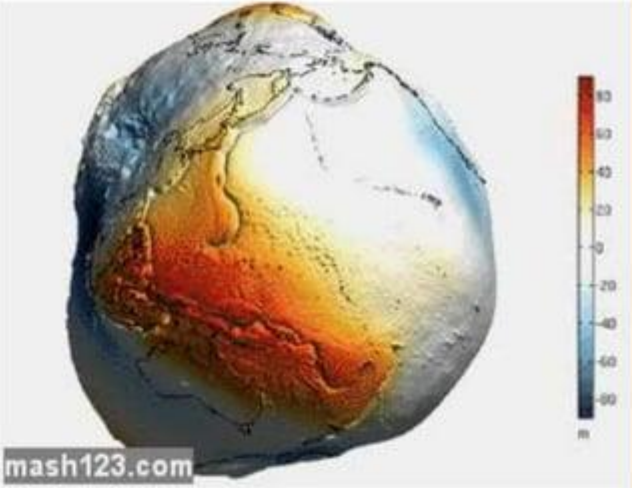
EARTH SUN RELATIONSHIP

WHAT IS EARTH

The third planet from the Sun and the only astronomical object known to harbour life



WHAT IS SUN?

The **Sun** is the star at the centre of the Solar System.

It is a nearly perfect sphere of hot plasma, with internal convective motion that generates a magnetic field via a dynamo process.

It is by far the most important source of energy for life on Earth.

EARTH'S ROTATION

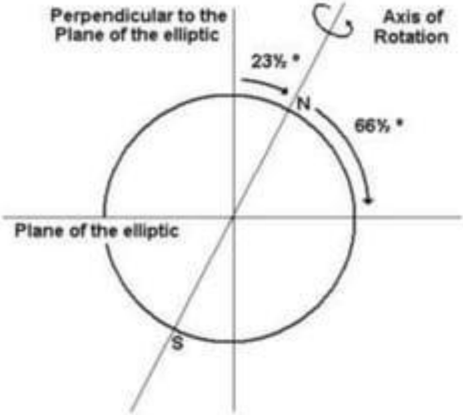
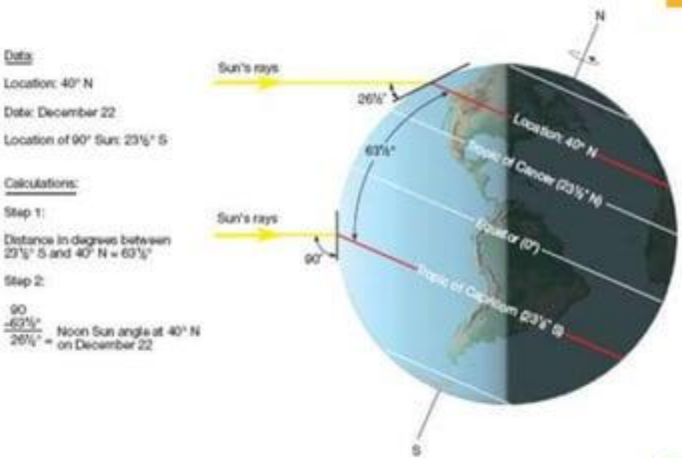


Fig. 2 : Earth's elliptical orbit

The tilt of axis is responsible for opposite seasons in northern and southern hemisphere.

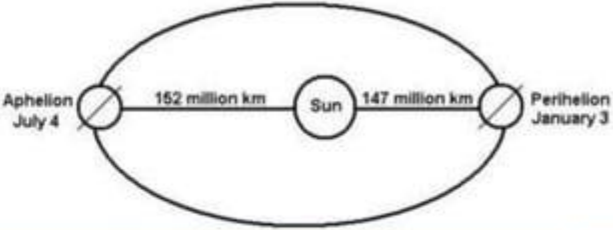


Turning eastward direction at uniform rate every 24 hours.

The most intense incoming sola radiation occurs where the sun's rays strike the earth at highest angle.

As the sun angle decreases the beam of light is spread over a larger area and the intensity decreases due to thickness of atmosphere, increase in reflection and scattering of light.

EARTH'S REVOLUTION



Equinox – Wednesday, 20 March 2019

Sun lies directly above the equator

Summer solstice – Friday, 21 June 2019

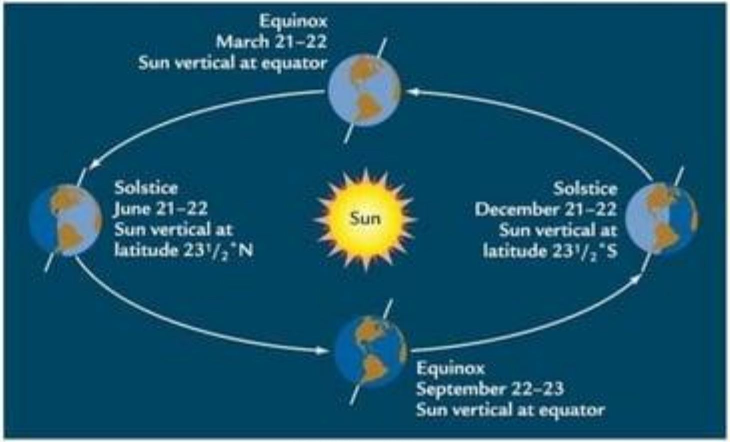
Sun lies directly above the tropic of Cancer

Equinox - Monday, 23 September 2019

Axis of rotation parallel to sun rays.

Winter – Sunday, 22 December 2019

Sun rays are direct at tropic of Capricorn

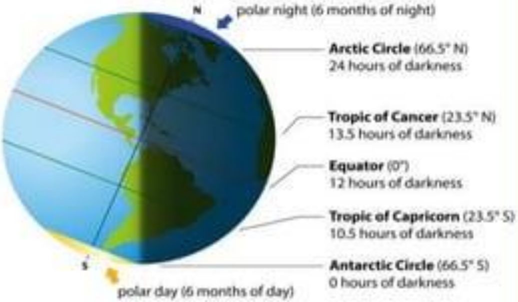


A

Earth's orbit

SOLSTICES

winter solstice (December 21)



6 months of night at the north pole.

Marks the shortest day in the northern hemisphere.

6 months of night at the south pole.

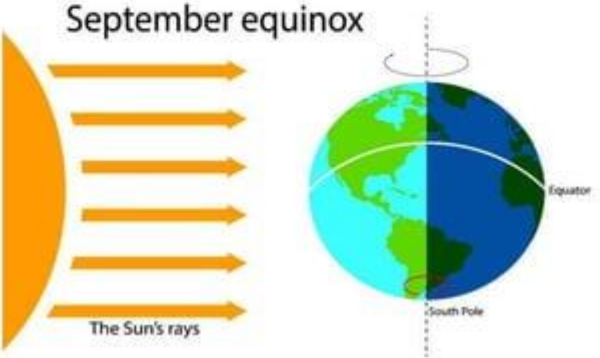
summer solstice (June 21)

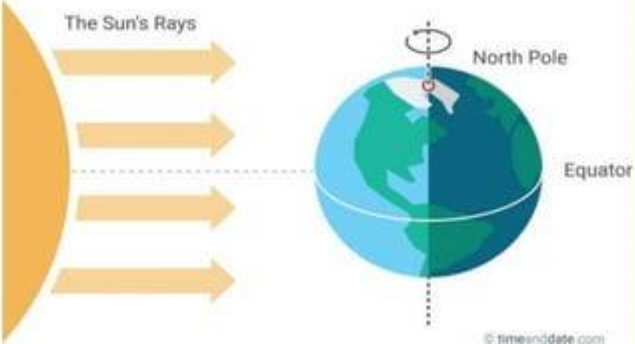
The axis of earth's rotation is still tilted but it is inclined sideways with respect to the sun. At these times, the tangent rays strike the poles so that the days & nights are equal over the entire earth.

EQUINOXES

The autumnal equinox on September 22 indicates the beginning of autumn season in the northern hemisphere.

March 22 is the first day of spring season & hence this date is known as the spring equinox. Equinoxes mark the transition between the two extreme seasons, summer & winter.





Equinox and Solstice

- **Equinox:**
- **Definition:** An equinox occurs twice a year when the day and night are of approximately equal length.
- **Timing:** There are two equinoxes each year, one around March 20th or 21st (known as the vernal or spring equinox) and the other around September 22nd or 23rd (known as the autumnal equinox).
- **Sun's Position:** During an equinox, the Sun crosses the celestial equator, and day and night are roughly equal in duration worldwide.

- **Solstice:**
- **Definition:** A solstice occurs twice a year when the Sun reaches its highest or lowest point in the sky at noon, resulting in the longest and shortest days of the year.
- **Timing:** There are two solstices each year, one around June 21st (known as the summer solstice in the Northern Hemisphere and the winter solstice in the Southern Hemisphere) and the other around December 21st (known as the winter solstice in the Northern Hemisphere and the summer solstice in the Southern Hemisphere).
- **Sun's Position:** During a solstice, the Sun is at its highest point in the sky during the summer solstice and at its lowest point during the winter solstice.

WEATHER

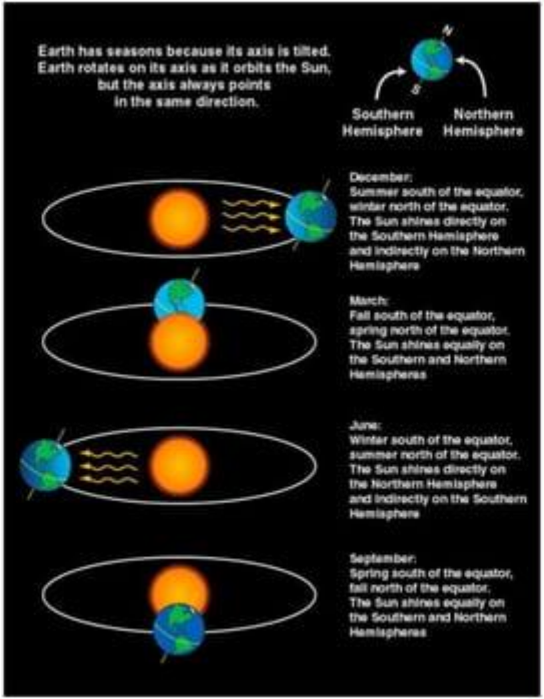
Winter is when the hemisphere is tipped away from the sun.

Summer is when the hemisphere is tipped towards the sun.

Spring is time between winter and summer where the rise in temperature is pleasant

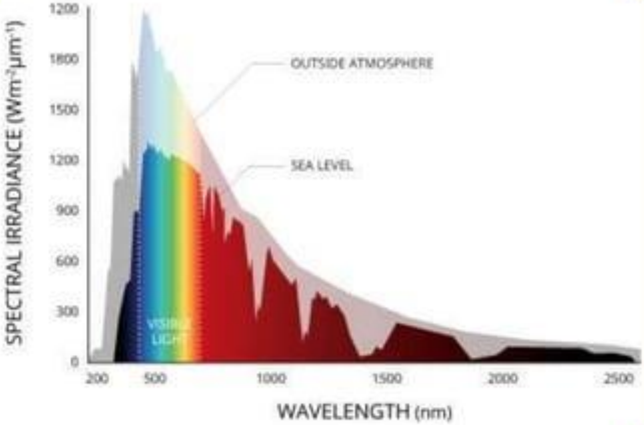
Monsoon when most of the region's average annual rainfall occurs.

Monsoon is followed by Autumn



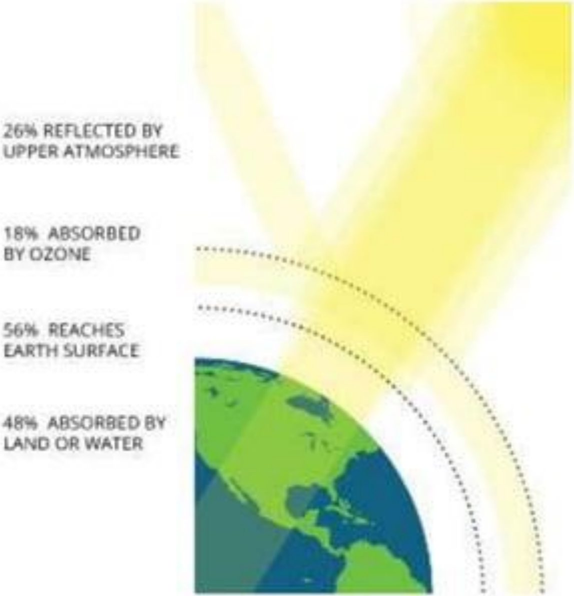
SOLAR RADIATION

- The energy received by all the earth's surface is in three forms of radiation
- Ultra-violet 290 nm to 280 nm, produces photo-chemical effects, bleaching, sunburn etc.
- Visible light 380 nm (violet) to 700 nm (red)
- Infra-red radiation 700 nm to 2300 nm, radiant head and some photo chemical effect.

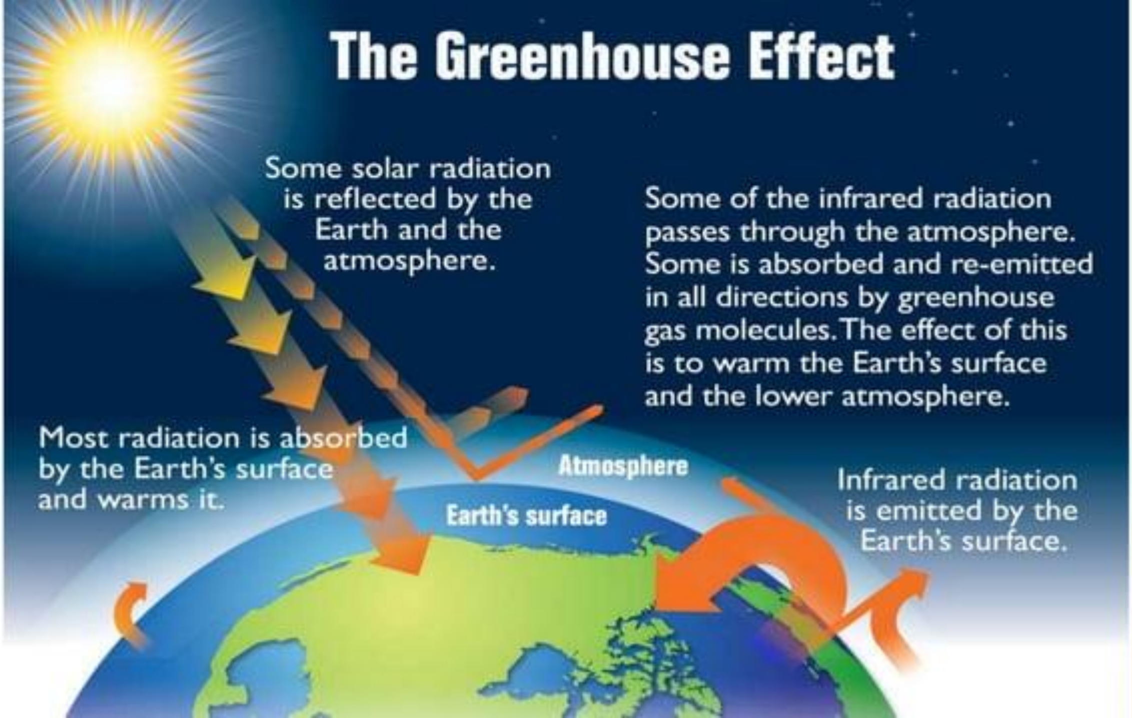


- Solar radiation provides heat, light, and energy necessary for all living organisms. Infrared radiation supplies heat to all habitats, on land and in the water. Without solar radiation, Earth's surface would be about 32°C colder.

RADIATION AT EARTH SURFACE



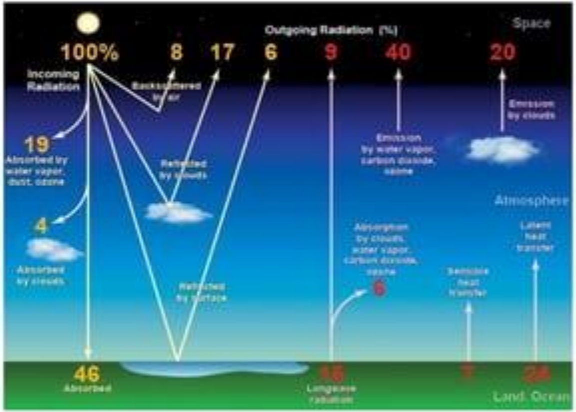
- The sun's radiation must make it through multiple barriers before it reaches Earth's surface.
- The first barrier is the atmosphere. About 26% of the sun's energy is reflected or scattered back into space by clouds and particulates in the atmosphere.
- Another 18% of solar energy is absorbed by the Ozone.
- Ozone absorbs ultraviolet radiation, while carbon dioxide and water vapor can absorb infrared radiation.
- The remaining 56% of solar radiation is able to reach the surface.


The Greenhouse Effect
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere. Some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Most radiation is absorbed by the Earth's surface and warms it.
Atmosphere
Earth's surface
Infrared radiation is emitted by the Earth's surface.

HEAT LOSS BY THE EARTH SURFACE

The total amount of heat absorbed by the earth each year is balanced by a corresponding heat loss.

Without the cooling the thermal balance of earth would not be maintained.



By ***long-wave radiation*** to cold outer space, around 16% escapes to space.

By ***evaporation*** as the surface liquid changes into vapour and mixes with the air.

By ***convection*** air coming in contact with the warm earth surface becomes lighter and rises to the upper atmosphere and dissipates its heat to space.

REGIONS

Polar regions

Desert

Tropic regions

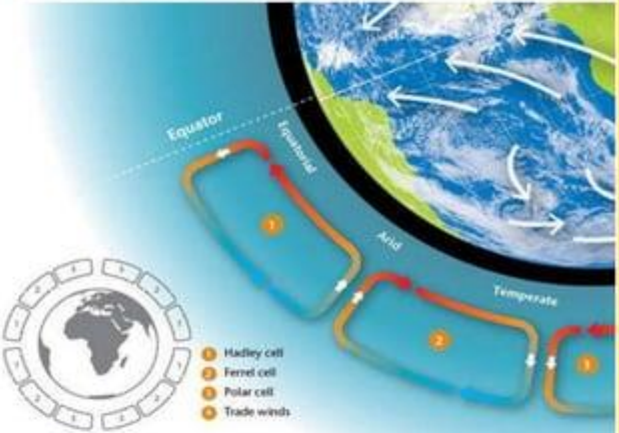
GLOBAL WIND PATTERN

At the maximum heating zones, air is heated by the hot surface.

It expands, pressure decreased, it becomes lighter and rises vertically and flows off at a high level towards colder regions.

Part of this air, cools down and descends at the surface in subtropics region.

From here the cooler, heavier air is drawn in towards the equator from north and south.



Our weather and climate

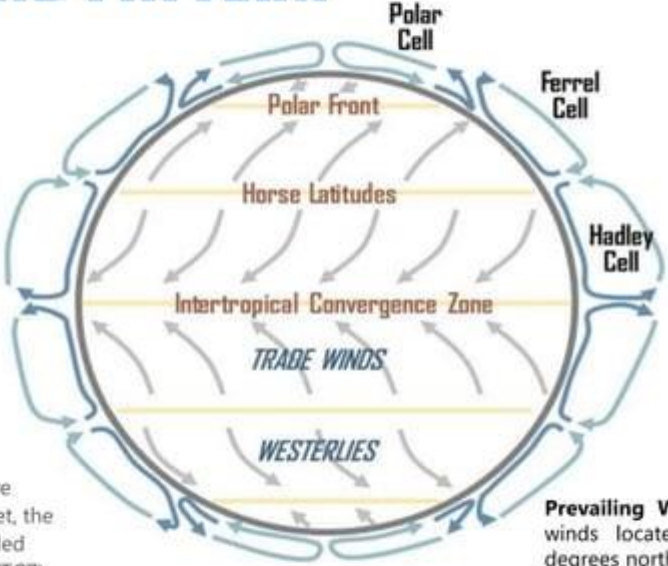
The Earth is a sphere, which means that the Sun's energy hits the Equator more directly than the poles and heats the Equator more. As the air at the Equator is heated it expands, rises and tends to move towards the poles. This displaces colder air, causing large-scale atmospheric circulation and creating the ever-changing areas of high and low pressure we're familiar with in our everyday weather.

GLOBAL WIND PATTERN

The polar easterlies are winds that are found between 60 and 90 degrees north and south latitude that blow from the poles and are deflected towards the west.

Tropical easterlies or trade winds blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere and are located between 0 and 30 degrees north and south latitude.

The area where the air rises, where northern and southern winds meet, the tropical front is formed and is called Intertropical Convergence Zone (ITCZ)



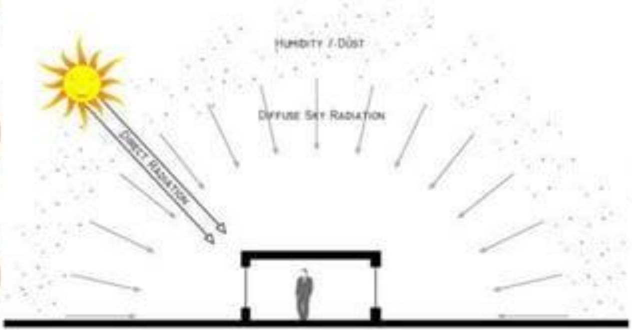
Prevailing Westerlies are winds located 30 to 60 degrees north and south of the equator that blow eastward towards the poles

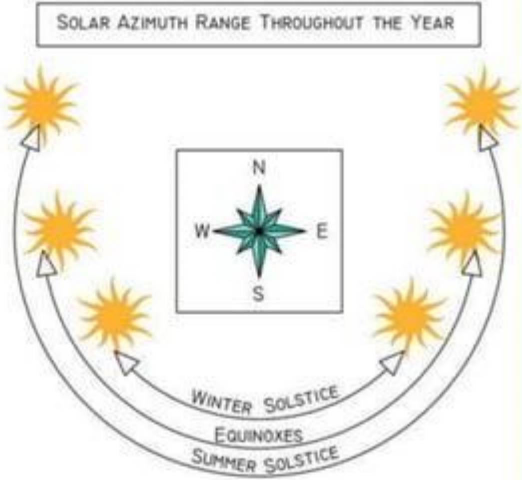
CONTROLS OF CLIMATE

- The most fundamental control of both weather & climate is the unequal heating & cooling of the atmosphere in different parts of the earth.
- Unequal heating occurs due to differential between high & low latitudes, between continents & oceans, between snow-covered & snow-free areas, between forested & cultivated land.
- These heating & cooling differences & the air movements they induce represent the overall general background control of climate.

SOLAR GEOMETRY

- "Solar Altitude" is the bearing of the sun above the horizon. At sunrise and sunset, the solar altitude angle is 0. At solar noon, the sun reaches its highest point (greatest altitude).



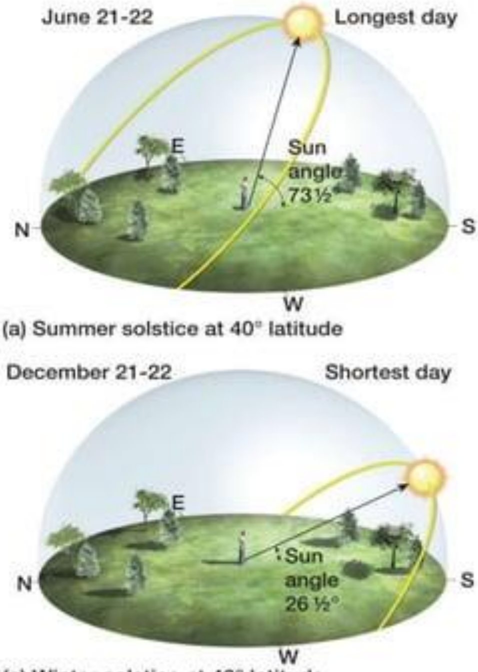


"Solar Azimuth" is the bearing of the sun from true south. At solar noon, the sun is at true south and the solar azimuth angle is defined as 0. Morning angles are measured as negative.

SUN PATH

- While viewing the sun **from different locations** on the earth, **the sun will rise and set from a different point on the horizon** and **move along different paths across the sky**. To understand where you stand on the earth, it is specified by the latitude and longitude coordinates.

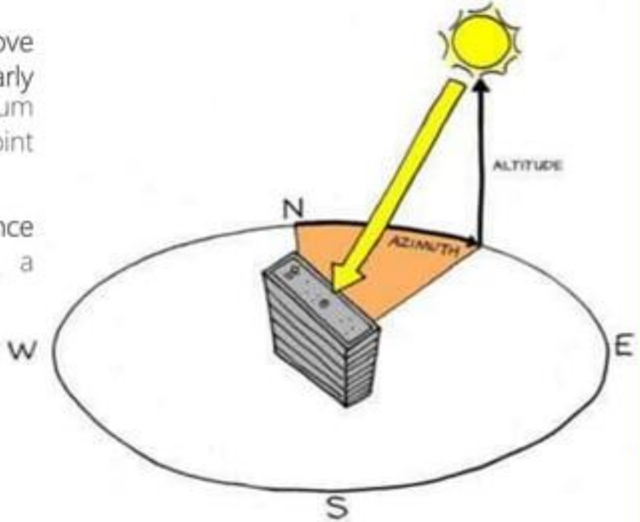
- The **latitude and longitude** will have significant effects on the sun path and hence **affect the behavior of the sun's lighting and heating characteristics**.



(a) Summer solstice at 40° latitude

(c) Winter solstice at 40° latitude

- Altitude is the angular distance above the horizon measured perpendicularly to the horizon. It has a maximum of 90^0 at the zenith, which is the point overhead.
- Azimuth is the angular distance measured along the horizon in a clockwise direction.



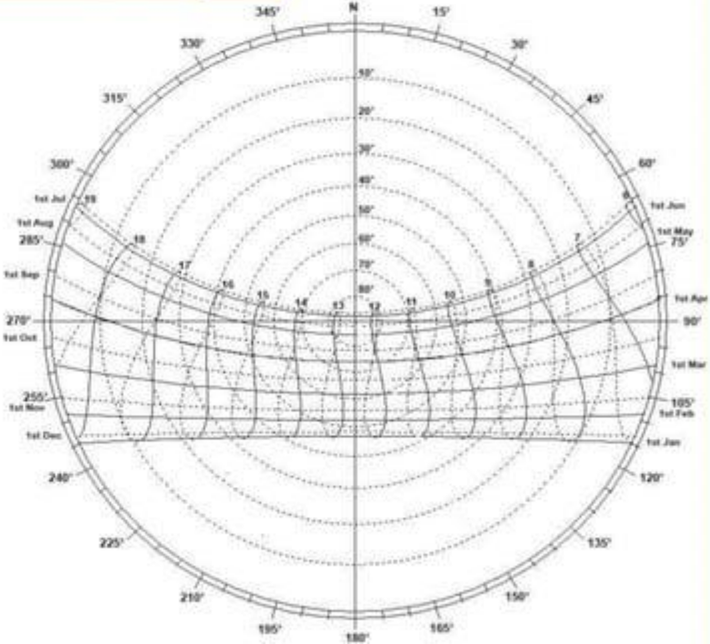
The Sun path Diagram- Few terminologies

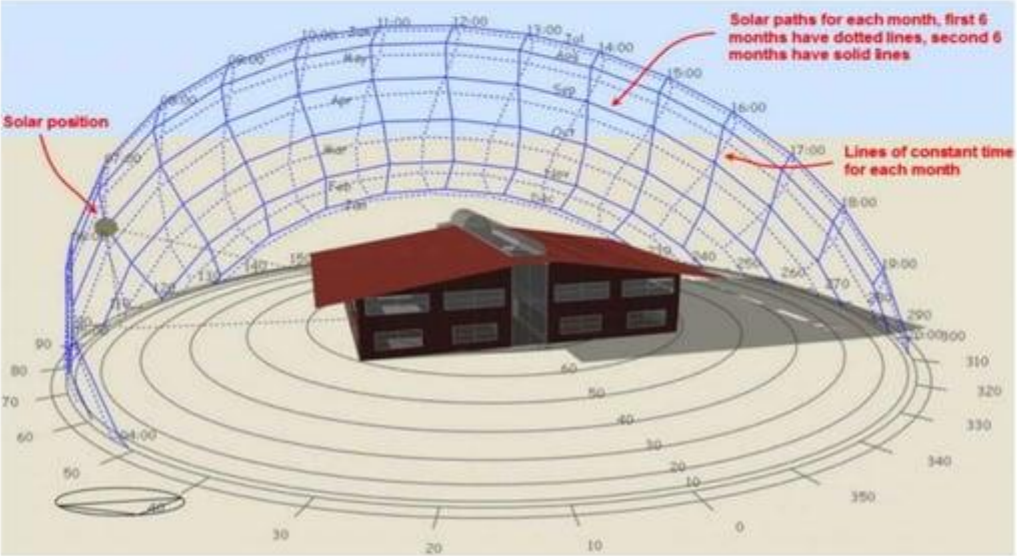
Azimuth Lines - Azimuth angles run around the edge of the diagram.

Altitude Lines - Altitude angles are represented as concentric circular dotted lines that run from the center of the diagram out.

Date Lines - Date lines start on the eastern side of the graph and run to the western side and represent the path of the sun on one particular day of the year.

Hour Lines - Hour lines are shown as figure-eight-type lines that intersect the date lines and represent the position of the sun at a specific hour of the day. The intersection points between date and hour lines give the position of the sun.

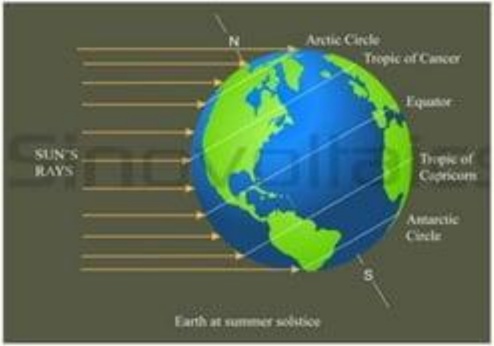



Solar paths for each month, first 6 months have dotted lines, second 6 months have solid lines
Solar position
Lines of constant time for each month

SOLAR RADIATION –

The Source of never Ending Energy

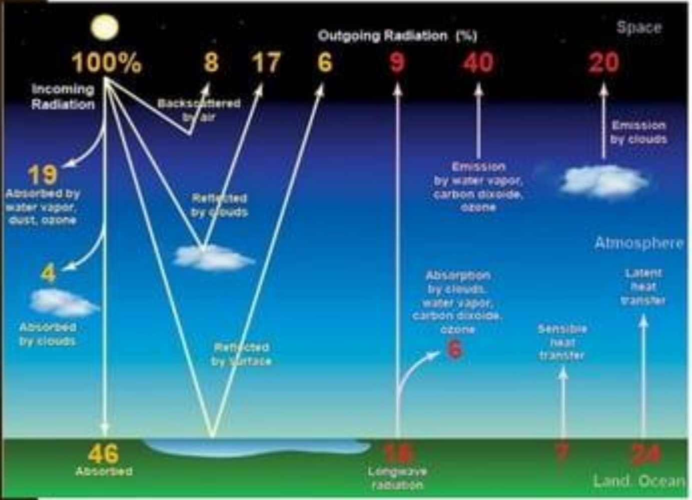
The complete concept of harnessing solar energy to generate electricity is based upon the phenomenon of solar radiation



Components of Solar Radiation

- **Direct Radiation** (the radiation which comes directly from the sun)
- **Diffused Radiation** (the radiation which is diffused by the sky, layers of atmosphere and other surroundings)
- **Reflected Radiation** (the radiation which is reflected back by the lake, seas and other water bodies)

Direct Normal Irradiance (DNI) is the amount of solar radiation received per unit area by a given surface that is always held perpendicular to the incoming rays.



The total ground reflection is a sum of all the above three components.

Although the sun's energy output is fairly constant, the total solar radiation falling on the earth's surface varies and depends on a lot of factors

- **Atmospheric Conditions** (Cloud Ozone layer condition, etc.)
- **Earth's Rotation** (time of the day, activity, etc.)
- **Earth's Revolution** (distance between earth and sun, seasons, angle of inclination of earth's surface, etc.)

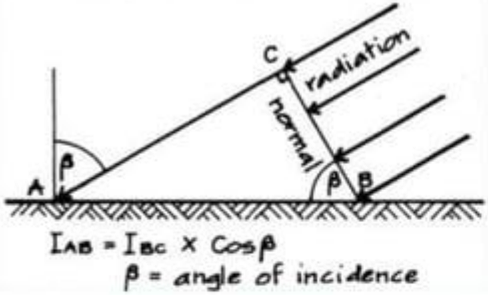
GLOBAL INSOLATION

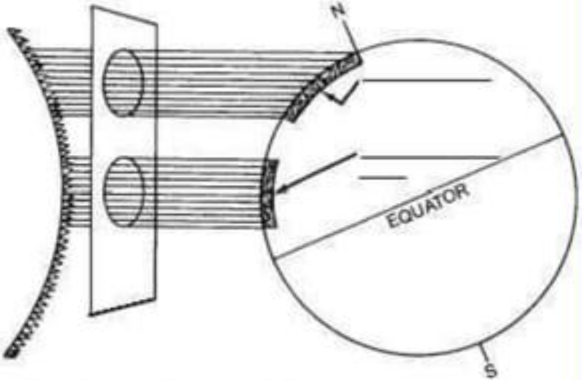
- Solar insolation is affected by factors such as atmosphere, angle of the sun and distance.
- The thinner the atmosphere in which the sun is passing through, the more the insolation.

- Insolation is also at its highest when the sun is directly overhead in an area. This is also the shortest distance between the sun and an area.
- World insolation maps show the amount of solar insolation in a given area at a given time.

COSINE LAW

The intensity on a tilted surface equals the normal intensity times the cosine of the angle of incidence.





The absorption of radiation by ozone, vapors and dust particles.

The lower the solar altitude angle, the longer path of radiation through the atmosphere

ATMOSPHERIC DEPLETION

FACTORS AFFECTING CLIMATE

Both weather and climate are characterized by the certain variables known as **climatic factors**.

- Solar radiation
- Ambient temperature
- Air humidity
- Precipitation
- Wind
- Sky condition

1. SOLAR RADIATION

Solar radiation is the radiant energy received from the sun.

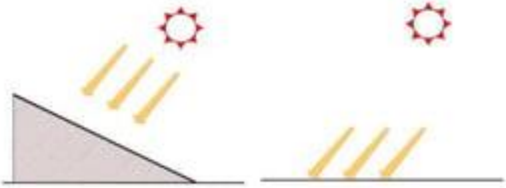
It is the intensity of sunrays per unit time per unit area and is usually expressed in Watts per meter (W/m^2).

The radiation incident on a surface varies and it depends on

- **Geographical location** (latitude and longitude)
- **Orientation**
- **Seasons**
- **Time of day**
- **Atmospheric conditions**

EXAMPLE:

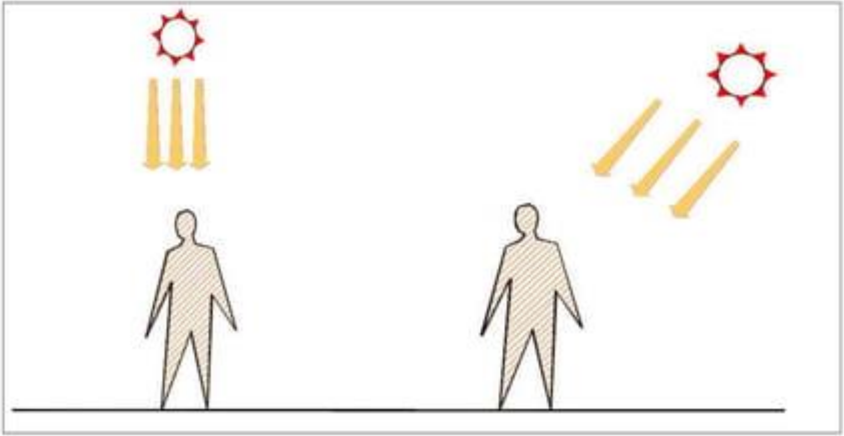
BUILDING ON A SOUTH FACING SLOPE IN SHIMLA WILL RECEIVE MORE RADIATION COMPARED TO OTHER ORIENTATIONS



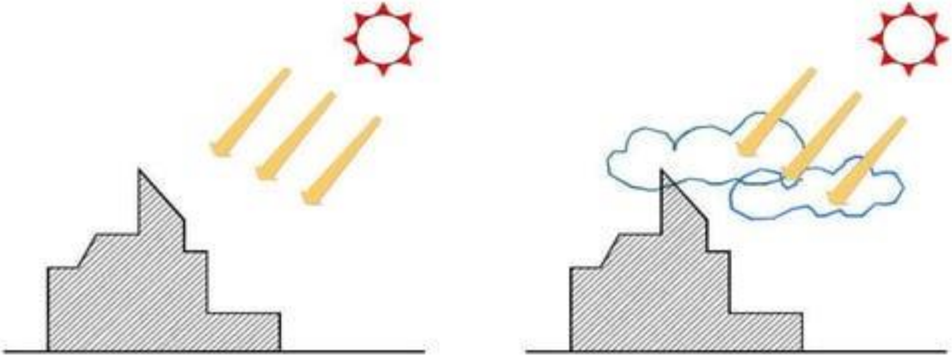
Solar radiation on surfaces normal to suns' rays is higher than on horizontal surfaces

EFFECT OF ORIENTATION

1. SOLAR RADIATION



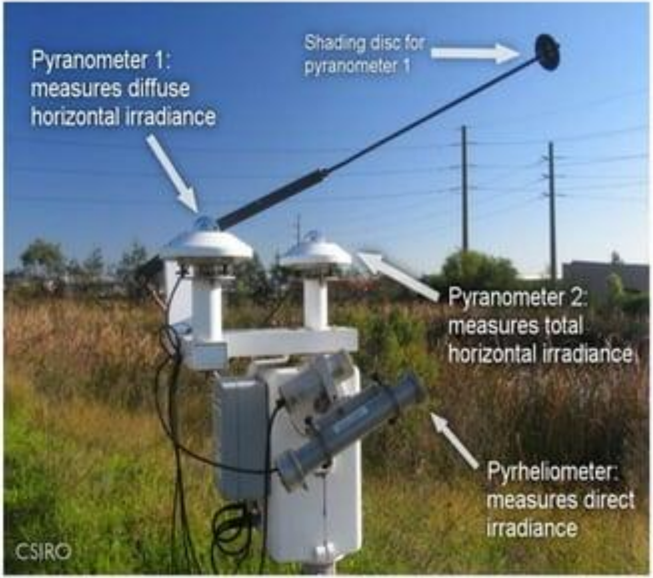
1. SOLAR RADIATION



1. SOLAR RADIATION

Solar radiation is the most important weather variable that determines whether a place experiences high temperatures or is predominantly cold.

The **instruments** used for measuring of **solar radiation** are the **pyranometer** and the **pyrheliometer.**



SUNSHINE RECORDER

DURATION?

Sunshine recorder essentially consists of a glass sphere mounted in a spherical bowl and a metallic groove which holds a record card.

Sun's rays are **refracted** and focused sharply on the record card beneath the glass sphere, leaving burnt marks on the card.

As the sun traverses, continuous burnt marks will appear on the card. Observers can measure the sunshine duration based on the length of the burnt marks.

SUNSHINE METER

The **sunshine meter** consists of three sensors. When sunlight is detected by the sensor, it will be transformed into electricity. Solar radiation can be calculated based on the generated voltage.

The **front sensor** measures global solar radiation and is not shaded and receives sunlight from all around.

The **middle sensors** and the **rear sensors** are partly shaded to avoid direct sunshine for measurement of diffuse solar radiation