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FYBA

GEOGRAPHY PAPER - I

SEMESTER - II

PHYSICAL GEOGRAPHY

SUBJECT CODE : UBA 2.27

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Unit - 1

COMPOSITION AND STRUCTURE OF THE ATMOSPHERE AND DISTRIBUTION OF TEMPERATURE

Unit Structure:

1.0. OBJECTIVES:

Atmosphere is one of the most important components of our earth.

- To study the composition of earth's atmosphere
- To study the structure of earth's atmosphere
- To study the factors controlling the distribution of temperature.
- To understand the variation in spatial distribution of temperature on the surface of the earth.
- To know the significance of atmosphere and temperature for living kingdom.

1.1. INTRODUCTION

The earth's atmosphere is composed of gaseous, suspended particles and water molecules. In the initial period after the formation of the earth the processes of chemical and biological reactions on the earth formed the gaseous envelop encircling the earth called as atmosphere. The differences in the cooling and heating of the elements in the atmosphere due to incoming solar energy and outgoing heat radiated from the earth helps to differentiate between atmospheric layers.

1.2 COMPOSITION AND STRUCTURE OF THE ATMOSPHERE

1.2.1 Composition of the Atmosphere:

The gaseous envelope which surrounds the Earth is termed as the ‘atmosphere’. Most of the atmosphere is confined to a thin shield around the earth, with the pressure and density of air decreasing rapidly with altitude and gradually merging into the emptiness of space. Fifty percent of the mass of the atmosphere is within 5.5 kilometers of sea level; 90 percent is within about 16 kilometers of sea level, and 99.9 percent is below 49 kilometers. The atmosphere contains many gases. The atmosphere also contains water vapour and aerosols (small microscopic particles). Most of them are concentrated near the Earth’s surface. This is due to the gravitational pull of the Earth and as the density of air is maximum. As we move up above the surface of the earth, the density of air decreases.

It is important to note that 50 percent of the atmosphere lies below the height of 5.6 km. and about 90 per cent below 16 kilometers. Only about 0.00003 percent of all the gases found in the atmosphere are beyond 100 kilometers.

Table 1.1. Composition of air in the earth’s atmosphere

Component	Symbol	Volume of dry air in %
Nitrogen	N_2	78.08 %
Oxygen	O_2	20.94 %
Argon	Ar	0.93
Carbon dioxide	CO_2	0.03
Neon	Ne	0.0018
Helium	He	0.0005
Ozone	O_3	0.00006
Hydrogen	H_2	0.00005
Krypton	Kr	Trace element
Xenon	X_2	Trace element
Methane	CH_4	Trace element

Nitrogen and oxygen together make up about 99 percent of the volume of atmospheric gases. Some of the minor gases such as CO_2 and O_3 play an important role in the atmosphere. CO_2 absorbs heat radiated by the earth surface during night and so is responsible for warming the globe. O_3 gases protect the earth by absorbing the incoming harmful ultraviolet (UV) rays of the sun. This composition of the atmospheric gases remains the same up to a height of about 80 km. Therefore, the lower parts of the atmosphere up to 80 km are termed as the Homosphere. Composition of the atmosphere varies after 80 km of height. Hence, it is termed as Heterosphere.

The lower parts of the atmosphere up to 10-15 km contain water vapour. It is derived from the evaporation and evapo-transpiration from water bodies, soil cover and vegetation respectively. The amount of vapour is determined by the temperature conditions near the surface of the earth. As temperatures are higher near the equator and decreases towards the poles, the amount of vapour therefore is more near the equator and become less as we move towards the poles. In terms of vertical distribution of vapour content more than 90 % of the total atmospheric vapour is held up to an altitude of 5 kilometer. Condensation of water vapor in the atmosphere is responsible for different types of weather phenomena.

The atmosphere also composes of microscopic elements such as dust and salt particles, etc. They are termed as aerosols. The hygroscopic salt particles absorb water and act as condensation nuclei in the formation of clouds. They also scatter solar radiation. The sky appears blue due to the scattering of violet rays of the incoming solar radiation.

Structure of the Atmosphere: On the basis of the characteristics of temperature and air pressure the structure of the atmosphere is divided into four layers upwards from the surface of the earth **(Figure:1.1).** These are:

i) Troposphere: Troposphere' means 'a region of intense mixing of atmospheric components' where weather conditions are formed. Human activities are directly related to the weather conditions of this layer. It contains 75 percent of the atmospheric gases, water vapour and aerosols. Hence this lowest layer of the atmosphere is very useful to man. It is important to note that temperature decreases with increasing height at the rate of **6.5^0 Centigrade per 1000 meter** (1 kilometer). This rate of decrease of temperature is called as **Normal Lapse rate (Figure 1.2).** However it should be noted that there is seasonal variation in the height of the troposphere and changes from equator towards the poles. The average height of the troposphere is about 16 kilometer over the equator and 6 kilometer over the poles. The upper limit of the troposphere is called tropopause. The boundary between Troposphere and Stratosphere (the next layer) is known as **Tropopause**. It is an inversion layer (i.e. temperature does not decrease with increase in altitude in this layer). Tropopause acts as a lid for Troposphere. Therefore, troposphere becomes a self-contained layer of the atmosphere. Strong vertical convectional air currents are found near the Equator **(Figure 1.3.)**. Therefore the height of the Tropopause is about 16 km at the Equator, but it is only 8 km near the poles **(figure 1.4)**.

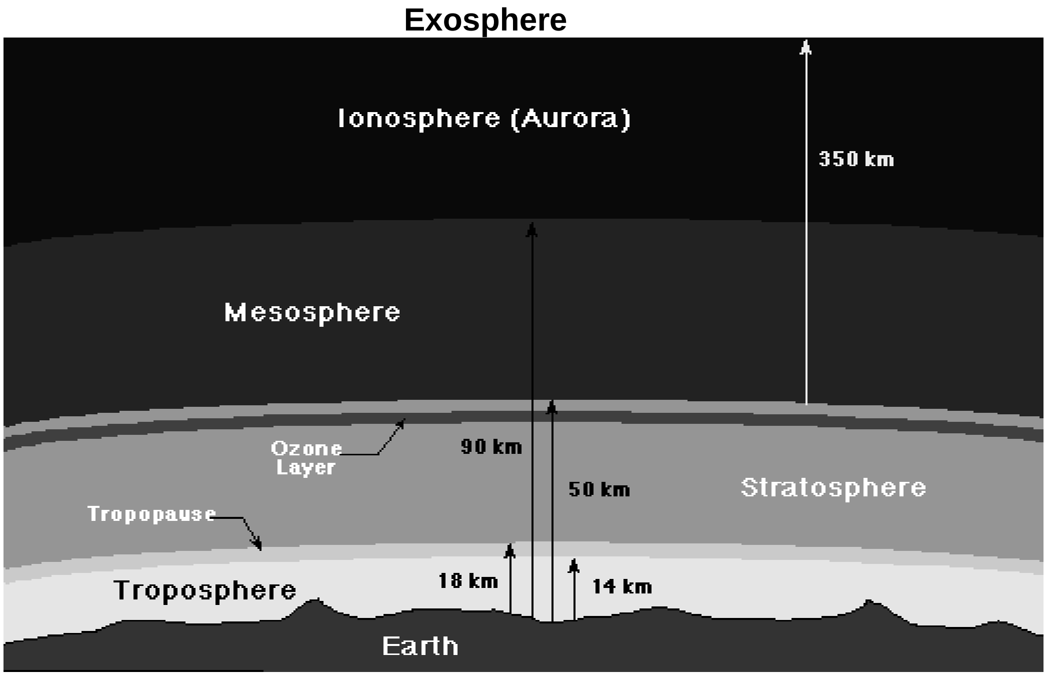

Figure: 1.1. Structure of the Atmosphere

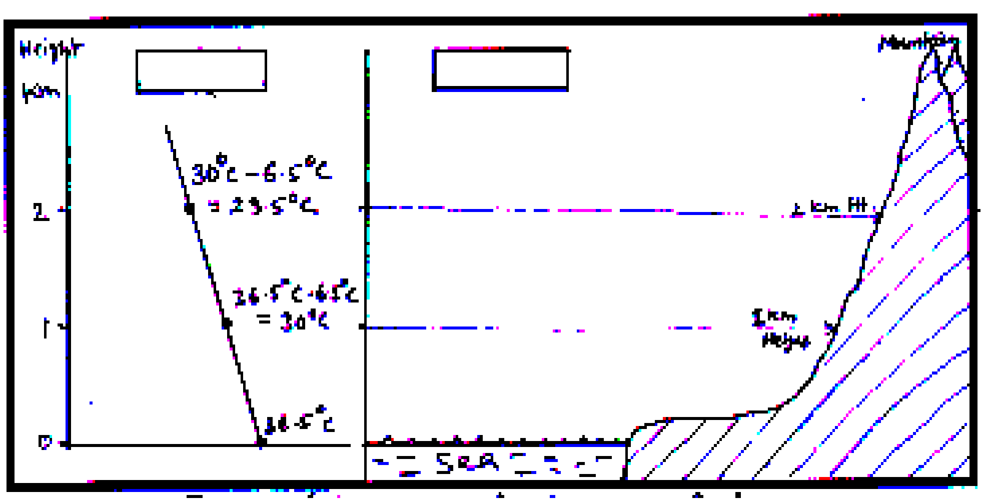

Figure: 1.2. Normal Lapse rate

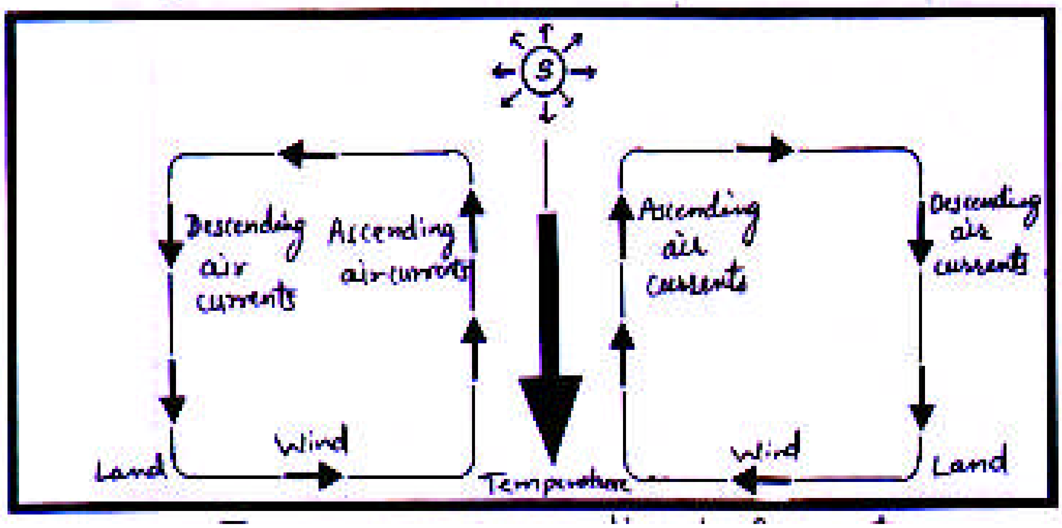

Figure: 1.3. Convectional Currents

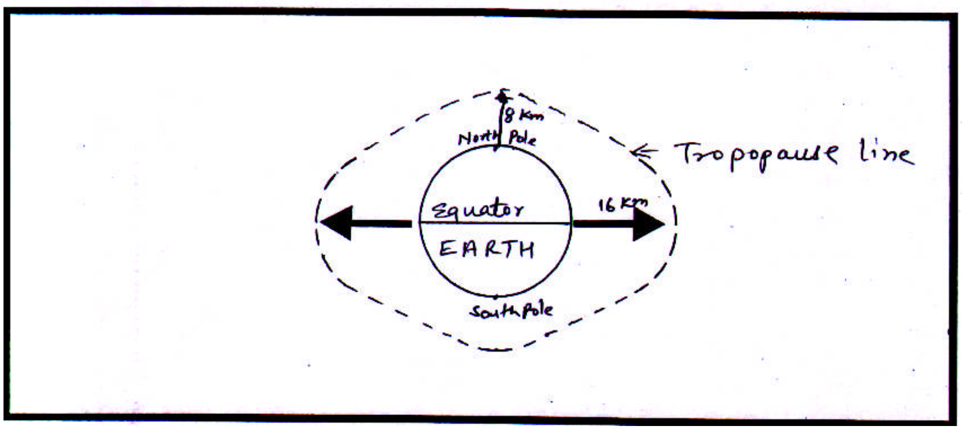

Figure: 1.4. Tropopause

ii) Stratosphere: Stratosphere extends from Tropopause up to the height of 50 km. There is an absence of storm or changing weather conditions and water vapour. Temperature remains constant at the lower part of the stratosphere, but it increases with increase in height. The lower part of the stratosphere is used by jet aircrafts. The ozone layer is mainly found in the lower portion of the stratosphere from approximately 20 to 30 kilometers above earth. Its thickness varies seasonally and geographically. Ozone layer in this region absorbs the harmful ultra-violet rays of the sun from reaching the earth. The composition of the stratosphere also changes with the latitude i.e. it begins with 9 km above the poles, 10 or 11 km in the middle latitudes, and 16 km at the equator, and extends outward up to 32 km. It is a zone of dry, thin air, cold and clear, with a horizontal temperature gradient. In Polar Regions the temperature is - 40°C to - 46°C, but near the equator it ranges from - 62°C to below - 74°C; in the middle latitudes it remains steady at about - 55°C **(Figure: 1.5)**. No weather occurs in the stratosphere. Air temperature slowly increases with height in the stratosphere.

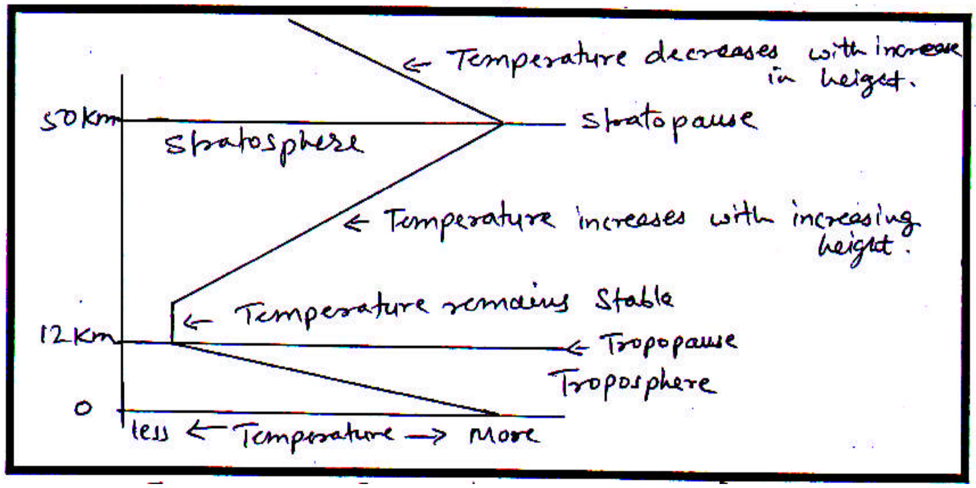

Figure: 1.5. Temperature changes in the stratosphere with height

1.2.3. Role of the ozone layer: Concentration of ozone (O_3) is found in this zone between 25-50 km. Ozone is made up of three atoms of oxygen (O_3) – ordinary oxygen molecule is made up of only two atoms (O_2). Oxygen molecule is broken into two atoms by UV radiation **(Figure 1.6)**. Therefore the unstable atom combines with the other molecule of oxygen ($O+O_2 = O_3$). Thus, O_3 or ozone is formed. O_3 molecule may also split into O_2 molecule and the unstable oxygen atom by the UV radiation. This constant conversion of ozone to oxygen and oxygen to ozone utilizes much of the UV radiation. Thus the amount of UV radiation reaching the Earth's surface is considerably reduced. (Excessive quantity of UV radiation reaching Earth's surface may create problems such as blindness, skin cancer and can even damage vegetation) **Figure 1.7.**

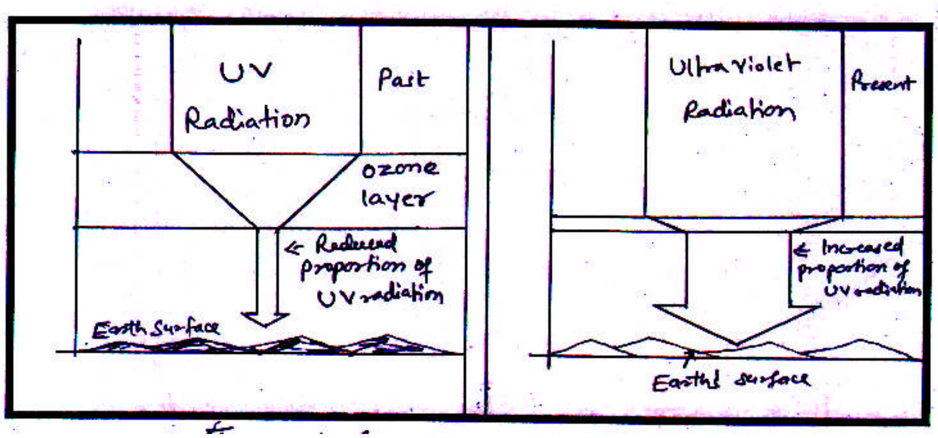

Figure: 1.6.Effect of Ultra violet radiation

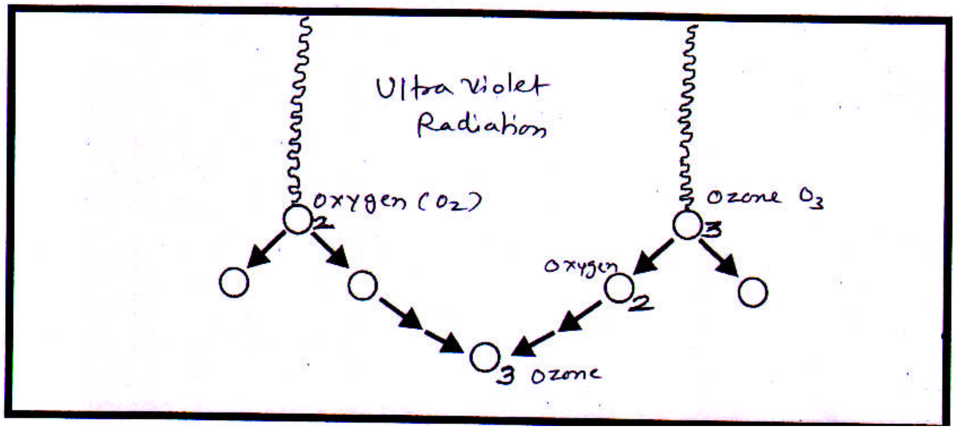

Figure: 1.7. Ultra Violet radiation and Ozone layer

Mesosphere: Mesosphere lies above stratosphere and below the thermosphere. It extends from about 50 to 85 km from the earth's surface. Temperature in the mesosphere decreases with height. The coldest temperatures in the Earth's atmosphere i.e.about -90°C is found near the top of the mesosphere. Mesopause is a boundary that lies between mesosphere and thermosphere. Various types of waves and tides in the atmosphere influence the mesosphere. These waves and tides carry energy from the troposphere and the stratosphere upward into the mesosphere, driving most of its global circulation.

iii) Thermosphere: Above the mesosphere, in the thermosphere and beyond, gas particles collide so infrequently that the gases become somewhat separated based on the types of chemical elements they contain. The thermosphere lies between the mesosphere and the exosphere. It extends from about 90 km to between 500 and 1,000 km geographically above the earth surface. Temperatures increase sharply in the lower thermosphere i.e. from 200 to 300 km height. The density of air is very low in thermosphere. Solar activity strongly influences temperature in the thermosphere. The aurora (the Southern and Northern Lights) primarily occurs in the thermosphere. Charged particles (electrons, protons, and other ions) from space collide with atoms and molecules in the thermosphere at high latitudes, exciting them into higher energy states. Those atoms and molecules shed this excess energy by emitting photons of light, which we see as colorful auroral displays. Thermo pause is a boundary that lies between the thermosphere and the exosphere. The Earth's thermosphere also includes the region of the atmosphere called the ionosphere. The ionosphere is a region of the atmosphere that is filled with charged particles. The high temperatures in the thermosphere can cause molecules to ionize. The ionosphere represents less than 0.1% of the total mass of the Earth's atmosphere but is extremely important because upper atmosphere is ionized by solar radiation where the Sun's energy is strong at this level which breaks apart molecules. Different regions of the ionosphere make long distance radio communication possible by reflecting the radio waves back to Earth **(Figure 1.8 and Figure 1.9.).**

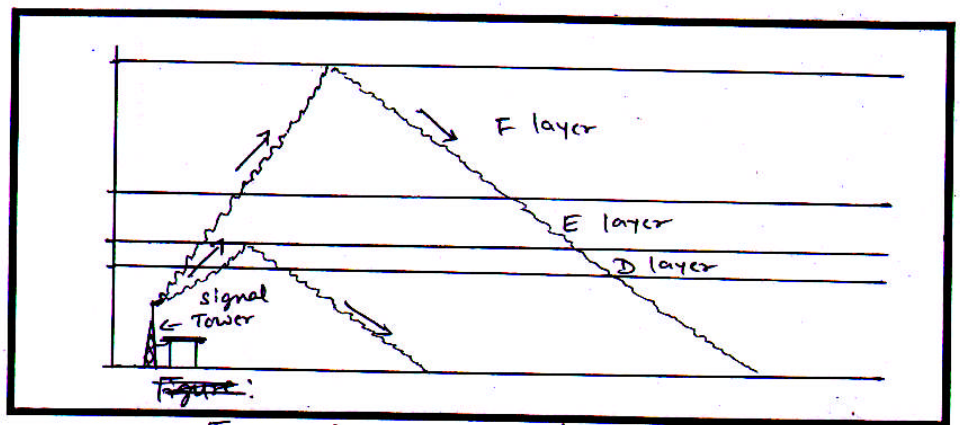

Figure: 1.8. Broadcasting of Radio / T.V. Waves

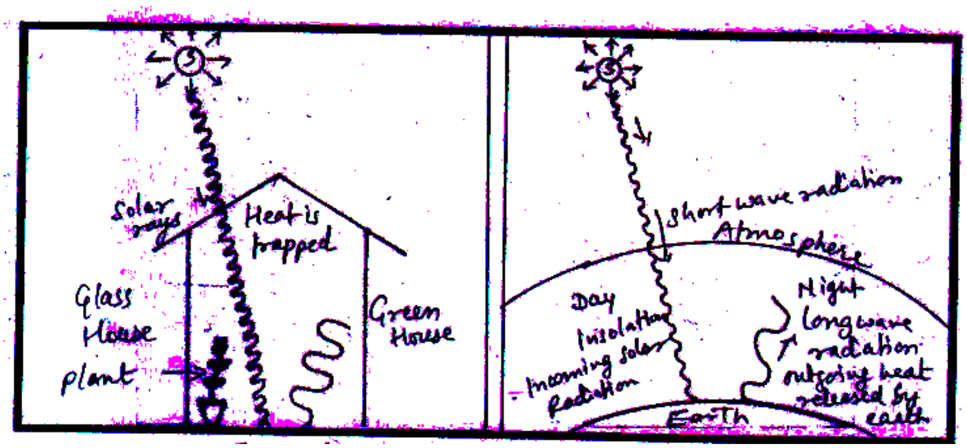

Figure: 1.9. Green House effect

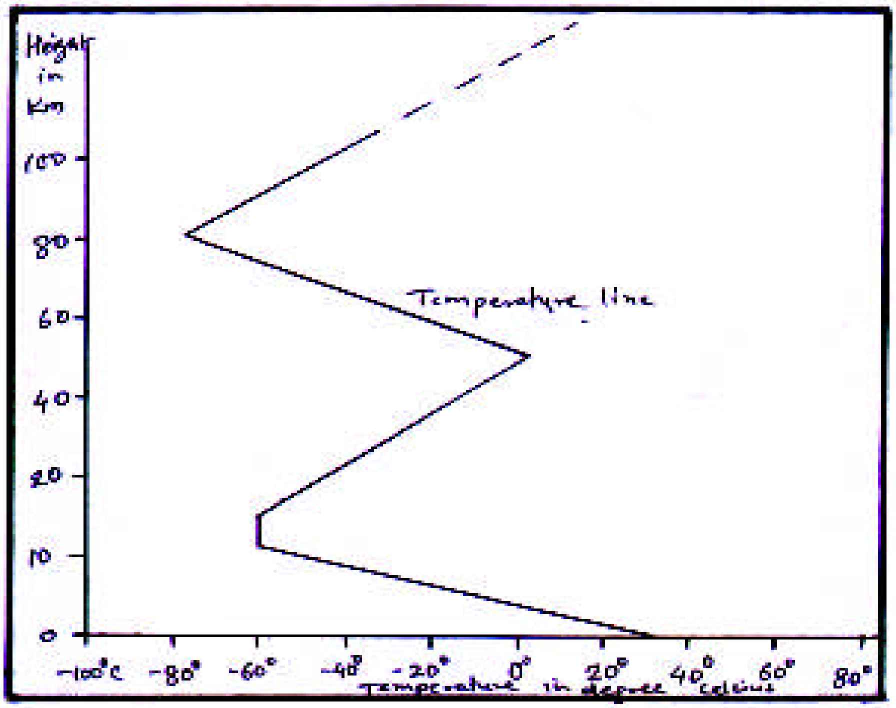

Figure: 1.10. Vertical Distribution of Temperature

iv) Exosphere: The exosphere is the outermost region of Earth's atmosphere and gradually fades into the vacuum of space. Air in the exosphere is extremely thin or almost airless. The lower boundary of the exosphere is called the exopause. At this altitude barometric conditions are absent. Atmospheric temperature becomes almost constant above this altitude. Exosphere lies at a height of about 500 to 1,000 kilometers from the earth's surface depending on the solar activity. In principle, the exosphere covers distances where particles are still gravitationally bound to Earth, i.e. particles still have ballistic orbits that will take them back towards Earth. The exosphere is a transitional zone between Earth's atmosphere and space.

Check Your Progress:

Q1. What is atmosphere?

Q2. What is the composition of atmosphere?

Q3. Give the structure of atmosphere.

1.3 INSOLATION AND TEMPERATURE

The heat received from the sun travels in the form of short and long wave's radiation. The temperature of the atmosphere is determined by the rate of insolation i.e. the amount of heat received from the sun by the earth which is released by the earth (long wave radiation) that heats the atmosphere from below. The atmosphere contains various green house gases such as carbon dioxide, ozone and water vapour that absorb out going heat released by the earth after sunset. This phenomenon is termed as the Greenhouse Effect of the atmosphere. Greenhouse is a glasshouse constructed normally in the temperate belt region for growing plant. As greenery is inside house, it is termed as Greenhouse. Temperature inside the greenhouse is more in comparison of outside the greenhouse. This is possible due to dual properties of glass. Glass is transparent and it is a bad conductor of heat. Hence, the solar radiation enters into the glasshouse, i.e. greenhouse-without any obstruction. There it is converted into heat. This heat is trapped inside the glasshouse**.** It is important to note that atmospheric gases cannot prevent insolation (short- wave radiation) from reaching the Earth and so the earth's surface gets heated from above. However the heat received by the earth is released in the form of long-wave radiation that is absorbed by the atmospheric gases **(Figure 1.11)**. As a result the atmospheric temperature is raised this is termed as Greenhouse Effect of the atmosphere.

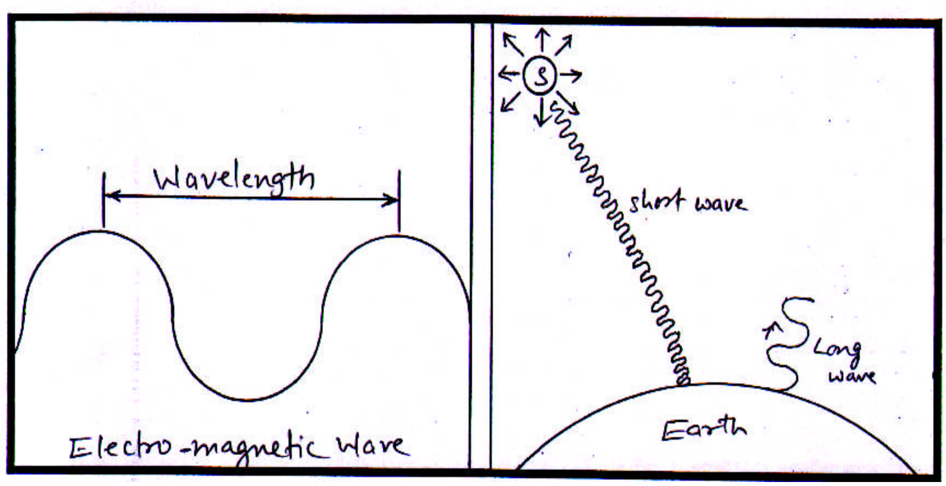

Figure: 1.11. Electromagnetic waves and Short and Long wave

1.4 FACTORS CONTROLLING DISTRIBUTION OF TEMPERATURE:

Temperature of different places on surface of the earth is not same everywhere. This is because the amount of **i**nsolation received at the surface of the Earth is controlled by the angle of the **sun**, the state of the atmosphere, altitude, and geographic location as explained below:

i) Latitude: Solar rays are vertical within the tropical belt (i.e. from the Tropic of cancer to the Tropic of Capricorn) vertical rays are concentrated over smaller surface area on the earth as compared to the oblique solar rays **(Figure 1.12)**. Similarly the resistance offered by the aerosols and other elements in the atmosphere is less in the case of vertical solar rays, than the oblique solar rays. Intensity of solar radiation decreases due to the resistance offered by the atmosphere i.e. due to reflection, diffusion, scattering. Due to these two factors areas receiving vertical solar radiation record higher temperature than the areas receiving oblique solar radiation **(Figure 1.13).**

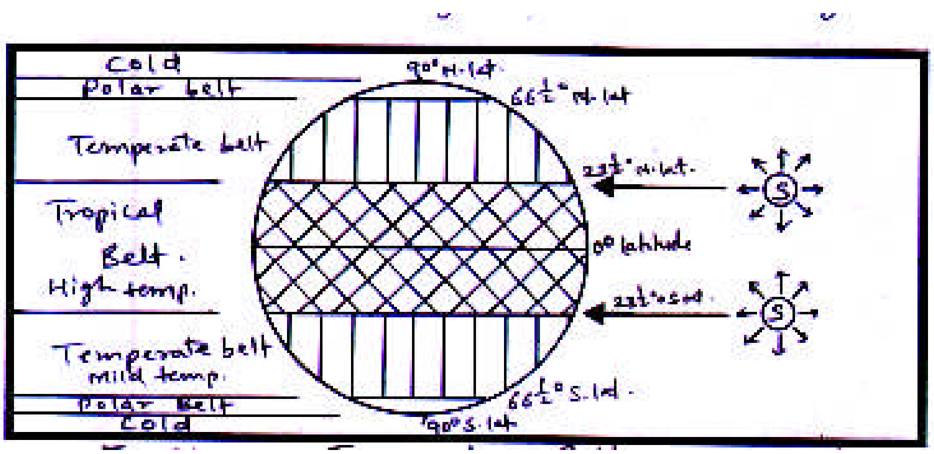

Figure: 1.12. Temperature Belts of the Earth

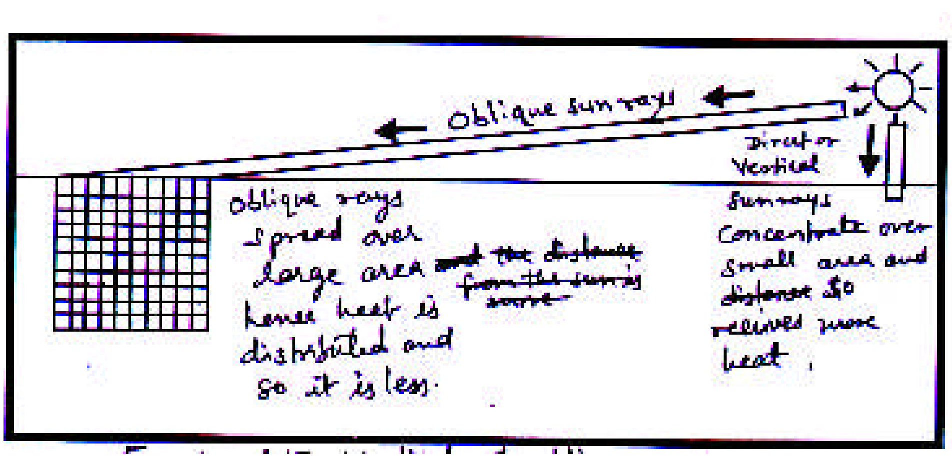

Figure: 1.13: Vertical and oblique rays and heat received

Generally temperature decreases away from the equator towards pole **(figure 1.14**).

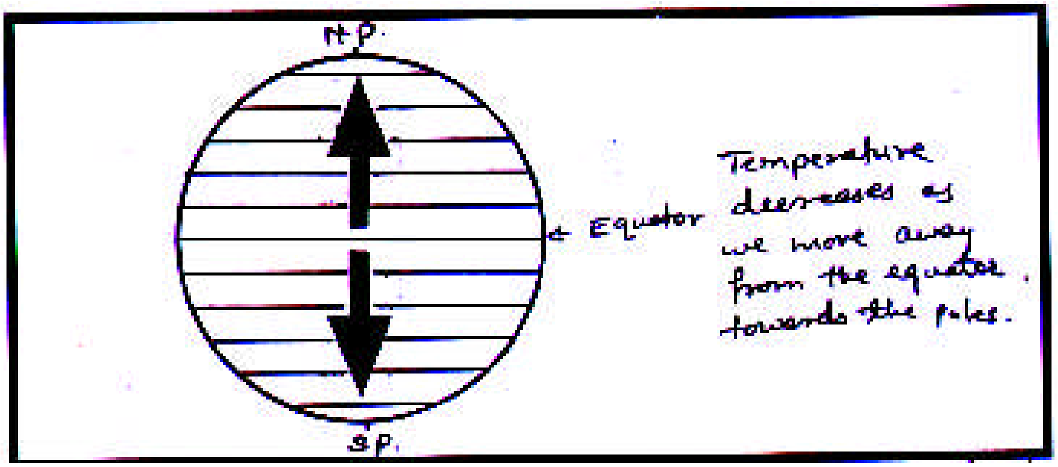

Figure: 1.14.Temperature decreases from the Equator towards Poles

ii) **Altitude:** Temperature decreases with increase in altitude from the earth's surface. Solar rays pass through the atmosphere, in the form of short wave radiation. Earth's surface is heated and then it emits heat in the form of long wave radiation Earth radiation. This long wave is absorbed by the water vapour enters into the atmosphere by the process of evaporation from the earth's surface. Co is added to the atmosphere by the processes like burning, combustion etc. As the concentration of water vapour and Co2 is more near to the earth's surface, the lower layers of the atmosphere absorb more heat. As we move towards higher altitude the amount of water vapour and Co2 decreases, so the capacity of the atmosphere to absorb heat. Hence the temperature decreases with increase in the altitude **(Figure 1.15.).**

iii)

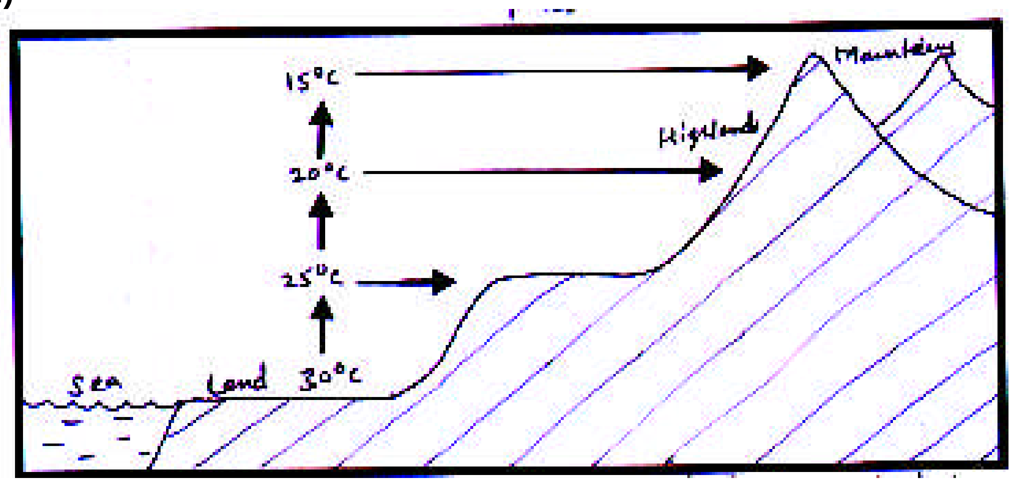

Figure: 1.15. Temperature decreases with increase in height.

iv) Distance from the Sea: Temperature characteristics of land and water are different. Land is heated more than water due to solar radiation during day time as solar heat is absorbed and released more slowly by water than by land. Water retains heat for a longer time and hence land becomes cool while water remains warm during night time. This difference in the heating properties of land and water is the main cause of land and sea breezes in the coastal areas. Difference in maximum and minimum temperature is less in the coastal areas but it is more in the interior parts of the continents due to the absence of water **Figure: 1.16.**.

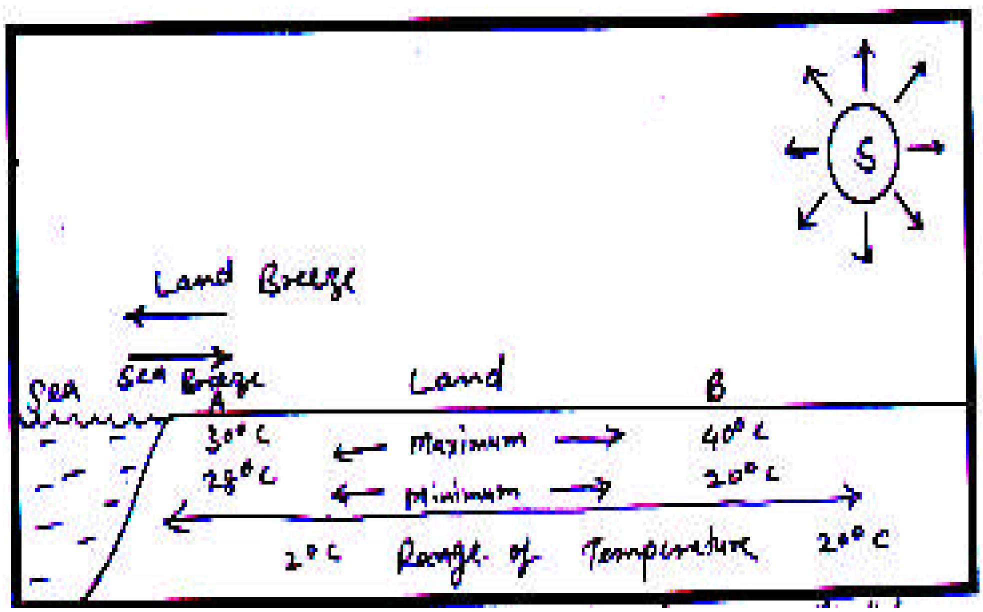

Figure: 1.16. Range of temperature increases with distance from the sea towards the land

v) Angle effect: (Effect of slope): Solar rays are slant in the temperate region. South facing slopes of the mountains in the temperate region of northern hemisphere receive ore sunshine (insulation) than the north facing slopes. Hence vegetation and settlements are found on the sunny slopes (south facing) which are termed as ‘Adret’. The north facing slopes of the mountains in the temperate region, which remain in shade are known as ‘Ubac’ slope. This effect of slope on temperature is termed as the Aspect effect **Figure: 1.17.**.

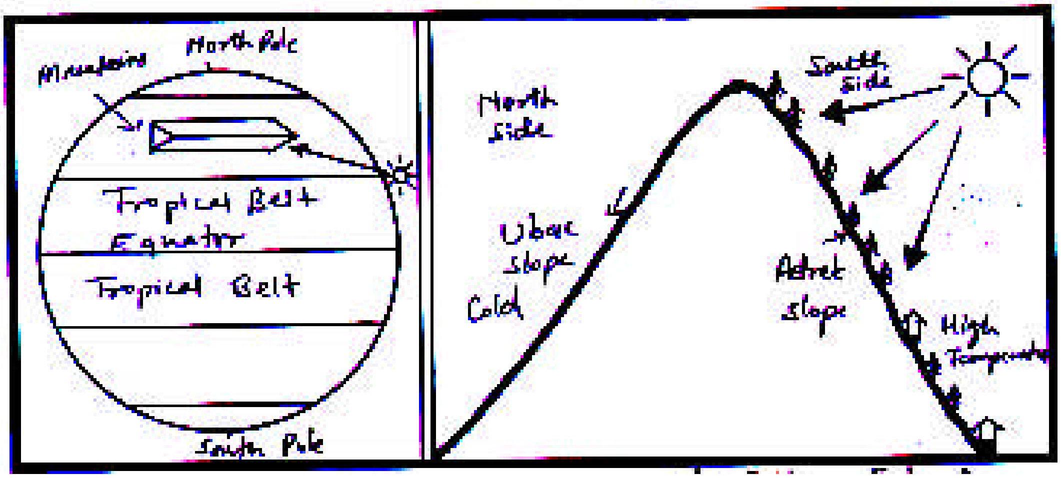

Figure: 1.17. Aspect effect- Slope facing sun is warmer

v) Ocean Currents: Warm ocean currents are responsible for increasing temperature of the surrounding region. e.g. Coastal areas of west Europe remain warm due to the Gulf stream of the Atlantic Ocean. Similarly cold ocean currents reduce temperature of the surrounding areas, for example Labradaor cold current near Greenland..

vi) Local Winds: Warm local winds increase temperature of the surrounding region and cool local winds reduce temperature of the surrounding region.

vii) Nature of Cloud cover: Solar rays are reflected back due to the cloud cover. Diffused solar radiation reaches earth's surface, due to the presence of cloud cover. Earth radiation is reflected back to the earth due to the cloud cover. Difference in the maximum and minimum temperature is less at the Equator due to constant cloud cover, but desert areas record extremes of temperature due to the absence of cloud cover **(Figure 1.18 and 1.19).**

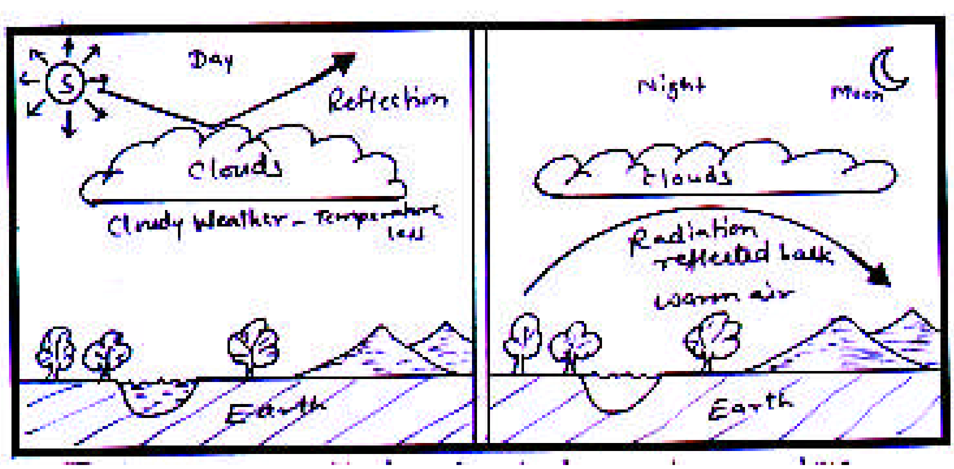

Figure 1.18. Effects of cloud cover on temperature

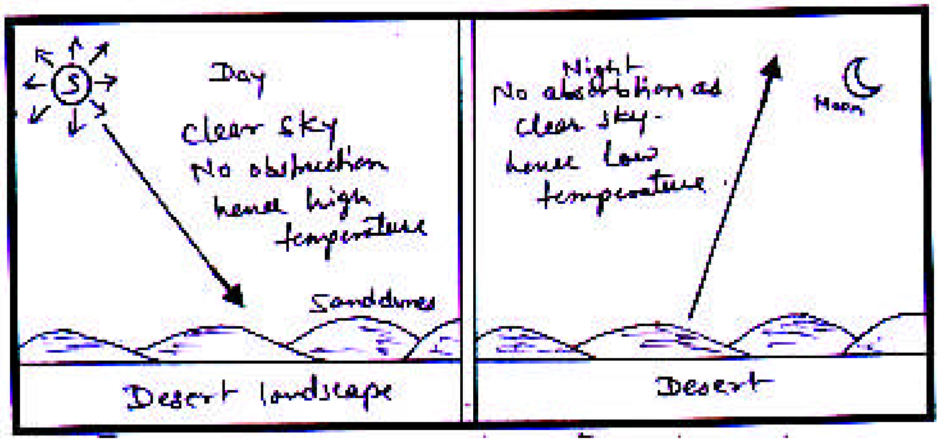

Figure: 1.19. Effects of cloud cover on temperature

viii) Duration / length of day: Duration of day is more during summer than in winter hence more solar radiation is received during summer than in winters. Hence temperature is more in summer and less in winter.

Check Your Progress:

Q. Name the factors controlling distribution of temperature.

Q. Explain inversion of temperature in the atmosphere.

Q. Write a note on Ozone Layer.

1.5 DISTRIBUTION OF TEMPERATURE ON THE EARTH:

Distribution of temperature is explained as under:

a) Vertical distribution of temperature: The distribution of the temperature varies vertically as well as horizontally on and above the earth's surface. Generally the temperature goes on decreasing with increasing altitude from the sea level. It is caused due to two reasons:

i) The atmosphere near the earth's surface absorbs most of the long wave radiation. Thus the air gets heated from below that makes air to warm-up and so it rises up. In this process of uplift of warm air it gets expanded that releases the heat and so the temperature goes on decreasing as we move upwards.

ii) Secondly the green house gases such as carbon-dioxide and water vapour are more near the surface of the earth and become thinner with increasing height. Hence lower atmosphere is warmer while temperature becomes cooler with increasing height of the atmosphere which is limited only to the lower region of the atmosphere.

However at times there is inversion of temperature in the vertical temperature distribution. It occurs when there is absence of winds blowing, the sky is clear, winters are long, air is cold and dry and the land surface is covered with snow.

Inversion of Temperature: Temperature inversion is a condition in which the temperature of the atmosphere increases with altitude in contrast to the normal decrease with altitude. When temperature inversion occurs, cold air underlies warmer air at higher altitudes. It may lead to different weather effects such as Pollutants hazards. Pollutants may get trapped below the inversion as the sky becomes very hazy causing respiratory problems. It usually occurs in high pressure zones, where the air is gradual sinking down in the lower atmosphere.

b) Horizontal Distribution of temperature on the earth: The horizontal distribution of temperature across the globe is governed by various factors. These are absolute location (latitudes and longitudes); relative location (maritime / continental), time (season), duration and intensity of sunlight received (location – equatorial to polar; day and night), soil type and vegetal cover, relief, water bodies, winds, ocean currents, cloud cover. This horizontal temperature distribution can be identified across the globe with the help of isotherms for the months of January and July as best example. The solar rays are perpendicular on the lower latitudes and become slanting as we move towards the higher latitudes. As a result temperatures are higher in the tropical region and lower in the polar region. Tropic of cancer (23 ½ ^{0} North latitude) and Tropic of Capricorn (23 ½ ^{0} South latitude) are the upper latitudinal limits of perpendicular solar insolation receiving maximum heat from the sun. Isotherms are imaginary lines drawn with areas having same temperature. These isotherms generally run from east-to west and are parallel to the latitudes. These isotherms are irregular in the northern hemisphere due to more land surface with its diversity whereas they are more uniform in the southern hemisphere due to more water surface with less diversity. Variation in temperature is rapid in the higher latitudes hence isotherms are closely spaced whereas temperature variation is relatively slow in the lower latitudes therefore isotherms are widely spaced. Isotherm map for the months of July and January explains the given concept of horizontal distribution of temperature.

1.6 SIGNIFICANCE OF ATMOSPHERE AND TEMPERATURE:

The existence of life on the earth is because of the gaseous envelop of the atmosphere that provides warmth by trapping heat released by the earth and other necessary gaseous elements dissolving in rain water reaching the earth's surface to enter into ecosystem**.**

- **Advantages of the Atmosphere**

Some of the advantages of the atmosphere are as follows:

i) It provides oxygen required for our survival as well as for other forms of life.

ii) It provides carbon dioxide to plants for their survival.

iii) The atmosphere controls the temperature of the Earth, which is essential for the existence of various forms of life in the environment. Without the atmosphere, the temperature of the Earth would have increased to more than 200^0C, which is certainly not suitable for the environment found on the Earth.

iv) The atmosphere (ozone layer) protects us from the harmful effects of the ultra-violet radiation, which is a part of solar radiation.

v) 'Weather' and 'Climate' are the terms used to indicate changes in the atmospheric condition. Our daily and annual activities are associated with weather and climate.
vi)It protects us from the harmful meteors, which are attracted towards the Earth. Many of them are burnt down as they enter into the Earth's atmosphere.

1.7 CONCLUSION

i) The vertical distribution of temperature, pressure, density, and composition of the atmosphere constitutes atmospheric structure. Spatial variation and distribution in temperature is determined by the season, its geographical location, and the time (day time or night time), and its distance and height from the sea.

ii) A mixture of a number of gases is termed as air that constituents abundantly molecular nitrogen (N2), molecular oxygen (O2), and a little amount of the inert gas argon (Ar). They together constitute 99.9 percent of the mass of dry air. This ratio of the number of each molecule is nearly stable up to a height of about 80 to 90 kilometers from the earth surface. Water vapor (H2O) and carbon dioxide (CO2) are other important gases that absorb and emit long wave radiation, and ozone (O3) gas that absorbs ultraviolet radiation from the Sun as well as some long wave radiation from the Earth. The distribution of these gases therefore affects the vertical temperature distribution.

iii) Temperature thus cools with height throughout the troposphere, but it then warms through the stratosphere, only to cool again through the mesosphere. Finally it heats up in the thermosphere and exosphere. This distribution comes about through changing interactions among shortwave radiation from the Sun, long wave radiation from the Earth, and various gases in the air.

1.8 QUESTIONS

1. Explain the composition and structure of atmosphere. Draw suitable diagrams.
2. Discuss the factors determining distribution of temperature. Draw suitable diagram.
3. Describe the horizontal distribution of temperature. Draw suitable diagram.
4. Explain the vertical distribution of temperature. Draw suitable diagram.
5. Examine the importance of atmosphere and temperature giving suitable examples.

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1. Pednekar,Shinde,Thakur…..(2015): Physical Geography, F.Y.B.A. Semester I and II, Sheth Publishers Private Limited, Mumbai.

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Unit - 2

THE ATMOSPHERIC PRESSURE BELTS AND WINDS

Unit Structure:

2.0 OBJECTIVES :

- To understand the nature of atmosphere, its structure and composition
- To know the factors influencing pressure conditions and its impact on temperature conditions
- To study the distribution of local winds, monsoon winds and planetary winds
- To study the variable character of winds in different areas of the world.

2.1. INTRODUCTION :

Atmosphere contains air. Air is a mixture of gases. Most of these gases have weight, therefore atmosphere has pressure. High pressure and low pressure belts are formed on the Earth due to insolation, rotation of the Earth, etc. Air always moves from the high pressure area to low pressure area. Hence wind belts are formed in between pressure belts. Similarly, various types of wind systems are formed due to local variations in the atmospheric pressure.

2.2. ATMOSPHERIC PRESSURE AND WIND BELTS

Air Pressure :

Air is mixture of gases. Most of these gases have their own weight. Therefore air exerts pressure on the Earth's surface. The weight of air on a unit area of the Earth is called Air Pressure.

Air pressure at sea level is equal to 1013.2 mb (millibar). Air pressure decreases with increase in height/ altitude from the sea level.

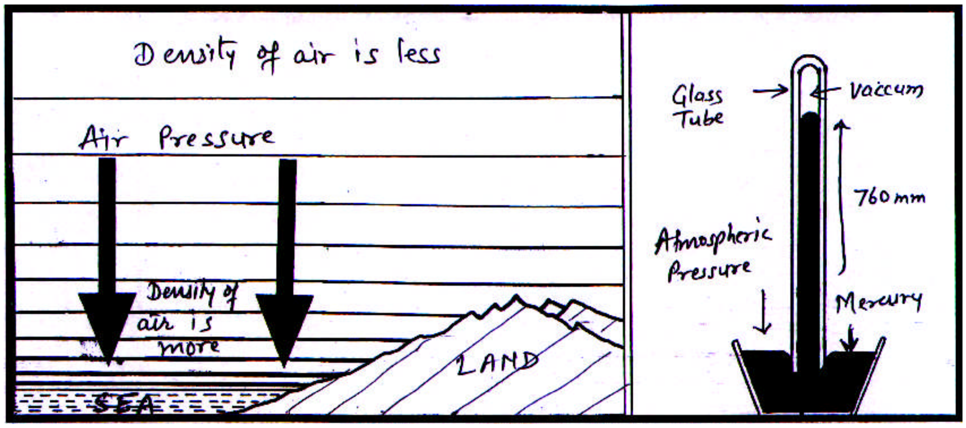

Figure:2.1 Air pressure decreases with increase in altitude

In this, diagram the weight of air at sea level '(A)' is maximum. The weight of air at (B), (C) and (D) becomes less. Therefore the air pressure at (B), (C) and (D) will be less. (D) records lowest air pressure.

2.3 DISTRIBUTION OF LOCAL WINDS, MONSOON AND PLANETARY WINDS :

- **Pressure Belts**
  Two types of pressure belts are found on the Earth. They are:

a) High pressure belts and
b) Low pressure belts.

Before going into the details of these pressure belts, it is necessary to understand how these belts are formed. Temperature and the atmospheric pressure are related to each other. There is an inverse relationship between the temperature and the atmospheric pressure. Areas of high temperature are generally associated with low pressure, and the areas of low temperature are associated with high pressure.

In this diagram, place (A) receives oblique solar rays. Therefore it records low temperature. Place (B) receives vertical solar rays. Therefore it records high temperature. **(Figure: 8.2)** Due to high temperature the earth's surface at (B) will be heated more. The air near to this surface will become warm and expand. So its density will decrease. Air of low density is lighter than the air of high density. Hence, the warm air being less dense will be lighter and will move in the upward direction. The upward moving air will displace upper air, due to the gravitational atmosphere. As a result, the upper air will move towards nearby area, i.e. (A) in this example. Now the accumulation of air is more at (A). Therefore the weight of air at (A) is more and, hence, (A) will be the area of high pressure and (B) will be the area of low pressure.

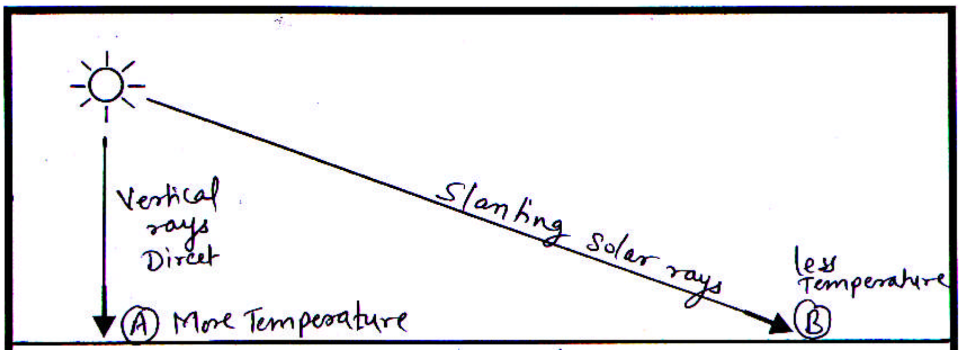

Figure: 2.2. Solar radiation and Temperature amount.

As place (A) has high pressure and place (B) has low pressure, air from place (A) will move towards place (B) in order to maintain the balance in the pressure at (A) and (B) **(Figure 2.3)**. This air which moves from high pressure area to the low pressure area is known as wind.

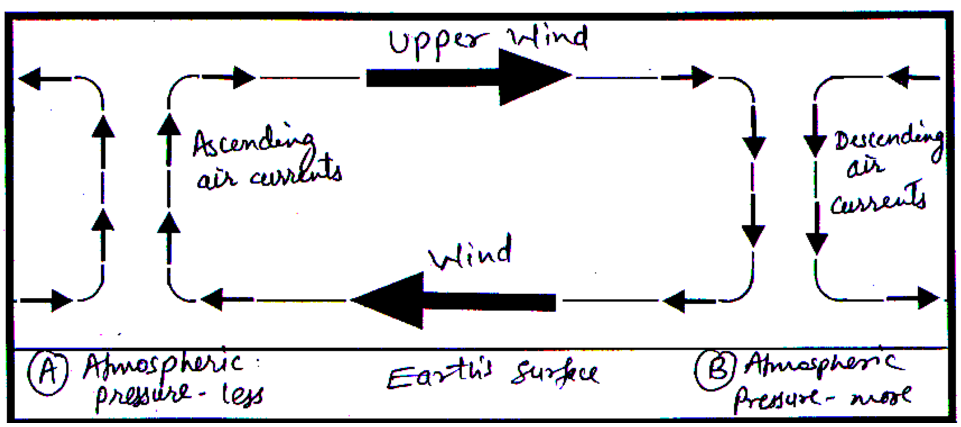

Figure: 2.3. Low and High pressure Areas and wind

On a global scale, air near the equatorial area is more heated due to more intense solar radiation. This air moves in the upward direction in the form of convectional currents. Therefore low pressure area is formed at the Equator which is termed as 'Doldrums'. Air which is displaced by the equatorial low pressure area descends down near 30^0N and 30^0S latitudes. Hence high pressure belts are formed at 30^0N and 30^0S latitudes.

This pattern of alternate belts of low pressure and high pressure are found on the entire Earth. The major pressure and wind belts are given in the following diagram **(Figure 2.4.)**.

i) Doldrums: It is the low pressure belt situated between 5^0N to 5^0S latitude. Due to intense heating, low pressure area is developed. Air rises upward in the form of convectional air currents. The air is generally calm in this belt. Therefore it is termed as ‘Doldrums’ which means ‘Belt of Calm’.

ii) Subtropical High Pressure Belt: This high pressure belt is found at 30^0 to 35^0 north and south of the Equator. The upward moving air at the equatorial low pressure belt descends in these latitudes. Therefore these become areas of high pressure.

The descending air currents are found in this area of high pressure. This creates calm air without much movement of air. In olden times sailors found it difficult to steer their ships (due to lack of wind) across these regions. In such situations horses that were commonly carried as their cargo, were thrown into the sea in order to conserve the food on the ship for survival of the sailors. Hence, these latitudes are also termed as Horse latitudes. Air which moves from this high pressure area to the equatorial low pressure area is termed as Trade Winds.

iii) **Sub-Polar Low Pressure Belt:** These low pressure areas are situated between 60^0 to 65^0 north and south latitudes in both the hemispheres. Cold air at the poles is very heavy. Therefore high pressure area is formed at the poles. Descending air at the subtropical high pressure area is divided into two parts. One part moves towards the Equator as Trade winds while the other part moves towards the pole as westerlies. Due to the rotation of the Earth, winds coming from poles i.e. polar easterlies and westerlies – converge at 60^0 to 65^0 north and south latitudes forming sub-polar low pressure belt.

iv) Polar High Pressure Belt: The ascending air at the sub-polar low pressure area descends down at the pole region. Thus forms polar high pressure belt.

- **Shifting of Pressure Belts**

The Earth’s axis is tilted by $23½^0$ to the vertical plane. Though the Sun is stationery but due to the tilting of Earth’s axis and revolution of the Earth around the Sun, it appears that the position of the Sun changes in different seasons or time of the year. This is termed as the apparent movement of the Sun.

All pressure and wind belts shift to the north during summer in the northern hemisphere and to the south during winter in the northern hemisphere (or summer in the southern hemisphere). Hence, the shifting of pressure and wind belts is directly related to the apparent movement of the Sun.

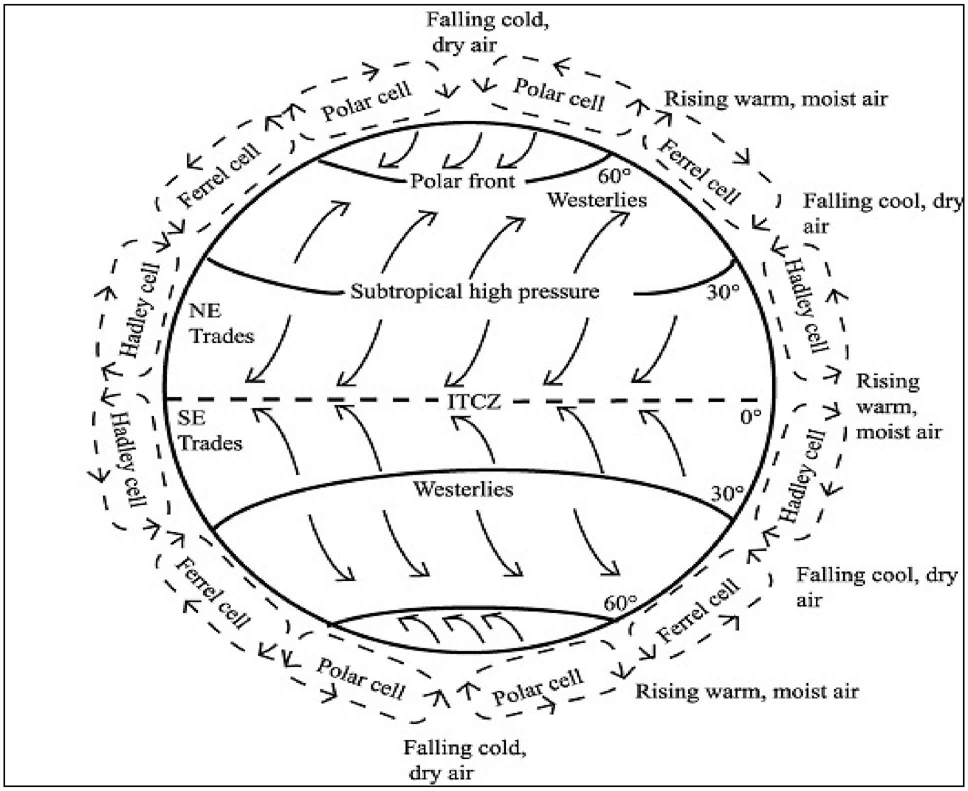

Figure: 2.4. Winds and Pressure belts

Due to the shifting of pressure and wind belts, various natural regions experience different types of climatic conditions in different seasons. Rainfall is most impacted by them.

- **Distribution of Atmospheric Pressure**

Distribution of atmospheric pressure is represented with the help of isobars. Isobar is an imaginary line drawn on the map which joins the places of equal atmospheric pressure.

Spacing between the isobars helps us to understand the pressure gradient **(Figure:2.5)**.

(a) Steep pressure gradient: When spacing between isobars is less and Isobars are close together, hence, the wind speed will be higher. Generally, in the case of a cyclone, pressure gradient is very steep and wind speed is more.

(b) Gentle pressure gradient: In this case the spacing between isobars is less. Isobars are farther apart. Hence, wind speed will be lower. Generally, in the case of anticyclones, pressure gradient is very gentle and wind speed is less.

(c) Equal pressure gradient: There is no wind when the atmospheric pressure is same at two places **(Figure 2.6.).**

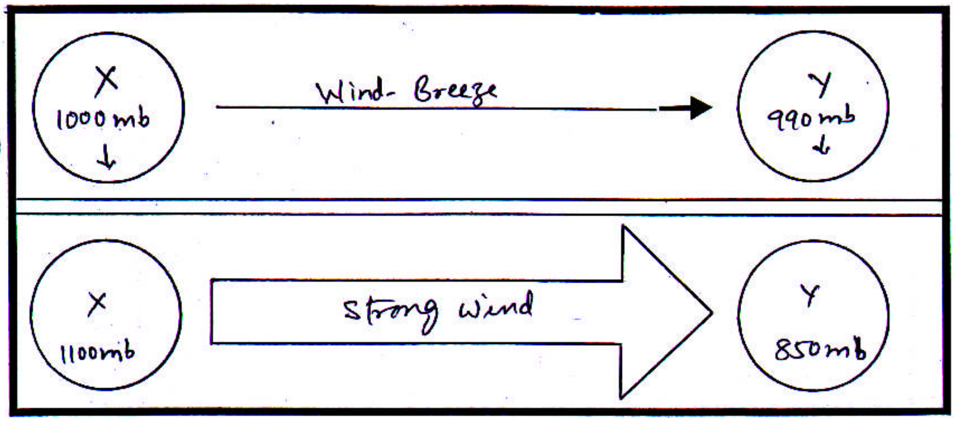

Figure:8.5. Atmospheric pressure and wind speed

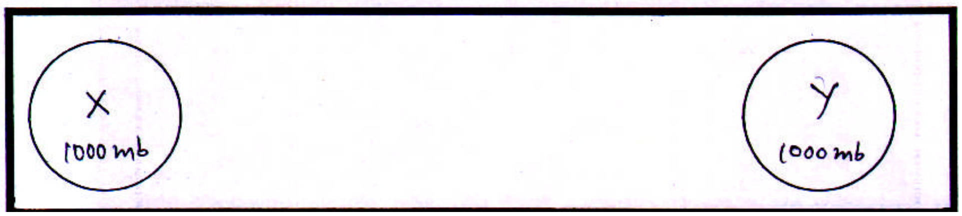

Figure: 2.6. Equal atmospheric pressure – no wind

Check Your Progress:

1. Define air pressure.
2. What causes variation in atmospheric pressure?

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2.4. VARIABLE WINDS AND CYCLONES

- **Winds :**

Distribution of the atmospheric pressure is uneven in the world. Winds are caused due to uneven distribution of pressure. Winds move parallel to the Earth's surface. (Vertical movement of air is termed as air current.

Factors Affecting Direction and Speed of Wind :

Direction of wind means the direction from which wind blows. For example, 'easterly wind' means wind coming from the east. 'South-westerly' wind means wind coming from the south-west direction. Various forces are responsible for determining the direction of winds. Some of them are as follows:

Pressure Gradient Force :

The rate of change of air pressure between two places is called Pressure Gradient. The direction of pressure gradient is at right angles to the isobars. Air (wind) moves from high pressure area to the low pressure area. The velocity or speed of wind depends on the pressure difference between the two places. Wind speed is more when pressure gradient is more or steep. Wind speed is less when pressure gradient is less or gentle.

Coriolis Force

The force which deflects wind and is formed due to the rotation of the Earth is termed as the Coriolis force (after the name of French engineer Coriolis).

Winds are displaced from the direction of wind gradient due to the Coriolis force. Ferrel formulated a law to indicate the actual direction of wind in the northern and southern hemispheres after considering the impact of Coriolis force. This law is known as Ferrel's law **(Figure 2.7)**.

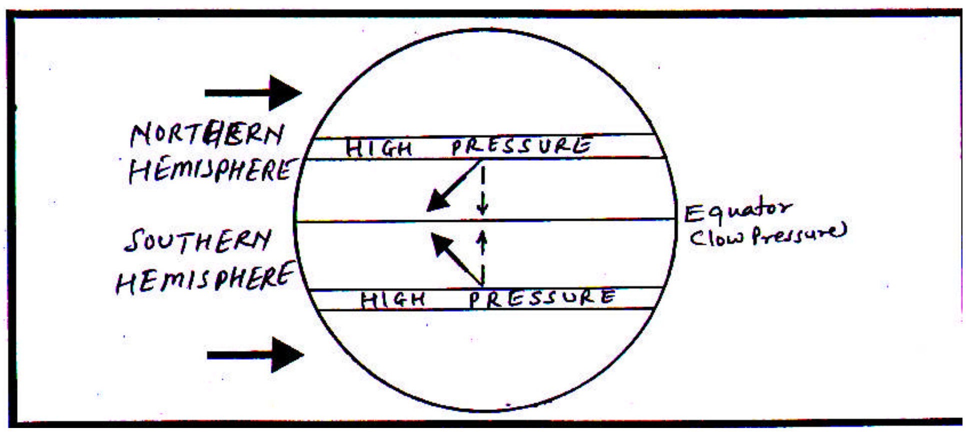

Figure: 2.7. Deflection of winds

According to Ferrel's law, if we stand facing the direction in which the wind is blowing, we will feel greater impact of the wind on our right-hand side in the northern hemisphere and towards our left hand in the southern hemisphere. The effect of rotation of Earth on the direction of wind is minimum at the Equator and is maximum at the poles.

Classification of winds:
Permanent Winds

These winds have influence all over the world. Hence they are also termed as planetary winds. Due to their regular nature, these winds are also known as prevailing winds.

Trade Winds

These winds blow from the subtropical high pressure belt (30^0-35^0 North and South latitudes) to the equatorial low pressure area, i.e. Doldrums (5^0 North and South of the Equator).

Characteristics of Trade Winds

- These winds blow towards from the subtropical high pressure belts towards the equator.
- Trade winds are deflected to the right of their path in the northern hemisphere and to the left of their path in the southern hemisphere.
- They bring rain to the eastern margins of the continents but are unable to provide rain to the western margins of the continents – creating hot deserts on the western margins of the continent. Hence, these deserts are also termed as Trade Wind Deserts.
- Trade winds are known for their steady direction and wind speed.
- Trade winds are replaced by the monsoon winds in the monsoon region.
- These winds are associated with cyclones and depressions.

Westerlies

These winds blow from the subtropical high pressure belts (30-35^0 N and S) to the sub-polar low pressure regions (60^0 – 65^0 N and S). These are also termed as anti-trade winds as their direction is opposite to the direction of trade winds.

Characteristics of Westerlies

- These are found in the temperature belt between 30^0-60^0N and 30^0 – 60^0S latitudes.
- Their direction is south-west in northern hemisphere and north-west in the southern hemisphere.
- Since the expanse of sea is very large in the southern hemisphere, the westerlies blow here uninterrupted. Hence, the direction of westerlies is constant and the speed is very high in the southern hemisphere. These are known by different names in different latitudes as given below:

Latitude	Westerlies (known as)
40^0S	Roaring Forties
50^0S	Furious Fifties
60^0S	Stormy or Shrieking Sixties

Westerlies are associated with the changing nature and accompanying changing weather. The velocity of the Westerlies is more during winter as compared to their velocity during summer.

These winds cause rainfall almost throughout the year in Western Europe, western Canada and south-west Chile in South America.

Due to the shifting of pressure and wind belts, Westerlies shift southward in the Northern hemisphere during winter and provide rainfall to the Mediterranean region.

These winds play an important role in the balance of heat at global level by carrying warm equatorial water and air to the temperate region.

Polar Winds

These winds blow from Polar High Pressure areas towards sub-polar low pressure areas, i.e. from 90^0N/S to 65^0N/S.

Characteristics of Polar Winds

- These are very cold and dry winds as they come from the cold Polar region.
- Coriolis force is maximum near the poles. Therefore polar winds are more affected by this force As a result their direction is changed.
- These winds are experienced between the Poles and Sub-polar low pressure belts.
- Polar winds are better developed in the southern hemisphere.

DISTRIBUTION OF LOCAL WINDS, MONSOON AND PLANETARY WINDS :

Monsoon (Seasonal winds) : The word ‘Monsoon’ is derived from the Arabic word Mawsim meaning ‘season’. These winds change their direction according toe the season, i.e. the direction of the winds in winter is opposite to that during summer season. Asia has the greatest monsoon influence as it is the largest continent. Here India, Myanmar, Indonesia, China and Japan experience monsoon. The other major regions of the world include parts of Australia, North America, South America and the western coast of Africa.

Summer Monsoon winds : In the northern hemisphere, during summer, the solar rays are vertical over the Tropic of Cancer. Therefore the Asian land mass is heated more. As a result, low pressure areas develop over at central Asia in China and Peshawar in Pakistan. These low pressure areas are so strong that the air from southern subtropical high pressure belt reaches the Equator as south-east trade winds. After crossing the Equator these winds change their direction due to rotation of the Earth and become South**-** West Monsoon winds. As these winds come from the sea they carry moisture. Hence they are able to give rainfall in India and other parts of Asia.

Winter Monsoon winds: The solar rays are vertical over the Tropic of Capricorn in winter season. As a result, low pressure area develops in Australia and high pressure area in Asia. Hence, the monsoon winds change their direction and become north-east monsoon winds. As these winds mainly come from land, they are not able to give rainfall to a large area The Coromandal coast in Tamil Nadu gets some rainfall from the North-eastern Monsoon winds **(Figure 2.8)**.

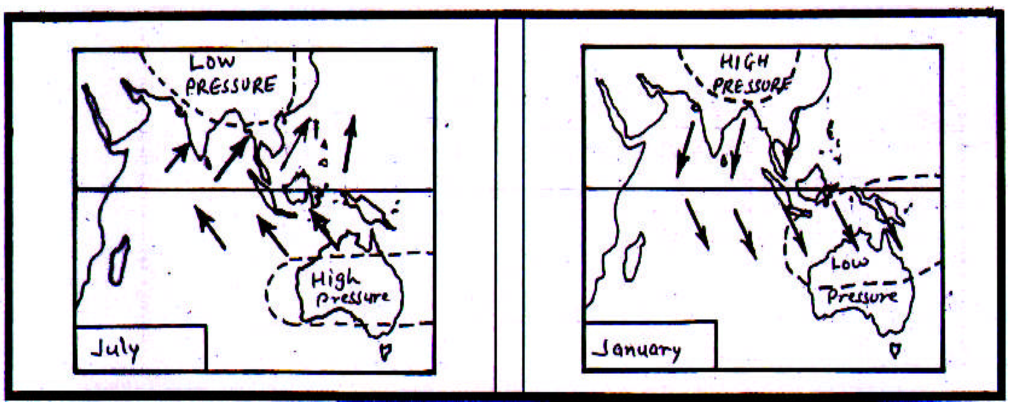

Figure 2.8. **Monsoon winds in Summer and Winter**

Sea breeze: During daytime land is heated faster than the water along the coastal areas **.** Air near the land is also heated. As a result it expands. The density of warm air becomes less than the surrounding cooler air. Therefore it moves in the upward direction. Hence, low pressure area develops over the land. The air pressure is comparatively higher over the sea, as water is relatively cooler. Therefore the air from the sea moves towards the land as sea breeze during daytime **Figure: 2.9**.

Land breeze : Water retains its heat for a longer period of time than land. Hence the cooling process at sea is very slow. On the other hand, land is cooled more quickly. Hence, high pressure area develops over the land and low pressure area develops over sea. Thus the air from the land moves towards the sea as land breeze during night-time

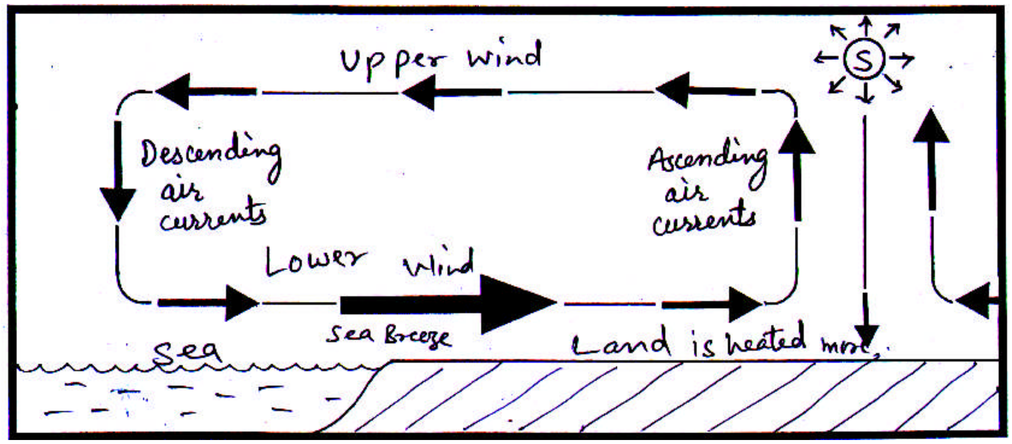

Figure: 2.9. Development stages of sea breeze

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Land and sea breezes have moderating influence on the climate of the coastal areas. Hence in this region, the range of temperature is less. Fishermen take advantage of these winds for going into the sea for fishing and returning to the shore.

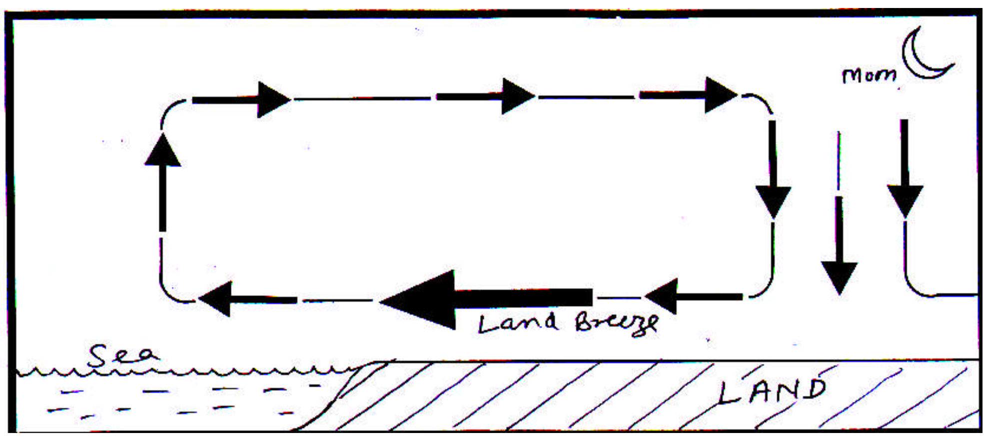

Figure: 2.10. Development stages of land breeze.

Local Winds :

Planetary or permanent winds have their influence on the entire globe but local winds have their influence only on smaller local areas over which they prevail. Therefore these winds are termed as local winds. These are known by different names in different regions. Some of the local winds are as follows :

Mountain and Valley Winds :

These are formed in the hilly regions. During the night the air at the mountain tops becomes quite cool. Its density increases and it flows down the slopes into the valley below during nigh-time or early in the morning before sunrise. As these winds come from mountains these are termed as Mountain winds. These are also known as Katabtic winds.

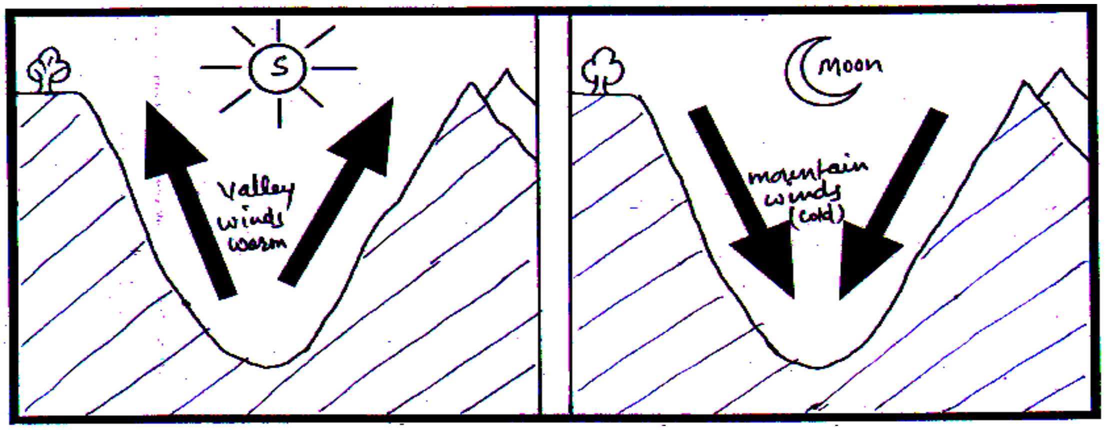

Figure 2.11. Mountain and Valley winds

During the day, air at the bottom of the valley is heated due to solar radiation. Its density becomes less. This light and warm air moves in the upward direction along the hill slopes. As these winds come from the valley, these are termed as Valley winds or Katabatic winds.

Chinook :

'Chinook' means 'snow eater'. This local wind descends down the eastern slope of the Rockies mountain range in the western part of North America.

As Chinook descends down from the eastern slope of the Rockies, it becomes warm (ascending air along hill slope becomes cool, while descending air becomes warm) Snow melts due to Chinook in winter. Hence, it is termed as snow eater or Chinook. It increases the temperature of the prairies and helps in farming activities in the region.

Fohn :

The winds which cross the Alps and descend down in Switzerland are called as Foehn (or Fohn). Other similar winds which descend down the mountain slopes and increase the temperature are as follows:
Norwester – In New Zealand
Santa Ana – in California
Samun – In Iran
Bergs – in South Africa

Other types of local winds are –
Sirocco – (hot) – Sahara
Salano – (hot) – South Spain
Khamsin – (hot and dry) – Egypt
Simoon – (hot and dry) – Arabia
Mistral – (Cold) – France
Bora- (cold) – Adriatic coast of Yugo-slavia

Check Your Progress:

1. Define winds. Give a classification of winds.
2. Explain land breeze and sea breeze. Draw diagram
3. What is Chinook?

These winds are associated with the pressure system, i.e. low pressure or high pressure. These winds do not blow in any particular direction regularly. Their origin and direction of movement depends upon the formation of pressure system. The major types of variable winds are Cyclones and Anticylones.

Cyclones :

Cyclones are associated with the low pressure system. Cyclones which develop in tropical belt are known as Tropical cyclones, while the cyclones which are developed in the temperate belts are known as Temperate cyclones. Tropical cyclones are more intense and more destructive than the temperature cyclones.

Tropical Cyclones :

A tropical cyclone is represented by concentric circles of isobars having low pressure area in the centre. The pressure gradient is very steep and so the isobars are very close to each other. Winds move towards the centre and the direction of winds is anticlockwise in the northern hemisphere and clockwise in the southern hemisphere.

Major characteristics of tropical cyclones:

- Tropical cyclones mostly develop over the seas (water-bodies).
- Isobars are usually in the form of concentric circles.
- Pressure gradient is very steep.
- Wind speed is more than 100 km. per hour.
- Tropical cyclones are small in size.
- These are associated with heavy rainfall.
- These cyclones occur mostly in summer.

- The cyclones travel from east to west.
- The centre of the cyclone is known as ‘eye of the cyclone’ . There is no movement of air (‘calm’ condition) and no rainfall at the centre of the cyclone.
- Direction of wind is anticlockwise in the northern hemisphere and clockwise in the southern hemisphere.

Tropical cyclones are known by different names in different parts of the world, e.g. Typhoons in China, Tornadoes in USA, Cyclones in India, Hurricanes in the Caribbean and Willy-Willies in Australia.

Tornadoes : These are more intense tropical cyclones, where the wind speed is between 300-500 kilometres per hour. These are mainly found on the Mississippi plains of the USA. They cover a very small area, i.e about 100 to 500 metres of diameter. Funnel-shaped thick ground to sky. It appears dark as bricks, sand and other material on the Earth is lifted in the funnel by the strong wind. Hence it causes maximum destruction.

2.5. CONCLUSIONS:

It is important to note that the differences in pressure caused by temperature differences due to variable factors give rise to the formation of different seasons. Hence throughout the year when it is harvesting in northern hemisphere, the southern hemisphere undertakes the sowing of seeds. This seasonal difference provides us with food crop and other agricultural products throughout the year.

2.6. QUESTIONS:

1. Define air pressure. Explain factors determining atmospheric pressure conditions on the earth.
2. Write a detailed note on distribution of pressure belts. Draw neat diagram.
3. How do land and sea breeze influence the pressure conditions?
4. Write a note on mountain winds.
5. How is a cyclone formed? Give different types of cyclone
6. Draw a neat diagram to represent Chinook wind.
7. Explain the following:

   a) Doldrum b) Ferrel’s law c) Tornadoes

References:

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5.https://www.google.co.in/search?q=diagram+for+winds+and+pressure+of+world&biw=1366&bih=655&tbm

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Unit - 3

HUMIDITY, CONDENSATION AND PRECIPITATION

Unit Structure :

3.0 Objectives
3.1 Introduction
3.2 Humidity
3.3 Condensation
3.4 Precipitation and its types
3.5 Precipitation and its distribution
3.6 Conclusions
3.7 Questions

3.0. OBJECTIVES:

- To understand humidity, its nature and its types.
- To study the methods used for measuring humidity.
- To know the process of condensation and its types.
- To understand the formation of clouds and its types.
- To study precipitation, its types and nature of distribution.

3.1 INTRODUCTION

The Earth is known as a Wet planet as 71% of it consists of water, which is essential for all forms of life. Water is available on the earth in various forms depending upon its location, position and time. The following diagram represents three stages of water.

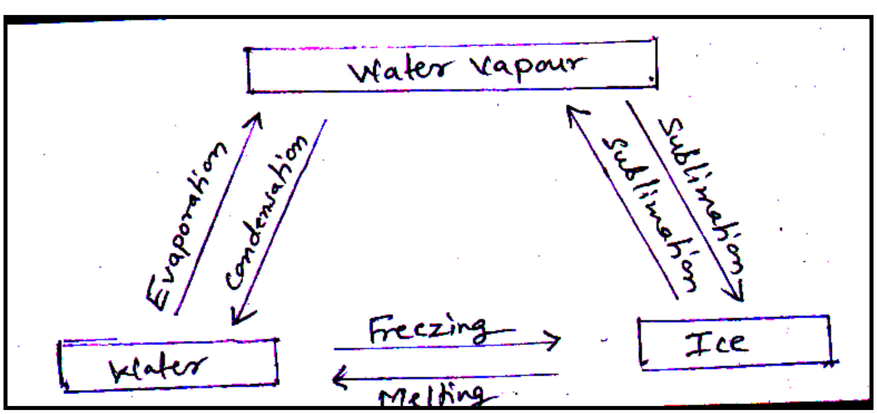


Figure:3.1.Three forms of water

Latent heat is required for the transformation of water from one stage to another. This heat is not recorded on thermometers. It is required for the change of state, e.g. when 80 calories (cal) of latent heat is given to ice, it melts and ice (solid) is converted into water (liquid). Similarly, evaporation requires latent heat of 560 calories. This heat is released into the atmosphere at the time of condensation which is termed as latent heat of condensation.

3.2. HUMIDITY

Humidity is the amount of water vapour present in the air. The proportion of water vapour in the air is not same everywhere. It varies from less than one percent to about 4 percent by volume. It is less in the arid regions and more in the humid regions.

Water vapour is invisible. It becomes visible when water vapour is converted into water droplets of ice crystal by condensation

- **Types of Humidity:**
  When air contains large amount of water vapour it is termed as humid or wet air. When the amount of water vapour present in the air is less it is termed as dry air. Humidity can be expressed in three ways. They are:

i) Absolute Humidity: It is the actual amount of water vapour present in the air. It is expressed in grams of water vapour per cubic meter of air. Absolute humidity varies with the expansion or contraction of air, due to change in temperature. It is a theoretical concept and is not much used in day-to-day measurements of humidity.

ii) Specific Humidity: It is the weight of water vapour per weight of a given mass of air. Specific humidity is usually expressed as grams of water vapour per kilogram of air. It is not affected by changes in temperature of air. It is maximum at the equator and minimum at the poles. It is more on the oceans than on land.

iii) Relative Humidity: Relative humidity is a ratio between the amount of water vapour actually present in the air-absolute humidity (AH) to the amount of water vapour that air can hold at the given temperature-saturation humidity (SH).

Relative humidity is expressed in percentage. $RH = \frac{AH}{SH} \times 100$

Where:

RH : Relative humidity

AH : Actual humidity, i.e. the amount of water vapour actually present in the air.
SH : Saturation humidity, i.e. the amount of water vapour that the air can absorb/hold at the given temperature.

The capacity of air to hold moisture changes according to the change in temperature. Air can absorb and hold more water vapour when the temperature of air is more. Air is contracted when temperature is less. Therefore, less amount of water vapour is absorbed in such air.

Relative Humidity		Type of Air
RH=20%	$\rightarrow$	Dry air
RH=80%	$\rightarrow$	Humid air
RH=100%	$\rightarrow$	Saturated air

Wet and dry bulb thermometers (psych-rometer or hygrometer) are used for the measurement of relative humidity.

- **Measurement of relative humidity**: **Wet and dry bulb thermometers** consist of two ordinary thermometers. The bulb of the wet bulb thermometer is kept permanently moistened by a piece of muslin (cloth) wrapped around it and an attached length of wick is dipped into a reservoir of water which is kept below this thermometer.

Evaporation of water takes place from the wet muslin which covers the wet bulb thermometers. Some amount of heat will be extracted from the wet bulb thermometer. Therefore, the wet bulb thermometer always records lower temperature than the dry bulb thermometer.

The rate of evaporation is related to the amount of water vapour present in the air. If the air is dry, there is a lot of space to accommodate water vapour. Hence,, the rate of evaporation is rapid. More heat is extracted from the wet bulb thermometer. Therefore, it records much lower temperature than the dry bulb thermometer.

Check Your Progress:

1. Define humidity.
2. Give different types of humidity.
3. How is humidity measured?

3.3. CONDENSATION

Condensation is the process through which water vapour change into liquid state and become tiny droplets of water or ice **Figure: 9.2.** This process is opposite to evaporation. In evaporation water turns into vapour (gaseous) form. Thus any further cooling of the saturated air starts the process of condensation. Temperature of air decreases with increase in height from the Earth's surface. The rate of decrease in temperature with increase in height is termed as **Lapse Rate** which is about 6.5^0C per kilometer. With decrease in temperature, the capacity of the air to hold moisture also decreases. As a result relative humidity increases. Air is said to be saturated when the relative humidity is 100 percent. At this stage the process of condensation, (conversion of water vapour into water droplets) begins. The temperature at which relative humidity becomes 100 percent and condensation begins is termed as Dew Point Temperature.

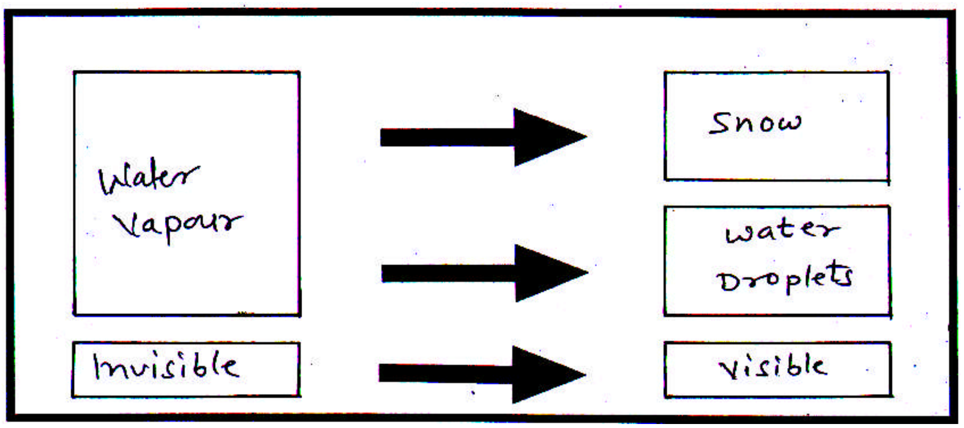


Figure: 3.2.Condensation

- **Process of Condensation:**

Condensation is a process in which water vapour is converted into water droplets or snow (ice crystals).Water vapour, which is in gaseous form in the air and is invisible, is converted into liquid – visible water droplets, if the temperature of the air is above 0^0C (i.e. freezing point). If the temperature of the air is less than 0^0C, i.e. less than freezing point, then the condensation is in solid form as ice crystal. Latent heat of about 560 calories is released during the process of condensation.

Condensation depends upon two factors –

a) Relative humidity of the air
b) Degree of cooling

a) **Relative humidity** of the air is less in desert region (where the air is dry). Hence, greater degree of cooling is required to start the process of condensation in these regions, where the air contains lot of water vapour. Hence lesser degree of cooling is sufficient to start the process of condensation.

b) **Condensation by degree of cooling** is a result of four distinct processes.

i) **Cooling by expansion** – Adiabatic process: The Earth's surface is heated due to solar radiation during daytime. Air near the Earth's surface is also heated. After sunset and during the night, the surface of the Earth cools down due to terrestrial radiation. As a result, the air near the surface of the Earth is also cooled. Due to the process of condensation, the water vapour present of condensation, the water vapour present in the air near the surface of the Earth is now converted (condensed) into dew (water droplets on grass blades and other low level vegetation) or into frost (small ice crystals).

ii) **Cooling of air when it comes in contact with cold surface of land or water**: Air mass is a huge mass of air having uniform characteristics, i.e., temperature and humidity. Condensation takes place when warm and cold air masses come in contact with each other (boundary between warm and cold air masses is known as front.) Condensation and precipitation take place at the front.

iii) Cooling of air due to direct outgoing radiation (Earth's radiation): Atmospheric pressure decreases with increase in height from sea level. In the diagram above at (A), the atmospheric pressure is more as compare to that at (B) and at (C). Imagine an air parcel moving in the upward direction from (A). This air parcel will expand or increase in size as it rises to (B) and (C) positions. Temperature of the air parcel will decrease due to the expansion of air. This type of change is termed as adiabatic temperature change. Air is attracted towards the Earth's surface due to the gravitational force. The weight of the air at sea level is 1013 mb, i.e. average atmospheric pressure.

A) Decrease in temperature due to increase in height:

In this case, the air parcel which is moving in the upward direction expands due to reduction in air pressure at higher elevation. Hence, the air parcel expands – molecules of air in air parcel move further apart and temperature of the air parcel decreases to 20^0C. This change in temperature due to reduction in pressure caused by an increase in the altitude is known as Adiabatic temperature change.

B) Increase in temperature due to decrease in height:

The temperature of air parcel in this case is 20^0C. This air parcel is moving in the downward direction towards the Earth's surface. The temperature of this air parcel will increase from 20^0C to 30^0C. This is mainly due to the increase in the outside pressure.

In the process of condensation water vapour needs some kind of a surface on which it may condense, e.g. dew is formed on vegetation at the ground level or on cooled metal objects.

At higher elevation such type of surface (and support) is provided by very small, microscopic particles which are termed as aerosols or condensation nuclei. These are added to the atmosphere through various sources as ocean spray-salt particles, dust, smoke, active volcano, fires, factories, etc.

Raindrops may grow up to 7mm (7000 microns) in diameter, while drizzle droplets are less than 0.5 mm in diameter. The hygroscopic particles are much smaller (< 1 micron). The cloud droplets vary in size from 2-3 microns to 20 microns.

Relative sizes of raindrop, drizzle droplet, fog droplets, cloud droplets and condensation nuclei (aerosol).These being very tiny, are practically weightless. Therefore, clouds can remain suspended in the air.

- **Forms of Condensation**

Condensation can be in liquid form (water droplets), or in solid form (ice crystals) depending on temperature of the air **Figure 9.3.**

i) **Liquid forms of condensation :** (temp >0^0C) – dew, fog, mist and clouds.
ii) **Solid forms of condensation :** (temp <0^0C) – frost, rime and clouds.

Forms of condensation can also be classified according to their place of formation:

i) On the ground : Dew and frost.
ii) Near the ground : Mist, fog and rime.
iii) At higher elevation : Clouds.

i) On the Ground:

a) Dew: It is a liquid form of condensation formed on the ground, on grass blades, etc. It is formed early in the morning before sunrise when the temperature of the Earth's surface and the air near the surface is the lowest. Dew is mostly found in the areas having temperature more than 0^0 centigrade. The conditions necessary for the formation of dew are:

- Sky without cloud cover.
- Calm weather.
- Presence of sufficient amount of water vapour in the air.

Dew is very useful for plants. Desert areas have very less humidity in the air, the plants depend on dew for water.

b) Frost: It is a type of condensation, at the ground level. It results in the formation of solid ice crystals. Weather conditions required for the formation of frost are same as those for dew, except that the temperature is below freezing point. At the time of condensation, if the temperature of air is below freezing point, water vapour is directly converted from gaseous state (water vapour) to solid state (ice crystals). Hence, frost should not be termed as frozen dew.

Valleys are the ideal locations for the formation of frost. During right-time cold and heavy air accumulates in such locations. (This air displaces warm air at the valley bottom and thus causes the inversion of temperature). Hence, valley floors or bottoms are affected by frost but the sides of valley remain unaffected. Therefore, human settlements are located at these areas and not at the valley bottom.

Frost is harmful to plants. Protection against frost is a great challenge to horticulturists in some of the temperate belt countries of the world. Various heat conservation methods are used for the protection of plants, e.g. covering the plants with paper or cloth.

ii) Near the Ground

a) Mist and Fog: These are formed near the ground. They are the forms of condensation in which minute droplets of water remain suspended in the air. Mist and fog both reduce visibility. If the horizontal visibility is up to 2 km, it is termed as mist. But if the horizontal visibility is only up to 1km, it is termed as fog. Fog is denser than mist. Therefore visibility is reduced in the case of fog. Based on the visibility there are various types of fog. For example, moderate fog, thick fog, dense fog, very dense fog, killing fog etc.

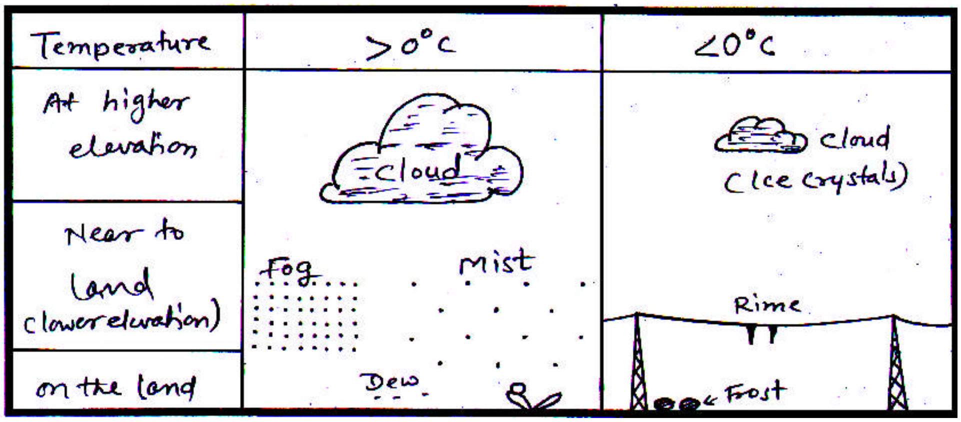


Figure 3.3. Types of Condensation

c) Smog : Combination of smoke and fog is termed as smog (smog is also termed as pea-soup fog) which is more dense and dangerous. Since smog includes pollutants, smoke, etc. people suffering from chest problems such as asthama, bronchitis, etc. are more affected by smog. Visibility is greatly reduced during dense fog and smog. Therefore it is hazardous for traffic. In temperate belts, solar rays are slant and in winter days are shorter than the nights. The presence of excessive smoke near the ground during smog obstructs the solar radiation from reaching the Earth's surface. Therefore the Earth's surface is not much heated. As a result a smog prevails for several days.

A combination of smoke and haze is termed as Smaze.

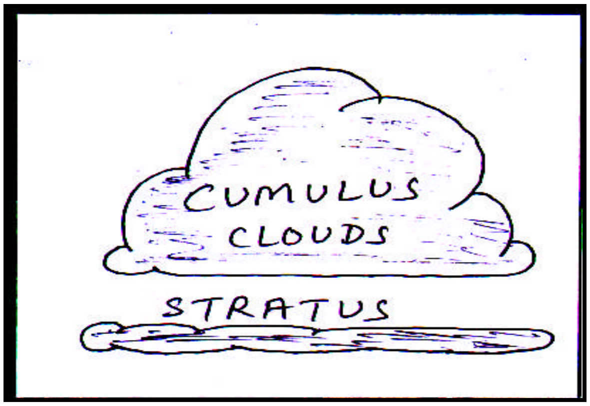
d) Haze is a mass of very small solid particles of dust, smoke, etc., due to which the visibility is reduced to below 2km, and up to a minimum distance of 1 km.

Check Your Progress:

1. What is condensation?
2. What are the processes involved in condensation?
3. Give different forms of condensation.

iii) Clouds:

Clouds are a condensation at the upper level. Clouds are composed of tiny water droplets or ice crystals. Clouds are basically classified according to their shapes. Two main shapes of clouds are (a) cumulus and (b) stratus **(Figurer 9.4).**



Figurer: 3.4. Types of Clouds

World Meteorological Organisation (WMO) has classified clouds into following 10 types **as per their occurrence at specific heights. Figure: 9.5.**:

a) Upper level clouds (about 6 km.)

i) **Cirrus clouds :** These upper level clouds have fibrous appearance and are white in colour.

ii) **Cirrocumulus :** These are in the form of thick white patches, made up of small ripples.

iii) **Cirrostratus :** Transparent, whitish clouds with hair-like smooth appearance. They cover large portions of the sky and produce halo effects.

b) Middle level clouds (approx. 4 km.)

i) Altocumulus : They are white or grey rolls or rounded masses of clouds.

ii) Altostratus : Greyish or bluish clouds in the form of sheets, or layers. They cause precipitation.

c) Low level clouds (below 2 km.)

i) Cumulus : Dense with sharp outlines, developing vertically in the form of rising mounds or domes. The bulging upper parts of these coloudss resemble cauliflower.

ii) Stratus : it is a low, grey cloud cover. This layer may produce drizzle or snow.

iii) Stratocumulus : These are low, whitish or grey clouds with dark patches.

iv) Cumulonimbus : Cloud with great vertical extent, in the form of a huge tower. Upper part spreads in the shape of an anvil dome **(Figure 9.5)**. These clouds are associated with heavy rain, thunder, lightning, hail and tornadoes.

v) **Nimbostratus :** These are low level clouds associated with rain, snow or sleet. Streaks of rain or snow falling from these clouds but not reaching the ground are called 'Virga'.

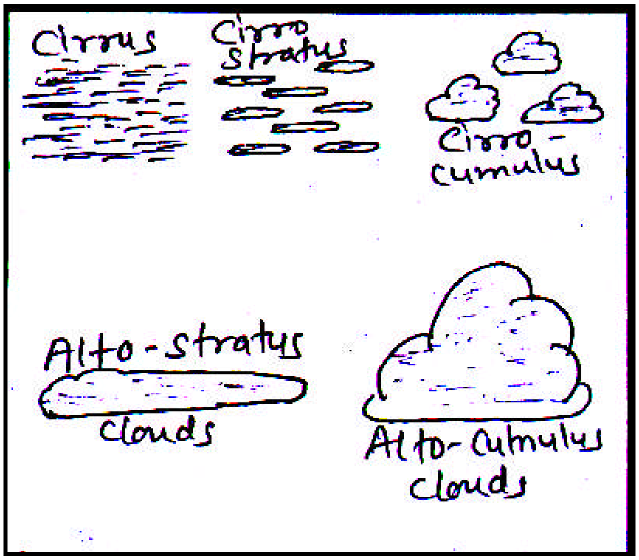


Figure: 3.5. Types of Clouds at higher elevation

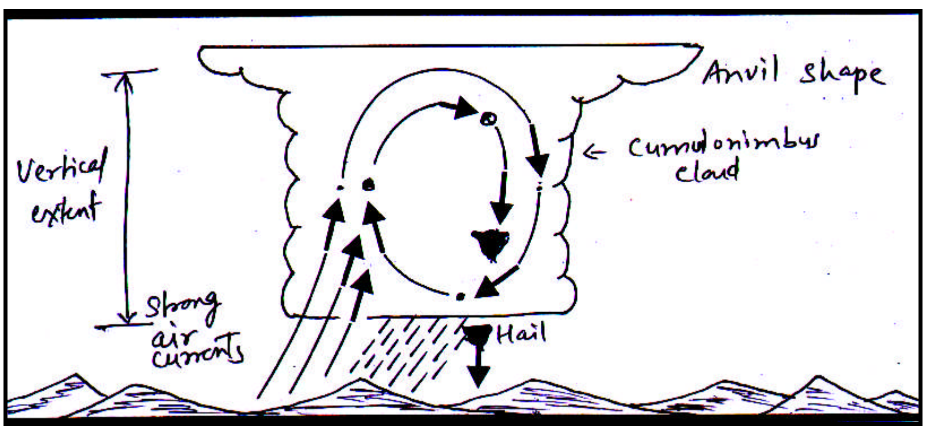


Figure: 3.5.1. Cumulonimbus Clouds

Check Your Progress:

1. What are clouds?
2. Mention different types of clouds.

3.4. PRECIPITATION:

- **Process of Precipitation**

If you are doing some chemical reaction in a test tube and tiny particles are formed around it during the process of this reaction, these particles will slowly move in the downward direction and settle at the bottom of the test tube. This deposition of tiny particles in the test tube is known as precipitate.

The term precipitation is used for the deposition of water in either liquid (e.g. drizzle, rain) or solid (e.g. snow, hail) form, which reach the Earth from the atmosphere.

- **Forms of Precipitation**

Precipitation can be in liquid or in solid form or a combination of both. Major types of precipitation are as follows **(Figure 9.6.) :**

i) Drizzle: It is a liquid form of precipitation. The size of the water droplets in drizzle is very small (less than 500 micro-metres). It is often associated with fog.

ii) Rainfall: It is a liquid form of precipitation. The size of raindrops is larger than the drizzle droplets. The size varies from 200 microns to up to 7000 microns. Millions of cloud droplets are required to form one single raindrop. For example, a raindrop of 3 millimetres in diameter contains 27 million cloud droplets of 10 micron diameter.

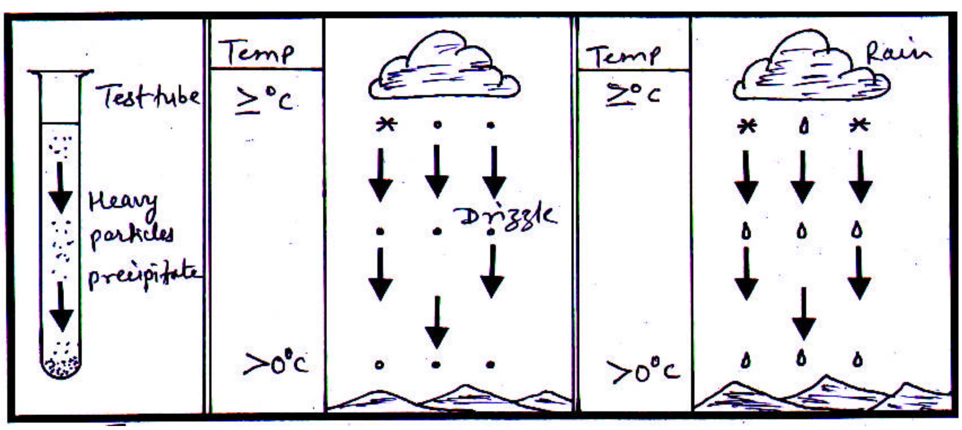


Figure: 3.6. Drizzle and rainfall

iv) Sleet: Sleet is a mixture of rainfall and snowfall. If the temperature of the upper air is less than freezing point (<0^0C) then the condensation will be in the form of ice crystals. Some ice crystals will be large and some will be small. If the temperature of the air at the ground level is more than 0^0C then these ice crystals will melt while coming down towards the Earth's surface. Small ice crystals will melt completely and will be converted into water droplets and large ice crystals will partly melt, but will remain as smaller ice crystals. Hence, the precipitation will be a combination of rainfall and snowfall which is termed as sleet.

v) Snowfall: In the case of snowfall temperature at the ground level and upper level is less than freezing point ($<0^0$C).

vi) Hail: Hail or hailstones are small balls of ice having diameter ranging from 5 to 40 mm. Hailstones consist of concentric layers of ice alternating with layers of snow (like onions). Hail is normally associated with cumulonimbus clouds. Due to strong vertical air currents the raindrops are taken at higher elevation where they freeze and are converted into ice crystals. These ice crystals come down due to the Earth's gravitational force, but again they are trapped in the strong vertical air currents and move in the upward direction. More ice crystals and water droplets are added to original ice crystals. As a result, the size of the original ice crystals increases. Ultimately, it falls on the Earth's surface as hailstones. Hailstones are very destructive. They can destroy crops. They are also dangerous for aircraft.

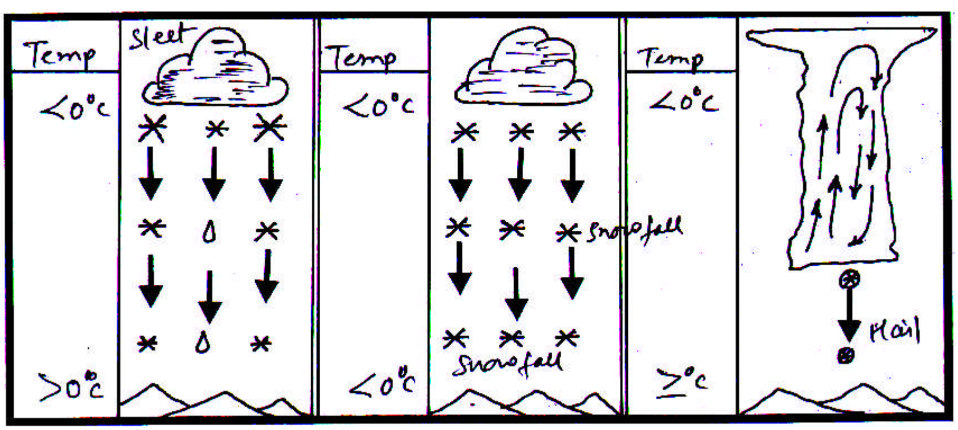


Figure: 3.7. Sleet, Snowfall and Hail

- **Types of Rainfall**

The upward-rising air becomes cool. Its relative humidity increases, and condensation begins, leading to cloud formation and subsequent rainfall. Types of rainfall are based on the method by which air is uplifted. Types of rainfall are as follows:

i) Convectional rainfall.
ii) Relief or Orographic rainfall.
iii) Cyclonic rainfall or Frontal rainfall.

i) Convectional Rainfall: This type of rainfall is experienced in the equatorial region. Air near the equatorial region is heated more due to high intensity solar radiation. It expands, becomes lighter and moves in the upward direction in the form of convectional currents.

The rising air cools down. Relative humidity increases and condensation begins. Clouds are formed and every day at about 4.00 p.m. the equatorial regions get convectional type of rainfall **Figure:3.8**. Hence, it is said that there are no seasons in the equatorial region.

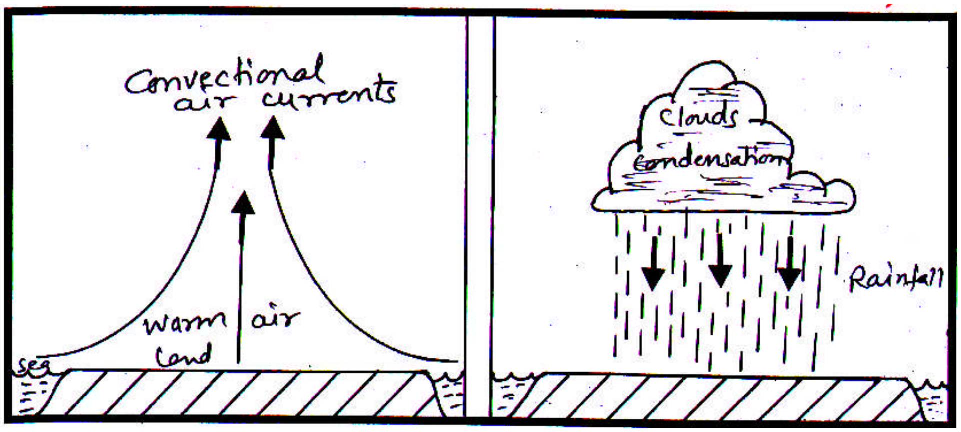


Figure: 3.8.Convectional rainfall

ii) Relief or Orographic Rainfall: In this case, wind is obstructed by mountain ranges and is forced to rise up. As the air rises upward, it cools, relative humidity reaches 100 percent (air is saturated) and condensation begins. This cause the formation of clouds. They provide rainfall to the windward side of the mountain slope. Western side of the Western Ghat, i.e. Konkan coast, receives this type of rainfall. As in this rainfall air is lifted due to the obstruction caused by the Western Ghats, it is termed as Orographic ('Oro' means mountains) rainfall or Relief rainfall **Figure: 3.9**.

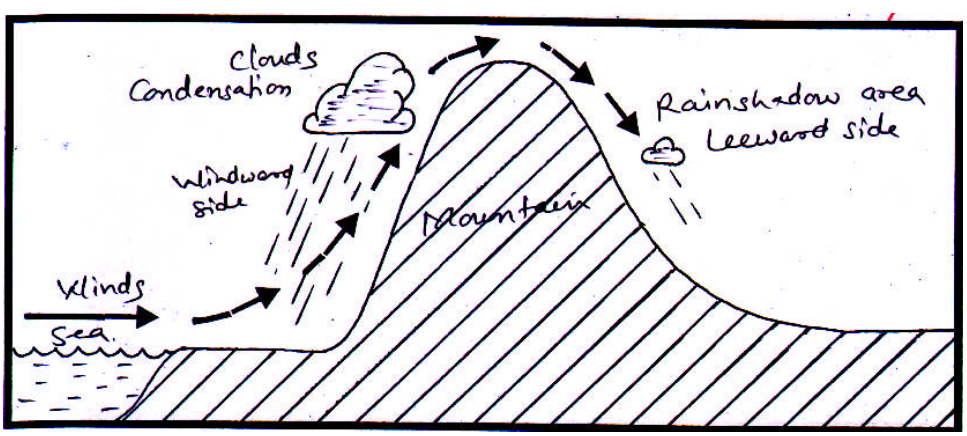


Figure: 3.9. **Orographic/Relief Rainfall**

When rain-bearing winds cross the mountain ranges, they become warm and expand. Hence they are able to absorb more water vapour. So the clouds coming towards this region are not able to give rainfall or very less amount of rainfall is received in the leeward side of the mountains. Therefore it is termed as the **rain-shadow zone.**

Konkan coast, north-eastern part of India, Southern slopes of Himalayas, East China, South-East United States and East Brazil receive orographic type of rainfall.

iii) Cyclonic Rainfall or Frontal Rainfall: Tropical cyclones develop in the tropical region. Due to cyclonic activity, air is lifted up with a great force. Condensation takes place due to cooling. As a result clouds are formed. The region gets heavy rainfall, but it lasts only for a few hours **Figure 3.10**.

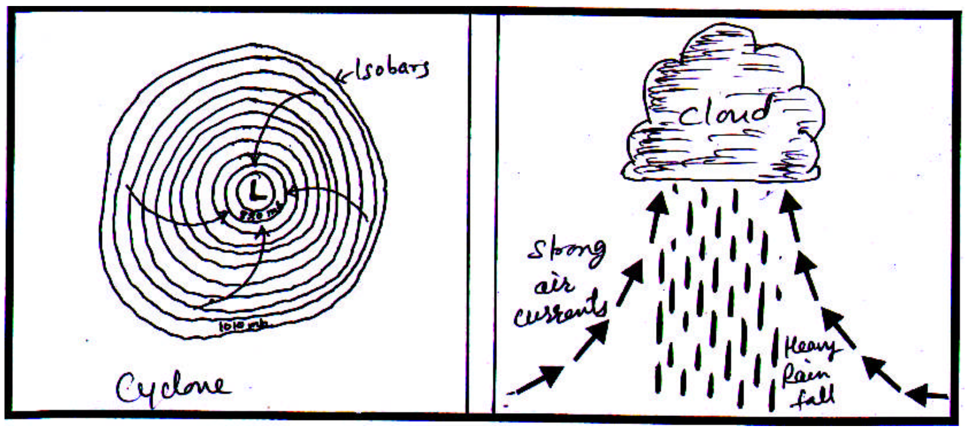


Figure: 3.10 Tropical Cyclone

On the other hand, frontal rainfall is experienced in the temperate regions due to the development of fronts. They are formed due to the merging of air masses having different characteristics. Air mass is a huge quantity of air with respect to temperature and humidity conditions. Thus, when two air masses having different characteristics (cold and warm) move towards each other, they do not mix instantly as their properties are different. The warm air mass being lighter and less dense rides over the dense cold air mass. Thus a zone of separation develops as a front. Warm air uplifted along the front cools and clouds are formed along the front. As a result, the region gets rainfall. This rainfall is in the form of drizzle and covers larger areas. This type of rainfall may last for many days. **Figure: 3.11**

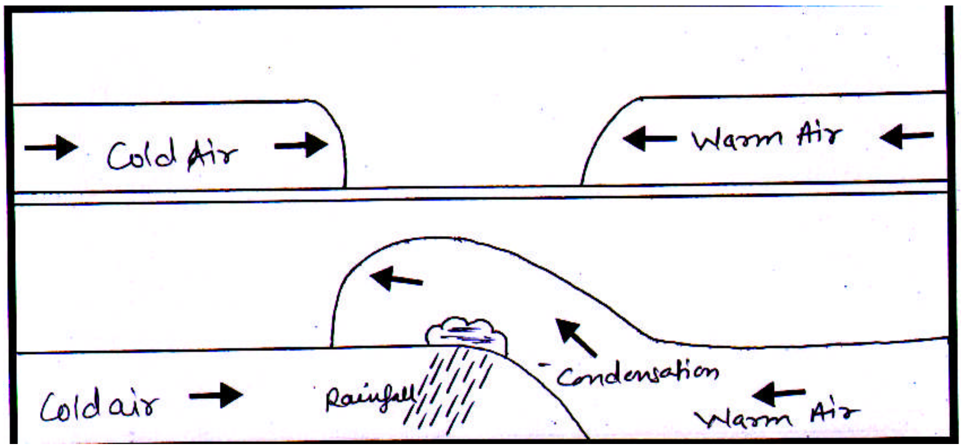


Figure: 3.11. Temperate Cyclone

- **Thunderstorm**

Thunderstorms are different from cyclones. In the case of a cyclone wind rotates around the centre but in a thunderstorm, the wind does not rotate. Thunderstorms are associated with strong upward moving air current, cumulonimbus clouds, lightning and thunder with heavy rainfall. They are sometimes termed as cloudburst.

Due to intense heating of the Earth's surface very strong and hot convectional currents are generated. Cumulonimbus clouds are formed having great vertical extent. Development of static electricity (i.e. positive and negatively charged particles) causes flashes of lightning and thunder is produced by the expansion of air due to the tremendous heat of the lightning flashes. Thunderstorms are also associated with hailstones.

3.5. DISTRIBUTION OF RAINFALL

Distribution of rainfall on the Earth is not even all over. Some regions receive rainfall throughout the year while some regions receive it either in summer or in winter. Various factors influence amount of rainfall received by a region. These are location, nature of relief, amount of vegetation etc. Distribution of rain amount is as follows :

a) Rainfall throughout the year: Equatorial region and areas of Western Europe, influenced by westerlies, get rainfall throughout the year. Rainfall in the equatorial region is heavy.

b) Summer Rainfall: The savanna region (continental interiors) and tropical monsoon regions receive rainfall during summer. Tropical monsoon regions in India receive heavy rainfall during summer due to sough-west monsoon winds. Due to the apparent change in the direction of vertical sunrays, southern part of India also receives rainfall from north-east monsoon winds during winter.

c) Winter Rainfall: The Mediterranean region is the region which gets rainfall only in winter. Due to southward shifting of pressure and wind belts, this region is under the influence of westerlies during winter. Therefore, it gets rainfall in winter.

Distribution of Rainfall in the World:

S.N.	Nature of Rain	Rainfall amount in cm	Region
I	Regions of Heavy Rainfall	>200	i) Equatorial ii) Monsoon iii) West Coast of Europe and North America
II	Regions of Moderate Rainfall	200-25	i) South-East Asia ii) East China iii) East Brazil
III	Regions of Scanty Rainfall	< 25	i) Tropical hot deserts, e.g. Sahara. ii) Mid-latitude deserts, e.g. Gobi, Australian desert, etc. iii) Polar region, i.e. cold deserts such as Antarctica

Check Your Progress:

1. Define precipitation.
2. What are the processes involved in precipitation?
3. Give different forms of precipitation.
4. Why rainfall is not evenly distributed in the world?
4. Explain the following:

i) Equatorial rain   ii) Summer rain   iii) Winter rain

3.6. CONCLUSION:

The amount or precipitation in different forms that provides fresh water supply to a region is governed by various processes of humidity formation, its condensation and precipitation over the period of time. This is determined by its absolute and relative location, the nature of relief, amount of vegetal amount etc. Interference in this natural mechanism invites natural disasters in the form of floods or droughts, cyclones etc.

3.7. QUESTIONS:

1. Define humidity. How do we measure different types of humidity?
2. Define Condensation. Explain the processes and forms of condensation.
3. What are clouds? Give a classification of clouds.
4. What is precipitation? Why do we get variation the type of precipitation?

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Unit - 4

OCEAN RELIEF FEATURES AND SALINITY OF SEA WATER

Unit Structure:

4.1 OBJECTIVES

- To study the morphology of ocean.
- To study the distribution of relief features in Pacific Ocean.
- To study the salinity of sea water.
- To understand the factors responsible for variation in salinity of sea water.
- To study the distribution of salinity of sea water in the world.

4.2. INTRODUCTION TO OCEAN MORPHOLOGY:

The configuration of the ocean basin with reference to their nature and various dimensions is known as morphology of oceans. Different marine provinces form the basis for identification of various relief zones of ocean basins. Oceans cover approximately 65.7% (335 million square kilometers) of Earth's surface. Like the land surface, the ocean bottoms represent various kinds of marine features, i.e. plain, plateau, ridge, deep etc. The knowledge about the relief of ocean floors was very limited in the past centuries but the development of sound recording machine enabled the oceanographers to get more knowledge about the dept and topography of the ocean bottoms.

4.3. OCEAN MORPHOLOGY:

A hypsometric **curve** is essentially a graph that shows the proportion of land area that exists at various elevations by plotting relative area against relative height. The **hypsographic curve** is a scientific way of describing the topography of the seafloor.

After the study of hypsographic curve, the ocean and sea bottoms may be demarcated into various relief or depth zones as given below:

i. Continental shelves
ii. Continental slopes
iii. Abyssal or deep sea plains
iv. Ocean deeps

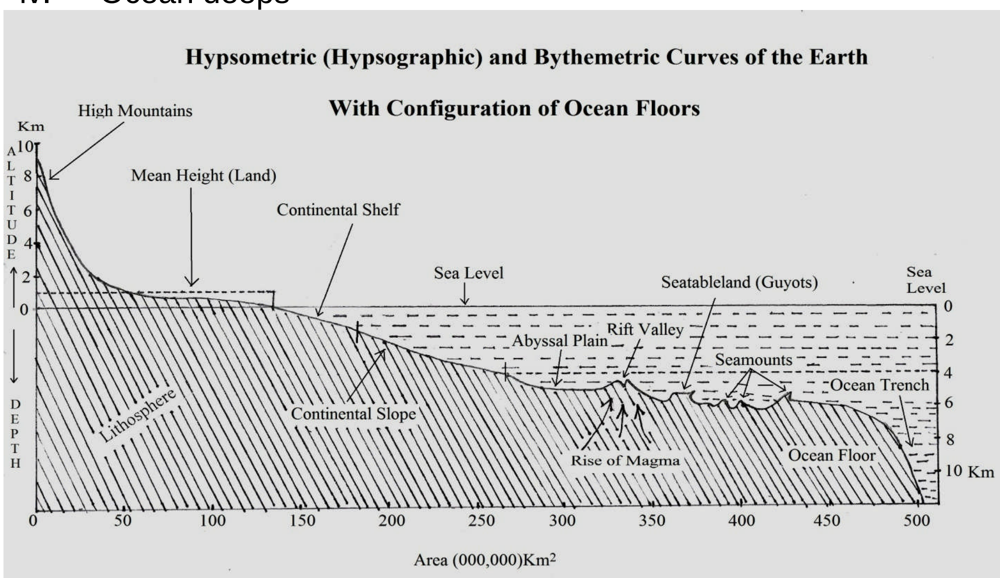

Figure4.1: Hypsographic Curve: A Schematic Representation of the Ocean Floor

i) Continental Shelves:

Continental shelves represent the shallow part, of the ocean and seas. It extends between low tide level and 100 fathoms depth of the sea water. It is almost uniform zone of sea bed with a gentle gradient. The width of the continental shelves varies from coast to coast depending upon the geographical structure and geomorphological nature of the coast. The average width of continental shelves is about 70 km.

The continental shelves are formed by erosion of coastal area by sea waves. Some continental shelves have been formed by deposition of sediments in the sea brought by the rivers. According to some views, the continental shelves were formed due to change in the sea level or subsidence of coastal land by tectonic movement. The formation of continental shelves is also thought due to emergence of the ocean and sea bottom.

The continental shelves have been grouped in following types on the basis of their formation and location. a) Glaciated shelf, b) Coral reef shelf, c) Riverine shelf, and d) mountainous shelf.

Importance of Continental Shelves:

a) Marine life is abundant due to availability of sunshine. Sunrays penetrate to the depth of the shelf and various kinds of grass, seaweeds and planktons are available. They are used as food for marine animals.
b) Various kinds of minerals like petroleum, natural gas are also found in shelf area.

ii) Continental Slope:

Continental slope is the next depth zone of ocean and sea floor to the continental shelf. It begins with outer edge of the shelf where the gradient of slope becomes steeper abruptly. The average slope of this zone is 4 degree but it varies from place to place. This zone is free from the deposits due to steep slope and about 60 per cent of sediments of continental slope are mud and the rest is composed of sands, gravels and organic remains. It covers smaller area of the oceans and seas. There are five types of slopes :

a) Fairly steep slope dissected by canyons,
b) Gentle slopes with elongated hills and basins,
c) Faulted slopes,
d) Slopes with terraces, and
e) Slopes with seamounts.

The origin of continental slope is still not known, although some may be as the result of large scale earth movement called Plate tectonic. It does not always extend up to deep sea but interrupted by wedge of deposited sediments. The deep waters of the **continental slopes** are very ideal for catching deep-living Rockfishes, Thorny heads, Sable fishes and Dover Sole. Generally, these species are caught as a group.

iii) Abyssal Plain or Deep Sea Plain

Beyond the continental slope a broad and featureless deeper part of the ocean is found. This deep plain is known as Abyssal Plain or Deep Sea Plain. It is found between 2000 to 6000 meters depth. Gradient of slope is very gentle and it appears as uniform flat plain without any relief. Moreover, the deep sea plain is formed by deposition of sediments of especially marine origin. The abyssal plain exerts significant influence upon ocean carbon cycling, dissolution of calcium carbonate and atmospheric CO_2

concentrations over timescales of 100–1000 years. The structure and function of abyssal ecosystems are strongly influenced by the rate of flux of food to the seafloor and the composition of the material that settles.

iv) Ocean Deeps

On the ocean bottom a large number of narrow elongated deep depressions have been recorded by the sound recorder device. Their depth is rather greater than the abyssal plain and some of them reach up to more than 9 kms below sea level. The peculiarity of the distribution of ocean deeps is that they do not occur amidst the ocean bottom but along the coast parallel to the fold mountain. Most of the heat from global warming is absorbed by the oceans as it covers 70% of the Earth's surface and therefore has a capacity to absorb heat a thousand times more than the atmosphere. Oceans are thus the main heat sinks of the earth.
Besides above discussed major relief of the ocean bottoms submarines canyons, submarine ridges, abyssal hills, seamount, guy outs and atolls are also are commonly found in the oceans.

v) Submarine Canyons

A long narrow depression is commonly found on the continental shelves and slopes. These depressions are called as Submarine Canyons. They are usually perpendicular to the coast. Their profiles resemble V-shaped valley with concave rock wall. There are three groups of canyons on the basis of their location and appearance: (1) submarine canyons which begin from continental shelves and extend to the slopes, (2) canyons, which are found at the mouth of the rivers and extend up to continental slopes, and (3) dendritic canyons which are cut down in many branches.

Submarine canyons are diverse and complex in terms of their origins, hydrography, geologic settings and biodiversity of marine reserves in many locations because of their association with higher biomass and biodiversity.

vi) Abyssal Hills, Seamount and Guyot

Some isolated hills on the bottom of the seas and oceans are called Abyssal Hills. The abyssal hills attaining height of more than 1000mt are called Seamounts. Broad and flat topped seamounts are called Guyots. Atolls, concentric coral reefs and deep wide lagoon are common features in any ocean.

vii) Submarine Ridges

Like mountain chains on land, a long continuous chain of mountains also spread out in the mid of the oceans. They form the longest series of mountains on the earth.

4.4 BOTTOM RELIEF FEATURES OF THE PACIFIC OCEAN

Pacific Ocean is the largest and the deepest ocean of the world. It extends from the Antarctic region in the south to the Arctic in the north and lying between the continents of Asia and Australia on the west and North and South America on the east.

Pacific Ocean, like the rest of the world's oceans, was formed millions of years ago and has a unique topography. It also plays a significant role in weather patterns around the globe and in today's economy.

The Pacific Ocean has a highly varied topography. Oceanic ridges are found in a few places in the Pacific Ocean and they are the areas where new oceanic crust is being pushed up from below the Earth's surface. The Explorer Ridge lies at the northern extremity of the Pacific Ocean. The Jaun de Fuca lies west of Vancouver.

Continental shelves cover rather less area while the deep sea plain occupies largest area of ocean bottom. The depth of the sea plains is also greater than that of sea plains in other oceans.

This ocean is associated with a large number of abyssal hills, sea mounts, guyots, and plateaus like Albatross near western coast of South America. An abyssal hill is a small hill that rises from the floor of an abyssal plain. The greatest abundance of abyssal hills occurs on the floor of the Pacific Ocean. These Pacific Ocean hills are typically 50–300 m in height, with a width of 2–5 km and a length of 10–20 km. They may be created along the flanks of the East Pacific Rise as horsts and graben features, and then become stretched out with the passage of time. Nearly half of the world's seamounts are found in the Pacific Ocean, and the rest are distributed mostly across the Atlantic and Indian oceans. Guyots are flat-topped seamounts. Thousands of guyots, often in chains and clusters, are spotted across the Western Pacific Ocean, especially between the Hawaiian Islands and Japan.

Pacific Ocean is basically known for the island arcs and ocean deeps or trenches. Out of 52 known ocean deeps, 32 are found in this ocean. The Pacific is home to the deepest ocean point in the world - the Challenger Deep in the Mariana Trench. This trench is located in the western Pacific to the east of the Mariana Islands and it reaches a maximum depth of 35,840 feet. Kurile Trench, Tonga Trench, Aleutian Trench, Japan Trench, Tuscarora Deep, etc are the other important ocean deeps in this ocean. This ocean is exceptionally free from the submarine ridges. The concentration of large number of deeps and island arcs from Aleutian island to New Zealand through Japan is attributed to the subduction of oceanic plate beneath the Asiatic continental plate along the margin of convergence in Pacific Ocean. The northern Pacific Ocean (and also the northern hemisphere) also has more land in it than the South Pacific. There are many island chains and small islands throughout the ocean. The largest island within the Pacific is the island of New Guinea. Volcanic eruption and earthquakes are very common phenomena in this ocean.

The characteristic features of this ocean are the feeble development of continental shelves, absence of any continuous middle dividing rise and abundance of deeps and trenches.

Check your progress:

1. What do you understand by morphology of ocean?
2. With the help of hypsographic curve explain different relief features of ocean basin.
3. Explain with examples various relief features found in the Pacific Ocean.

SALINITY OF SEA WATER

4.5 INTRODUCTION TO SALINITY OF OCEAN:

Salinity is defined as "the ratio between the weight of the dissolved materials and the weight of the sample sea water". Salinity is expressed as gram percentage (%). Salinity can be measured using a Handled Refract meter, Hydrometer or Conductivity Meter. Salinity of the oceans and seas vary in open seas. Usually where there is free mixing of fresh water, the proportion of salinity remains constant, but where free mixing is absent, variation is seen. The average salinity of the sea water is 34.5%. The total amount of salt in sea water is gradually increasing every year. This is because it is brought from the land every year. Ditmar, during his Challenger Expedition in 1844, reported the existence of 47 types of salts in sea water.

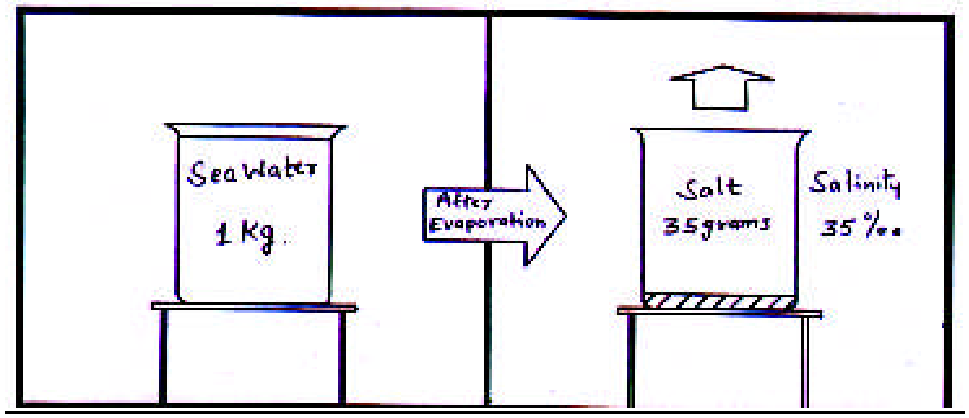

Figure 4.2: Salinity

a) <u>Sources of Salinity:</u>

i) In areas where temperature is high evaporation will be greater leading to lower dilution of salt. Together with high temperature if humidity is also low then salinity will be high.

ii) Secondly, if fresh water is continuously added in the form of precipitation, rivers or icebergs, then salinity will not be high.

b) <u>Factors Controlling Salinity in an Ocean</u>

i) Rate of Evaporation:

There is direct positive relationship between the rates of evaporation and salinity. Greater the rate of evaporation higher is the salinity. The sub-tropical region has highest salinity. Here the sky is clear for more periods in a year, land is relatively more in this latitudinal belt, and sources of fresh water supply are relatively low. All this contributes towards higher rates of evaporation and so more salinity in the sea water.

ii) Precipitation:

Higher the precipitation lower the salinity, lower the precipitation, higher the salinity. This is the reason why the regions of high rainfall are associated with comparatively lower salinity than the regions of low rainfall.

iii) Influence of river water:

Though the rivers bring salt from the land to the ocean, big and voluminous river pours down immense volume of fresh water into the seas and so the salinity is reduced at their months. For example: - comparatively low salinity is found near of mouth of the Ganga, the Congo, the Nile, the Amazon, St. Lawrence etc. The influence of river water is more pronounced in the unclosed seas. For example: - the Danube river reduces the salinity in Black Sea [18%].

iv) Atmospheric Pressure & Wind Direction:

Anticyclone conditions with stable air and high temperature increases salinity of the surface water of the oceans. Sub-tropical High Pressure Belt represents such conditions to cause high salinity. Wind also helps in the redistribution of the salt in the oceans and seas as winds drive away saline water to less saline areas resulting into a decrease of salinity in the former and increase in latter.

v) Circulation of Ocean Water:

Ocean current affects the spatial distribution of salinity by mixing sea water.

4.6 WORLD DISTRIBUTION OF SALINITY

The latitudinal distribution shows that there is a low salinity at the equator ranging from 34 to 35.5% because of high rainfall and the large number of days with overcast sky. The region between 20-40 degrees N and 10-30 degrees S are the region of high salinity due to large number of cloudless days, which increase heat and promotes evaporation. Sargasso Sea (37%) S. E. Brazil (37%) Western Australia (36%) and near Peru-Chile (36.5%) are the high salinity zones.

After obtaining maximum in the lower middle latitudes salinity again decreases to 31% in the northern hemisphere and 33% in southern hemisphere that is (40 – 60 degrees N and S). Further pole ward salinity decreases due to the melting of ice. The average salinity for northern hemisphere is 34% while in South it is 35%. This is attributed to the fact that in the south a comparative less of mixing and less addition of fresh water takes place and there is absence of land.

Salinity either decreases or increases with depth according to that nature of water mass. Generally there is a decrease with increase of depth. At the equatorial region of Indian Ocean salinity increase with depth (34% to 35%) At the southern boundary of the Atlantic surface salinity is 33% increasing to 34.5% and still deeper it reaches up to 34.8%. Generally it can be said that in high latitude salinity increases with depth due to denser water mass found at the bottom.

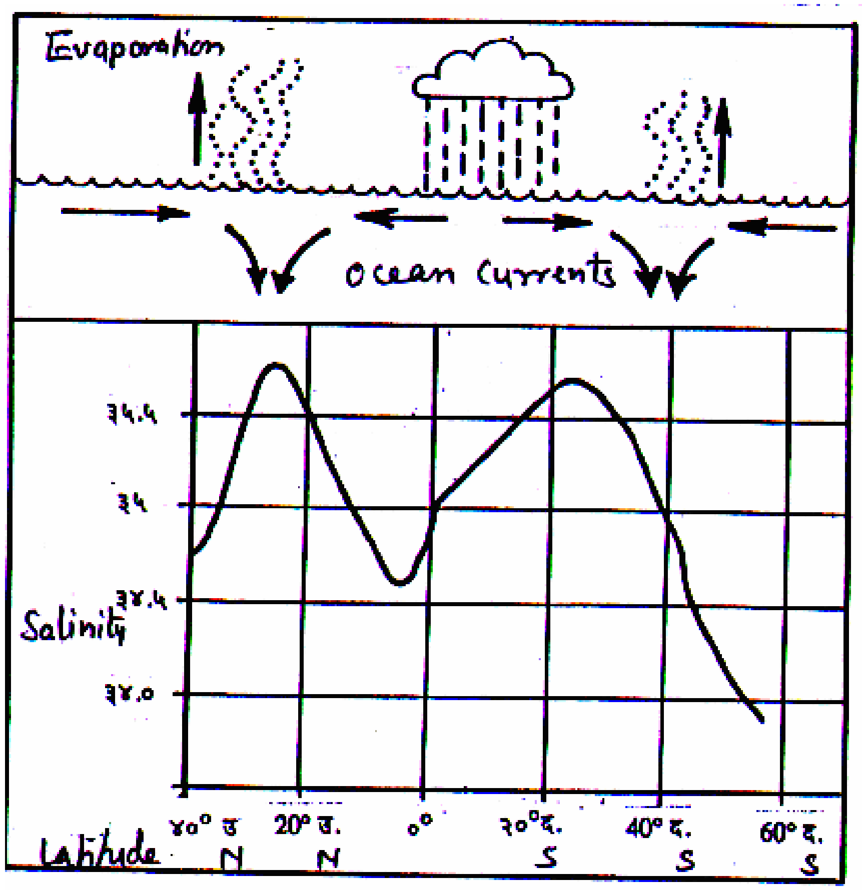

Figure: 4.3. Distribution of Salinity in the World

Check your progress:

1. Define salinity of sea water. Examine the factors influencing salinity of sea water.
2. Account for the differences in the distribution of salinity sea water in the world.

4.7 CONCLUSIONS:

The study of ocean morphology has helped to understand the types of submarine relief features in the ocean basin**.** The relative importance of different oceanic relief features provide with different types of resources required either for bio-geo-chemical cycle functioning or directly as resources in the form of marine organisms, minerals and fossil fuels. The temperature balance of the earth is largely maintained by the oceanic surface as it absorbs huge amount of global heat.

Salinity of oceanic water is governed by different factors. Differences in salinity provides different of bio-reserves in oceanic waters besides deriving salts from sea water.

4.8 QUESTIONS:

1. What do you understand by morphology of ocean?
2. Explain the importance of ocean morphology.
3. Examine the distribution and location of bottom relief features of Pacific Ocean.
4. 'Salinity of sea-water varies in different areas'. Explain giving reasons.
5. Account for the distribution of salinity of sea water in the world.

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Unit - 5

TIDES AND OCEAN CURRENTS: CAUSES, TYPES AND EFFECTS

Unit Structure:

5.0. OBJECTIVES:

- To study the origin and different types of tides.
- To understand the significance of tides.
- Understanding of origin of ocean currents.
- To study the factors responsible for formation of ocean currents
- To study the distribution of different types of ocean currents of Atlantic Ocean.
- To study the effects of ocean currents on the atmosphere and human activities.

5.1. INTRODUCTION:

The sea water rises regularly twice a day at regular intervals. This periodic phenomenon of alternate rise and fall in the level of the seas is known as tides. Tides are produced as a gravitational interaction of the earth, moon and the sun. The nature and magnitude of tides vary from place to place **figure 5.1.**

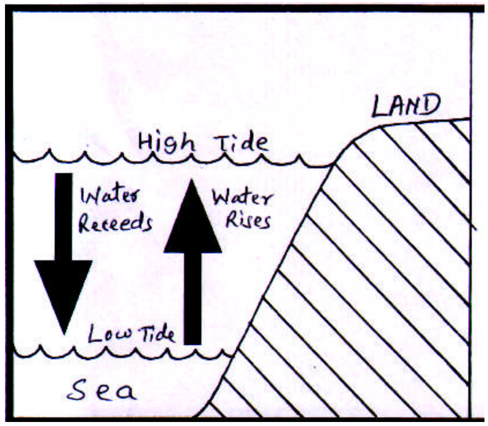

Figure5.1. High and Low Tides

5.2 TIDES – ORIGIN, TYPES AND SIGNIFICANCE OF TIDES:

a) **Origin of tides**: Origin of tides is due to the gravitational force exerted by the moon, the sun and the earth. As the position of the moon in the planetary system is close to the earth than the sun, the gravitational pull exerted by the moon is therefore twice as strong as that of the sun. Whereas the sun though bigger in size in at greater distance from the earth hence its influence is relatively less. The magnitude of the tides therefore is determined by the position of the moon in relation to the earth **figure 5.2.**

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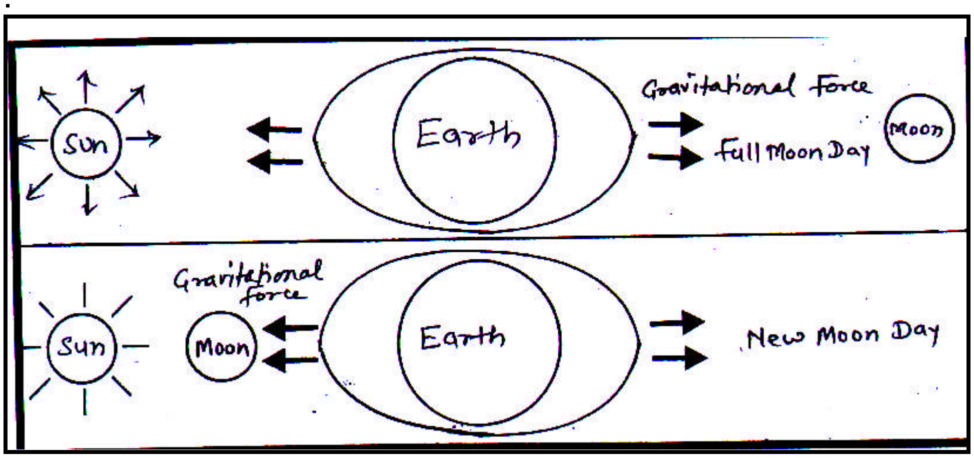

Figure:5.2. High and low tide with reference to position of moon.

b) **Following are different types of tides:** These tides are determined by the position of the moon, the sun and the earth with reference to the rotation and revolution of the earth and the moon around itself and the sun respectively.

Spring Tide: Highest tides known as **'Spring Tide'** occur on two days in a month i.e. on full moon and new moon days, i.e. when the moon, the sun and the earth are almost in a line . **figure 5.3**.

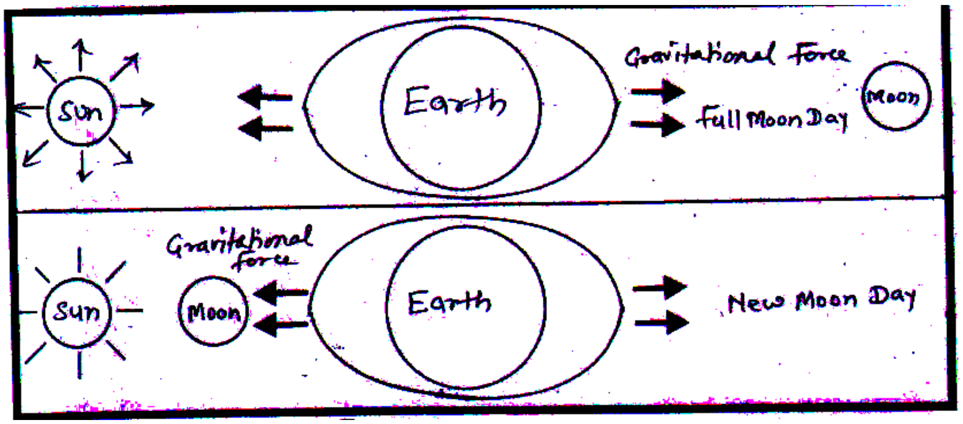

Figure: 5.3. Spring Tide

Neap Tide: Lowest amplitude tides called as **'Neap Tide'** occur when the moon is at first and last quarter of full moon, and the position of the sun and the moon are at right angles to the earth. During this period the pull exerted by the sun and the moon tend to balance each other resulting in the occurrence of lowest amplitude of tides **figure 5.4** .

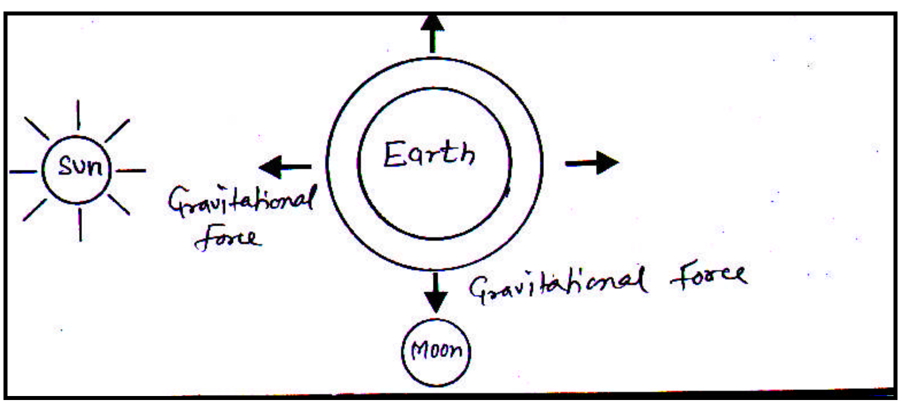

Figure: 5.4. Neap Tide

ii) Aphelion and Perihelion Tides:

The proximity of the Moon in relation to Earth and Earth in relation to the Sun also has an effect on tidal ranges **(figure 5.5.)**. . Earth moves around the Sun in an elliptic orbit that takes a little over 365 days to complete. Its gravitational force is greatest when the Earth is at perihelion i.e. the position when it is closest to the Sun in early January; and gravitational force is least when the Earth is at aphelion position i.e. farthest from the Sun in early July. The Perihelion tides occur when the Earth, Moon and Sun are aligned at perigee and perihelion, resulting in the largest tidal range seen over the course of a year. So, tides are enhanced when the Earth is closest to the Sun around 2nd January of each year. Tides are reduced during aphelion when it is furthest from the Sun i.e. around 2nd July.

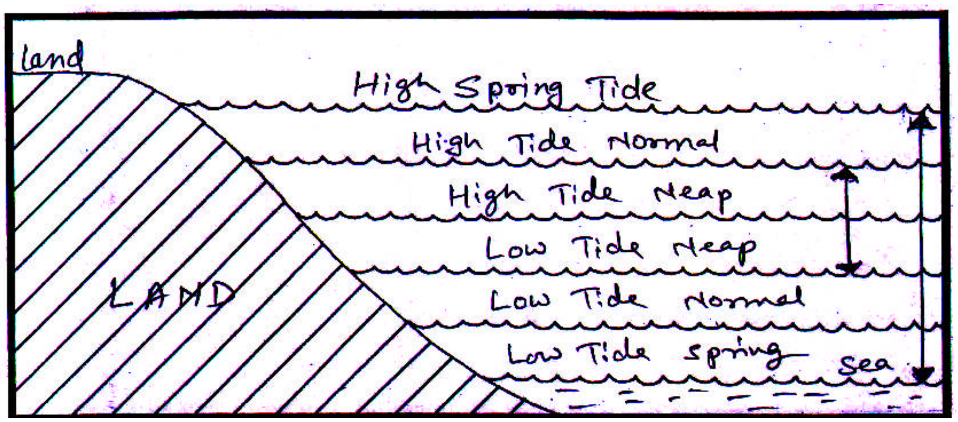

Figure:5.5. Tidal range

iii) Daily and Semi-diurnal tides: is classified on the basis of time interval between the tides **Figure 5.6**. These are:

- **Diurnal tides:** The tides occurring at the interval of 24 hours 52 minutes daily are called diurnal or daily tides.
- **Semidiurnal tides:** Tides occurring at the interval of 12 hours 26 minutes are called as semi-diurnal tides

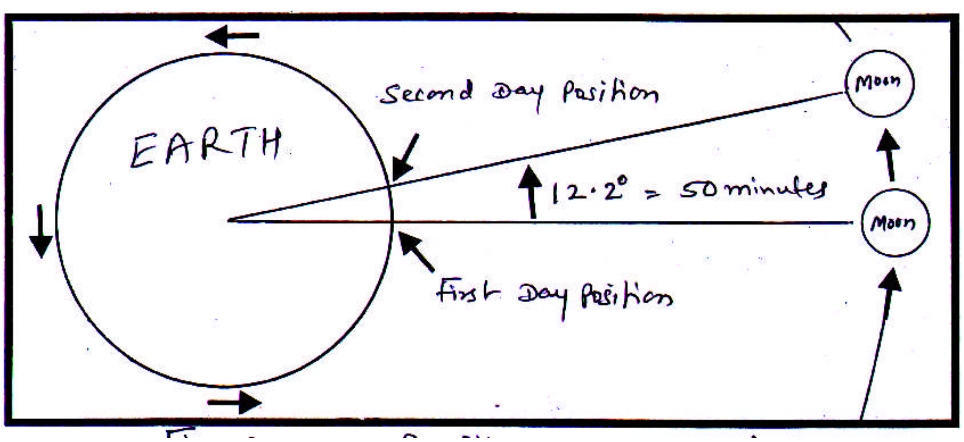

Figure 5.6. Position of earth and moon

c) Significance of Tides:

i) Inland Navigation in rivers: Tides generally help in making some of the rivers navigable for ocean-going vessels. For example river Rhine, Elbe, Danube in Europe, River Thames in London, River Mississippi In U.S.A., River Hooghly in Kolkata.

ii) Desilting of river mouths: Tides clear away the sediments brought by the rivers and thus maintains the depth of water near the coast that provides natural harbor for fishing and shipping.

iii) Tidal energy: The tidal force is also used as a source for generating electricity. For example France and Japan have installed power stations that convert tidal energy into electricity.

iv) Fishing activity: A large amount of fish are brought to the coast during high tides that provides easy fish catch for fishermen to earn their livelihood and a source of nutrient food, feed, and fertilizer to man, his animals and cultivable land respectively.

Check your progress :

1. Explain the origin of tides with the help of a diagram.
2. Discuss different types of tides with suitable diagrams.
3. Examine the importance of tides in human life.

11.3 ORIGIN OF OCEAN CURRENTS:

The general movement of a mass of oceanic water in a definite direction is called 'ocean currents' **Figure 5.7**. Ocean currents originate in all parts of the world and are most powerful of all features of the ocean because they drive oceanic waters for thousands of kilometers.

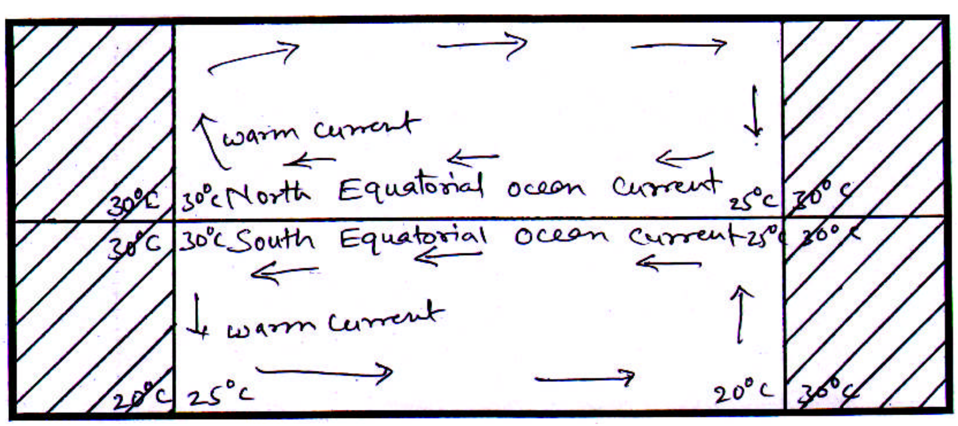

Figure 5.7. **Ocean Currents**

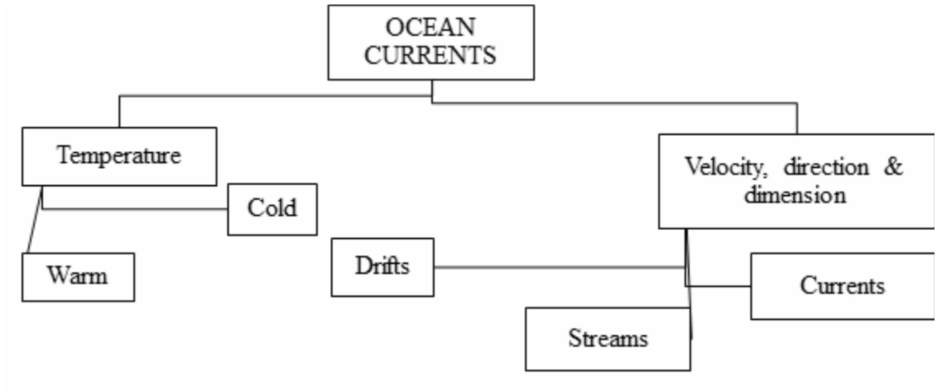

Figure 5.7.1: Classification of Ocean Currents

The currents in the oceans are originated due to combined effects of several factors acting internally as well as externally which are as follows:

1. Factors related to the Oceans: Local variations in the physical properties of the ocean e.g. pressure gradient, temperature differences, salinity differences; density variations etc. generate ocean currents.

(i) Temperature Difference – Water moves from high temperature belts to lower temperature belts. Thus, currents from the equator move towards the pole. But, subsurface water also moves from poles towards equator to compensate the loss of water. Hence, temperature is an effective phenomenon.

(ii) Salinity Difference – Oceanic salinity affects the density variation causes ocean currents. Salinity increases the density of ocean water. If two areas having equal temperature are characterised by varying salinity, the areas of high salinity will have greater density than the areas of low salinity. Ocean currents on the water surface are generated from the areas of less salinity to the areas of greater salinity. Such system of surface and sub-surface currents caused by salinity variation is originated in open and enclosed seas.

(iii) Density Difference – Difference in the density of oceanic water is the main cause for the movement of oceanic water as oceanic currents. Water moves from the areas of lower density to areas of higher density.

2. Factors related to atmospheric pressure: Ocean currents are greatly influenced and controlled by atmospheric pressure and its variation, wind direction, rainfall and evaporation etc. These are:

(i) Air pressure and Winds – Water moves from higher pressure areas to lower pressure areas in the form of currents, due to differential water levels.

(ii) **Rainfall and Evaporation –** The sea water levels becomes relatively higher in the areas of low evaporation and high rainfall than those areas which record low rainfall but high evaporation. Low evaporation coupled with high rainfall lowers the amount of salinity and thus reduces water density. This mechanism results in the rise of sea level. On the other hand high evaporation and low rainfall increases salinity and water density and thus lowers the sea level. Thus, surface ocean currents are generated from the area of low water level.

5.4 OCEAN CURRENTS OF THE ATLANTIC OCEAN:

The type and movement of ocean currents is determined the temperature conditions of the sea water in the ocean. Following are the types of ocean currents found in the Atlantic Ocean.

1. North Equatorial Current (warm)

Normally, the north equatorial current is formed between the equator and 10^0 N latitude. The current is generated because of upwelling of cold water near the west coast of Africa. This warm current is also pushed westward by the cold canary current. On an average, the north equatorial warm current flows from east to west but this saline current is deflected northward when it crosses the mid-Atlantic Ridge near 15^0 N latitude. It again turns southward after crossing over the ridge. This current, after being obstructed by the land barrier of the east coast of Brazil, is bifurcated into two branches e.g. (i) **Antilles Current** (ii) **Caribbean Current**.

2. South Equatorial Current (warm)

South equatorial current flows from the western coast of Africa to the eastern coast of America between the equator and 20^0latitude. This current is more constant than the north equatorial current. In fact, this current is the continuation of the Benguela current. This warm current is bifurcated into two branches due to obstruction of land barrier in the form of the east coast of Brazil. The northward branch after taking north westerly course merges with the north equatorial centre near Trinidad while the second branch turns southward and continues as Brazil warm current parallel to the east coast of America. This current is basically originated under the stress of trade winds.

3. Counter-Equatorial Current (warm)

The counter equatorial current flows from west to east in between the westward flowing strong north and south equatorial currents. This current is less developed in the west due to stress of trade winds. In fact, the counter current mixes with the equatorial currents in the west but it is more developed in the east where it is known as the Guinea Stream. The counter – equatorial current carries relatively higher temperature and lower density than two equatorial currents.

4. <u>Gulf Stream (warm)</u>

The Gulf Stream is a system of several currents moving in north-easterly direction. This current system originates in the Gulf of Mexico around 20^0N latitude and moves in north easterly direction along the eastern coast of North America and reaches the western coast of Europe near 70^0N latitude.

(i) **<u>Florida Current</u>**: This current is the northward extension of the north equatorial current. These current flows through Yucatan channel into the Gulf of Mexico, thereafter the current moves forward through Florida Strait and reaches 30^0N latitude.

(ii) **<u>Gulf Stream:</u>** The Florida current after having the water of Antilles current is known as Gulf Stream beyond Cape Hatteras. This current is very wide and warm and is separated from the Sargasso Sea to its right (in the east) and relatively cold water near the coast to its left.

(iii) **<u>North Atlantic Current</u>**: The Gulf Stream is divided into many branches at 45^0 N latitude and 45^0W longitude. All the branches are collectively called as North Atlantic Drift or current.

5. <u>Canary Current (cold)</u>

The Canary Current, a cold current, flows along the western coast of North Africa between Madeira and Cape Verde. In fact, this current is the continuation of north Atlantic Drift which turns southward nears the Spanish Coast and flows to the south along the Coast of Canaries Island.

6. <u>Labrador Current (cold)</u>

The Labrador Current, an example of cold current, originates in the Baffin Bay and Davis Strait and after flowing through the coastal waters of Newfoundland and Grand Bank merges with the Gulf Stream around 50^0W latitudes.

7. <u>Brazil Current (warm)</u>

This current is generated because of the bifurcation of the south equatorial current because of obstruction of the Brazilian coast near Sun Rock. The northern branch flows northward and merges with the north equatorial current while the southern branch known as the Brazil current flows southward along the east coast of South America up to 40^0S latitude.

8. **Falkland Current (cold)**
   The cold waters of the Atlantic Ocean flows in the form of Falkland cold current from south to north along the eastern coast of South America up to Argentina. This current becomes most extensive and developed near 30^0S latitude.

9. **South Atlantic Drift (cold)**
   This current is originated because of deflection of the Brazil warm current eastward at 40^0S latitude due to deflective force of the rotation of the earth. The South Atlantic Drift, thus, flows eastward under the influence of the westerly's.

10. **Benguela Current (cold)**
    The Benguela current, a cold current, flows from south to north along the western_coast of South Africa. In fact, the South Atlantic Drifts turns northward due to_obstruction caused by the southern tips of Africa. Further northward this current_merges with the South Equatorial Current.

5.5 EFFECTS OF OCEAN CURRENTS:

The climate of the coastal region is also influenced by ocean currents. Ocean currents therefore influence agricultural and other economic activities of coastal regions. Following are the effects of Ocean Currents:

i) **Brings Precipitation**: Warm ocean currents provide moisture to the winds blowing from the sea to the land. It helps in reducing the temperatures and so leads to precipitation (rainfall/snowfall / drizzle etc). For example Gulf Stream near western coastal Europe, North Atlantic drifts along the eastern coast of Mexico and USA, Brazilian current along the eastern coast of Brazil.

ii) **Weather and Climate:** Warm Ocean currents of tropical move towards Polar Regions to provide water. While cold ocean current of polar region bring cool water to tropical water areas. This exchange warm and cool water has a moderating climatic effect on temperate coastal regions. High temperatures during summers of coastal regions in temperate areas with cold and dry climate are brought down by the presence of these warm winds. For example north Atlantic drift (warm) current, which flows along the western coast of Canada, makes the region much warmer than other places on the same latitude.

iii) **Scanty Rain / no rain**: Cold current are devoid of any moisture and so the winds blowing from the sea are dry with no moisture. These coastal regions therefore receive scanty rain or no rain. For example Kalahari Desert and Benguela cold current of South Atlantic Ocean.

iv) Confluence of ocean currents and fishing grounds: Places where cold and warm currents meet are ideal for the growth of Plankton that forms food for fish. These regions thus support a large number of fish to develop as major fishing grounds of the world. Newfoundland on the eastern coast of North America is the meeting point of the Warm Gulf Stream current and the cold Labrador Current.

On the other hand these places with confluence of warm and cold current also give rise to the formation of thick fog that reduces visibility and so are dangerous for shipping. It may cause accidents of ship since the shipping traffic is heavy in this North Atlantic Ocean.

v) Shipping and Navigation: Ships sailing with ocean current gains natural speed, which helps to save fuel and time. Ships moving against a current lose speed. Warm currents keep the Arctic regions free from icebergs, which can be dangerous for ships. Besides it keep ports free from freezing during winters thus making shipping possible throughout the year.

5.6. CONCLUSIONS:

From the present study it is very clear that tides also play an important role in influencing the weather and climate of the coastal regions. They help in the functioning of aquatic ecosystem in the coastal waters that facilitates fishing activity. Ocean currents largely govern the temperature of waters in the sea. They influence the weather conditions along the coast and play dominant role in the temperate coastal areas. In addition Ocean currents help the shipping and navigation activities in the areas that are favourable.

5.7. QUESTIONS

1) How are tides formed? Draw suitable diagram
2) Explain different types of tides with neat diagrams.
3) What is the importance of tides in human life?
4) What are the causes and effects of ocean currents?
5) What is the significance of ocean current?
6) Define current and describe the types and distribution of current in Atlantic Ocean.

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Unit - 6

PRACTICAL PART B:
ATMOSPHERE AND WEATHER

Unit Structure:

6.0. OBJECTIVES :

- To study different weather phenomena that influence day to day activity of mankind.
- To understand the functioning of different weather instruments and their recording of weather data.
- To study different techniques used to know weather phenomena.
- To study weather maps with the help of conventional signs and symbols used in weather maps.

6.1. INTRODUCTION:

Weather denotes the atmospheric conditions of weather elements at a particular place and time. The weather elements include temperature, atmospheric pressure, wind, humidity and cloudiness. These weather conditions are obtained from various weather stations and recorded by the meteorological department on day to day basis to produce daily weather maps.

Meteorology is the study of the earth's atmosphere and weather. Scientists who study these conditions and forecast weather conditions are called as meteorologists. Weather instruments given in table 6.1 are used for recording weather phenomenon at weather stations.

Table 6.1
INSTRUMENTS FOR MEASURING WEATHER ELEMENTS

S.N.	Weather Element	Name of the Weather Instrument	Unit of Measurement
1	Temperature	i) Maximum and Minimum thermometer, ii) Thermograph	i) In British system : Degree Celsius (^{0}C) ii) In French system: Degree Fahrenheit (^{0}F)
2	Atmospheric Pressure	i) Barometer ii) Barograph	Millibar (mb)
3	Humidity	i) Wet and Dry bulb thermometer	In Percentage (%)
4	Precipitation	Rainguage	Millimeter, centimeter (mm), (cm)
5	Wind vane	Wind direction	North, South , East, West
6	Wind Velocity	Anemometer	Kilometer per hour

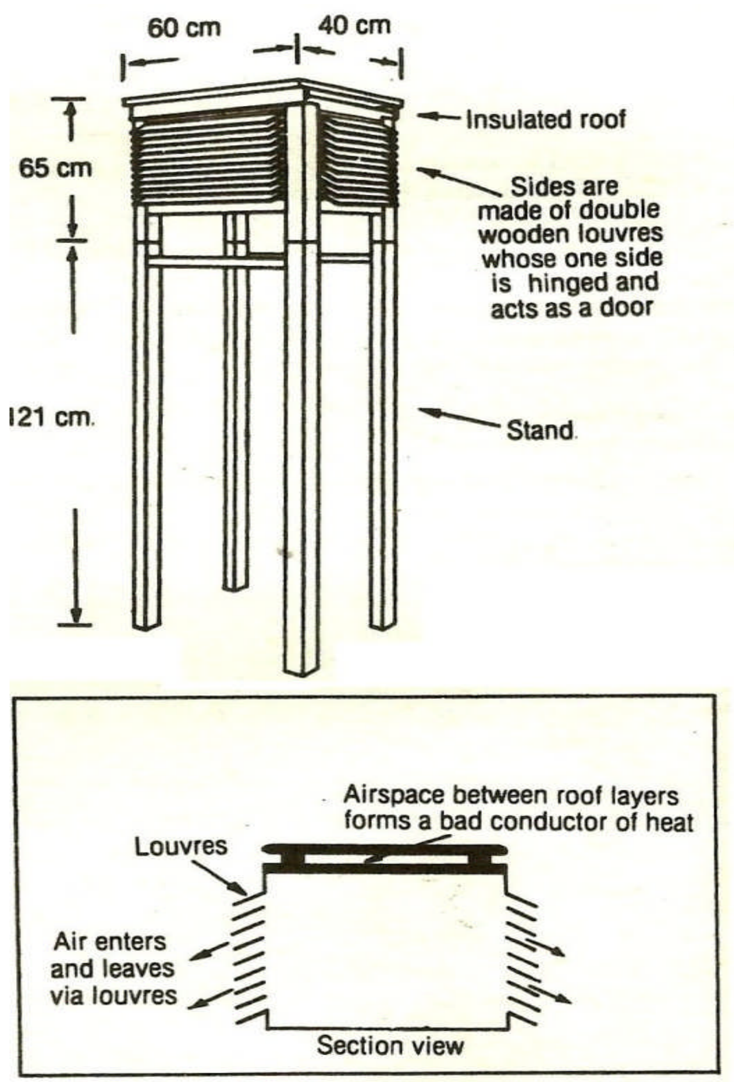
The science of meteorology now with its advanced technology of Doppler is able to predict weather phenomenon more accurately. Hence precautions are taken well in advance that saves much of the loss of life and property. Weather forecasts are of great importance in the field of aviation, shipping, agriculture etc.

Weather Instruments: Various instruments are used for measuring different weather phenomena. Some of the common important weather instruments given in table 6.1 are explained below:

i) Thermometer: is used to measure atmospheric temperature. Most thermometers are in the form of a narrow closed glass tube with an expanded bulb at one end. The bulb and the lower part of the tube are filled with liquid such as mercury or alcohol. Before the other end is sealed off, the air in the tube is released by heating it. The bulb of the thermometer in contact with the air gets heated or cooled, as the case may be, as a result of which the mercury in the bulb rises or falls. A scale is marked on the glass tube and readings are recorded from the same.

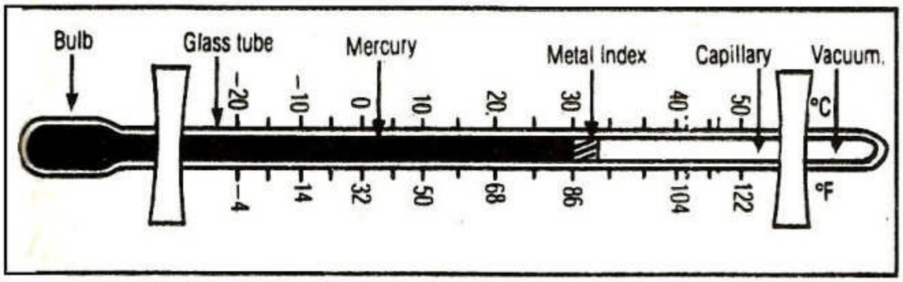
The two most common scales used in the thermometer are centigrade and Fahrenheit. On the centigrade thermometer, the temperature of the melting point is marked 0^0C and that of boiling water as 100^0 C, and the interval between the two is divided into 100 equal parts. On the Fahrenheit thermometer, the freezing and the boiling points of water are graduated as 32^0F and 212^0F respectively.

While the maximum and the minimum thermometer are used to measure the atmospheric temperature, the dry bulb and the wet bulb thermometers are used to determine the humidity conditions in the air. A set of these thermometers is kept in the **Stevenson's Screen Figure 6.1**



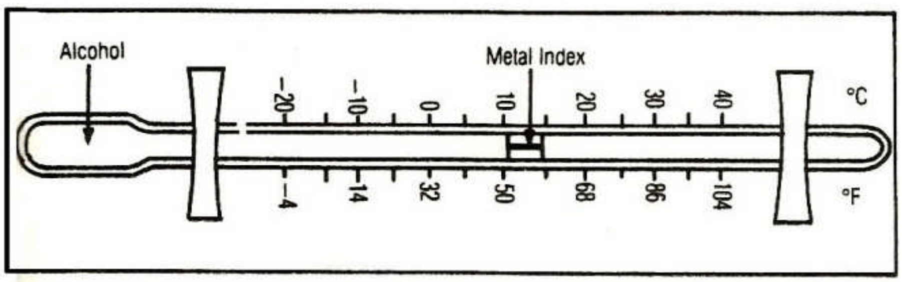
Stevenson's Screen: Figure 6.1

a) The **maximum thermometer** is designed to record the highest temperature during a day. As the temperature increases, the mercury moves up into the tube, however as the mercury cools, it cannot moves downwards because of a constriction in the tube. It must be reset again to bring it down. **Figure 6.2**



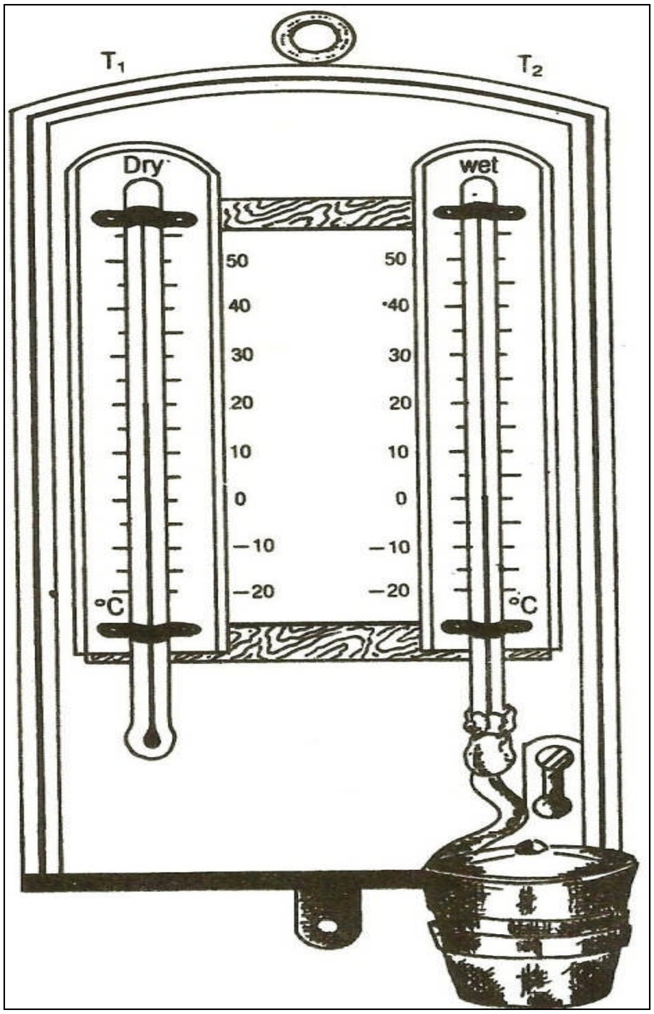
Maximum Thermometer Figure 6.2

b) The **minimum thermometer** records the lowest temperature in a day. In this thermometer, alcohol is used in place of mercury. When the temperature decreases the metal pin in the tube goes down and strikes at the minimum temperature. **Figure 6.3**



Minimum Thermometer: Figure 6.3

c) **The dry bulb and the wet bulb thermometers are used for measuring the atmospheric humidity**. The dry bulb and the wet bulb thermometers are two identical thermometers fixed to a wooden frame. The bulb of dry thermometer is kept uncovered and is exposed to the air while the bulb of the wet bulb thermometer is wrapped up with a piece of wet muslin, which is kept continuously moist by dipping a strand of it into a small vessel of distilled water. The evaporation from the wet bulb lowers its temperature. Dry bulb readings are not affected by the amount of water vapor present in the air, but the wet bulb readings vary with it since the rate of evaporation is dependent upon the amount of water vapor present in the air. The greater the humidity in the air, the slower the rate of evaporation and hence, the difference between the readings of dry bulb and wet bulb will be small. On the other hand, when the air is dry the evaporation from the surface of the wet bulb is rapid, which would lower its temperature and the difference between the two readings would be larger. Hence, the difference of the readings of the dry bulb and wet bulb thermometers determines the state of the atmosphere with regard to its humidity. The larger the difference in the wet and dry bulb thermometer, the more arid is the air. **Figure 6.4**

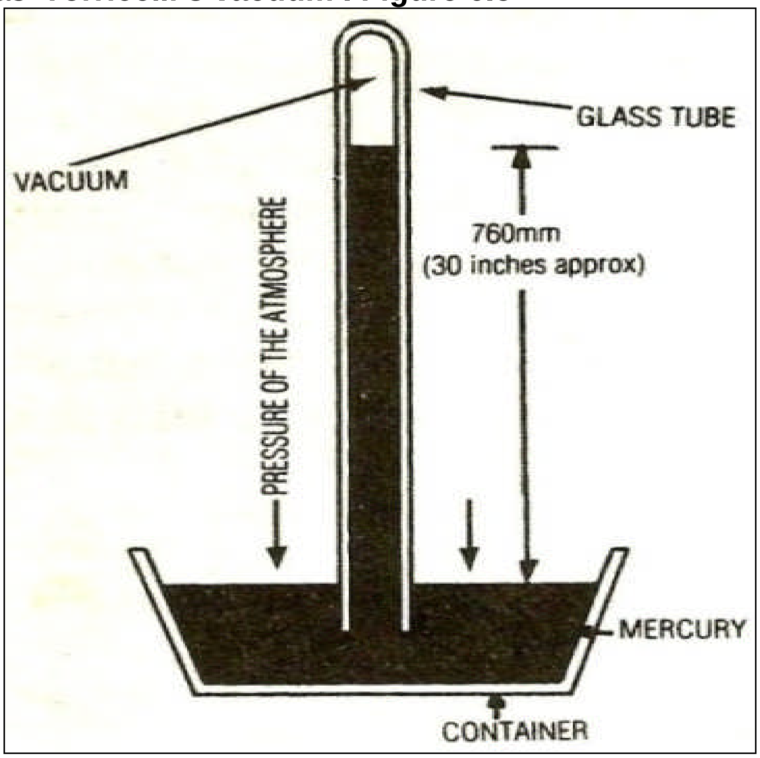


Dry and Wet Bulb Thermometer: Figure 6.4.

2) Barometer and Barograph: These weather instruments are used to measure and record air pressure at the weather stations respectively. The unit of measurement used to measure air pressure is millibars (mb).

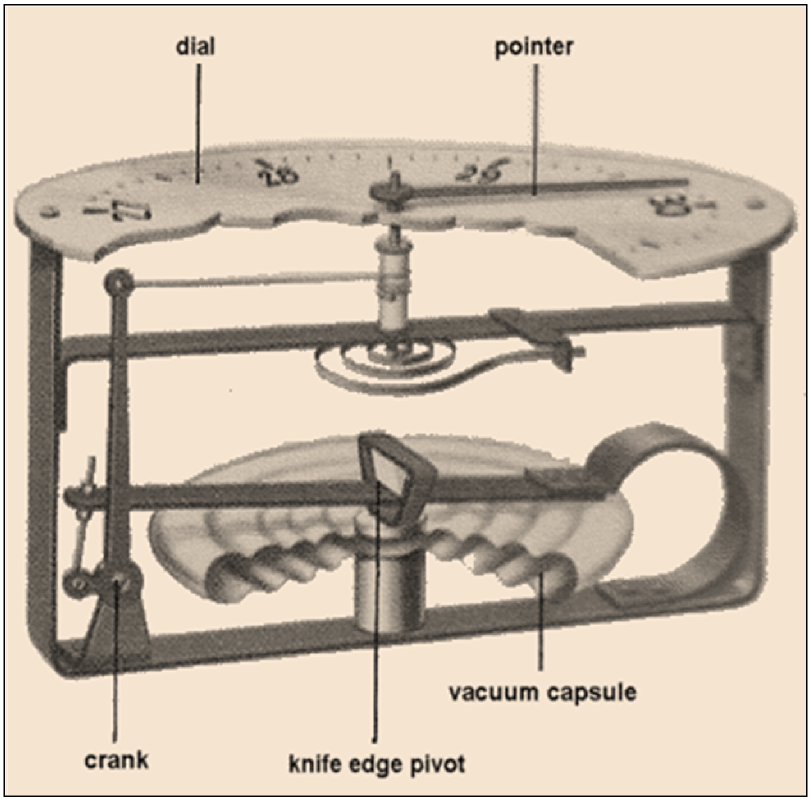
There are two common types of barometer used to record air pressure:
(a) Simple mercury barometer and (b) Aneroid barometer.

(a)Simple mercury barometer: This instrument has much greater accuracy than aneroid barometer and is used in many weather stations. A thick glass tube of meter length is filled with mercury and its mouth is closed with the help of a finger. Another cup is taken and is filled completely with mercury. This glass tube in then dipped into a cup filled with mercury. Care is taken while removing finger from preventing air to enter the glass tube while inverting in the cup. The mercury thus will flow out from the glass tube into the cup. The level of mercury in the glass tube thus goes down and gets stable at certain level. This stable mercury level is measured in millimeter. This height of the mercury level in the glass tube will represent the air pressure. The vacuum portion in the glass tube is called as '**Torricelli's vacuum'. Figure 6.5**



Simple mercury barometer: Figure 6.5

(b) Aneroid barometer: It is most convenient to use as it is light in weight and easily portable. Aneroid barometer consists of a hollow metal box with a spring placed inside the box that has flexible sides. Any change in atmosphere makes the top of the box to bend slightly. Thus when the air pressure is high the box bends in and when the air pressure is low the spring pushes the box top outwards. These movements of the box (bending in and out) are magnified by a system of levers which control the movement of a pointer over a dial. This aneroid barometer is attached to a rotating drum on which a graph paper is fixed to get a chart. This instrument is called as **barograph.** The pointer of the barometer is a pen which continuously draws a line on the graph paper to given a chart **Figure 6.6 and 6.7**



Aneroid Barometer: Figure 6.6

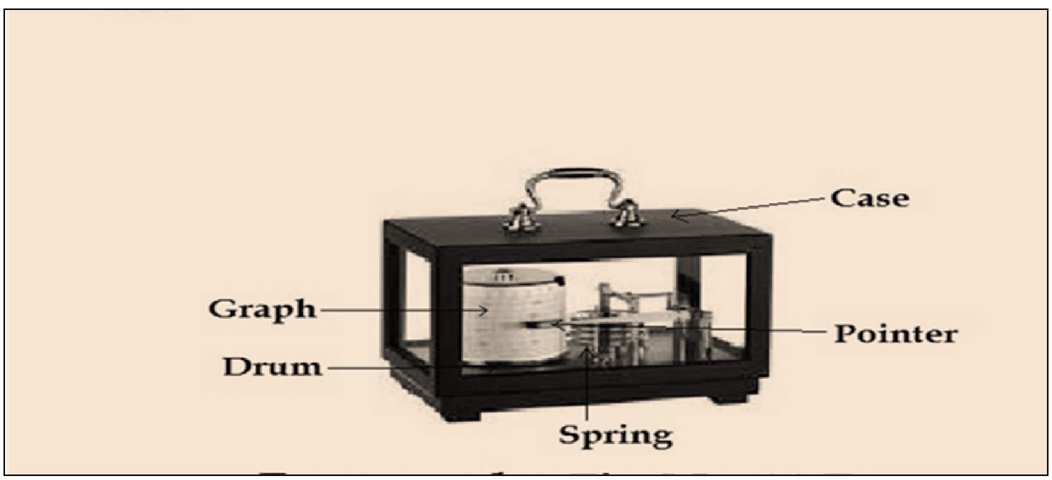
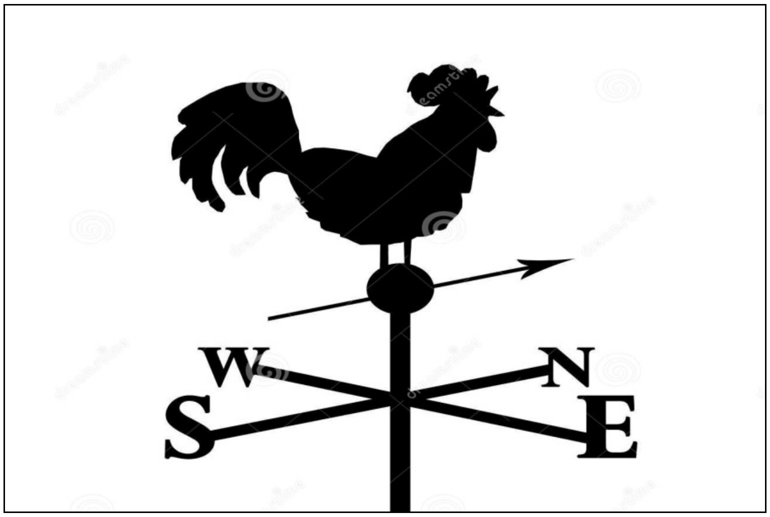


Figure 6.7 barograph

3) Wind Vane and Cup Anemometer: These weather instruments are used to know wind direction and wind velocity respectively.

A Wind Vane indicates wind direction. A lever with arrow as a pointer at one end and a small two metal plates attached at same angle to the other end is fixed on a vertical rod. The arrow of the wind vane always points to the direction from which the blows. North, South, East and West directions are marked on the fixed support of the wind vane **Figure 6.8**. To obtain accurate data a wind vane is sited on the top of the tall building that is relatively without any obstruction.



Wind Vane Figure 6.8

Cup Anemometer: It helps in measuring the velocity of the wind. Four metallic cups are fixed on a frame that is balanced on a vertical rod. As the wind blows the cup starts blowing in a horizontal direction. wind in knots per hour or kilometers per hour **Figure 6.9.** These rotations of the axel are transmitted through gears to a meter which records the frequency of rotations that gives the speed of the wind

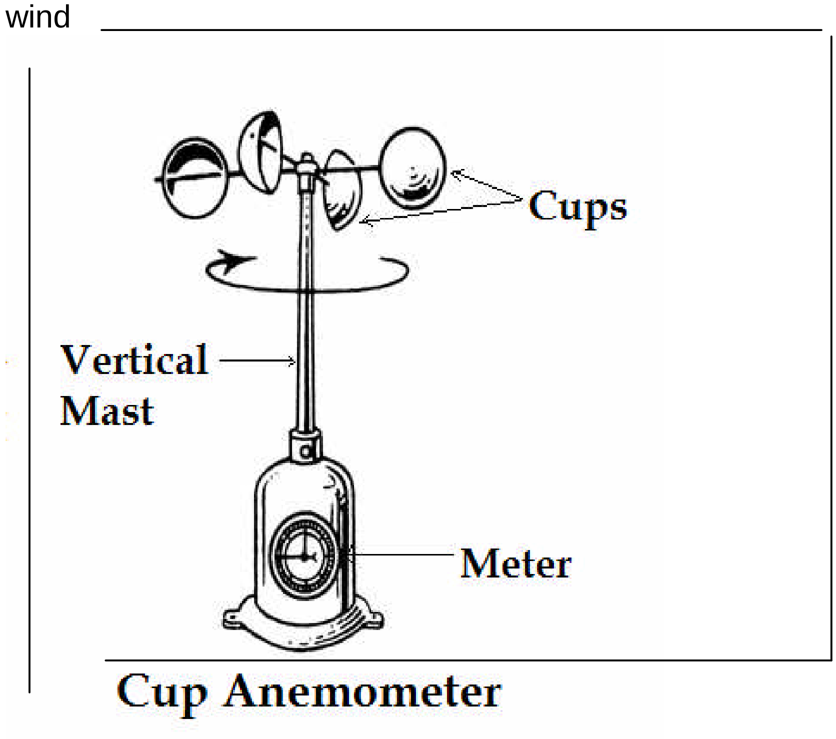
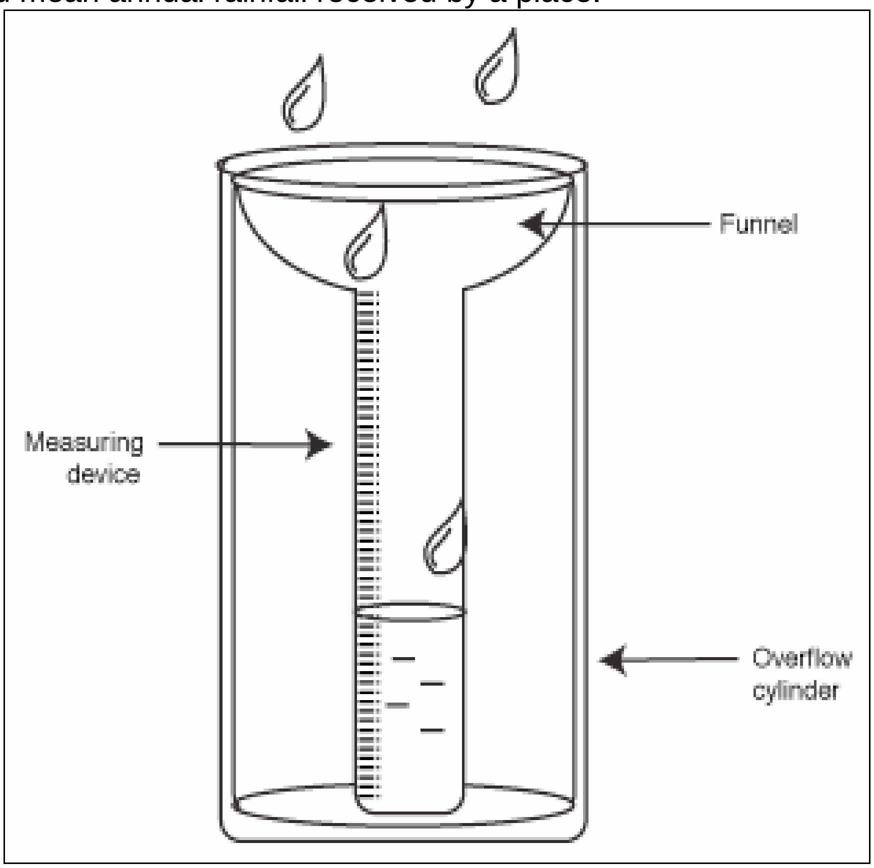


Figure 6.9

4) Rain Gauge: It is a weather instrument used to measure rainfall accompanied by a corresponding measuring jar in millimeter. It consists of an outer metal casing (copper), inner container (glass or copper) with a metallic funnel. The rainguage is fixed in an open area without any obstructions in the form of trees, buildings, walls in its vicinity. It is partly sunk in the ground having grass so that it is not blown or knocked. The top of the funnel stands 30 cm from the ground level so that rain from the nearby cannot enter into the rain gauge. The rainfall gets collected in the inner container. The overflow from the inner container is collected in the outer container. The funnel has a tapering end so that evaporation of the collected rainwater is minimized. The amount of rain is measured using a measuring jar which is calibrated according to the diameter of the gauge. The rainfall amount is measured daily or several times a day depending upon the amount of rainwater received **Figure 6.10**. The records are used to calculate the mean daily, mean monthly and mean annual rainfall received by a place.



Rain-Gauge : Figure 6.10

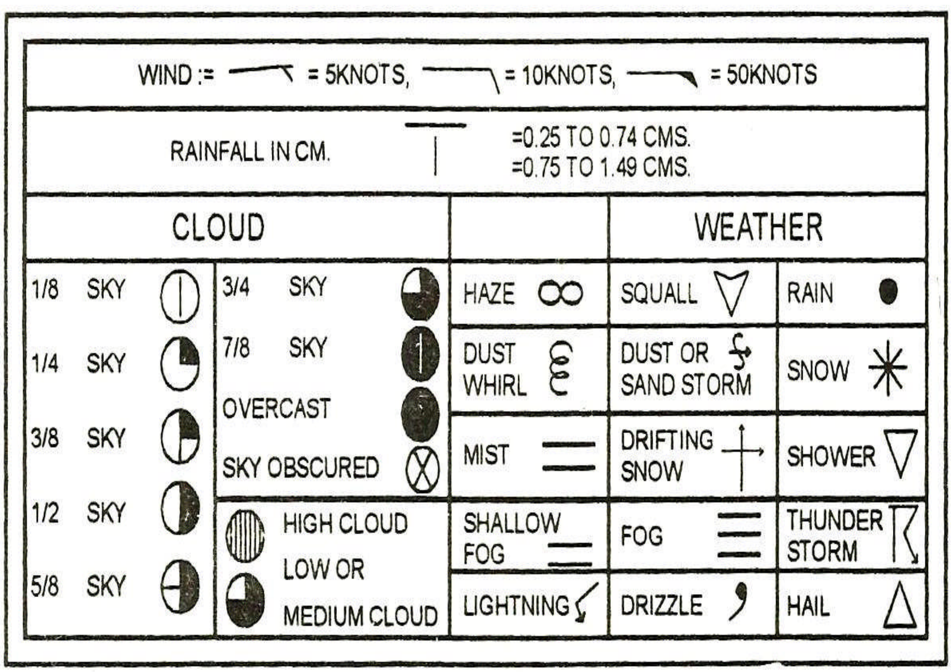
Check your Progress:

1. Define weather. What are the elements of weather?
2. Who is a meteorologist?

6.2. SIGNS AND SYMBOLS USED IN WEATHER MAPS

Following chart gives various signs and symbols used in weather maps for understanding the weather phenomena at a particular place and time. Weather maps in India are produced by India Meteorological Department referred to as Indian daily Weather Report as given in Chart 1.

Signs and Symbol of Weather conditions: Chart- 1



These are universally used signs and symbols that help to have a comparative study with spatial analysis and spatial differentiation in the world.

Sea Condition: Chart 2.

SN	Sea Condition	Sign and Symbol
1	Calm	Cm
2	Smooth	Sm
3	Slight	Sl
4	Moderate	Mod.
5	Rough	Ro.
6	Very Rough	V.Ro.
7	High	H
8	Very High	V.H.
9	Phenomenal	Ph.
10	Direction of Wave	

Check Your Progress:

1. Draw all the signs and symbols used in weather maps.
2. How do these signs and symbols on a weather map help to understand the weather of different places?

6. 3 CONCLUSIONS:

This module therefore explains the importance of signs and symbols and quantitative techniques in identifying different types of weather phenomena to determine atmospheric conditions of a particular place or a region on the surface of the earth. Comparative analysis and spatial differentiation of weather and atmospheric conditions is therefore possible with the help of such geographical techniques used in practical geography.

6.4. QUESTIONS:

1. How is weather condition studied? Explain with correct diagrams.
2. Explain the importance of studying weather conditions.
3. What are weather maps? How are they useful?

References:

1. Gopal Singh (2001):'Map Work and Practical Geography', 4th revised and enlarged edition, Vikas Publishing House Pvt. Ltd.

2. Linda lau (2000): Physical Geography, Union Book Co.Pvt. Ltd. and Greenwood Press, Hong Kong.

3. https://www.google.co.in/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF8#q=image+of+doppler+radar+in+India

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Question Paper Pattern for Semester End Assessment implemented From 2020-2021
For Geography courses at F.Y.B.A

Duration of examination - 3 hours
Total Marks - 100 (per semester)

N. B. : (1) All Questions (Question No. 1 to 5) is compulsory.
(2) Draw neat sketches and diagrams wherever necessary.
(3) Attach map supplement to the main answer book.
(4) Figures to the right indicate full marks.

Q1. Attempt any **One** question (*module 5*) **20 marks**

A)
B)

Q2. Attempt any **Two** questions (*module 1*) **20 marks**

A)
B)
C)

Q3. Attempt any **Two** questions (*module 2*) **20 marks**

A)
B)
C)

Q4. Attempt any **Two** questions (*module 3*) **20 marks**

A)
B)
C)

Q5. Attempt any **Two** questions (*module 4*) **20 marks**

A)
B)
C)
