10 Winds

Atmospheric Pressure

The sphere of air which is spread over thousands of kilometres above the surface of the earth is called Atmosphere.

The air in the atmosphere is a physical matter and so it has its own weight. This layer of air in the atmosphere exerts some pressure according to its weight on the earths surface, which is called Atmospheric Pressure. Earths gravitational force is responsible for the atmospheric pressure. Polar regions experience more gravitational force than the equator, so the weight of the matter is more on poles.

Among the elements deciding the weather and climate of any region, atmospheric pressure is very important. Its direct impact is not felt on human life but a slight difference in the pressure changes the velocity and direction of winds. It directly affects the distribution of temperature and humidity. Thus the atmospheric pressure indirectly controls the life of living organisms. It is necessary to know about atmospheric pressure to understand the cyclones and other phenomena associated with atmosphere.

Recording of Pressure

Atmospheric pressure is recorded in centimetres or inches or millibars. However the unit millibar is more used to show atmospheric pressure for recording at the weather stations and in weather maps. The atmospheric pressure at mean sea level is either 76 cm or 30 inches or 1013 millibars. (This is mentioned as mb in the maps.)

[1 cm = 13.32 millibars, and 1 millibar = 0.295299 inches]

Atmospheric pressure can be recorded by instruments such as Barometer, Anaroid Barometer and Barograph. It can be recorded more precisely by Fortins Barometer which uses mercury.

Factors affecting Atmospheric Pressure

Atmospheric pressure is perceived differently at different places on the earth. Altitude, temperature, humidity etc. are major factors responsible for the distribution of atmospheric pressure.

(1) Altitude : Air is prevalent upto many kilometres in the atmosphere from the surface of the earth. Due to gravitation force of the earth, every upper layers exerts pressure on the lower layer. So, the air at the lower strata remains compressed and dense while it is thin in the upper layers.

Higher the place the air will be thinner. The thin air is lighter and exerts less pressure. The air pressure decreases @ 1 cm or 13.32 mb for every 165 metres. Everest in Himalayas is 8848 metres high. The air there is very thin so the pressure there decreases by about 54 cm or 320 mb.

Air Pressure at different altitude according to Chrichfield

Altitude (metres)	Air Pressure (in Millibars)
Sea Level	1013
1000	899
3000	710
5000	540
10000	265

(2) Temperature : Air expands due to heat and occupies more space. So the pressure decreases. Air contracts due to cold and occupies less space. Such air becomes heavy so the air pressure becomes high.

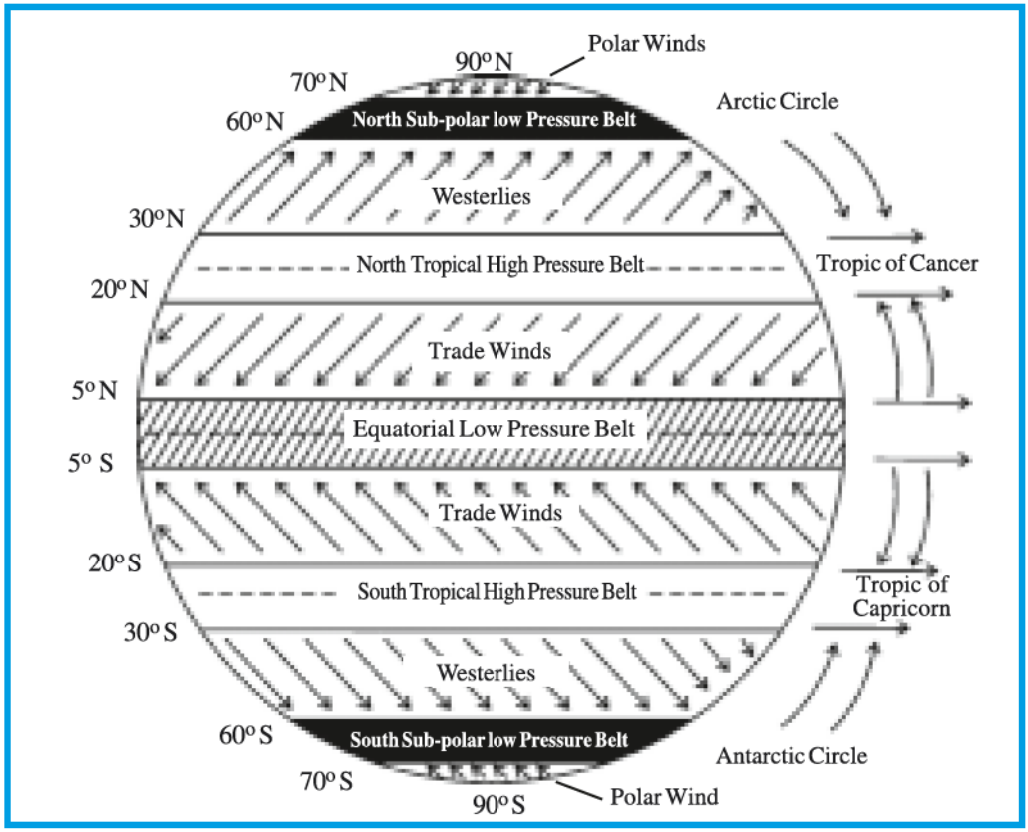
Due to the difference in temperature , the day time pressure is less while the pressure is more during night time. The pressure is less over landmass during summer and is high during winter. Similarly, the temperature in equatorial region is high so the pressure is low, while the polar regions feel more pressure due to very low temperature. Thus, the atmospheric pressure depends on the temperature of respective places.

(3) Humidity : Water vapour is lighter than the air. So, if the humidity increases lower will be the air pressure. When the humidity in the air decreases its pressure increases.

During rainy season, there is more humidity in the air so the pressure is low. The air over the oceans contains more humidity. As a result the air pressure remains low over oceans compared to landmass. The air over equatorial region is more humid so the low air pressure develops over there.

Pressure Belts

Due to the factors bringing changes in the atmospheric pressure, different regions on the earth experience low or high air pressure. Such pressure which is restricted over certain area on the earths surface is called **Pressure Cells**. Low and high pressure formed over the earths surface are pressure cells in their initial stage, expand eastwards or westwards under favourable situation and then become Pressure Belts. Thus the pressure belts are pressure cells arranged in the same latitudinal boundary and having identical pressure. If the east-west latitudinal zone has high pressure area, it is called High Pressure Belt. Similarly, in the east-west latitudinal zone, the low pressure area is called Low Pressure Belt. These belts are clearly shown in figure 10.1 below.



10.1 Pressure Belts and Permanent Winds

There are a total of seven pressure belts on the earths surface. These are as follows :

Sr. No.	Pressure Belt	Amount of Pressure	Hemisphere	Latitudes
1.	North polar High Pressure Belt	High	North	80° N. to 90° N.
2.	North sub polar Low Pressure Belt	Low	North	60° N. to 70° N.
3.	North Tropical High Pressure Belt	High	North	20° N. to 30° N.
4.	Equatorial Low Pressure Belt	Low		5° N. to 5° S.
5.	South Tropical High Pressure Belt	High	South	20° S. to 30° S.
6.	South Sub-polar Low Pressure Belt	Low	South	60° S. to 70° S.
7.	South polar High Pressure Belt	High	South	80° S. to 90° S.

Equatorial Low pressure Belt :

The sun rays fall almost vertical between 5^0 North latitude to 5^0 south latitude around equator. The region gets more insolation throughout the year, so the air remains warm consistently. The warm air expands and becomes light so the low air pressure develops here. There is more moisture in the air so it reduces the pressure. As a result, a low pressure is created in the east-west belt in the region of hot and humid climate around equator. This belt is called **Equatorial Low Pressure Belt**. With changing seasons, this belt shifts up to 10^0 latitudes in respective hemisphere. There is hardly any wind in this region, so this region is also called **Doldrums**.

Tropical High Pressure Belt : A Tropical High Pressure belt is developed between 20^0 to 30^0 latitudes in both hemispheres. The thin and light air of Equatorial Low Pressure belt rises high, reaches an altitude of about 3 to 7 km, bifurcates due to coriolis force and flows in the horizon direction towards North Pole and South Pole. Some volume of this air descends down towards the surface between 20^0 to 30^0 latitudes. It accumulates there and a high pressure zone is developed. These belts are known as **North Tropical High Pressure Belt** in northern hemisphere and **South Tropical High Pressure Belt** in southern hemisphere.

Sub-Polar Low Pressure Belt : Polar Low Pressure Belt develops between 60^0 to 70^0 latitudes in both hemispheres. The Coriolis Force is responsible for this development. Air in the form of Polar winds from Polar High Pressure Belt and as Westerlies from South Polar belt have different characteristics. It rises high near the polar latitudes in the form of a cyclone. Due to a large scale circulation of air, which rises high in a cyclonic pattern, low pressure pockets spreading east-west develop near polar latitudes. In northern hemisphere it is called **North Sub- Polar Low Pressure Belt** in northern hemisphere and **South Sub - Polar Low Pressure Belt** in southern hemisphere.

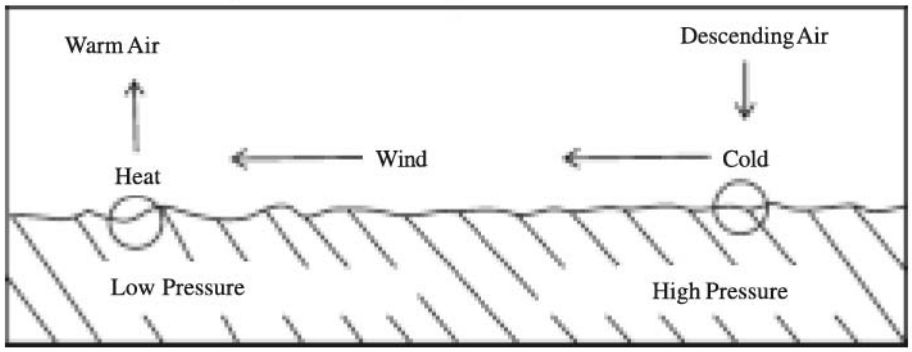
Polar High Pressure belts : Sunrays are slant over both the poles so the temperature there is very low. There is no evaporation here and so the air does not have any moisture. Most of this region is snow clad throughout the year. Due to these reasons a high pressure belt develops over polar regions. These are known as **North Polar High Pressure Belt** in northern hemisphere and South Polar High Pressure Belt in southern hemisphere.

Winds

The air sphere around the earth is very unstable. It constantly circulates horizontally as well as vertically. **A Wind** is the air which moves in horizontal direction while the air rising in vertical direction

is called **Air Currents**. Winds and air currents decide the atmospheric circulation. Winds blowing from hot deserts circulate the heat and winds blowing from over the humid oceanic regions circulate humidity.

The direction of the wind and its velocity depend on the pressure gradient. A pressure Gradient is the difference between the pressure of two places.



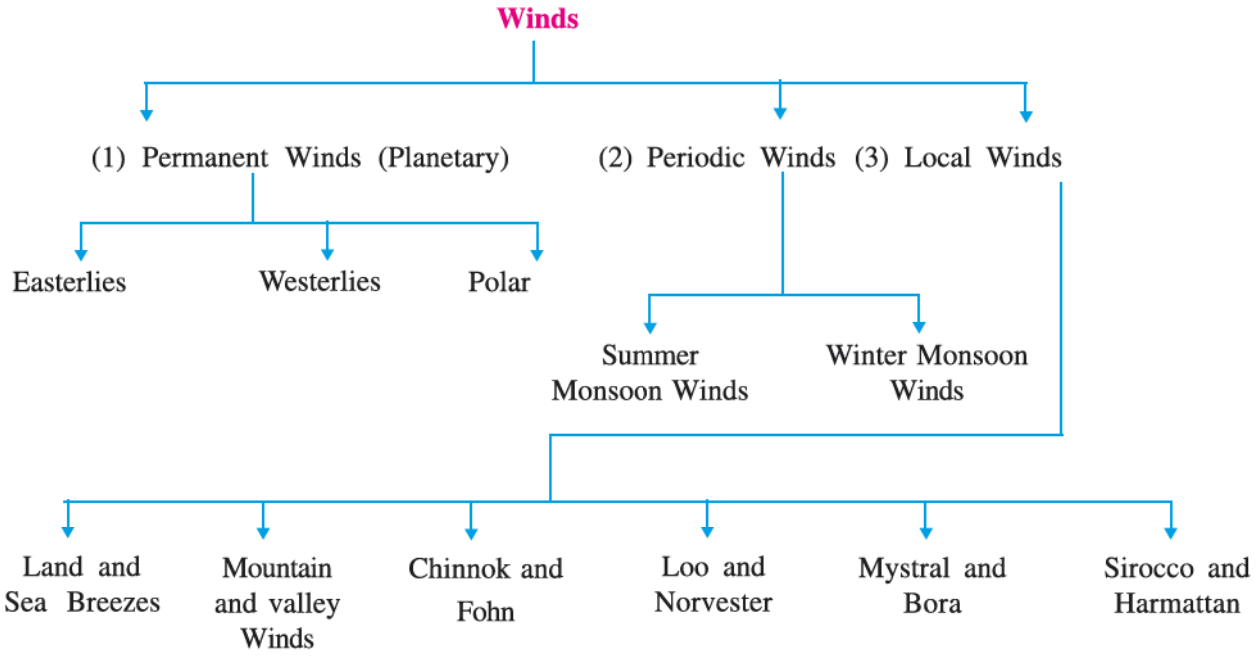
10.2 Origin of Winds

Winds always move from high pressure to low pressure area to supplement the low pressure. If the gradient is less then the wind will blow with lesser velocity, and if the gradient is more it will blow faster. It originates cyclones such as hurricane, typhoon, norvesters etc.

American scientist Ferrell (1856) studied the effects of coriolis force on the winds and air currents. According to Ferrells Law, Winds are deflected to their right in Northern Hemisphere and to their left in Southern Hemisphere. (Fig. 10.1)

Wind Wane and Anemometer are used to record the direction and velocity of wind respectively. Wind velocity is measured in kilometres, mile or in knots per hour.

Types of Wind :



(1) Permanent (Planetary) Winds : As these winds blow from the same direction throughout the year, these are called Permanent winds. These winds, blowing from high pressure area to low pressure area cover a large part on the surface of the earth. That is why these are also known as Planetary Winds. There are three sub types of these winds.

Easterlies : In both hemispheres, these winds blow from Tropical High Pressure belt towards the Equatorial Low Pressure Belt in the Torrid zone (i.e. from Tropic of Cancer` Capricorn to Equator). Easterlies blow in the same direction continuously with the same velocity. These winds deflect towards east due to coriolis force, so these are called Easterlies. As these winds blow in a stable velocity, they were used for trade by sea routes, so these are also called as **'Trade Winds'**.

As per **Ferrell's** Law, these winds deflect to their right in northern hemisphere. These are seen coming from north-east direction and hence are also called **'North-East Trade Winds'**. In southern hemisphere, these winds blow from south-east direction and are called **'South-east Trade Winds'**. As these winds come from warm region, their capacity to retain moisture increases but capacity to shower rain decreases.

Westerlies :

These winds blow towards temperate zone from Tropical High Pressure belt to Sub-Polar Low Pressure belt. These winds deflect and come from western direction, so these are known as Westerlies. These winds blow from south-west to north-east in northern hemisphere, and from north-west to south-east in southern hemisphere. These are also called South-West Westerlies in northern hemisphere and are called North-West Westerlies in southern hemisphere.

The direction of Westerlies is opposite to the direction of Trade Winds, so these are also called **Anti-Trade Winds**. As these winds blow from hot regions towards cold region, they become cooler, and give rain on the western part of Europe, Canada, Chili etc. which are situated on the western side of the continents.

Like to know :

Southern hemisphere is a Water Hemisphere. There is no obstruction of any landmass between 40^0 S to 80^0 S latitudes so these winds blow at very fast velocity making blast sound. Due to the high intensity sound made by these winds, the sailors call these Westerlies as Roaring Forties on 40^0 south latitudes, Furious Fifties on 50^0 south latitudes and Screeching Sixties on southern 60^0 latitudes.

Polar Winds : These winds blow from Polar High Pressure Belt towards Sub-Polar Low Pressure Belt in both hemispheres. These winds blowing from poles are known as Polar Winds. These winds blow from north-east to south-west in northern hemisphere and from south-east to north-west in southern hemisphere.

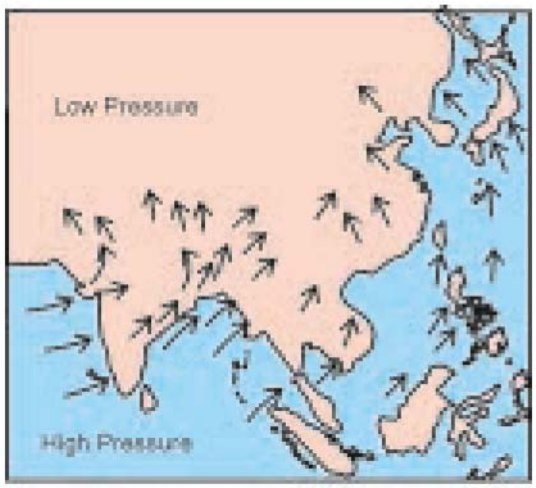
These winds are extremely cold as they happen to come from polar regions. A cold wave grips the area wherever they blow. These cold waves do not have the capacity to hold moisture, so they hardly give any rain.

When there is a confluence of cold winds from poles with the warm winds from temperate zone, it develops cyclonic and anti cyclonic conditions.

(2) Seasonal Winds : At some places on the earth season changes according to the prevailing winds. These winds which change their direction according to the season are called Seasonal Winds, and are also called Monsoon Winds. India, Pakistan, Bangladesh, Myanmar, Sri Lanka, China, Korea, Japan, Taiwan etc. experience seasonal winds. Besides, Australia, Madagascar, Nigeria, Ghana and southern U.S. also feel slight effects of seasonal winds. These Monsoon winds can be divided into two parts :

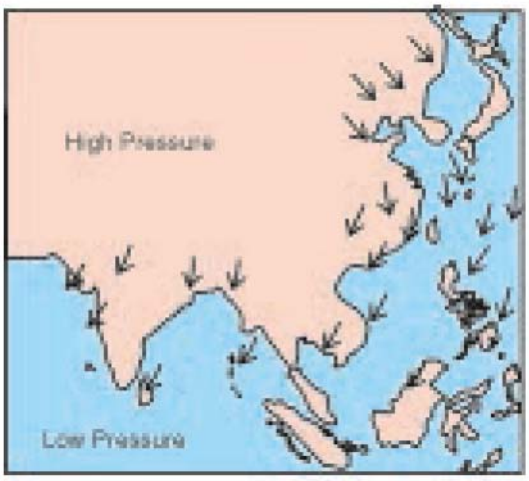
(1) Summer Monsoon winds (2) Winter Monsoon Winds

(1) Summer Monsoon Winds (South-West Monsoon Winds) : In summer, a low pressure develops over the north-western landmass due to high temperature. Over the water mass of Arabian Sea and Bay of Bengal, low temperature results in the development of high pressure. Under these circumstances, the Easterlies Trade Winds from the south of equator serge ahead towards north to maintain the pressure equilibrium. After crossing equator these winds change their direction and become South-West monsoon winds. These are known as Summer Monsoon Winds.



10.3 Summer Monsoon Winds

As these winds happen to blow over a vast water mass they contain abundant moisture and so give heavy rains near coastal area. Heavy rainfall occurs on the windward side of the mountains which obstruct these winds, e.g. due to Western Ghats, Malabars on the western coast gets more than 200 cm rainfall.



10.4 Winter Monsoon Winds

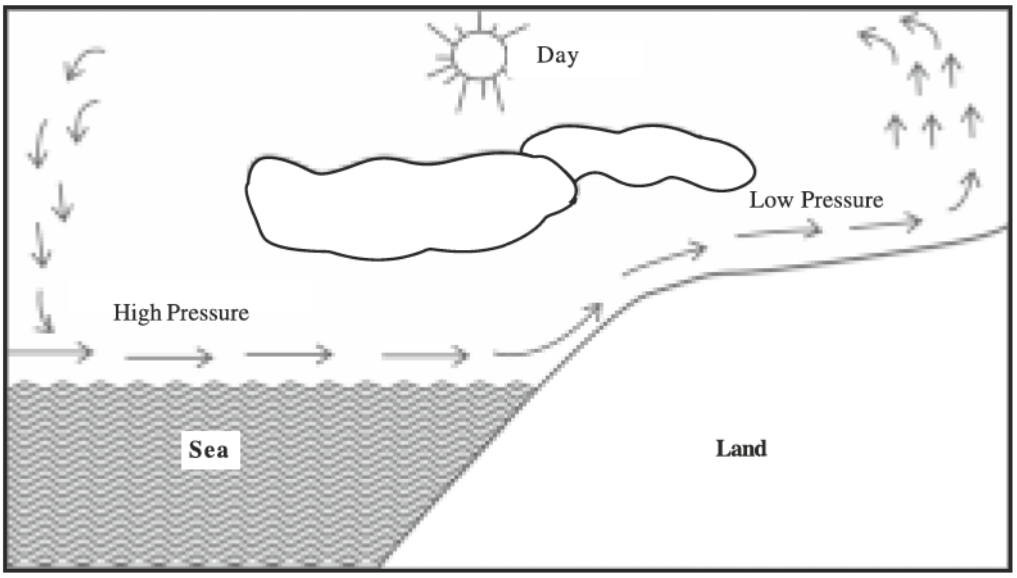
(2) Winter Monsoon Winds (North-East Monsoon Winds) : Some Asiatic landmass cools faster in Winter. So high pressure pockets develop here. At this time the nearer water mass is a little warmer, so low pressure pockets develop there. As a result, winds blow from landmass towards oceans. These winds blow over South and South-Asian countries from north-east direction, so these are called North-East Monsoon Winds.

As these winds blow over from landmass, they contain less moisture and do not give much rain. When some of their branches pass over the ocean, they hold moisture. In December January, the North-East Monsoon winds shower most of the annual rains over Coromandel coast on the eastern sea coast of India and to northern parts of Sri Lanka.

Rains caused by these monsoonal winds is irregular and uncertain. The rainy season starts earlier sometimes and ends also earlier. It starts late sometimes but ends earlier. Sometimes these monsoon winds cause very heavy rains or occasionally cause droughts. That is why the farmers of this region believe in fate. In India, monsoon winds are responsible for uncertainty of rainfall.

(3) Local Winds : Often winds blow over a limited area. These winds originate due to special characteristics or some factors of the area. Unequal relief features, nearness to water and land area, unequal heating and cooling of water etc. give rise to local winds. These winds affect very limited local area only. Details of the local winds is as follows :

(a) Sea breezes :

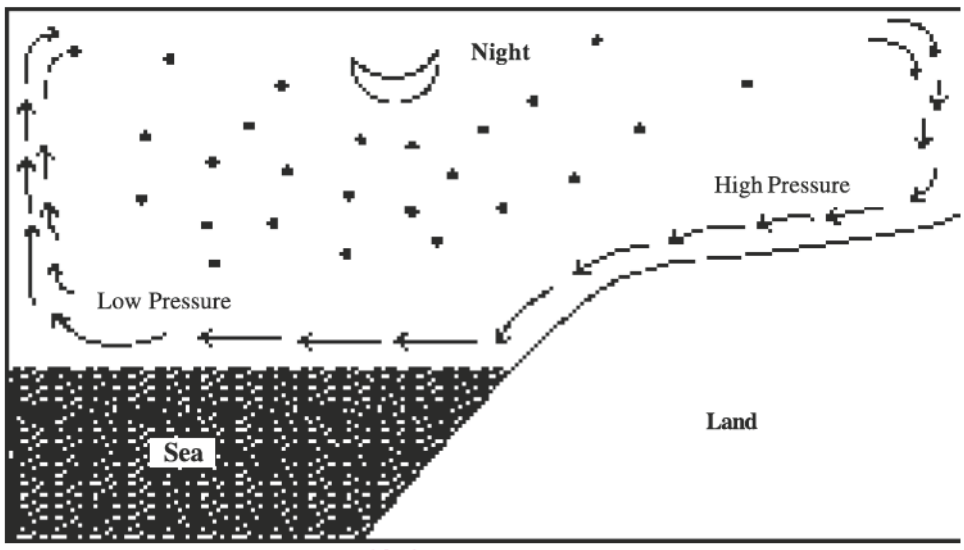


10.5 Sea Breezes

Land area heats up faster than sea during day time, so a low pressure develops over land and a high pressure over the sea, and so winds blow from sea to land during day. There are called Sea Breezes.

Due to sea breezes, temperature of coastal land area lowers down by 5^0 to 7^0 C. Coastal areas feel less heat during summer than the continental area. This region experiences temperate climate.

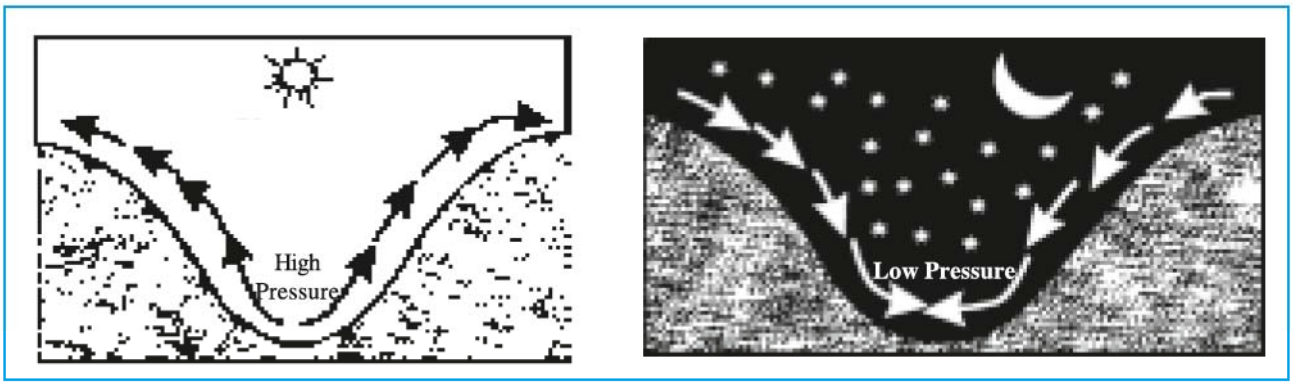
Land breezes :



10.6 Land Breezes

During night land cools down faster so a high pressure develops over land. Compared to land, the sea is comparatively warmer and so low pressure develops over seas. As a result, winds blow from land to sea during night. These are called **Land Breezes**. Due to these land breezes, temperature in coastal does not fall very much during winter.

(b) Mountain and Valley Breezes : These winds originate due to unequal temperature and pressure

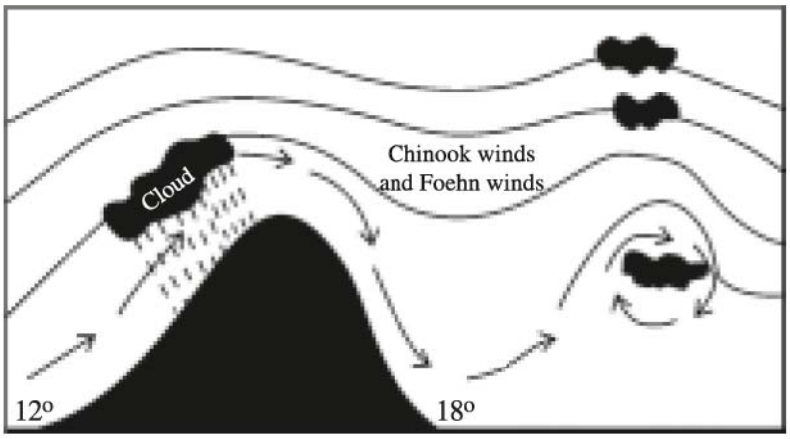


10.7 Valley and Mountain Breezes

between a mountain and a valley. During the day, mountain slopes become warmer faster than the valley. So the warmer air on the slopes becomes lighter and rises high. To fill up this blank the air in the valley rushes towards the higher slopes. Thus winds blow from valley to mountain slopes during day which are known as Valley Breezes.

Contrary to this, the peaks and mountain slopes cool faster during night while the valley area is relatively warmer. So winds blow from mountain slopes to the valley area during night, which are called **Mountain Breezes**.

(c) Chinook and Foehn :



10.8 Chinook Winds

In North America, warm and dry winds coming over from Pacific Ocean descend down on the eastern slopes of Rocky mountains in cold season and raise the temperature in Prairie Plains by 15^0 to 25^0 C within two hours. The snow in the Prairie melts due to this warm winds. This enables the farmers and shepherds living in the eastern side of Rocky to procure some agricultural land and grass for animals. People feel comfort against the cold. Due to this characteristics, the Red Indians call them Chinook, which means snow-eater winds.

Foehn winds are also dry, warm and stormy winds like Chinook which blow towards the European (Switzerland) plains after crossing the Alps from south. These are known as Foehn there. While descending from the mountain slopes these winds become warmer due to the friction and melt the snow. This helps to carry out animal husbandry here. These warm winds help the plantation of citrus fruits like grapes, sweet lime (mosambi) etc.

Like to know :

The increase in temperature by 22^0 C within 24 hours for Chinook is a common thing. Temperature increased by 19^0 C within 7 minutes at Kipp in Montana State of U.S. Similarly, temperature increases by 21.3^0 C within 4 minutes at Pincher Creek in Alberta State on 6th January, 1966

(d) Loo and Norwester :

In the SindhuGanga plain of India and Pakistan, the warmer and dry winds coming from western direction in the afternoon in May and June are called Loo, which raise the temperature up to 50 ^{0} C. in North India. This loo often causes deaths of people and animals. In May, 2015 more than 1000 people died of loo in Andhra Pradesh, Telengana and Odisha States.

With the onset of monsoon, dry and warm winds with sand storms rush down over West Bengal from north-west. These winds are known as Norwester. These winds blow during the Vaishakh month and cause devastation, so these are also called Kal-Baisakhi.

(e) Mistral and Bora : Cold and dry winds descending from snow covered mountains are known as **Mistral** on the Mediterranean coast and as **Bora** on the Adriatic coast of croatia. As these winds are cold and dry, they damage the crops.

(f) Sirocco and Harmattan : Warm and dry winds blowing over from Sahara desert are known as **Sirocco** in Italy, Sicily and Spain along the Mediterranean coast. People in Guinea fall sick due to hot and dry winds, and then the **Harmattan** winds bring some solace to them. That is why the local people know these winds as **Harmattan** i.e. Doctor Wind.

Air Mass

An Air Mass is a part of the larger atmosphere where there is a horizontal homogeneity in the temperature and humidity. A large mass of the air showing equality in temperature and humidity is called Air Mass. The temperature and humidity are almost uniform in horizontal direction at various altitude. When the air remains stationary over a level land for a considerable time, it receives its heat, cold and humidity, then it becomes an Air Mass. Those regions where such air masses are formed on the earths surface, are the source regions of air masses.

Characteristics of Air Masses :

- One air mass can be wide spread upto hundreds of kilometres.
- Sometimes, it is as large as one continent.
- From altitude point of view, it can exist up to Troposphere.
- An air mass travels towards another region in the direction of pressure gradient.

The glacial plains of Canada, cold Siberia during winter, vast oceans in torrid zone, hot Sahara desert during summer etc. are source regions of air masses. These air masses are formed due to extreme heat or cold over these source regions. These are divided into two parts :

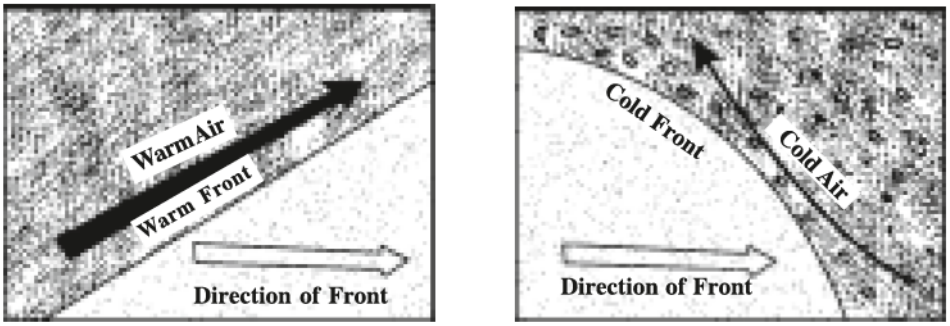
(1) Tropical Air Masses (2) Polar Air Masses

Fronts

The confluence zone between two air masses is called **'Fronts'.**

When two different air masses having different characteristics of temperature, humidity and other characteristics come closer, they do not merge within each other, but they create a separate surface where they meet. This surface is called Fronts.

A front is about 5 to 80 km wider area. The air of the warmer air mass from the slopes of the fronts is pushed in the upper atmosphere over the cold air mass. Condensation of the humidity takes place in this rising air, forms clouds and gives rains. Air pressure decreases near the front so the area becomes stormy. The cyclones on the earth are formed in the frontal zones. This way front is important in determining the weather and climate of any region.



10.9 Types of Fronts

There are two types of fronts :

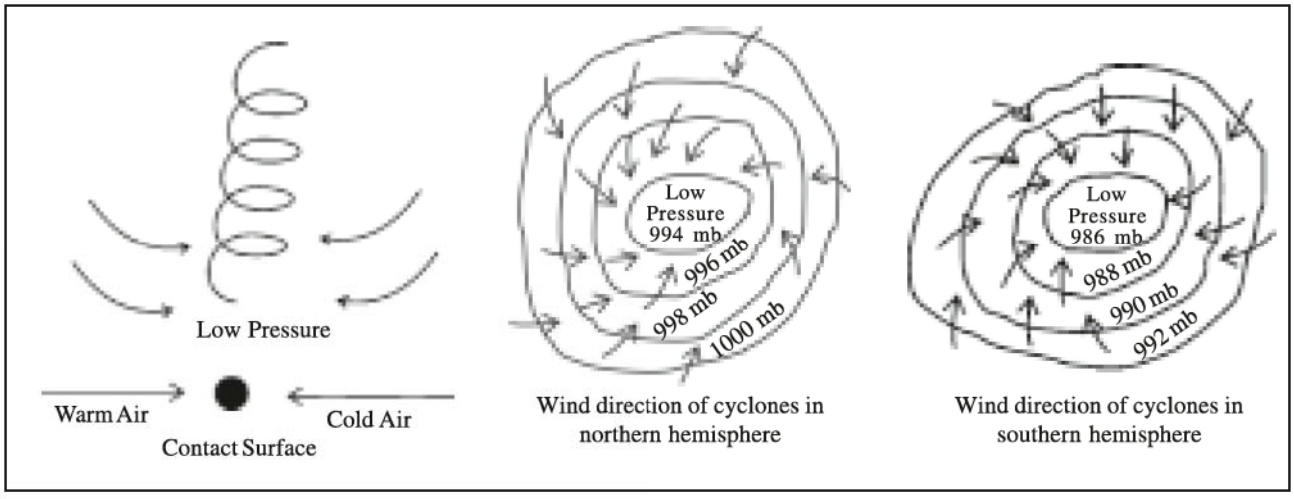
(1) Warm Front (2) Cold Front

Warm front has a gentle slope while the slope of cold front is curved. (see fig. 10.9).

In Europe and U.S., weather changes frequently due to cyclones. Front are shown along with the isobars in the weather maps there.

Variable Winds : Cyclones and anti cyclones are the result of atmospheric disturbances. Generally, cyclones are devastating and have more velocity.

Cyclones : When two air currents having different temperature are confronted, they collide instead



10.10 Wind Directions in Cyclones

of merging with each other. The air pressure near their meeting surface reduces suddenly and so the cyclone starts.

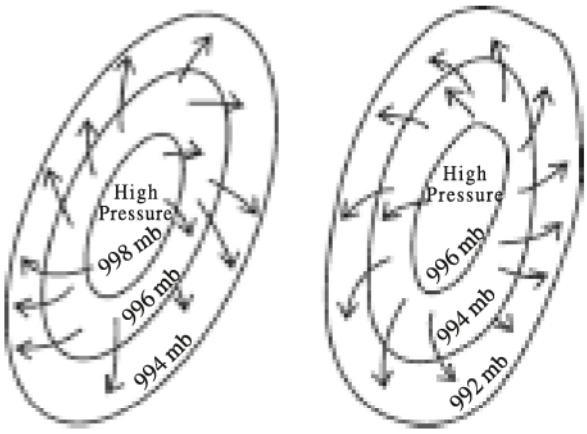
Low pressure prevails at the centre of the cyclone and it increases outwards. Due to coriolis force, winds rush towards the central low pressure and rises high in a circular motion above the surface. Winds move in anti clockwise direction in northern hemisphere and clockwise in southern hemisphere.

Cyclones bring large scale changes in weather of Europe and North America. It causes heavy damage to lives and property. Most devastating cyclones in the world blow over Antarctica continent. Some times, such stormy cyclones blowing over from sea contain much humidity, bring rains and cause heavy damage near sea coasts. In 1999, a cyclone over Kachchh (Gujarat) caused very heavy devastation. On 29th October, 1999, the cyclone which hit the Odisha coast was the most devastating. Its velocity was 260 km per hour. Cyclones are known by different names in different countries. These are known as Hurricane in West Indies and in Gulf of Mexico, as Typhoons in Japan and Philippines, as Tornado in U.S. and as Willie Willi in Australia.

Anticyclones : In Anticyclones, a high pressure prevails at the centre and the surrounding area in under low pressure. Winds blowing away from the centre spread out. These winds have less velocity, so they do not cause any damage.

In anticyclones, wind move in clockwise direction in northern hemisphere and move anticlockwise in southern hemisphere. Winds descend down in anticyclones thereby increasing the temperature so do not bring rain. If the anticyclone passes over any sea, it may give some rain.

In recent times RADAR and artificial satellites help to predict the arrival of cyclones-anticyclones. People can be alerted by informing them through TV, Radio and Newspapers and precautions can be taken in advance.



Northern Hemisphere Southern Hemisphere

10.11 Wind Directions in Anticyclones

EXERCISE

1. Answer the following questions in details :

(1) What is meant by wind ? State the types of wind and give information about Monsoon winds.

(2) Explain illustratively the Sea and Land Breezes.

(3) Draw a figure showing pressure belts and describe Equatorial Low Pressure Belt.

(4) Factors affecting the atmospheric pressure Explain in details.

2. Write short notes :

(1) Cyclone (2) Loo and Norwester

3. Give geographical reasons :

(1) Coromandel coast in Tamil Nadu gets rain in winter.

(2) Malabar coast gets heavy rain.

(3) Low pressure prevails over equatorial region.

4. Answer in one or two sentences :

(1) What is meant by atmospheric pressure ?

(2) State the instruments to record atmospheric pressure.

(3) Describe the Ferrells Law.

(4) In which countries are the effects of monsoon winds felt ?

(5) Which winds are known as Kal-Baisakhi ?

(6) In which two parts can the air mass be divided into ?

5. Select a correct option from the following options and write the answer :

(1) What is the average atmospheric pressure at mean sea level ?

(a) 1023 mb (b) 1013 mb (c) 1003 mb (d) 1031 mb

(2) While going above the sea level, for how many metres does the pressure decrease by 1 cm ?

(a) 265 (b) 365 (c) 165 (d) 465

(3) By which name is a cyclone known in U.S. ?

(a) Hurricane (b) Typhoon (c) Willie-Willie (d) Tornado

(4) What is the pressure at the centre of a cyclone ?

(a) Low (b) Heavy (c) Medium (d) Negligible

(5) Which winds are snow-eaters ?

(a) Loo (b) Chinook (c) Harmattan (d) Norwester

(6) Which pressure belt is also known as Doldrum ?

(a) Equatorial Low Pressure Belt (b) Tropical High Pressure Belt

(c) Polar High Pressure Belt (d) Sub Topical Low Pressure Bel **t**