CHAPTER
4

Atmosphere

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In the previous chapters, you read about Lithosphere and Hydrosphere. In this chapter, we will read about Atmosphere.

We breathe the oxygen present in the air. Living beings can't live without it. When we breathe out, we give out carbon dioxide. Apart from giving oxygen to us, atmosphere also makes life possible for us in many other ways. For example, it prevents the harmful rays of the sun from reaching us. Green plants take in the carbon dioxide present in the atmosphere, use sunlight and water to photosynthesis, and we end up getting delicious fruits, vegetable, grains etc. from them. These give us proteins, carbohydrates, sugars, fats, minerals, and other nutrients that we need to live. It is the atmospheric winds that transports water from the oceans to the continents in the form of rain. Without this, the different types of rocks would not erode. This means that different kinds of soils would not be available. So, we would not be able to grow different kinds of crops.

We wouldn't be able to enjoy the cooling monsoon rains, the scents of fragrant flowers, and the sounds of music in the absence of atmosphere. We would not be able to fly the beautiful kites as there would be no wind. Birds would n't fly or soar in the sky. Flags would not flutter.

So, what is this wonderful and awesome thing called atmosphere?

Fig. 4.1: A picture of Earth taken from about 322 km above the Earth. The atmosphere is that thin blue band between Earth and the black colour of space

Atmosphere is a sea of gases surrounding the Earth. In a sense, we are all swimming in a sea of gases (just as fishes swim in a sea of water). When we compare it with the size of the Earth, atmosphere is a very thin blanket surrounding Earth. The atmosphere is about 1,000 kms thick. [National Aeronautics and Space Administration (NASA), the space agency of the USA] gives this description: if Earth were the size of a basketball, the atmosphere would be like a thin sheet of plastic wrapped around it.

- What will happen if water vapour is not present in air?
- Our skin dries up more during winters. Why?

Being composed of gases, the atmosphere exhibits all the properties of gases – it compresses and expands and it has no shape. (Gas can be stuffed more and more into a small space like you do it in your cycle tube – this is compression of gas.) There are many gases in the atmosphere, but oxygen (about 21% in volume) and nitrogen (about 78% in volume) dominate. Other gases are present in very small percentages; these include argon, neon, carbon dioxide (about 0.03% by volume), methane, ammonia, ozone etc.

Water vapour accounts for about 0.4% of volume in the atmosphere, but most of it is close to the surface (within about 6 km above Earth). Yes, water vapour is a gas! No, the clouds that you see in the sky are not water vapour, they are water droplets.

Apart from these gases, the atmosphere also has fine dust particles; these are called particulates. Particulates may come from natural processes (for example: sand storms over deserts and natural forest fires) and from human activity (for example: burning forests, burning petroleum and industrial emissions).

These particulates can change the atmospheric conditions that may be beneficial for life on Earth. Have you ever seen a beautiful, bright orange sunrise or sunset? Particulates in the atmosphere cause that bright colour! And that rainfall you love to play in? The hail stones you love to collect and eat? The particulates make these also possible. The particulates can also cause problems by altering the temperature and rainfall patterns. For example: they can make it difficult for people to breathe, they can settle on leaves and make it difficult for plants to breathe and photosynthesise.

- List out some of the ways in which particulates in the atmosphere are beneficial and harmful to us.
- Why is atmosphere important for us?
- Can you imagine why life is not possible on the Moon?

Structure of the Atmosphere

Just like the interior of the earth is arranged as layers, atmosphere too is arranged into various layers, having different compositions. Can you imagine the layers? It is not an easy job to study the structure of the atmosphere which is very widely spread. Scientists research about it through air balloons, satellites etc. On the basis of chemical composition, the atmosphere is divided into two broad layers:

1) Homosphere
2) Heterosphere

Homosphere: Homosphere extends up to a height of 90 kms. It consists of three layers: Troposphere, Stratosphere, Mesosphere. It is characterised by uniformity in composition of gases like nitrogen, oxygen, argon and carbondioxide.

Heterosphere: The layer above 90 kms of the homosphere is called heterosphere. It has a heterogenous composition and hence, the name heterosphere. It has two layers called Thermosphere and Exosphere.

Atmosphere can also be divided into various layers based on density and temperature.

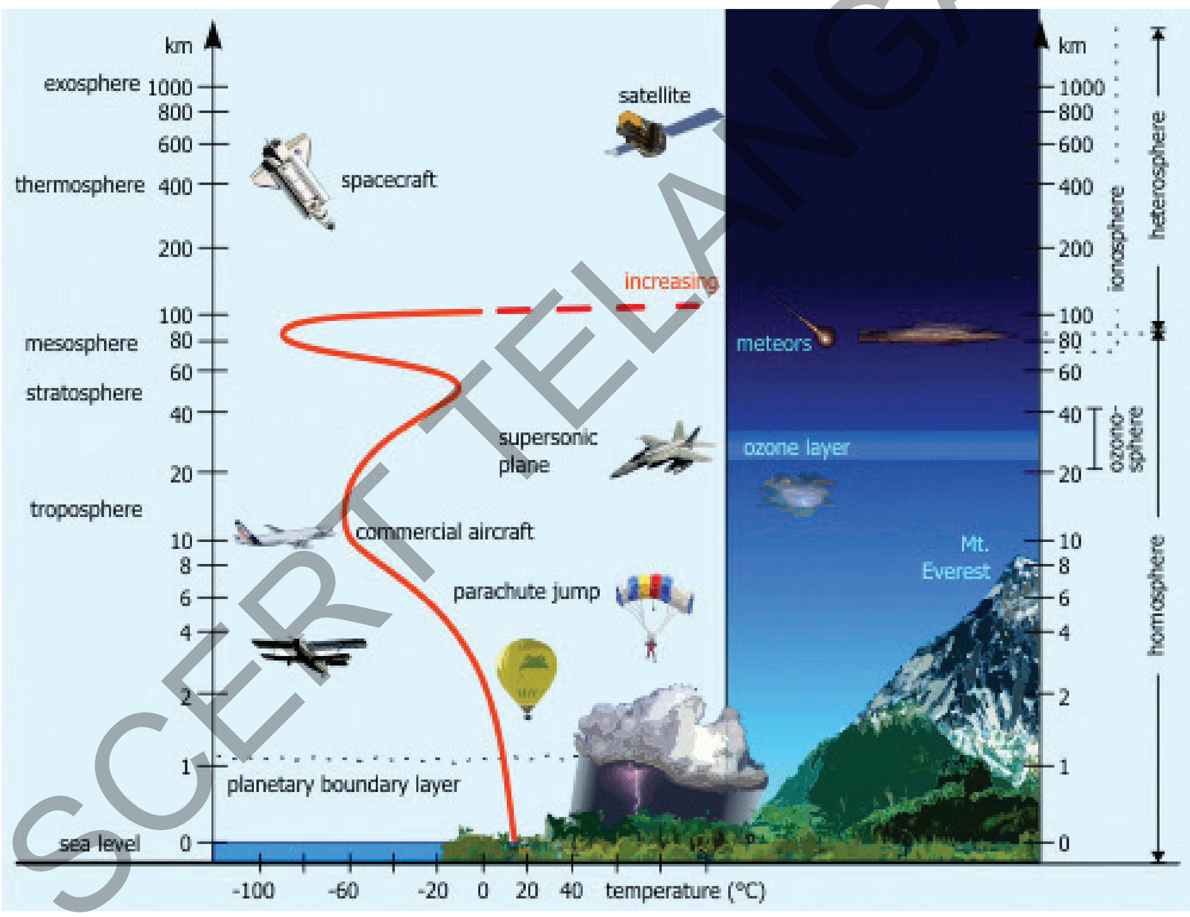

Fig. 4.2: Structure of the atmosphere

1. Troposphere: Troposphere is the lower most layer of the atmosphere. Its average height is 13 kms and extends roughly to a height of 8 kms near the poles and about 18 kms at the equator. Thickness of the troposphere is greatest at the equator because heat is transported to greater heights by strong convectional currents, greater sinking of air near the poles.

It contains about 75% of the total gaseous mass of the atmosphere and practically all the moisture and dust particles. The entire weather phenomenon happens in this sphere. The temperature in this layer decreases as we go higher which is known as Normal Lapse Rate. Condensation, evaporation, precipitation, rainfall, cyclones etc. occur in this layer.

2. Stratosphere: This layer extends up to a height of 50 kms. This layer is almost free from clouds and associated weather phenomenon, making conditions most ideal for flying jet aircrafts. One important feature of stratosphere is that it contains ozone layer. The temperature increases as there is increase in altitude.

3. Mesosphere: It extends up to a height of 80 kms. Meteorites burn up as they enter this layer from the space. Temperature starts decreasing with the increase in altitude.

4. Thermosphere: It extends up to 400 kms. In thermosphere, temperature rises rapidly with increase in height. It contains electrically charged particles known as ions. Radio waves transmitted from the earth are reflected back to the earth by these ions. It is also known as Ionosphere.

5. Exosphere: It is the upper most layer of the atmosphere. This is the highest layer and very little is known about it.

- In which layer is life present in the atmosphere?
- About which layer do we have very little knowledge?
- Which layer of the atmosphere is ideal for flying jet aircrafts? Why?

Pressure Belts and Planetary Winds

Air Pressure: The air around us is composed of gas molecules (very tiny particles). These molecules are constantly pushing each other or any object that comes their way. This push effect they exert together on any object is described as Air Pressure. Thus, air exerts pressure not only from the top but also from the bottom and all the sides of an object that it is exposed to air on those sides.

The pressure of air increases if there are more molecules present – This usually happens on the surface of the earth – as the earth pulls most of the air molecules to its surface due to its gravitational pull.

However, this changes when the air is heated up. When gas molecules are heated up (usually due to the heating of the Earth's surface), they get a lot of energy and start moving very fast. This initially would mean an increase in pressure as they will push the object more. However, the energised molecules start flying off higher and higher. Remember they have more energy now to defy the pull of the earth! When more molecules go to higher reaches of the atmosphere, the places near the earth will have less of them – this means less pushing around or less pressure.

That is why geographers say that when it gets hot, the air pressure becomes low and when it becomes cool, air pressure increases. In simpler terms: if one increases, the other decreases – this is called an inverse relationship.

When heated air rises, it starts losing the energy (in the form of heat) that it got from Earth's surface. When the energy decreases, the molecules slow down, become more sluggish, and get closer to each other – air becomes cooler and denser. Dense air starts falling back towards Earth's surface due to gravity. They don't have enough energy to fight against gravity any more! Wherever this cool air descends, the air pressure increases.

That is not all. When any part of the earth heats up and causes low pressure, it means that there is more vacant space and less molecules. Now, air from other parts where the pressure is higher moves towards this vacant place. It is not difficult for them for they have to only move along the earth's surface and thus need not go too much against gravity. That is why we say that wind flows from high pressure areas to low pressure areas.

Pressure Belts

The Earth's surface does not heat uniformly. Land heats up faster than sea. The land which is deep inland heats up faster than the land near the sea. So the air above the land gets heated more quickly. Water takes more time to heat. So the air above water gets heated more slowly.

However, when it comes to cooling, land cools faster and water cools down slower in comparison to land. So, the heating and cooling is happening at different rates in different places. Therefore, the pressures are also varying from place to place.

There's even more! You have learned about the relationship between latitudes and seasons. You learned that the tropical latitudes receive the most intense amount of solar radiation and are hotter than temperate or polar latitudes that receive less intense solar radiation. Hence, the tropics are hotter than the rest of the world. So, with temperature variation there is pressure variation around the world.

Just as water moves from a higher place to a lower place and heat moves from warmer objects to cooler objects, air moves from areas of higher pressure to areas of lower pressure. When air moves like that, we call it wind.

If it moves at a slow pace and we feel comfortable in it, we call it a breeze. If the wind comes in a short and fast burst, we call it gust. If it moves very fast and blows things around, we call it a storm. Along the Andhra Pradesh coast, we experience cyclones which are very high-speed winds.

Winds are constantly moving all over the world. At the equator, the high temperature heats up the atmosphere and the hot air rises, creating lower pressure at the Earth's surface around the equator. This low-pressure belt (it is like a belt around the Earth!) is called equatorial low pressure belt or the Inter-Tropical Convergence Zone (shortened to 'ITCZ'). As this air rises, it cools and starts descending. But it cannot come back from the same path that it took when it went up. As it reaches the higher layers of the atmosphere, the air spreads away from the equatorial region towards northern and southern hemisphere. As it spreads, it also starts descending – it is cooler, denser, and so starts to sink back to Earth. Where it descends, we find the pressure is higher and this phenomenon is called sub tropical high pressure belt.

Having come down, as the air hits the Earth's surface, it splits into two parts - one part again rushes towards the equatorial lower pressure area. When they get there, they get heated again and rise. Thus, the equatorial cycling of wind continues.

The other part is pushed towards the next higher latitudes where the pressure is lower. To understand the process better let us call these winds "A." (Remember, "A" is not an official name for these winds, we are using it for convenience.)

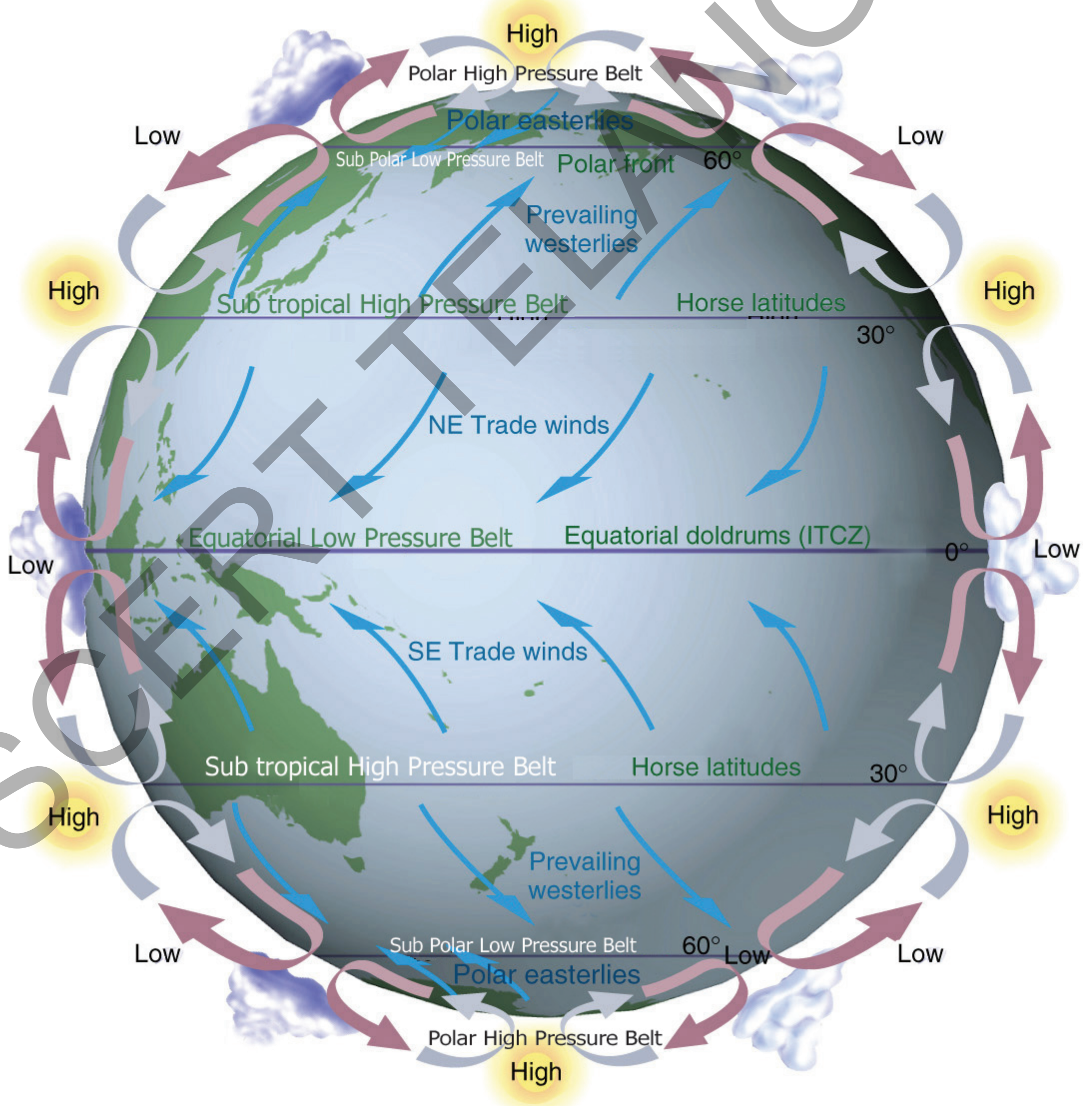

Fig. 4.3:Pressure Belts and Planetary winds

The air in the areas near the north pole and south pole is so cold that the air there is at higher pressure (polar high pressure belt) than in the area around the latitudes, along the Arctic Circle (in the north) and the Antarctic Circle (in the south) (sub polar low pressure belt). So, the polar winds rush towards these lower pressure areas. There, they meet the "A" winds.

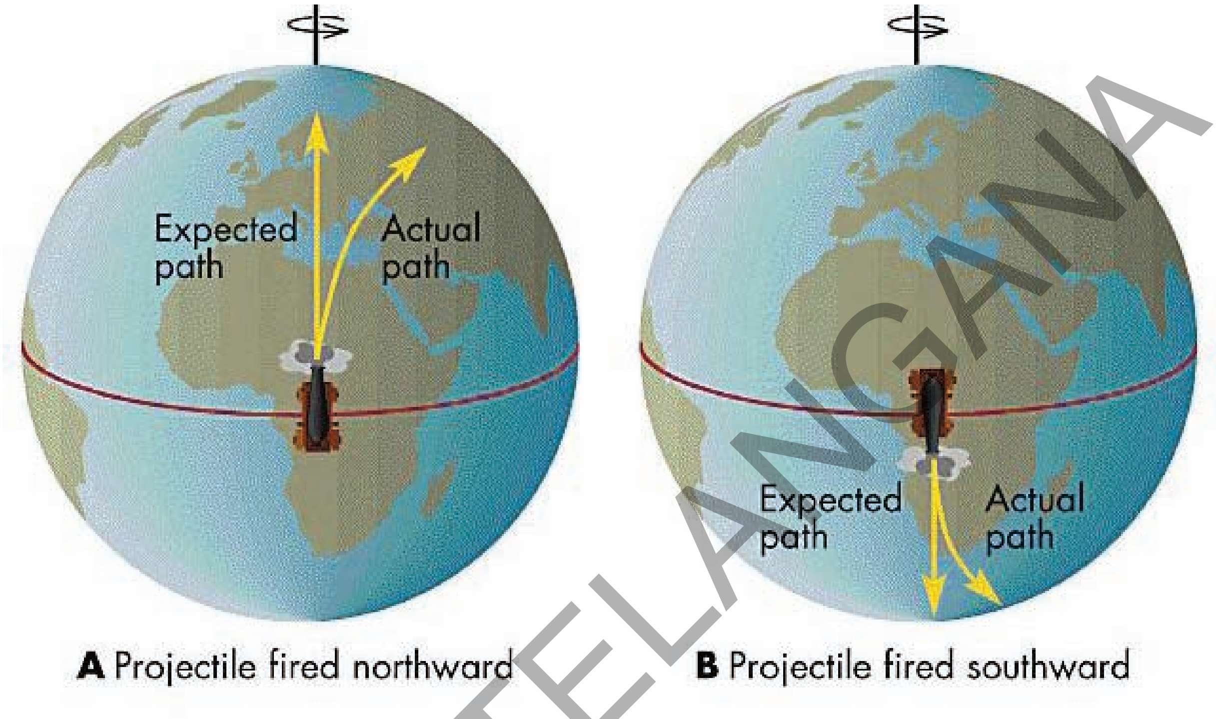

Fig. 4.4: Diagram showing Coriolis effect

Normally we would have expected the winds to move in a straight line from north to south, or south to north from the temperate zone to the tropic zone. (remember that temperate zones are there both to the south and north of the Equator.) But actually the winds move slightly to the right in the northern hemisphere and to the left in the southern hemisphere. This is because of the impact of Earth's rotation on its own axis. This effect is called 'Coriolis effect', having '0' effect near the equator and maximum effect near the poles.

Thus, the atmosphere is always surrounding the earth on all sides in circulation. The winds play a very important role in the weather and climate patterns around the world. They have also played a very important role in history. For example, Vasco da Gama found the sea route to India using winds to power his ships. He was able to transport and trade large quantities of pepper, cinnamon etc. to Portugal because of this. In this way, these winds also were crucial to the establishment of the Portuguese rule over Goa.

Remember, there are also many small local variations in the wind patterns.

Classification of Winds

Depending upon the speed of the winds, their features, their directions and the way they occur, winds are classified into three types :

A. Planetary winds - Present on the planet as a whole through out the year.

B. Seasonal winds - Restricted to regions or seasonal in character.

C. Local winds - Local in character.

A. Planetary Winds: The winds that blow continuously and regularly above the world pressure belts are known as planetary winds. These are of 3 types -Trade winds, Westerlies and Polar winds; Trade winds in the tropics, westerlies in the temperate belt, polar winds in the polar belt. Trade winds are Easterly in direction i.e moving from East to West. They are North East trades in Northern hemisphere and South East trades in Southern hemisphere. Westerlies, on the other hand, blow from West to East, that's why they are called westerlies. They are South West bound in Northern hemisphere and North West bound in Southern hemisphere. Polar regions also experience Easterlies.

- Observe the figure 4.3 and describe between which pressure belts are the Westerlies, trade winds and polar Easterlies are blowing.

Effects of Planetary Winds: You would have noted that the pressure and wind systems are actually a result of the impact of Lithosphere and Hydrosphere on Atmosphere. These winds play a crucial role in transporting heat and moisture across the world. That is why no part of the world gets too cold or too hot for life to survive. Had there been no atmosphere (as on the Moon) it would have got intolerably hot during day or in the tropics and intolerably cold at night or in the Polar regions. However, these winds do not distribute heat or moisture uniformly – which is why some parts of the earth are quite hot, some parts cooler and some parts with high rainfall and some which are deserts.

B. Seasonal Winds: The rainfall that happens in India is mainly due to seasonal winds. All factors in the country are related to monsoons. Monsoon is derived from Arabic word *Mausam.*

Existence of monsoon is due to differential cooling of land and sea. A low pressure area develops over north-western India, while south-east trades cross the equator. As a result of coriolis effect, it becomes south west monsoon over peninsular India and adjacent countries. In winter, reversal of pressure belts i.e north-east trade winds cross the equator. As a result of coriolis effect, it becomes north-west monsoon over the north, north-east Australia.

C. Local Winds: The local winds blow due to local variation in the temperature and pressure, and influence a very small area. Hot local winds raise the temperature of the area. Cold local winds sometimes bring the temperature of the affected area below the freezing points. These local winds blow in the lower layer of the troposphere. The mountain and the valley breezes, as well as sea and land breezes are also one class of local winds. These winds respond to local pressure gradients (pressure changes) set up by heating or cooling of the lower atmosphere.

Hot Local Winds

1. Chinook : These winds move down the Rocky mountains in the USA-Canada and part of North America. Many people believe that the word Chinook means "snow eater".

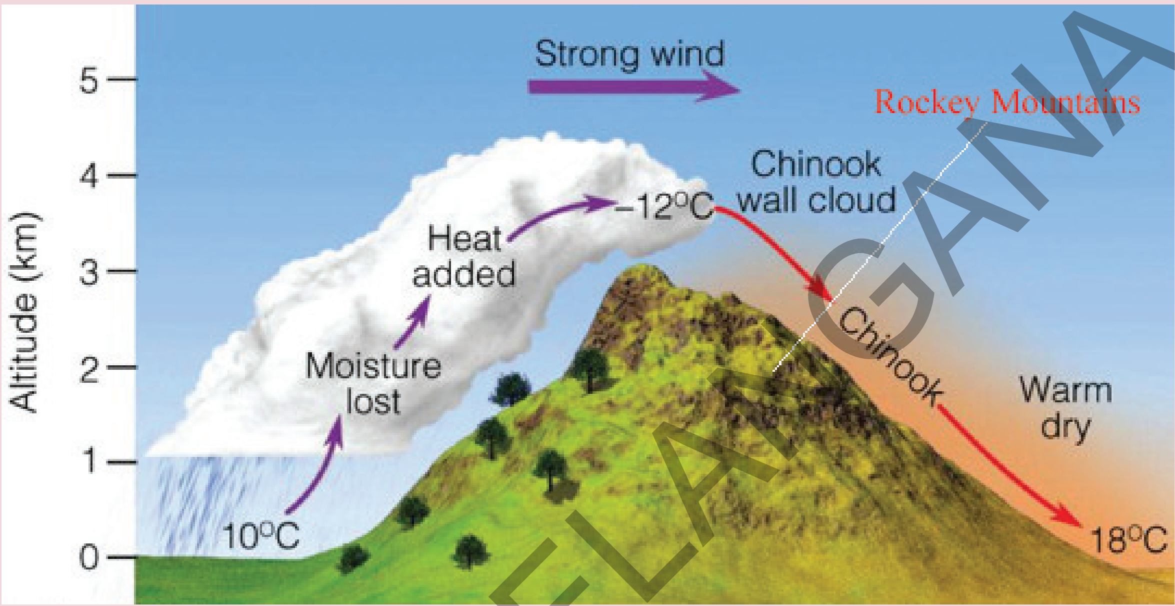

Fig. 4.5: Chinook

Actually, it is the name of a native American tribe called the Chinook, people who lived in the region where these winds are observed. It keeps the grass lands clear of snow during must of the winter. Similar winds that below in Europe are called Foehn. They blow along the northern slope of the Alps. This melts the snow, makes the weather pleasant and helps in early ripening of the grapes.

2. Loo: These are hot and dry winds blowing in the plains of northern India from the west to east in the months of May and June. It may cause sunstroke to people because of high temperatures.

Simmon in Arabian desert, Yoma in Japan, Norwester in New Zealand are some of the other examples of hot winds.

Cold Local Winds

1. Mistral: The most famous is the mistral that blows from the Alps over France towards the Mediterranean Sea. It is channeled through the Rhome Valley. It is a very cold and dry wind.

2. Puna: This is the cold local wind in the Andes region.

3. Pampero: These are the cold polar winds blowing very fast in the Pampas region of South America.

Weather and Climate

Perhaps you have heard of a cricket match being postponed due to 'bad' weather (rain). You may have had to postpone your own games due to rain or excessive heat saying, "The weather is not suitable." You may have also heard people say, "This year, the monsoons are on time." The prices of most fruits go up when they are 'not in season' but come down when they are 'in season.' You may also have heard things like, "The climate in north India is not suitable for me!"

These two words, weather and climate are very important concepts in geography. They shape our lives in many ways. And many people confuse the terms and say 'weather' when they mean 'climate' and vice versa. You will know the difference between the two by the end of this section.

This mixture of gases and particulates that we call the 'atmosphere' is not static. It is very dynamic; it moves up and down and horizontally in all directions. As it does so, its characteristics change – it may get warmer or cooler, wet or drier etc. When we describe the condition of the atmosphere for small period of time (usually about 10 days at most), we are talking about weather. Weather can change daily even within a day!

Climate is description of the average atmospheric conditions for specific areas over a long period of time. Climatic descriptions are based on decades of atmospheric data and finding the averages of these data. Climate descriptions tell us what conditions are going to prevail at a given time of the year, but not on specific days.

How do we describe the atmosphere? We measure (a) temperature, (b) pressure, (c) wind, (d) humidity, and (e) precipitation. These are called the elements of weather. We use these to describe climate also, as you will see soon; so these are also elements of climate. You have just learned about pressure and winds above. Let us take a look at the other elements now.

Temperature: In class VIII, you learnt about the temperature of the atmosphere. We had compared the temperature patterns for Panaji, Shimla, and Delhi. You had also learned that Shimla, being at a higher altitude than Panaji and Delhi, had cooler temperature. On Earth's surface, as you go higher in altitude, the temperatures decreases.

Humidity and Precipitation

In this section, we will understand how water cycle works in the atmosphere. You can see how hydrosphere and atmosphere interact with each other. Water vapour is a very important component in the atmosphere. In most places, the amount of water vapour in the atmosphere varies over time and as part of changing weather patterns. In many places, in winter, it is dry and cold. In such places, our skin may feel itchy, dry, and it may crack. You will probably have experienced cracked lips for which you may have used lip balm, vaseline, or oil.

Combined with high temperature, it is the water vapour that makes you feel sultry and sweaty. When this happens, we say it is 'very humid' or 'the humidity is high.' But not all places are similar in this respect. Some places feel very dry (example: deserts). The moisture (water vapour) in the atmosphere is derived from water bodies through evaporation and from plants through transpiration. Humidity is the amount of water vapour in the air. In high humidity, our sweat doesn't cool us because it cannot evaporate. In low humidity, we also feel more thirsty.

Do You Know?

Hygrometer is an Instrument that measures the water vapour content (Humidity) of the air.

Remember those particulates you learned about earlier? Recall how they help in rainfall.

We express humidity not directly, but using the concept of relative humidity. Relative humidity is the ratio between two things:

1. The maximum water vapour that the air can hold at a given temperature and pressure, and
2. The actual amount of water vapour it holds at any given time.

For example, at 20°C temperature air can contain 80 gms of water vapour per cubic meter. If the actual water vapour present is only 40 gms, the relative humidity is 50%. Relative humidity increases with the decrease of temperature or addition of water vapour. Relative humidity decreases with the increase of temperatures and decrease of water vapour. The critical temperature at which saturation level is reached is called dew point. Have you seen dew drops? Where are they found? If the atmosphere has 100% relative humidity, it is known as saturation level.

Condensation

Condensation is the opposite of evaporation, as it involves conversion of water vapour into droplets of water or crystals of ice. When the relative humidity exceeds 100%, the excess of water vapour present in the atmosphere gets condensed as minute droplets of water. For example, when air at a temperature of 20°C contains 49 gms of water vapour per cubic meter and gets cooled to 10°C it can hold only 40 gms of water vapour at saturation level. The excess of 9 gms of water vapour gets condensed. Condensation can take place only when minute solid particles are present in the atmosphere. Condensation can also take place on a contact surface. For example, have you observed what happens when cold water is filled in a glass? Condensation happens on the outer side of the glass as the moisture in the air comes in contact with a cold surface. When water vapour condenses on surfaces such as plants, dew drop form.

Dust particles also attract water molecules from the water vapour in the atmosphere. This causes condensation (condensation means becoming denser) of the vapour into droplets. Millions and millions of these droplets appear together as different kinds of clouds. If the clouds are cold enough, they may also contain ice crystals. Clouds are classified into different types on the basis of their forms and heights at which they are found. For example, Cirrus clouds (at higher level), cumulus clouds (at middle level), stratus (at lower level), nimbus (rain bearing, and vertical clouds).

With condensation, the droplets get heavy and fall on Earth as precipitation (from the Latin word praecipitatio meaning to fall headlong, to plummet) – in the form of rain, snow, hail, etc. If these droplets condense very close to Earth's surface, the droplets are lighter and we get fog.

Forms of Precipitation

Rainfall is the most common form of precipitation. When condensation takes place at temperatures below freezing point, water vapour condenses directly into ice crystals. These may fall on the earth as a powdery mass or flakes of snow. This form of precipitation is called snowfall. Snowfall is quite common in middle and high latitudes, and mountain regions.

When rain falls through a cold layer of air near the earth's surface, rain drops get frozen into ice and fall down. This form of precipitation is called sleet.

When there are strong vertical currents in the atmosphere, condensation takes place at high altitudes at low temperature. Ice crystals grow in size gradually but do not fall owing to ascending currents. Eventually, the ice crystals grow to a large size of a few centimeters in diameter and fall down as solid masses. This form of precipitation is called hail stone. Hail stone causes damage to crops and buildings.

Types of Rainfall

On the basis of their origin, rainfall may be classified into three main types:

1) Convectional Rainfall
2) Orographic Rainfall
3) Cyclonic Rainfall

Convectional Rainfall: This type of rainfall takes place when moist air over the heated ground becomes warmer than the surrounding air and is forced to rise. This forced air then expands, cools and condenses to form water. Convectional rainfall is common in low latitudes and on summer days in interior part of the continents, and usually come in the form of short heavy showers just after the hottest part of the day, sometimes accompanied by thunder and lightening.

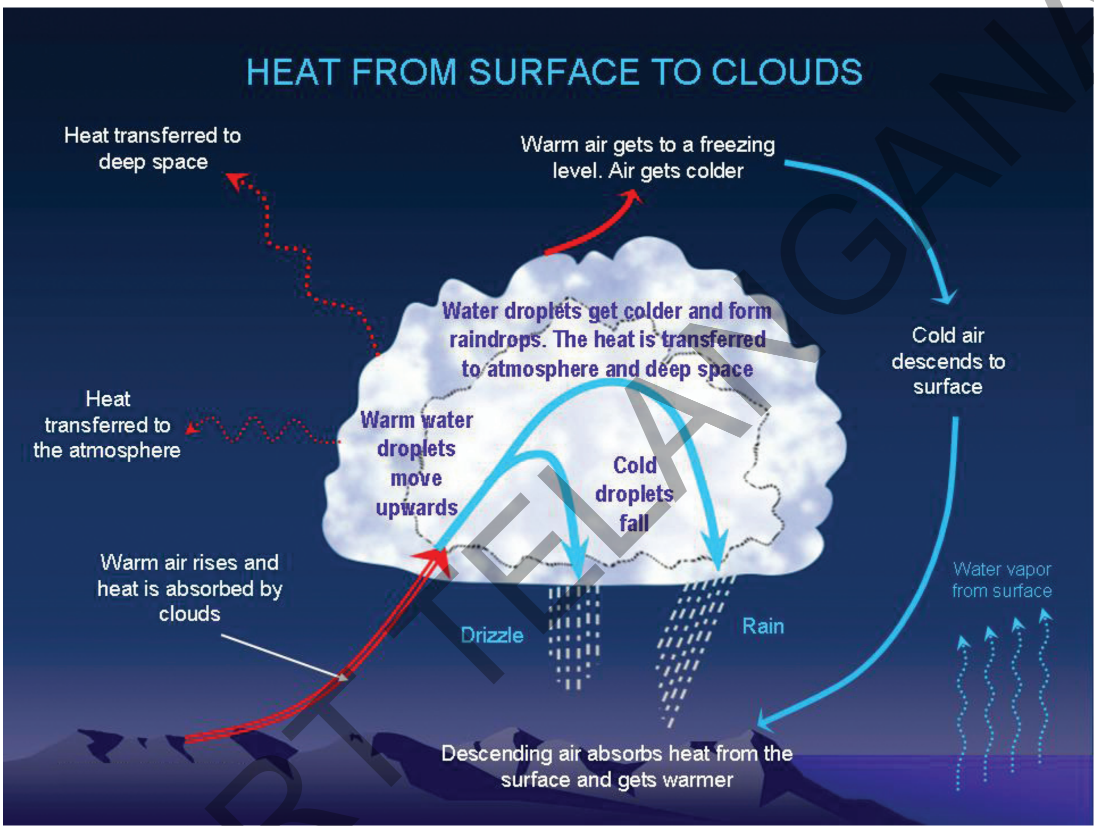

Fig. 4.6: Convectional rainfall

Orographic Rainfall: 'Orographic' rainfall is also sometimes called 'orogenic' rainfall. We get this term from the Greek word oros, meaning 'mountain.' This occurs when moist wind is forced to rise over a mountain or other elevation in its path. Thus the windward sides of many mountain ranges receive heavy precipitation; whereas the leeward sides along which the air moves down receives less rain fall. Such situation occurs widely along the western coast of India.

The moist air from the Arabian Sea is forced by the Western Ghats to rise up resulting in expansion, cooling, and rainfall. On the other side of the Western Ghats, the descending wind is devoid of moisture and hence, does not give the rain in the central part of Deccan Plateau. Hence, this region is dry and known as rain-shadow region.

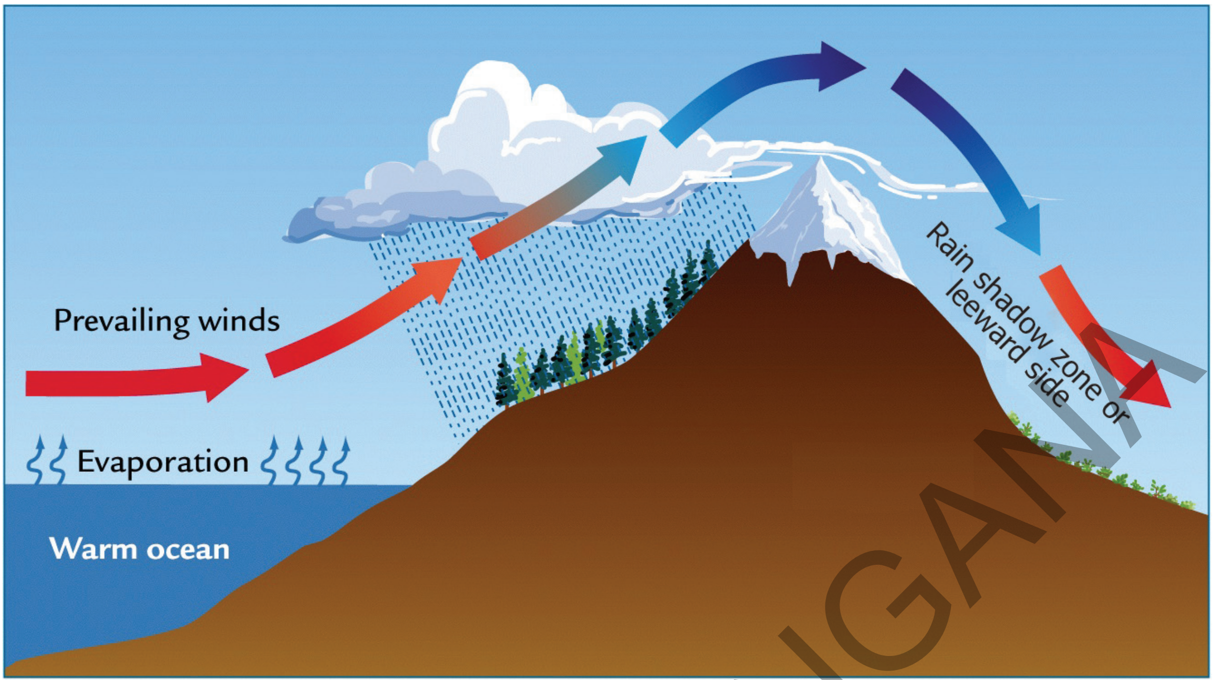

Fig. 4.7: Orographic Rainfall

Cyclonic rainfall: This type of rainfall is associated with the passage of a cyclone or a depression. There are two types of cyclones – the tropical cyclones and the temperate cyclones. The term cyclone is derived from the Greek word 'kyklon' meaning 'revolving.'

Tropical cyclones are warm-core vortex circulation of tropical origin with a small diameter (some hundreds of kilometers) often of an approximately circular shape, minimum surface pressure (less than 900 mb) with sustained maximum winds of at least 33m/sec. They are developed on the warm sea surface (26°C to 27°C) and move towards the land. The winds are lifted up by the movement of cyclones. The uplifted air gives heavy rainfall. Temperate cyclones occur when the cold, dry, denser air masses converge with warm, wet, lighter air masses. The warmer air, being lighter, is lifted up by the denser cold air and results in rainfall.

Fig. 4.8: Tropical Cyclone

Rainfall across the globe:

1. Between the latitudes 10° and 30° N and S of the equator, due to the trade winds, rainfall is heavier on the eastern coasts, and decreases towards the west.
2. Between the latitudes 40° and 60° N and S of the equator due to the westerlies, the rainfall is heavy on the west coast, and decreases towards the East.
3. Low pressure areas, especially around the equator receive high rainfall than high pressure areas.
4. The rainfall is higher over the oceans than on the continent.

Keywords

1. Convectional currents
2. Inter Tropical Convergence Zone
3. Coriolis effect

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Improve your learning

1. Explain the composition of the atmosphere.
2. Discuss the structure of the atmosphere along with a diagram.
3. Differentiate weather and climate.
4. Compare and contrast convectional and orographic rainfall.
5. Describe the distribution of rainfall across the world.
6. How do climatic changes influence human life?
7. Explain relative humidity.
8. Why does the amount of water vapour decrease rapidly with altitude?
9. What is coriolis effect? Explain its effects.
10. Identify the location of the given local winds in the world map?

a) Chinook	b) Loo	c) Simoon	d) Yoma
e) Norwester	f) Mistral	g) Puna	h) Pampero

11. Read the paragraph under the title 'Effects of Planetary Winds' on page 43 and comment on it.

Project

1. Collect weather information covered by media such as newspapers, TV, Radio etc. to understand weather phenomenon.
2. Collect the newspapers from July to December and note down the news related to extreme rainfall in different parts of country.