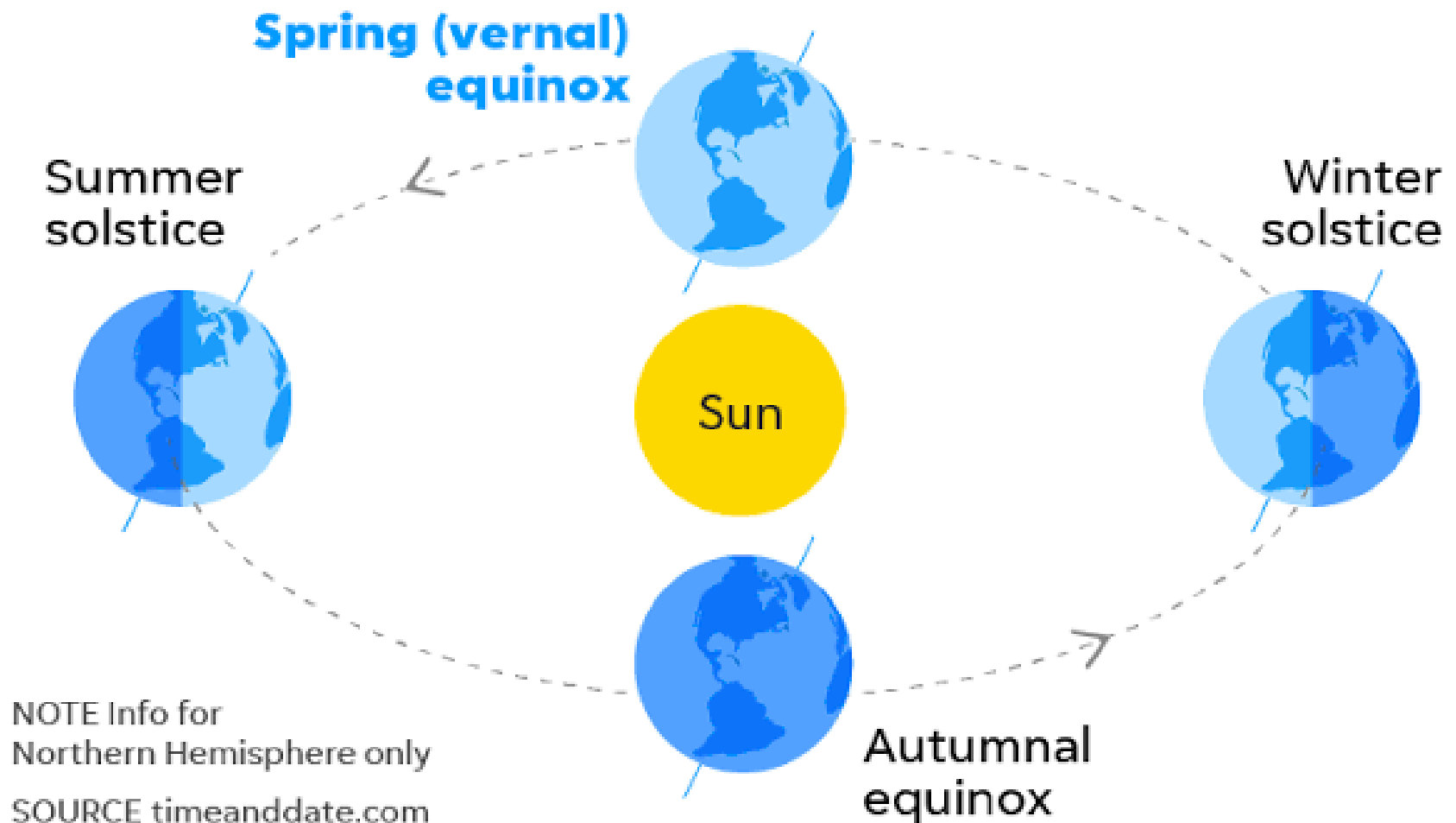
EQUINOX VS. SOLSTICE





It's the first day of spring!

Spring begins **Wednesday at 5:58 p.m. EDT** with the vernal equinox, when the sun is directly over the equator. Each day until the summer solstice on June 21, the sun will continue to get higher in the sky and the amount of daylight will increase.



Northern Hemisphere

Spring Equinox

Days longer than nights
Days get longer

Nights longer than days
Nights get shorter

Summer

Days longer than nights
Days get shorter

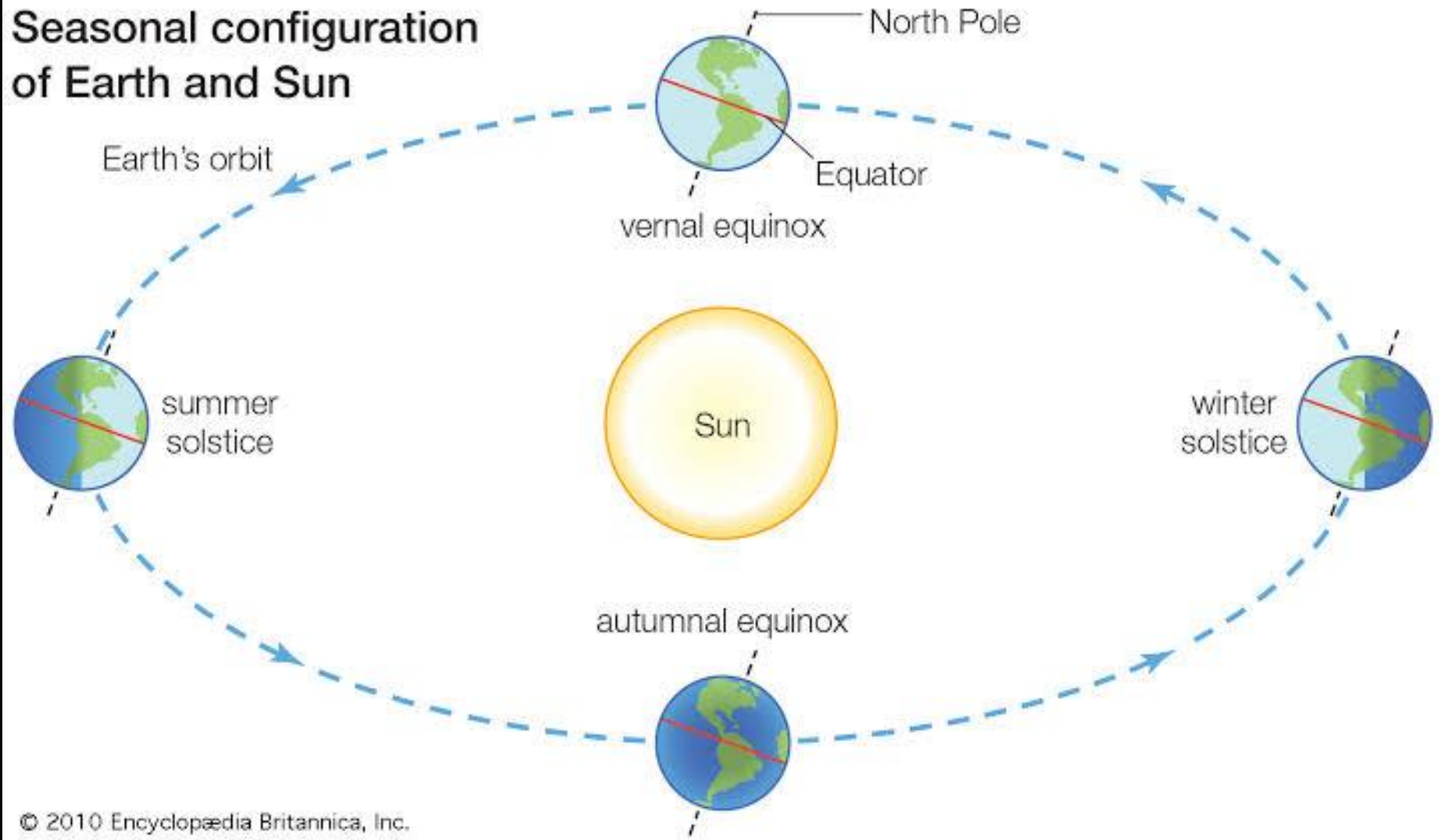
Winter

Nights longer than days
Nights get longer

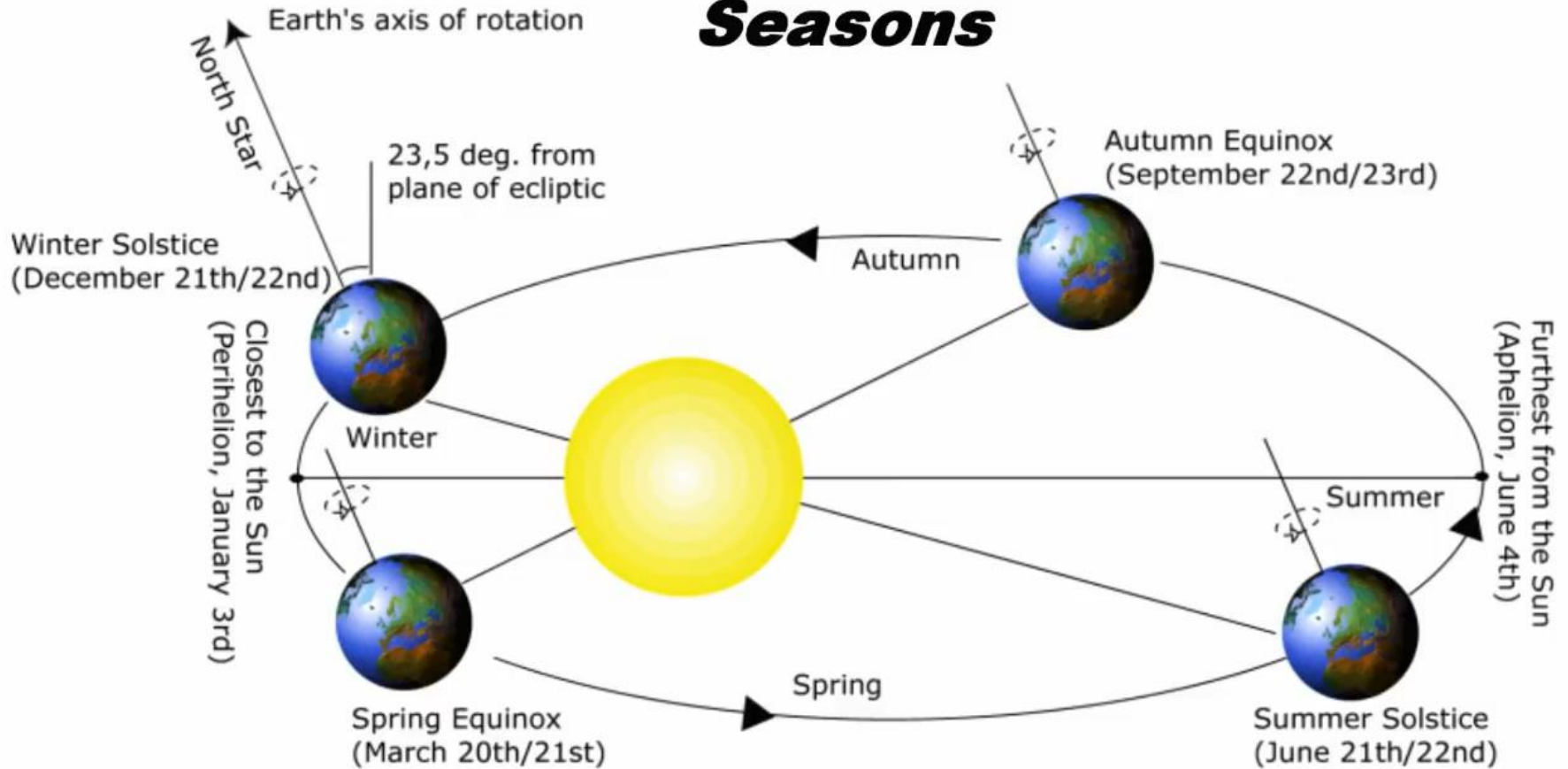
Autumnal Equinox

Not to Scale

Seasonal configuration of Earth and Sun



Seasons



Kurdistan Planetarium

VIDEO: Ayele B (Assi Prof)

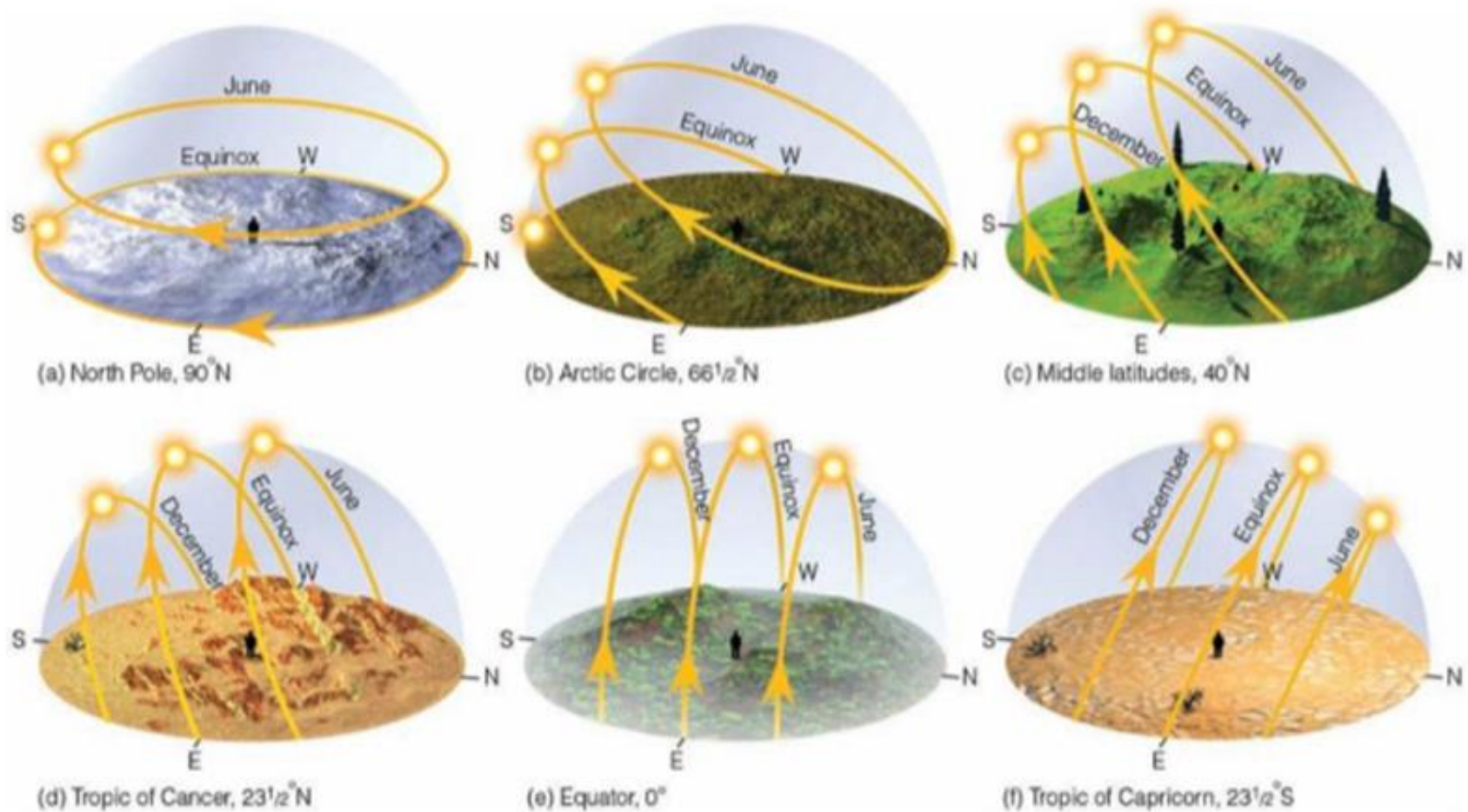


Figure 5.1. The apparent path of the sun at different latitudes.

Source: Ahrens & Henson, 2019

VIDEO



Understanding the Equinox and the Solstice - EM SC 100- First Year Seminar.mp4

: **Ayele B (Assi Prof)**

Month	Length of day time (Hours)	Length of night time (Hours)	total hrs. of the day
September	12	12	24
October	11	13	24
November	10	14	24
December	9	15	24
January	10	14	24
February	11	13	24
March	12	12	24
April	13	11	24
May	14	10	24
June	15	9	24
July	14	10	24
August	13	11	24

c. Altitude

Do you have any experience of visiting high elevation places? What differences have you felt between the lowest and highest elevations?

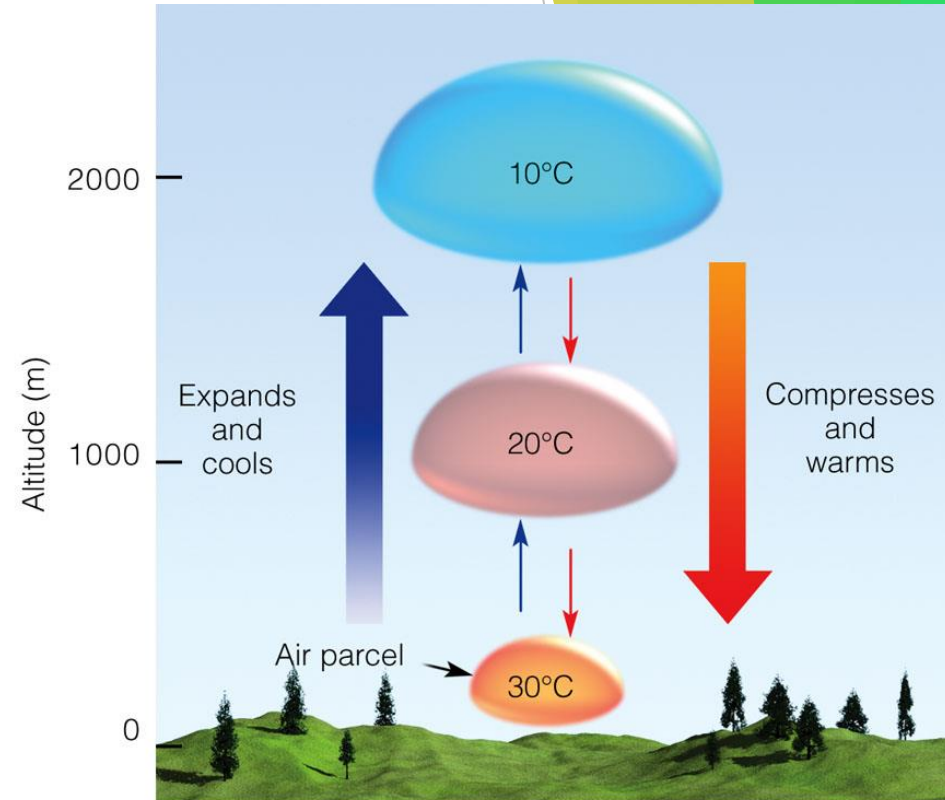
- Altitude is the height of *location above the sea level*.
- Under normal conditions there is a general decrease in temperature with *increasing elevation*.
- The average rate at which temperature changes per unit of altitudinal change is known as lapse rate.
- The *lapse rate* is limited to the lower layer of the atmosphere named as *troposphere*.
- The *normal lapse rate* is 6.5°C per kilometer rise in *altitude*.

The **lapse rate** is the rate at which an atmospheric variable, normally temperature in Earth's atmosphere, changes with altitude. *Lapse rate* arises from the word *lapse*, in the sense of a gradual change. It corresponds to the vertical component of the spatial gradient of temperature. Although this concept is most often applied to the Earth's troposphere, it can be extended to any gravitationally supported parcel of gas.



Adiabatic cooling/heating

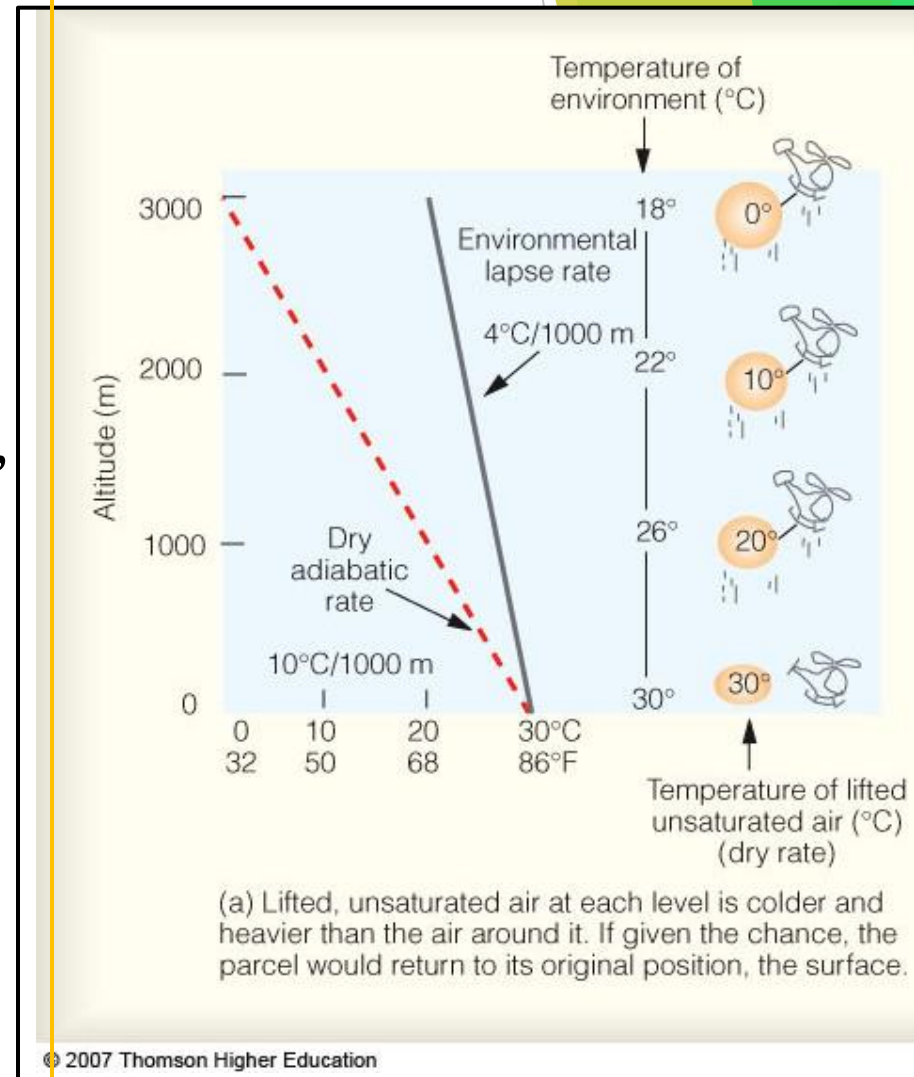
- ▶ **Ascending motion:** the parcel of air expands, does work on the rest of the atmosphere and **cools down**.
- ▶ **Descending motion:** the air parcel compresses, work is done on the air parcel and it **warms up**.
- ▶ **Adiabatic process:** **no heat** is exchanged between the air parcel and the rest of the atmosphere



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Adiabatic lapse rates

- ▶ **Adiabatic lapse rate:** the rate of change of the temperature of a rising (sinking) air parcel with altitude as a result of adiabatic expansion (compression).
- ▶ **Dry adiabatic lapse rate:** the air parcel is unsaturated ($RH < 100\%$), (otherwise condensation, latent heat, see below)
 - ▶ For the Earth: 10 deg C/km .
 - ▶ For Jupiter: 2 deg C/km .
- ▶ **Environmental lapse rate:** the actual rate of change of the temperature with height.

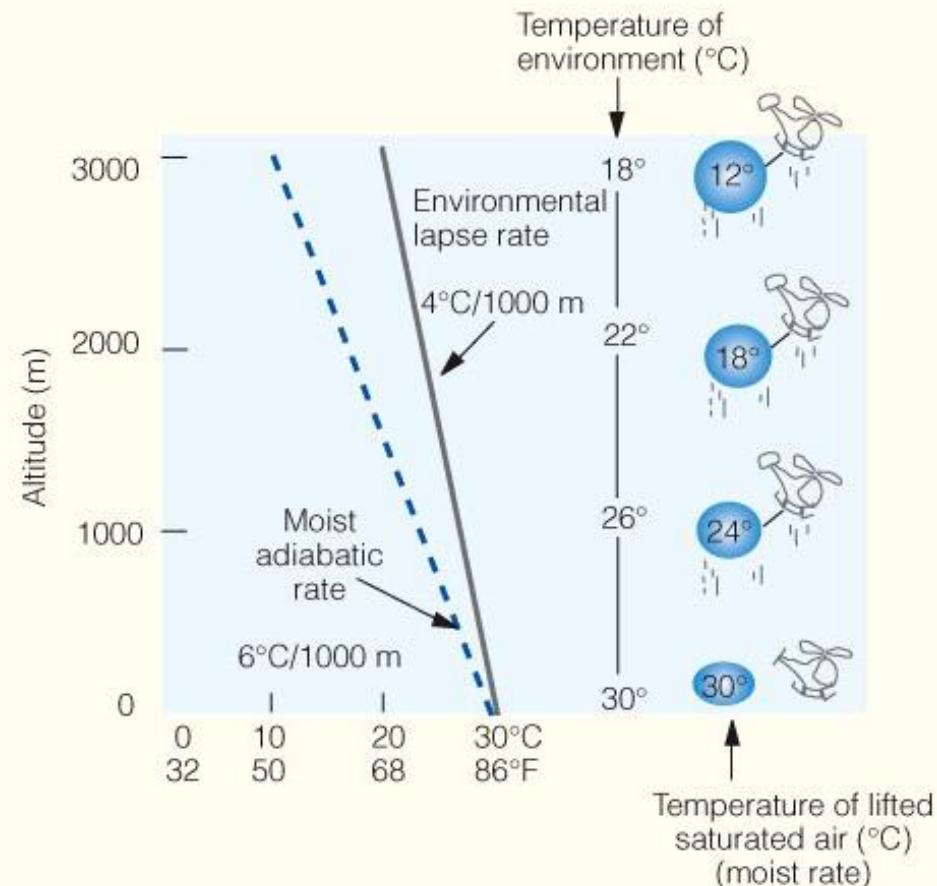


Moist adiabatic lapse rate

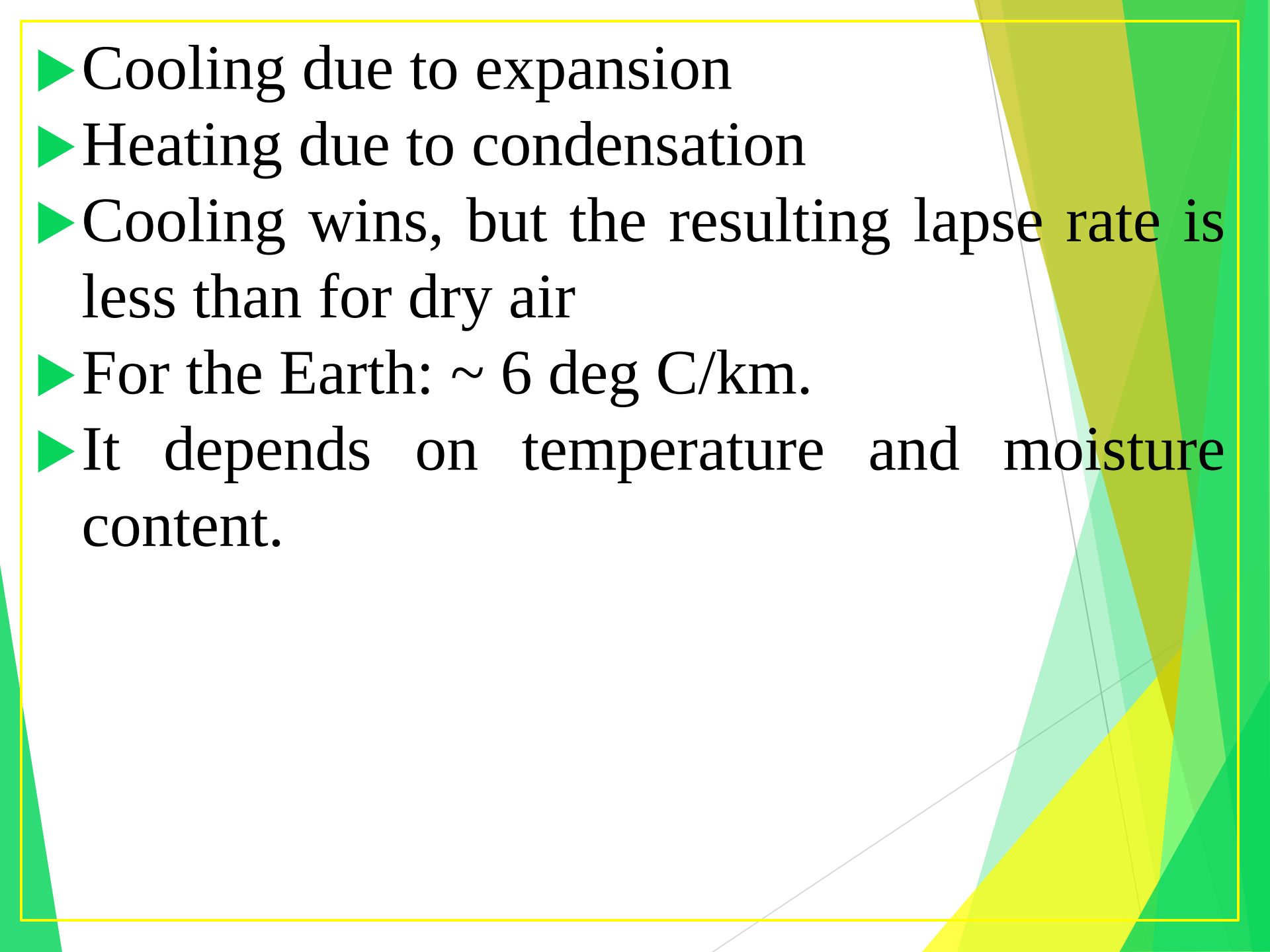
- ▶ A rising air parcel is cooling -> its RH increases -> air becomes saturated -> condensation -> latent heat released -> partially offsets the cooling effect

Moist adiabatic lapse rate: the adiabatic lapse rate for saturated air.

It is the result of two competing effects:



(b) Lifted, saturated air at each position is colder and heavier than the air surrounding it. If released, the parcel would return to its original position, the surface.

- 
- ▶ Cooling due to expansion
 - ▶ Heating due to condensation
 - ▶ Cooling wins, but the resulting lapse rate is less than for dry air
 - ▶ For the Earth: ~ 6 deg C/km.
 - ▶ It depends on temperature and moisture content.

Types of lapse rate

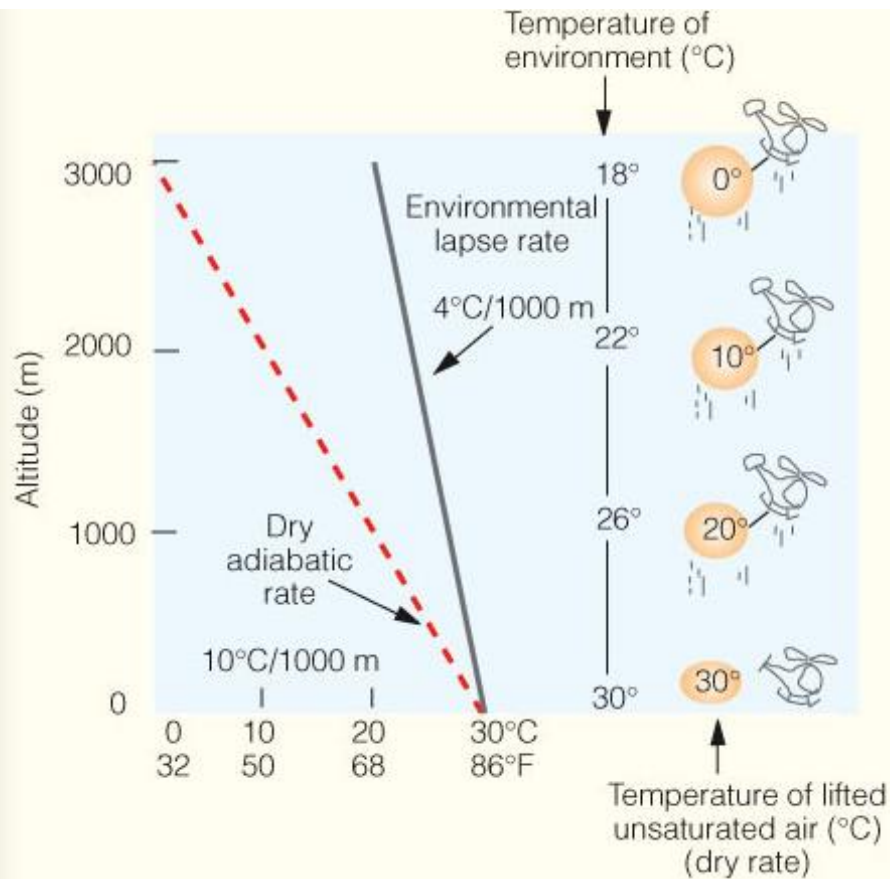
▶ Three types of lapse rates are identified;

i. **Dry adiabatic lapse rate**

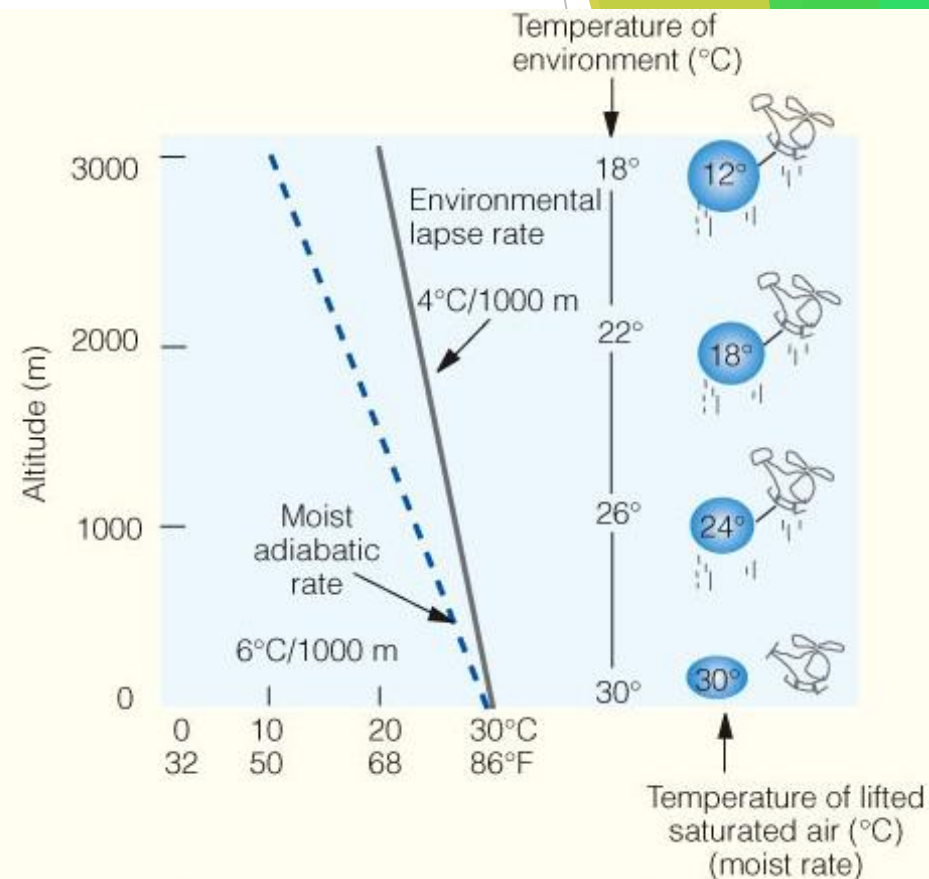
- The temperature changes occurring in the rising or subsiding air mass are not the result of additions of heat to, or withdrawals of heat from outside sources, but rather are the consequence of internal processes of expansion and contraction.
- This is known as *adiabatic temperature change*.
- An *adiabatic lapse rate* is *the rate at which the temperature of an air parcel changes in response to the expansion or compression process associated with a change in altitude*.

Dry versus moist adiabatic rate

- The moist adiabatic rate is **always less** than the dry rate



(a) Lifted, unsaturated air at each level is colder and heavier than the air around it. If given the chance, the parcel would return to its original position, the surface.



(b) Lifted, saturated air at each position is colder and heavier than the air surrounding it. If released, the parcel would return to its original position, the surface.

- *Vertical displacements* of air are the major cause of adiabatic temperature changes.
- When *air rises*, it expands because there is *less weight of air* upon it. .
- Thus, if a mass of dry air at sea level rises to an altitude of about 18,000ft (5486.22 meters), the pressure upon it is reduced by nearly half and consequently its volume is doubled.

- As long as the air in the parcel is unsaturated (the relative humidity is less than 100 percent), the rate of adiabatic cooling or warming remains constant.
- More precisely, if the *upward movement of air does not produce condensation*, then the *energy expended by expansion will cause the temperature of the mass to fall at the constant dry adiabatic lapse rate*.
- *The rate of heating or cooling is about 10°C for every 1000 m of change in elevation.*
- This rate applies only to *unsaturated air*, and thus it is called the *dry adiabatic lapse rate*.

ii. Wet Adiabatic lapse rate

- Due to the fact that the heat added during condensation starts cooling following the expansion, the air will no longer cool at the *dry adiabatic rate*.
- This is due to the *latent heat in the water vapor carried by the air*.

- The *heat is released in the process of ascent*, therefore affecting or **lowering** the rate of temperature change of the *rising air*.
- If a *saturated air containing water droplets were to sink*, it would compress and warm at the moist adiabatic rate because *evaporation of the liquid droplets would start the rate of compressional warming*.

- Hence, the *rate at which rising or sinking saturated air changes its temperature is less than the dry adiabatic rate.*
- Prolonged cooling of air invariably produces condensation, thereby liberating latent heat.
- Therefore, *rising and saturated or precipitating air cools at a slower rate than air that is unsaturated.*
- This process is called wet adiabatic temperature change.
- The rate of cooling of wet air is approximately **5** °C per 1000 meters ascend.

iii. Environmental lapse rate or Atmospheric lapse rate

- This refers to the *actual, observed change of temperature with altitude*.
- The fact that *air temperature is normally highest at low elevations next to the earth and decreases with altitude clearly indicates that most of the atmospheric heat is received directly from the earth's surface and only indirectly from the sun*.

- But the *lower layer is warmer, not only because it is closest to the direct source of heat but also of its high density.*
- It contains more water vapor and dust, which causes it to be a more efficient absorber of earth radiation than is the thinner, drier, cleaner air aloft.
- This *decrease in temperature upward from the earth's surface normally prevails throughout the lower atmosphere* called **troposphere**.
- The principal exception to the rule is the cause of *temperature inversions*. The rate of change is **6.5 °C/1000** meters.

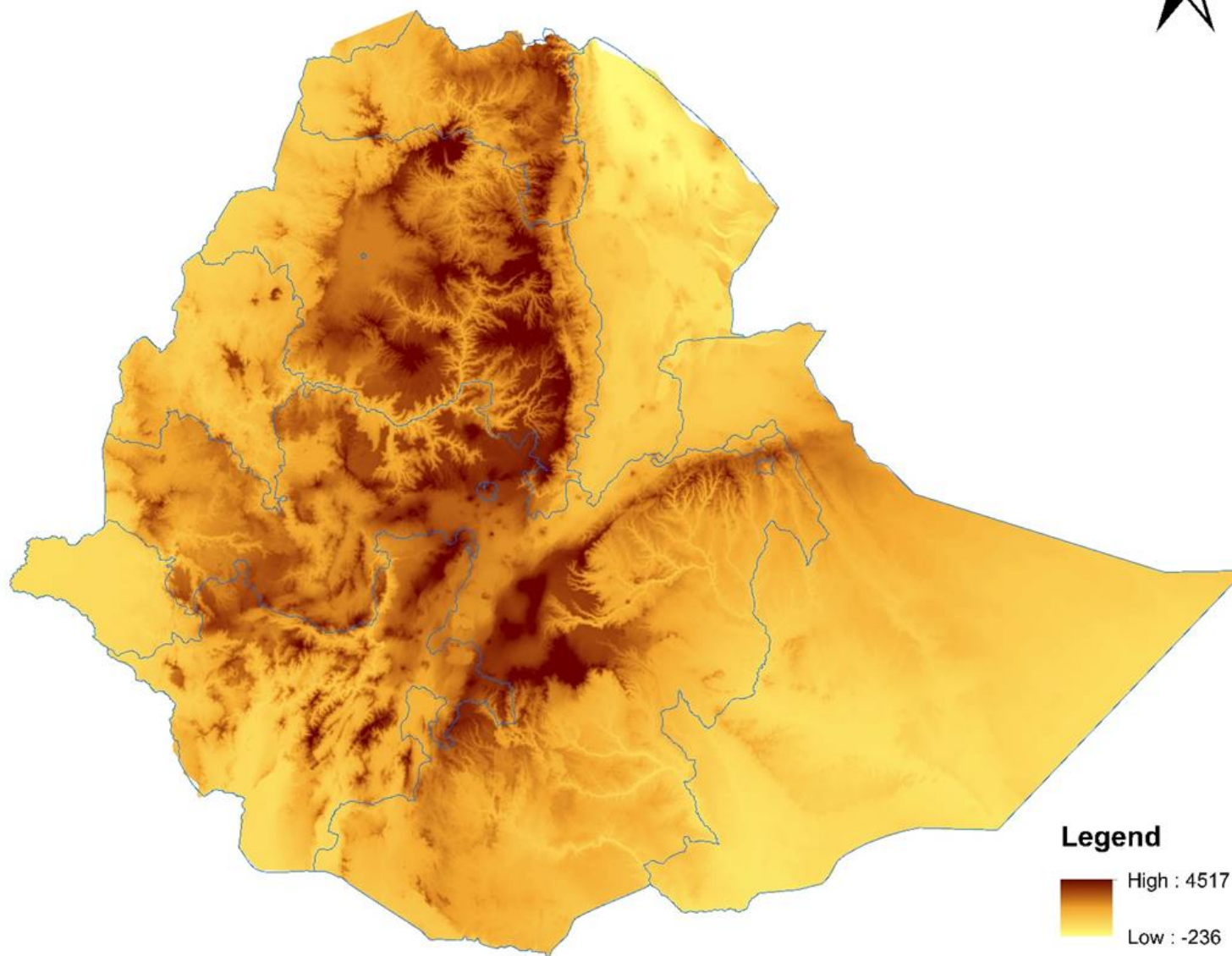
5.3. Spatiotemporal Patterns and Distribution of Temperature and Rainfall in Ethiopia

5.3.1. Spatiotemporal Distribution of Temperature

- **Altitude** is an important element in determining *temperature of Ethiopia and the Horn.*
- **Latitude, humidity and winds**, with varying magnitude have also *significant impacts* on *temperature conditions in Ethiopia.*
- The *spatial distribution of temperature* in Ethiopia is primarily determined by *altitude* and *latitude.*

- The *location of Ethiopia* at close proximity to equator, a zone of maximum **insolation**, resulted for every part of the country to experience *overhead sun twice a year*.
- However, in Ethiopia, as it is a *highland country*, *tropical temperature conditions* have *no full spatial coverage*.
- They are limited to the *lowlands* in the *peripheries*.
- Away from the *peripheries* the *land begins to rise gradually* and considerably, *culminating/ending in peaks* in various parts of the country.
- Thus **temperature**, as it is affected by **altitude**, *decreases towards the interior highlands*.

DEM of Ethiopia



Legend



Legend

Compiled By Ayale B. Alemsegn November 2019

Ayale B. Alemsegn

- Mean annual temperature varies from over 30 °C in the *tropical lowlands* to less than 10 °C at very *high altitudes*.
- The **Bale Mountains** are *among highlands* where *lowest mean annual temperatures* are recorded.
- The *highest mean maximum temperature* in the country is recorded in the *Land of extremes* . . .
- Moreover, *lowlands of north-western, western and south-eastern Ethiopian* experiences *mean maximum temperatures of more than 30 °C*.
- Environmental influences have their own traditional expressions in Ethiopia and there are *local terms denoting temperature zones* as shown in the table below:

ETHIOPIA

Land of Extremes

SIRAKIYAYO

VIDEO: Ayele B (Assi Prof)



Ethiopia Land of Extremes.mp4

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ERUPTING LAVA LAKE

DanAKIL DESERT, eTHIOPIa

VIDEO: Ayele B (Assi Prof)



ERTA ALE VOLCANO - Part 1- The Largest Permanent Lava Lake on Earth, Ethiopia (Erupting Lava Lake)(1).mp4

Table 1: Temperature versus Altitude

<i>Altitude (meter)</i>	<i>Mean annual Temp ($^{\circ}$C)</i>	<i>Description</i>	<i>Local Equivalent</i>
<i>3,300 and above</i>	<i>10 or less</i>	Cool	<i>Wurch</i>
<i>2,300 - 3,300</i>	<i>10 – 15</i>	Cool Temperate	<i>Dega</i>
<i>1,500 - 2,300</i>	<i>15 – 20</i>	Temperate	<i>Woina Dega</i>
<i>500 - 1,500</i>	<i>20 – 25</i>	Warm Temperate	<i>Kola</i>
<i>below 500</i>	<i>25 and above</i>	Hot	<i>Bereha</i>

Source: MoA, 2000

- The *temporal distribution of Ethiopian temperature* is characterized by **extremes**.
- The major controls determining its distributions are **latitude** and **cloud cover**.
- However, *some parts* of the country enjoy a *temperate climate*.
- In the **tropics**, the *daily range of temperature* is *higher* and the *annual range is small*, whereas the reverse is true in the *temperate latitudes*.
- In Ethiopia, as in *all places in the tropics*, the air is frost free and *changes in solar angles* are small making *intense solar radiation*

- Ethiopia's *daily temperatures* are *more extreme* than its *annual averages*.
- Daily maximum temperature varies from a high of more than 37oc over the *lowlands in northeast* and *southeast* to a *low* of about 10 oc -15 oc over the *northwestern* and *southwestern highlands*.
- The *variation* in the *amount of solar radiation received daily* is *small* throughout the year.

- As already explained, **temperature is high** during the **daytime** in some places, and is considerably **reduced** at **night** resulting *maximum difference in the daily range*.
- But in the case of *monthly averages*, *variation is minimal* and *the annual range of temperature is small*.
- This holds true in both the highlands and lowlands.

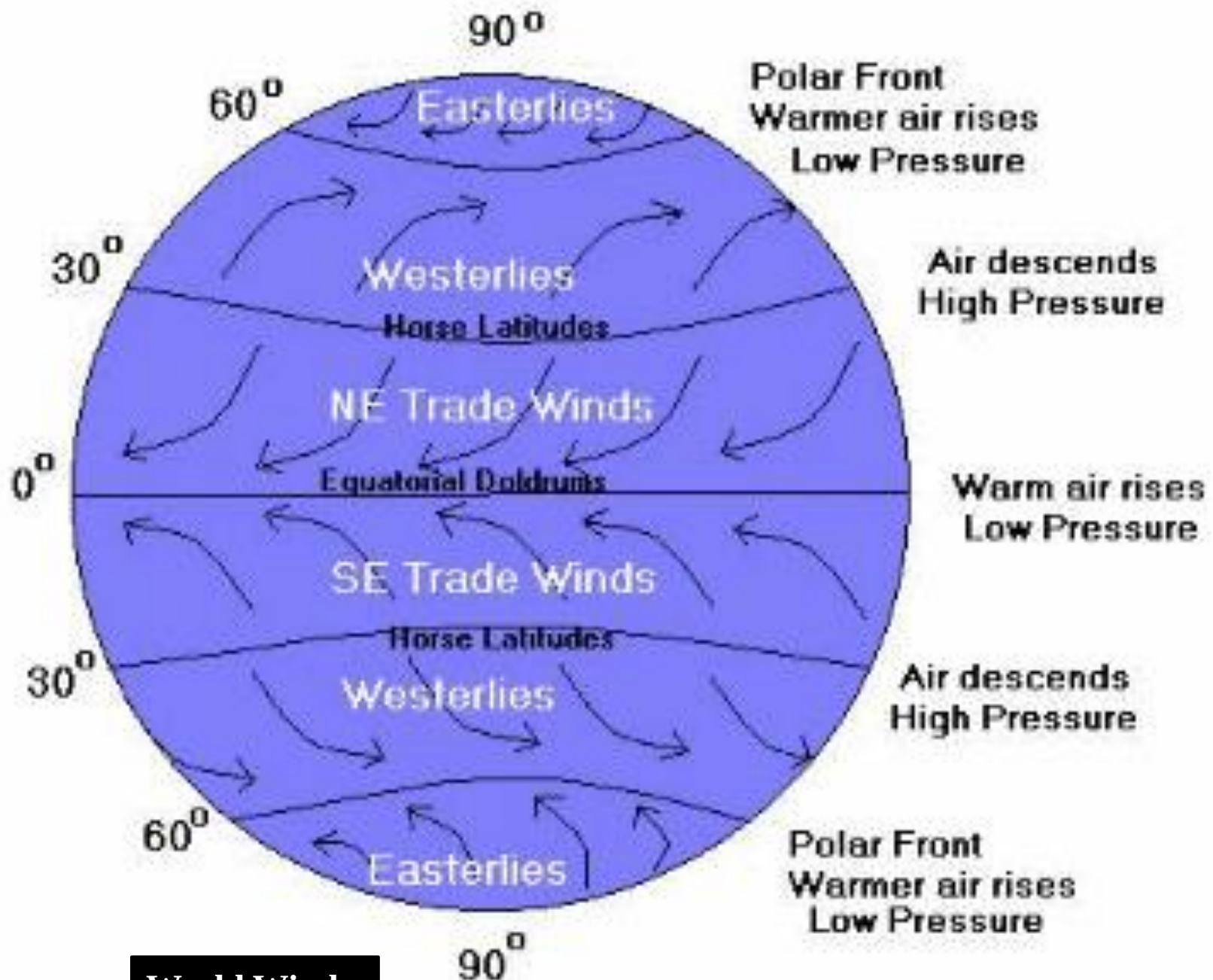
- In Ethiopia and elsewhere in the Horn, *temperature shows seasonal variations.*
- For example, months from *March to June* (*Vernal/spring equinox where sun is overhead in northern Hemisphere*) in Ethiopia have records of *highest temperatures.*
 - Conversely, **low temperatures** are recorded from *November to February* (*Autumn equinox where sun is overhead in southern Hemisphere*) .

- It is *not easy to observe distinct variation* in temperature between seasons *as the sun is always high in the tropics*.
- However, there is a *slight temperature increase in summer*.
- Southern part of Ethiopia receives *highest records of temperature* in *autumn* and *spring* following the *relative shift of the sun*; whereas in the *northern part of the country, summer season* is characterized by *higher temperature*.

- It has to be noted that certain seasons should have special considerations.
- For instance, unlike other parts of Ethiopia, the ***southern*** and ***southwestern highlands*** experience ***reduced temperature***.
- This is because the temperature and the amount of energy reaching the surface is directly related with the ***directness of the sun***.
- The direction of ***rain bearing winds*** (***leeward or windward side***) also determines the ***temperature variations*** in ***mountainous regions***.

5.3.2. Spatiotemporal Distribution of Rainfall

- *Rainfall system in Ethiopia* is characterized by *complexities*.
- To encompass the system, it needs an understanding of the position of *Inter Tropical Convergence Zone (ITCZ)*, *pressure cells*, and *Trade Winds*.
- Thus, the *rainfall system in Ethiopia* is characterized by *spatial and temporal variabilities*.
- Rainfall in Ethiopia is the result is influenced by the *position of Intertropical Convergence Zone (ITCZ)*.
- The convergence of *Northeast Trade winds* and the *Equatorial Westerlies* forms the ITCZ, which is a *low-pressure zone*.



World Winds

Ayele B (Assi Prof)

- The *inter-annual oscillation of the surface position of the ITCZ* causes a variation in the *Wind flow patterns over Ethiopia* and the Horn.
- Following the position of the overhead sun, the ITCZ shifts north and south of the equator.
- As the shift takes place, equatorial westerlies from the south and southwest invade most parts of Ethiopia bringing moist winds.

- However, these *winds decrease the length of rainy seasons* and *magnitudes* on the *line* of the *shift*.
- The shift takes place when the *trade winds* from the *north retreat giving* the *space* for *equatorial westerlies*.
- This development mainly happens in *July* in Ethiopia and the Horn causing variability and seasonality.

- The *ITCZ shifts towards south of equator* (*Tropic of Capricorn*) in *January*.
- During this period, the *Northeast Trade Winds* carrying *non-moisture-laden* dominates the region.
- *Afar* and *parts of Eritrean coastal* areas experience *rainfall* in this period.
- Following the directness of the *Sun in March and September around the equator*, the *ITCZ shifts towards* equator.
- During this time, the *central highlands, southeastern highlands* and *lowlands* receives rainfall as the *South Easterlies* bring moist winds.

Seasonal or Temporal Variabilities

- What winds bring summer rainfall for Ethiopian highlands?
- The rainfall is highly variable both in amount and distribution across regions and seasons.
- The seasonal and annual rainfall variations are results of the macro-scale pressure systems and monsoon flows which are related to the changes in the pressure systems discussed in the previous sections of this chapter.
- The *temporal variabilities of rainfall* are characterized by:

I. Summer (June, July, August)

- From *mid-June to mid-September*, majority of Ethiopian regions, except *lowlands in Afar* and *Southeast*, receive rainfall during the summer season as the *sun overheads north of the equator*.

- High pressure cells develop on the Atlantic and Indian Oceans around the *tropic of Capricorn* although the *Atlantic contributes a lot*, the *Indian Ocean* is *also* source of rainfall.
- During this season, Ethiopia and the Horn come under the influence of the *Equatorial Westerlies (Guinea monsoon)* and *Easterlies*.
- Hence, the **Guinea monsoon** and the **South easterly winds** are responsible for the *rain in this season*.

ii. **Autumn** (*September, October and November*)

- **Autumn** is the season of the year between *summer* and *winter*.
- The exact position of the ITCZ changes over the course of the year, *oscillating across the equator*.
- In **autumn** the ITCZ shifts towards the equator weakening the *equatorial westerlies*.
- During this season, the *south easterlies* from *Indian Ocean* showers the *lowlands* in *southeastern part of Ethiopia*.

iii. Winter (*December, January and February*)

- In winter, the **overhead** sun is far south of equator.
- During this season, *northeasterly winds* originating from the *landmass of Asia* dominantly prevail *Ethiopian landmass*.
- However, it has *no significant coverage* compared to other seasons.
- The *northeasterly winds crossing the Red Sea* carry *very little moisture* and supplies rain only to *the Afar lowlands* and the *Red Sea coastal areas*.

iv. Spring (*March, April and May*)

- In this season, the *noonday sun* is shining directly *on the equator* while *shifting north from south*.
- The shift of the ITCZ, results in *longer days* and more direct solar radiation providing warmer weather for the *northern world*.
- In this season, the effect of the *northeast trade wind* is *very much reduced*.
- Conversely, the *south easterlies* from the *Indian Ocean provide rain to the highlands of Somalia*, and to the *central* and *southeastern lowlands* and *highlands* of Ethiopia.

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Rainfall Regions of Ethiopia

- Based on rainfall distribution, both in space and time, four rainfall regions can be identified in Ethiopia and the Horn.
- These are:

i. Summer rainfall region

- This region comprises almost all parts of the country, except the *southeastern and northeastern lowlands*.

www.ayeleyby.org

- The region experiences most of its *rain during summer (kiremt)*, while some places also receive *spring (Belg) rain*.
- The region is divided into *dry* and *wet summer rainfall regions*.
- Hence, the wet corresponds to the area having rainfall of **1,000** mm or more.
- The *High altitudes* and the *windward* side experience such *rainfall amount*.

ii. All year-round rainfall region

- ❖ It has *many rainy days* than any part of the country.
- ❖ It is a rainfall region in the *southwestern part of the country.*
- ❖ The wetness of this region is particularly due to the prepotency of moist air currents of *equatorial Westerlies called the Guinea Monsoons.*

- ❖ Both duration and amount of rainfall decreases as we move from southwest to north and eastwards.
- ❖ Months in summer gain highest rainfall whereas the winter months receive the reduced amount.
- ❖ The average rainfall in the region varies from 1,400 to over 2,200 mm/year.

iii. Autumn and Spring rainfall regions

- ❖ The region comprises areas receiving rain following the influence of *southeasterly winds*.
- ❖ *South eastern lowlands of Ethiopia* receive rain during *autumn* and *spring* seasons when both the *north easterlies* and *equatorial westerlies* are weak.
- ❖ The *south-easterlies* bring rainfall from the *Indian Ocean*.
- ❖ About **60** percent of the rain is in *autumn* and **40** percent in *spring*.
- ❖ The average rainfall varies from less than **500** to **1,000** mm.

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You please refer the following to see the effect of Indian ocean on Ethiopian seasonal rainfall



www.ayeleby.org

Getachew_et_al-2019.pdf

iv. Winter rainfall region

- ❖ This rainfall region receives rain from the *northeasterly winds*.
- ❖ During the winter season, the Red sea escarpments and *some parts of the Afar region* receive their main rain.

5.4 Agro-ecological Zones of Ethiopia

- ❖ As a result of the diversified altitude and climatic conditions, Ethiopia possesses diverse agro climatic zones.
- ❖ These zones have traditionally been defined in *terms of temperature*.
- ❖ This system divides the nation into five *major climatic zones* namely Bereha, Kolla, Woina- Dega, Dega and Wurch.
- ❖ A description on each of the zones is presented as follows.

The Wurch Zone

- ❖ The Wurch-zone is an area having *altitude higher than 3,200 meters above sea level* and *mean annual temperature of less than 10 oc.*
- ❖ Mountains having typically fitting characteristics of this zone include mountain systems of *Ras Dashen*, *Guna*, *Megezez* in *North Shoa, Batu, Choke, Abune Yoseph* etc.

Table 5.2: Agro Ecological Zones of Ethiopia

Zones	Altitude (m)	Mean annual rainfall (mm)	Length of growing periods (days)	Mean annual temperature (⁰ C)	Area share (%)
<i>Wurch</i> (cold to moist)	>3,200	900-2,200	211-365	Below 10	0.98
<i>Dega</i> (cool to humid)	2,300 - 3,200	900-1,200	121-210	≥11.5-17.5	9.94
<i>Weyna Dega</i> (cool sub humid)	1,500 - 2300	800-1,200	91-120	>17.5 – 20.0	26.75
<i>Kola</i> (Warm semiarid)	500 - 1,500	200-800	46-90	>20.0 – 27.5	52.94
<i>Berha</i> (Hot arid)	<500	Below 200	0-45	>27.5	9.39

Source: MoA, 1998

Dega Zone

- ❖ This is a *zone of highlands* having relatively *higher temperature and lower altitude* compared to the *wurch Zones*.
- ❖ In Ethiopia, the Dega-zone is *long inhabited and has dense human settlement* due to *reliable rainfall* for *agriculture* and *absence of vector-borne diseases* such as *malaria*.

Weyna Dega Zone

- ❖ This zone has warmer temperature and moderate rainfall.
- ❖ It lies between 1500-2,300 meters above sea level.
- ❖ It is the second largest zone covering more than 26% of the landmass of Ethiopia.
- ❖ The *temperature* and *rainfall* of this category is *highly suitable* for majority of crops grown in Ethiopia.
- ❖ Hence, the zone includes most of the agricultural land.
- ❖ The Weyna Dega zone has also two growing seasons.

Kolla Zone

- ▶ In Ethiopia, the geographic peripheries in *south, southeast, west and northeastern* part are mainly in this category.
- ❖ Kolla is the climate of the *hot lowlands* with an altitudinal range of 500 to 1500 meters above sea level.
- ❖ Average annual temperature ranges between 20oC and 30oC.
- ❖ Although mean annual rainfall is erratic, it can be as high as 1500 mm in the *wet western lowlands of Gambella*.
- ❖ Rainfall is highly variable from year to year.
- ❖ The region is boundary between the hot arid (Bereha) and the *humid climates (Woina Dega)*.

Bereha Zone

- ❖ Bereha is the *hot arid climate* of the *desert lowlands*.
- ❖ The Bereha agro-climatic zone is largely confined to lowland areas with *altitude of lower than 500 meters*.
- ❖ Around Danakil depression, the elevation goes below the sea level.

- ❖ Its *average annual rainfall is less than 200 mm*, and *average annual temperature is over 27.5oC*.
- ❖ Strong wind, high temperature, low relative humidity, and little cloud cover usually characterize Bereha.
- ❖ Evapotranspiration is always in excess of rainfall.
- ❖ *Djibouti, majority* of *Somalia*, and *coastal areas* of *Eritrea* are categorized under *Kolla and Bereha zones*.

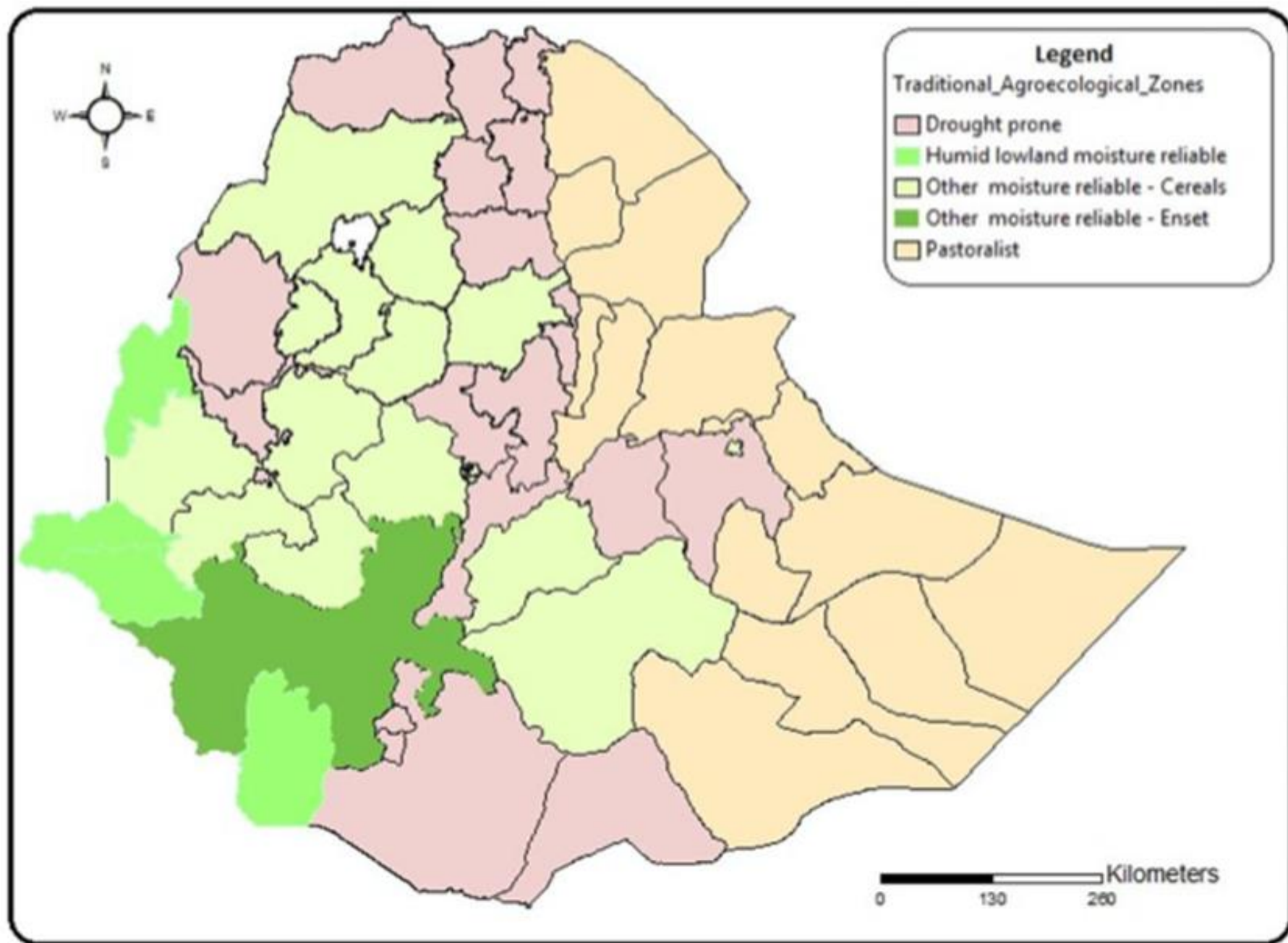


Figure 5.2. Traditional Agro Ecological Zones of Ethiopia.

5.5. Climate Change/Global Warming: Causes, Consequences and Response Mechanisms

- ▶ *Climate change is natural and has always been there. So why is it our concern now?*
- Climate change refers to a ***change in the state of the climate that can be identified*** (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer.
- It refers to any change in climate over time, due to either natural variability or human activities.

5.5.1. Current Trends of Climate in Ethiopia

- ▶ Besides spatial and temporal variations in different parts of the country, Ethiopian climate *experiences extremes* such as drought, flood etc.
- Ethiopia ranked *5th* out of *184* countries in terms of its risk of drought.
- In the country, *12* extreme drought events were recorded between *1900* and *2010*.
- Among the 12, seven of the drought events occurred since 1980.

- The majority of these resulted in famines.
- The severe drought of 2015-2016 was exacerbated by the strongest *El-Nino* that caused successive harvest failures and widespread livestock deaths in some regions.

Trends in Temperature Variability

- Over the last decades, Ethiopia has experienced climatic changes.
- Mean annual temperature has shown 0.2°C to 0.28°C rise per decade over the last 40-50 years.
- A rise in average temperature of about 1.3°C has been observed between 1960 and 2006.
- The rise has spatial and temporal variation.
- Higher rise in temperature was noted in drier areas in northeast and southeast part of the country.

- Notably the variability is higher in July-September.
- The number of “*hot days*” and “*hot nights*” has also shown increment.
- Consequently, the country’s minimum temperature has increased with 0.37°C to 0.4°C per decade.

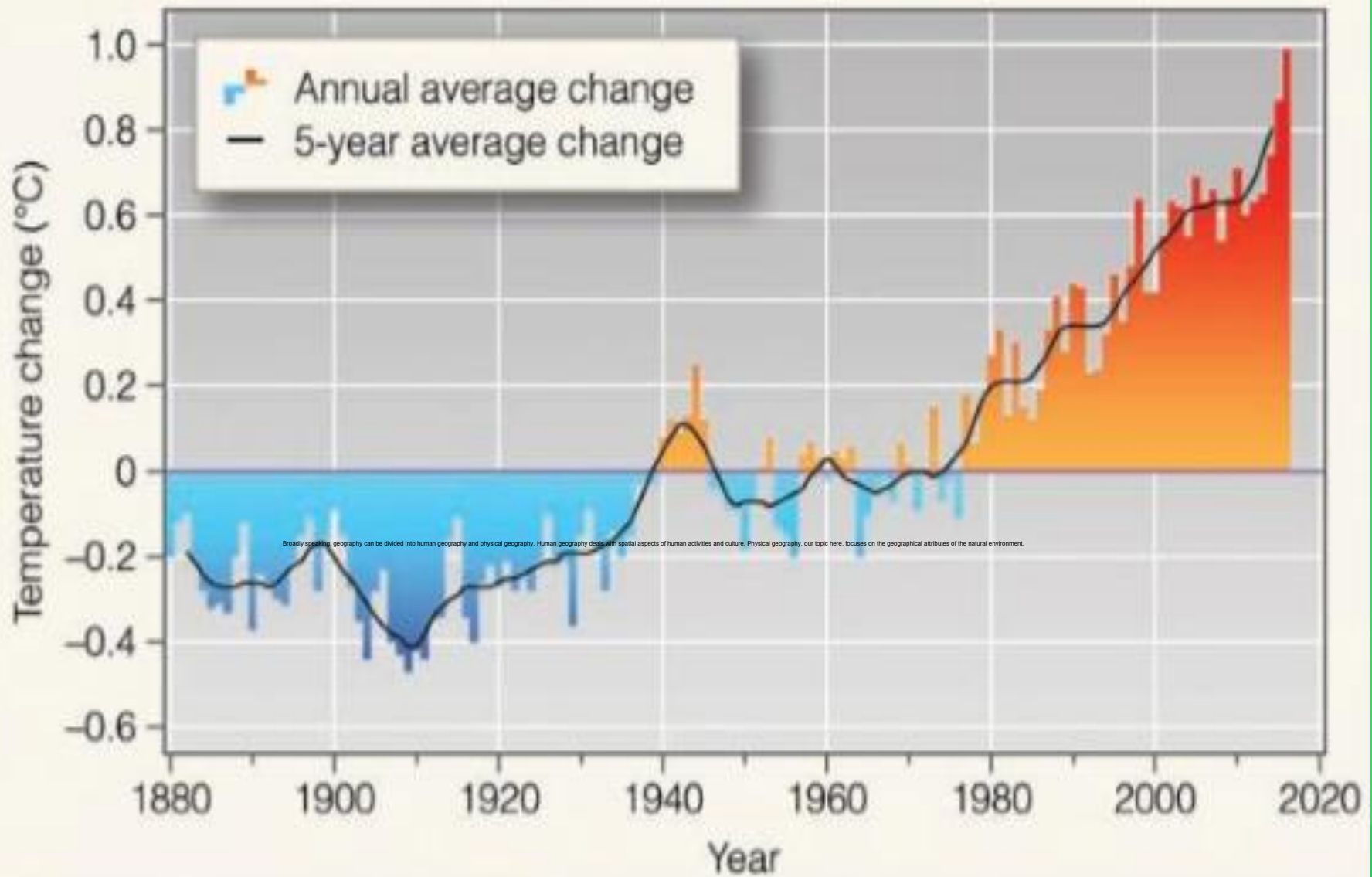


Figure 5.4: Global mean temperature anomaly.

Orange (land) and blue (sea)

Source: Meteorology Today, 2019

Trends in Rainfall Variability

- Precipitation has remained fairly stable over the last 50 years when averaged over the country.
- However, these averages do not reflect local conditions which are extremely divergent and the natural variability in rainfall in the country makes it difficult to detect long-term trends.

- Rainfall variability is increasing (and predictability is decreasing) in many parts of the country. In some regions, total average rainfall is showing decline.
- For instance, parts of southern, southwestern and south-eastern regions receiving Spring and Summer rainfall have shown decline by 15-20% between 1975 and 2010.

- This has strong implications for crop production, which becomes clear when assessing the change in areas that receive sufficient rain to support crop production.
- Changes in temperature and rainfall increase the frequency and severity of extreme events.

Broadly speaking, geography can be divided into human geography and physical geography. Human geography deals with spatial aspects of human activities and culture. Physical geography, our topic here, focuses on the geographical attributes of the natural environment.

- Major floods have been a common occurrence, leading to loss of life and property in numerous parts of the country.
- Warming has exacerbated droughts, and desertification in the lowlands of the country is expanding.

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5.5.2. Causes of Climate Change

- The causes of climate change are generally categorized as anthropogenic/manmade and natural causes.

A. Natural Causes

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- ❖ Climate change has many natural causes, such as variations in the energy budget, the position of Earth relative to Sun, the position of continents relative to the equator, and even whether the continents are together or apart. Here are some of the major natural causes:

- ❖ **Earth orbital changes:** The earth is tilted at an angle of 23.5° to the perpendicular plane of its orbital path.
- ❖ Changes in the tilt of the earth can lead to small but climatically important changes in the strength of the seasons. More tilt means warmer summers and colder winters

- ❖ **Energy Budget:** Although the Sun's energy output appears constant, small changes over an extended period of time can lead to climate changes.
- ❖ Since the Sun was born, 4.5 billion years ago, the star has been very gradually increasing its amount of radiation so that it is now 20% to 30% more intense than it was once.

- ❖ **Volcanic eruptions:** volcanic *eruption releases* large volumes of Sulphur dioxide, carbon dioxide, water vapor, dust, and ash into the atmosphere.
- ❖ The release of large volume of gases and ash can increase planetary reflectivity causing atmospheric cooling.

B. Anthropogenic Causes

- The growing influence of human activities on the environment is being increasingly recognized, and concern over the potential for global warming caused by such anthropogenic effects is growing.
- The warming of earth planet in the past 50 years is majorly driven by human activities.

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- The industrial activities that our modern civilization depends upon have raised atmospheric carbon dioxide levels from 280 parts per million to 400 parts per million in the last 150 years.
- Human induced greenhouse gases such as carbon dioxide, methane and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years.

➤ The decomposition of wastes in landfills, agriculture, ruminant digestion and manure management, synthetic compounds manufacturing, clearing of land for agriculture, industrial activities, and other human activities have increased concentrations of greenhouse gases.

- The major gases that contribute to the greenhouse effect include Water vapor, Carbon dioxide (CO₂), Methane, Nitrous oxide, Chlorofluorocarbons (CFCs).
- Although methane is less abundant in atmosphere, it is by far more active greenhouse gas than carbon dioxide.

5.5.3. Consequences of Climate Change

- In many parts of the world, climate change has already caused loss of life, damaging property and affecting livelihoods.
- The impact of climate change is higher in low income countries, since they have limited capacity to cope with the changes.
- Some of the consequences of the changing climate include:

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- **Impacts on human health:** The change can cause increased heat related mortality and morbidity, greater frequency of infectious disease epidemics following floods and storms, and substantial health effects following population displacement to escape extreme weather events.
- Climate change also raises the incidence malaria.

- ▶ **Impact on water resources:** Climate change is leading to melting of snow and glaciers that increases rise in sea level, increase drought and floods, distorts wind flow pattern, decreases water table.
- ▶ More frequent and longer droughts reduce the amount of run-off into rivers, streams and lakes.

- **Impact on Agriculture:** changes in temperature and rainfall patterns as well as significantly affect agricultural production.
- Climate change increases physiological stress and fodder quality and availability.

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- ▶ **Impact on Ecosystem:** climate change affects the success of species, population, and community adaptation.
- ▶ The rate of climatic warming may exceed the rate of shifts in certain range species, these species could be seriously affected or even disappear because they are unable to resist.

- Climate change is already evident.
- scholars of the field reported that we human beings harassed the natural environment including the atmosphere.
- Now it is time for the environment to revenge us more than double for the evil we did on it.
- Students, let's look the following videos on major Climate change borne environmental hazards in USA, Mexico, India, China, Greece, Sudan, Turkey, Afghanistan, Belgium, France, Sudan etc. in summer 2021.



NEPAL.mp4

??WHAT HAPPENED IN THE WORLD on August 6-8, 2021_?? Continuous floods in India ??Big wildfire in Greece.mp4



Enoch, Utah flooding August 1st, 2021.mp4



Severe Floods Hit Jaipur, Rajasthan State, India - Aug. 13_ 14, 2020.mp4



China Floods 2021 _ Affected More Than 54.8 Million People_ Wuhan Flood _ China Flood Footage.mp4



USA is WASHED AWAY! Crazy flash flood in Utah, USA.mp4



CHINA(14).mp4

Rescue RAIN hit TURKEY! Heavy rain in Antalya, Turkey.mp4



02-02-2021 Scituate, MA - Drone shots of massive waves crash into homes, flooded and damaged homes.mp4



NEPAL.mp4



The Dangers of Flash Flooding _ IMR.mp4



A Devastating Flood has Hit France AGAIN!.mp4



SUDAN.mp4



China's Black Swan worst dam catastrophe _ China Flood 2021.mp4



In USA, an INCREDIBLE Chaos! Scary flash flood in Omaha, Nebraska, USA.mp4



Huge stones from the sky destroy cars in Italy! The rage of nature hit Europe.mp4



Footage of flooded streets in London today, heavy rain again.mp4



Update World's Scariest Flash Flood (California) 2021#12 - Disastrous Catastrophe (Caught On Camera).mp4



True hero_ Man rescues Mule from flood-swollen Himalayan river.mp4



Is China drowning in its own dams_.mp4



What is Wrong with the World Today_ Islamabad is in trouble with Severe Flood ?? Pakistan Flood.mp4



Anger of Nature hit US !! Severe thunderstorm and flood in Omaha, Nebraska !.mp4



Flooding in India_ Dams overflowing, several bridges destroyed.mp4



Catastrophic flooding across western Europe as politicians blame climate change - BBC News.mp4



Thousands evacuate as North Korea floods damage homes and crops.mp4

Broadly speaking, geography can be divided into human geography and physical geography. Human geography deals with spatial aspects of human activities and culture. Physical geography, our topic here, focuses on the geographical attributes of the natural environment.

1. Athens BURN! Capital of Greece is engulfed in Wildfires. ?? Forest fire in Athens..mp4



Broadly speaking, geography can be divided into human geography and physical geography. Human geography deals with spatial aspects of human activities and culture. Physical geography, our topic here, focuses on the geographical attributes of the natural environment.

Activate Windows
Go to Settings to activate Windows.

Athens, Greece, July 2021



Broadly speaking, geography can be divided into human geography and physical geography. Human geography deals with spatial aspects of human activities and culture. Physical geography, our topic here, focuses on the geographical attributes of the natural environment.

Belgium

July 12-15, 2021



Broadly speaking, geography can be divided into human geography and physical geography. Human geography deals with spatial aspects of human societies and culture. Physical geography, the topic here, focuses on the geographical attributes of the natural environment.

Belgium

July 12-15, 2021

Broadly speaking, geography can be divided into human geography and physical geography. Human geography deals with spatial aspects of human activities and culture. Physical geography, our topic here, focuses on the geographical attributes of the natural environment.

Activate Windows

Belgium

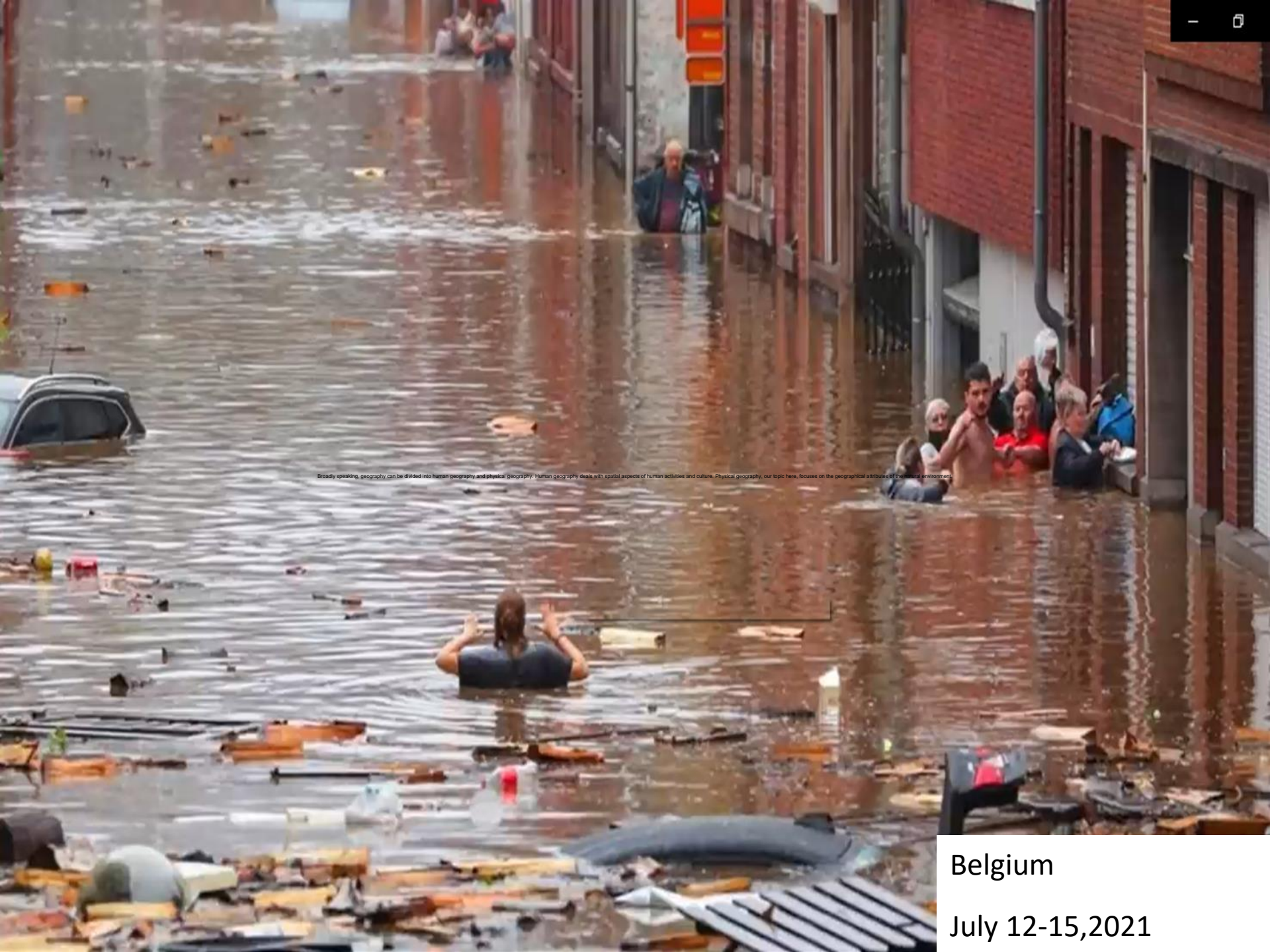
July 12-15, 2021



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China
August 2021



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India July, 2021



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Afghanistan July & August, 2021



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Japan July 2021



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USA August, 2021



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USA August, 2021



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23:45



Western USA California
August, 2021



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China July, 2021

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5.5.4. Climate Response Mechanisms

- ▶ *How do our forefathers react to the changing climate?*
- ▶ *Do we have any traditional (indigenous) mechanism?*

➤ Climate change is one of the most complex issues facing us today.

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➤ So even if we stopped emitting all greenhouse gases today, global warming and climate change will continue as it has natural source of emission.

- Hence, there has to be response mechanism to reduce the impact of extreme events.
- There are ***three major response mechanisms to climate change*** namely ***mitigation, adaptation and resilience***.

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Mitigation and its Strategies

- *Mitigation* measures are those actions that are taken to reduce and control greenhouse gas emissions changing the climate.
- Moreover, it implies reducing the flow of heat trapping greenhouse gases into the atmosphere, either by reducing sources of these gases or enhancing the “sinks” that accumulate and store these gases (such as the oceans, forests and soil).

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- The goal of mitigations is to avoid significant human interference with the climate system.
- There are some mitigation measures that can be taken to avoid the increase of pollutant emissions.
- ▶ Practice Energy efficiency

- ▶ Increase the use of renewable energy such as solar
- ▶ Efficient means of transport implementation: electric public transport, bicycle, shared cars etc.

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Adaptation and its Strategies

- ⇒ Throughout history, people and societies have adjusted to and coped with changes in climate and extremes with varying degrees of success.
- ⇒ **Adaptation** is simply defined as *adapting to life in a changing climate.*
- ⇒ It involves adjusting to actual or expected future climate.
- ⇒ The goal is to reduce our vulnerability to the harmful effects of climate change such as extreme weather events or food insecurity.

⇒ It also encompasses making the most of any potential beneficial opportunities associated with climate change (for example, longer growing seasons or increased yields in some regions).

⇒ Some of the major adaptation strategies include:

- ⌚ building flood defenses,
- ⌚ plan for heatwaves and higher temperatures
- ⌚ installing water-permeable pavements to better deal with floods and storm water

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- ④ improve water storage and use are some of measures taken by cities and towns
- ④ landscape restoration and reforestation,
- ④ flexible and diverse cultivation to be prepared for natural catastrophes
- ④ preventive and precautionary measures (evacuation plans, health issues, etc.)

Review questions

1. Differentiate between weather and climate.
2. Which control of weather and climate predominantly affect Ethiopian climate?
How?
3. Discuss spatiotemporal distribution of temperature and rainfall in Ethiopia.
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4. Do we have dynamics in temperature and rainfall in Ethiopia? Is it warming or cooling?
5. What causes climate change?
6. How can we respond to the changing climate?