Notes

7

ATMOSPHERIC PRESSURE AND WINDS

You have learnt in the previous lesson about the atmosphere's composition and its structure, insolation, distribution of temperature and heat budget. We all can feel the sensation of moving air. Have you ever thought about why it moves or what is the reason behind the movement of air? You have also observed its speed and frequency which vary from one place to another. It is all due to variation in the atmospheric pressure which is controlled by temperature.

In this lesson, you will learn about atmosphere pressure, factors affecting atmospheric pressure, pressure belts, planetary and local winds.

OUTCOMES

After studying this lesson, learner:

- defines atmospheric pressure;
- explains factors affecting atmospheric pressure;
- describes atmospheric pressure belts; and
- distinguishs between planetary and local winds.

7.1 ATMOSPHERIC PRESSURE

As we have learnt that, the air is the mixture of gases, water vapour and dust particles. The air with heavy weight means gases, water vapour and dust particles come together or air particles are compressed, while in low weight or pressure, air particles are dispersed or located far to each other. This weight of the air is known as air pressure or atmospheric pressure.

In other words, the mass of the air molecules can define atmospheric pressure. It is measured at a particular surface per unit area. It acts as a force on the earth's surface. It may be measured at any surface. Therefore, the total mass of the air column above that surface is

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compressed for measuring air pressure. This air pressure on the earth's surface varies from place and over time.

The air pressure is measured by Barometer. The atmospheric pressure measuring unit is Millibar (mb). The atmospheric pressure is maximum at sea level. The standard sea level atmospheric pressure is 1013.2 mb.It is because above sea level the thickness of the atmosphere is greater, so the atmospheric pressure is highest. You might have gone to some hill stations. Those hill stations have more height then plain or sea coast. Hence, the air pressure over hill station is less because air parcel is less, hence the pressure is less.

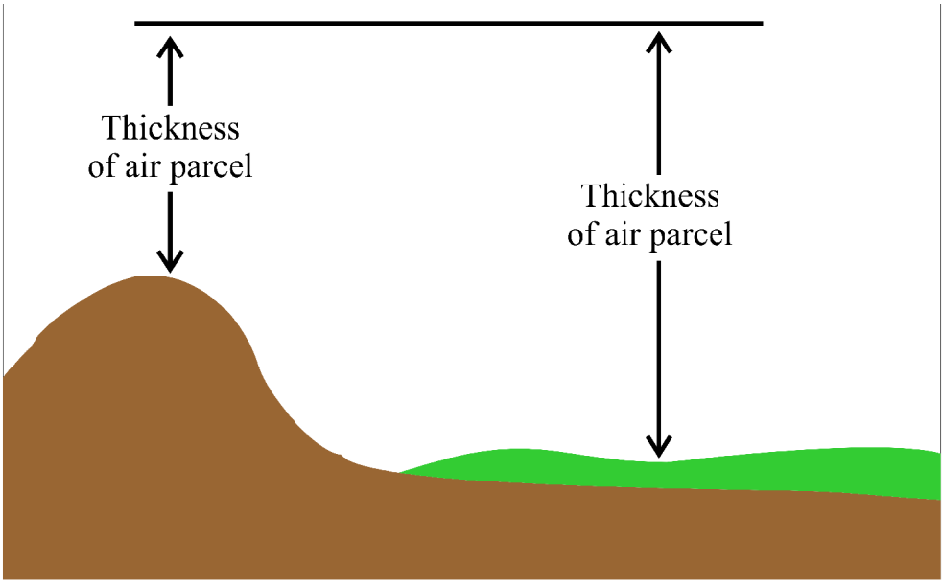

Fig 7.1 Pressure decreases with Height

Air pressure can be shown by Isobars lines on a weather map. It means all the places with same air pressure is joined by a line and the line is known as isobars.

Mainly, there are two types of atmospheric pressure; high pressure and low pressure. The pressure variations can be identified by the shape of isobars. On the earth's surface, an area with more air is known as high pressure areas and an area with less air is known as low pressure areas. In a high pressure system, pressure decreases outward from the centre and in the low pressure system pressure decreases towards the centre. The high and low pressure is the result of temperature differential in the atmosphere.

The difference in atmospheric pressure between the two places on the surface is known as Pressure Gradient. The pressure gradient is a result of differential heating over space. Through the study of spacing between isobars, we can understand pressure gradients. Small difference in pressure over large space indicates weak gradient while close spacing of isobars express strong pressure gradient. As air is a compressible fluid, due to the pull of gravity it is most dense near the ground surface. Moreover, it also decreases rapidly with height.

There are two types of air motion i.e. horizontal and vertical. Convergence and divergence of air is an example of horizontal motion. Whenever winds flow towards each other or converge, besides this when surface winds diverge there must be a subsidence of the air. Ascent and subsidence is an example of vertical motion.

DO YOU KNOW?

On a weather map for a designated place, where sea-level atmospheric pressure is comparatively high, pressure is expressed with symbol "H" and low pressure with "L" symbol.

Let us see figure which shows convergence and divergence associated with high and low pressure systems.

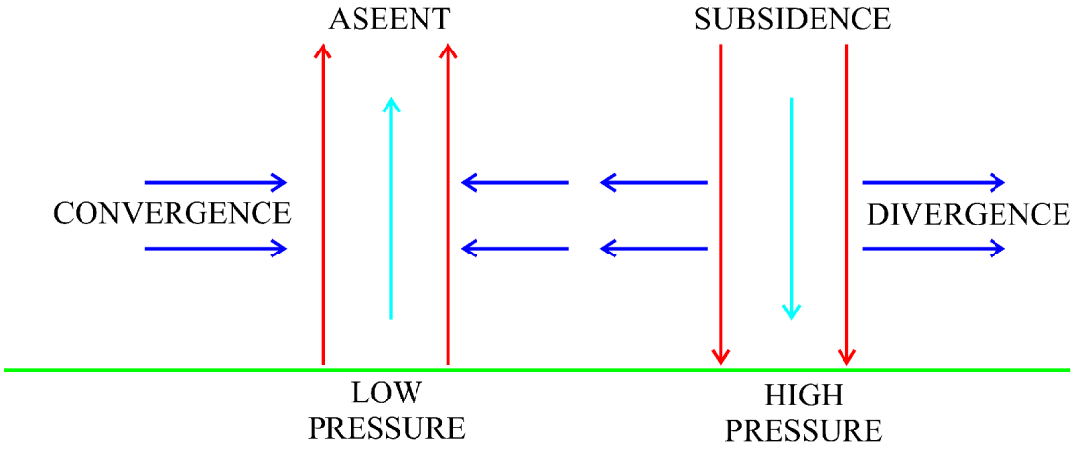

Fig 7.2 Horizontal and vertical movement of Air

The low-pressure regions are associated with clouds and precipitation while the high pressure system is generally associated with dry weather and mostly clear skies with longer diurnal temperature changes; due to greater radiation at night and greater sunshine during the day.

INTEXT QUESTIONS 7.1

Give an appropriate term for the following:

1. A force per unit area exerted by the atmosphere above earth's surface.
2. Name the term by which air pressure is shown on the map?
3. An instrument which is used for measuring air pressure.
4. Name the term showing the difference between two isobars?

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7.2 FACTORS AFFECTING ATMOSPHERIC PRESSURE

Till now, you have learned that atmospheric pressure varies with time and space. Let's discuss why and how? In this regard, the following factors need to be studied which affect atmospheric pressure.

i. Altitude

ii. Temperature

iii. Earth Rotation

iv. Water Vapour

Let's discuss one by one.

I. Altitude

Atmospheric pressure decreases with increasing height. It means pressure at ground level is higher than air pressure at the top of High Mountain. Because atmospheric pressure is the weight of all the air above the level at which it is measured.

- Height of the air column is maximum at sea-level and that's why pressure of air is greater at ground level than less pressure at higher elevations.
- As we know, air is highly compressible and a mixture of various gases. Due to the weight of overlying layers, density of lower layers is increased. Its atmospheric pressure increases at lower layers of the atmosphere.
- Heavy gases and particles are found at lower layers and lightweight gases and fewer particles float at higher layers.

DO YOU KNOW?

Atmospheric pressure decreases with increased altitude but rapidly at lower atmosphere then slowly at high altitude.

ii. Temperature

The atmospheric pressure is closely linked with atmospheric temperature. It means the spatial variation in the atmospheric pressure is directly controlled by the temperature. There is an inverse relationship between temperature and pressure because when air is heated due to high temperature, its molecules and particles expand over a large area. Its air pressure decreases. Therefore, we can say, atmospheric pressure decreases when temperature increases. When air is cooled, it contracts and air molecules spread

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only at smaller areas. Because of this phenomenon, the pressure of the air increases. In other words, atmospheric pressure increases when the temperature falls.

Let's understand the impact of temperature on pressure through flow diagram

Low air temperature → Shrunk → Density increase → pressure increase
High air temperature → Expand → Density decrease → Pressure decrease

For example, you have already learned in the last lesson that the temperature is very low at the poles and high mountain regions which results in the contraction of the air. Thus, high pressure areas develop at poles. On the other hand, high temperature along the equator and near earth's surface results in expansion of the air and development of low-pressure areas.

iii. Earth's Rotation

Earth's rotation also makes a great impact on pressure belts of the globe. Due to the earth's rotation on its axis, equatorial air moves far away from the centre while polar air attracts towards the centre. As a result, the air column of mid latitudes changes more. Atmospheric pressure is high at lower layers of the atmosphere due to the gravitational pull of the earth.

iv. Water Vapour

The existence of water vapour also affects the atmospheric pressure. The greater the concentration of water vapour in the air, the density of air is less. Air with lower water vapour makes it heavy or high in density. Because the molecular weight of water is less than the average molecular weight of dry air. Thus, dry air is heavier than moist air. Similarly, the air is lighter in the rainy season due to the presence of water vapour.

DO YOU KNOW?

Water vapour reduces the density of air and thus the light air exists on oceans and heavy air on continents.

INTEXT QUESTIONS 7.2

Write 'True' for correct and 'False' for incorrect statements-

i. There is an inversely proportional relationship between temperature and pressure.

ii. The maximum atmospheric pressure is at the mountain top.

iii. Earth's rotation on its axis affects the pressure especially in mid latitude.

iv. Continental airs are lighter in weight than oceanic air.

7.3 DISTRIBUTION OF ATMOSPHERIC PRESSURE

It is very important to know about the distribution of the atmosphere. Its distribution varies spatially, diurnally and seasonally. Here, you are going to learn vertical and horizontal distribution of atmospheric pressure.

A. Vertical Atmospheric Pressure

Generally, Atmospheric pressure decreases with increasing height at the rate of 34 the millibars per 300 metres of height. For example figure shows how altitude affects the pressure distribution. At the height of 5.5 kms air pressure decreases to 550 mb which is half of the sea-level pressure. In other words, we can say that half of the atmospheric mass lies between the earth's surface and the height up to 5.5 kms. In this way, at the altitude of 50 kms, air pressure is about 1 mb. Out of total atmospheric pressure, 99.9 percent lies within 50kms of the earth's surface.

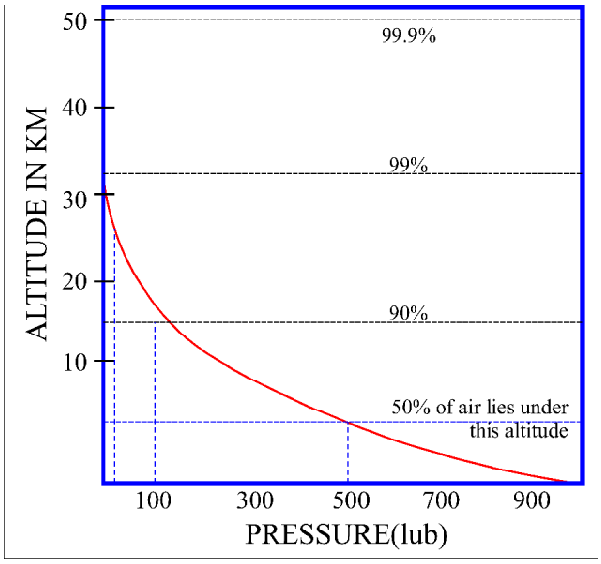

Fig 7.3 Vertical air Pressure and Altitude

B. Horizontal Distribution of Atmospheric Pressure

As you know, the distribution of air pressure is shown by Isobars. Isobar means the line which connects those places having equal pressure. After studies of pressure distribution, we can say there is a close relationship between pressure and temperature. The horizontal distribution of atmospheric pressure is controlled by some factors. It can be categorised in two groups' i.e. thermal factor and dynamic factor. There are clearly distinguishable homogeneous pressure belts at global level. On that basis, Earth can be divided into seven pressure regimes or belts in which three pressure belts in each hemisphere and one lies near the equator in both hemispheres.

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i. **Equatorial low pressures belt:** Equatorial low-pressure belt lies between 5° north and 5° south latitudes. This region receives intense heating throughout the year; air gets warmed up and rises over the equatorial region and creates low pressure. The vertical upward movement of air is the main reason for creating low pressure at the surface of the equatorial zone. The position of this low-pressure belt varies with apparent movement of the sun.

This belt is the zone of convergence of trade winds from subtropical high pressure belts of both the hemisphere. It is known as Inter Tropical Convergence Zone (ITCZ). In this zone winds are very light and variable with frequent calms. It is also called the doldrums. The position of the belt varies with the apparent movement of the sun.

ii. **Sub-tropical high-pressure belt:** Sub tropical high-pressure belt extends from 30° to 35° in north and south latitudes. The following two reasons are responsible for creating high pressure in this region even after intense heating of about 10 months in a year. Here the dynamic factor is responsible for high pressure.

- Due to subsidence of air at 30° north and south latitude, which rises over the equator and moves towards poles and descends after becoming cold and heavy in the upper troposphere.
- Due to the earth's rotation, poleward moving winds are deflected from polar areas to sub-tropical areas and cause high pressure near tropics.

The descending air creates dry, calm conditions with variable and light winds in this high-pressure region. Therefore, they are called 'belt of calm' or 'horse latitudes'. Most of the hot deserts are located in the western side of this belt in both the hemispheres.

iii. **Sub - Polar low-pressure belt:** The sub - polar belt located around 60^{o} north and south latitude. Here, low pressure exists as a result of convergence of westerlies and polar easterlies. Due to great contrast between the temperature of the winds from subtropical warm and polar cold regions produce cyclonic activity in this region.

This sub-polar low-pressure area is best developed over the oceans where temperature differences between summer and winter are negligible.

iv. **Polar high-pressure belt:** The Polar high-pressure belt situated on the north and south poles at 90° in both the hemispheres where temperature is extremely low below freezing point. It causes air compressions and density increases. Thus, create a belt of high-pressure.

On the basis of the above explanation, equatorial low pressure belt and polar high pressure belt are thermally induced while sub tropical high pressure belt and sub polar low pressure belt are dynamically induced. Above pressure belts are just a generalised picture, not permanent. Because they change their position and shift northward in July and southward in January.

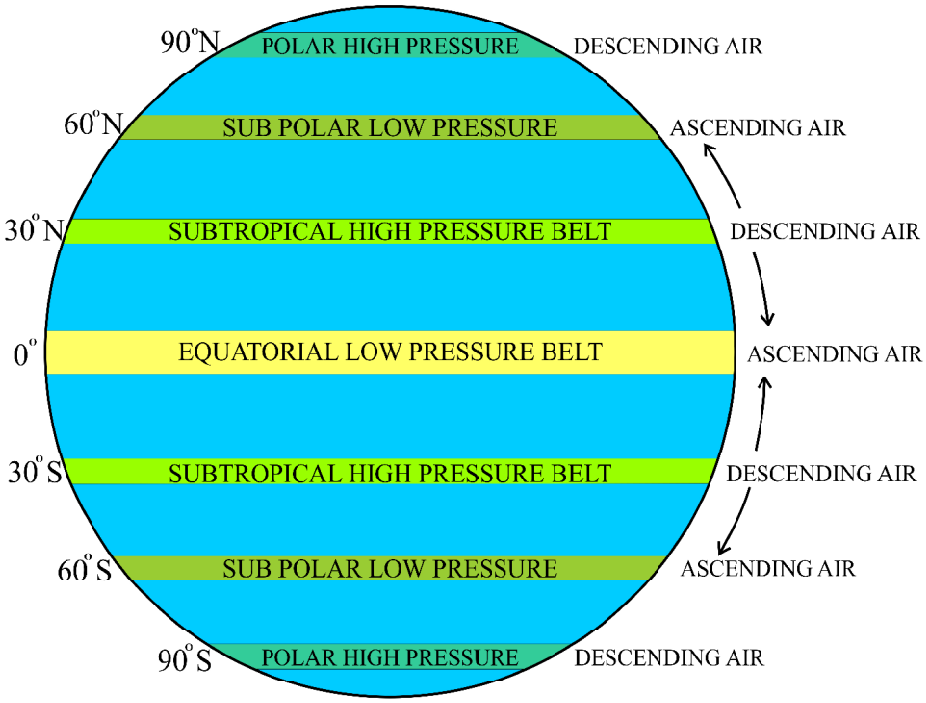

Fig 7.4 Distribution of world pressure belt

C. Seasonal Distribution of Pressure

The pressure variation from place to place and season are important in respect of weather and climate. The variation can be analysed by the study of isobar maps. Pressure of all places drawn on an isobar map is reduced to sea level to avoid the effect of altitude on air pressure. World isobaric maps are generally constructed to show average pressure for two months - January and July.

i. Pressure conditions of January

In the month of January, the apparent movement of the sun is towards the Tropic of Capricorn. This is the time of summer in the southern hemisphere. The equatorial low pressure belt shifts little towards the south. The areas of lowest pressure occur over the warm continents of Australia, Africa and South America. We know land tends to get hotter rapidly than water and the subtropical high-pressure cells are centred over the ocean in the southern hemisphere. The high pressure belt is interrupted by the continental land masses where the temperature is much higher. There are well - developed

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circumpolar belts of low pressure in the southern hemisphere. This is due to no land masses in the high latitudes. It has also been observed that over the coastal regions of Antarctica and the southern oceans clearly indicate that beyond latitude 65° south, there is a gradual increase in the atmospheric pressure.

In the northern hemisphere, the sub - tropical high pressure belt is located well to the north mainly over the continents. The high pressure exists over North America and Eurasia. This is due to the fact that land cools more rapidly than oceans. Its temperature is lower in winter than the surrounding seas. The north - eastern part of Asia has the highest pressure on the earth's surface. Because of large continental areas in the northern hemisphere the sub-polar low-pressure belt is represented by individual oceanic cells and their continuity is broken. There are two low pressure cells namely Iceland low and Aleutian low develop over the north atlantic and north pacific oceans respectively in the northern hemisphere.

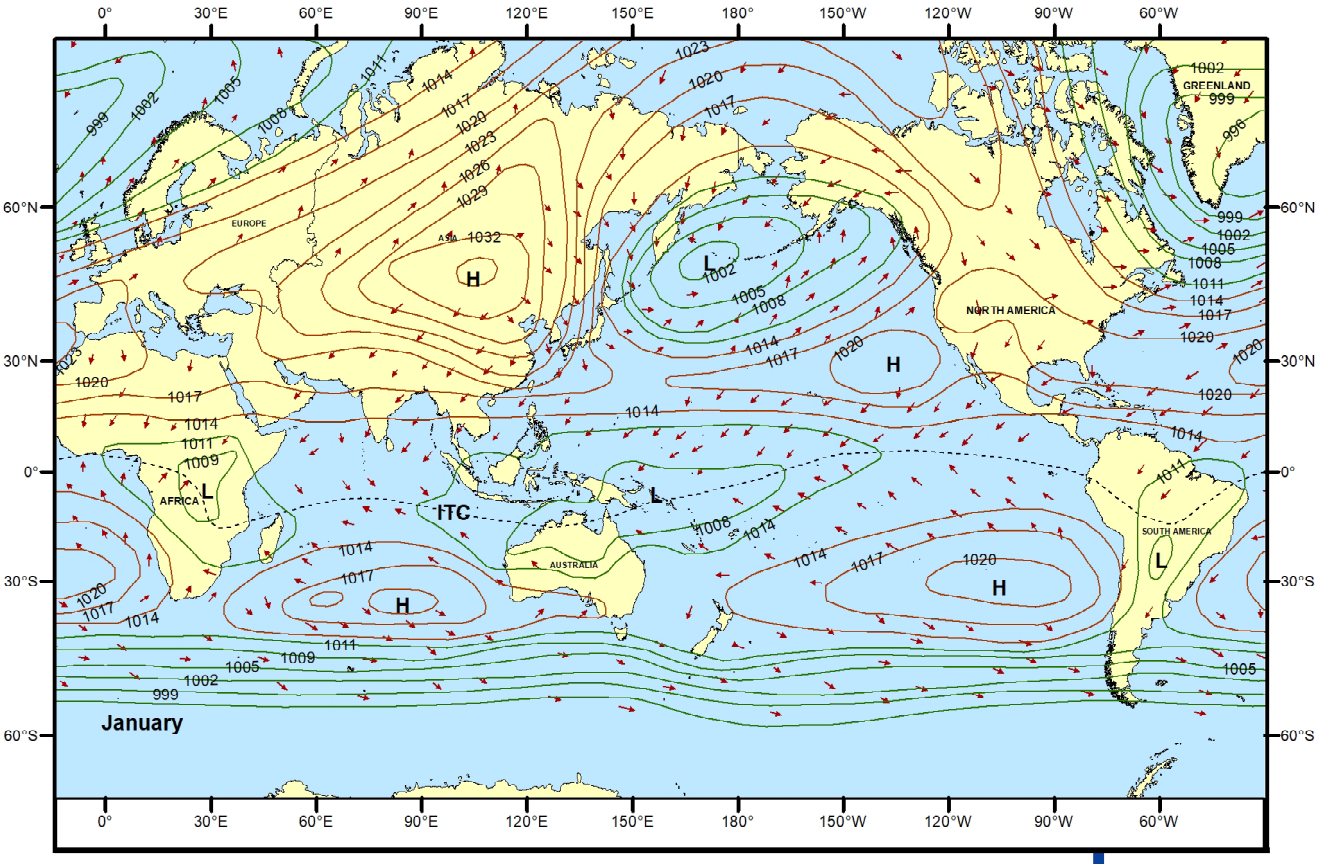

Fig. 7.5 Pressure Condition in January

ii. Pressure conditions of July

This is the season of summer in the northern hemisphere because of the apparent movement of the sun towards the Tropic of Cancer. Therefore, all pressure belts shift northward. Equatorial trough is located well north of the equator over the warm land

mass. The sub - tropical high-pressure cell is more developed and found over the north atlantic and north pacific. They are called the Azores high and the Hawaiian high. There is a winter season in the southern hemisphere. The subtropical high pressure belt is a continuous and high pressure cell established over the continent of Australia. The Sub - polar low forms a continuous belt in the southern hemisphere. In the northern hemisphere, the sub polar low-pressure belt continues to a small degree over oceans.

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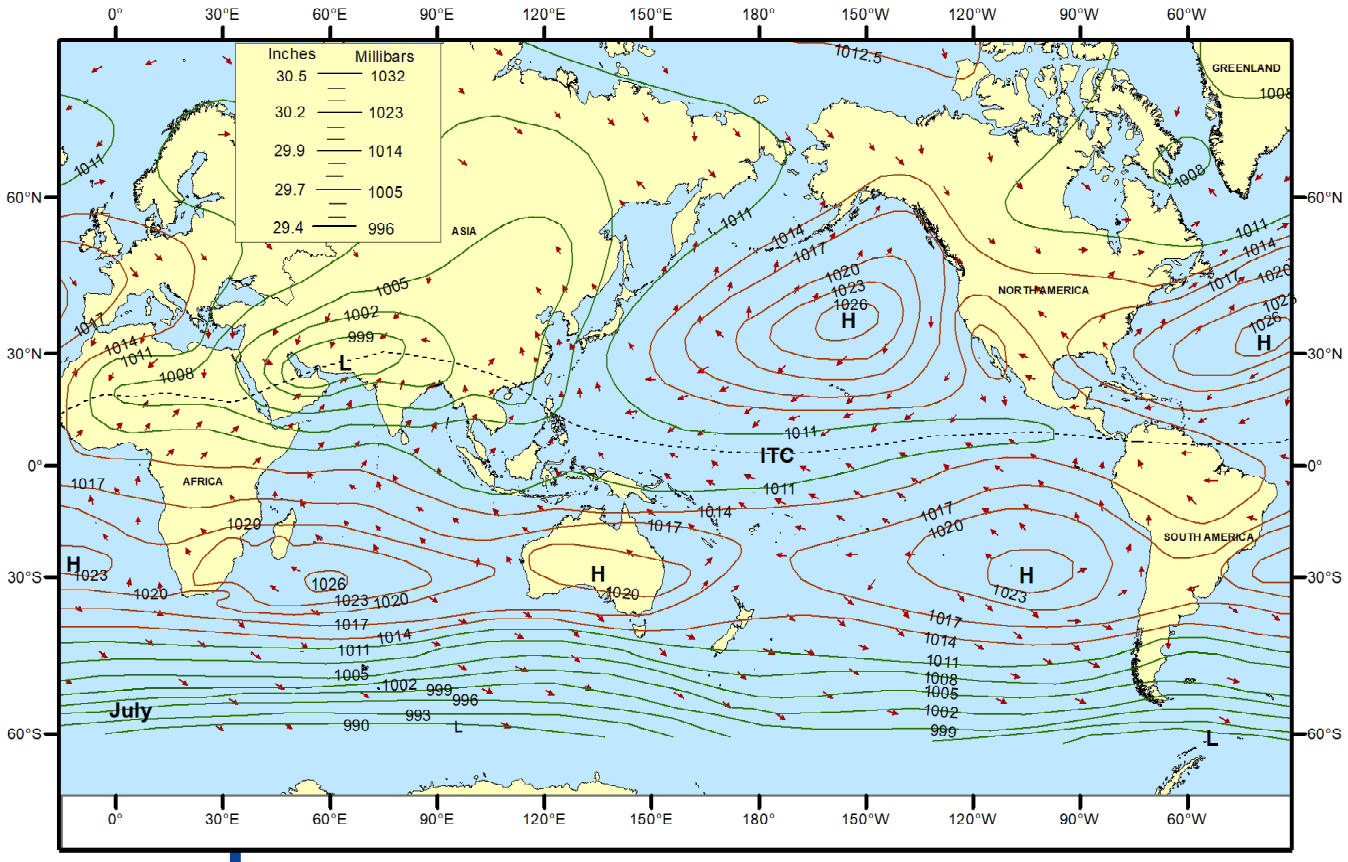

Fig. 7.6 Pressure Condition in July

INTEXT QUESTIONS 7.3

i. What is the other name of inter tropical convergence zone?

ii. Name the pressure belt which is related to horse latitude.

iii. Which factor is responsible for the sub-polar low pressure belt?

iv. Name the continents where the low pressures exist in the month of January.

Notes

7.4 WIND

Wind is the common name to use for the movement of air from one place to another place. The nature of wind, its speed and frequency vary from one place to another due to the variation in the atmospheric pressure. Air moves wherever and whenever the pressure difference exists in the atmosphere.

Technically, wind is the horizontal movement of air molecules over the earth's surface. It is the result of spatial difference in the air pressure. Wind is one of the important modes of equalisation of the atmosphere, transporting heat, moisture, pollutants and dust to a great distance around the globe.

We have learnt in previous lessons that water and air are important in maintaining the heat budget of the earth surface. Like water in the oceans through the motion of wind, transfer heat over the earth's surface and carries water vapour from ocean to the continents. Life is possible on earth's surface only because of this heat transfer from equator to poles and poles to equator. Winds also influence various economic activities and human comfort. They not only have a larger impact at global level but they have also influence at local level. Winds tend to blow from the high-pressure belts to the low-pressure belts. Air direction and velocity are two important characteristics of wind.

A. Factors Affecting Wind Motions

An air movement is a normal phenomena of the atmosphere. It moves as the difference in atmospheric pressure develops. The Pressure gradient plays an important role in air movement and controls the direction and speed of the air. Once air moves along the pressure gradient, several other forces affect its direction and velocity. For example, instead of blowing directly from one pressure belt to another, winds tend to deflect the direction of the winds due to the effect of earth's rotation.

Pressure gradient is defined as difference in pressure over space. The difference in pressure gradient is due to the difference in heating over space. The two key factors affect wind motion are:

i. **The pressure gradient force:** The pressure gradient force has been generated due to horizontal difference in pressure which is a result of uneven heating. With the effect of this force air moves from high pressure areas to low pressure areas, without this difference air cannot move. It means the wind direction follows the direction of change of pressure. Not only wind direction but wind speed is also controlled by the pressure gradient force. For example, closely spaced isobars indicate steep pressure gradient and large space between isobars is an example of weak gradient. The pressure gradient is the force that determines the strength of the wind.

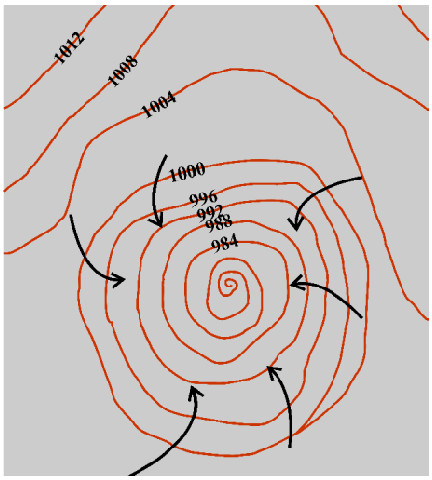

Fig 7.7 ISOBAR showing steep pressure Gradient

ii. **The Coriolis force:** Normally winds will follow the direction of pressure gradient. But it is not like this, winds do not cross the isobars at right angles according to pressure gradient. Therefore, winds are greatly deflected by their original path due to Coriolis force which is a result of rotational movement of earth on its axis. The effect of Coriolis force can be stated as any object and liquid moving horizontally tends to be deflected to the right to its path of motion in the northern hemisphere and deflection towards the left of the path of motion in the southern hemisphere. The Coriolis Effect is absent (0) at equator but increases towards the poles (100%).

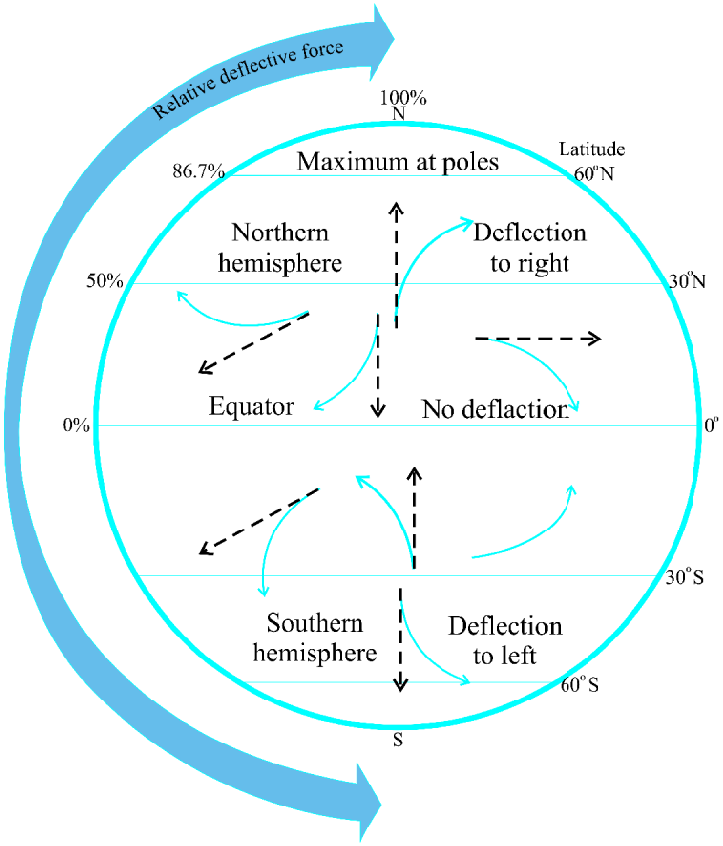

Fig. 7.8 The coriolis force

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B. Types of Winds

Winds play an important role in understanding the climatic characteristics of different parts of the world or our surroundings. There is a closer relationship between winds and the belt of atmospheric pressure. Throughout the world there are many wind systems which influence not only our economic activities but also our comfort. Winds are classified broadly in following categories.

a. Planetary winds or permanent winds

b. Periodic or seasonal winds

c. Local winds

a. Planetary winds- The planetary winds blow from high pressure areas to low pressure areas in the same direction throughout the year. These winds blow extensively over the continent and oceans. They are known as the easterlies or trade winds, westerlies and polar easterlies.

i. The Easterlies or Trade winds - The Easterlies winds blow from sub- tropical high-pressure areas towards equatorial low-pressure areas. It is also known as trade winds. The direction of these winds in the northern hemisphere is from north-east to south - west and southern hemisphere south - east to north - west. The deflection of winds is a result of Coriolis Effect. Because winds tend to blow out of the east, they are called easterlies.

These winds are stable in their area of origin and when they reach the equator becomes humid after picking moisture on their way. The Trade winds of both the hemisphere meet at equator and due to convergence, they rise and cause heavy rainfall.

ii. Westerlies -The westerlies are the winds which blow towards poles from sub - tropical high-pressure belts in the northern hemisphere deflected to the right and blow from south-west to north-west. In contrast wind deflected to the left in the southern hemisphere and blew from north-west. Thus, these winds are called westerlies. In the southern hemisphere, there is a vast expanse of ocean. Therefore, westerlies blow with great force and regularly throughout the year between 40° south latitude to 60° south latitudes. Due to their tremendous speed they are known as Roaring forties, Furious fifties and Shrieking sixties.

iii. Polar easterlies- The polar easterlies blow from polar high pressure regions towards sub-polar low pressure regions. It blows from the north east to the south west direction in the northern hemisphere. In the southern hemisphere, the direction of wind is from South-East to North-West. The Polar easterlies have characteristics of being extremely cold, dry and stable.

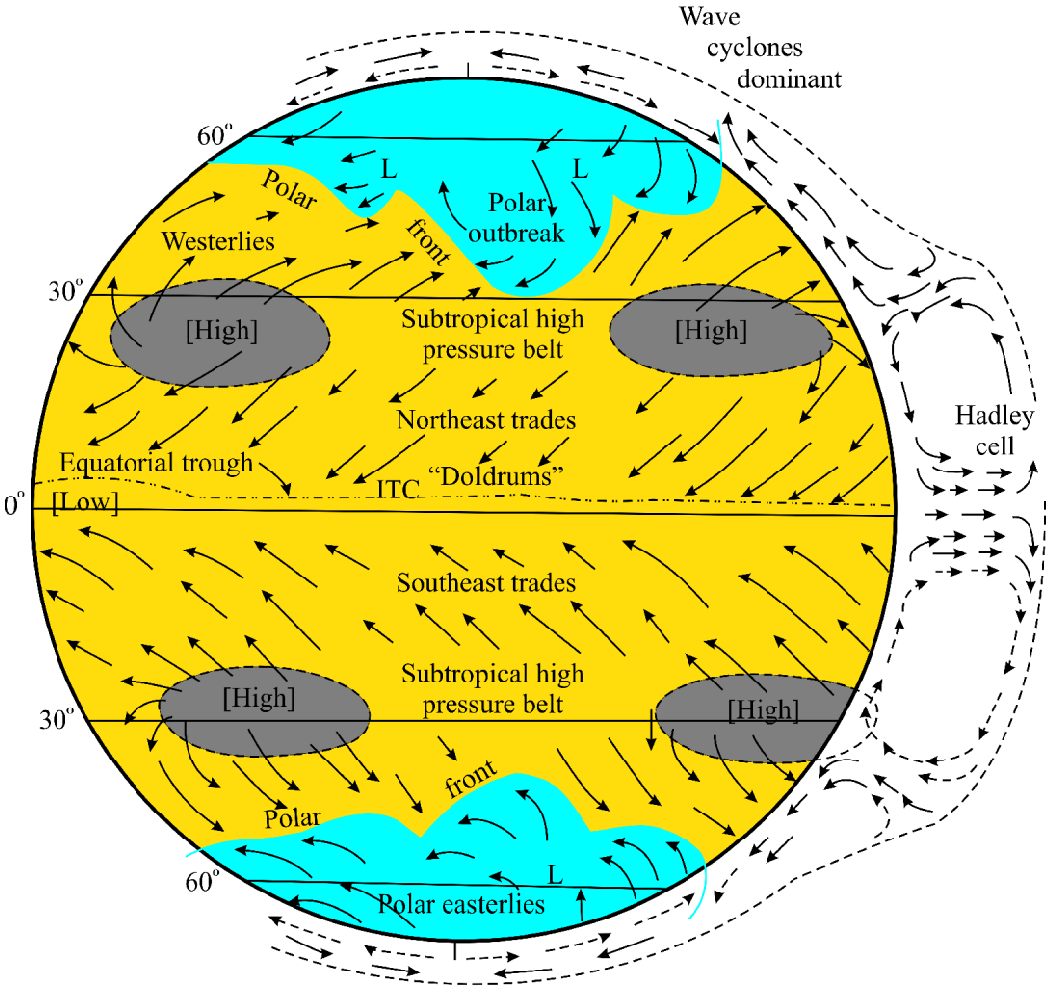

Fig.7.9 Planetary Winds

b. **Periodic winds -** The Periodic winds are those winds which change their direction with the change of seasons. This is also known as seasonal winds. Monsoon winds are the best example of periodic winds.

i. **Monsoon winds -** The word "monsoon" is described as a wind of seasonal reversal. It means monsoon winds are those seasonal winds which completely reverse their direction with the change of seasons. Monsoon winds blow from sea towards land in summer seasons and from land towards sea in winter. They blow on an extensive area of the Asian continent, and other parts of the world. Monsoon of Asian region is the result of interaction of both planetary wind systems and regional factors, both at the surface and in the upper troposphere. The most important areas of monsoon climate are located in India, Burma, Bangladesh, China, and Philippines etc.

India truly represents monsoonal climate. The climate of India is marked by distinct winter and summer seasons. The rain comes in summer in one part of the country and in winter in another part.

c. **Local winds -** Local winds develop due to local differences in temperature and pressure. Such winds affect small areas in extent and are confined to the lowest level of the troposphere. Some examples of local winds are as follows:

i. **Land and Sea Breezes-** Land and sea breezes are a good example of the change in temperature and pressure of the air over land in contrast to that over water. The land and sea absorb and transfer heat differently. In the daytime the land area gets more heated and becomes warmer than the adjacent sea. Thus, over the land the air rises and develops low pressure. Whereas the sea is relatively cool and pressure over sea is comparatively high. Therefore, pressure gradient from sea to land is created. Wind blows from sea to land as 'sea breeze'. At night the reversal of conduction takes place. After sunset land loses heat faster and becomes cooler than the sea. This results in high pressure over the land and low pressure over the sea. The pressure gradient is from the land to the sea. Air starts blowing from land to sea and it is known as 'land breeze'.

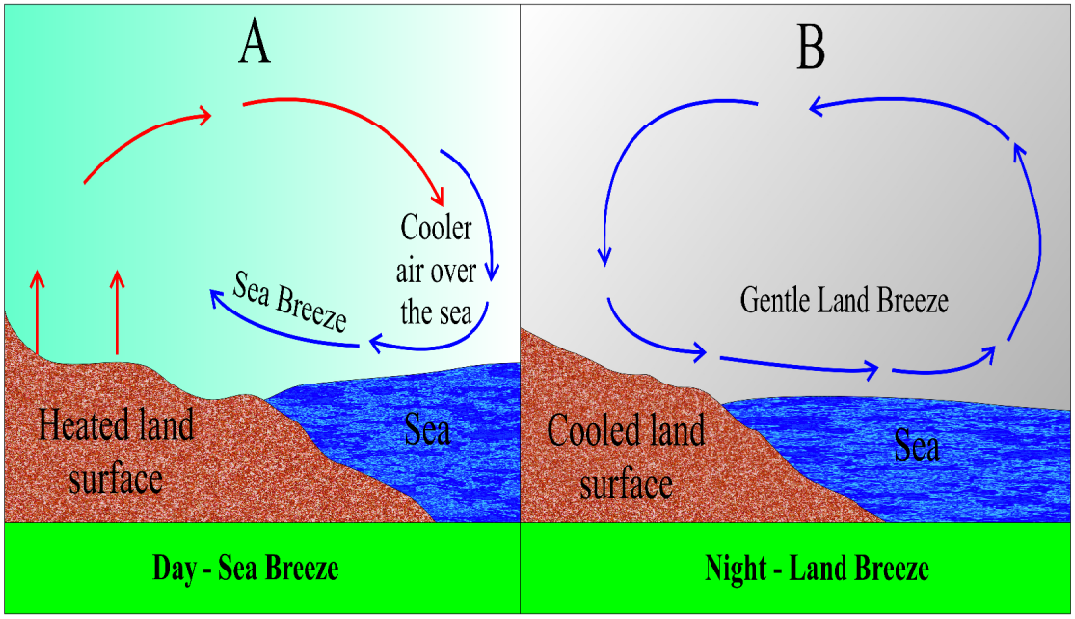

Fig. 7.10 Sea and land Breezes

ii. **Mountain and Valley Breezes-** A mountain and valley breeze is an example of a diurnal wind system. It develops frequently over areas with large differences in relief or some highland areas. During the day , the sun heats up the valley air rapidly. This causes it to raise a warm, upslope wind. The warm air rises creating a valley breeze. In the night mountain air cools rapidly and cold air is dense so it sinks from the mountain tops into the valley below creating a mountain breeze. A mountain breeze and a valley breeze are two related, localised winds that occur one after the other on a daily cycle.

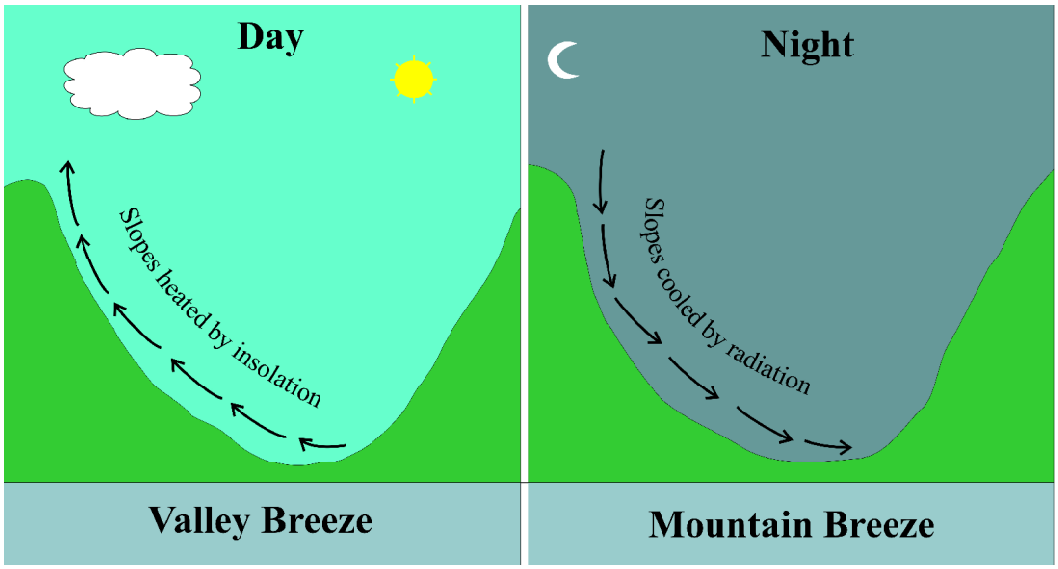

Fig 7.11 Valley and Mountain Breezes

iii. Hot winds

Let's know about some of the important hot winds.

Name of hot winds	Location	Characteristics
Loo	Plain of north India and Pakistan	Loo is a very hot and dry wind, which blows in the months of May and June, usually in the afternoon. Its temperature varies from 45 degree Celsius to 50 degree Celsius.
Fohn	Alps mountain	The fohn is warm, dry, gusty wind which occurs over lower slopes on the lee side of a mountain barrier. The onset of fohn is generally sudden. It may raise the temperature by 15 degrees to 30° F within an hour.
Chinook	Eastern slopes of Rockies	A very dry and warm wind with a capacity to evaporate snow. The meaning of chinook is 'the Snow eater'. Chinook have been known to raise temperature by 35° F within 15 minutes.
Leveche	Spain	A dry, dust laden wind blowing from Sahara Desert into Spain
Sirocco	Sahara desert	A hot, dry wind blowing north across the Mediterranean sea.

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Khamsin	North Africa and Arabia	A hot desert, dry, dust- laden, wind occurring mainly in Egypt. It occurs during the period February to June, being most frequent in March and April.
Zonda	Argentina	A warm, dry wind on the edge of the Andes.
The Santa Ana	Southern California	A hot, dry, strong, blustery, fohn-type wind. It is most frequent in winters but may also occur in spring or autumn. In spring Santa Ana winds can cause considerable damage to fruit trees.
Harmattan	West Africa	A hot, dry, dusty north-eastern wind blowing out of the Sahara across the Sahel. It is hot from about March to June and cool from November to February.

iv. Cold winds

Some of the important cold winds are:

Name of cold winds	**Location**	**Characteristics**
Bora	Adriatic coast	A cold, dry winter, blowing down off the highlands of Yugoslavia and affecting the Adriatic coast.
Blizzard	Rocky Mountain	An extremely cold, violent, storm of powdery snow ice carried by a high wind during which visibility is limited.
Buran	Central Asia and Russia	A extremely cold, strong northeasterly or easterly winds blowing found in central Asia and Russia chiefly during the winter
Mistral	Rhone valley	A strong, cold, dry and violent wind originates on the Alps in france. It blows from north or north-west towards the Mediterranean through the Rhone valley. It may blow any time of year continuously for a day or two with speeds of 100 km/h.

Notes

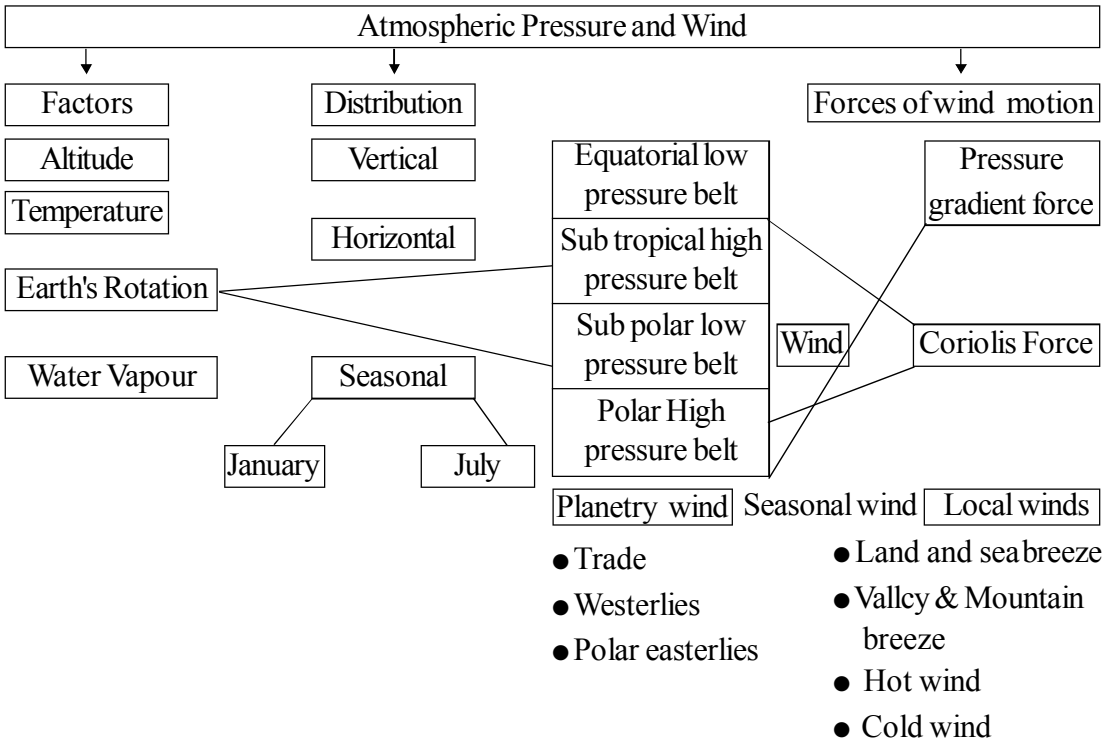
Norther	Texas, Gulf of Mexico to W. Caribbean	A cold, strong, northerly wind whose rapid onset may quickly drop the temperature. Severe thunderstorms and hail are common and the wind can reach speeds of between 40 and 60 mph.

The distinctive wind patterns from planetary to local in various parts of the world are the result of variation in atmospheric pressure.

INTEXT QUESTIONS 7.4

1. Name the forces of wind motions.
2. Give an example of planetary winds.
3. Loo, Chinook and Sirocco are examples of which type of wind?
4. What is the main characteristic of Monsoon winds?

WHAT YOU HAVE LEARNT



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ACTIVITY

Let's make a map showing different winds of your area and try to find out their reason for movement.

TERMINAL QUESTIONS

1. Choose the correct answer for each of the following:

   a. Sirocco is a type of wind.

      (i) Hot local wind

      (ii) Cold local wind

      (iii) Seasonal wind

      (iv) Planetary wind

   b. Where is the maximum deflective force ?

      (i) Equator

      (ii) Tropics

      (iii) Poles

      (iv) Mid latitudes

   c. Which one is a example of periodic wind

      (i) Land and Sea Breezes

      (ii) Westerlies

      (iii) Monsoon

      (iv) Fohn

2. Name the factors on which the atmospheric pressure of any place depends.

3. Define atmospheric pressure and how it can be measured?

4. Write a short notes on following:

   a. Pressure gradient force

   b. Land and sea Breezes

5. Distinguish between the following:

Notes

a. Planetary winds and Periodic winds

b. Mountain and Valley Breezes

6. Explain the role of Coriolis force in wind motion.

7. With the help of diagrams show the various pressure belts of the earth surface.

8. Describe any two planetary winds.

9. Explain the seasonal variation in pressure distribution of earth with the help of a map.

ANSWERS TO INTEXT QUESTIONS

7.1

(i) Atmospheric pressure

(ii) Isobar

(iii) Barometer

(iv) Pressure gradient

7.2

(i) True

(ii) False

(iii) True

(iv) False

7.3

(i) Doldrums

(ii) Subtropical high pressure belt

(iii) Dynamic factor

(iv) Australia, Africa and South America

7.4

(i) Pressure gradient force and Coriolis force.

(ii) Trade winds, Westerlies and Polar easterlies.

(iii) Hot winds

(iv) Seasonal reversal of winds is the main characteristic of monsoon winds.