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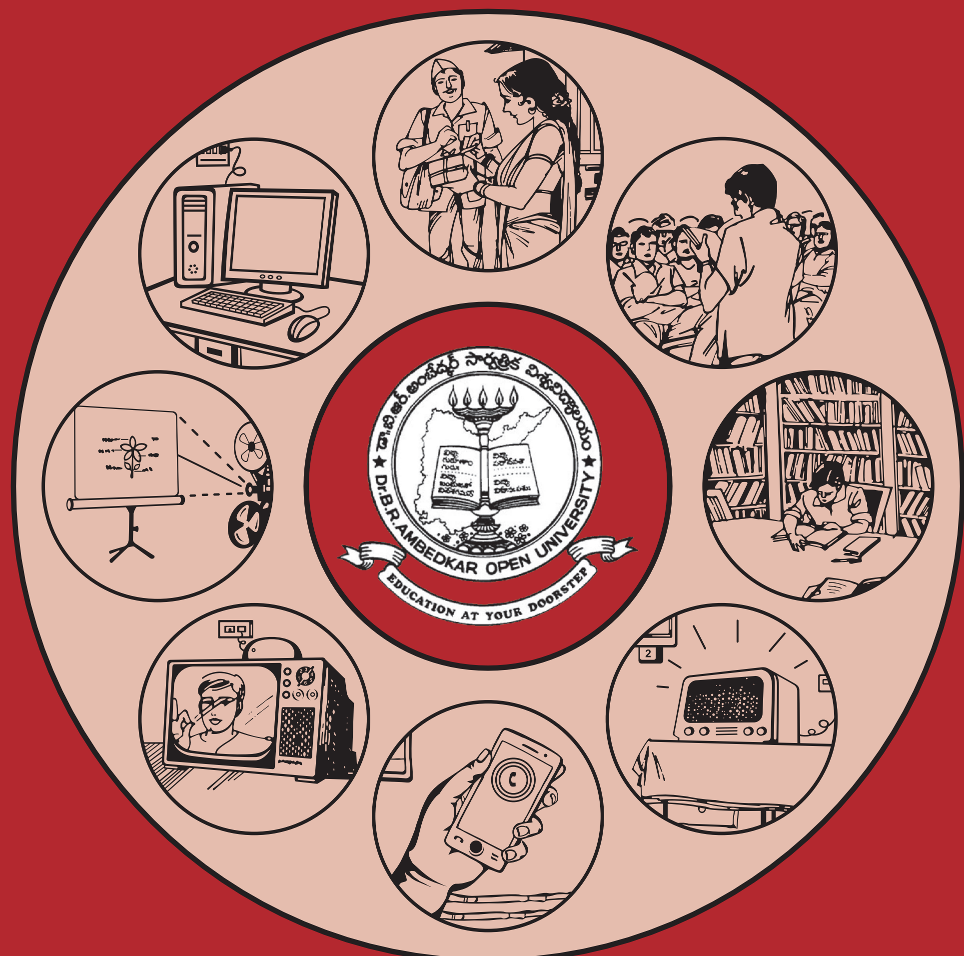

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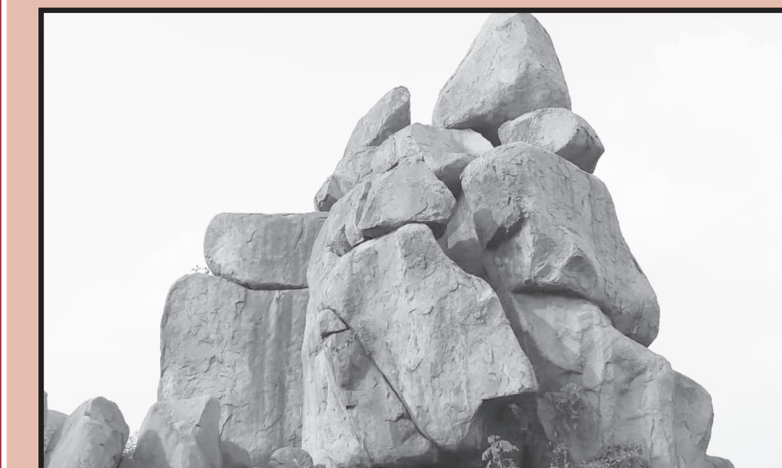
FIRST YEAR

GEOGRAPHY

FUNDAMENTALS OF GEOMORPHOLOGY

SEMESTER - I



CLIMATOLOGY & OCEANOGRAPHY

SEMESTER - II

Dr. B.R. AMBEDKAR OPEN UNIVERSITY
HYDERABAD

BA228GEO-E

B.A.

FIRST YEAR SEMESTER - II

ELEMENTS OF CLIMATOLOGY AND OCEANOGRAPHY

“We may forgo material benefits of civilization, but we cannot forgo our right and opportunity to reap the benefits of the highest education to the fullest extent.....”

Dr. B. R. Ambedkar

Dr. B.R. AMBEDKAR OPEN UNIVERSITY
HYDERABAD
2022

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Preface

In the second semester Elements of Climatology and Oceanography included. This course is designed to provide the candidates a good understanding about the atmospheric and oceanographic phenomenon. Climatology is a subfield of physical geography. It is a branch of the atmospheric sciences. The scope of climatology is broad. It has also expanded widely from its roots in ancient Greece. The term "climatology" is derived from the Greek term "klima".

Climatology is a holistic science in that it involves understanding the interaction of the atmosphere with other aspects of the Earth–ocean–atmosphere system using many different spatial and temporal scales. Climatology is the study of climate and how it changes over time. This science helps people better understand the atmospheric conditions that cause weather patterns and temperature changes over time. The study of Elements of Climate and the factors influencing the distribution of temperature and pressure are the key aspects covered. Apart from that the Heat budget, Insolation, Air masses, Fronts, Ocean currents are other interesting topics which enlighten the candidates to have a complete picture about the atmosphere and hydrosphere. It explains how closely these two are associated with each other to determine the world climate and there by the life on this earth.

Oceanography is a scientific discipline concerned with all aspects of the world's oceans and seas, including their physical and chemical properties, their origin and geologic framework, and the life forms that inhabit the marine environment. Oceanography deals with the properties of seawater, its movement (waves, currents, and tides), and the interactions between the ocean waters and the atmosphere. Oceanography also is vital to understanding the effect of pollutants on ocean waters and to the preservation of the quality of the ocean waters. Oceanography is an interdisciplinary science that involves the study of the entire ocean.

This book contains 5 blocks and 15 units. The candidates can easily learn through this material without any difficulty to understand. This book is also useful to the students those who are appearing for various competitive examinations at the state and national level.

B.A First Year

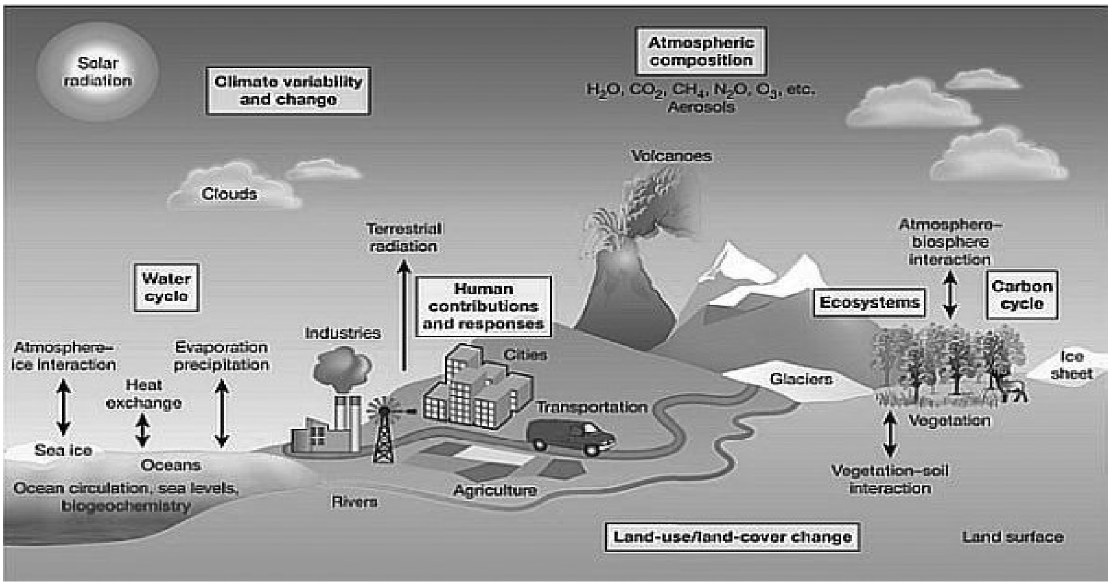
SEMESTER –II – Paper -2

ELEMENTS OF CLIMATOLOGY AND OCEANOGRAPHY

BLOCK - I: ATMOSPHERE

Earth is the only planet in the solar system with an atmosphere that can sustain life. The blanket of gases not only contains the air that we breathe but also protects us from the heat and radiation emanating from the sun. It warms the planet by day and cools it at night. **The atmosphere is a dynamic system that has undergone changes throughout geological time.** The composition of the atmosphere has changed throughout geological history.

The atmosphere is the result of energy from the sun producing the movements or currents in the atmosphere. This energy, the Earth's movement relative to the sun, and the components of the atmosphere and the Earth's surface maintain the long-term climate, the short-term weather, and the temperature conditions. These conditions fit for the forms of life found on Earth. The condition of the physical world affects and is affected by the life present. The entire system is called the biogeochemical system. Living organisms (biotic components) have transformed the atmospheric composition of the Earth and vice versa throughout history. The life on Earth requires a particular atmospheric composition, and this composition is in turn maintained by the interaction between biological systems and the atmospheric system.



The block has four units.

Unit 1: Definition and significance of climatology. Elements of weather and climate; their causes.

Unit 2: Composition and structure of the atmosphere.

Unit 3: Atmospheric Temperature: Insolation and global energy budget, vertical, horizontal and seasonal distribution of temperature.

Unit 4: Atmospheric humidity, evaporation; and condensation; hydrological cycle; types of precipitation, world patterns of rainfall: regional and seasonal distribution.

UNIT-1: DEFINITION AND SIGNIFICANCE OF CLIMATOLOGY, ELEMENTS OF WEATHER AND CLIMATE

Contents

1.0 OBJECTIVES

After reading this unit you will be able to;

- Understand the difference between Climate and Weather
- Explain the what constitutes climatology
- Explain the Elements of climate
- Explore the Factors affecting climate

1.1 INTRODUCTION

You might have observed that we feel hot in summer and tend to wear cool and lighter clothes and drink cool water, while in winter we tend to wear warmer clothes, drink and eat warmer things. These changes can be seen in different seasons in different weather conditions. These changes occur due to the changes in the weather elements like temperature, pressure, wind direction, humidity, precipitation etc. While we talk about the extinction of dinosaurs we refer to climate when we carefully look at the two examples above it can be said that there is a sort of difference in between weather and climate. To understand both the statements it is essential to know the basic difference between weather and climate.

What exactly is climate?
The average weather conditions in a location for a long period of time is called climate. The weather may change in a matter of hours, while climate change takes millions of years. Since the beginning of time, the climate of the planet has changed dramatically.

The climate of a region is ultimately determined by the radiation energy of the sun, and its distribution and temporal fluctuations. The long-term state of the atmosphere is a function of a variety of interacting elements. They are: Solar radiation, Air masses, Pressure systems (and cyclone belts), Ocean Currents, and topography.

1.2 SIGNIFICANCE OF CLIMATOLOGY

Climatology is essential because it aids in the prediction of future climatic condition. Climatology is the scientific study of climates, which is defined as the average weather conditions across time. It is a subfield of atmospheric sciences that considers the variables and averages of short- and long-term weather situations.

Climatology is distinct from meteorology and is separated into other fields of study. Paleoclimatology, which focuses on researching the climate across the history of the Earth's existence by examining records of tree rings, rocks and silt, and ice cores, is one approach to this discipline. Historical climatology is primarily concerned with climatic change over time and the influence of climate on people and events. Despite the fact that climatology and meteorology are both branches of comparable fields of study, climatology varies from meteorology in that it focuses on averages of weather and climatic conditions over a long period of time. Meteorology is mainly concerned with present weather conditions such as humidity, air pressure, and temperatures, as well as projecting future weather conditions.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. Write briefly about significance of Climate?

1.3 THE ELEMENTS OF WEATHER AND CLIMATE

Weather is defined by the various elements that make it up, as well as how they interact with one another to produce various atmospheric conditions or weather events. All weather is driven by eight basic elements/factors:

- Air Temperature (Atmospheric)
- Wind Pressure (Speed & Direction)
- Humidity
- Precipitation
- Visibility
- Clouds (Type & Cover)
- Duration of the sun
- Temperature

Temperature: Temperature is a very important factor in determining the weather, because it influences or controls other elements of the weather, such as precipitation, humidity, clouds and atmospheric pressure. Temperature is a measure of the amount of kinetic energy in the air that manifests physically as heat or cold. The Celsius, Fahrenheit, and Kelvin scales are often used to measure temperature. A device called thermometer is used to measure temperature. In more practical terms, kinetic energy is created when particles in the air move or vibrate at a given speed. The temperature rises as the particles begin to move/rotate faster. When particles slow down, the temperature drops, and the air pressure drops as well.

Air pressure: It is another important aspect of weather, which is essentially more important when it comes to establishing or modifying atmospheric conditions. It's also one of the most important factors in precise weather forecasting. The pressure formed by the weight of air in the Earth's atmosphere is known as air pressure. It's also known as a barometric pressure, after the device that measures air pressure. Air has weight, even though it is not apparent, since it isn't empty. It's packed with nitrogen, oxygen, argon, carbon dioxide, and a few more gases in microscopic particles. Due to the gravitational pull of the air, the weight of the particles in the air causes pressure. Air pressure is highest near the planet's surface as more air is present above the air closer to the ground, and it decreases as height increases. The device used to measure air pressure is barometer.

The wind (Speed & Direction): .The horizontal movement of the atmosphere is called wind. Wind can be felt only when it is in motion. One of the key driving causes of weather is air movement (wind). Wind is responsible for the bulk of important and even extreme weather occurrences such as cold and warm fronts, clouds, thunderstorms, and hurricanes. Wind is the large-scale movement of air in the atmosphere from a high-pressure location to a low-pressure area. The distance between low and high pressure zones, as well as the difference in air pressure, define the wind speed and strength. The anemometer is used to measures wind speed. A wind gauge is a device that is used to determine the direction of the wind.

Humidity: Atmospheric moisture is the most important element of the atmosphere which modifies the air temperature. Humidity is the measurable amount of moisture in the air of the lower atmosphere. There are three types of humidity:

a) Absolute humidity: The total amount of water vapor present in per volume of air at a definite temperature.
b) Relative humidity: Is the ratio of the water vapors present in air having a definite volume at a specific temperature compared to the maximum water vapors that the air is able to hold without condensing at that given temperature.
c) Specific humidity: Is defined as the mass of water vapor in grams contained in a kilogram of air and it represents the actual quantity of moisture present in a definite air. The humidity element of weather makes the day feel hotter and can be used to predict coming storms. The humidity element of climate is the prolonged moisture level of an area that can affect entire ecosystems.

It not only influences weather formation, but it also has a direct impact on our body comfort levels. Humidity refers to the quantity of water vapour in the atmosphere at any given time. Water vapour is simply water that has turned into a gas (after the liquid has evaporated). Despite the fact that humidity and its effects may typically be felt, they are usually imperceptible to the human eye. Humidity is a difficult concept to grasp and interpret accurately. The hygrometer is a device that measures wind speed.

Precipitation: Precipitation is the term given to moisture that falls from the air to the ground. Precipitation is simply any water form that falls to the Earth from overhead cloud formations. Precipitation is water in all of its forms, which is generated when water vapour condenses into a solid form and falls to the earth when it gets too heavy to remain suspended in the air. Rain, snow, hail, and grapple are all examples of precipitation. Evaporation and condensation are the primary causes of precipitation. A device named rain gauge is used to measures rainfall. It's simply a rain gauge that collects rain and calculates the amount that falls over a given period of time.

Visibility: The degree to which an item may be seen over a specific distance is measured by visibility. When circumstances such as mist, haze, fog, and freezing drizzle are present, this measurement is critical since visibility can be significantly hampered. The necessity of being able to quantify this factor is sometimes overlooked. It's especially useful in environments where visibility is critical, such as airports and harbors, where it's literally a matter of life and death. The tools used to detect visibility include visibility sensors such as the "forward scatter sensor."

Clouds (Type & Cover): Clouds are water droplets or water in various forms (such as ice and snow crystals) that develop when water vapour reaches a point where it can no longer continue in a gaseous state. When analysing weather conditions with just visual references, knowing how to recognize a specific type of cloud and the weather connected with it may be quite useful.

Cloud Measurement Instrument: Weather satellites and radars are modern devices that meteorologists employ to analyse clouds in depth. Cloud density, moisture content, temperature, and movement may all be reliably measured using satellite and radar imagery.

Duration of the sun: The amount of time the Earth's surface is directly exposed to solar radiation is known as sunshine duration. It's also known as sunshine hours, and it's a measurement of how much sun you get in a certain length of time (generally in hours per day or year). As previously said, solar duration has an impact on other meteorological factors, which can alter the overall makeup of the weather. Because of this, it is a far more powerful and influential force than you may assume.

Sunshine-Measuring Instrument: Sunshine recorders, more precisely Campbell–Stokes recorders, are equipment that are used to record the length of time that the sun is visible. Campbell–Stokes recorders are made up of a spherical lens that focuses sunlight on a certain type of tape to determine its length.

Climate is influenced by a variety of factors such as temperature, humidity, and precipitation in different parts of the world. People that live in various climates have diverse lifestyles as a result of these variances. Let us analyse the reasons that produce differences in the climate of a location or an area to better comprehend varied climatic conditions. Distance from the Equator, is also known as latitude.

1.4. FACTORS AFFECTING CLIMATE

Different regions of the world have differences in temperature, humidity and precipitation. These differences influence the lifestyle of the people living under different climatic conditions. To understand different climatic conditions, let us discuss the factors which cause the variations in the climate of a place or a region.

Latitude or Distance from the Equator: The areas closest to the equator are warmer than those further away. Because the sun's rays fall vertically on the equator and slantingly in the temperate and polar areas, this is the case the vertical rays have a smaller area of focus than the slanting ones. Before reaching the earth's surface, vertical rays travel a shorter distance through the atmosphere. As a result, the greater the temperature, the lower the latitude, and vice versa. Malaysia, which is close to the equator, is warmer than England, which is distant from the equator.

Altitude or the Height from the mean sea level: The height above mean sea level is known as altitude. Mountains are known to be colder than the lowlands. Shimla, which is at a higher elevation, is colder than Jalandhar, despite the fact that they are virtually on the same latitude. The temperature drops as the elevation of a location rises. The average temperature drops by 1 degree Celsius for every 165 metres climbed vertically.

Distance from the Sea: Water is a poor heat conductor, which means that it takes longer to heat and cool. Because to the seas cooling influence, locations along the coast have a narrow temperature range and high humidity. The sea does not have a moderating influence on regions in the heart of the continent. Extreme temperatures can be found in these areas. The diurnal (daily) and yearly temperature ranges are wider in regions distant from the sea. Mumbai has a lower temperature and more rainfall than Nagpur, despite the fact that they are virtually on the same latitude.

The Prevailing Winds' Nature: On-shore winds carry moisture from the sea shore, resulting in rain in the region they pass through. The dry off-shore breezes that blow from the land aid in evaporation. The on-shore summer monsoon winds in India bring rain, whilst the off-shore winter monsoon winds are mostly dry.

Coverage of Clouds: Because of the scorching daytime sunlight in locations with a typically cloudless sky, such as deserts, temperatures are quite high even in the shade. This heat rapidly radiates back from the earth at night. As a result, there is a significant temperature difference between the hours of the day and the hours of the night. In Thiruvananthapuram, the temperature range is modest due to gloomy skies and heavy rain.

Currents in the Ocean: Ocean waters flow from one location to another in part to equalize water temperature and density. Ocean currents are massive flows of water that generally occur from a warm to a colder location or vice versa. Warm ocean currents boost the shore's temperature and occasionally bring rain, while cold currents reduce the temperature and cause fog along the coast.

Even in the winter, Port Bergen in Norway is ice-free because to the warm North Atlantic Drift, but Port Quebec in Canada remains frozen due to the cooling impact of the Cold Labrador Current, despite being at a considerably lower latitude than Port Bergen. Warm air is carried to the interior by on-shore winds passing over a warm current, raising the temperature of inland places. Winds sweeping over cold currents, meanwhile, transport chilly air to the interior, resulting in fog and mist.

Check your progress

Note :(a) Space is given below for writing your answer
(b) Compare your answer with the one given at the end of this unit.

1. What are Ocean Currents?

Mountain Chains' Direction

The mountain ranges function as a natural wind barrier. After impacting the mountain, the on-shore moisture-laden winds are forced to climb, resulting in heavy rainfall on the windward side.

The leeward side of the wind causes relatively little rainfall. The Himalayas block moisture-laden monsoon winds from reaching Tibet. This mountain range also prevents icy arctic winds from entering India. This is why the northern plains of India receive rains whereas Tibet stays in a constant rain shadow, receiving less rainfall.

The Aspect and the Slope

Because the heat is concentrated more on the gentler slope, the temperature of the air above them rises. The temperature is lowered by its decreased concentration in steeper slopes. Mountain slopes facing the sun, on the other hand, are warmer than those facing away from the sun's beams. The Himalayan southern slopes are warmer than the northern slopes.

The Soil and Vegetation Cover's Nature

The texture, structure, and composition of soil determine its nature. These characteristics differ from one soil to the next. Stony or sandy soils transport heat well, but black clay soils readily absorb the heat of the sun's rays. The heat is easily reradiated by the naked surface. The deserts are hot during the day and freezing cold at night. In comparison to non-forested regions, forest areas have a reduced temperature variation throughout the year.

1.5 SUMMARY

The chapter Significance of climate explains the difference between weather and climate. The hourly change in the elements like temperature, humidity, pressure, wind direction, humidity, precipitation etc., are called as elements of weather. The short term changes in these elements which occur in a few hours are called weather changes. The average of long term changes in these elements of at least tens of years are called climate. Climatology is study of Earth's climate and its elements for over 30 years. The study of climatology is essential as helps to predict future climatic conditions. It says that elements of weather are- temperature, air pressure, wind, humidity, visibility, clouds, duration of the sun, sunshine, and the factors affecting climate are - altitude, relation of sea, prevailing winds nature, coverage of clouds, and ocean currents, mountain chains, aspect and slope, and vegetation.

1.6 CHECK YOUR PROGRESS-MODEL ANSWERS

1. A .The average weather conditions in a location for a long period of time is called climate.

Significance of climate:

Climatology is essential because it aids in the prediction of future climatic conditions. The chance of snow and hail reaching the surface may be determined using latitude. You can also determine how much solar thermal energy is available in a certain area. Climatology is the scientific study of climates, which is defined as the average weather conditions across time. It is a subfield of atmospheric sciences that considers the variables and averages of short- and long-term weather situations.

2. What are ocean currents? (50 words)

Ocean waters flow from one location to another in part to equalize water temperature and density. Ocean currents are massive flows of water that generally occur from a warm to a colder location or vice versa.

1.7 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. Discuss any two types of weather elements in detail.

II. Answer the following questions in about 10 lines

1. What are the element3s of weather?
2. Explain about humidity

1.8 FURTHER READINGS

Critchfield, H.J., 1997. General Climatology, Prentice Hall of India Pvt. Ltd, New Delhi.

T. Trewartha, G., Introduction to Weather and Climate.

Strahler, A.H. and Strahler, A.N., 1992. Modern Physical Geography, John Wiley and Sons, Inc.

Climatology by D S Lal

Climatology by Savindra Singh.

UNIT-2 : COMPOSITION AND STRUCTURE OF THE ATMOSPHERE

Contents

2.0 OBJECTIVES

After reading this unit you will be able to;

- Know the different layers of Atmosphere
- Understand the Composition of different atmospheric layer and their Functions
- Explore the Utility of different layers of atmosphere

2.1 INTRODUCTION

Air is the most important element that contributes to life on earth. Almost Every organism on earth needs air to survive. This makes a strong reason for us to understand what air is and what it constitutes.

What is the definition of atmosphere?

We all know that the presence of life on Earth makes it a unique planet. One of the basic prerequisites for life on this planet is the presence of air. The air is a combination of several gases that surrounds the planet on all sides. The atmosphere is the air that surrounds the world.

The air that surrounds the world is known as the atmosphere. The atmosphere is made up of a variety of gases. It includes gases that give life to people and animals, as well as carbon dioxide for plants. It completely envelops the world and is kept in place by the earth's gravity. It aids in the prevention of damaging UV radiation and the maintenance of the proper temperature required for life. In general, the atmosphere extends up to 1600 kilometres above the earth's surface. However, 99 percent of the entire mass of the atmosphere is made up of water vapour.

2.2 COMPOSITION OF ATMOSPHERE

Different gases, water vapour, and dust particles make the most of the atmosphere. The atmosphere's composition is dynamic, changing with the passage of time and location. The atmosphere is made up of a variety of gases. The Earth's atmosphere is composed primarily of nitrogen and oxygen, as well as some argon. There are also several other trace gases, meaning they occur in very small amounts. The nitrogen and oxygen together constitute 99 percent of the atmosphere. The remaining gases in the atmosphere include argon, carbon dioxide, neon, helium, hydrogen, and others.

However, industrial and other technological human activities (such as automobile traffic) have begun to increase the amounts of materials such as CO_2 by amounts that are beginning to make a difference in the balance of circulation and radiation absorption in the troposphere. Effects of these changes range from local atmospheric problems, like smog, to problems of much greater scale, such as global climate change. The proportion of gases fluctuates in the upper layers of the atmosphere to the point where oxygen is virtually non-existent at altitudes of 120 km. Carbon dioxide and water vapour are also only present up to 90 kilometres from the earth's surface.

Nitrogen - 78% - Dilutes oxygen and prevents rapid burning at the earth's surface. Living things need it to make proteins. Nitrogen cannot be used directly from the air. The Nitrogen Cycle is nature's way of supplying the needed nitrogen for living things.

Oxygen - 21% - Used by all living things. Essential for respiration. It is necessary for combustion or burning. Argon - 0.9% - Used in light bulbs.

Carbon Dioxide - 0.03% - Plants use it to make oxygen. Acts as a blanket and prevents the escape of heat into outer space. Scientists are afraid that the burning of fossil fuels such as coal and oil are adding more carbon dioxide to the atmosphere.

Water Vapor - 0.0 to 4.0% - Essential for life processes. Also prevents heat loss from the earth.

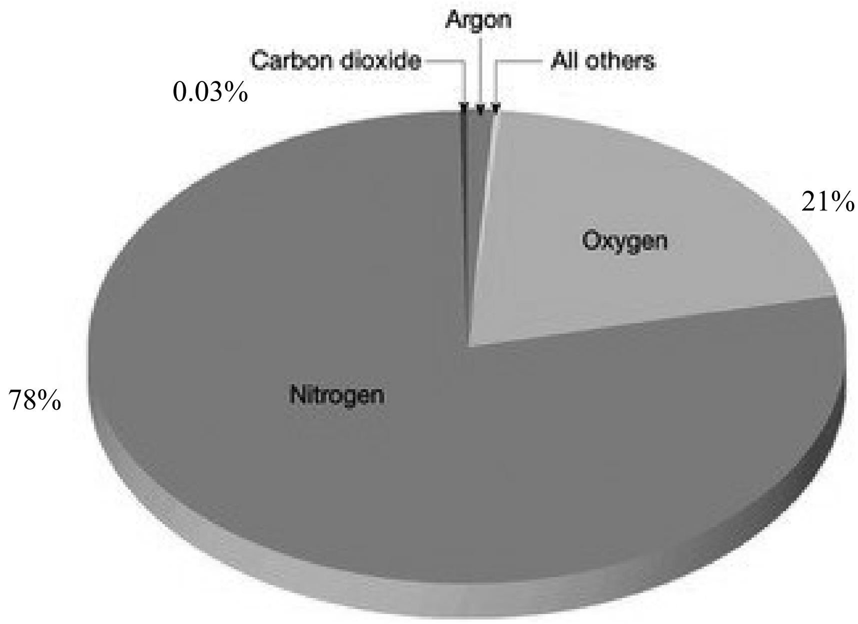
Trace gases - gases found only in very small amounts. They include neon, helium, krypton, and xenon.

Oxygen: Of all the gases Oxygen is very important, because it is very essential for all living beings without this no life is possible. It combines with all other elements to form different compounds, it also very important in combustion process, when any substance burns, oxygen is consumed. It constitutes nearly .one fifth of the atmosphere

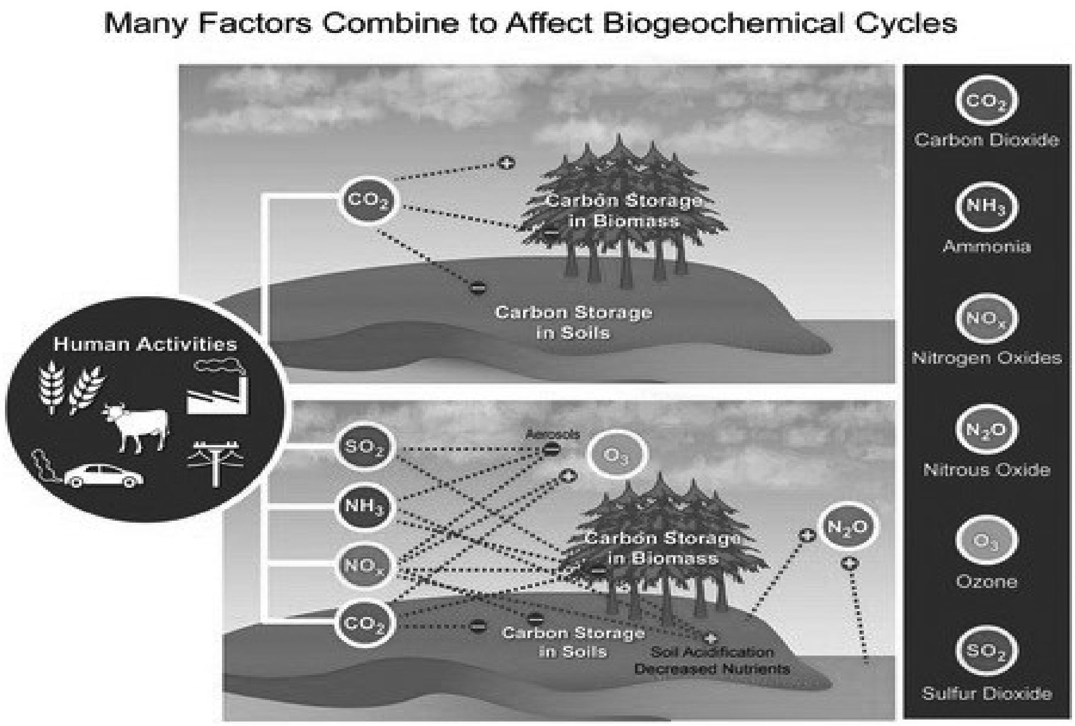
Nitrogen: It is very important gas which constitutes 78 percent of the atmosphere. Though it is relatively inactive chemically, but serves as a diluent. Main function in the atmosphere is to regulate combustion by diluting oxygen and indirectly helps in oxidation of different kinds.

Carbon dioxide: Carbon dioxide is a very essential gas in meteorology. It is transparent to incoming solar energy. It absorbs some of the terrestrial radiation and reflects some of it back to the earth's surface. The greenhouse effect is mostly caused by carbon dioxide. When the amount of other gases in the atmosphere remains constant, the volume of carbon dioxide in the atmosphere has risen in recent decades, owing mostly to the combustion of fossil fuels. The fundamental cause of global warming is the increase in carbon dioxide levels.

Ozone gas: Another essential component of the atmosphere is ozone, which is found mostly between 10 and 50 kilometres above the earth's surface. It works as a filter, absorbing the sun's ultra-violet radiation and preventing them from reaching the earth's surface. The amount of ozone gas in the atmosphere is quite small, and it is restricted to the stratosphere's ozone layer.



Water Vapour: Water vapour refers to a gaseous form of water found in the atmosphere. It is a major generator of precipitation in all forms. With increasing altitude, the amount of water vapour is reduced. It decreases from equator to poles, that is, it decreases from low latitudes to higher latitudes. Its greatest level in the atmosphere, which is found in warm and moist places, might be as high as 4%. Through evaporation and transpiration, water vapour enters the atmosphere. Oceans, seas, rivers, ponds, and lakes evaporate, whereas plants, trees, and living creatures transpire. Water vapour absorbs a portion of the sun's incoming solar energy (insolation) and retains the heat released by the earth. As a result, it works as a blanket, preventing the ground from being excessively hot or cold. The stability and instability of the air are also influenced by water vapour.



Most scientists believe that human activity is altering the composition of the atmosphere by increasing the concentration of greenhouse gases (GHGs). The recent attention given to the greenhouse effect and global warming is based on the recorded increases in concentrations of some of the greenhouse gases due to human activity. Of particular interest are water vapor, carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and ozone. With the exception of chlorofluorocarbons, all of these gases occur naturally and are also produced by human activity.

Check your progress

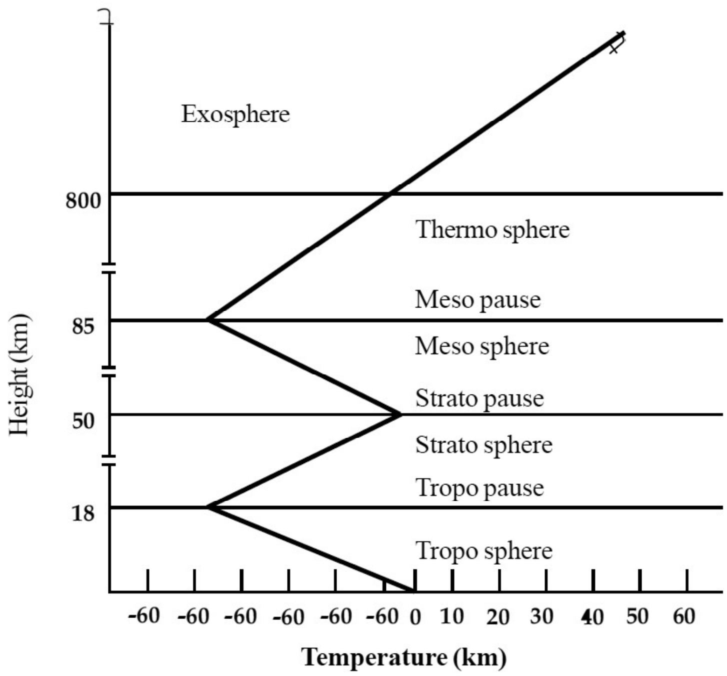
Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. Write few words about the composition of atmosphere.

2.3 STRUCTURE OF THE ATMOSPHERE

The atmosphere consists of five layers according to the difference of temperatures and density. They are; the troposphere, the stratosphere, the mesosphere, the thermosphere (ionosphere), and the exosphere. The thickness of these layers is slightly different around the globe, and also varies according to temperature and season. The troposphere and the stratosphere are the most affected by anthropogenic (or man-made) pollutants.



Troposphere:

1) It is the atmosphere's lowermost layer. On the equator, this layer is roughly 18 kilometres thick, while at the poles, it is about 8 kilometres thick. Because the air expands due to the heat and it is carried to vast heights by powerful convectional currents, so the troposphere layer is thickest at the equator.
2) Dust particles and water vapour are found in the troposphere.

3) This is the most significant layer of the atmosphere since it is only in this layer that all weather changes occur.

4) In this stratum, the air is never static. As a result, this layer is referred to as the ‘changing sphere’ or troposphere.

5) The temperature of the environment drops as the altitude of the atmosphere rises. It drops by 1 degree Celsius for every 165 metres gained in height. This is referred to as the Normal Lapse Rate.

6) Tropopause is the zone that separates the troposphere from the stratosphere.

7) The Tropopause air temperature is around – 80 degrees Celsius above the equator and around – 45 degrees Celsius in the poles. The temperature is essentially constant here, that is why it’s called the Tropopause.

Stratosphere:

1) Just above the troposphere lies the stratosphere. It reaches a height of 50 kilometres. Up to a height of 20 km, the temperature in the bottom section of this layer is nearly constant.

2) Following that, the temperature gradually rises as the height rises. The presence of ozone gas in the upper section of this layer raises the temperature.

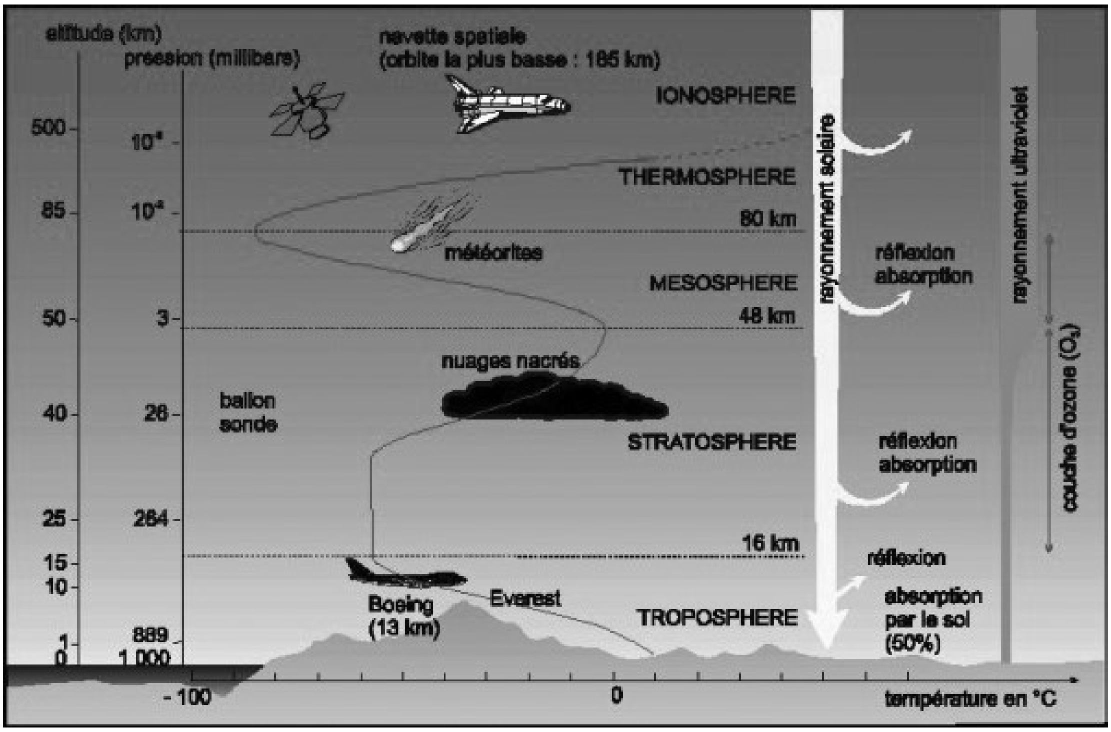
3) This layer does not have any weather-related occurrences. Here, the air is blown horizontally. As a result, this layer is thought to be excellent for aircraft flight.

4) The stratopause is the highest boundary of the stratosphere.

5) The presence of an ozone layer in the stratosphere is an essential aspect.

6) It is mostly found in the lower stratosphere, between 20 and 30 kilometres above the earth’s surface. In comparison to other sections of the atmosphere, it has a high concentration of ozone (O_3).

7) Most of the sun’s ultra-violet energy is absorbed by this area of the stratosphere.



Mesosphere:

1) It is the atmosphere's third layer, which extends into the stratosphere.
2) It reaches a height of 80 kilometres.
3) The temperature in this layer begins to drop as altitude rises, reaching - 100 degrees Celsius at an altitude of 80 kilometres.
4) This stratum is where meteors and falling stars can be found.
5) The menopause is the upper limit of the mesosphere.

Thermosphere:

1) Between 80 and 400 kilometres above the menopause, this layer may be found.
2) It is called the ionosphere because it includes electrically charged particles known as ions.
3) This layer reflects radio waves emitted from the earth back to the ground, allowing radio transmission to be feasible.
4) As you climb higher, the temperature begins to rise.

Exosphere:

1) Exosphere The exosphere is the atmosphere's highest layer.
2) Due to the lack of gravitational pull, gases are extremely scarce in this environment. As a result, the air density is quite low here.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

2. Write about the layer stratosphere.

Most clouds form in the troposphere and play an important role in the albedo effect of the planet. Albedo is a measure of the reflectivity of a surface. The albedo effect when applied to the Earth is a measure of how much of the Sun's energy is reflected back into space. More water vapour in the atmosphere means more cloud formation. More clouds lead to increased albedo of the earth.

Different parts of the Earth have different albedos. For example, ocean surfaces and rain forests have low albedos, which means that they reflect only a small portion of the sun's energy. Deserts, ice, and clouds, however, have high albedos; they reflect a large portion of the sun's energy. Over the whole surface of the Earth, about 30 percent of incoming solar energy is reflected back to space. Because a cloud usually has a higher albedo than the surface beneath it, the cloud reflects more shortwave radiation back to space than the surface would in the absence of the cloud, thus leaving less solar energy available to heat the surface and atmosphere.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

3. **Discuss the role of the albedo**.

2.4 SUMMARY

The air surrounding earth is called the atmosphere. It contains many gases such as oxygen, Nitrogen, carbon dioxide, ozone gas, water vapour and other inert gases. The structure of the atmosphere is divided into five layers. They are - troposphere, stratosphere, mesosphere, thermosphere, and exosphere. Troposphere is the atmosphere's lowest layer. On the equator, this layer is roughly 18 kilometres thick, while at the poles, it is about 8 kilometres thick. The second layer is the stratosphere reaching up to 50 kms, this also called as flight zone as air crafts fly in this zone as there are non-weather disturbances in this layer. The mesosphere is the third layer reaching up to 80 km of height and -100 degree Celsius. The penultimate layer is thermosphere at the height of 80-400 kms, it includes electrically charged particles called ions and so is also called the ionosphere. The exosphere is the last layer of the atmosphere.

2.5 CHECK YOUR PROGRESS-MODEL ANSWERS

1 Different gases, water vapour, and dust particles make the most of the atmosphere. The atmosphere's makeup is dynamic, changing with the passage of time and location. The atmosphere is made up of a variety of gases. The two primary gases in the atmosphere are nitrogen and oxygen, which together make up 99 percent of the atmosphere. The remaining gases in the atmosphere include argon, carbon dioxide, neon, helium, hydrogen, and others.

2. Just above the troposphere lies the stratosphere. It reaches a height of 50 kilometres. Up to a height of 20 km, the temperature in the bottom section of this layer is nearly constant. The temperature gradually rises as the height rises. The presence of ozone gas in the upper section of this layer raises the temperature. This layer does not have any weather-related occurrences. As a result, this layer is thought to be excellent for aircraft flight. The stratopause is the highest boundary of the stratosphere. The presence of an ozone layer in the stratosphere is an essential aspect. It is mostly found in the lower stratosphere, between 20 and 30 kilometres above the earth's surface.

3. Clouds have a major role in reflecting some of the Sun's radiation back into space. The proportion of incident radiation reflected by a substance is called its albedo. The albedo of low thick clouds such as stratocumulus is about 90 percent. The albedo of high thin clouds such as cirrus may be as low as 10 percent. The albedo could vary with the wavelength of the radiation, but for clouds it does not as evidenced by the fact that they are white under white light.

2.6 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. Write few words about structure of atmosphere?
2. Write about the Troposphere

II Answer the following questions in about 10 lines

1. What is Atmosphere?
2. Write a short note on Stratosphere

2.7 FURTHER READINGS

Critchfield, H.J., 1997. General Climatology, Prentice Hall of India Pvt. Ltd, New Delhi.

Ttrewartha, G., Introduction to Weather and Climate. Strahler, A.H. and Strahler, A. N., 1992.

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Climatology by Savidar Singh

UNIT-3: ATMOSPHERIC TEMPERATURE: INSOLATION AND GLOBAL ENERGY BUDGET

Contents

3.0 OBJECTIVES

After reading this unit you will be able to:

- Explain the heat and temperature and their relation
- Understand the concepts like Insolation, Radiation and Heat budget
- Explore the how heat balance is maintained on earth and the results of the disruption of the heat balance
- Know the concept of temperature and its effects
- Explain the Vertical and horizontal difference in temperature along the globe
- To identify the Effect of water body and landmasses on temperature
- To Build a Relation between seasonal changes, revolution and changes in temperature

3.1 INTRODUCTION

The sun provides almost all of the energy for the earth. The energy collected from the sun is radiated back to space by the earth. As a result, the earth does not warm up or cool down over time. As a result, the quantity of heat received by different places of the globe varies. Pressure changes in the atmosphere result from this variation. As a result, heat is transferred from one location to another via winds. This chapter describes the process of the atmosphere heating and cooling, as well as the temperature distribution over the earth's surface.

Have you ever thought why it is hot at the equator and tropics while it is freezing cold at poles? The definite answer anyone would give for this is that there is significant difference in temperature near the equator and at the poles. In this chapter we will study the possible factors that will affect the distribution of temperature.

The sun is the most powerful generator of heat. And the sun's heat is distributed differently over the globe, which is the ultimate cause of all climatic traits. As a result, knowing the patterns of temperature distribution in different seasons is crucial for understanding other climatic aspects such as wind systems, pressure systems, and precipitation, among others.

3.2 TEMPERATURE

The heat energy is measured by temperature. Temperature means the degree of hotness or coldness. Solar heating, which occurs from sunrise to sunset, regulates the Earth's surface temperature. During the day, the surface heats up, and at night, it cools down. Unusual wind occurrences, in which warm or cold air travels across the surface, are an exception to this rule. Surface temperature changes heat or cool the air above, causing air movement (wind). The sun supplies a surprisingly consistent flow of energy to the outer atmosphere, which scientists refer to as the solar constant.

The atmosphere absorbs, transmits, and scatters this flow, with the transmitted portion being reflected, absorbed, or dispersed. Because land heats quicker than water, solar heating of the Earth's surface is uneven, causing air to warm, expand, and rise over land while cooling and sinking over the colder ocean surface.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

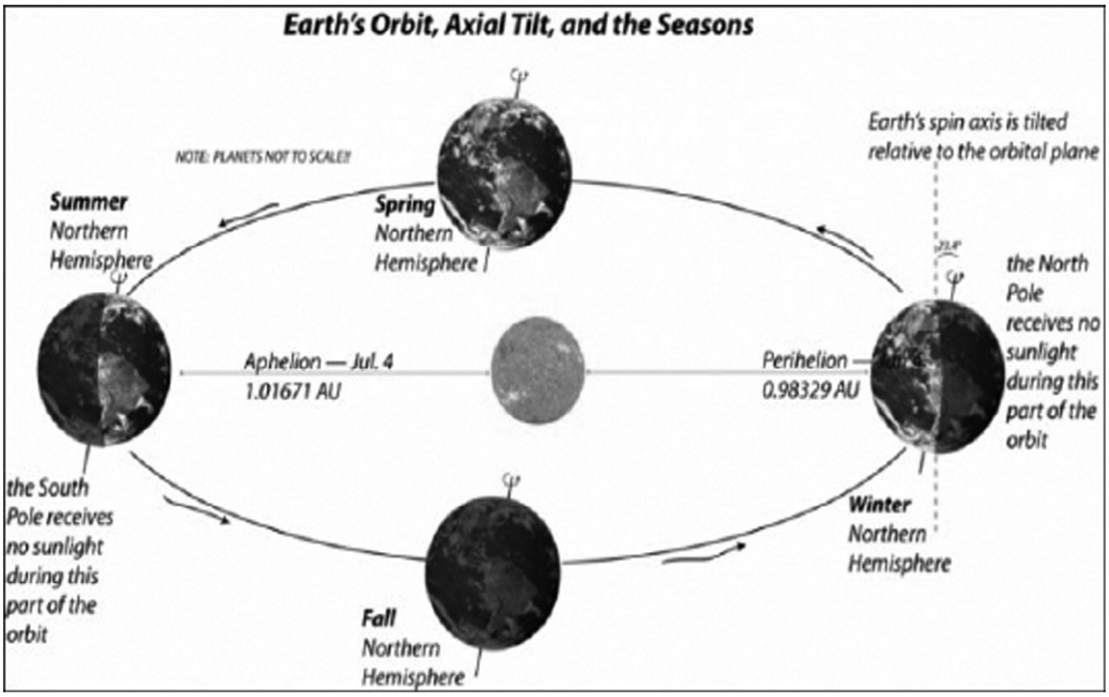
1. What is temperature

3.3 INSOLATION

It all starts with the Sun, where hydrogen fusion produces an enormous amount of energy and heats the surface to around 6000°K; the Sun then radiates this energy outwards in the form of ultraviolet and visible light, with a small amount in the near-infrared spectrum. By the time this energy reaches the Earth, its intensity will have to be dropped to around 1370 W/m^2 —this is commonly referred to as the solar constant (even though it is not truly constant — it varies on several timescales) — and the Earth only intercepts one out of every two billion parts of solar radiation.

The proportion of solar energy received or intercepted by the earth is known as insolation. Volcanoes, springs, and geysers transmit some of the heat from the core and mantle to the surface and ocean bottoms. However, when compared to the heat received from the sun, the heat absorbed at the surface from the earth's inwards is minimal. The Earth gets the Sun's radiation (heat) in the form of short electromagnetic waves. During the day, the earth absorbs short-wave radiation and reflects it back into space as long-wave radiation at night. The insolation is not uniform over the Earth's surface; it is concentrated at the equator due to the curvature of the planet.

However, because the Earth's spin axis is tilted by 23.4° relative to a line perpendicular to the Earth's orbital plane, insolation is concentrated in the northern hemisphere (summer in the northern hemisphere) and subsequently the southern hemisphere (winter in the southern hemisphere). Seasons are caused by the tilt of the spin axis, commonly known as the obliquity.



Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

2. Explain how seasons occurred?

3.4 HEAT BUDGET

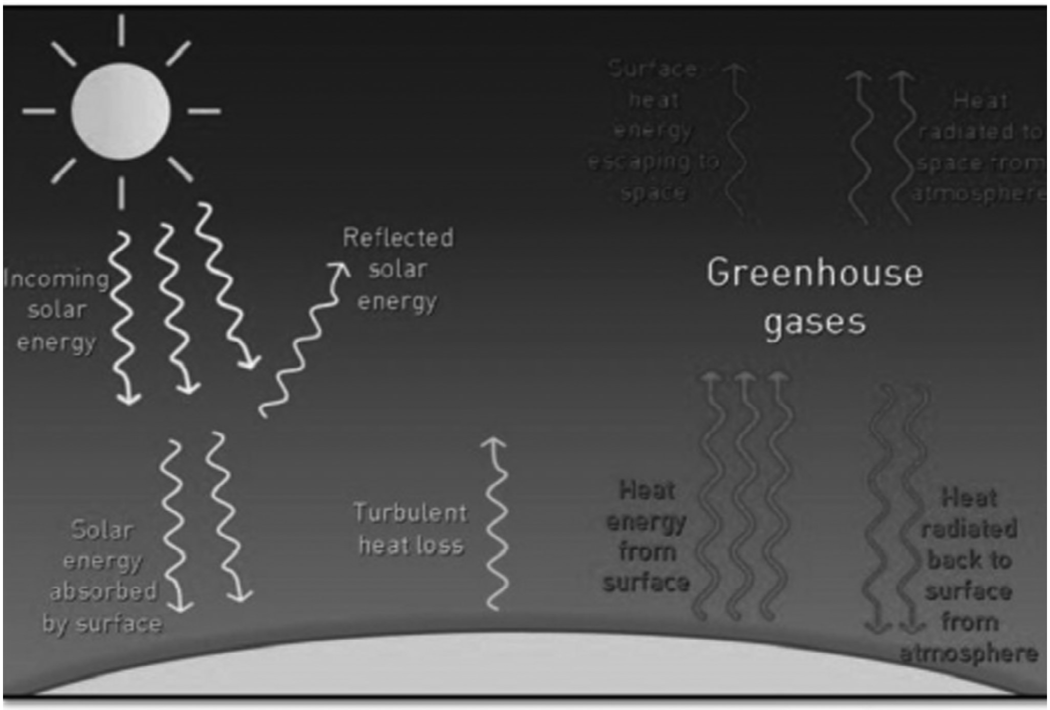
The earth gets a certain amount of insolation (short waves) and then radiates heat back into space through terrestrial radiation (long wave radiation). The planet maintains a steady temperature via this give and take, or heat budget. The first rule of thermodynamics, generally known as the law of conservation of energy, governs the Earth's energy balance. Energy can be transported from one system to another, but it cannot be generated or destroyed, according to this rule of thermodynamics. As a result, any energy "lost" during one phase will be offset by energy "gained" during the next. Many components are involved in the energy movements and storage in and between each of the Earth's subsystems.

Each of these components reflects either the planet's input of radiation (solar heating), its output (infrared cooling), heat storage or release within the climate system (evaporation, condensation, melting, and freezing), or heat movement from one area of the climate system to another (wind and ocean currents). These processes act as the climate system's driving factors when combined. The distribution of solar radiation entering and leaving the Earth provides the majority of the total energy available to drive all climatic processes. All of the sun's energy that enters Earth's atmosphere must eventually be returned back to space in order to maintain a steady global average temperature. This is made possible by the Earth's energy balance.

About half of the solar energy entering the atmosphere is absorbed by the Earth's surface (land and seas), 30% is reflected back to space by clouds, the Earth's surface, and other gases and particles in the atmosphere, and 20% is absorbed by the atmosphere and clouds.

Warming is caused by the absorption of 70% of the sun's energy by the surface, clouds, and atmosphere. Any item or gas with a temperature emits radiation that is reradiated back into space as long-wave radiation is 24 hours a day. The majority of the energy released by the earth's surface does not go into space. Clouds and gases in the atmosphere absorb the energy that is released.

Convection redistributes some of the energy, while condensation releases even more into the environment. The greenhouse gases, such as methane, nitrous oxide, ozone, carbon dioxide, and water vapour, absorb the bulk of the energy. These gases continuously reflect the sun's energy back into the atmosphere, maintaining a livable temperature on Earth. The majority of the energy eventually returns to space, and the Earth's energy balance is maintained.



A simplified diagram of Earth's energy budget

Some solar energy is absorbed, some is dispersed, and some is transported straight to lower layers of the atmosphere as it reaches the Earth. Within the atmosphere, absorption, scattering, and transmission are not evenly distributed. Depending on the wavelengths of the transmitted energy, a range of molecules, particles, or surface characteristics absorb, transmit, or scatter radiation at very varied energy levels.

Radiation is scattered by molecules. The degree of scattering is determined by the particle's properties, distance, and wavelength (size, shape, density). In comparison to the wavelengths of most sunlight, the molecules that make up the gases in the atmosphere are all relatively tiny. As a result, Rayleigh scattering causes shorter wavelength light to disperse more efficiently than longer wavelength radiation. During the day, the dispersion of sunlight by the numerous small molecules of the Earth's atmosphere favor's shorter wavelengths, such as blue light, which is why the sky looks blue.

The scattering effectiveness of significantly bigger particles in air aerosols, such as dirt, dust, or sulfuric acid, is much more equally spread over visible wavelengths. Back scattering occurs when a portion of the incoming solar energy is dispersed back, or reflected to space, as a result of scattering from clouds and dust.

Albedo, which is another word for reflectivity, affects how much sunlight will be absorbed and warm the surface as compared to a surface that reflects most of the light and maintains the same temperature. Something that seems white reflects the majority of the light it receives, whereas something that appears black absorbs the majority of the light it receives, suggesting a low albedo. The atmosphere's gases and particles allow around half of the sun's radiation to reach the Earth's surface. However, not all of it makes it to the surface without interruption.

On a foggy day, much of it comes in the form of diffuse radiation, which has been scattered by air particles and molecules. Roughly a third of the total radiant energy from the Sun reaches the Earth surface without being scattered, and about a quarter of it reaches the surface as diffuse radiation.

About 85% of the entire quantity is absorbed at the surface. Over a dark surface like the seas, more than 90% of the light is absorbed. This absorbed heat is utilized to evaporate water in the oceans or in particularly moist, vegetated regions.40-80 percent of light is reflected off bright surfaces like deserts and snowfields. In deserts, for example, just 1% of the absorbed energy is used to evaporate water; the rest is merely used to warm the surface.

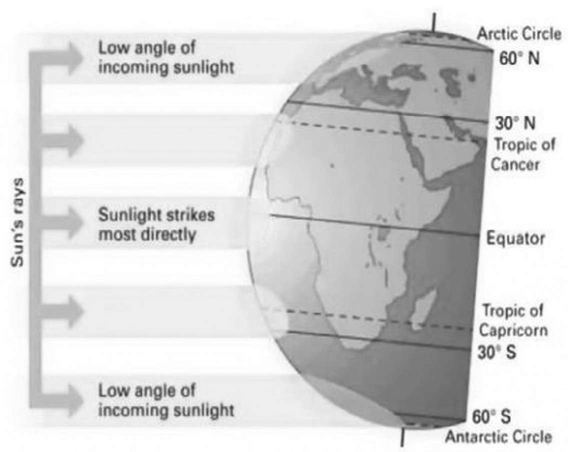
3.5 TEMPERATURE DISTRIBUTION IN THE HORIZONTAL PLANE

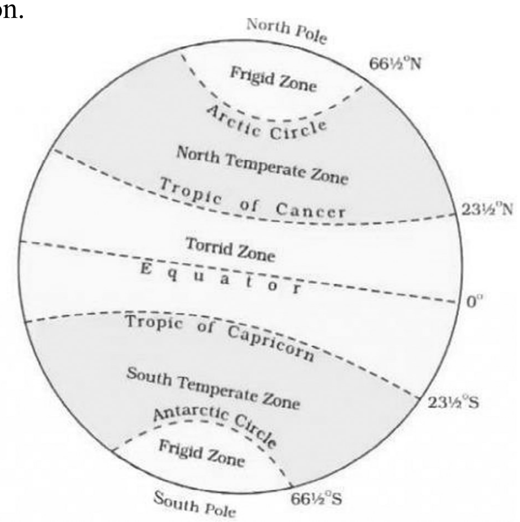
The horizontal distribution of temperatures refers to the temperature dispersion across latitude on the Earth's surface. Isotherms depict the horizontal distribution of temperature on Earth. Isotherms are points on a line that have the same temperature. When looking at the isotherm map, it's clear that the horizontal temperature distribution is unequal.

The following are some of the elements that influence temperature distribution:

The angle of incidence, or the sun's rays' Duration of exposure to sun

The amount of heat received varies depending on whether it is day or night, whether the sky is clear or cloudy, if it is summer or winter, and so on.





Atmosphere & Transparency

Transparency is affected by aerosols (smoke, sand), dust, water vapour, clouds, and other factors. Radiation scattering occurs when the wavelength (X) of the radiation exceeds the radius of the obstructing particle (such as a gas). Total reflection occurs when the wavelength of the obstructing particle (such as a dust particle) is shorter than the wavelength of the obstructing particle. If the blocking particles are water vapour, ozone molecules, carbon dioxide molecules, or clouds, solar radiation is absorbed. The majority of the light that reaches Earth is dispersed light.

Differential land and water heating

The albedo of land is substantially higher than that of oceans and other bodies of water. Snow-covered regions, in particular, can reflect up to 90% of insolation. The average penetration of sunlight is higher in water (up to 20 metres) than on land (up to 1 metre). As a result, land cools or heats up more quickly than seas. The continual convection cycle in seas aids heat transmission across strata, reducing diurnal and yearly temperature variations. (Learn more about ocean salinity and temperature dispersion) Because water's specific heat is 2.5 times that of landmass, it takes longer for it to heat up and cool down.

Prevailing Winds

Heat is transferred from one latitude to another by winds. They also aid in the transfer of heat from land to water. Oceanic winds have the ability to transport the sea's cooling impact to coastal locations, resulting in cool summers and warm winters. Only on the windward side does this impact become noticeable (the side which is facing the ocean). The sea's moderating impact is not felt on the leeward side or in the interiors, resulting in temperature extremes.

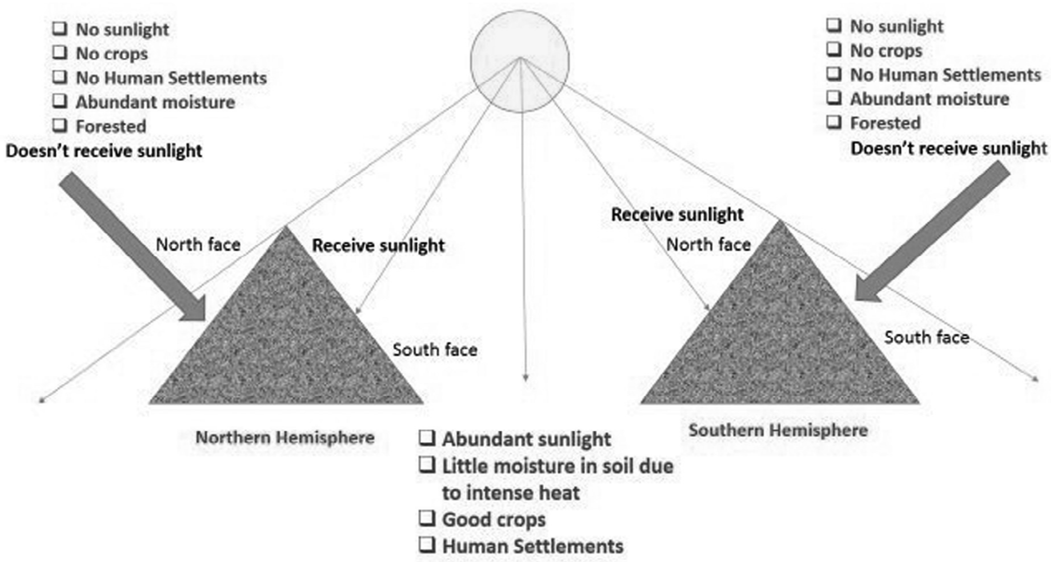
Slope and its Aspects

The amount of solar energy received locally is determined by the slope's direction and angle. Slopes that are more exposed to the sun get more solar radiation than those that are not.

Slopes that get direct sunlight are dry because moisture is lost through evaporation. If irrigational facilities are not available, these hillsides would stay barren. However, because of the ample sunshine available, slopes with adequate irrigational facilities are suitable for agricultural. Human settlements are densely populated on these islands. Slopes with little direct sunlight are typically well-forested.

Currents in the ocean

The temperature of neighbouring land regions is greatly influenced by ocean currents.



Altitude

As one rises in altitude, the pressure reduces, the influence of greenhouse gases lessens, and therefore the temperature drops (applicable only to troposphere). For every 165 metres of altitude, the usual lapse rate is around 1 degrees Celsius.

The Earth's Distance from the Sun

The earth is the furthest away from the sun during its rotation around the planet (152 million km on 4th July). This is referred to as the earth's position. The earth gets closest to the sun on January 3rd (147 million km). As a result, the yearly insolation received by the earth on the 3rd of January is somewhat higher than on the 4th of July. However, other variables like land and sea distribution and air circulation hide the influence of this change in solar output. As a result, variations in solar output have little impact on daily weather fluctuations on the earth's surface.

Vertical distribution of Temperature

The temperature in the troposphere drops as you climb higher in altitude, but the pace at which it drops varies with the seasons. The vertical temperature gradient, also known as the normal lapse rate, is 1000 times greater than the horizontal lapse rate. The fact that the atmosphere receives heat from the Earth surface via conduction, radiation, and convection is demonstrated by the temperature drop upward in the atmosphere. As a result, it is self-evident that the air temperature falls as the distance from the Earth's surface (the source of direct heat energy to the atmosphere) increases (i.e. as the altitude increases).

Temperature Distribution around the Globe

The temperature distribution for the months of January and July may be used to understand the worldwide temperature distribution. Isotherms are commonly used to depict temperature dispersion on a map. Isotherms are lines that connect points of equal temperature.

The effects of latitude are often well depicted on the map, as isotherms are generally parallel to latitudes. The departure trend is more common in January than in July, particularly in the northern hemisphere. The northern hemisphere has a far bigger land surface than the southern hemisphere. As a result, the influence of land masses and ocean currents may be seen clearly.

3.5.1 Temperature Distribution in January

In January, the Northern Hemisphere experiences winter, while the Southern Hemisphere experiences summer. Because the westerly may bring high temperatures onto landmasses, the western borders of continents are substantially higher in January than their eastern equivalents. The temperature gradient is substantially closer to continents' eastern edges. In the southern hemisphere, the isotherms show more consistent behaviour.

3.5.2 Temperature Distribution in July

In the Southern Hemisphere, July is winter, but in the Northern Hemisphere, it is summer. The behaviour of the isotherm is the polar opposite of what it was in January. In July, the isotherms are mostly parallel to the latitudes, warmer than 27 degrees Celsius has been recorded in the tropical waters. In the subtropical continent region of Asia, at the 30 ° N latitude, temperatures of more than 30 degrees Celsius are observed across the land.

3.6 INVERSION OF THE TEMPERATURE

Temperature inversion, also known as thermal inversion, is a reversal of typical temperature behaviour in the troposphere (the part of the atmosphere closest to the Earth's surface) in which a layer of chilly air at the surface is overlain by a layer of warmer air. (Under normal circumstances, air temperature drops as one rises.) Cloud formation, precipitation, and visibility are all influenced by inversions. The upward movement of air from the layers below is slowed by an inversion. As a result, convection caused by below-inversion heating is restricted to levels below the inversion. Dust, smoke, and other air pollutants are also limited in their spread.

Convective clouds cannot develop high enough to create showers in places where a substantial low-level inversion exists, and vision below the inversion may be considerably impaired, even in the absence of clouds, due to the buildup of dust and smoke particles. Fog is typically prevalent towards the base of an inversion because the air is cold. Diurnal changes in air temperature are also affected by inversions. During the day, air is heated mostly through contact with a land surface that has been heated by the Sun's radiation. Conduction and convection transport heat from the earth to the air.

Because an inversion normally controls the higher level to which heat is transferred by convection, if the inversion is low and large, only a shallow layer of air will be heated, and the temperature rise will be significant.

Temperature Inversion - Ideal Conditions

Long nights, resulting in more outgoing radiation than incoming radiation. Clear sky allow for unrestricted radiation escape. There is no vertical mixing at lower elevations because the air is calm and steady.

Types of Temperature inversion

Ground, turbulence, subsidence, air drainage, and frontal inversions are the five types of inversions.

Ground inversion: When air is cooled by contact with a colder surface, it becomes cooler than the surrounding atmosphere; this happens most commonly on clear nights, when the ground cools off quickly due to radiation. Fog can form when the temperature of the surface air falls below the dew point.

The degree of ground inversions is largely influenced by topography. If the terrain is hilly or rolling, the cold air created on the higher land surfaces drains into the hollows, resulting in a greater and thicker inversion above low ground and little or no inversion above higher heights.

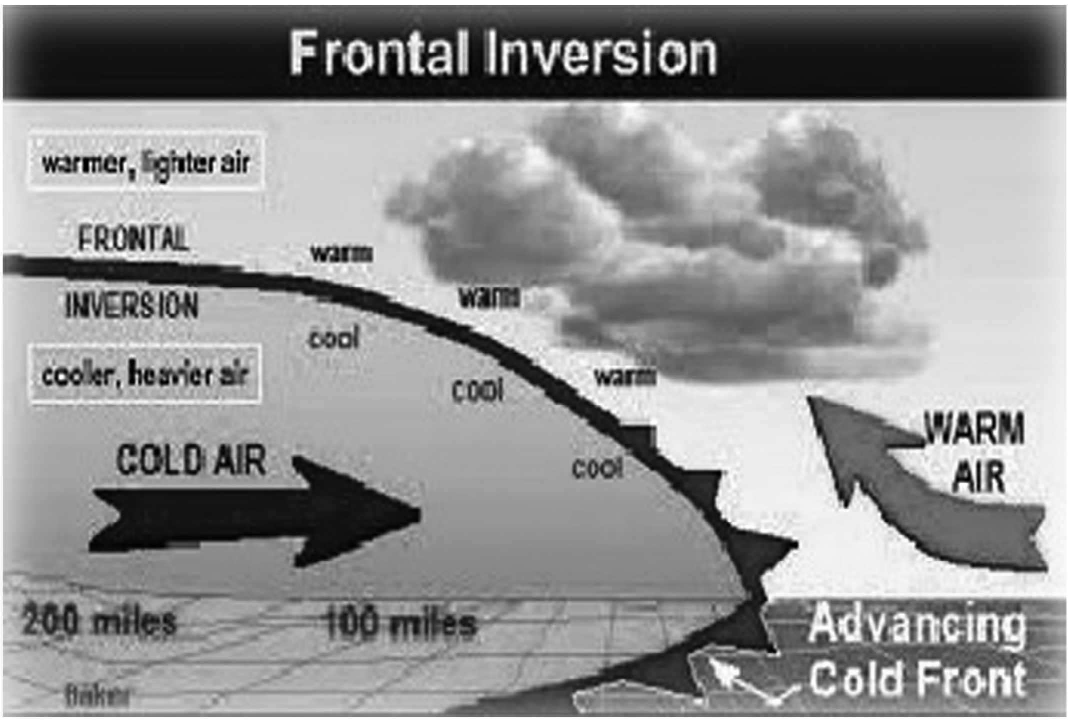
Turbulence inversion: When quite air (motionless) overlies turbulent air, a turbulence inversion occurs. Vertical mixing inside the turbulent layer transports heat downward and cools the top layer. The unmixed air above does not cool, and it ultimately becomes warmer than the air below, resulting in an inversion.

Subsidence Inversion: When a large layer of air falls, it creates a subsidence inversion. As a result of the increased air pressure, the layer is compressed and heated, and the lapse rate of temperature is lowered. When an air mass dips low enough, the air at higher elevations becomes warmer than the air at lower elevations, resulting in a temperature inversion.

In the winter, subsidence inversions are widespread across the northern continents and the subtropical oceans; these locations contain sinking air due to their proximity to huge high-pressure centres.

Air drainage types of inversion: With elevation, the temperature in the lower layers of the air can sometimes increase rather than decrease. This is a regular occurrence on a sloping terrain. The surface here rapidly radiates heat back to space and cools down quicker than the top layers. The lower cold layers condense and become heavier as a result. Because of the sloping surface underneath them, they gravitate to the bottom, where the cold layer settles as a low-temperature zone, while the top layers are somewhat warmer. Temperature Inversion is a circumstance in which the vertical distribution of temperature is the polar opposite of the typical vertical distribution. In other words, during a temperature inversion, the vertical temperature is inverted. In the middle and upper latitudes, this type of temperature inversion is particularly powerful. It may also be powerful in areas with steep mountains or deep valleys.

Frontal inversion: When a cold air mass undercuts a warm air mass and lifts it, a frontal inversion occurs; the front between the two air masses then has warm air above and cold air below. This type of inversion has a steeper slope than others, which are virtually level. Furthermore, humidity levels may be high, and clouds may be present just above it.



3.7 SUMMARY

It is evident that sun provides the energy needed on earth. The incoming energy from sun on earth is called insolation. This heat energy is measured in form of temperature. The heat is received in various parts of earth is different and this difference in heat energy is transferred from one place to another via winds. The earth receives heat energy in the form of short wave radiation and radiates back into space through terrestrial radiation in the form of long wave radiation. The cycle to maintain balance the heat on earth, thus it is called heat budget. If the transparency of the atmosphere is more, then more energy is absorbed by the earth surface. The temperature on the coastal areas are comparatively less than that of the land locked areas as the coastal area temperature is moderated by the presence of sea. The slopes that get direct sunlight get more solar radiation. It is also seen that as one rises in altitude the pressure reduces, the greenhouse gases reduce and the temperature drops, this is called normal lapse rate. The normal lapse rate is usually around a drop of 1 degree Celsius for every 165 mts increase in height. As you climb higher in the atmosphere the temperature drops. In January the northern hemisphere experiences winter while the southern hemisphere experiences summer and vice versa. The reversal of the normal lapse rate condition is called inversion of temperature, this usually witnessed in valley areas. The temperature inversion can be of many types like ground inversion, turbulence inversion, subsidence inversion, and frontal inversion.

3.8 CHECK YOUR PROGRESS-MODEL ANSWERS

1. What is temperature: The heat energy is measured by temperature. Temperature means the degree of hotness or coldness. Solar heating, which occurs from sunrise to sunset, regulates the Earth's surface temperature.

2. Because the Earth's spin axis is tilted by 23.4° relative to a line perpendicular to the Earth's orbital plane, insolation is concentrated in the northern hemisphere (summer in the northern hemisphere) and subsequently the southern hemisphere (winter in the southern hemisphere) (winter in the northern hemisphere). Seasons are caused by the tilt of the spin axis, commonly known as the obliquity.

3.9 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1 Explain the distribution of temperature around the globe in January and July.

2. Explain any two type's temperature inversion and its ideal conditions

II Answer the following questions in about 10 lines

1. Explain the temperature Inversion?
2. Write a short note on Heat Budget?
3. What is Albedo?

3.10 FURTHER READINGS

Critchfield, H.J., 1997. General Climatology, Prentice Hall of India Pvt. Ltd, New Delhi.

Ttrewartha, G., Introduction to Weather and Climate. Strahler, A.H. and Strahler, A. N., 1992.

Modern Physical Geography, John Wiley and Sons, Inc.

Climatology by D S Lal

Climatology by Savidar Singh

UNIT- 4: ATMOSPHERIC HUMIDITY: EVAPORATION, CONDENSATION AND HYDROLOGICAL CYCLE

Contents

4.0 OBJECTIVES

After reading this unit you will be able to:

- Explain the Significance of atmosphere
- Explain the Hydrological cycle happening in the Atmosphere
- Explain the humidity and it's types
- Understand the different types of precipitation and rainfall

4.1 INTRODUCTION

Atmospheric humidity, which is the amount of water vapour or moisture in the air, is another leading climatic element, as is precipitation. All forms of precipitation, including drizzle, rain, snow, ice crystals, and hail, are produced as a result of the condensation of atmospheric moisture that forms clouds in which some of the particles, by growth and aggregation, attain sufficient size to fall from the clouds and reach the ground.

We all know that there is water vapour in the air it ranges from 0% to 4% of the atmosphere's volume and has a significant impact in meteorological occurrences. Water exists in three states in the atmosphere: gaseous, liquid, and solid. Evaporation from water bodies and transpiration from plants are the sources of moisture in the atmosphere. Thus, there is a continuous exchange of water between the atmosphere, the oceans and the continents through the processes of evaporation, transpiration, Condensation and precipitation. The water vapour form a cycle of circulation in the atmosphere from one form to another and from one sphere to other. In this chapter we'll study about the presence of water vapour in atmosphere and the humidity which is caused due to the water vapour.

4.2 HUMIDITY

Humidity refers to the amount of water vapour in the air. In other words Water vapour present in the air is known as humidity. It is expressed quantitatively in different ways.

4.2.1 Absolute Humidity

The absolute humidity refers to the amount of water vapour present in the atmosphere. It is defined as the weight of water vapour per unit volume of air, given in grammes per cubic metre. Absolute humidity varies from location to place on the earth's surface. The ability of air to contain water vapour is completely determined by its temperature (Warm air can hold more moisture than cold air).

4.2.2 Relative Humidity

The relative humidity is the proportion of moisture in the atmosphere compared to its full capacity at a particular temperature. The capacity to hold moisture increases or decreases with changes in air temperature, and the relative humidity is also influenced. Over the seas, relative humidity is higher, whereas over the continental, it is lower (absolute humidity is greater over oceans because of greater availability of water for evaporation). The quantity and rate of evaporation are determined by relative humidity, making it an essential climatic component. At a certain temperature, air is considered to be 'saturated' if it contains all of the moisture it can hold. The air cannot contain any extra moisture at this temperature. As a result, the saturated air's relative humidity is 100 percent. When the quantity of moisture in the air is half of what it can transport, it is unsaturated, and the relative humidity is just 50%. The relative humidity can be altered in one of two ways:

By evaporating moisture (raising absolute humidity): When moisture is evaporated, the relative humidity rises, and vice versa. A drop in temperature (thus, a decrease in moisture-holding capacity/decrease in saturation point) causes a rise in relative humidity, and vice versa.

Temperature at which dew forms

Saturated air is defined as air that contains all of the moisture it can at a particular temperature.

It indicates that at that point, the air at that temperature is incapable of retaining any extra moisture.

Dew point is the temperature at which a particular sample of air becomes saturated. When Relative Humidity Equals 100%, dew point occurs.

4.2.3 Specific Humidity

It is measured as the weight of water vapour per unit weight of air. The specific humidity is unaffected by changes in pressure or temperature since it is measured in weight units (typically grammes per kilogramme). Specific Humidity is a constant, whereas Absolute and Relative Humidity are variable.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. Write briefly about Relative Humidity and Specific Humidity?

4.3. EVAPORATION AND CONDENSATION

The amount of water vapour in the atmosphere is added or withdrawn due to evaporation and condensation respectively. ***Evaporation*** is a process by which water is transformed from liquid to gaseous state. Heat is the main cause for evaporation. The temperature at which the water starts evaporating is referred to as the latent heat of vaporization. Increase in temperature increases water absorption and retention capacity of the given parcel of air. Similarly, if the moisture content is low, air has a potentiality of absorbing and retaining moisture. Movement of air replaces the saturated layer with the unsaturated layer. Hence, the greater the movement of air, the greater is the evaporation.

The oceans, which span 71% of the earth's surface, contain 97 percent of the world's water supplies. The hydrological cycle can be said to begin with evapotranspiration. Oceans account for 84 percent of yearly totals, whereas continents account for 16 percent. Because to the impact of the Gulf Stream and the Kurishio Current, the maximum yearly evaporation occurs in the subtropics of the western North Atlantic and North Pacific, as well as in the trade wind zone of the southern oceans. Because of the strong insolation, the land maximum occurs in the equatorial zone.

Condensation: The transformation of water vapour into water is called *condensation*. Condensation is caused by the loss of heat. When moist air is cooled, it may reach a level when its capacity to hold water vapour ceases, the excess water vapour condenses into liquid form. If it directly condenses into solid form is known as *sublimation*. Condensation also takes place when the moist air comes in contact with some colder object and it may also take place when the temperature is close to the dew point. Condensation, therefore, depends upon the amount of cooling and the relative humidity of the air. Condensation is influenced by the volume of air, temperature, pressure and humidity.

However, the most favorable condition for condensation is the decrease in air temperature. After condensation the water vapour or the moisture in the atmosphere takes one of the following forms; dew, frost, fog and clouds. Forms of condensation can be classified on the basis of temperature and location.

Dew: When the moisture is deposited in the form of water droplets on solid objects such as stones, grass blades and plant leaves, known as dew. The ideal conditions for its formation are clear sky, calm air, high relative humidity, and cold and long nights.

Frost: when condensation takes place on cold surfaces below freezing point (0^{0} C), Frost will form i.e. the dew point is at or below the freezing point. The excess moisture is deposited in the form of minute ice crystals instead of water droplets.

Fog and Mist: The fog is a cloud with its base very near to the ground. Fog is a visible aerosol consisting of tiny water droplets or ice crystals suspended in the air at or near the Earth's surface. Fog can be considered a type of low-lying cloud usually resembling stratus. The only difference between the mist and fog is that mist contains more moisture than the fog.

Clouds: Cloud is a mass of minute water droplets or tiny crystals of ice formed by the condensation of the water vapour in free air at considerable elevations.

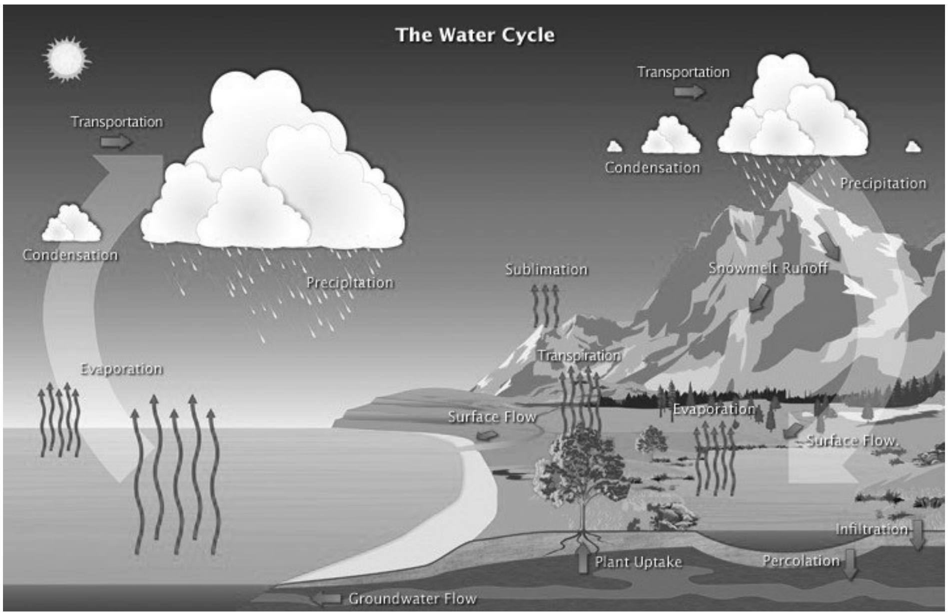
4.4 WATER CYCLE – HYDROLOGICAL CYCLE

The water, or hydrologic, cycle describes the pilgrimage of water as water molecules make their way from the Earth's surface to the atmosphere and back again, in some cases to below the surface. This gigantic system, powered by energy from the Sun, is a continuous exchange of moisture between the oceans, the atmosphere, and the land. Evaporation, transpiration, condensation, and precipitation all contribute to the constant circulation of water between the atmosphere, seas, and continents.

Evaporation from water bodies and transpiration from plants are the sources of moisture in the atmosphere (evapotranspiration). evaporation—the process by which water changes from a liquid to a gas—from oceans, seas, and other bodies of water (lakes, rivers, streams) provides nearly 90% of the moisture in our atmosphere. The remaining 10% found in the atmosphere is released by plants through transpiration. Clouds are formed when evaporated water condenses. When clouds approach saturation, they release water in the form of precipitation. Because the total quantity of moisture in the system remains constant, evapotranspiration and precipitation must be balanced. This equilibrium is maintained by the hydrological cycle.

4.4.1 Water Vapour in Atmosphere

Water vapour in the atmosphere ranges from 0% to 4% by volume of the atmosphere (averaging around 2 percent in the atmosphere). A device called a hygrometer is used to measure the amount of water vapour (humidity).



4.4.2 Significance of atmospheric moisture

Radiation, both incoming and terrestrial, is absorbed by water vapour. As a result, it is critical to the earth's heat budget. The amount of water vapour present determines how much latent energy is stored in the atmosphere for storms and cyclones to form. The pace of cooling of the human body is influenced by ambient moisture, which influences the perceived temperature.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

2. Explain about Water Cycle?

4.5 PRECIPITATION:

Precipitation is water which falls to the ground in liquid or solid form. It always comes before condensation, sublimation, or a mixture of the two, and is largely used to raise air temperature. Isohyets are used to demonstrate rainfall distribution in the same way as isotherms and isobars are used to show temperature and pressure distribution, respectively. An isohyet is a line that connects sites with equal rainfall amounts. It takes a long time for water vapour to turn into liquid water. When moist air comes into touch with cool surfaces, it can be chilled to the point where its capacity to contain water vapour is surpassed by the amount of water vapour in the air. Dew is formed when a portion of the water vapour condenses into liquid form on a cold surface. The latent heat of vaporization, also known as the latent heat of condensation, is released when this happens.

Water may bypass the liquid phase in its change of state at temperatures below freezing. When dry air with a temperature much below freezing comes into contact with ice, sublimation processes cause ice molecules (H2O) to transition straight into the vapour state. Water vapour condenses on nuclei in ideal meteorological circumstances, forming small water droplets with diameters of less than 0.1 mm. The nuclei are either salt particles or combustion products, and they are frequently plentiful. Cloud movement is aided by wind speed, while turbulence keeps water droplets suspended. When water droplets collide and consolidate to produce bigger drops that may fall, precipitation occurs. A large portion of this precipitation evaporates and returns to the atmosphere.

4.5.1 Types of precipitation:

The usual forms of precipitation are rainfall, snowfall, hail, frost and dew. Of all these, only the first two contribute significant amounts of water. Magnitude of precipitation varies with time and space.

Rain: Rain is any liquid that falls from the sky's clouds. Rain is defined as water droplets with a diameter of 0.5 mm or more. Drizzle is described as a droplet size of less than half a millimeter. Raindrops form when microscopic cloud particles collide and join together to form larger drops. As the process continues, the droplets become larger and larger until they are too heavy to be suspended in the air. Raindrops begin to fall as ice crystals or snow when they are high in the air, but they melt as they travel down the ground through warmer air. Rainfall rates vary from time to time; for example, light rain falls between 0.01 and 0.1 inch per hour, moderate rain falls between 0.1 and 0.3 inch per hour, and heavy rain falls above 0.3 inch per hour.

Snow: Almost every time it rains, snow falls. Snow, on the other hand, frequently melts before reaching the earth's surface. It is ice water precipitation in the shape of virga or flakes dropping from the sky. Cirrus clouds that are high, thin, and fragile are commonly observed with snow. Snow can fall while the air temperature is above freezing, but it is most common when the air temperature is below freezing. The snowflakes can partially melt as the temperature rises above freezing, but due to the relatively mild temperatures, the particles evaporate very soon. This evaporation causes the snowflake to cool surrounding it, causing it to fall to the earth as snow. Snow is fluffy, white, and soft, and it comes in a variety of forms, including flat plates and tiny needles. Each sort of snow occurs due to certain combinations of humidity and temperature in the atmosphere.

Sleet (Ice Pellets): Sleet occurs when the temperature drops below freezing. Sleet, also known as ice pellets, is formed when snow falls into a warm layer, melts into rain, and then falls into a freezing layer of air, where the raindrops refreeze as ice pellets. As a result, sleet is characterized as a type of precipitation that consists of tiny, semitransparent ice balls. They are not to be mistaken with hailstones since they are smaller. During thunderstorms, sleet is common, and it's usually accompanied with frosty ice crystals that create white deposits, as well as a combination of semisolid rain and mushy snow. When ice pellets (sleet) collide with the ground or other solid objects, they bounce and fall with a loud thud. Except when combined with freezing rain, sleet does not freeze into a solid mass.

Freezing rain: When rain falls at temperatures below freezing, it is known as freezing rain. Raindrops will usually solidify as a result of this. Raindrops are super-cooled as they pass through the sub-freezing layer of the atmosphere, and by the time they reach the ground, they have frozen. It is typical to see an even layer of ice on automobiles, roadways, trees, and power wires during freezing showers. Glaze is the term for the subsequent ice covering, which may reach a thickness of several centimeters. The routine operations of vehicle transit, aero planes, and electricity lines are all jeopardized by freezing showers.

Hail: Hailstones are enormous, irregular ice balls that fall during heavy thunderstorms. Hail is a type of precipitation that is entirely made up of solid particles. Unlike sleet, which may develop in any temperature when thunderstorms occur, hailstones are most commonly encountered in the winter or cold weather. Hailstones are mostly comprised of water ice and range in diameter from 0.2 inches (5 millimeters) to 6 inches (15 centimeters). The diameter of this varies from that of a pea to that of a grapefruit. As a result, they are extremely harmful to crops, pulling leaves apart and lowering their value. When violent thunderstorms with powerful updrafts occur, ice can be held against the gravitational force, resulting in hailstones when they ultimately escape and fall to the earth. As a result, hailstones are generated from super-cooled droplets that gradually solidify into a sheet of transparent ice.

Drizzle: Drizzle is a type of rain that is very light. It's more powerful than mist but not as forceful as a rain. Mist is a thin fog that forms near the ground due to condensation. Ice crystals or cloud water droplets hanging in the air near or at the earth's surface make up fog. Drizzle droplets have a diameter of less than 0.5 millimeters (0.02 inches). Low stratocumulus clouds give birth to them. Because of their small size, they can occasionally evaporate before reaching the earth. When the weather is chilly, drizzling might last for a long time.

Sun Showers: A sun shower is a type of precipitation that occurs when rain falls when the sun is shining. It happens when rain-carrying winds and rainstorms are blown many miles away, causing showers to fall in a region where there are no clouds. As a result, when a single rain cloud passes over the earth's surface and the sun's rays pierce through the droplets, a sun shower occurs. It is frequently accompanied by the appearance of a rainbow.

Snow grains: Snow grains are ice grains that are very tiny, white, and opaque. Snow grains are relatively flat, with a diameter of less than 1mm. They're practically the same size as a snow grains of drizzle.

Diamond Dust: Diamond dust is made up of incredibly tiny ice crystals that develop at low temperatures below -30 °C. The dazzling image formed when light reflects off ice crystals in the air gave rise to the 'diamond dust'.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

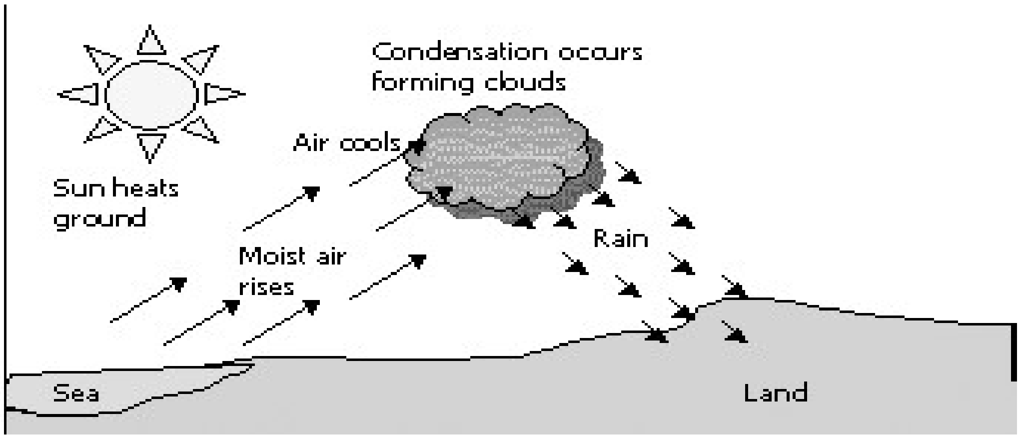
3. What are the types of precipitation?

4.5.2 Rainfall Types

Rainfall is divided into three categories according on its source: convectional, orographic or relief, and cyclonic or frontal.

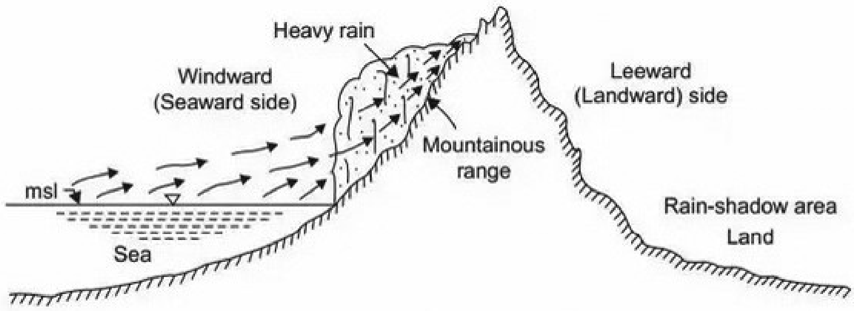
Convectional Rainfall: When heated air gets lighter and rises in convection currents. As it rises, it expands and loses heat, causing condensation and the formation of cumulous clouds.

This process releases latent heat from condensation, which warms the air even more and drives it to rise.



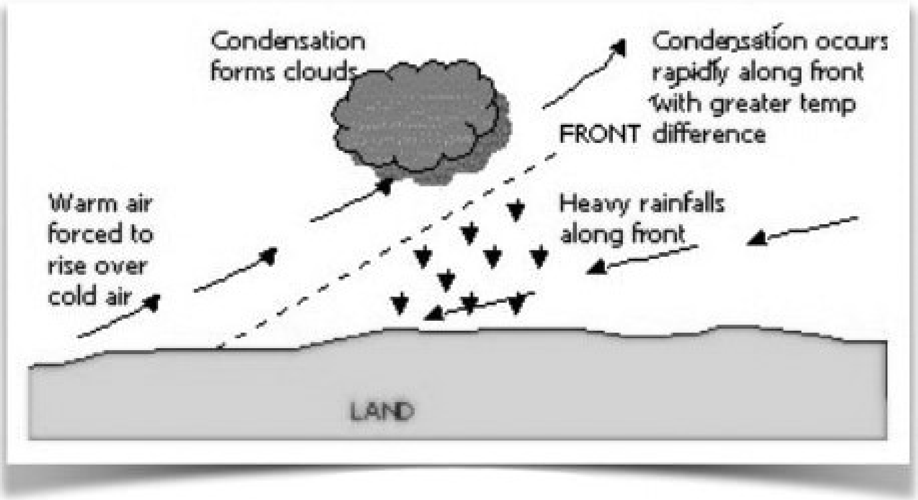
This conventional rainfall is heavy but short lived (smaller duration spells), extremely localized, and linked with a low level of cloudiness. It occurs primarily in the summer and is frequent over the tropical doldrums in the Congo, Amazon, and Southeast Asian islands.

Orographic or relief rainfall: When a saturated air mass passes over a mountain, it is forced to ascend, and as it does, it expands (due to a decrease in pressure), the temperature drops, and the moisture condenses. When warm, humid air collides head-on with an orographic barrier (a mountain range), this form of precipitation. The air is pushed to ascend due to the initial momentum. Condensation occurs as the moisture-laden air rises, and saturation occurs quickly. Along the windward slopes, the excess moisture falls as orographic precipitation.



The main feature of this type of rain is that it falls more heavily on the windward slopes. When these winds reach the other hill after raining on the windward side, they fall and their temperature rises. As a result, their ability to absorb moisture increases, and these leeward slopes stay rain-free and dry. The rain-shadow area is located on the leeward side and receives less rainfall. (Some arid and semi-arid regions are formed as a result of direct result of the rain-shadow effect.) For example, the Patagonian Desert in Argentina and the Eastern Slopes of the Western Ghats. It's also referred to as "relief rain." For example, Mahabaleshwar, which is located on the Western Ghats, receives over 600 cm of rainfall, but Pune, which is located in a rain shadow area, receives just approximately 70 cm. The Wind Descending on the Leeward Side is known as Katabatic Wind because it is heated adiabatically.

Frontal rainfall: This form of rainfall happens at the point where a warm and cool air mass collide. When two huge air masses of differing temperatures collide, the warmer air is raised above the colder air, making it lighter. Warm air rises, cools, and condenses, resulting in rain. A front is the border that separates cold and warm air. Such rainfalls due to formation of fronts are called frontal rainfall and the process of formation of fronts is called 'fronto Genesis'.



4.6 SUMMARY

This chapter helps us to understand the concept of water vapour and humidity and water cycle. The water cycle involves the process such as evaporation, transpiration, condensation and precipitation which contribute to circulation of water between atmosphere, seas and continents. Water vapour absorbs the both incoming and terrestrial radiation which is critical to heat budget. The humidity is the content of water vapour in the air. The dew is formed when a portion of water vapour condenses into liquid form or solid form, this is called precipitation. The precipitation can occur in many forms like rain, snow, sleet, hail, drizzle, snow grains, and diamond dust. Rainfall is divided into three categories according on its source: convectional, orographic or relief, and cyclonic or frontal.

4.7 CHECK YOUR PROGRESS-MODEL ANSWERS

1. The relative humidity is the proportion of moisture in the atmosphere compared to its full capacity at a particular temperature. Specific Humidity is measured as the weight of water vapour per unit weight of air. The specific humidity is unaffected by changes in pressure or temperature since it is measured in weight units (typically grammes per kilogramme). Specific Humidity is a constant, whereas Relative Humidity is variable.

2. Evaporation, transpiration, condensation, and precipitation all contribute to the constant circulation of water between the atmosphere, seas, and continents. Evaporation from water bodies and transpiration from plants are the sources of moisture in the atmosphere (evapotranspiration). Clouds are formed when evaporated water condenses. When clouds approach saturation, they release water in the form of precipitation. Because the total quantity of moisture in the system remains constant, evapotranspiration and precipitation must be balanced. This equilibrium is maintained by the hydrological cycle.

3. **Types of precipitation**: The usual forms of precipitation are rainfall, snowfall, hail, frost and dew. Of all these, only the first two contribute significant amounts of water. Magnitude of precipitation varies with time and space.

4.8 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. Write any two types of precipitation in detail.
2. What are three types of rainfall? Explain any one type of Rainfall in detail.

II Answer the following questions in about 10 lines

1. Distinguish between Drizzle and sleet.
2. Write a short note on Significance of atmospheric moisture.

4.9 FURTHER READINGS

Critchfield, H.J., 1997. General Climatology, Prentice Hall of India Pvt. Ltd, New Delhi.

Ttrewartha, G., Introduction to Weather and Climate. Strahler, A.H. and Strahler, A. N., 1992. Modern Physical Geography, John Wiley and Sons, Inc.

Climatology by D S Lal

Climatology by Savidar Singh

BLOCK - II: WINDS AND CYCLONES

A natural calamity caused by difference in air pressure in the atmosphere is called a cyclone. A cyclone is a violently rotating windstorm. Cyclones are dangerous. Cyclones begin as thunderstorms. In tropical regions like India, thunderstorms are common, but very few thunderstorms convert into cyclones.

An atmosphere is a layer of air surrounding our planet Earth. All living beings on this earth depend on the atmosphere for their survival. It is this mass of air that has made the temperature on the earth livable.

The pressure exerted by air on all bodies at all times in all directions is called air pressure.

When air moves at high speeds, it creates a low pressure area.

Winds are caused by variations in air pressure. A wind blows from a region of high pressure to a region of low pressure. The speed of the wind mainly depends on the difference between the pressures of the air in the two regions.

The block contains 3 units.

Unit 5: Atmospheric pressure and winds
Unit 6: Cyclones and anti-cyclones
Unit 7: Air masses and fronts

UNIT-5: ATMOSPHERIC PRESSURE AND WINDS

Contents

5.0 OBJECTIVES

- to understand features of air
- To understand about atmosphere components
- to understand the reasons for generation of wind currents.

5.1 INTRODUCTION

Distribution of temperature is not similar at all the places on the Earth. Because of difference in temperature, air pressure also varies immensely. Air is a composition of various gases therefore it has specific weight. Weight of air is known as ***air pressure***. Weight of air on any unit of area on Earth is known as air pressure while it is represented in Millibar unit. Air expands in summer due to high temperature and in winter it shrinks due to low temperature.

High temperature causes scanty air and less air pressure, while low temperature brings thick air and higher air pressure. Thus difference between air pressures creates air movement from high pressure areas to low pressure areas which is known as ***wind***.

Air moves from the region where the air pressure is high to the region where the pressureis low. The greater the difference in pressure, the faster the air moves. On heating the air expands and occupies more space. When the same thing occupies more space, it becomes lighter. The warm air is, therefore, lighter than the cold air. That is the reason that the smoke goes up. The equator gets maximum heat from the Sun. The air in these regions gets warm. The warm air rises, and the cooler air from the regions in the 0–30 degrees latitude belt on either side of the equator moves in. These winds blow from the north and the south towards the equator. At the poles, the air is colder than that at latitudes about 60 degrees. The warm air at these latitudes rises up and the cold wind from the Polar Regions rushes in, to take its place. In this way, wind circulation is set up from the poles to the warmer latitudes.

5.2 TEMPERATURE AND AIR PRESSURE

Air pressure is defined as the pressure exerted by the weight of air on the earth's surface. As we go up the layers of the atmosphere, the pressure falls rapidly. The air pressure is highest at sea level and decreases with height. Horizontally the distribution of air pressure is influenced by the temperature of the air at a given place. In areas where temperature is high the air gets heated and rises. This creates a low-pressure area. Low pressure is associated with cloudy skies and wet weather. In areas having lower temperature, the air is cold and heavy. Heavy air sinks and creates a high pressure area. High pressure is associated with clear and sunny skies. The air always moves from high-pressure areas to low-pressure areas.

These expansion and shrinking of air which further results into distribution of heat and moisture in the atmosphere. Instrument used to measure air pressure is known as ***Barometer***. The units used for this purpose are called millibar (mb). In normal circumstance average air pressure at sea level is 1013.2 millibar. It may, however, fluctuate on either side of this value.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. Define air pressure and wind?

5.3 DISTRIBUTION OF AIR PRESSURE

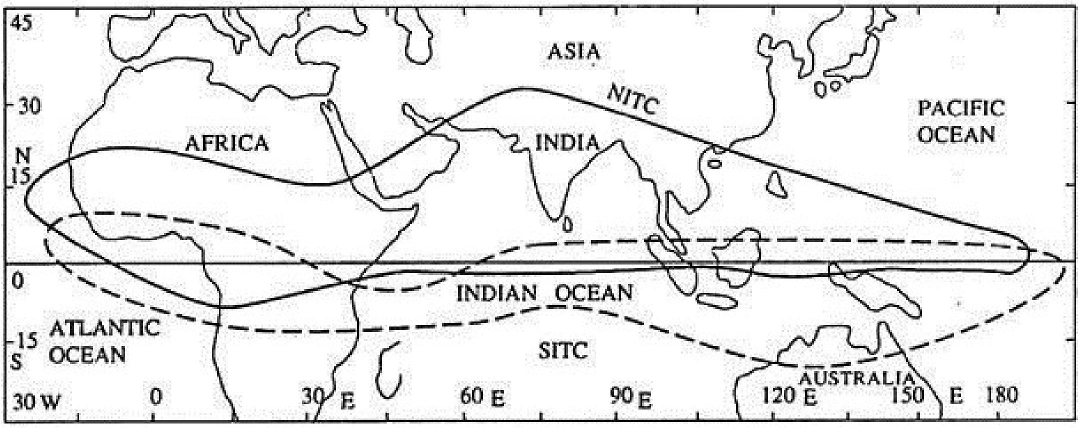
As air is present all around the Earth, the distribution of atmospheric pressure is not uniform over the earth's surface. It may be distributed in two ways namely; horizontally and vertically.

1. Horizontal Distribution: The distribution of atmospheric pressure across the latitudes is termed as global horizontal distribution. This distribution is characterized by presence of distinctly identifiable zones of homogeneous pressure regimes or 'pressure belts'. Air pressure of a particular place changes with day and night, with summer and winter but average air pressure conditions remain same. The division of air pressure on Earth reveals that there are various high and low pressure regions. The distribution of atmospheric pressure is shown on a map by isobars. An isobar is an imaginary line drawn through places having equal atmospheric pressure reduced to sea level. The spacing of isobars expresses the rate and direction of pressure changes and is referred to as pressure gradient. Generally air pressure is divided into two types: a. High pressure and b. Low pressure.

On the basis of combined effect of various factors affecting the air pressure on different latitudes seven air pressure belts are found on the Earth. The seven pressure belts are: equatorial low, the sub-tropical highs, the sub-polar lows, and the polar highs. Except the equatorial low, all others form matching pairs in the northern and southern hemispheres.

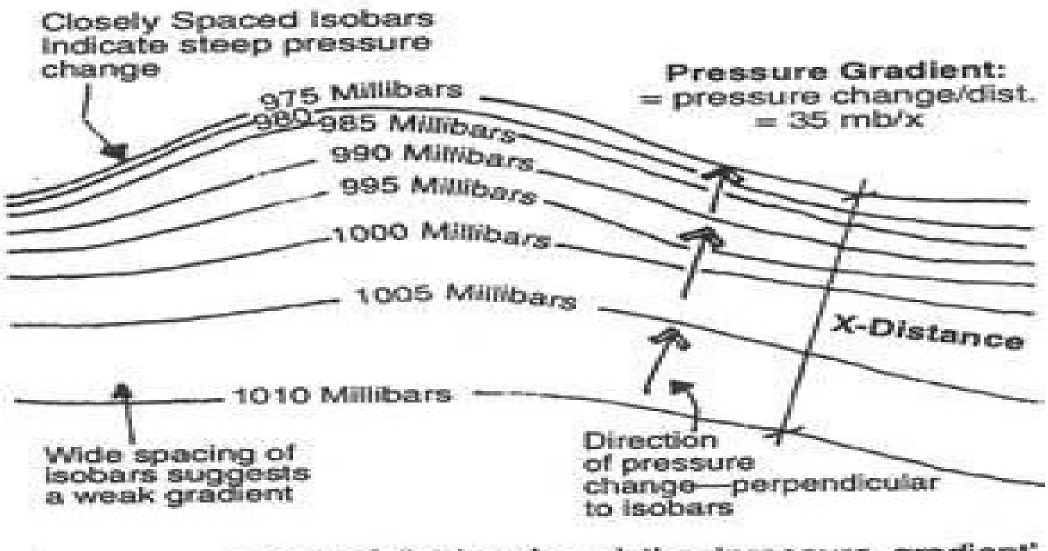
1. Equatorial Low Pressure Belt or 'Doldrums': This belt lies between 10°N and 10°S latitudes, although the width may vary between 5°N and 5°S and 20°N and 20°S. Due to intense heating, air gets warmed up and rises over the equatorial region and produces the equatorial low pressure belt. This belt is characterized by extremely low pressure with calm conditions.

Surface winds are generally absent since winds approaching this belt begin to rise near its margin. Thus, only vertical currents are found. This belt happens to be the zone of convergence of trade winds from two hemispheres from sub-tropical high pressure belts. This belt is also called the ***Doldrums***, because of the extremely calm air movements. Equatorial low pressure belt region extending between 5°N latitude of Equator to 5°S latitude is known as *Equatorial low pressure belt*.



Intertropical convergence (NITC and SITC).

The actual direction of pressure change is always perpendicular to the isobar lines. A rising pressure indicates fine, settled weather, while a falling pressure indicates unstable and cloudy weather.



A set of 'isobars' and the 'pressure gradient'.

Following are the reasons which are responsible for origin of *Equatorial low pressure belt*:

(i) Rays of sun fall vertically in this region whole the year and because of this, temperature is high which creates low pressure.

(ii) Owing to high temperature, evaporation process is also very fast, while large number of water vapors decreases the weight and density of air resulting in reduction of air pressure.

(iii) Rotation of Earth has its maximum effect on Equator and so is effect of centrifugal force which results into reduction in air pressure. At about 30°N and 30°S latitudes high pressure regions are found in both hemispheres which are formed with descending winds on this latitudes risen up at hot Equatorial regions. Further at 60°N and 60°S latitudes low pressure regions are found. At poles high pressure regions are formed because temperature remains low for whole of the year. It is important to mention that these belts are not stable. They shift according to the situation of sun as on earth. E.g. During winters (December) in northern hemisphere, sun rays fall vertically on the tropic of Capricorn. During this period, pressure belts shift towards south. On the other hand situation is opposite in the summer.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

2. What is doldrums?

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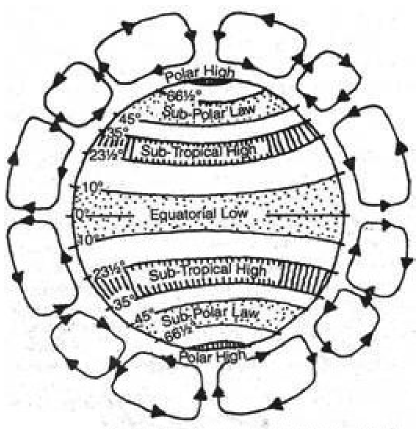
2. Sub-Tropical High Pressure Belt or 'Horse Latitudes': The sub-tropical highs extend from near the tropics to about 35°N and S. The high pressure along this belt is due to subsidence of air coming from the equatorial region which descends after becoming heavy. The high pressure is also due to the blocking effect of air at upper levels because of the Coriolis force. The subsiding air is warm and dry; therefore, most of the deserts are present along this belt, in both hemispheres.

The descending air currents feed the winds blowing towards adjoining low pressure belts. A calm condition with variable and feeble winds is created in these high pressure belts, called ***horse latitudes***. In early days, the sailing vessels with a cargo of horses found it difficult to sail under such calm conditions. They used to throw horses into the sea when fodder ran out. This belt is frequently invaded by tropical and extra-tropical disturbances.

3. Sub-Polar Low Pressure Belt: This belt is located between 45°N and S latitudes and the Arctic and the Antarctic circles. The low pressure exists along this belt due to ascent of air as a result of convergence of westerlies and polar easterlies. During winter, because of a high contrast between land and sea, this belt is broken into two distinct low centres—one in the vicinity of the Aleutian Islands and the other between Iceland and Greenland. During summer, a lesser contrast results in a more developed and regular belt. Also, due to a great contrast between the temperatures of the winds from sub-tropical and polar source regions, cyclonic storms or 'lows' are produced in the region.



Positions of various 'pressure belts'.

4. Polar High: The lowest temperatures are found over the poles, which cause subsidence of air and hence the polar highs. The polar highs are small in area and extend around the poles.

Table

Height from Sea level (in Kms)	Air Pressure with volume (in mb)	Temperature (^{0}C)	Comparison (km/m^3)
0	1013.25	15^0	1.23
0.5	954.61	11	1.17
1.0	898.76	8.5	1.11
2.0	795.01	2.0	1.01
5.0	540.48	–17.5	0.74
10	264.99	–49.9	0.41
20	55.92	–56.5	0.09
30	11.97	–46.5	0.02

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

3. What is horse latitudes?

5.4 VERTICAL DIVISION

Air pressure on Earth exists due to pressure of upper layers. Atmosphere extends up to the height of hundred kilometres from the Earth surface. Air pressure is highest at sea level because the density of gases is highest in lower layers. Density changes due to the expansion and the air shrinks because of low temperature. Air pressure and height are reversely proportional to each other, which mean air pressure decreases due to increase in height. But the rate of fall in air pressure decreases with increase in height.

Fast blowing winds originate due to the difference between air pressures at earth surface but on the other hand air pressure decreases as the height increases in spite of this we do not feel fast blowing upward winds. The reason behind this is that the gravitational force of Earth also decreases with increase in height. At the height of Mt. Everest, the air pressure is about two-thirds less than what it is at the sea level. The decrease in pressure with altitude, however, is not constant. Since the factors controlling air density—temperature, amount of water vapour and gravity are variable, there is no simple relationship between altitude and pressure. In general, the atmospheric pressure decreases on an average at the rate of about 34 millibars every 300 metres of height.

5.5 FACTORS CONTROLLING PRESSURE SYSTEMS

There are two main factors which controlling the pressure systems; thermal and dynamic, for the pressure differences resulting in high and low pressure systems.

Thermal Factors: An important factor while studying the pressure systems is temperature and its variations from equator to the poles, since a chain of events takes place due to heating and cooling of the earth's surface and its atmosphere. When air is heated, it expands and, hence, its density decreases. This naturally leads to low pressure. On the contrary, cooling results in contraction. This increases the density and thus leads to high pressure. Formations of equatorial low and polar highs are examples of thermal lows and thermal highs, respectively.

Dynamic Factors: Apart from variations of temperature, the formation of pressure belts may be explained by dynamic controls arising out of pressure gradient forces and rotation of the earth. The warm equatorial air cools during its ascent and, upon reaching the upper layers, it starts moving towards the pole. It further cools and begins to subside in a zone between 20° and 35° latitude. Two factors are responsible for the general subsidence of air in this belt.

First, cooling of the air results in increased density, which accounts for its subsidence. Second, owing to the rotation of the earth, the pole-ward directed winds are deflected eastwards, which is also called the *Coriolis force*—after a French scientist who first expressed its magnitude quantitatively.

The rate of deflection increases with the distance from the equator. As a result, by the time the pole-ward directed winds reach 25° latitude, they are deflected into a nearly west-to-east flow. It produces a blocking effect and the air piles up. This causes a general subsidence in the areas between the tropics and 35°N and S, and they develop into high pressure belts.

The location of these pressure belts is further affected by differences in net radiation resulting from apparent movement of the sun and from variations in heating of land and water surfaces. In the northern hemisphere, during summer, with the apparent northward shift of the sun, the thermal equator (belt of highest temperature) is located north of the geographical equator.

5.6 FACTORS AFFECTING AIR PRESSURE

Temperature: As the temperature increases, air expands because of which its density decreases which results in low pressure. On the other hand air shrinks due to low temperature because of which its density increases which creates high pressure. The relation between air pressure and temperature is defined with following quote- **"When the mercury of thermometer raises, mercury of barometer falls"**. Equatorial regions have low pressure because of high temperatures. On the other hand Polar Regions have high pressure due to low temperature.

Height from Sea Level: Air pressure is created due to weight of air therefore sea level has highest air pressure. As we move upward from sea level leaving behind the heavy gases at lower layers of atmosphere, air pressure decreases because the upper air is light and its density is low. There is no fixed rate of fall in air pressure with increase in height but it decreases with increase in height. Air pressure is reduced to half at the height of 5 Kms from sea level and at the height of 11 kms it is reduces to one fourth. It is because of low pressure in mountainous regions that breathing gets hard.

Moisture in Air (Humidity): Conversion of water from liquid state to gaseous state because of evaporation is known as ***atmospheric humidity***. Water vapours are light in weight therefore they rise up and pressure of humid air decreases as compared to dry air. Amount of water vapours changes with time and place and because of this the pressure of air also varies.

Gravitation of Earth: Atmosphere glues around the Earth due to its gravitation, the intensity of gravitational pull decreases as we get away from core of Earth. Another fact is that as Earth rotates round its axis, average distance of Polar Regions and equatorial regions varies from the core of Earth. For example Polar Regions are nearer to core of the Earth as compared to Equatorial regions and hence have higher air pressure.

Rotation of Earth: Rotation of Earth produces centrifugal force which has more effect in Equatorial region while lesser effect on Polar Regions. Centrifugal force Pushes things away from its core. Same is the effect on air pressure which results into lesser pressure in Equatorial regions as compared to that in Polar Regions.

Check your progress

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(b) Compare your answer with the one given at the end of this unit.

4. What are factors affecting air pressure?

5.7 FACTORS INFLUENCING THE AIR PRESSURE

1. **Altitude:** With an increase in the altitude, the length of the column of the overlying air on the surface of the earth decreases and hence the weight or the pressure exerted by the atmosphere also decreases.

2. **Temperature:** When the atmospheric temperature increases, the air expands and loses density and similarly when the temperature decreases the air becomes denser and naturally air pressure increases.

3. **Water Vapour:** Water Vapour is lighter than the dry air so, if the content of water vapor in the air is higher, the air pressure would be lower and vice-versa.

4. **Atmospheric Pressure and air currents:** When temperature increases in an area, the air becomes lighter and rises up, as a result, a low pressure develops there and to fill up the void and neutralize that low pressure, Cooler air descends in that area.

Check your progress

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(b) Compare your answer with the one given at the end of this unit.

5. What are factors influencing the air pressure?

WINDS

Winds are classified as Permanent winds or Primary winds or Prevailing winds or Planetary Winds. The **planetary winds** which blow extensively over continents and oceans. The two most well-understood and significant winds for climate and human activities are;

The **trade winds, westerlies and easterlies.** Secondary or Periodic Winds**.**

Periodic winds: Land and sea breeze, mountain and valley breeze.

Local winds*: These blows only during a particular period of the day or year in a small area.* Winds like **Loo, Mistral, Foehn, and Bora**.

Seasonal winds: These winds change their direction in different seasons. For example: **monsoons** in *India.*

5.8 TRADE WINDS

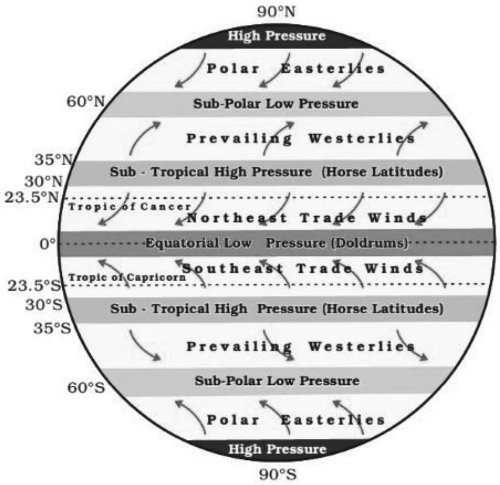
There is more or less regular inflow of winds from subtropical high pressure belts to equatorial low pressure belt. These tropical winds have north-easterly direction in the northern hemi-sphere while they are south-easterly in the southern hemisphere. These winds are called *trade winds* because of the fact that they helped the sea merchants in sailing their ships as their (of trade winds) direction remains more or less constant and regular. According to Ferrel's law (based on Coriolis force generated by the rotation of the earth) trade winds are deflected to the right in the northern hemisphere and to the left in the southern hemisphere. There are many variations in the weather conditions in the different parts of trade winds.

The pole ward parts of the trade winds or eastern sides of the subtropical anticyclones are dry because of strong subsidence of air currents from above. Because of the dominance of anticyclone conditions there is strong atmospheric stability, strong inversion of temperature and clear sky. On the other hand, the equator-ward parts of the trade winds are humid because they are characterized by atmospheric instability and much precipitation as the trade winds while blowing over the oceans pick up moisture.

It may be stated that the trade winds are more regular and constant over the oceans than over the lands. At some places on the lands (e.g. S.E. Asia and southern USA) the trade winds disappear during summer season due to formation of low pressure belts because of high temperature but the trade winds are more constant and regular over the continents during winter season.

5.9 PLANETARY WINDS

The winds blowing almost in the same direction throughout the year are called *prevailing or permanent winds.* These are also called as invariable or *planetary winds* because they involve larger areas of the globe. On the other hand, winds with seasonal changes in their directions are called *seasonal winds* (e.g., monsoon winds).



Major Pressure Belts and Wind System

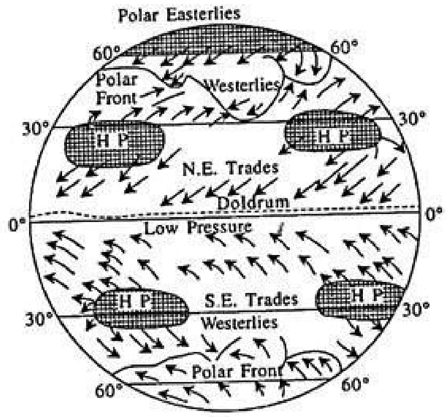


Fig. 35.7 : The generalized global pattern of planetary winds.

On an average, the location of high and low pressure belts is considered to be stationary on the globe. Consequently, winds blow from high pressure belts to low pressure belts. The direction of such winds remains more or less the same throughout the year though their areas change seasonally.

Thus, such winds are called *permanent winds*. Since these winds are distributed all over the globe and these are related to thermally and dynamically induce pressure belts and rotation of the earth and hence they are called *planetary winds*. These winds include trade winds, westerlies and polar winds (fig).

Winds in the Tropics: Generally, the areas extending between 30°N and 30°S latitudes are included in tropical zone. Formerly, it was believed that trade winds blow from the subtropical high pressure belts to the equatorial low pressure belt. The north-east and south-east trades converge along the equator and there are upper air anti-trades blowing in the opposite directions of the surface trade winds.

The weather conditions throughout the tropical zone remain more or less uniform. There is a belt of calm or *doldrums* characterized by feeble air circulation. Trade winds blow with regularity only over some parts of the tropical oceans (mainly over the eastern parts). The weather conditions in the tropics are not calm and uniform but they are frequently interrupted by atmos-pheric disturbances (cyclones, hurricanes, typhoons, sea waves etc.). Thus, the tropical zone is characterized by doldrums, equatorial westerlies, and trade winds.

Check your progress

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(b) Compare your answer with the one given at the end of this unit.

6. Discuss in brief about trade winds?

5.10 ANTICYCLONES:

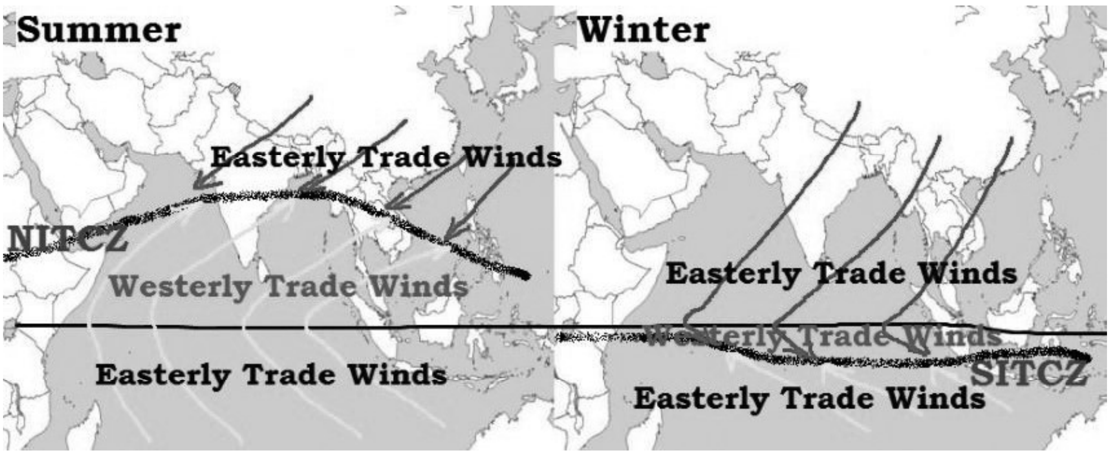
These are produced due to subsidence of air currents in the horse latitudes. These anticyclones are known as 'subtropical highs' or subtropical anticyclones, the eastern and western parts of which are characterized by contrasting weather conditions. The eastern parts (spreading over the western parts of the continents) are marked by descent of air currents, inversion of temperature and consequent atmospheric stability and dry conditions.

This is why hot and dry tropical deserts are found in the western parts of the continents within the latitudinal zones of 20°-30° in both the hemispheres (e.g. Sahara and Kalahari in Africa, Chile, Peru desert or Atacama in South America, Arabian and Thar deserts in Asia, deserts of S. W. USA, and Australian deserts). The western parts of subtropical anticyclones (covering the eastern parts of the continents and western parts of the oceans) are humid because some sort of atmospheric instability is caused due to weakening of air descent (e.g., in the areas of Caribbean Sea, Mexican Gulf and adjoining areas, eastern China, southern Japan, southeast Brazil and eastern Australia).

Westerlies: The permanent winds blowing from the subtropical high pressure belts (30°-35°) to the sub polar low pressure belts (60°-65°) in both the hemispheres are called *westerlies*. The general direction of the westerlies is S.W. to N.E. in the northern hemisphere and N.W. to S.E in the southern hemisphere. There is much variation in the weather conditions in their pole ward parts where there is convergence of cold and denser polar winds and warms and lighter westerlies.

In fact, a cyclonic front, called as polar front, is formed due to two contrasting air masses as referred to above and thus temperate cyclones are originated. These cyclones move along with the westerlies in easterly direction. Thus, the general characteristic features of the westerlies are largely modified due to cyclones and anticyclones associated with them. These westerlies bring much precipitation in the western parts of the continents (e.g., north-west European coasts) because they pick up much moisture while passing over the vast stretches of the oceans.

The westerlies become more vigorous in the southern hemisphere because of lack of land and dominance of oceans. Their velocity increases southward and they become stormy. They are also associated with boisterous-gales. The velocity of the westerlies becomes so great that they are called ***roaring forties*** between the latitudes of 40°-50° S, **furious fifties** at 50°S latitude and **shrieking sixties** at 60° S latitude.



Trade Winds

5.11 POLAR WINDS

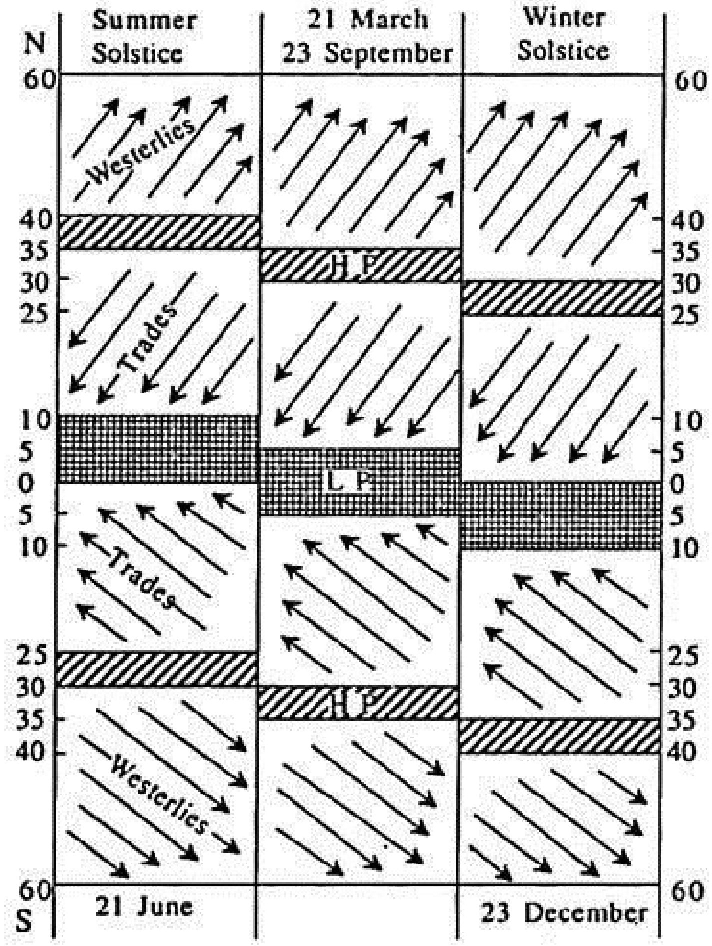
A low pressure belt, produced due to dynamic factor, lies within the latitudinal belt of 60°-65° in both the hemispheres. This belt of low pressure is more persistent in summer season but generally disappears in winter season. The Icelandic and Aleutian low pressure belts persist throughout the year. There is very high pressure over the poles because of exceedingly low temperature.

The winds blows from polar high pressure to sub-polar low pressure cells are called *polar winds* which are north-easterly in the southern hemisphere and south-easterly in the southern hemisphere. The zone of polar winds shrinks due to northward shifting of pressure belts at the time of northern summer (summer solstice) in the northern hemisphere but it is extended up to 60°N latitude during northern winter (winter solstice).

5.12 SEASONAL SHIFTING OF WIND BELTS

In the absence of the revolution of the earth around the sun in about 365 days the global pressure belts would have been permanent and stationary at their places but the relative position of the earth with the sun changes within a year due to earth's revolution and thus the position of all the pressure belts except the polar high pressure belts changes with the northward and southward migration of the sun.

At the time of summer solstice the sun is vertical over the tropic of Cancer (June 21) and therefore all the pressure belts except the northern polar high pressure belt shift north-ward (fig.). The equatorial low pressure belt prevails between 0° latitude (equator) and 10° N latitude, subtropical high pressure belt extends between 30°- 40°N latitudes. Thus, all the wind belts associated with the said pressure belts also shift north-ward.



Shifting of pressure and wind belts.

The sun becomes vertical over the equator at the time of autumnal equinox (23 September) and hence all the pressure belts which shifted to the north occupy their normal positions. After this there is southward migration of the sun which becomes vertical over the tropic of Capricorn at the time of winter solstice (23 December) and hence the pressure and wind belts shift southward except the southern polar high pressure belt. Thereafter the sun again becomes vertical over the equator at the time of vernal equinox (21 March) and hence all the pressure and wind belts occupy their normal positions, thus, there is shifting in the positions of the pressure and wind belts due to seasonal changes of position of the earth in relation to the sun.

Secondary Winds or Periodic Winds: These winds change their direction with change in season. **Monsoons** are the best example of large-scale modification of the planetary wind system. Other examples of periodic winds include land and sea breeze, mountain and valley breeze, cyclones and anticyclones, and air masses.

Check your progress

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(b) Compare your answer with the one given at the end of this unit.

7. Discuss in brief about westerlies winds?

5.13 MONSOONS

Monsoons were traditionally explained as land and sea breezes on a large scale. Thus, they were considered a convectional circulation on a giant scale. The monsoons are characterized by seasonal reversal of wind direction. During summer, the trade winds of southern hemisphere are pulled northwards by an apparent northward movement of the sun and by an intense low pressure core in the north-west of the Indian sub-continent. While crossing the equator, these winds get deflected to their right under the effect of Coriolis force.

These winds now approach the Asian landmass as south-west monsoons. Since they travel a long distance over a vast expanse of water, by the time they reach the south-western coast of India, they are over-saturated with moisture and cause heavy rainfall in India and neighbouring countries. During winter, these conditions are reversed and a high pressure core is created to the north of the Indian subcontinent.

Divergent winds are produced by this **anticyclonic movement** which travels southwards towards the equator. This movement is enhanced by the apparent southward movement of the sun. These are north-east or winter monsoons which are responsible for some precipitation along the east coast of India.

The monsoon winds flow over India, Pakistan, Bangladesh, Myanmar (Burma), Sri Lanka, the Arabian Sea, Bay of Bengal, south-eastern Asia, northern Australia, China and Outside India, in the eastern Asiatic countries, such as China and Japan, the **winter monsoon is stronger** than the summer monsoon.

5.14 LAND BREEZE AND SEA BREEZE

The land and sea absorb and transfer heat differently. During the day the land heats up faster and becomes warmer than the sea. Therefore, over the land the air rises giving rise to a low pressure area, whereas the sea is relatively cool and the pressure over sea is relatively high.

Thus, pressure gradient from sea to land is created and the wind blows from the sea to the land as the sea breeze. In the night the reversal of condition takes place. The land loses heat faster and is cooler than the sea. The pressure gradient is from the land to the sea and hence land breeze results.

Valley Breeze and Mountain Breeze: In mountainous regions, during the day the slopes get heated up and air moves upslope and to fill the resulting gap the air from the valley blows up the valley. This wind is known as the valley breeze. During the night the slopes get cooled and the dense air descends into the valley as the mountain wind. The cool air, of the high plateaus and ice fields draining into the valley is called **katabatic wind.**

Check your progress

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(b) Compare your answer with the one given at the end of this unit.

8. Discuss in about land and sea breezes?

5.15 TERTIARY WINDS OR LOCAL WINDS

Local differences of temperature and pressure produce local winds. Such winds are local in extent and are confined to the lowest levels of the troposphere. Some examples of local winds are discussed below.

Loo: **Harmful Wind.** In the plains of northern India and Pakistan, sometimes a very hot and dry wind blows from the west in the months of **May and June**, usually in the afternoons. Its temperature invariably ranges between **45°C and 50°C**. It may cause **sunstroke** to people.

Foehn or Fohn: **Beneficial Wind.** Foehn is a **hot wind** of local importance in the **Alps**. It is a strong, gusty, dry and warm wind which develops on the leeward side of a mountain range. As the windward side takes away whatever moisture there is in the incoming wind in the form of orographic precipitation, the air that descends on the leeward side is dry and warm **(Katabatic Wind).** The temperature of the wind varies between 15°C and 20°C. The wind **helps animal grazing** by melting snow and **aids the ripening of grapes**.

Chinook: Beneficial Wind: Foehn like winds in **USA and Canada** move down the west slopes of the **Rockies** and are known as Chinook. It is **beneficial to ranchers** east of the Rockies as it keeps the grasslands clear of snow during much of the winter.

Mistral: It is a **Harmful Wind**. Mistral is one of the local names given to such winds that blow from the Alps over France towards the Mediterranean Sea. It is channeled through the Rhine valley. It is **very cold and dry with a high speed**. It brings blizzards into southern France.

5.16 CHECK YOUR PROGRESS-MODEL ANSWERS

1. Air is a composition of various gases therefore it has specific weight. Weight of air is known as ***air pressure***. High temperature causes scanty air and less air pressure, while low temperature brings thick air and higher air pressure. Thus difference between air pressures creates air movement from high pressure areas to low pressure areas which is known as ***wind***.

2. Doldrums: a belt of calms and light baffling winds north of the equator between the northern and southern trade winds in the Atlantic and Pacific oceans.

3. The horse latitudes are the latitudes about 30 degrees north and south of the Equator. They are characterized by sunny skies, calm winds, and very little precipitation. They are also known as subtropical ridges, or highs.

4. The factors affecting air pressure are: Temperature, height from the sea level, moisture in the air / humidity, gravitation of the earth and rotation of the earth.

5. The factors influencing air pressure were; altitude, temperature, water vapour and atmospheric pressure and air currents.

6. The trade winds are winds that reliably blow east to west just north and south of the equator. The trade winds or easterlies are the permanent east-to-west prevailing winds that flow in the Earth's equatorial region. The winds help ships travel west, and they can also steer storms such as hurricanes, too.

7. Westerlies are permanent winds blowing from the sub tropical high pressure belts to the sub tropical low pressure belts in both the hemispheres.

8. Due to the difference in pressure and the air flows from the high pressure over the sea to the low pressure over the land. This flow of air from the sea to the land is termed as the sea breeze. a low-pressure situation develops over the sea as the temperature above it is higher when compared to the land. Due to this, the air flows from the land to the sea which is termed the land breeze.

5.17 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in 30 words

1. Discuss the factors affecting the speed and direction of the wind

2. Draw a simplified diagram to show the general circulation of the atmosphere over globe

3. What are the possible reasons for the formation of subtropical high pressure over 30^0 N and S latitudes?

4. Explain the land and sea breezes

II. Short answer questions

1. Doldrums; 2. Horse latitudes, 3. Relative humidity, 4. Absolute humidity, 5. Atmospheric pressure.

UNIT-6: CYCLONES AND ANTI CYCLONES

Contents

6.0 OBJECTIVES

- To understand what is Thunderstorm and Cyclone.
- To know the destruction caused by cyclones and the safety measures

6.1 INTRODUCTION

Let's start the chapter with an article.

"Orissa was hit by a cyclone with wind speed of 200 km/h on 18 October 1999. The cyclone smashed 45,000 houses making 7,00,000 people homeless. On 29 October the same year, a second cyclone with wind speed of 260 km/h hit Orissa again. It was accompanied by water waves about 9 m high. Thousands of people lost their lives. Property worth crores of rupees was destroyed. The cyclone affected agriculture, transport, communication, and electricity supply." In this chapter we shall seek answers to some of these questions.

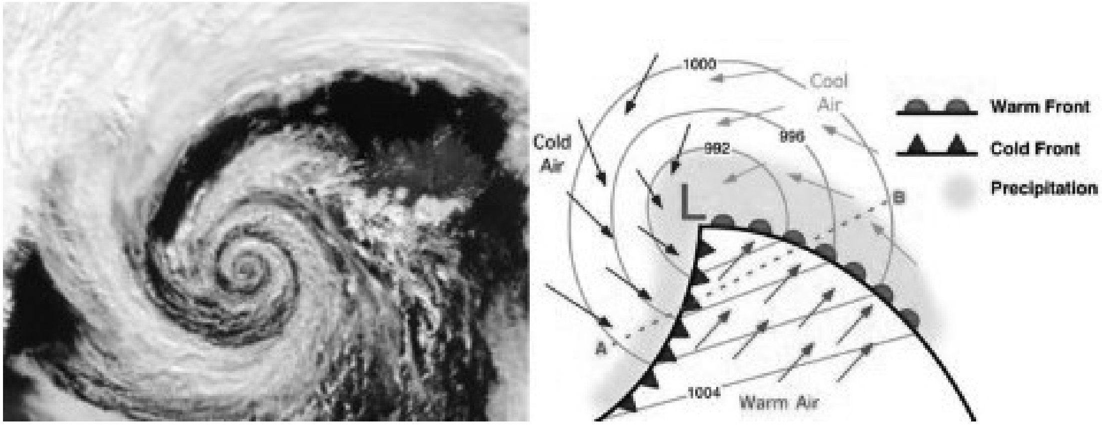
1. What are the cyclones?
2. How are they formed?
3. Why are they so destructive?

Cyclone is a system of low atmospheric pressure in which the barometric gradient is steep. Cyclones represent circular fluid motion rotating in the same direction as the Earth. This means that the inward spiraling winds in a cyclone rotate anticlockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere of the Earth. Most large-scale cyclonic circulations are centered on areas of low atmospheric pressure. Cyclones are rotating low pressure systems. They are well developed low pressure systems into which violent winds blow. The cyclones may be classified into two categories; i) Temperate cyclones ii) Tropical cyclones.

6.2 TEMPERATE CYCLONES

The temperate cyclones are also known as extra tropical cyclones and frontal cyclones. The temperate cyclones occur in the middle and high latitudes beyond the tropics (30 deg N/S-60deg N/S). Extra tropical cyclones form along the polar front, initially the front is stationary. Temperate cyclones are generally called depressions. They have low pressure at the centre and increasing pressure outwardly. They are of varying shapes such as circular, elliptical. The formation of tropical storms as we read above are confined to oceans, the temperate cyclones are formed over land and sea alike. Temperate Cyclones are formed in 35-65° North as well as South Latitudes. While the tropical cyclones are largely formed in summer and autumn, the temperate cyclones are formed in generally winter. Rainfall in these cyclones is low and continuous not as furious as in case of tropical cyclones.

In the Northern Hemisphere warm air blows from the south and cold air from the north of the front. When the pressure drops along the front, the warm air moves northwards and the cold air moves southwards setting in motion an anticlockwise cyclonic circulation. In Southern Hemisphere the cyclonic circulations occurs in clockwise direction. The warm air glides over the cold air and a sequence of clouds appear over the sky ahead of the warm front and cause precipitation. The temperate cyclones move in easterly (west to east) direction under the influence of westerly winds combined with Coriolis force and control the weather conditions in the middle latitudes.



Cyclone and cold and warm fronts

Characteristics of temperate cyclones:

1) The temperate cyclone may be 1600kms wide.

2) The isobars are elliptical in shape.

3) The cold air mass moves faster than the warm air mass.

4) These cyclones move at a speed of 5 to 25 kmph.

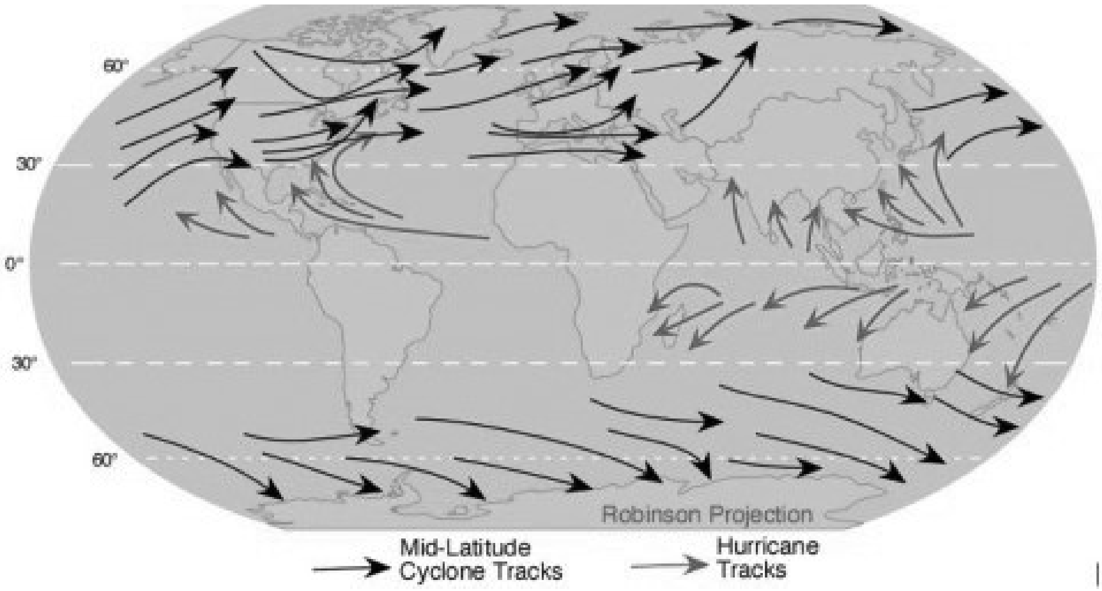
5) They give light showers which are highly beneficial for the crops and human health and efficiency.

6) In the ending part of the cyclone there is thunder and lightning.

7) Each cyclone is followed by a clear weather.

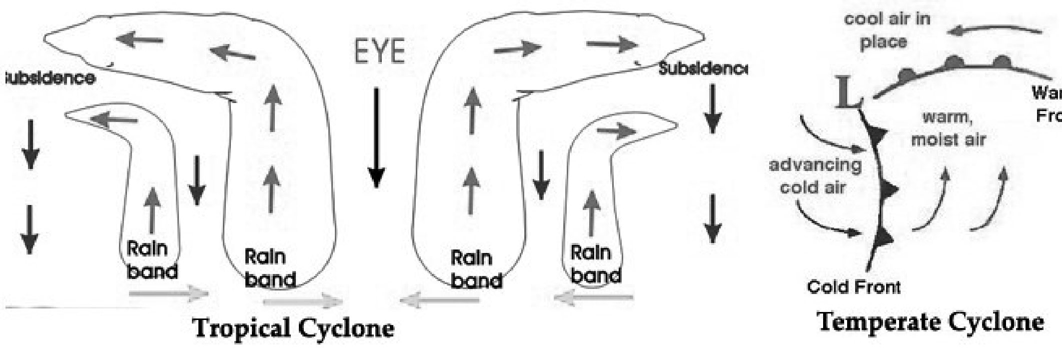
Distribution of Temperate Cyclones

- USA and Canada – extend over Sierra Nevada, Colorado, Eastern Canadian Rockies and the Great Lakes region,
- the belt extending from Iceland to Barents Sea and continuing over Russia and Siberia,
- winter storms over Baltic Sea,
- Mediterranean basin extending up to Russia and even up to India in winters (called western disturbances) and the Antarctic frontal zone.



Cyclone tracks

The extra tropical cyclones differ from the tropical cyclones in number of ways. The former have a clear frontal system which is not present in the latter. They cover a large area and can originate over the land and sea whereas the tropical cyclones originate only over the seas and reaching the land they dissipate. The extra tropical cyclone affects a much larger area as compared to the tropical cyclone. The velocity of wind in a tropical cyclone is much higher and is more destructive.



Temperate and tropical cyclones

Check your progress

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1. What are the characteristics of the temperate cyclones?

6.3 TROPICAL CYCLONES

A tropical cyclone is a rapidly rotating storm system characterized by a low-pressure center, a closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain. Tropical refers to the geographical origin of these systems, which form almost exclusively over tropical seas.

The term "tropical cyclone" is used to refer to warm-core, low-pressure systems that develop over tropical or subtropical oceans. This definition differentiates tropical cyclones from extra tropical (mid latitude) cyclones that exhibit a cold-core in the upper troposphere and often form along fronts in higher latitudes. Subtropical cyclones are hybrid systems that exhibit some characteristics of tropical cyclones and some characteristics of extra-tropical cyclones. Tropical cyclones extract much of their energy from the upper layer of the ocean, while extra tropical cyclones derive much of their energy from the baroclinic temperature gradients in which they form.

These cyclones originate over oceans in tropical areas where the temperature varies between 25deg and 27 degrees and move over to the coastal areas bringing about large scale destruction caused by violent winds, very heavy rainfall and storm surges. The tropics extend from the Tropic of Cancer at 23.5 degree N to the Tropic of Capricorn at 23.5 degree S. They derive their energy through the evaporation of water from the ocean surface, which ultimately recondenses into clouds and rain when moist air rises and cools to saturation. The tropical cyclones are found over the North Atlantic Ocean, Southern Atlantic Ocean, the eastern, central and western North Pacific Ocean, the central and western South Pacific Ocean and the northern and southern Indian Ocean.

Tropical cyclone, also called **typhoon** or **hurricane: A**n intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain. Drawing energy from the sea surface and maintaining its strength as long as it remains over warm water, a tropical cyclone generates winds that exceed 119 km per hour. In extreme cases winds may exceed 240 km per hour, and gusts may surpass 320 km per hour. Accompanying these strong winds are torrential rains and a devastating phenomenon known as the storm surge, an elevation of the sea surface that can reach 6 metres (20 feet) above normal levels. Such a combination of high winds and water makes cyclones a serious hazard for coastal areas in tropical and subtropical areas of the world. Every year during the late summer months (July–September in the Northern Hemisphere and January–March in the Southern Hemisphere), cyclones strike regions as the Gulf Coast of North America, north-western Australia, and eastern India and Bangladesh.

Cyclonic winds blow counter clockwise in the Northern Hemisphere and blow clockwise in the Southern Hemisphere. The opposite direction of circulation is due to the Coriolis Effect. Coastal regions are particularly vulnerable to the impact of a tropical cyclone, compared to inland regions. The primary energy source for these storms is warm ocean waters, therefore these forms are typically strongest when over or near water, and weaken quite rapidly over land. Coastal damage may be caused by strong winds and rain, high waves (due to winds), storm surges (due to severe pressure changes), and the potential of spawning tornadoes.

Tropical cyclones also draw in air from a large area—which can be a vast area for the most severe cyclones—and concentrate the precipitation of the water content in that air (made up from atmospheric moisture and moisture evaporated from water) into a much smaller area. This smaller area is known as eye. Around the eye is the eye wall, where there is a strong spiraling ascent of air to greater height reaching the Tropopause.

Tropical cyclones are known by various names in different parts of the world depending on their area of formation. In the North Atlantic Ocean and the eastern North Pacific they are called *hurricanes*, and in the western North Pacific around the Philippines, Japan, and China the storms are referred as *typhoons*. In the western South Pacific and Indian Ocean they are referred as severe *tropical cyclones*, or simply cyclones and *Willie-willies* in the Western Australia. All these different names refer to the same type of storm.

There are other types of tropical disturbances namely tropical depressions and tropical storms. A tropical depression or tropical low is a tropical disturbance that has a clearly defined surface circulation with maximum sustained winds of less than 63kmph. A tropical storm is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds between 63 km/h and 119 km/h. At this point, the distinctive cyclonic shape starts to develop, although an eye is not usually present. Though tropical storms are less intense than tropical cyclones they can produce significant damage.

Characteristics of tropical cyclones:

1) The isobars are circular in shape.
2) Their diameter varies between 150 and 300 meters.
3) The central area is designed as the eye of the cyclone.
4) They do not have fronts.
5) They derive their energy from the latent heat.
6) Their velocity varies between 50 and 300kms.
7) They occur in the autumn season.
8) The clouds in the tropical cyclone are cumulonimbus having vertical extension upto 12kms.
9) They give torrential rainfall.

Formation of tropical cyclones:

Tropical cyclones usually develop in the summer season. Tropical cyclones are one of the mechanisms by which surface heat energy is redistributed from the equator to the poles. Water temperatures of at least 26.5 °C are needed down to a depth of at least 50 m, causing the overlying atmosphere to be unstable enough to sustain convection and thunderstorms.

Another factor is rapid cooling with height, which allows the release of the heat of condensation that powers a tropical cyclone. High humidity, especially in the lower-to-mid troposphere; when there is a great deal of moisture in the atmosphere; conditions are more favourable for disturbances to develop.

Low amounts of wind shear are needed, as high shear is disruptive to the storm’s circulation. Tropical cyclones generally need to form more than 555 km or five degrees of latitude away from the equator, allowing the Coriolis Effect to deflect winds blowing towards the low pressure center and creating a circulation.

Lastly, a formative tropical cyclone needs a pre-existing system of disturbed weather. Tropical cyclones will not form spontaneously. Low-latitude and low-level westerly wind bursts associated with the Madden-Julian oscillation can create favorable conditions for tropical cyclogenesis by initiating tropical disturbances.

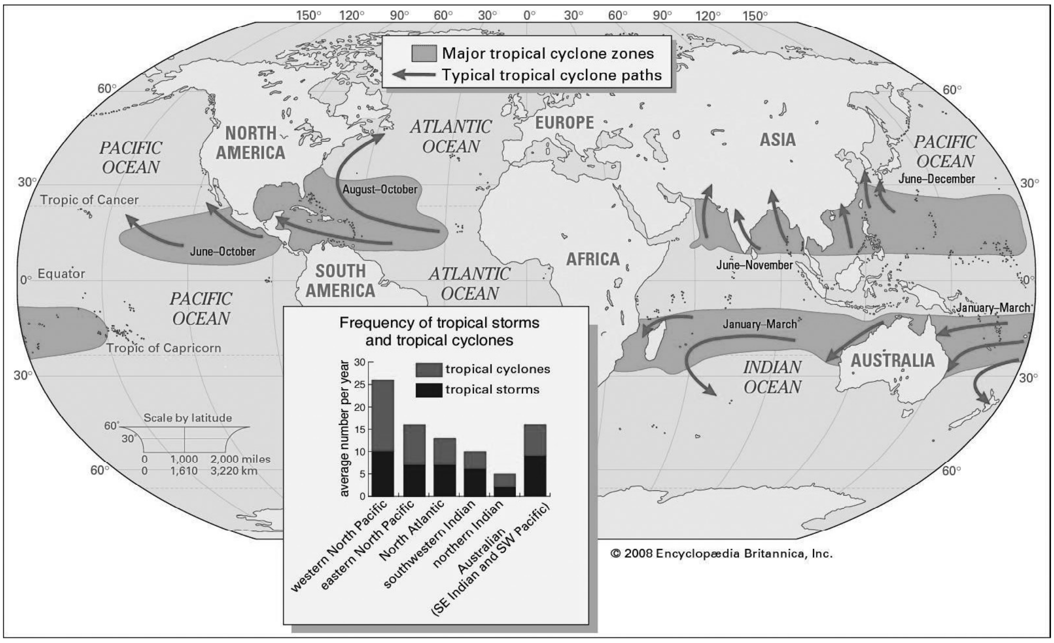
On a worldwide scale, May is the least active month, while September is the most active month. November is the only month in which all the tropical cyclone basins are active. In the Northern Atlantic Ocean, a distinct cyclone season occurs from June 1 to November 30, sharply peaking from late August through September. In the North Indian basin, storms are most common from

April to December, with peaks in May and November. In the Southern Hemisphere, the tropical cyclone year begins on July 1 and runs all year-round encompassing the tropical cyclone seasons, which run from November 1 until the end of April, with peaks in mid-February to early March.

Weather conditions associated with tropical cyclones:

The arrival of the cyclone causes sudden increase in air temperature and wind velocity, accompanied by cumulonimbus clouds, lightning, thunder and emergence of high waves in the oceans. Visibility decreases and this condition last for few hours due to thick and overcast sky.

The arrival of centre of eye of the cyclone is marked by fair weather, calm breezes, clear sky and no rains. After 10 to 15 minutes, very severe weather again commences which is an indication of arrival rear of the cyclone. After 3-4 hours ferocity of the cyclone decreases and the weather becomes calm after cyclone has passed.



Disasters associated with the tropical cyclones:

Tropical cyclones cause large waves, heavy rain, flood and high winds, disrupting international shipping and, at times, causing shipwrecks. On land, strong winds can damage or destroy vehicles, buildings, bridges, and other outside objects, turning loose debris into deadly flying projectiles. The storm surge, or the increase in sea level due to the cyclone, is typically the worst effect from land falling tropical cyclones, historically resulting in 90% of tropical cyclone deaths. The broad rotation of a land falling tropical cyclone, and vertical wind shear at its periphery, spawns *tornadoes* which persist until landfall.

Tropical cyclones significantly interrupt infrastructure, leading to power outages, bridge destruction, and the hampering of reconstruction efforts. The majority (83%) of tropical cyclone damage is caused by severe hurricanes, category 3 or greater. However, category 3 or greater hurricanes only account for about one-fifth of cyclones that make landfall every year.

Advantages of tropical cyclones:

Although cyclones take an enormous toll in lives and personal property, they may be important factors in the precipitation regimes of places they impact, as they may bring much-needed precipitation to otherwise dry regions. Tropical cyclones also help maintain the global heat balance by moving warm, moist tropical air to the middle latitudes and Polar Regions, and by regulating the thermohaline circulation through upwelling. The storm surge and winds of cyclones may be destructive to human-made structures, but they also stir up the waters of coastal estuaries, which are typically important fish breeding locales. Tropical cyclone destruction spurs redevelopment, greatly increasing local property values.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

2. Discuss in in brief about tropical cyclones?

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3. What are the advantages of tropical cyclones?

6.4 ANATOMY OF A CYCLONE

Tropical cyclones are compact, circular storms, generally some 320 km in diameter, whose winds swirl around a central region of low atmospheric pressure. The winds are driven by this low-pressure core and by the rotation of Earth, which deflects the path of the wind through a phenomenon known as the 'Coriolis force'. As a result, tropical cyclones rotate in a counter clockwise (or cyclonic) direction in the Northern Hemisphere and in a clockwise (or anticyclonic) direction in the Southern Hemisphere.

The wind field of a tropical cyclone may be divided into three regions. First is a ring-shaped outer region, typically having an outer radius of about 160 km and an inner radius of about 30 to 50 km. In this region the winds increase uniformly in speed toward the centre. Wind speeds attain their maximum value at the second region, the eye wall, which is typically 15 to 30 km from the centre of the storm. The eye wall in turn surrounds the interior region, called the eye, where wind speeds decrease rapidly and the air is often calm.

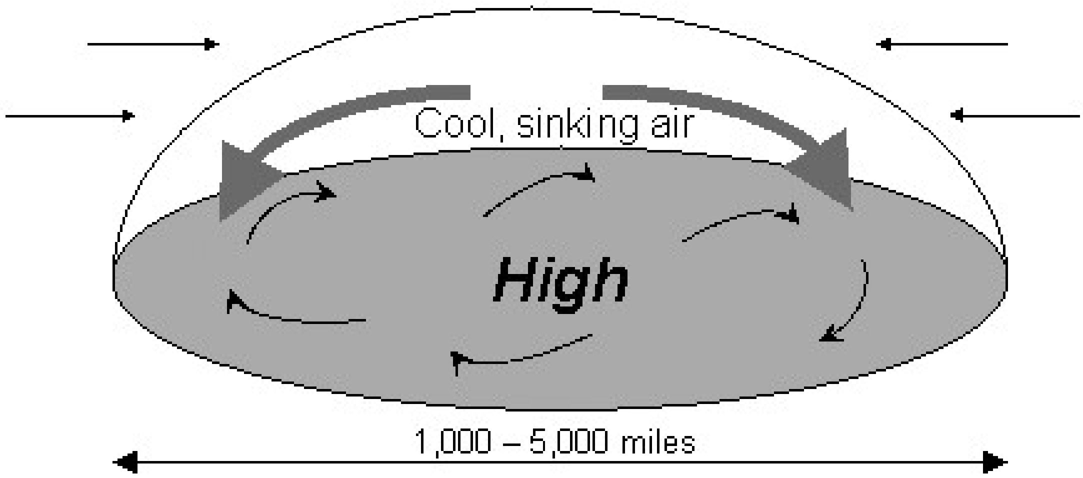
These main structural regions are described in greater detail below.

The eye: A characteristic feature of tropical cyclones is the eye, a central region of clear skies, warm temperatures, and low atmospheric pressure. Typically, atmospheric pressure at the surface of Earth is about 1,000 millibar. At the centre of a tropical cyclone, however, it is typically around 960 millibar, and in a very intense 'super typhoon' of the western Pacific it may be as low as 880 millibar. In addition to low pressure at the centre, there is also a rapid variation of pressure across the storm, with most of the variation occurring near the centre. This rapid variation results in a large pressure gradient force, which is responsible for the strong winds present in the eye wall.

6.5 ANTICYCLONE

Areas of sinking air which result in high pressure are called anticyclones. The opposite of an anticyclone is the cyclone or depression. High pressure systems have small pressure gradients.

This means that the winds are gentle. As the air sinks, it warms up, leading to warm and dry weather. An anti-cyclone also known as a high pressure area is a large atmospheric circulation system with the wind flowing clockwise around it in the Northern Hemisphere, and counter-clockwise in the Southern Hemisphere. Anticyclones form from air masses cooling more than their surroundings, which causes the air to contract slightly making the air denser. Since dense air weighs more, the weight of the atmosphere overlying a location increases, causing increased surface air pressure.



Anticyclone

The air mass cooling that results in an anticyclone forming can be caused by either conduction as the air flows over a relatively cool ocean surface, or through the loss of infrared radiation over land during the fall, winter, or spring when little sunlight is available to warm the air mass.

Anticyclones are much larger than depressions and produce periods of settled and calm weather lasting many days or weeks. Anticyclones often block the path of depressions, either slowing down the bad weather, or forcing it round the outside of the high pressure system. As air descends, air pressure increases. When air hits the ground, it has to go somewhere. The earth's rotation makes the air change direction. In the Northern Hemisphere the air is pushed clockwise. In the Southern Hemisphere the air is pushed anticlockwise.

The strongest anticyclones occur over snow-covered portions of Asia and North America in the winter when clear, dry air masses cool from a loss of infrared radiation, while little sunlight is absorbed to offset that infrared cooling.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

4. Discuss in brief about anticyclones?

6.6 CHECK YOUR PROGRESS - MODEL ANSWERS

1. The temperate cyclone may be 1600kms wide. 2) The isobars are elliptical in shape. 3) The cold air mass moves faster than the warm air mass. 4) These cyclones move at a speed of 5 to 25 kmph. 5) They give light showers which are highly beneficial for the crops and human health and efficiency. 6) In the ending part of the cyclone there is thunder and lightning. 7) Each cyclone is followed by a clear weather.

2. **Tropical cyclone**, also called **typhoon** or **hurricane**, an intense circular storm that originates over warm tropical oceans and is characterized by low atmospheric pressure, high winds, and heavy rain. Drawing energy from the sea surface and maintaining its strength as long as it remains over warm water.

3. Advantages of tropical cyclones: Tropical cyclones help maintain the global heat balance by moving warm, moist tropical air to the middle latitudes and Polar Regions, and by regulating the thermohaline circulation through upwelling. The storm surge and winds of cyclones may be destructive to human-made structures, but they also stir up the waters of coastal estuaries, which are typically important fish breeding locales. Tropical cyclone destruction spurs redevelopment, greatly increasing local property values.

4. Areas of sinking air which result in high pressure are called anticyclones. The opposite of an anticyclone is the cyclone or depression. An anti-cyclone also known as a high pressure area is a large atmospheric circulation system with the wind flowing clockwise around it in the Northern Hemisphere, and counter-clockwise in the Southern Hemisphere.

6.7 MODEL EXAM QUESTIONS

Answer the following questions in about 30 lines

1. Why tropical cyclones originate over the seas
2. In which part of the tropical cyclone do terrestrial rains and high velocity winds blow.
3. Discuss about distribution of temperate cyclones

Short answer questions

What are the effects of a cyclone?
What is a ‘Tornado’?
1. Ocean currents, 2. Diamond dust, 3. Cyclone eye.

UNIT-7: AIR MASSES AND FRONTS

Contents

7.0 OBJECTIVES

To know about the air masses and its types
To discuss about the fronts
To know about different types of fronts

7.1 INTRODUCTION

It is important for forecasters to be able to identify air masses, as they form the basis on which a forecast is constructed. For the majority of time air mass weather affects the UK, with fronts occasionally crossing the country. Most of our significant precipitation is associated with fronts. However, at times air masses can bring large amounts of precipitation too. By interpreting and understanding the air mass, regions that are likely to be affected by precipitation can be identified.

In the Northern Hemisphere, the idea that northerly winds are cold (i.e. winds from the north) and southerly winds are warm (winds from the south) is quite common. Similarly, air that has travelled over the sea picks up moisture, while air that has travelled over land is relatively dry. These simple concepts help in the understanding of air masses.

What is an air mass?
An air mass is a huge body of air where temperature and humidity (and hence subsequent weather) are reasonably consistent. The clouds are similar in size, shape, type, etc. For this to happen, the values of temperature and humidity must be fairly similar anywhere within the area shown. It is this uniformity and lack of variation that identifies an air mass type.

Air Mass is an extremely large body of air whose properties of temperature and moisture content (humidity), at any given altitude, are fairly similar in any horizontal direction. It can cover hundreds of thousands of square miles. There can be small variations. Source Regions are simply geographic areas where an air mass originates. It should be uniform surface composition – flat and light surface winds. The longer the air mass stays over its source region, the more likely it will acquire the properties of the surface below.

Where do air masses come from?
Air masses develop in the major high-pressure areas around the world, and gain their distinctive temperature and humidity characteristics from prolonged contact with their underlying surface. The atmosphere is heated and cooled almost entirely by contact with the earth's surface.

There are 4 main divisions of air mass commonly recognized. These are: 1.Polar (cold) (polar latitudes **P** - located pole ward of 60 degrees north and south), 2. Tropical (warm) (tropical latitudes **T** - located within about 25 degrees of the equator), 3.Maritime (moist) (marine **m** - located over the oceans——moist), and Continental (dry) (continental **c** - located over large land masses—dry). These can be combined to give specific air mass types as follows: Tropical Maritime - Warm and moist (**mT** maritime tropical warm, moist, usually unstable), Tropical Continental - Warm and dry (**cT** continental tropical hot, dry, stable air aloft—unstable surface air), Polar Maritime - Cold and (fairly) moist (**mP** maritime polar cool, moist, and unstable), Polar Continental - Cold and dry (**cP** continental polar cold, dry, stable).

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. What is an air mass?

7.2 TYPES OF AIR MASS

There are 4 main divisions of air mass commonly recognized. These are; Polar (cold). Tropical (warm), Maritime (moist), and Continental (dry).

These can be combined to give specific air mass types as follows:

Tropical Maritime -Warm and moist
Tropical Continental -Warm and dry
Polar Maritime - Cold and (fairly) moist
Polar Continental -Cold and dry

The two main air masses affecting the UK are Tropical Maritime and Polar Maritime. There are also two further classifications known as Returning Polar Maritime and Arctic Maritime.

An air mass attains its characteristics from its source region, the area from which it originates. However, if an air mass moves away from its source region, it will modify or change its properties of temperature and moisture content. A Continental air mass, for example, will pick up moisture if it travels over the sea, but if it travels across land it will stay dry. Cold air travelling over a warm surface will rise (convection), possibly forming shower clouds. Understanding how the air mass has been modified is crucial to forecasting the weather that it will eventually bring. So, to positively define an air mass we need to know both the region of origin and the course travelled before arrival.

UK Air masses

Six air masses affect the UK and the direction they approach the UK. When the weather is unsettled' we may experience two or three different air masses during the course of a day.

7.3 TROPICAL MARITIME

This south-westerly air mass originates from the subtropical Atlantic Ocean, typically the Azores area, as a hot, moist air mass. As it approaches the UK though, its temperature lowers over increasingly cooler water to become warm or mild while the long sea track keeps the moisture content high.

Wind facing coasts and hills may experience fog, low cloud and drizzle in this air mass. Bodmin Moor, Dartmoor, Dyfed, western Ireland and western Scotland can be shrouded in mild, damp conditions whether it be winter or summer. Further inland, particularly to the lee of high ground, the cloud may break up bringing a lot of sunshine. Favored locations like Northumberland and the Moray Firth can bask in spring-like weather on a January day.

Check your progress

Note :(a) Space is given below for writing your answer.

(b) Compare your answer with the one given at the end of this unit.

2. Discuss about types of air masses?

7.4 TROPICAL CONTINENTAL

Chiefly in the summer, when UK residents talk of "heat waves", this is the air mass that generally provides it. It begins life in North Africa, before crossing the Mediterranean into Spain and France and arriving into the UK from the south or southeast. It does pick up some moisture in crossing the Mediterranean Sea, but loses much of this over the mountains of Southern Europe. However, it can produce widespread thunderstorms (day or night), heavy precipitation and flooding. This is known as the 'Spanish Plume'. Summer weather is hot or very hot, and dry. It is also quite hazy and it is common for this air mass to deposit Saharan dust over parts of the UK.

Polar Maritime

This air mass develops over cold source regions such as Greenland or Canada, to the northwest of the UK. As the cold air travels over the relatively warm sea it is warmed from below, making the air rise (convection) and it also picks up moisture. This means shower clouds (and possibly thunderstorms) develop.

This air mass is very common in winter, with frequent showers of rain, sleet and snow and occasional thunderstorms. The showers tend to be concentrated near the west coast, although they can penetrate inland, particularly through northwest facing openings such as the Cheshire Gap to reach Birmingham and London. Many eastern areas in winter usually stay clear and dry, sheltering behind hills and mountains.

In summer however, hot temperatures over the land allows showers and perhaps thunderstorms to develop anywhere in the UK. These showers tend to disperse overnight however. Another feature of note is the very good visibility experienced in this air mass, both winter and summer — although visibility can fall to almost nil in winter snow showers.

Returning Polar maritime

This air mass has exactly the same source regions as Polar Maritime, but travels southwards, instead of southeast, before turning north towards the UK. This more southerly track allows it to become warmer than Polar Maritime, before it curves back towards the UK. This re-curving brings it back over cooler water again. Therefore, at low levels of the atmosphere this air mass appears warm and moist – similar to Tropical Maritime. Higher up, the air remains unchanged from its source region, and behaves more like the Polar Maritime air mass. On exposed coasts and hills this may lead to low cloud and hill fog. However, like Polar Maritime, showers or possibly thunderstorms are also a feature. To the lee of high ground, in the north and east, skies may be clearer and it can be quite warm.

Polar Continental

A Polar Continental air mass originates from high pressure areas over Scandinavia or Russia and reaches the UK on Easterly or Northeasterly winds. UK meteorologists sub-divide this air mass type, depending upon how long the air has taken to cross the North Sea and season. If the air has a short crossing, for example from Holland to East Anglia, it is likely to remain dry and relatively cloud-free. If the sea journey is long, from Scandinavia to London for example, the air will pick up moisture en route.

Polar Continental air is associated with very low temperatures and bitterly cold winds in winter, and wind chill can be significant. The moisture obtained from the sea brings winter showers of snow or hail, while the west benefits from shelter of hills and mountains, staying clear, dry and very cold.

In summer, Continental air from the east is cooled as it crosses the North Sea. This leads to another common feature of East Coast weather — the North Sea “haar” or “fret”. If the air crossing the sea cools enough, it condenses into low cloud or sea fog. The fog is generally confined to the coastal strip, evaporating as it tries to move over the warm land, although it may be brought further inland upon the easterly wind. As the land cools at night, the fog is able to penetrate well inland (possibly feeding through natural ‘gaps’, the Forth/Clyde valley for example) and it may persist through much of the morning before the sun is able to burn it back to the coast. Occasionally, the additional moisture and warm temperatures inland in summer and mountain uplift can combine to produce showers or possibly thunderstorms over the Pennies.

Arctic Maritime

This is similar to Polar Maritime air, but colder. As with Polar Maritime, convection (cold air heated by relatively warm seas) occurs. Consequently, showers of rain, snow, sleet and hail affect windward facing coasts and high ground. The Highlands of Scotland usually take the brunt of a ‘screaming northerly’, with blizzards on low and high ground. Parts of eastern England, North York Moors, North Norfolk, North Wales and Western Cornwall are also susceptible to wintry showers. Elsewhere there tends to be clear skies.

Final Thoughts on air masses

Air mass considerations can help predict future weather, but local effects such as proximity to coasts and topography may be as important. The actual weather depends on the detailed history of the air, the speed of movement and the surface over which if flows. Where two different types of air mass meet is known as a front. Fronts are explained in this section.

Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

3. Briefly discuss about polar maritime air mass?

7.5 FRONTS AND FRONTAL DEPRESSIONS

Definition of a Front: The boundary between two contrasting air masses. In the UK fronts are often formed when Tropical Maritime air meets Polar Maritime air. Differences in temperature (resulting in differences in density), means that air masses do not mix easily when they come together. The less dense air mass will tend to rise up over the other, creating a three-dimensional boundary called the frontal zone.

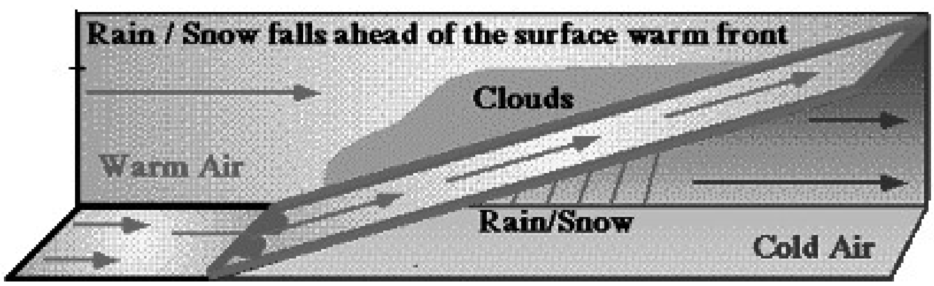
A front moving such that warm air replaces cold air on the earth's surface is termed a warm front. One that moves so that cold air replaces warm air is called a cold front. Meteorologists often mark the position of the cold front on operational weather maps with a blue line, and use red for a warm front. Similarly, warm fronts have semi-circles draw in the direction of movement –this warm front too would be moving towards the northeast. A simple way to remember the difference is to think of the triangles on the cold front as icicles, and the semi- circles on the warm front as the sun on the horizon, bringing warmer weather.

7.6 TYPES OF FRONTS

Warm front

A warm front is where warm air is overriding cold air so that at the surface, warm air replaces cold air.

Shallow leading edge warm air must "overrun" cold air—cold air recedes moves slow 10-15 knts. Warm occlusion mostly in NW. Precipitation is similar to the cold occlusion.



The warm front, less dense air rises up and over the colder air ahead of the front. Again, the air cools as it rises and its moisture condenses to produce clouds and precipitation. Warm fronts have a gentler slope and generally move more slowly than cold fronts, so the rising motion along warm fronts is much more gradual. Precipitation that develops in advance of a surface warm front is typically steady and more widespread than precipitation associated with a cold front.

Cloud: Increasing amounts of upper cloud, thickening and lowering with approach of front. Leading edge of upper cloud about 800 km ahead of surface front.

Weather: Slight rain approximately 200–400 km ahead of surface front becomes moderate close to surface front, ceasing after passage. Scattered outbreaks of slight rain or drizzle may occur in warm sector.

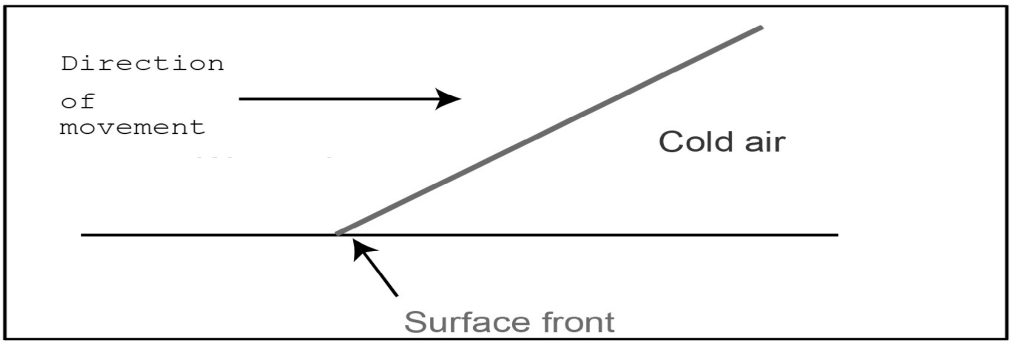
Temperature: May rise on passage of front, but not necessarily as rain depresses temperature.

Potential hazards associated with a warm front:

Snow: Snow may occur ahead of the front as precipitation falls through cold air. On most occasions it will turn to rain as warmer air pushes across the area.

Freezing rain: On very rare occasions there is a risk of freezing rain in the cold air ahead of the front producing a glaze on any surface it falls.

Heavy rain: An active warm front may produce prolonged and heavy rainfall with a risk of flooding.



Diagrammatic cross-section through a warm front

Behind a warm front: Widespread fog may well develop as warm air passes over a cold surface.

Rapid thaw: If there is lying snow the introduction of warmer air may cause it to thaw, giving a risk of flooding.

Check your progress

Note :(a) Space is given below for writing your answer

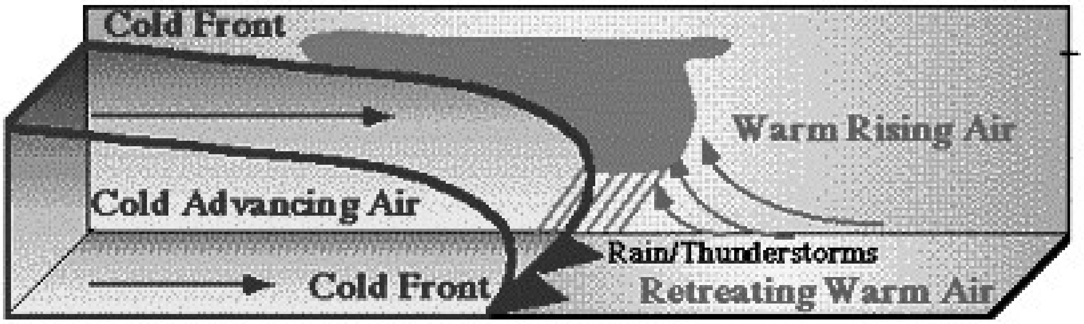
(b) Compare your answer with the one given at the end of this unit.

4. Define fronts. Discus about Potential hazards associated with a warm front?

Cold front

On a cold front the cold polar air undercuts the warmer tropical air (usually tropical maritime). This causes the ascent and cooling of air on the front resulting in thick cloud layers and precipitation. A cold front can be an active feature with heavy rain and strong winds or weak with little or no rain. Potential hazards associated with a cold front.

A cold front is cold air displacing warm air. A colder, denser air mass lifts the warm, moist air ahead of it. As the air rises, it cools and its moisture condenses to produce clouds and precipitation. Due to the steep slope of a cold front, vigorous rising motion is often produced, leading to the development of showers and occasionally severe thunderstorms. On a cold front the cold polar air undercuts the warmer tropical air. This causes the ascent and cooling of air on the front resulting in thick cloud layers and precipitation. A cold front can be an active feature with heavy rain and strong winds or weak with little or no rain.



Cloud: Thick layers of strati form cloud. Some active cold fronts have occasional embedded cumulonimbus, and some are composed principally of convective cloud, though this tends to be more a feature of cold fronts at lower latitudes. Cloud becoming convective and well-broken behind front.

Weather: A fairly narrow band of rain around the surface frontal position, some heavy, especially on the front. Risk of hail and thunder if cumulonimbus is present.

Temperature: Usually falls, but may rise due to the suns heating in clearer air behind front.

Thunderstorms and heavy rain: Lightning and heavy rain from embedded cumulonimbus (Cb) on an active cold front can lead to a risk of flooding/landslides. Salt wash-off is a high probability.

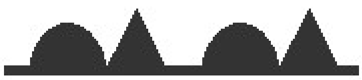
Strong winds: Strong winds are possible due to down draughts from any Cb. Perhaps gusty, squally winds behind the front.

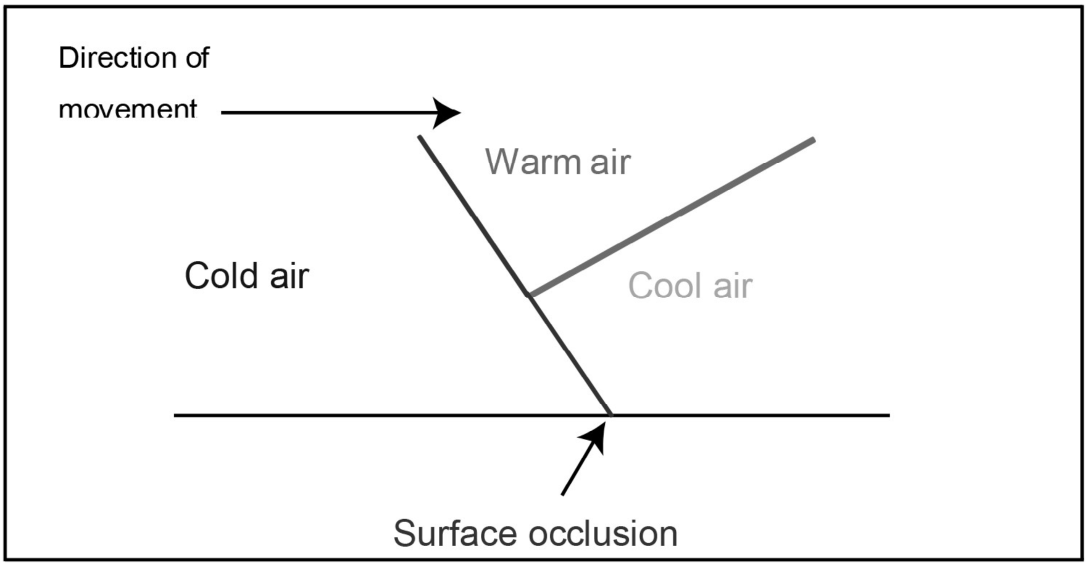
Snow: Rain may turn to sleet then snow during the passage of a cold front. The rain may also turn to snow if the front is associated with heavy and prolonged rainfall.

Behind a cold front: Rapid clearance of front (cloud) could result in RST falling quickly. Possible wash-off on front or showers following front giving ice hazard.

Occluded Fronts:

An occluded front is symbolized as on a weather map.





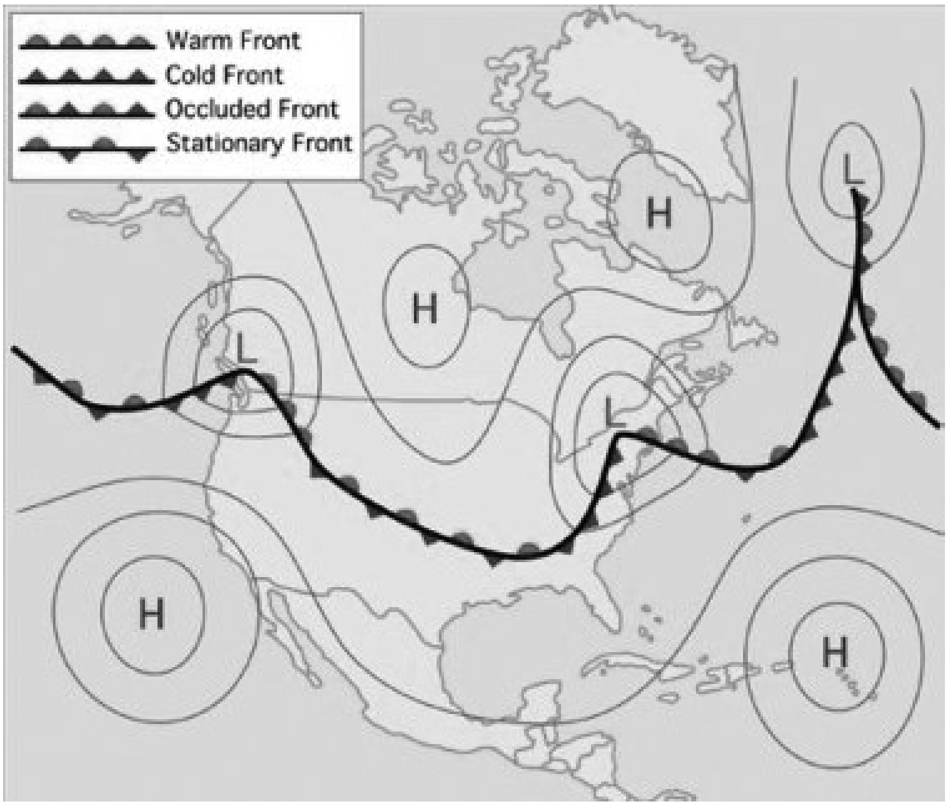
Diagrammatic cross-section through an occlusion

These are slightly more complex than cold or warm fronts. The word 'occluded' means 'hidden' and an occlusion occurs when the cold front 'catches up' with the warm front, the warm air is lifted up from the surface, and therefore 'hidden'. An occlusion can be thought of as having the characteristics of both warm and cold fronts. They can also be responsible for very heavy rain or snow.

Potential hazards associated with an occlusion:

Heavy rain/snow: The rain intensity may be heavy enough that it cools the air and turns to snow. If the air is cold enough behind the front then any precipitation may be of snow. The amount of rain may be enough to cause flooding.

A stationary front is characterized by no movement of the transition zone between two air masses.



Check your progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

5. Discus about occluded front?

7.7 CHECK YOUR PROGRESS ANSWERS

1. **Air Mass** is an extremely large body of air whose properties of temperature and moisture content (humidity), at any given altitude, are fairly similar in any horizontal direction. It can cover hundreds of thousands of square miles.

2. There are 4 main divisions of air mass commonly recognized. These are; Polar (cold). Tropical (warm), Maritime (moist), and Continental (dry).

These can be combined to give specific air mass types as: Tropical Maritime -Warm and moist; Tropical Continental -Warm and dry; Polar Maritime - Cold and (fairly) moist; Polar Continental -Cold and dry.

3. A Polar Continental air mass originates from high pressure areas over Scandinavia or Russia and reaches the UK on Easterly or Northeasterly winds. If the air has a short crossing, it is likely to remain dry and relatively cloud-free. If the sea journey is long, from Scandinavia to London, the air will pick up moisture en route. Polar Continental air is associated with very low temperatures and bitterly cold winds in winter, and wind chill can be significant.

4. **A Front is the** boundary between two contrasting air masses. The Potential hazards associated with a warm front are snow, freezing rain and heavy rain. Snow may occur ahead of the front as precipitation falls through cold air. There is a risk of freezing rain in the cold air ahead of the front producing a glaze on any surface it falls. An active warm front may produce prolonged and heavy rainfall.

5. The word ‘occluded’ means ‘hidden’ and an occlusion occurs when the cold front ‘catches up’ with the warm front, the warm air is lifted up from the surface, and therefore ‘hidden’.

7.8 MODEL EXAM QUESTIONS

Answer the following questions in about 30 lines.

1. What are the types of air masses? Discuss any one of the air mass.
2. Write about tropical maritime air mass
3. Discuss about polar continental air mass

Short Answer questions

1. Cold fronts, 2. Occluded fronts, 3. Warm fronts.
2. Arctic maritime.
3. Define air mass.

7.9 FURTHER READINGS

1. Savindra Singh, 2021; Physical Geography, Pravallika Publications.
2. Savindra Singh, 2020; Oceanography, Pravallika Publications
3. Critchfield, H: General Climatology, Prentice-Hall, NewYork,1975.
4. Stringer, E.T.: Foundation of Climatology, Surjeet Publications, Delhi, 1982.
5. Trewartha,G.T.: An Introduction to Climate, International Students edition, McGraw-Hill, NewYork, 1980.

BLOCK - III: INTRODUCTION TO OCEANOGRAPHY

Oceanography is a science that deals with the oceans and includes delimitation of their extent and depth, the physics and chemistry of their waters, marine biology, and the exploitation of their resources.

Oceanography or marine science, is the branch of Earth science that studies the ocean. Oceanography is an interdisciplinary science that involves the study of the entire ocean. It covers a wide range of topics such as: Ocean currents, waves and tides, Plate tectonics. Physical properties like temperature, pressure, salinity, density of ocean water etc.

blend to further knowledge of the World Ocean and understanding of processes within it

Why study the Ocean?

The answer depends on our interests, which devolves from our use of the oceans. Three broad themes are important:

1. The oceans are a source of food. Hence we may be interested in processes which influence the sea just as farmers are interested in the weather and climate. The ocean not only has weather such as temperature changes and currents, but the oceanic weather fertilizes the sea. The atmospheric weather seldom fertilizes fields except for the small amount of nitrogen fixed by lightening.

2. The oceans are used by man. We build structures on the shore or just offshore; we use the oceans for transport; we obtain oil and gas below the ocean; and we use the oceans for recreation, swimming, boating, fishing, surfing, and diving. Hence we are interested in processes that influence these activities, especially waves, winds, currents, and temperature.

3. The oceans influence the atmospheric weather and climate. The oceans influence the distribution of rainfall, droughts, floods, regional climate, and the development of storms, hurricanes, and typhoons. Hence we are interested in air-sea interactions, especially the fluxes of heat and water across the sea surface, the transport of heat by the oceans, and the influence of the ocean on climate and weather patterns.

There are 3 units in this block.

Unit 8: Relevance of oceanography in earth and atmospheric sciences: Definition of oceanography.

Unit 9: Surface configuration of the ocean floor, continental shelf, continental slope, abyssal plain, mid-oceanic and oceanic trenches. Relief of Atlantic, Pacific and Indian Oceans.

Unit 10: Distribution of temperature and salinity of oceans and seas.

UNIT-8: RELEVANCE OF OCEANOGRAPHY IN EARTH AND ATMOSPHERIC SCIENCES

Contents

8.0. OBJECTIVES

•Able to understand an overview of Oceanography

•To know the scope, growth and development of oceanography.

•Able to understand area and depths of oceans

8.1 INTRODUCTION

Oceanography is the branch of science that deals with the study of oceans and the oceans form a fundamental unit of the earth's surface and their volume is considerably greater than that of the land above sea level. If all the inequalities of the earth were levelled off, there would be enough water in the oceans to cover the entire surface of the earth to a depth of about 2,800 metre (8,600 feet). Most of the land lies close to the sea-level, the mean height of the continents being 750 m (2.300 feet), while the oceans of the other hand, have their greatest area between about 4,000 and 6,000 metre (12,000 and 18,000 feel) below sea-level. In fact 41% of the whole surface of the earth lies between the last two depths. Surface area wise the oceans cover about 71% of the total for the globe, leaving only some 29% under the landmasses.

8.2 DEFINITION AND SCOPE

Geography, the science of the earth, is a synthetic science which largely depends for its data on the results of specialized sciences such as astronomy, physics, geology, oceanography, meteorology, biology and anthropology. The science of Geography, since its inception in antiquity up to the present time, includes definite aspects of all those terrestrial phenomena (land lithosphere; air: atmosphere; water; hydrosphere) which are now treated exhaustively under the heads of geology, meteorology and oceanography, The science of oceanography, explaining the conditions of the hydrosphere, is the part and parcel of physical geography. For its data it depends upon geology, meteorology, physics, chemistry and biology of sea water. The significance and importance of oceanography in the science of geography can very well be realized considering the great expanse of the hydrosphere, covering about three-fourth of the earth's surface, that is, the total water area is about 361,059,000 square kms (71%), whereas the land area is about

148,892,000 square kms. J. Proudman' states that "Oceanography studies the fundamental principles of dynamics and thermodynamics in relation to the physical and biological properties of the sea water."

8.3 GROWTH AND HISTORICAL DEVELOPMENT

The foundation of oceanography can be traced back to the observations of naturalists and the records of seamen from the voyages of Phoenicians, Carthaginians and Greeks in the nearer parts of the Indian Ocean and the Atlantic Ocean outside the Pillars of Hercules. The early period of its development (1000 B. C to 2nd century A. D.) is divided into three stages:

(1) Traditional voyages crystallized in the knowledge of the world from Homer (1000 B. C.) to Hecateous (500 B. C.) showing the great river-like 'oceans' surrounding the known lands bordering the Mediterranean;

(2) Discoveries of the astronomer Pytheas (4th century B. C.), a contemporary of Alexander. He imparted knowledge of latitudes and tides at different places. The Greek scholar Strabo (1st century B. C.) also wrote a comprehensive treatise on the physiography of land and sea. Later on, Posidonius asserted that he measured the sea in the neighborhood of Sardinia to a depth of 300 meters.

(3) The third stage resulted in the contribution of a map by C. Ptolemy in 2nd century A. D. in which he represented the Indian Ocean as an enclosed sea-an error which remained uncorrected till the time of Captain James Cook in the 18th century.

With Ptolemy we come to the end of the period of scientific oceanographic researches of classical times. There was a faint knowledge and little progress in oceanography during the following period, known as Dark Age. This period was again followed by the Great Age of Discoveries and explorations in 15th and 16^{th} centuries which resulted in immense knowledge about oceans. During this period Prince Henry of Portugal called 'The Navigator' founded his school of maritime research on south-west corner of Portugal at Sagres near Cape St. Vincent in 1420 Later on, Columbus discovered America, Vasco da Gama opened the route to India and Magellan circumnavigated the globe. The achievements of this illustrious trio of the Great Age opened a new era of history for geography and oceanography. Hence in 1570, the world map of Ortelius showed enormous changes in the knowledge of land and sea.

Again, a period of comparative inactivity followed the Great Age and remained till late in 18th century, when Captain James Cook (1728-79) explored South Pacific Region.

Oceanography in the 19th century. The knowledge and development of the science of the sea during 19th century is divided into three phases:

(1) The period of Edward Forbes,

(2) The period of Wyville Thompson and the Challenger expedition, and

(3) The post 'Challenger' period of Sir John Murray and the modern oceanography.

These three phases were marked by the pioneer work in marine biology, regarding the exploration of the depths of ocean, and the study of plankton, coral reefs and submarine deposits. During this time the study of oceanography was directed towards more scientific lines. Data collection became important and many scientific expeditions in various oceans were carried out by eminent scientists of the time. Following are the great contributors to oceanographic researches during the 19th century.

8.4 OCEANOGRAPHY AND OTHER SCIENCES

Oceanography is a science which has taken its birth from geographic soil. Hence, like it, oceanography is also intimately associated with the exact sciences. Geology, which is concerned with the history of the earth and rocks, covers and elucidates the basic concepts of Physical Oceanography. Practically for its vital issues of the origin, age and composition of oceanic basins, origin and permanency of ocean basins, and the nature of the ocean bottom, oceanography depends and maintains a clear relationship with geology. Sea is a fluid in motion, hence for its thermodynamic studies, oceanography depends on physics, mathematics and hydrodynamics. Different principles of applied mathematics, and the concept of hydrostatics and hydrokinetics, elucidate different motion in sea water, viz., wind waves, currents, tides and tidal waves, etc.

Oceanography and Meteorology have their foundation on the geographic soil. Meteorology, in general, studies various climatic phenomena with the help of physics and chemistry. Marine Meteorology emphasizes the role played by the atmosphere on the oceans, thereby studying insolation in the atmosphere above oceans, temperature and heat budget of the oceans, pressure and wind system of the lower atmosphere, and their interactions on the biology, physics and chemistry of the water masses. This finally leads to the study of the climatic regions of the oceans. Due to this interrelationship between oceanography and meteorology, the former is also regarded as 'Inverted Meteorology' (studies directed upside down). Chemistry, Zoology and Botany have also some contributions towards Oceanography.

Oceanography in India: the development of Oceanography in India is quite recent. It was the international Indian Ocean Expedition (IIOE), and the Indian Institute of Oceanography was established to full fill the above aim. IIOE is the first major cooperative effort to search of Indian Ocean. The scientific work planned in Physical Oceanography, Chemical Ooceanography, marine Biology and fisheries, meteorology, marine geology and geophysics.

The area under oceans and sea is nearly 2.5 times as great as that of the land. In the northern hemisphere continents take up 39.3 percent and oceans 60.7 percent, where's in the southern hemisphere to the share of the continents fall merely 19.1 and that of the oceans 80.9 percent of the area. This is the reason why Northern hemisphere is called continental Hemisphere and southern hemisphere is oceanic hemisphere.

Definition of Oceanography: The scientific study of phenomena associated with oceans is known as oceanography. Oceanography includes Physical oceanography and biological oceanography.

i) Physical oceanography: The extent and the shape of ocean basins, the structure and relief of their floors, the movements of seawater, its temperature and salinity.

ii) Biological oceanography: The study of life in the oceans.

Check your progress

Note :a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Definition of Oceanography?

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2. Explain the research contribution in Oceanography in 19th century?

Geographers have divided the oceanic area into 4 oceans, namely the pacific, the Atlantic, the Indian, and the Arctic. These oceans includes the sea, bays, gulf and other oceanic inlets attached to them. The dimensions and depths has shown in the table.

AREAS AND DEPTHS OF OCEANS

OCEAN (With Seas communi-cating with it)	AREA (Thousand square kilometre)	PERCENTAGE (of the entire area of World Ocean)	DEPTH (in metre)		LOCATION OF MAXIMUM DEPTH
			Mean	Maximum	
1	2	3	4	5	6
Pacific Ocean	165384	50	4028	11033	Mariana Trench
Atlantic Ocean	82217	25	3926	9200	Puerto Rico Trench
Indian Ocean	73481	21	3897	8047	Java Trench
Arctic Ocean	14056	04	1205	5450	Nansen's Trough
World Ocean	335138	100	3795	11776	—

8.5. ATLANTIC OCEAN

Shape and size: The Atlantic Ocean extends over about 16.5% of the total area of the earth. This percentage does not include that of its marginal seas. The area of this ocean is about 50% of the Pacific Ocean. The most striking feature about the bottom of the Atlantic is the presence of the Mid Atlantic Ridge that divides this ocean in half. This ridge extends 2.5 km above the deep-sea plains on either side. This submarine ridge slopes gently towards the deep-sea plain on either side. It is S –shaped following the general trend of the coastlines. On the eastern side, the coast of Saharan Africa bulges towards the west, while the north coast of South America recedes into the Caribbean Sea; while the Cape Sao Roque projects eastwards, the gulf of guinea recedes in the same direction. From the Nature of the shape of the respective coasts together with other geological and biological evidences, it becomes clear that in the remote part the continents on both the sides of the present ocean must have been parts of a single land-mass.

This ocean basin becomes narrower towards the equator. The distance between the Liberian coast of Africa and Cape Sao Roque is only 2560 km. To the north of equator the north Atlantic basin is 4800km wide in latitude 40^0N, while the south Atlantic Basin is 5920kms. Wide in latitude 35^0S. Whereas the south Atlantic opens broadly into the southern ocean, the north Atlantic is rather enclosed by Greenland and Iceland.

8.6 THE PACIFIC OCEAN

It is triangular in shape with its apex in the Bering Strait. It is bounded by Asia and Australia on the west, and North America and South America to the east. Antarctica lies to the south of this vast ocean whose length from north to south is 14900km, whereas its width along the equator is a little more than 16000km.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

3. Give a brief note on Atlantic Ocean

8.7 INDIAN OCEAN

The third largest, stretches from Cape Comorin in India to the Antarctic at the South Pole, takes up only about 21 percent of the world's ocean water surface (14.6 percent of the total earth surface area. Its greatest depth is 7725 meters to 8047 meters.

8.8 ARCTIC OCEAN

Is strictly not an ocean it is not navigable. It winds round the North Pole and is completely frozen in winter and covered with drifting ice for the rest of the year. However, its separate existence and its area of over 13 million Square KMs. i.e. entire it to be called an Ocean.

Summary: The science of oceanography, explaining the conditions of the hydrosphere it also the part and parcel of physical geography. The growth and development of oceanography in 19^{th} century contributed in research of oceanography. Further the area and shape of four oceans is discussed.

8.9 CHECK YOUR PROGRESS ANSWERS

1. Oceanography is a science that investigates and interprets the characteristics and origin of Ocean basins and reliefs thereof, physical and chemical properties of sea water, ocean dynamics, ocean deposits, marine resources, man and marine environment.

2. Following are the great contributors to oceanographic researches during the 19th century. The development of the science of the sea during 19th century is divided into three phases:

(1) The period of Edward Forbes,
(2) The period of Wyville Thompson and the Challenger expedition, and
(3) The post 'Challenger' period of Sir John Murray and the modern oceanography.

These three phases were marked by the pioneer work in marine biology, exploration of the depths of ocean, and the study of plankton, coral reefs and submarine deposits. Data collection and many scientific expeditions in various oceans were carried out by eminent scientists.

3. The Atlantic Ocean, the second largest ocean covers a little more than half of the area occupied by the pacific (20.9 percent of the earth surface). Its greatest depth is 8385 meters. The most striking feature about the bottom of the Atlantic is the presence of the Mid Atlantic Ridge that divides this ocean in half. This ridge extends 2.5 km above the deep-sea plains on either side. This submarine ridge slopes gently towards the deep-sea plain on either side.

8.10 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each

1. Explain the definition and scope Oceanography
2. Discuss the oceanography and other sciences

II. Answer the following questions in about 10 lines each

1, Give a short note on growth and development of Oceanography.
2. Give an account on oceans of the World.

8.11 GLOSSARY

Bay: A wide, open, curving indentation of the sea or a lake into the land Hudson Bay

Gulf: is a large inlet of the sea, usually more enclosed and more deeply indented than a bay. Example: Gulf of Mexico

Hydrosphere: is the aqueous shell which includes all the natural waters - the water of Oceans, Seas, lakes and rivers which covers more than 70 percent of the Earth's Surface.

Meteorology: is the science dealing atmosphere and its phenomena, including weather and climate.

8.12 FURTHER READINGS

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UNIT-9: SURFACE CONFIGURATION OF THE OCEAN FLOOR

Contents

9.0. OBJECTIVES

•Able to understand an overview of physical Oceanography in terms of morphology and relief features of oceans.

•To know the distribution of water temperature on the surface of oceans and various features.

•Able to understand salinity of oceans in the world

9.1. INTRODUCTION

The oceans are confined to the great depressions of the earth's outer layer. The oceans, unlike the continents, merge so naturally into one another that it is hard to demarcate them. The geographers have divided the oceanic part of the earth into five oceans, namely the Pacific, the Atlantic, the Indian Southern ocean and the Arctic. The various seas, bays, gulfs and other inlets are parts of these four large oceans.

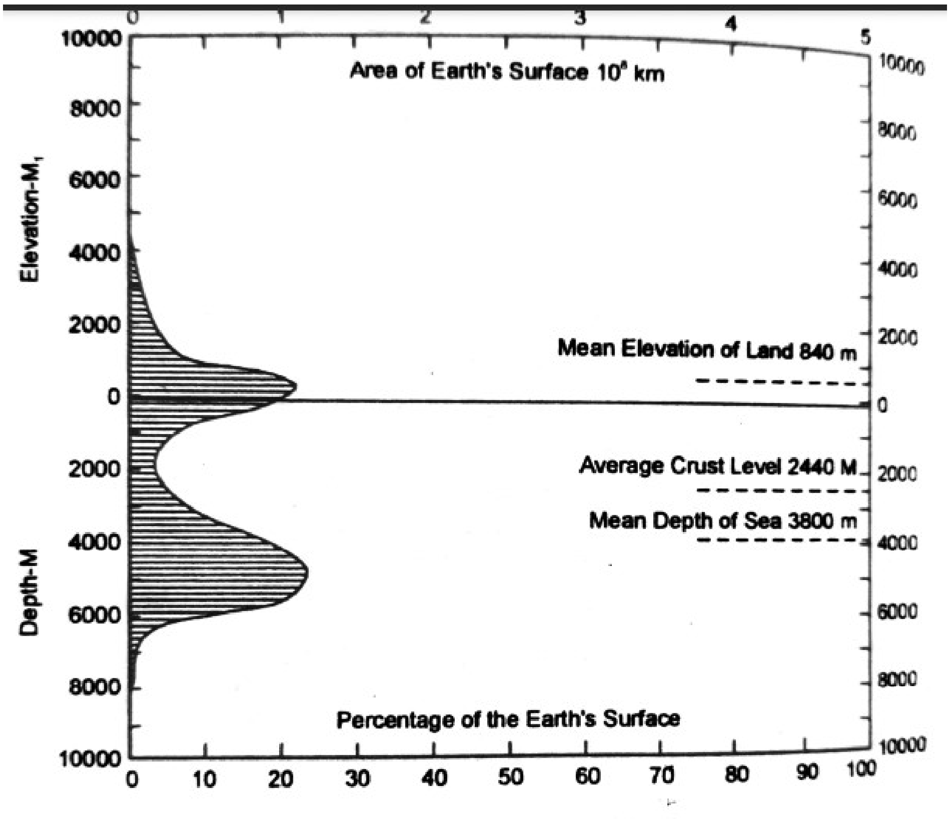
In the recent past, a large number of bathymetric and nautical charts were published about the bottom relief of the oceans. Example: International Hydrographic also published world ocean charts. All the charts show that there is remarkable regularity of the bottom relief.

World's largest underground Ocean: The world's largest underground ocean i.e. subterranean water body was discovered in the year 2007. It extends from Indonesia to the northern tip of Russia for a length of 700 to 1400 km below the ground surface.

9.2 THE HYPSOGRAPHIC/ HYPSOMETRIC CURVE

It shows the distribution of the earth's solid surface elevations above and below the sea level. It also shows the percentage of the Earth's total area, land area, and Ocean area at depths and elevations indicated along left margin of the figure. Hypsographic curve indicates that the floor of oceans may be divided into four parts.

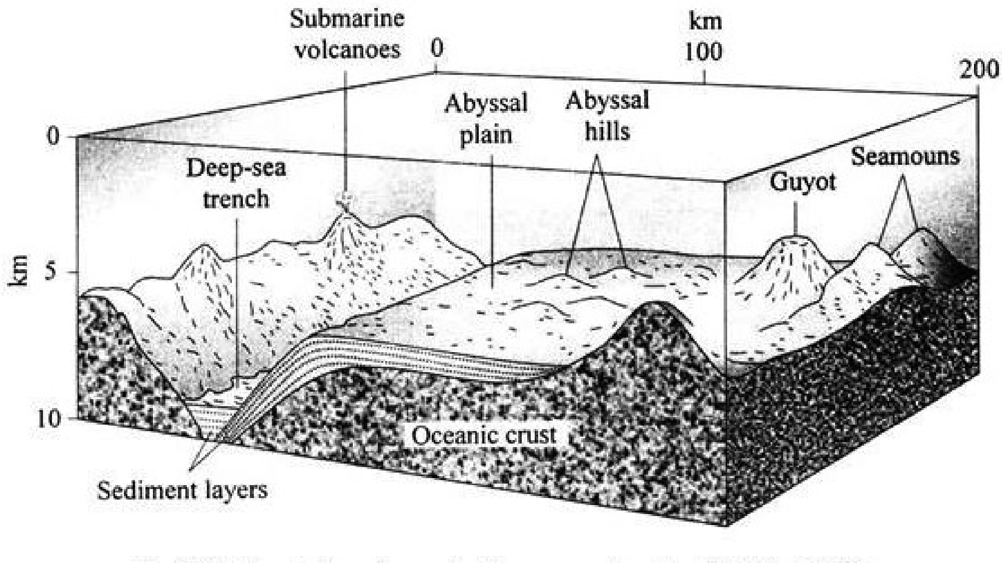
Figure 9.1



9.3 MAJOR AND MINOR RELIEF FEATURES

The ocean floors can be divided into four major divisions: (i) the Continental Shelf; (ii) the Continental Slope; (iii) the Deep Sea Plain; and (iv) the Oceanic Deeps.

Besides, these divisions there are also major and minor relief features in the ocean floors like ridges, hills, sea mounts, guyots, trenches, canyons, etc.



Morphology of Ocean basins, Source: based on P.R.Pinet, 2000

A major portion of the ocean floor is found between 3-6 km below the sea level. The 'land' under the waters of the oceans, that is, the ocean floor exhibits complex and varied features as those observed over the land. The floors of the oceans are rugged with the world's largest mountain ranges, deepest trenches and the largest plains. These features are formed, like those of the continents, by the factors of tectonic, volcanic and depositional processes.

Continental Shelf

The continental margins which have been flooded by the oceans are called the continental shelf. It is the shallowest part of the ocean showing an average gradient of 1° or even less. The width of the continental shelves vary from one ocean to another. The average width of continental shelves is about 80 km. The shelves are almost absent or very narrow along some of the margins like the coasts of Chile, the west coast of Sumatra, etc. On the contrary, the Siberian shelf in the Arctic Ocean, the largest in the world, stretches to 1,500 km in width. The depth of the shelves also varies. It may be as shallow as 30 m in some areas while in some areas it is as deep as 600 m. The continental shelves are covered with variable thicknesses of sediments brought down by rivers, glaciers, wind, from the land and distributed by waves and currents. Massive sedimentary deposits received over a long time by the continental shelves, become the source of fossil fuels.

The continental shelf area is one of the most useful parts of the ocean to man. The water on the continental shelf is shallow so that light penetrates to the sea floor. Because of the availability of light and nutrients, plants and animals grow and thrive in abundance in these regions. Naturally, therefore, the most abundant supplies of fish can be found in the continental shelf.

Continental Slope

The continental slope refers to a relatively steeply sloping surface lying seaward of the continental shelf. It connects the continental shelf and the ocean basins. It begins where the bottom of the continental shelf sharply drops off into a steep slope. Usually there is gently sloping depositional surface at the base of the continental slope which is known as continental rise. The gradient of the slope region varies between 2-5°. The depth of the slope region varies between 200 and 3,000 m. The slope boundary indicates the end of the continents. Canyons and trenches are observed in this region. The continental slope is steeper in Pacific Ocean than the Atlantic and the Indian Ocean.

Deep Sea Plain

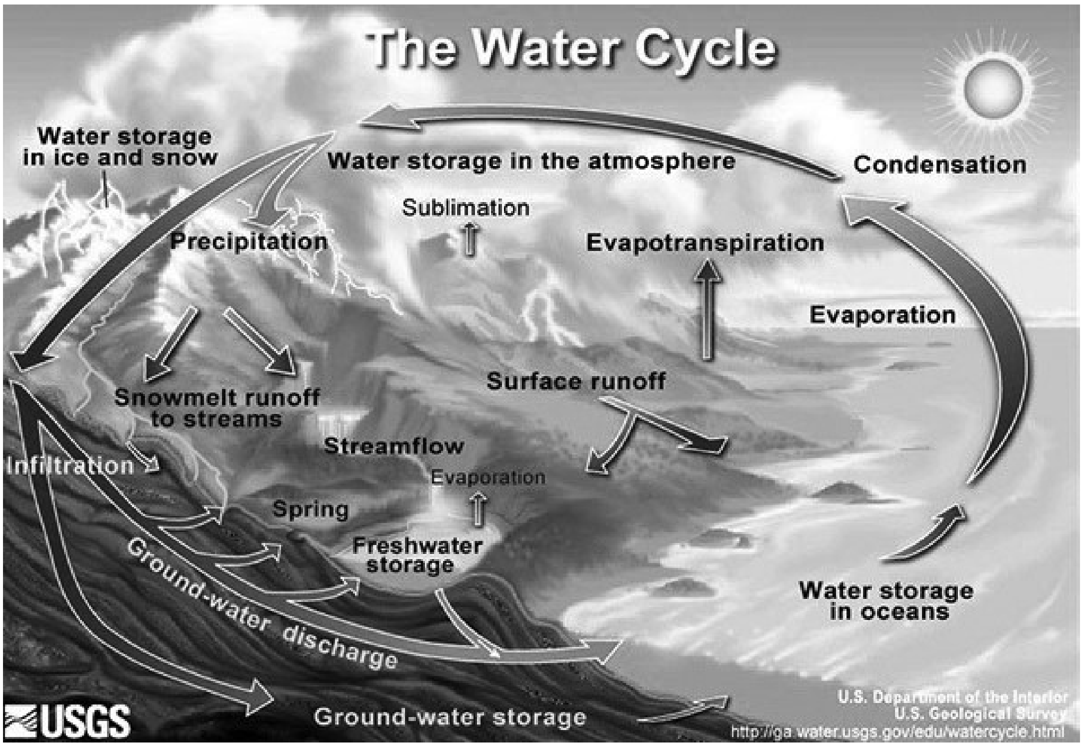
Deep sea plains, also called abyssal plains. These are gently sloping areas or nearly level area of the entire ocean floor. The depths vary between 3,000 and 6,000m.The major characteristic of the abyssal plains is the complete absence of sediments brought by the rivers. Deep sea plaines are characterized by pelagic deposits of plant, marine animal and silicious remains but there is absence of erosional debris of terragenous origin. Volcanic deposits have been reported at a few places.

Oceanic Deeps or Trenches

The term Ocean deeps refers to two types of depression found on the ocean floor. The depressions are classified as trenches and troughs. Trenches are defined as long, narrow and deep depressions on the ocean floor, with relatively steep sides. They are usually arc shaped. Ocean troughs, on the other hand, are long and relatively broader than the trenches. However the sides have gentle slopes (The Barlet Troughs in the Caribbean Sea and the waver trough in the Molucca Sea are the most important).

Major ocean deeps

Ocean deeps are the deepest parts of the oceans. They are some 3-5 km deeper than the surrounding ocean floor. They occur at the bases of continental slopes and along island arcs and are associated with active volcanoes and strong earthquakes. As many as 57 deeps have been explored so far; of which 32 are in the Pacific Ocean; 19 in the Atlantic Ocean and 6 in the Indian Ocean.



The challenger Deep, in the south Pacific's Mariana Trench, is the deepest part of the ocean. It is interest to note that if Mt. Everest, is placed in this trench, it would be completely drowned, and would still have 1.6 Km of water above its peak. Located in the south-west Pacific Ocean and at the Kermadec Tonga Subduction Zone's northern end, the Tonga Trench lies around 10.882 km below sea level. The deepest point in the Tonga trench, known as the Horizon Deep, considered to be the second deepest point on earth after the Challenger Deep and the deepest trench of the Southern Hemisphere. The third deepest point in the world, the Galatea Depth in the Philippine trench is 10.54 km below sea level. Also known as Mindanao Trench, this submarine trench is located in the Philippine Sea.

Another deepest part of ocean belonging to the Pacific Ocean, this trench lies at a considerable depth of 10.5 km below sea level. Lying close to Kuril Island and off the coast of Kamchatka. Another deep submarine trench located east of the Japanese islands, Japan Trench (as shown in image above) is part of the Pacific Ring of Fire in the northern Pacific Ocean. With a maximum depth of 9 km, the Japan Trench stretches from the Kuril Islands to the Bonin Islands and is also the extension of the Kuril-Kamchatka Trench and the Izu-Ogasawara Trench to the north and south respectively.

Located between the Caribbean Sea and the Atlantic Ocean, the Puerto Rico trench marks the deepest point in this region and the eighth deepest point found on the earth's surface. Lies at a depth of 8.64 km, spotted at Milwaukee Deep and measures a length of over 800 km, this trench has been responsible for many tragic tsunamis and earthquake activities in this region. The deepest trench in the Atlantic Ocean after Puerto Rico Trench, South Sandwich Trench is at a depth of about 8.42 km, described as Meteor Deep and runs for over 956 km, making it one of the most noticeable trenches of the world.

Check your progress

Note :a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. What is Hypsometric curve?

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2. What is an Abyssal Plain?

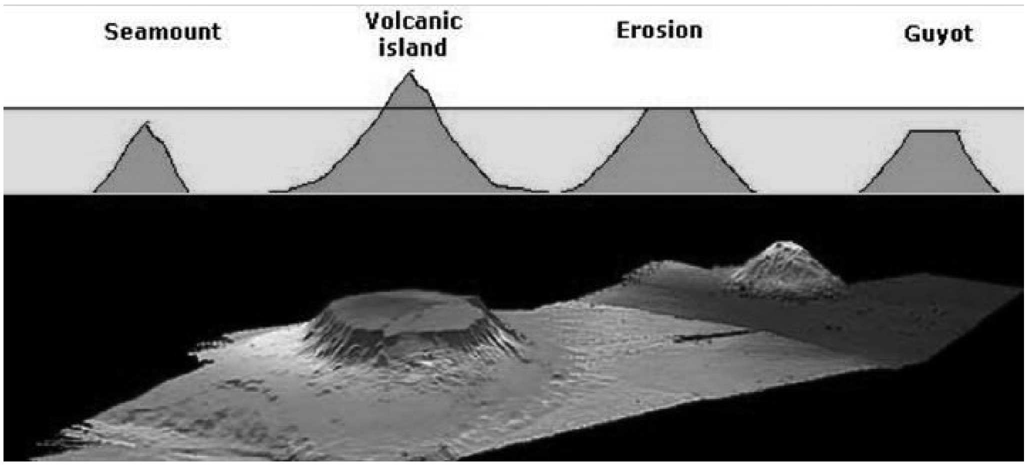
Minor Relief Features

Apart from the above mentioned major relief features of the ocean floor, some minor but significant features predominate in different parts of the oceans.

Mid-Oceanic Ridges: A mid-oceanic ridge is composed of two chains of mountains separated by a large depression. The mountain ranges can have peaks as high as 2,500 m and some even reach above the ocean's surface. Example: Iceland, a part of the mid-Atlantic Ridge.

Seamount: It is a mountain with pointed summits, rising from the seafloor that does not reach the surface of the ocean. Seamounts are volcanic in origin. These can be 3,000-4,500 m tall. The Emperor seamount, an extension of the Hawaiian Islands in the Pacific Ocean, is a good example.

Submarine Canyons: These are deep valleys, some comparable to the Grand Canyon of the Colorado River. They are sometimes found cutting across the continental shelves and slopes, often extending from the mouths of large rivers. The Hudson Canyon is the best known submarine canyon in the world.



Guyots: It is a flat topped seamount. They show evidences of gradual subsidence through stages to become flat topped submerged mountains. It is estimated that more than 10,000 seamounts and guyots exist in the Pacific Ocean alone.

Atoll: These are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression. It may be a part of the sea (lagoon), or sometimes form enclosing a body of fresh, brackish, or highly saline water.

Oceans of World: Pacific Ocean is the largest and the oldest of the oceans and occupies 50 percent of the world oceans. The Atlantic Ocean is the second largest ocean covers 25 percent. The Indian Ocean, the third largest covers 21 percent. The arctic is strictly not an ocean, however its existence and its area of over 13 million square entitle it to be called ocean.

Ocean Relief

Relief of Atlantic, Pacific and India Ocean: Physical Configuration of the Ocean Floor. The relief features which are found on the ocean floor resemble the major topographic features on land from the point of view of size and shape.

9.4 BOTTOM RELIEF FEATURES OF ATLANTIC OCEAN

The continental shelf – the Atlantic Ocean is characterized by having a broad continental shelf all around. The continental shelves of the North Atlantic are almost broad and flat – surfaced everywhere. Continental shelf is rather narrow from the Bay of Biscay of the Cape of Good Hope. But the shelf near the Brazilian coast is very narrow because of the presence of a plateau flanking the sea coast. Continental shelf of the South Atlantic Ocean is generally narrow. Africa and Brazil being plateaus, the narrowness of the shelf is quite natural.

Mid-Oceanic ridges and rises- As stated earlier, the S-shaped Mid-Atlantic Ridge occupies the middle part of the ocean basin. This ridge extends from the Bear Islands in the north to Bouvet Island in the south, over a distance of about 15,000 km. It may be stated that with the exception of the Bermuda Islands, all the oceanic islands of this ocean belong to this ridge and other transverse ridges rising from it. The presence of this longitudinal ridge is the most characteristic feature of the bottom relief of this Ocean. The average depth of water above the ridge is about 1700 fathoms. The northern part of this ridge is known as the Dolphin Rise, and the southern part as the Challenger Rise. In the North Atlantic, the Mid-Atlantic Ridge is relatively wider and forms the broad Telegraph Plateau. This submarine plateau extends from Ireland to Labrador. The submarine ridge is located between northern Scotland and Iceland is called the Wyville-Thompson. In the south Atlantic the Mild Atlantic ridge is 960km broad, and several transverse ridges rise from it on both the sides. Beyond the Cape of good hope the mid–Atlantic Ridge.

Oceanic deeps: The Atlantic Ocean floor is characterized by a general absence of linear deeps. There is a very deep trough called Puerto Rico deep/Trench. It is the deepest of all the troughs or deeps found on the floor of the Atlantic Ocean.

Islands in the Atlantic Ocean: The British Isles and New Found land are merely the slightly raised parts of the continental shelf. Iceland and the Faeroes are actually the highest peaks or the higher parts of the mid-oceanic ridge between northern Scotland and Greenland, Sandwich Islands, Falklands Islands, Southern Most tip of South America and Graham Land peninsula of Antarctica.

Marginal Seas: The South Atlantic Ocean is characterized by the absence of marginal seas. On the contrary the European and the American sides of the North Atlantic have a number of broad and extensive marginal seas. On the eastern side of the North Atlantic it was the submergence of the continental margins of Europe that produced a highly indented coastline. The marginal seas of the Barongan side comprise the Baltic Sea, the North Sea, and the Mediterranean Sea. The Mediterranean Sea extends from east to west, and has a very irregular coastline dividing it into sub-seas. It is bounded by Europe and Asia Minor on the north and east respectively and Africa to the south. It is surrounded by land except for a narrow connection with the Adam Ocean through the Strait of Gibraltar. It is also connected with the Black Sea through the Bosporus Strait which is very narrow. The Suez Canal, which is man-made connects it with the Red Sea

9.5 BOTTOM RELIEF FEATURES OF PACIFIC OCEAN

On the eastern margin of this ocean the width of the shelf is rather narrow. East Indies and East Asia and relatively much more Broader. Major part of the floor of this ocean is made up of the abyssal plains. The bottom relief of the Pacific Ocean is characterized by the; absence of any mid-oceanic ridges. Oceanic trenches and deeps and the deepest ones are found around the rim of the Pacific Ocean. The challenger Deep, in the south Pacific's Marianas Trench, is the deepest known part of the ocean. Its bottom lies 10,900 meters below the sea level. 20,000 Islands of the western Pacific are structurally parts of the main land that have been submerged under sea water. Kurile Islands, Japan Islands, Philippines, East Indies and New Zealand in the eastern part of north Pacific Ocean the important islands are the following; Aleutian Islands, Islands off the coast of British Colombia south-western part.

Marginal seas: Gulf of California is the only marginal sea on this side of the Pacific. Coast there is a large number of marginal seas between the main land and nearby island groups. North Pacific are located the following marginal seas; the bearing. Sea surrounded by the Aleutian Islands.

9.6 BOTTOM RELIEF FEATURES OF INDIAN OCEAN

The Indian Ocean covers 20% of the total area of the world. It is generally narrow with the average width of about 96km. In the tropical areas different types of coral reefs such as fringing reef, barrier reef and atoll are found on the shelf. The continental shelves are characterized by a large number of submarine valleys and canyons. The width of the shelf along the coast if America is just normal, but in the vicinity of Madagascar the shelf is relatively broader than elsewhere. This ocean has a continuous central ridge, called the Arabic-Indian Ridge.

The central ridge separates the eastern basin from the western basin. Remember that all the oceanic islands in this ocean are situated on the central ridge. However, the cocas and Christ mas islands are two exception.

The Indian Ocean is characterized by having a large number broad submarine ridges, separating several individual basins of the abyssal plain. One of its most distinguishing feature is presence of the series of curving ridges in the North West segment of the ocean.

The above mentioned ridges divide the Indian Ocean into three distinct parts:

1) African part; 2) Australian part; 3) the part adjoining the continent of Antarctica.

Significance of the study of ocean relief

- Ocean relief controls the **motion of sea water.**
- The oceanic movement in the form of currents, in turn, causes many variations in both oceans and in atmosphere.
- The bottom relief of oceans also influences **navigation and fishing.**

Check your progress

Note :a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

3. List out the most common features found on the ocean floor.

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4. Give a brief account on Mid- Atlantic Ridge

Check your progress Answers

1. The average depth of oceans is 3,800 metres against the 840m average height of the lithosphere the different height and depth zones of lithosphere and the hydrosphere are represented by hypsometric curve. The ocean basin are calculated by 4 relief zones ex-continental shelf, Continental slopes, Ocean deeps and oceanic trenches.
2. Abyssal plain is a deep-sea plain. It is a very large and relatively level area of the ocean floor, covered with a thin layer of sediment. Thus abyssal plain is an area of the deep ocean floor having a flat bottom with a very' faint slope. Characteristically situated at the foot of the continental rise, the abyssal plain is present in all ocean basins. It is formed by long-continued deposition of very' fine sediments and, therefore, has a nearly perfect flatness.
3. The most common features found on the ocean floor are: (1) Continental shelf; (2) Continental slope; (3) Submarine canyon; (4) Abyssal plains; (5) Submarine ridge; (6) Ocean deeps; (7) Troughs.
4. The S-shaped Mid-Atlantic Ridge Occupies the middle part of the ocean basin. It is representing the zone of divergent and constructive plate margins. This ridge extends from the Bear Islands in the north to Bouvet Island in the south, over a distance of about 15,000 km. It may be stated that with the exception of the Bermuda Islands, all the oceanic islands of this ocean belong to this ridge and other transverse ridges rising from it. The presence of this longitudinal ridge is the most characteristic feature of the bottom relief of this Ocean. The average depth of water above the ridge is about 1700 fathoms. The northern part of this ridge is known as the Dolphin Rise, and the southern part as the Challenger Rise. In the North Atlantic, the Mid-Atlantic Ridge is relatively wider and forms the broad Telegraph Plateau. This submarine plateau extends from Ireland to Labrador. The submarine ridge is located between northern Scotland and Iceland is called the Wyville-Thompson. In the south Atlantic the Mild Atlantic ridge is 960km broad, and several transverse ridges rise from it on both the sides. Beyond the Cape of good hope the mid–Atlantic Ridge.

Model Examination Questions

I. Answer the following questions in about 30 lines each

1. What are the major relief features of oceans water
2. What are minor relief features of ocean water

II. Answer the following questions in about 10 lines each

1. Discuss the importance of continental Shelf.
2. Discuss the main bottom relief features of Atlantic Ocean.

9.7 GLOSSARY

Abyssal plain: This lie between the continental margins and mid oceanic ridges.

Atoll: these are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression

Continental shelf: It is the shallowest part of the ocean showing an average gradient of 1^{O} Or even less.

Continental slope: the marked slope from the edge of the continental shelf to the deep sea or Abyssal plain.

Abyssal plain: This lie between the continental margins and mid oceanic ridges.

Seamount: it is a mountain with pointed summits, rising from sea floor that does not reach the surface of the ocean.

Trench: An elongated trough or deep in the ocean floor is called trench.

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UNIT-10: DISTRIBUTION OF TEMPERATURE AND SALINITY OF OCEANS AND SEAS

Contents

10.0. OBJECTIVES

•To know the distribution of water temperature on the surface of oceans and various features.

•Able to understand salinity of oceans in the world

10.1. INTRODUCTION

Temperature is one of the most important physical properties of sea water. Salinity and temperature together control the sea water density. Sea water temperature controls the distribution of marine organisms and fish. Because of the influence heat has upon chemical reactions (metabolism) sea water temperature has profound effects on the life processes of fish. Sea water temperature has profound effects on the life processes of fish. Sea water temperature influences the properties of surface air over the ocean. The vertical temperature structure affects the propagation of sound in the sea and is therefore important for anti-submarine warfare. Sea water temperature is indicative of other changes and conditions in the sea such as upwelling intensities, current and water mass boundaries.

The temperature of the oceanic water is important for marine organism and it also affects the climate of coastal lands. The distribution of surface water temperature in the oceans is a complex matter. There is gradual decrease in the annual average temperature of the waters. The range is greater in Atlantic than in Pacific because of its smaller size and greater in the oceans of the northern hemisphere than those in pacific, because of the effect of cool air masses moving over the oceans from the northern landmasses in winter. The distribution of water temperature on the surface of oceans is determined by many factors.

Factors Influencing Sea water Temperature

Sea water temperature varies with respect to space (horizontally and vertically) and time. Major variations in temperature are very common in the upper layers of the ocean because of the influence of external environmental factors. The factors which affects sea water temperature and its variation can be broadly classified into two groups: (1) energy transfer processes taking place below the sea surface and (2) advective heat transfer processes taking place below the sea surface.

i) The degree of heating by solar rays which varies depending upon the latitude.
ii) The prevailing winds and
iii) Ocean currents carrying water of different temperature

An important regularity in the distribution of water temperature on the surface is its close connection with the climatic zonality. Maximal values of the temperature are recorded near the thermal equator and below zero temperature in high latitudes. Isotherms lies of equal temperature in most cases touch almost along the balance in compliance with the latitudinal zonation of the climate your temperature distribution over the surface portions this is particularly manifest in the southern hemisphere starting from 40 Degrees South latitude and farther on to win not up to the Antarctic certain changes that orientation. The distribution pattern of temperature of ocean water is studied in two ways viz: Horizontal distribution and vertical distribution.

10.2 HORIZONTAL DISTRIBUTION OF TEMPERATURE

The average annual temperature for the southern and northern hemisphere are 19.4^0 C and 16.1^0 C, the temperature in the northern and southern hemisphere varies because of unequal distribution of land and ocean water. On an average, the temperature of surface water of the oceans is 26.7^0 C and the temperature gradually decreases from equator towards the poles. The oceans in the northern hemisphere record relatevely higher average temperature than in the southern hemisphere.

10.3 VERTICAL DISTRIBUTION OF TEMPERATURE

The most important feature of the vertical distribution of temperature in the open oceans is that there is a decrease of temperature with increasing depth. With respect to temperature, there are three layers in the oceans from surface to bottom in the tropics. 1. Top layer of warm oceanic water with increasing depth the temperature of water decreases. 2. Thermocline layer is below the top layer and here also we notice decrease of water temperature. 3. The third layer is very cold and extends up to deep ocean floor. But in polar areas only one layer of cold water from surface to the deep ocean floor. There are certain special areas in the oceans where the temperature are high even at great depths. Example Sargasso Sea offers a typical example.

The temperature of ocean depths: Water temperature decreases with depth, except in the polar seas, and after certain depth it becomes extremely slight and gradual. In the polar seas a small inversion of temperature is noticeable with depth of thin layer of cold water formed by the melting polar ice floats on the layer of slightly warmer and more saline water but below about 360M the usual decrease takes place. It is different in Partial enclosed seas may have a very different temperature gradient from that in the open Ocean.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. Give an account on vertical distribution of temperature of oceans?

10.4 SALINITY OF OCEANS

All the water in the nature contain different dissolved minerals also the total amount content of salt dissolved in the sea water is known as salinity. It is expressed in terms of PPM thousand parts or Salinity has been defined as the total amount of solid material in grammes contained in 1 kg of sea – water. The degree of salinity is generally expressed in terms of number of parts of salt per thousand parts of sea water; if in 1000 grams of water there are 35 grams of dissolved salts. It is an important property of sea water and it is determined by measuring the electric conductivity of water with the Salinometer.

10.5 FACTORS CAUSING VARIATIONS IN SALINITY

The amount and distribution of salinity is controlled by a number of factors. The salinity of water in the surface layer of oceans depends mainly on **evaporation** and **precipitation** and in Polar Regions by the processes of **freezing and thawing** of ice. Surface salinity is also greatly influenced in coastal regions by the fresh water and prevailing winds and mixing through movement of the ocean currents contribute to the salinity variations. Salinity, of water are interrelated hence, any change in the temperature or density influences the salinity of an area.

1. Rate of evaporation: The higher the rate evaporation produce areas of high surface salinity.
2. Supply of clean and fresh water through precipitation in humid region the rainfall is heavier, fresh water dilute the sea water and reduce the salinity. In arid and semi-arid area evaporation is higher than precipitation there is greater concentration of salts is high area
3. Due to the addition of fresh water to the oceans salinity near the mouths of rivers decreases. The Mediterranean Sea records higher salinity due to high evaporation. Salinity is, however, very low in Black Sea due to enormous fresh water influx by rivers.
4. Prevailing winds: The winds blowing over the sea surface paly a important in the distribution of surface salinity. Example: The trade winds in both the hemispheres transport warm and saline water from the eastern part of the ocean towards the western part rising the degree of salinity. It is clear that this prevailing winds called the trade winds go a long way in producing salinity. Differences along the eastern and western source of the ocean similarly the intrusion of warm and saline water of the Gulf Stream is most important active factor in raising the salinity of the north east the ocean comes up this phenomenon is called a upwelling. It is the most important cache factor in raising the salinity in the North East Atlantic
5. Mixing through the movement of the ocean water: The oceans have three distinct types of moment's i.e. tides, currents and waves. Because of this major movements there is a continuous mixing of the surface water with those of the subsurface layers of the ocean. Warm oceans carry warm and more saline water towards the polar. The cold current cold and less saline water higher to lower latitudes.

Check your progress

Note: a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

2. What is meant by Salinity?

10.6 CHECK YOUR PROGRESS ANSWERS

1. The maximum temperature of the oceans is at their surface it directly receives the insulation and heat transmitted to the lower sections of the oceans. The temperature decreases from the ocean surface with increasing depth but it is not uniform everywhere the rate of decrease of temperature with increase in depth from equator towards the poles is not uniform. Vertically the oceans are divided into three layers the upper layer with average temperature ranging

between 20 degrees to 25 degree centigrade. The lower layer extends depth up to ocean bottoms this layer is very cold and represents denser ocean water mass these 2 layers separated by transitional zone of rapid change of temperature with increase in depth this zone of ocean water mass is called thermocline.

2. Salinity is defined as the ratio between the weight of the dissolved materials and weight of the sample sea water. Generally, salinity is defined as the local amount of solid material in grams contained in one kilogram of sea water and is expressed as part per thousand.

10. 7 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. What are the factors determine the temperature of the oceans.
2. What is ocean salinity and explain its horizontal and vertical distribution.

II. Answer the following questions in about 10 lines each.

1. Explain the distribution of temperature of the sea water.
2. The amount and distribution of salinity varies Discuss.

10.8 GLOSSARY

Salinity: is a measure of the quantity of dissolved solids (salts) in the ocean. It is measured in part per thousand.

Thermocline: It is the layer of ocean water between the depth zones of 300m-100m characterized by sharp change of temperature in the vertical section of seawaters.

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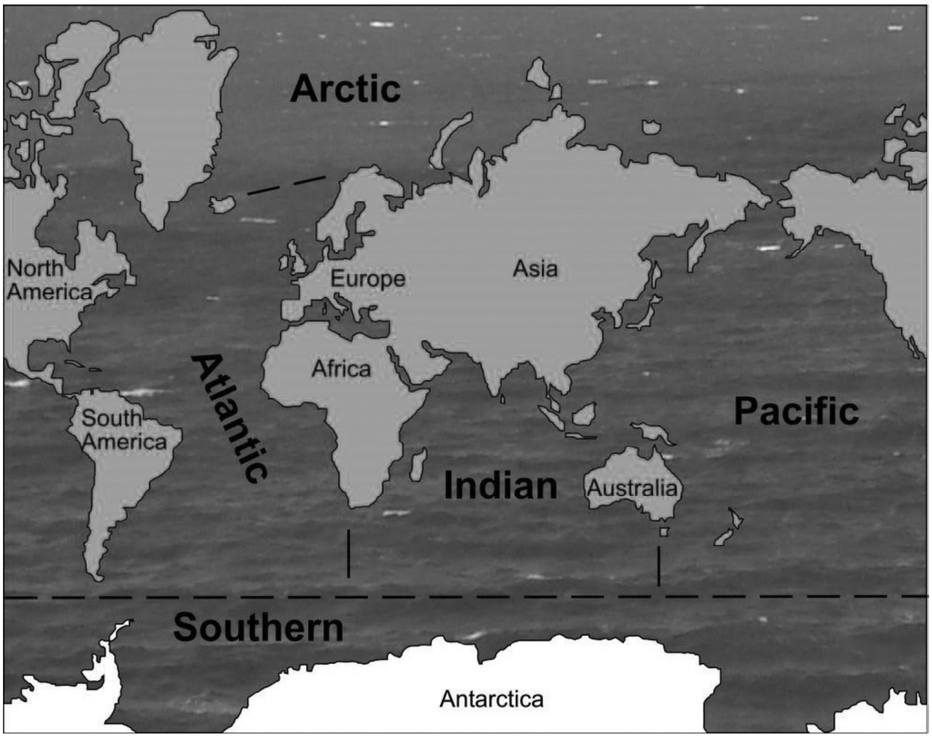
BLOCK - IV: OCEAN WATERS

The ocean is a continuous body of salty water that covers two-thirds of our planet. Five main regions of the ocean have been given the names Pacific, Atlantic, Indian, Arctic and Southern Oceans. There are also smaller areas called seas. Some of these are part of a larger ocean – for example, the Tasman Sea between New Zealand and Australia is part of the Pacific Ocean. Other seas are almost surrounded by land but are still connected to an ocean – an example is the Mediterranean Sea, which is connected to the Atlantic Ocean only by a small gap between Europe and Africa.



Ocean water is composed of many substances. The salts include sodium chloride, magnesium chloride, and calcium chloride. Perhaps the most important substance dissolved in the ocean is salt. Salt comes from mineral deposits that find their way to the ocean through the water cycle. Salts comprise about 3.5% of the mass of ocean water. Where ocean water mixes with fresh water, like at the mouth of a river, the salinity will be lower. But where there is lots of evaporation and little circulation of water, salinity can be much higher. The Dead Sea, for example, has 30% salinity—nearly nine times the average salinity of ocean water. It is called the Dead Sea because so few organisms can live in its super salty water. Pollution of ocean water is a major problem in some areas because many toxic substances easily mix with water.

Some properties of seawater influence the climate of Earth and the ability of life to survive. The ocean is a complex system, and there are close links between the different properties. To understand how this works, we need to look at these properties – what they are, what causes the properties to vary around the world and what happens when they change in the following two units. i. circulation of oceanic waters ii. ocean deposits and coral reefs.

UNIT-11: CIRCULATION OF OCEAN WATERS: WAVES, TIDES AND CURRENTS

Contents

11.0 OBJECTIVES

- To state the various types of ocean movements
- To establish relationship between the planetary winds and circulation of ocean currents

11.1 INTRODUCTION

Ocean circulation is primarily the result of wind pushing on the surface of the water and density differences between water masses. Earth's spin causes the Coriolis force which deflects the direction of air and water currents moving towards or away from the poles. All the water present on the earth makes up the Hydrosphere. The water in its liquid state as in rivers, lakes, wells, springs, seas and oceans. Oceans are the largest water bodies in the hydrosphere. In this lesson we will study about ocean basins, their relief, causes and effects of circulation of ocean waters, Ocean currents and importance.

Water in Earth's atmosphere and crust comes from saline seawater, while fresh water accounts for nearly 1% of the total. The vast bulk of the water on Earth is *saline* or *salt water* though this varies slightly. According to the amount of runoff received from surrounding land. In all, water from oceans and marginal seas, saline groundwater and water from saline lakes amount to over 97% of the water on Earth.

Oceans are the life blood of planet and human kind. Seen from the space, our planet's surface appears to be dominated by the blue colour. The earth appears blue because large distribution of oceans regions and continents is unevenly distribute across the earth's surface, is the most prominent feature on our planet. The world oceans are currently under threat from number of human impacts on local scales, over fishing, deforestation and pollution etc.

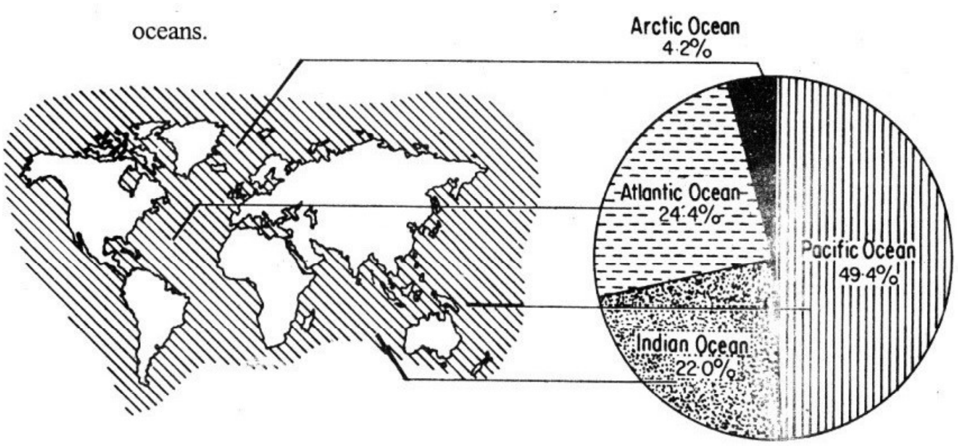
11.2 MOVEMENT OF OCEAN WATER

Nearly 71 percent of the earth surface is covered by seas most of which forms the Atlantic and Pacific Ocean with the deep seas occupying almost 55 percent of the total water surface. The surface of all the seas are in motion through the generation of waves by frictional effect of the wind but below the surface there is a continuous comment of water which is not the wind generated and which results in the transfer of vast amount of energy all of which is derived from the sun because of their surface area. The area is received almost 71 percent of all incoming solar energy. Ocean circulation can be conceptually divided into two main components: **a fast and energetic wind-driven surface circulation, and a slow and large density-driven circulation** which dominates the deep sea. Wind-driven circulation is by far the most dynamic.

Ocean currents are continuous, directed movements of ocean water generated by the forces acting upon this mean flow, such as breaking waves, wind, Coriolis force, temperature and salinity differences and tides caused by the gravitational pull of the Moon and the Sun. Depth contours, shoreline configurations and interaction with other currents influence a current's direction and strength.

Ocean currents can flow for great distances, and together they create the great flow of the global conveyor belt which plays a dominant part in determining the climate of many of the Earth's regions. Perhaps the most striking example is the Gulf Stream, which makes northwest Europe much more temperate than any other region at the same latitude. Another example is the Hawaiian Islands, where the climate is cooler (sub-tropical) than the tropical latitudes in which they are located, due to the effect of the California Current.

The amount of solar energy observed by a sea surface depends on the way the sun's rays meet the surface. When they are vertical, all Sun energy is observed by the sea surface. When they oblique, most of the sun energy is reflected. The energy absorbed by the sea is confined to the surface layers, which are warmed by it and which become less dense as a result. This means that the heated surface layers remain about the colder, denser layers beneath. The sun rays are vertical or near vertical for several hours on almost every day of the year in equatorial latitude, where as in the polar latitude they are always very oblique this means that the seas are much warmer in equatorial latitude than in polar latitudes. These differences in surface water temperature produce a movement of water which is called as an ocean current.



The Oceans and their Percentage Share of the Planet's total Ocean Area.

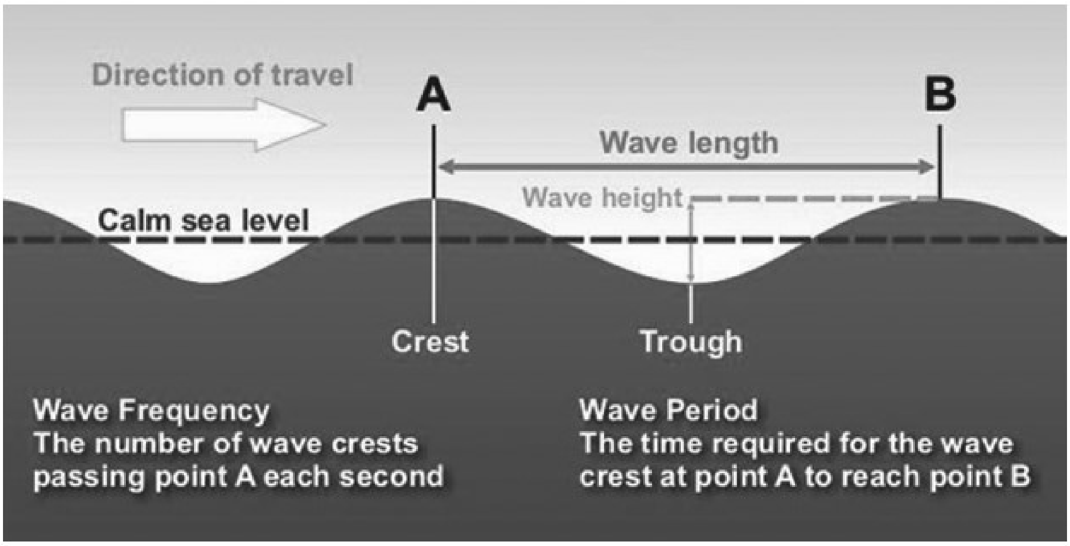
Currents are the general movement of a mass of surface water in a fairly defined direction in other words, ocean water. Ocean currents are convectional currents and they are similar to air currents in the atmosphere results from difference in temperature and heat energy. At the surface, currents are mainly driven by four factors—wind, the Sun's radiation, gravity, and Earth's rotation. All of these factors are interconnected. The Sun's radiation creates prevailing wind patterns, which push ocean water to bunch in hills and valleys. Gravity pulls the water away from hills and toward valleys and Earth's rotation steers the moving water.

Ocean currents which transfer heat are called as "Warm ocean currents" and they are the surface currents. The movement of these currents produces a worldwide water circulation that affects all the oceans in which there is a returning current of cold water for which warm current. A flow of cold water in this circulation is called a "cold ocean current". In general warm ocean currents flow more quickly than cold ocean currents.

There are three major types of movements in the ocean i.e. Waves, Tides and Ocean Currents. Waves represent the oscillatory motions of the ocean surface induced by the force of winds. Tides are simply rise and fall of ocean water that can be seen in coastal areas.

11.3 WAVES

Waves represent the oscillatory motions of the ocean surface induced by the force of winds. Waves on the ocean surface are usually formed by wind. When wind blows, it transfers the energy through friction. The faster the wind, the longer it blows, or the farther it can blow uninterrupted, the bigger the waves. Therefore, a wave's size depends on wind speed, wind duration, and the area over which the wind is blowing Waves may travel thousands of kms, before rolling as share, breaking and dissolving as surf. The maximum wave height is determined by strength of wind i.e. how long it blows and the area over which it blows in a single direction. The highest and lowest points of wave are called crest and trough respectively. Vertical distance from the bottom of a trough to the top of a crest as called as wave amplitude. Wave speed is measured in knots.



The anatomy of a wave

Wind provides energy to the waves. Wind causes waves to travel in the oceans and energy released on shorelines. Waves travel because wind pushes the water body in its course while gravity pulls the crest of the waves downwards falling of water pushes the former troughs upwards, and the wave move to a new position. The actual motion of the water beneath the wave is circular. It indicates that things are carried up and forward as the wave approaches, and down and back as it passes.

Tsunami wave occurs when the tectonic plates beneath the ocean slip during an earthquake. The physical shift of the plates force water up and above the average sea level by a few meters. This then gets transferred into horizontal energy across the ocean's surface. From a single tectonic plate slip, waves radiate outwards in all directions moving away from the earthquake.

Tsunami waves are capable of destroying seaside communities with wave heights that sometimes surpass around 66ft (20 m). Tsunamis have caused over 420,000 deaths since 1850—over 230,000 people were killed by the giant earthquake off Indonesia in 2004, and the damage caused to the Fukushima nuclear reactor in Japan by a tsunami in 2011 continues to wreak havoc. The highest tsunami wave reached about 1,720 ft (524 m), a product of a massive earthquake and rockslide.

11.4 TIDES

The periodical rise and fall of the sea level is known as Tides. These are influenced by the gravitational forces of the Sun, Moon, and Earth.When the sea-level water falls is called as the low tide, while the rising of the water known as the high tide. In the open ocean the difference in height between the high and low tides is known as the tidal range. The time interval between two high tides is called tidal intervals. The rise and fall of waters occurs every 6 hours 15 minutes thus the interval between two high tides and between two low tides is about 12 hours 26 minutes.

Tides are two types of tides based on Sun, Moon and Earth Position.

1. Spring tide; 2.Neap tide

Spring tides: The Position of both the sun and moon in relation to earth as direct bearing on tide height. When the sun, the Moon and Earth are in a straight line, the height of the tide will be higher. These are called spring tides and they occur twice a month on full moon period and new moon period.

Neap tides: Normally this is a seven day interval between the spring tides and neap tides. At this time, the sun and the moon are at right angles to each other and the forces of the sun and the moon tend to counter act one another. The moon's attraction is diminished by counter acting forces of Sun gravitational pull. The tides can be treated well in advance this helps navigators and the fisherman plan their activities.

Check your Progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

1. What are Waves?

11.5 OCEAN CURRENTS

Currents are the movements of ocean, which are regular constant and in a definite direction. These currents are caused by three main forces:

i) The Prevailing winds; ii) Earth rotation; iii) Difference in the density of water

Winds drive immense bodies then, forming surface currents. If the earth rotation which deflects moving things to right in the Northern hemisphere and to the left in the southern hemisphere and to the left in the southern hemisphere, causes the sea, ocean surface currents to move in a clockwise or anticlockwise direction.

Difference in water density affect vertical mobility of ocean currents water with high salinity is denser than water with low salinity. Denser water tends sink, while lighter water tends rises cold ocean currents slowly moves toward the equator from the poles warm ocean currents travel from equator along the surface following towards the to replace the sinking cold water.

Ocean currents are classified into two on the basis of temperature

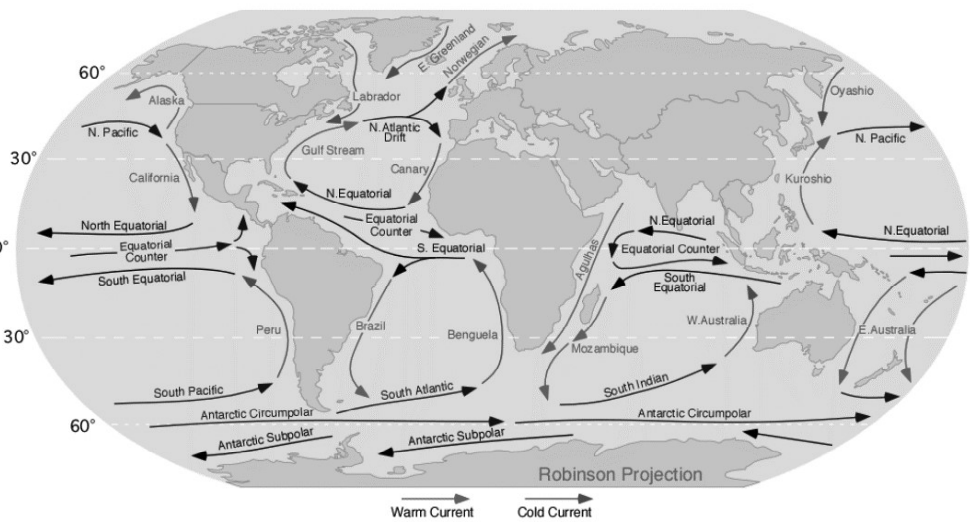
1. Warm currents; 2.Cold currents

Warm Currents: These currents are higher temperature than the surrounding, example gulf stream which modifies the temperature of cold regions. The British Isles and Western Europe define the benefits from these warm currents.

Cold Currents: These currents are relatively cold than it's surrounding. Example: Labrador Current which flows round the south of Green land. It flows past the Eastern Coast of North American and brings a great fall in the temperature.

11.6 IMPORTANT OCEAN CURRENTS

Major Ocean currents are generally influenced by the stress exerted by the prevailing winds and Coriolis force. The ocean circulation pattern roughly corresponds to the earth's atmosphere circulation pattern. The air circulation over the oceans in the middle latitude is mainly anticyclone (more in SH than NH) the oceanic circulation pattern corresponding with the same. At the higher latitude where the wind flows is a mostly cyclone, the ocean circulation flows in this pattern due to Coriolis force. The warm currents from low Latitude tend to move to the right in northern hemisphere and to their left in the southern hemisphere.

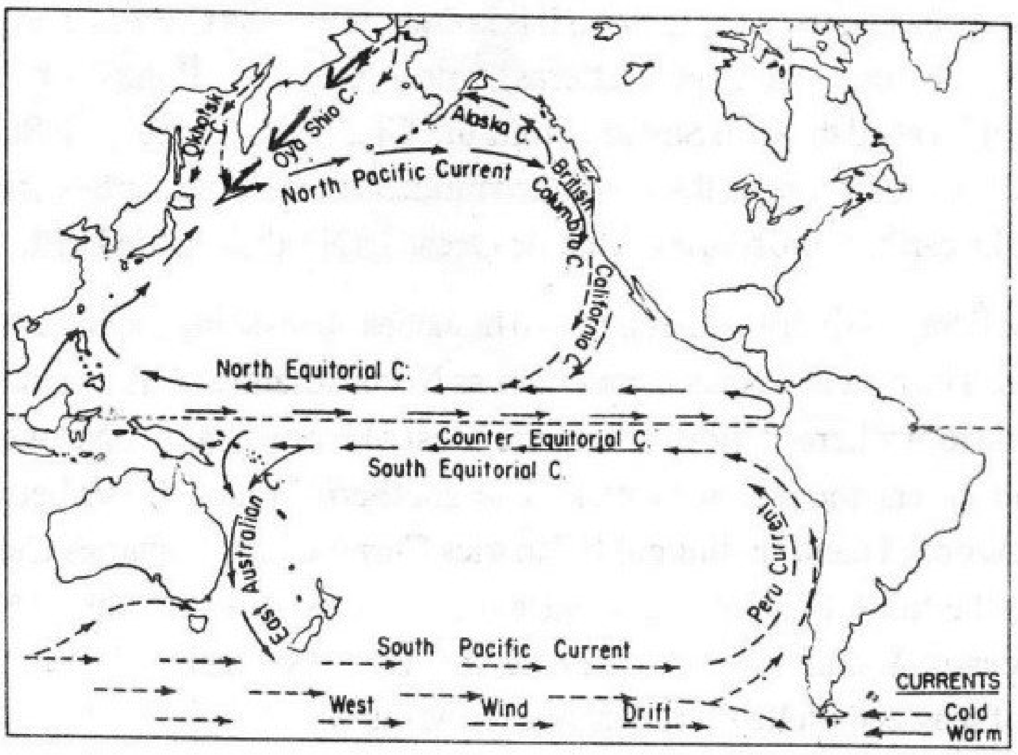


11.6.1 Pacific Ocean Currents:

Under the influence of the prevailing trade winds, the north-equatorial current starts from the west coast of central America and traverse a distance of 14,500km moving from the east to west before it turns northward off the Philippines to form the Kuroshio current. From the southeast coast of Japan, under the influence of the prevailing current, and reaches the west coast of North America, and bifurcates into two. The northern branch flows anti-clockwise along the coast of British Colombia and Alaska and is known as, Alaska current, the water of this current is relatively warm as compared to the surrounding water in this zone. The southern branch of the current moves as a cold current along the west coast of the USA and is known as the California current. The California current joins the north equatorial current to complete the circuit. Also there are two cold currents in the northern Pacific. Oyashio flows across the east coast to Kamchatka peninsula to merge with the warmer water of Kuroshio. The Okhotsk current flow past Sakhalin islands to merge with the Oyashio current off Hokkaido.

Following the pattern of the northern hemisphere, the South equatorial current flows from east to west and turn southwards, as the east Australian current. It then meets the south pacific current near Tasmania which flows from west to east. Reaching the south western coast of southern America, it turns northwards as Peru Current. It is a cold warm current which finally feeds the south Equatorial current, thus completing the great circuit.

Another current flows parallel to the North and South equatorial currents but in the opposite direction-from west to east. This current is known as the counter Equatorial current. The genesis of this current is explained by an upset is the water balance, because of accumulation of water in the western sector due to the movement of two equatorial currents. The west to east flowing counter equatorial current maintains the water balance.



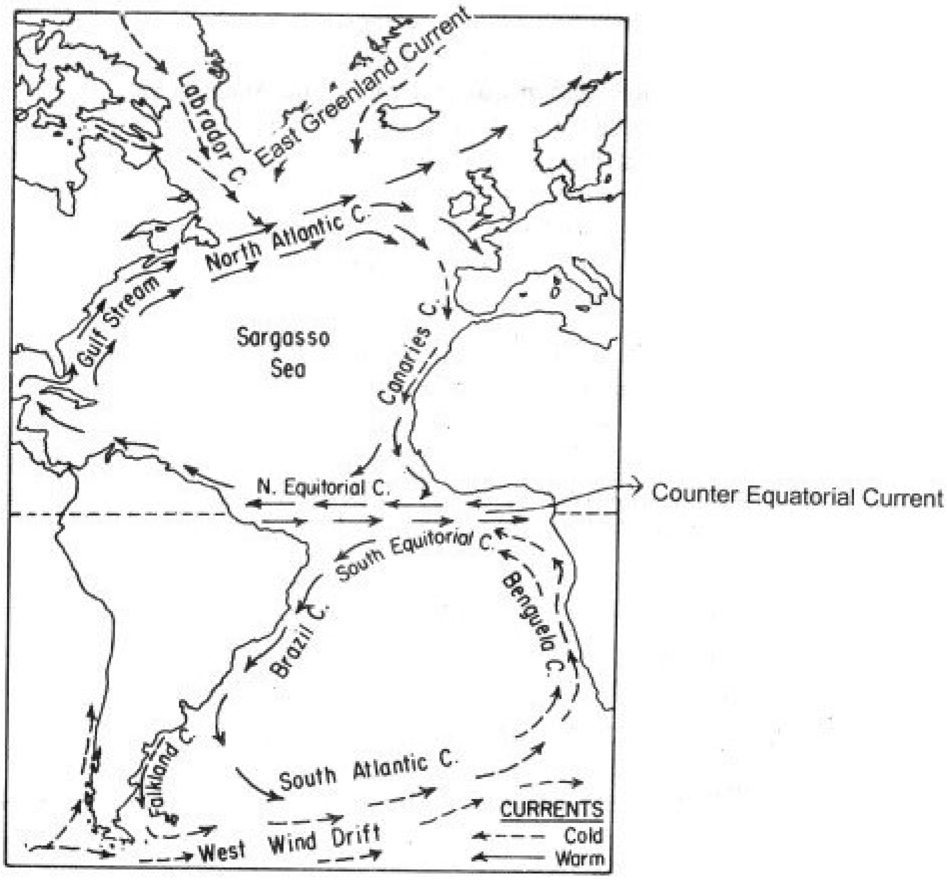
The Currents of the Pacific Ocean

11.6.2. Atlantic Ocean Current

As in the Pacific Ocean, the two equatorial currents move from east to west in the northern and southern hemisphere and a counter equatorial current flows from west to east. The south equatorial current bifurcates into two branches near Cape De Soa Roaque (Brazil). Is northern branch reinforces the north equatorial current. Part of the combined currents enters the Caribbean Sea and the Mexican Gulf because of a large amount of water driven by the trade winds and because of water brought by the Mississippi river. As a result, a current flows out through the strait of Florida to be joined by the Antilles current from the south. This combined current moves along the east coast of USA and is stream beyond that. From the Grand Banks, the Gulf Stream flows eastwards across the Atlantic as the North Atlantic drift. The main motive force for this current is supplied by the prevailing south westerly winds.

The North-Atlantic current breaks up into two branches on reaching the eastern part of the ocean. The main current, containing as the North Atlantic drift reaches the British Isles from where it flows along the coast of Norway as the Norwegian current and enters the Arctic ocean. The southerly branches flow between Spain and Azores as the cold Canary current. This current finally joins the North Equatorial current completing the circuit in the north Atlantic. The Sargasso Sea, lying with this circuit, is full of large quantity of sea weeds.

The two cold currents East Greenland current and Labrador Current flow from the Arctic Ocean into the Atlantic Ocean. The Labrador Current flows along part of the east coast of Canada and meets the warm Gulf Stream. The confluence of these two currents, one hot and the other cold, produces the famous fog around New Found land. As a result of mixing of cold and warm waters, one of the most important fishing grounds in the world is created here. In the South Atlantic Ocean, the South Equatorial current, flows from east to west, splits into two branches near Cape De Sao Roque. The north branch joins the north equatorial current, whereas the southern branch turns southwards and flow along the South American coast as the Brazil current. The Brazil current swings eastwards about latitude 35°S to join the West Wind Drift flowing from west to east. A branch of South Atlantic current flows along the west coast of South Africa as the cold Benguela current, which joins the South Equatorial current to complete the circuit.

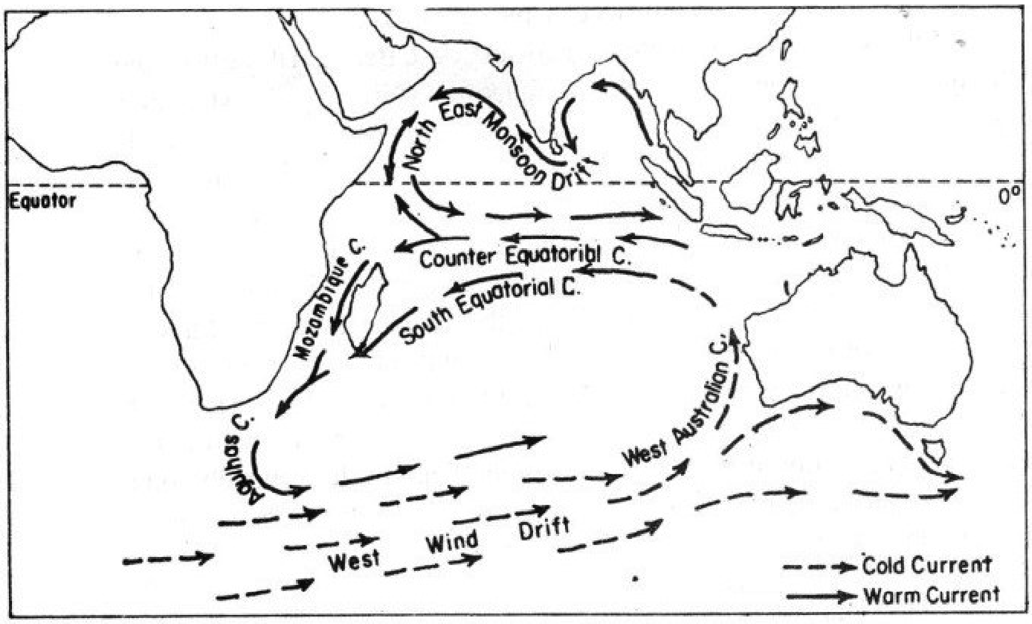


Currents of the Atlantic Ocean

Another cold current, the Falkland current flows along the South-eastern coast of South American from South to North.

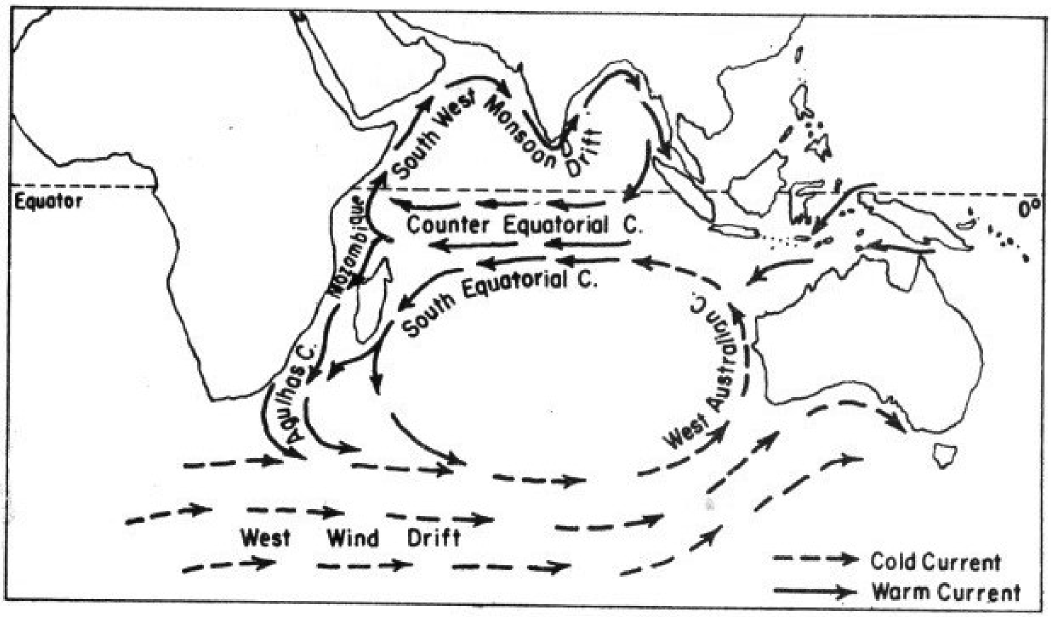
11.6.3. Indian Ocean Currents:

Being small in size, spanning only the southern Hemisphere, the Indian Ocean is a completely landlocked in the North. The characteristic current circulation of the Indian Ocean is different from that of the Atlantic and Pacific Oceans. The currents in the northern part of the Indian Ocean differ entirely from the general pattern of circulation. They change their direction from season to season in response to the seasonal rhythm of the monsoons. The effect of winds is comparatively more pronounced in the Indian Ocean.



The Currents of the Indian Ocean (Winter)

In the northern section of the Indian Ocean, there is a clear reversal of currents between winter and summer. In winter the North-Equatorial current and the South-Equatorial current flow from east to west. A counter equatorial current flows from west to east, between the two equatorial currents. The north east monsoon drives the water along the coast of Bay of Bengal to circulate in an anti-clock wise direction. Similarly along the coast lands bordering the Arabian Sea an anticlockwise circulation develops.



The Currents of the Indian Ocean (Summer)

In summer, a strong current flows from west to east which completely obliterates the north-equatorial current during the season. This is due to the effect of the strong south-west monsoon and the absence of north-east trades. There is no counter equatorial current at this time of the year. Thus the circulation of the water in the north part of the ocean is clock wise during the season.

The southern part of the Indian Ocean is less marked by the seasonal changes. The general pattern of circulation is simple and is anti-clock wise like that of the other southern oceans. The south equatorial current, partly led by the corresponding currents of the Pacific Ocean flows from east to west and thus southwards along the coast of Mozambique in the Africa.

The current flowing from the Mozambique Channel is known as the warm Mozambique current. Further southwards, the Mozambique current is joined by another branch of the south-equatorial current flowing past Madagascar islands. After the confluence of these two streams, it is known as Agulhas currents. It still continues to be a warm current, till it merges the west wind drift.

The west wind drift flows across the oceans in the higher latitudes from west to east and reaches the southern tip of the west coast of Australia. One of the branches of this cold current turns northwards along the west coast of Australia. This current is known as the west-Australian current and flows northwards to feed the south equatorial current.

Check your progress

Note :a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

2. Explain about Cold Currents?

11.7 CONCLUSION

The earth is the only known planet in the solar system with abundant water. The oceans are the single largest continuous body of water encircling land. The oceans contain 97.2% of the world's water. There are four oceans - the Pacific oceans, the Atlantic oceans, the Indian Ocean and the Arctic Ocean.

Ocean waters are in constant motion. There are three types of movements in the oceans waters -waves, tides and currents. Waves are 'caused by winds. Tides are the periodic change in the elevation of the ocean's surface at a particular place. Currents are distinct and generally horizontal flow of a mass of water in a fairly defined' direction. These currents form a clockwise pattern in the northern hemisphere and move in anti-clockwise pattern in the southern hemisphere. The currents of the Indian Ocean are influenced by Monsoon winds.

11.8 CHECK YOUR PROGRESS ANSWERS

1. Waves represent the oscillatory motions of the ocean surface induced by the force of winds. Waves may travel thousands of kms, before rolling as share, breaking and dissolving as surf. The maximum wave height is determined by strength of wind i.e. how long it blows and the area over which it blows in a single direction.
2. Cold currents are relatively cold than its surrounding. Example: Labrador Current which flows round the south of Green land. It flows past the Eastern Coast of North American and brings a great fall in the temperature.

11.9 MODEL EXAMINATION QUESTIONS

I. Essay type Questions

1. Describe the circulation of ocean currents in the Atlantic Ocean with the help of a diagram.

II. Short Answers Questions

1. What are Waves? How are they caused?
2. Write short notes on: (a) Spring tide (b) Neap tide

11.10 FURTHER READINGS

1.Physical Geography by Telugu Academy (TS), Hyderabad.

2.Sharma R C Vital, M (1993) Oceanography for Geographers, Chaitanya Publishing House, Allahabad.

UNIT-12: OCEAN DEPOSITS

Content

12.0 OBJECTIVES

- To know about definition of Ocean deposits and explain its importance in the study of Oceanography
- To learn about classify Ocean deposits on the basis of its location
- To identity different sources of Ocean deposits as well as its composition

12.1 INTRODUCTION

The study about Ocean deposits, which is an important topic of study regarding oceans. They are the unconsolidated layer of sediments lying on the ocean floor. This study of ocean deposits is important as oceans are the final repository of all debris from the land. It can also reveal earth's history as these must have been deposited in several layers since beginning of the origin of earth. In this unit you will study about different types of ocean deposits on the basis of their area of occurrence. You will also learn about different types of ocean deposits based on their source and composition. These ocean deposits are widely distributed in all the oceans of the world. Distribution of ocean deposits in terms of both horizontal and vertical distribution is dealt with. Ocean deposits also transported from one place to another in the oceans by waves, currents, tides, rivers, and other agents of erosion. Transportation and deposition of ocean deposits is discussed.

Sediments are particles of organic or inorganic matter that accumulate in a loose, unconsolidated form. i.e. material deposited by water, wind or glacier. Sediments and Volcanism are the most important agents of physical change on the deep ocean floor. Study of sediments is important to Ocean's chemistry, morphology and history as well as to earth's climate. The position and nature of sediments provide important clues to earth's recent history and valuable resources can sometimes be recovered from them. The ages of portions of the ocean floor can be determined by studying core samples of sediments just above the basalt seabed. The youngest sediments are found near the ridges and rises and the oldest close to the trenches.

Over geological time mountains rise as lithospheric plates collide, fuse and sub duct. Water and wind erode the mountains and transport resulting sediment to the sea. The sediments are deposited on the seafloor, where they travel with the plate and are either uplifted or sub ducted. Thus the material is eventually made into mountains again.

12.2 MARINE DEPOSITS

The term 'marine deposits' refer to all the materials that are being deposited on the bottom of the sea of ocean. The ocean deposits can broadly be divided into two types – the terrigenous deposits and the pelagic deposits.

12.3 TERRIGENOUS DEPOSITS

The terrigenous deposits are those which are found on the continental shelves and slopes and mainly consist of the rock material derived because of wear and tear. Terrigenous deposits are derived from the wear and tear of land and volcanic and organic products. The greater part of the deposits on the continental shelf and slopes is derived from rock material let loose by disintegration and decomposition by the agents of weathering and carried to sea by the agents of erosion, such as running water, wind etc. The process and extent of disintegration depends on the nature of rock material, climate and time taken. The larger particles of the terrigenous deposits are found near the shore and the finer ones carried deeper. The extent to which they are carried outwards depends on the size of rock material and strength of sea waves and currents.

On the basis of size of particles, the terrigenous deposits may be categorized into three classes – mud, sand and gravel. Mud refers to the finest particles which comprise the minute particles of rock forming minerals, principally quartz. Murray has classified the mud deposits into blue, green and red types, based on the colour of constituents. Sand refers to the coarser particles, while gravel has even bigger particles.

Terrigenous deposits include continental rocks which after getting disintegrated are carried by agents of erosion to the sea. These deposits include both littoral and shallow water deposits.

Terrigenous Deposits and their size

Deposits	Size in mm (Diameter)
Gravel	2-256
Sand	1-1/6
Silt	1/32 - 1/256
Clay	1/256 - 1/8192
Mud	Finer than 1/8192

Check your progress

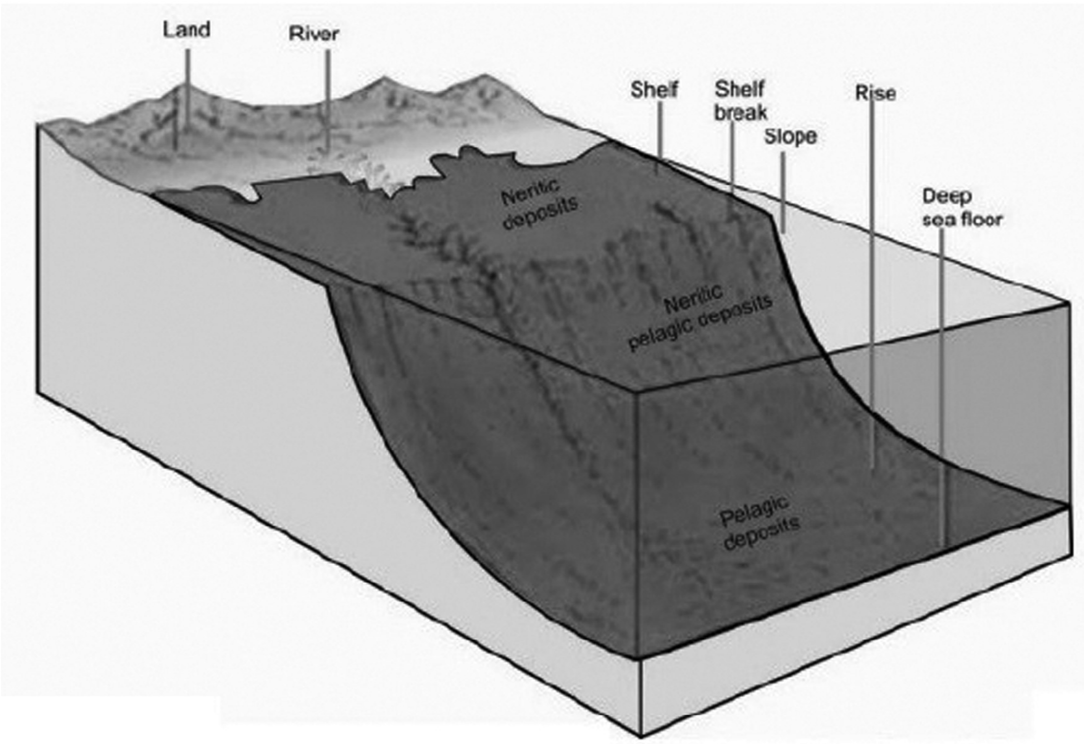
Note :a) Space is given below for writing your answer

b) Compare your answer with one given at the end of this Unit

1. What are the Terrigenous Deposits?

12.4 PELAGIC DEPOSITS

The pelagic deposits are those which are found over deep sea plains and the ocean deeps. Pelagic deposits are the most conspicuous of all deposits –covering about 75% of the total sea floor. This is because, except for fine volcanic ash, little terrigenous material is carried into the deeps. The pelagic deposits consist of both organic and inorganic material. Pelagic deposits are found beyond 100 fathom depth. On the basis of source and composition, ocean deposits related to organic remains, inorganic deposits and extra-terrestrial material.



Classification of Ocean Deposits on Basis of Area of Occurrence

Organic Material:

This is the form of a kind of liquid mud, called 'ooze', which contains shells and skeletons of various marine organisms. The ooze is said to be calcareous while the shell is made calcium carbonate. The *calcareous ooze* may be either pteropod ooze, most part of the Indian and Atlantic Ocean have calcareous ooze as deposits. When the shell is made of silica, the ooze is said to be *siliceous ooze*, which can be either a diatom type or the radiolarian type of ooze. The southern fringes of the Indian and Atlantic Ocean have siliceous type of ooze.

Inorganic Material:

This is in the form of red clay, which is apparently of a volcanic origin. The chief constituents of red clay are silicon or aluminium dioxide, while other constituents include iron, manganese, phosphorous and radium. The red clay is the most widely spread pelagic deposit and cover 38% of the sea floor. The red clay covers more than half of the Pacific floor.

Check your Progress

Note :(a) Space is given below for writing your answer

(b) Compare your answer with the one given at the end of this unit.

2. What are the Pelagic Deposits?

Percent of Different Types of Ocean Deposits of the Total Oceanic Floor area

Types of Ocean Deposits	Percent Area
Littoral and Shallow Water	9.1
Terrigenous	15.4
Pelagic	75.5
Total	100

12.5 VOLCANIC PRODUCTS

In volcanic regions the deposits of continental shelf and slope consist chiefly of products of volcanism, which are subject to chemical and mechanical weathering and are carried to the ocean by actions of running water and wind. The volcanic deposits differ from the ordinary terrigenous deposits in one respect-they are made of pyroclastic volcanic product sand lava, rather than quartz.

Organic Products such deposits consist of shells and skeletons of various plants and animals that live and grow on the sea floor and are changed into mud and sand by chemical and mechanical processes. They differ from the ordinary terrigenous deposits in the sense that they consist of calcium carbonate only.

12.6 EXTRA-TERRESTRIAL DEPOSITS

Meteors and their ash fall on the earth. These meteoric particles also reach the ocean. They are in the form of meteoric dust or cosmic spherules coming from heavenly bodies and so they are also called as cosmogenous deposits. They are widely scattered due to which it is difficult to recognize them easily. They normally consist of iron oxide particles especially that of magnetite iron. They are intact only in ocean deeps, example in Pacific Ocean deep. They form in the form of burnt ashes. The natural object now on earth that originated in outer space. Such materials include cosmic dust and meteorites. Extra-terrestrial materials are of value to sciences as they preserve the primitive composition of the gas and dust from which the sun and the solar system formed.

12.7 CONCLUSION

Oceanic deposits may be defined as unconsolidated layer of sediments lying on the ocean floor. Ocean deposits are classified on the basis of their location or area of occurrence and also on the basis of their source and composition. On the basis of area of occurrence, we broadly divide ocean deposits into several types Terrigenous, Pelagic deposits.

12.8 CHECK YOUR PROGRESS ANSWERS

1. The Terrigenous deposits are those which are found on the continental shelves and slopes and mainly consist of the rock material derived because of wear and tear.

2. The Pelagic deposits are those which are found over deep sea plains and the ocean deeps. Pelagic deposits are the most conspicuous of all deposits –covering about 75% of the total sea floor.

Model Examination Questions

I. Essay Questions

1. What is the difference between Terrigenous and Pelagic deposits?

II. Short Answer Questions

2. How volcanic deposits differ from the ordinary terrigenous deposits?
3. Discuss about the extra-terrestrial deposits?

12.9 FURTHER READINGS

1.Physical Geography by Telugu Academy (TS), Hyderabad.

2.Sharma R C Vital, M (1993) Oceanography for Geographers, Chaitanya Publishing House, Allahabad.

BLOCK - 5: SCALES

UNIT - 13: IMPORTANCE OF SCALES

Contents

13.0 INTRODUCTION

You might have read that the scale is an essential element of all types of maps. It is so important that if a network of lines and polygons does not carry a scale, we call it a "sketch". Why is the scale so important? What does it mean? What are the different methods of showing the scale on a map? How useful is the scale in measuring the distances and the area? These are some of the questions which will be taken up in the present chapter.

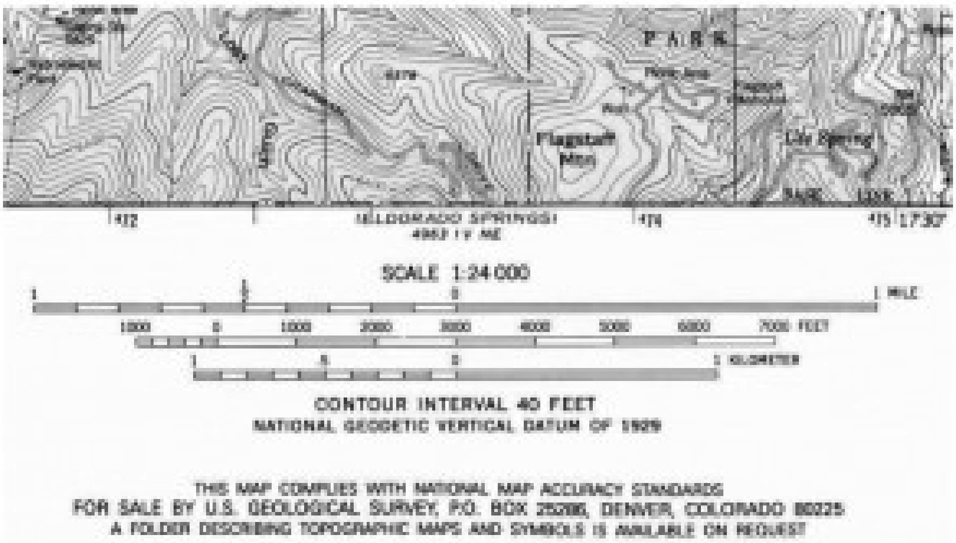
The map scales are highly important for **providing a sense of size and distance to readers**. Most often the map scale used on a particular map is stated on the map, itself. With the help of maps, and charts it becomes easier to determine various routes between cities, countries, and continents

13.1 WHAT IS SCALE?

You must have seen maps with a scale bar indicating equal divisions, each marked with readings in kilometres or miles. These divisions are used to find out the ground distance on the map. In other words, a map scale provides the relationship between the map and the whole or a part of the earth's surface shown on it. We can also express this relationship as a ratio of distances between two points on the map and the corresponding distance between the same two points on the ground.

The word 'scale' means measurement. When the distance between any two points on a map and the corresponding distance on the actual ground is expressed as a ratio, it is called map scale.

Cartographic scale considers spatial extent, its definition is essentially concerned with the direct relationship between what is shown on a map and the physical extent of that space in reality. ***Cartographic* or *representational scale* is based on the mathematical relationship (ratio) between the extent of the representation and that which it represents. The *representative fraction* exists within the continuum of ratios (or fractions) of any two rational numbers**. When comparing the relative size of two cartographic scales we compare the size of the number calculated by the ratio of the size on the map (numerator) and the size on Earth (denominator). For instance, a 1:100,000 cartographic map, would display a distance of 1km on Earth (1000 metres, 100,000 centimeters) with a distance of 1 cm on the map (1 cm on the map represents 100,000 cm in reality). Some might suggest that an extension to this broad definition be that the ratio must be less than one, resulting in a representation that is smaller than what it represents. It is for this reason that representational and *cartographic* are used above, to allow for representations, or models, that are larger than that which they represent. Therefore, this application of scale results in an infinite number of scales (for example, 1:24,000 or 1:50,000 for standard US and Canadian topographic sheets).



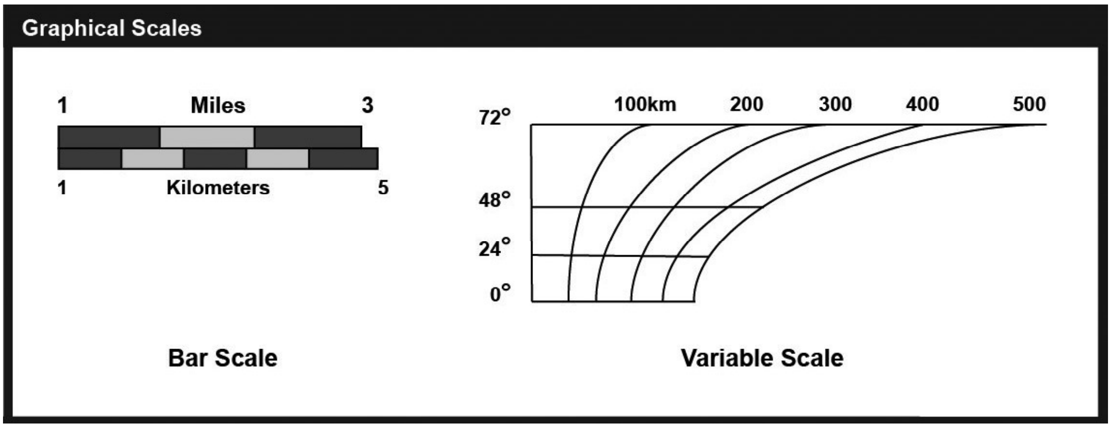
Cartographic scale is convenient for many reasons, not the least of which is that for any two scales we have an immediate understanding of the quantitative spatial relationship between them. As one changes cartographic scale, a direct relationship between the representation and the actual space is explicit and known; space and scale are dependent on one another. For a given cartographic scale, very little can be said about the phenomena being represented, in essence the square, or rectangle (or other shape).,

When cartographic scale increases (like from 1:1,000,000 to 1:50,000) the area on Earth that can be displayed decreases, while the detail of the geography being represented can increase.

Map scale is the proportion between a distance on a map and a corresponding distance on the ground (Dm / Dg). By convention, the proportion is expressed as a **representative fraction** in which map distance (Dm) is always reduced to 1. The representative fraction 1:100,000, for example, means that a section of road that measures 1 unit in length on a map stands for a section of road on the ground that is 100,000 units long. A representative fraction is **unit-less**, it has the same meaning if we are measuring on the map in inches, centimeters, or any other unit (in this example, the portion of the world represented on the map is 100,000 times as big as the map's representation). If we were to change the scale of the map such that the length of the section of road on the map was reduced to, say, 0.1 units in length, we would have created a **smaller-scale** map whose representative fraction is 0.1:100,000, or 1:1,000,000.

13.2 GRAPHIC SCALES

Another way to express map scale is with a graphic (or "bar") scale (Figure). Unlike representative fractions, **graphic scales** remain true when maps are shrunk or magnified, thus they are especially useful on web maps where it is impossible to predict the size at which users will view them. Most maps include a bar scale like the one shown above left. Some also express map scale as a representative fraction. The implication in either case is that scale is uniform across the map. However, except for maps that show only very small areas, scale varies across every map. This follows from the fact that positions on the nearly spherical Earth must be transformed to positions on two-dimensional sheets of paper. Systematic transformations of the world (or parts of it) to flat maps are called **map projections**. As we will discuss in greater depth later. All map projections are accompanied by deformation of features in some or all areas of the map. This deformation causes map scale to vary across the map. Representative fractions typically, therefore, specify map scale along a line at which deformation is minimal (**nominal scale**). We will discuss nominal scale in further detail later. Bar scales, also, generally denote only the nominal or average map scale. An alternative to a simple bar scale that accounts for map distortion is a **variable scale**. Variable scales, like the one illustrated above right, show how scale varies, in this case by latitude, due to deformation caused by map projection.



Bar Scale and Variable Scale

Mapping is a map creation process to show a part of Earth's specific surface detail. A map creator positions the exact location of a mountain, building, road, and bridge. Mapping uses computer graphic, hand drawing, and painting to show the detail of the map's landmarks.

Mapping provides important information about the landmark features. Maps analyze changes to a structure or landmark. A map requires regular update if there are significant changes observed in land features. One example is showing the presence of newly constructed buildings, roads, and bridges.

A map scale is the map distance ratio that corresponds to the actual ground distance. The scale on the map presents a distance measurement between each landmark. As an example on a 1: 1000000 cm scale map shows that 1 centimeter is equal to 1 kilometer on the ground.

13.3 SCALE USE IN GEOGRAPHY

Geographic analysis: A scale provides a geographical analysis to a specific surface feature on the map. The analysis explains the significance of the land feature and the distance between landmarks. The geographical analysis confirms the land feature type as a mountain, building, or road.

Accuracy: A scale presents an exact value of the object illustrated in the map. Accurate landmark information provides landmark facts and figure. Examples are naming a street, building, mountain, or road.

Geometrical Presentation: Using a geometrical presentation highlights the landmark's visibility. There are shapes that represent the distance, elevation, and the structure of a landmark. These are sharp-edged shapes that represent buildings and landmarks on the map.

Time Management: A scale conserves time and effort while studying the map's land geography. Each scale details the landmarks and geographical distance. Map readers are no longer required to conduct a research to understand landmark geography.

Introduce the place to visitors: Tourists relies on scale maps to navigate the landmark's geography. The scale map educates the tourists about the landmark's name and the distance between land features. As an example, the map illustrates the total distance of the white sand beach, which is 8 kilometers long.

Education: Scales in map increases anyone's knowledge about the geographic details of an object, scene, or a geographical position. The scale provides the actual name of the object to prevent confusion. An example is Mount Rainier, which has an elevation of 4,392 meters above sea level.

13.4 DISADVANTAGES OF SCALE

1. Consumes Time: Creating scales in a map consumes time and effort. This process takes at least one month to install scales in a map.

2. Requires Thorough Research: A scale needs a reliable information source about the actual name of the landmark. The purpose is to verify the name of the object and the distance between landmarks.

3. Need Constant Updates: Scales requires constant updates. Every landmark naturally changes over a time. The environment's weather and geology gradually changes the physical appearance of a landmark.

4. Expensive: Creating a map scale costs a significant amount of money. The equipment and the professional services of scale creators require fees to install a scale on maps. Each scale can cost from hundreds to thousands in USD currency on every map scale.

5. Safety concerns: Making a scale map risks the creator's lives and the health. Creators site visit might be a unsafe. As an example, scale map creators encounters road accidents or injuries while conducting a survey.

13.5 CONVERSION OF SCALE

If you have carefully read the advantages and limitations of the different methods of scale, then it will not be difficult for you to convert the Statement of Scale into Representative Fraction and vice-versa.

Statement of Scale into R. F.

Problem: Convert the given Statement of Scale of 1 inch represents 2 miles into R. F.

Solution: The given Statement of Scale may be converted into R. F. using the following steps.

1 inch represents 2 miles or 1 inch represents 2 × 63,360 inches (1 mile = 63,360 inches)
or 1 inch represents 126720 inches

Note: We can now replace the character "inches" into "units" and read it as: 1 unit represents 126,720 Units

Answer R. F. 1: 126,720

R. F. into Statement of Scale

Problem: Convert R. F. 1: 176, 150 into Statement of Scale (In Metric System)

Solution: The given R. F. of 1: 176, 150 may be converted into Statement of Scale using the following steps:

1: 176, 150 means that 1 unit on the map represents 176, 150 units on the ground.

or 1 cm represents 176, 150 /100,000 (1 km = 100,000 cm)

or 1 cm represents 1.7615 km After rounding of up to 2 decimals, the answer will be :

Answer 1 cm represents 1.76 km

13.6 DIFFERENCE BETWEEN LARGE SCALE MAP AND SMALL SCALE MAP

Large Scale Map: A large scale map makes every object or a landmark appear larger. Building and roads are clearly recognizable. The large scale map shows the name of malls, bridges, and the names of streets.

Small Scale Map: A small scale map makes objects and landmarks appear smaller. The building, road, bridge, or any land feature is not recognizable. A small scale map does not show the names of building, road, or bridge.

13.7 USES OF SCALE IN MAPS

(a) The actual size of any area on a map can easily be determined with the help of a scale.

(b) Use of scale is mandatory for drawing an accurate map.

(c) Any map can be reduced or enlarged accurately with the help of scale.

(d) The distance between any two points can be measured on a map in order to determine the actual distance on the ground with the help of scale.

(e) Land can be measured accurately using Vernier scale.

What is the importance of Scale in Reading Maps?

The map scales are **highly important for providing a sense of size and distance to readers**. Most often the map scale used on a particular map is stated on the map, itself. With the help of maps, and charts it becomes easier to determine various routes between cities, countries, and continents.

What is the importance of scale when reading a map?

If something is not represented correctly in scale on a map severe situations can occur like, constructing a building in the wrong location, **measuring incorrect distances affecting travel**, and other important distance, size, and locational issues.

13.8 IMPORTANCE OF SCALE

A map cannot be drawn and 'is incomplete without a scale.

Scale is important for determining the length, width, etc., of any region.

Scale is valuable in determining the cost of building or contracting anything by a planner or a designer.

Vernier scale is important for making minute measurements.

Scale updates recent changes in the map distance. These are the presence of new buildings or road networks.

When a new map is recently created, the scale compares the differences between the new and old maps. The comparison detects changes or improvements between the two maps.

The presence of scales in a map educates the readers about the prominent landmarks and structures. The map users learn the distance value and the name of prominent features in a specific land area.

A map scale guides anyone when visiting an unfamiliar landmark. The scale provides details about the landmark including their distance on the map.

Scale prevents confusion between two or more landmarks. Each scale provides factual information to avoid misidentification of a landmark.

Answer the following questions

1. What is scale?
2. Discuss about the importance of the scales
3. What is the advantages of the scale in a map?
4. Discuss about the uses of scales

13.9 FURTHER READINGS

Raghunandan Singh; 1973, Map Work and Practical Geography, Central Book Depot, Allahabad.

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Misra, R.P., and Ramesh, A. Fundamentals of Cartography, Mc Millan Co., New Delhi, 1986.

Singh, R.L. and Dutt, P.K.: Elements of Practical Geography, Kalyani Publishers, NewDelhi, 1979.

UNIT-14: TYPES OF SCALES

Contents

14.0 INTRODUCTION

Mapping is a map creation process to show a part of Earth's specific surface detail. A map creator positions the exact location of a mountain, building, road, and bridge. Mapping uses computer graphic, hand drawing, and painting to show the detail of the map's landmarks.

Mapping provides important information about the landmark features. Maps analyze changes to a structure or landmark. A map requires regular update if there are significant changes observed in land features. One example is showing the presence of newly constructed buildings, roads, and bridges.

Scale: A map scale is the map distance ratio that corresponds to the actual ground distance. The scale on the map presents a distance measurement between each landmark. As an example on a 1: 1000000 cm scale map shows that 1 centimeter is equal to 1 kilometer on the ground.

There are at least three ways in which this relationship can be expressed. These are:

1. Statement of Scale
2. Representative Fraction (R. F.)
3. Graphical Scale

Each of these methods of scale has advantages and limitations. But before taking up these issues, let us understand that the scale is normally expressed in one or the other system of measurement. You must have read and/or used kilometer, metre, centimeter etc. to measure the linear distances between two points on the ground. You might have also heard of miles, furlongs, yards, feet, etc. These are two different systems of measurement of the distances used in different countries of the world. Whereas the former system is referred to as the Metric System of Measurement and presently used in India and many other countries of the world, the latter system is known as the English System of Measurement and is prevalent in both the United States and the United Kingdom. India also used this system for measuring/showing linear distances before 1957. The units of measurement of these systems are given below.

The scale of the map may be expressed using one or a combination of more than one methods of scale. How these methods are used and what are their advantages and limitations.

Systems of Measurements

Metric System of Measurement

1 km = 1000 metres

1 metre = 100 centimeters

1 centimeter= 10 millimeters

English System of Measurement

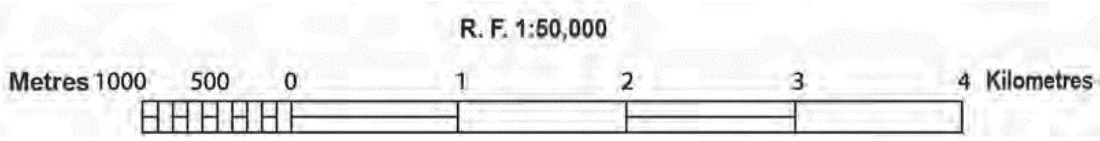
1 mile = 8 furlongs
1 furlong = 220 yards
1 yard = 3 feet
1 feet = 12 inches

14.1 STATEMENT OF SCALE

The scale of a map may be indicated in the form of a written statement. For example, if on a map a written statement appears stating 1 cm represents 10 km, it means that on that map a distance of 1 cm is representing 10 km of the corresponding ground distance. It may also be expressed in any other system of measurement, i.e. 1 inch represents 10 miles. It is the simplest of the three methods. However, it may be noted that the people who are familiar with one system may not understand the statement of scale given in another system of measurement. Another limitation of this method is that if the map is reduced or enlarged, the scale will become redundant and a new scale is to be worked out.

14.2 GRAPHICAL OR BAR SCALE

The second type of scale shows map distances and the corresponding ground distances using a line bar with primary and secondary divisions marked on it. This is referred to as the graphical scale or bar scale (Fig). It may be noted that the scale readings as shown on the bar scale in Figure reads only in kilometres and metres. In yet another bar scale the readings may be shown in miles and furlongs. Hence, like the statement of scale method, this method also finds restricted use for only those who can understand it. However, unlike the statement of the scale method, the graphical scale stands valid even when the map is reduced or enlarged. This is the unique advantage of the graphical method of the map scale.



14.3 REPRESENTATIVE FRACTION (R. F.)

The third type of scale is R. F. It shows the relationship between the map distance and the corresponding ground distance in units of length. The use of units to express the scale makes it the most versatile method.

R. F. is generally shown in fraction because it shows how much the real world is reduced to fit on the map. For example, a fraction of 1 : 24,000 shows that one unit of length on the map represents 24,000 of the same units on the ground i.e. one mm, one cm or one inch on the map representing 24,000 mm, 24,000 cm and 24,000 inches, respectively of the ground. It may, however, be noted that while converting the fraction of units into Metric or English systems, units in centimeter or inch are normally used by convention. This quality of expressing scale in units in R. F. makes it a universally acceptable and usable method. Let us take R. F. of 1 : 36,000 to elaborate the universal nature of R. F.

If the given scale is 1: 36,000, a person acquainted with the Metric System will read the given units by converting them into cm, i.e. the distance of 1 unit on the map as 1 cm and the distance of 36,000 units on the ground distance as 36,000 cm. These values may subsequently be converted into a statement of scale, i.e. 1 cm represents 360 metres. (by dividing values in denominator by the number of centimeter's in a metre, i.e. 100). Yet another user of the map familiar with the English system of measurement will understand the map scale by converting it into a statement of scale convenient to him/her and read the map scale as 1 inch represents 1,000 yards. The said statement of scale will be obtained by dividing 36,000 units in the denominator by 36 (number of inches in a yard).

1. Fractional or Ratio Scale: A fractional scale map shows the fraction of an object or land feature on the map. This type uses a set of numbers that represents the object or a landmark.

2. Linear Scale: A linear scale shows the distance between two or more prominent landmarks. The linear scale on maps is a set of lines or dots that represents a landmark. An example is a map using a linear scale on each road.

3. Verbal Scale: This type of scale use simple words to describe a prominent surface feature. A verbal map scale expands abbreviations to describe a landmark or an object. An example is the image to the left describes a scale as 1 cm is equal to 15 kilometers.

14.4 MODEL EXAMINATION QUESTIONS

Answer the following questions in about 30 words:

1. What are the two different systems of measurement?

2. Give one example each of statement of scale in Metric and English system.

3. Why the Representative Fraction method called a Universal method?

4. What are the major advantages of the graphical method?

14.5 GLOSSARY

Denominator: The number below the line in a fraction. For example, in a fraction of 1: 50,000, 50,000 is the denominator.

Numerator: The number above the line in a fraction. For example, in a fraction of 1: 50,000, 1 is the numerator.

Representative Fraction: A method of scale of a map or plan expressed as a fraction showing the ratio between a unit distances on the map or plan, and the distance measured in the same units on the ground.

UNIT-15: CONVERSION OF SCALE

Contents

15.0 INTRODUCTION

If you have carefully read the advantages and limitations of the different methods of scale, then it will not be difficult for you to convert the Statement of Scale into Representative Fraction and vice-versa.

15.1 STATEMENT OF SCALE INTO R. F.

Problem: Convert the given Statement of Scale of 1 inch represents 4 miles into R. F.

Solution: The given Statement of Scale may be converted into R. F. using the following steps.

1 inch represents 4 miles or 1 inch represents 4 x 63,360 inches (1 mile = 63,360 inches)

Or 1 inch represents 253,440 inches

NOTE: We can now replace the character "inches" into "units" and read it as:

1 unit represents 253,440 Units

Answer: R. F. 1: 253, 440

15.2 R. F. INTO STATEMENT OF SCALE

Problem: Convert R. F. 1: 253, 440 into Statement of Scale (In Metric System)

Solution: The given R. F. of 1: 253, 440 may be converted into Statement of Scale using the following steps:

1: 253, 440 means that

1 unit on the map represents 253, 440 units on the ground. Or 1 cm represents 253, 440/100,000 (1 km = 100,000 cm) or 1 cm represents 2.5344 km

After rounding of up to 2 decimals, the answer will be:

Answer: 1 cm represents 2.53 km

15.3 CONSTRUCTION OF THE GRAPHICAL/BAR SCALE

Problem 1: Construct a graphical scale for a map drawn at a scale of 1: 50,000 and read the distances in kilometer and metre.

NOTE: By convention, a length of nearly 15 cm is taken to draw a graphical scale.

Calculations To get the length of line for the graphical scale, these steps may be followed:

1: 50,000 means that 1 unit of the map represents 50,000 units on the ground or 1 cm represents

50,000 cm or 15 cm represents 50,000 x 15/100,000 km or 15 cm represents 7.5 km

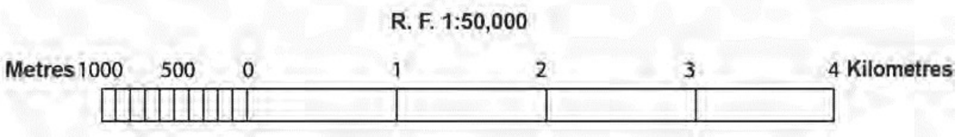
Since the value of 7.5 (km) is not a round number, we can choose 5 or 10 (km) as the round number. In the present case, we choose 5 as the round number.

To determine the length of the line to show 5 km, the following calculations are to be carried out:

7.5 km is represented by a line of 15 cm 5 km will be represented by a line of 15 x 5/7.5 or 5 km will be represented by a line of 10 cm

Construction The graphical scale may be constructed by following these steps:

Draw a straight line of 10 cm and divide it into 5 equal parts and assign a value of 1 km each for 4 right side divisions from the 0 mark. Also divide the extreme left side division into 10 equal parts and mark each division by a value of 100 metres, beginning from 0. (You may also divide it into 2, 4, or 5 parts and assign a value of 500, 250, or 200 metres to each of the subdivisions respectively from 0.



Problem 2: Construct a graphical scale when the given Statement of Scale is 1 inch representing 1 mile and read the distances in miles and furlongs.

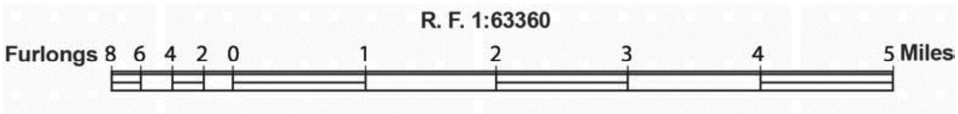
NOTE: By convention, a length of nearly 6 inches is taken to draw a graphical scale.

Calculations: To get the length of line for the graphical scale, these steps may be followed:

1 inch represents 1 mile or 6 inches represents 6 miles

Construction: The graphical scale may be constructed in the following steps:

Draw a straight line of 6 inches and divide it into 6 equal parts and assign a value of 1 mile each for 5 right side divisions. Also divide the extreme left side division into 4 equal parts and mark each division by a value of 2 miles each, beginning from 0.



Problem 3: Construct a graphical scale when the given R. F. is 1: 50,000 and read the distances in miles and furlongs.

Calculations: To get the length of the line for the graphical scale, these steps may be followed:

1: 50,000 means that 1 unit represents 50,000 units or 1 inch represents 50,000 inches.

Or 6" represents 50,000 x 6/63,360 miles = 6’ represents 4.73 miles Since a figure of 4.73 (miles) is not a round number, we take 5 as the round number.

To determine the length of the line to show 5 km, the following calculations are to be carried out:

4.73 miles are represented by a line of 6 inches 5 miles will be represented by a line of 6 x 5/ 4.73 =5 miles will be represented by a line of 6.34 inches

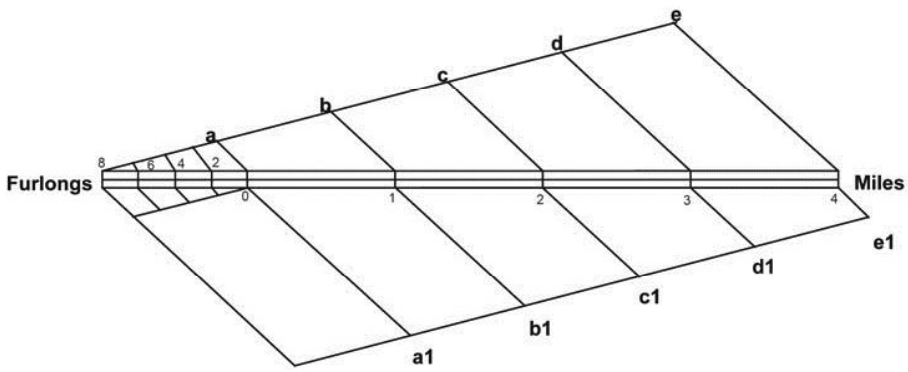
Construction: The graphical scale may be constructed in the following steps:

To construct a graphical scale to show 5 miles we need to draw a line of 6.34 inches and divide it into 5 equal parts. The question is how an unequal line of 6.3 inches can be divided into 5 equal parts. To do so we can use the following procedure:

Draw a straight line of 6.3 inches. Draw lines at an angle of 40^0 or 45^0 from the start and end nodes of the lines and divide them into 5 equal parts of 1 or 1.5 inches each.

Draw dotted lines joining the divisions marked on the two lines. Mark the intersections of these lines at the primary scale.

By doing so, you will divide the unequal line of 6.3 inches into 5 equal parts. You can repeat the same way to divide the extreme left part on the primary scale into 4 or 8 parts to show the number of furlongs that are equivalent to 1 mile.



Drawing of equal divisions in a graphical scale

15.4 MODEL EXAMINATION QUESTIONS

Answer the following questions in about 30 words:

1. What you understand from this chapter
2. What are the two different systems of measurement?
3. Give one example each of statement of scale in Metric and English system.
4. Why the Representative Fraction method is called a Universal method?
5. What are the major advantages of the graphical method?

15.5 FURTHER READINGS

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Glossary

Abiotic components: These include all the non-living elements of the biosphere

Abrasion: This is caused by boulders, pebbles and sand being hurled against the base of a cliff by breaking waves which results in undercutting and rock break-up.

Abyssal plain: These lie between the continental margins and mid-oceanic ridges.

Advection: This process of transfer of heat through horizontal movement of air (wind) is called advection.

Albedo: defined as a measure of how much light that hits a surface is reflected back without being absorbed

Anticyclones: Areas of sinking air which result in high pressure. **T**hese are produced due to subsidence of air currents in the horse latitudes. These are known as 'subtropical highs' or subtropical anticyclones,

Aphelion: During the earth's revolution around the sun, the earth is farthest from the sun on **4th July**. This position of the earth is called **aphelion**.

Atoll: These are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression

Atmosphere: The air is one among the necessary conditions for the existence of life on this planet. The air is a mixture of several gases and it encompasses the earth from all sides. The air surrounding the earth is called the atmosphere.

Atmospheric pressure: Atmospheric pressure is the "weight" of the air in the atmosphere, Changes in atmospheric pressure are mostly caused by the rise of warm air and the descent of cold air, and hence atmospheric pressure occurs mostly in regions near water bodies.

Barometers are used to measure atmospheric pressure. They may be either mercury or aneroid (vacuum) barometers.

Central meridian or **standard meridian** of a country is arbitrarily given to wide strips on both sides. In India, **82** ½^{O} E longitudes are taken as standard meridian, and the local time at this meridian is taken as standard time for the whole country.

Climatology: Study of structure of atmosphere and elements of weather and climates and climatic types and regions.

Climate: it is defined as the average weather conditions, of a place over a given period, usually over 30 years. Climate which takes place over a long period of time.

Cloudiness: cloudiness is simply the state of clouds in the atmosphere at a given time over an area.

Conduction: When two objects of unequal temperature come in contact with each other, heat energy flow from the warmer object to the cooler object and this process of heat transfer is known as conduction

Continental Margins: These include continental shelf, continental slope, continental rise and deep oceanic trenches. Formation of this is between continental shores and deep-sea basins.

Continental Shelf: The continental shelf is the extended margin of each continent occupied by relatively shallow seas and gulfs. It is the shallowest part of the ocean showing an average gradient of 1° or even less.

Convection: Transfer of heat by movement of a mass or substance from one place to another, generally vertical, is called convection.

Cyclones: Cyclone is a system of low atmospheric pressure in which the barometric gradient is steep. Cyclones represent circular fluid motion rotating in the same direction as the Earth.

Diamond Dust: Diamond dust is extremely small ice crystals usually formed at low levels and at temperatures below -30 °C.

Disaster: it is an undesirable occurrence resulting from forces that are largely outside human control, strikes quickly with little or no warning, which causes or threatens serious disruption of life and property including death and injury to a large number of people.

Doldrums: This belt happens to be the zone of convergence of trade winds from two hemispheres from sub-tropical high pressure belts. This belt is also called the Doldrums.

Doldrums and Equatorial Westerly's: A belt of low pressure, popularly known as equatorial trough of low pressure, extends along the equator within a zone of 5°N and 5°S latitudes. This belt is called the belt of calm or doldrums.

Drizzle: Drizzle is very light rain. It is stronger than mist but less than a shower. Mist is a thin fog with condensation near the ground.

Droughts: an extended period when there is a shortage of water availability due to inadequate precipitation, excessive rate of evaporation and over-utilisation of water from the reservoirs and other storages, including the ground water.

Equatorial low pressure belt. The region extending between 5°N latitude of Equator to 5°S latitude.

Foehn or Fohn: Beneficial Wind. Foehn is a hot wind of local importance in the Alps. It is a strong, gusty, dry and warm wind which develops on the leeward side of a mountain range.

Freezing Rain: Freezing rain happens when rain falls during below freezing conditions / temperatures. This normally results in the solidification of rain droplets.

Front: weather occurs along the periphery of these air masses at boundaries called fronts. Where two different types of air mass meet is known as a front. Fronts are boundaries between air masses. Front is the transition zone between air masses with distinctly different properties.

Greenwich Meridian: The meridian that passes through the old Royal Observatory at Greenwich, near London, England.

Hail: Hailstones are big balls and irregular lumps of ice that fall from large thunderstorms. Hail is purely a solid precipitation.

Hamada, or rocky desert: An extensive areas of bare rocks from which all fine materials have been removed by deflation (includes lifting and removal of dust and smaller particles from the surface of rocks), while abrasion polishes and smooth's the rock surfaces.

Horizontal distribution: Distribution of temperature across the latitudes over the surface of the earth is called its horizontal distribution. On maps, the horizontal distribution of temperature is commonly shown by isotherms.

Horse latitudes: The descending air currents feed the winds blowing towards adjoining low pressure belts. A calm condition with variable and feeble winds is created in these high pressure belts.

Horse latitudes: The air after being heated near the equator ascends and after blowing in opposite direction to the surface trade winds descends in the latitudinal zone of 30°-35°. Thus, the descent of winds from above causes high pressure on the surface which in turn causes anticyclonic conditions. This is why the anticyclonic conditions cause atmospheric stability, dry condition and very weak air circulation. This zone (30°- 35°) is characterized by weak and variable winds and calm. This belt of calm is very popularly known as *horse latitudes*

Humidity: It is simply the amount of water vapour in the air or in the lower atmosphere. The humidity is an element of weather that can influence the day by making it feel hotter.

Hydrology: It is the study of the realm of water over the surface of the earth including oceans, lakes, rivers and other water bodies and its effect on different life forms including human life and their activities.

Hydraulic action: This process also involves the breakdown of the rocks of valley sides due to the impact of water currents of channel. In this process water alone plays a vital role in removing of materials of rocks.

Infiltration: Some portions of the water from the precipitation is observed by the soil and some by the previous rocks and aquifers. Thus the process of passage of the surface water into the ground is known as the infiltration

Ionosphere or Thermosphere: The lower Thermosphere is called the Ionosphere.

This layer is found above Mesopause from 80 to 400 km.

Inselberg: In some deserts, erosion has removed the entire original surface except for isolated pieces that stand up as round-topped masses called inselbergs.

Isotherms: Isotherms are lines connecting points that have an equal temperature

Loo: In tropical regions particularly in northern India during the summer season, local winds called **'Loo'** is the outcome of advection process.

Mesosphere: The Mesosphere is found above the stratosphere.

Mistral: it is a Harmful Wind**.** Mistral is one of the local names given to such winds that blow from the Alps over France towards the Mediterranean Sea.

Moraines: A glacier is capable of transporting a vast amount of rock waste called moraine. Glacial erosion on the floor and sides of a valley produces a part of this rock waste.

Normal lapse rate": The rate of decrease of temperature with height is called as the "normal lapse rate".

Ocean Currents: Ocean waters move from one place to another partly as an attempt to equalize temperature and density of water. Ocean currents are large movements of water usually from a place of warm temperature to one of cooler temperature or vice-versa.

Oxidation: It is one of the varieties of chemical weathering in which oxygen dissolved in water reacts with certain rock minerals, especially iron, to form oxides. This manifests itself in brownish or yellowish staining of rock surface, which ultimately disintegrates.

Perihelion: The mean distance of the Earth from the Sun. On **3rd January**, the earth is nearest to the sun. This position is called **perihelion**.

Physical geography: The study of the natural characteristics of the earth.

Piedmont glacier: When valley glaciers extend on to the plains they sometimes join together to form vast lobes of ice- called piedmont glaciers.

Planetary Winds: The winds blowing almost in the same direction throughout the year are called *prevailing or permanent winds.* These are also called as invariable or *planetary winds* because they involve larger areas of the globe.

Plucking: The tearing away of blocks of rock which have become frozen into the sides or bottom of a glacier;

Polar High: The lowest temperatures are found over the poles, which cause subsidence of air and hence the polar highs. The polar highs are small in area and extend around the poles.

Polar winds: The winds blows from polar high pressure to sub-polar low pressure cells are called *polar winds* which are north-easterly in the southern hemisphere and south-easterly in the southern hemisphere.

Precipitation: It is a form of water in the atmosphere that falls on the earth; precipitation is a long-term, predictable factor of a region's makeup which is formed as a result of rapid condensation of moisture.

Radiation: Radiation is the process by which solar energy reaches the earth and the earth loses energy to outer space. When the source of heat transmits heat directly to an object through heat waves, it is known as radiation process.

Sea breeze: pressure gradient from sea to land is created and the wind blows from the sea to the land.

Seamount: It is a mountain with pointed summits, rising from the seafloor that does not reach the surface of the ocean. Seamounts are volcanic in origin.

Seifs: Ridge-shaped with steep sides and lying parallel to the prevailing wind, and parallel to each other

Sleet (Ice Pellets): Sleet takes place in freezing atmospheric conditions. Sleet, also known as ice pellets, form when snow falls into a warm layer then melts into rain and then the rain droplets falls into a freezing layer of air that is cold enough to refreeze the raindrops into ice pellets.

Solifluction: Mudflows also occur in tundra regions during the early summer when the frozen soil thaws and turns into a semi liquid state thus enabling it to slide over the still frozen subsoil. This is called Solifluction.

Spit: A spit is a low, narrow ridge of pebbles or sand joined to the land at one end, with the other end terminating in the sea. It is formed by long shore drift.

Spring tides: When the sun, the Moon and Earth are in a straight line, the height of the tide will be higher. These are called spring tides

Stratosphere: It is the second layer of the atmosphere found above the troposphere.

Stationary front: it is characterized by no movement of the transition zone between two air masses.

Temperate Cyclone: The temperate cyclones are also known as extra tropical cyclones and frontal cyclones. The temperate cyclones occur in the middle and high latitudes beyond the tropics

Terrigenous Deposits: Terrigenous deposits are derived from the wear and tear of land and volcanic and organic products

Terrestrial radiation: When the earth's surface after being heated up by the insolation (in the form of short waves), it becomes a radiating body. The earth's surface starts to radiate energy to the atmosphere in the form of **long waves** is called as terrestrial radiation.

Tombolo: A bar joins an island to the mainland it is called a tombolo.

Tides: The periodical rise and fall of the sea level is known as Tides

Trade Winds: There is more or less regular inflow of winds from subtropical high pressure belts to equatorial low pressure belt. These tropical winds have north- easterly direction in the northern hemi-sphere while they are south-easterly in the southern hemisphere. These winds are called *trade winds.*

Transpiration: after utilizing water for conducting their biological activities, plants discharge it in the form of water vapour through the small openings present in their leaves into the atmosphere(Stomata) this natural process is called transpiration.

Tropical Cyclones: A tropical cyclone is a rapidly rotating storm system characterized by a low- pressure center, a closed low-level atmospheric circulation, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain.

Troposphere: It is the lowermost layer in the structure of the atmosphere.

Volcano / Volcanic Mountains: a vent or opening on the Earth's crust through which molten rock (lava), ash and gasses reach the Earth's surface from below. The ejected lava and ash accumulate around the vent and forms a high, nearly conical mountain with a crater in the summit area. It is generally called a volcano or a volcanic mountain.

Waves: Waves represent the oscillatory motions of the ocean surface induced by the force of winds. Waves may travel thousands of kms

Weather: It is the atmospheric condition of a place for a short duration with respect to its one or more elements. Weather is simply a day-to-day temperature and precipitation conditions that take place in a given surrounding.

Westerly's: The permanent winds blowing from the subtropical high pressure belts (30°-35°) to the sub polar low pressure belts (60°-65°) in both the hemispheres are called *westerlies.*

Wind: wind is the air in motion that moves from areas of high air pressure to those of low air pressure.

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