Lesson - 13

Air Pressure Belts and Winds

The atmosphere that extends thousands of kilometers above the earth's surface, exerts enormous pressure on it. This pressure is maximum near the earth surface. It is reduced, as we move higher in the atmosphere. Pressure and wind, are those major elements of climate that affect the other factors to a great extent.

The atmosphere which envelopes the Earth from all the sides, is composed of many gases. This gaseous cover exerts enormous pressure on the earth surface which is called air pressure. In short the meaning of the air pressure is the weight of column of air at any given place and time. The air pressure was first discovered by Guericke in 1651. The air pressure is not uniform at all the places and at all the times but it is controlled by solar radiation. The air expands at higher temperature due to which its density reduces, this results in decrease in Pressure.

The air is much denser near the earth surfacethan the upper atmosphere due to the impact of gravitational force. Air becomes relatively thinner at higher altitudes. Therefore, on the mountains and plateaus, man has to breathe more often to get the required amount of oxygen. This is the reason why it is necessary for the mountaineers to carry oxygen cylinders along with them.

The vertical distribution of pressure is comparatively more important than its horizontal distribution. The weather department studies pressure as one of the controlling factors of climate or weather.

The slightest change in pressure conditions affect weather. The other elements of weather like clouds, rainfall, thunder , dust storms are actually controlled by pressure. The air pressure plays an important role in weather forecast. The most popular unit to measure pressure is millibar (mb). One Milli bar means Force of 1 gram of weight exerted on 1 square centimeter. The other factors that affect air pressure are temperature , water vapour, height above sea level.

Air pressure and Winds

There is a deep relationship between air pressure and the prevailing winds. The difference in pressure conditions is the main cause of origin of winds. The difference of pressure also affects the rainfall and temperature. The winds transfer the heat between the lower and higher latitudes which helps to maintain the latitudinal heat balance. The winds create the possibility of rainfall as they transfer the humidity from the oceans towards the continents.

Air Pressure Belts

The main basis for determining these pressure belts, is the temperature . As these pressure belts are determined it is also assumed that the earth is having a uniform surface (land or sea). Therefore these pressure belts are very generalized. Due to the variation of the factors of air pressure on earth, it is obvious to have an uneven distribution of air pressure. The air pressure is represented in 7 pressure belts.The following air pressure belts are

found in each hemisphere on the surface of the earth. (Fig. 13.3)

1. Equatorial Low Pressure Belt(Doldrums)
2. Subtropical High Pressure Belt
3. Subpolar Low Pressure Belt
4. Polar High Pressure Belt

1. Equatorial Low Pressure Belt

This belt extends upto 5° north and 5° South latitudes of equator. High temperatures and low pressure are observed in this belt, as the sun shines vertically over the equator for the whole year. This region is also characterized by high humidity and lower density of air. The rotation of the Earth is maximum at the equator and this results in the maximum development of centrifugal force.

The surface winds are absent in this belt whereas high temperature causes expansion in wind and it rises up, this gives birth to conventional currents. This is the reason that this belt is also called ' Doldrums' or equatorial calm belt.

2. Subtropical High Pressure Belt

This belt extends 30° to 35° north and South of the equator. Mostly this belt is characterized by high temperature, high pressure and clear sky.

The most important feature of this belt is that all the tropical deserts are found on the Western margins of the continents. Due to absence of friction in the upper layers of the atmosphere , these winds turns towards right and left in the northern and Southern hemispheres respectively. These belts of higher pressure are also called horse latitudes.

3. Subpolar Low Pressure Belts.

The subpolar low pressure belts extends between 60° to 65° north and South latitudes. The temperature is lower in these latitudes but instead of high pressure, lower pressure exists. This low pressure is observed due to rotation of the earth. Flowing of warm ocean currents also cause increase in temperature resulting the low pressure in the region.

4. Polar High Pressure Belts

As the temperature is lower at the polar regions , higher pressure always prevails near the poles. Both the belts located in both hemisphere are thermal generated. Due to lower temperatures, the surface of the poles and nearby regions remain always covered with snow. Therefore the air near the surface is cooler and more denser. This is the main reason of non availability of, the data related to the surface pressure of this region, in abundance.

Distribution of Air Pressure

The air pressure is depicted through isobars on the maps. Similar to temperature, two months(January and July) are selected for air pressure recording.

Pressure distribution in January

Figure 13.1 presents the pressure conditions of January. At this time the sun shines vertically over Tropic of Capricorn in southern hemisphere. Due to this the temperature is higher and the density of air is lower. The areas of Low pressure are found in South America, South Africa and interior parts of Australia. The well developed subtropical high pressure areas are found in the continents of Northern hemisphere.

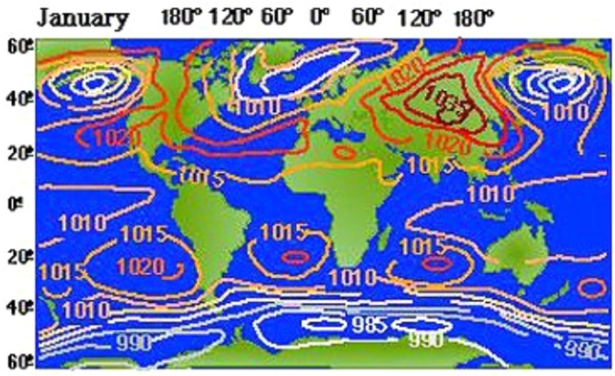

Fig. 13.1 : Air Pressure in January

Pressure conditions in July

The sun shines vertically over Tropic of Cancer in the month of July in northern hemisphere. This shift is observed maximum in Asia . The land masses of the northern hemisphere gets extremely hot and resulting in the development of low pressure areas and high pressure belt is developed in southern hemisphere.(Fig 13.2)

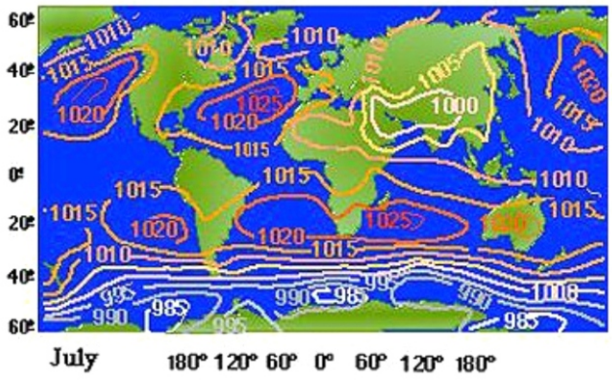

Fig. 13.2 : Air Pressure in July

Seasonal Changes of the Air pressure belts

The distribution pattern of the pressure belts does not remain the same as described above. Daily and annual changes occur in pressure, due to many factors like winter and summer solstice, effect of land and sea etc. During summer when the sun shines vertically in northern hemisphere, these pressure belts shift 5° north from their mean position and when the sun shines vertically in the Southern hemisphere, these pressure belts shift 5° towards the south from their mean position. The most ideal position of these pressure belts, is on 21st March and 23rd September when the sun shines vertically over the equator. During the shifting of the air pressure belts , the equatorial low pressure belt , instead of being located at 5° latitude, it shifts between 0° -10° latitude in northern and southern hemisphere depending upon the season. Similarly subtropical high pressure belt shifts from 30°-35° degree latitude to mid of 30° to 40° degree latitude, Whereas the Sub Polar Belts instead of being located on at 60° to 65° latitude shifts to mid of 60° to 70 ° latitudes. Due to the continental expansion in polar regions, especially in the Northern Polar region, it has a greater effect as the pressure belt becomes very narrow in summer. As the expansion of landmass is lesser in comparison to oceanic expansion in Southern polar regions, There is no specific difference in the shifting of air pressure belts.(Fig. 13.3)

Vertical distribution of atmospheric pressure

Pascal in 1643 proposed for the first time that there is a decrease of pressure with the increase

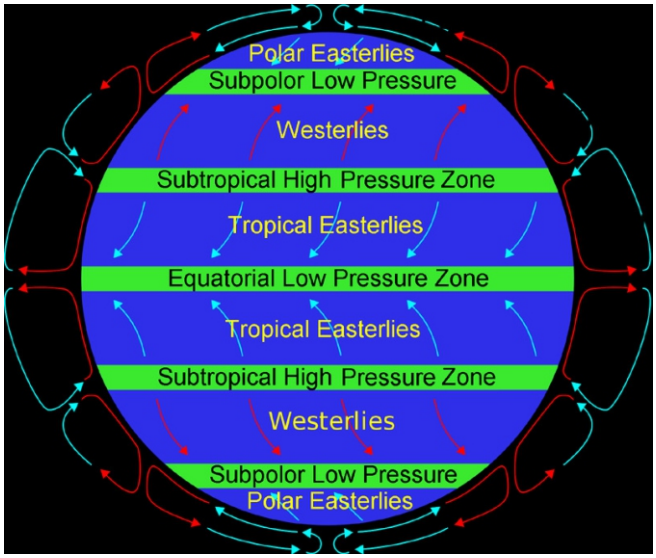

Fig. 13.3 : Air Pressure and Winds' Belts

in height in atmosphere.

The density of the lower layers of atmosphere is comparatively more as the upper layers exert more pressure. This results in high density and high pressure of the lower layers of atmosphere. Due to this, the air pressure always decreases with the increase in the height in atmosphere but this rate of decrease is not always uniform.

This depends on density, temperature and amount of water vapour and gravitational force of the earth. As these factors are constantly changing their is no direct proportional relationship between height and air pressure. But still the rate of decrease of air pressure in Troposphere is mostly 34 mb for every 300m of height. The gases becomes very thin and light in higher altitude. This results in decrease in air pressure. This is the main reason that mountaineers carry oxygen cylinders and special suits along with them while climbing higher peaks of mountains.

Winds

The horizontally moving air is called Wind. The winds always blow from high pressure areas to low pressure areas.It is the effort of nature to balance the variations of air pressure. If the earth would have been fixed and surface would have been plain , the winds would have blown straight and ,

perpendicular to the isobars, from high pressure to low pressure areas. But in reality this does not happen, because many factors affect the direction and speed of the wind. These factors are as follows-

1. Pressure Gradient

The difference of air pressure between any two places is called pressure gradient. This pressure gradient is in horizontal direction. Pressure Gradient is also called Barometric Slope. When the pressure gradient between the two places is high, the speed of the winds will also be higher contrary to this when the pressure gradient is low the speed of the wind will also be lower.

2. Rotation of the Earth

The winds are deflected because of the rotation of the earth. This is called Coriolis Force and the effect of this force is called Coriolis effect. Due to this force, the winds deflect towards right in northern hemisphere and towards left hand side in the southern hemisphere. This effect was proved by scientist named 'Ferrel' and it is also called Ferrel's law.

3. Landforms.

The irregularities of the Earth's surface serve as a obstruction in the path of wind, which in term affect the direction and speed of the winds. when the surface is plain it does not cause more friction and the winds blows in higher speed. On the other hand the irregularities of Earth's surface causes friction and obstruction that reduces the speed of the wind. This is the main reason that, the Westerlies follow a fixed direction and blows in high speed in southern hemisphere, as it has extensive oceans. Whereas in Northern hemisphere, the speed of the westerlies is comparatively slow as this hemisphere has more of land mass.

Nomenclature of Winds

The winds are named after the direction in which they blow. The winds which are blowing from the Western direction are called Westerly and the winds blowing from Eastern direction are called Easterly. (Fig 13.3)

Classification of Winds

Winds are classified under three categories on the basis of their area of influence and duration.

(i) Permanent winds
(ii) Periodical winds
(iii) Local winds

i)Permanent winds

The winds that blow through out the year in a particular direction and in a constant course are called permanent winds. These winds are popularly known with other names like also planetary winds , prevailing winds or invariable winds. These winds are related to air pressure belts. The major ones are Trade Winds, Westerlies and Polar Winds.

Trade Winds

The winds blowing in both the hemispheres, from subtropical high pressure areas towards the equatorial low pressure areas are called trade winds. Instead of blowing in the straight direction these winds follow the ferrel's law and deflect towards right in the Northern hemisphere and towards the left in the southern hemisphere. Thus according to the direction these winds are called 'North East Trade Winds' in the northern hemisphere and 'South East Trade Winds' in the southern hemisphere.These winds helped in sailing of the ships in the ancient period, hence are called trade winds.

These winds have different characterstics in different regions.The winds are dry and calm , due to descending of the winds near subtropical high pressure. As these winds proceeds further in their direction, they pick up moisture as they blow over the water bodies. These winds become almost saturated as they reach the equator, being unstable , they causes rainfall. The trade winds of both the hemispheres, clashe together near the equator ,and on the line of convergence by rising in the form of conventional current these winds cause heavy rainfall.

Westerlies

The winds that blow in both the hemispheres, from subtropical high pressure belt

towards subpolar low pressure belts are called Westerlies. The direction of these winds in the Northern hemisphere is from south -west to north-east in the Northern hemisphere. The wind system of westerlies distirbed in the Northern hemisphere due to dominance of land mass, and seasonal changes. These winds are more regular and constant in the southern hemisphere due to the large extension of oceans. The velocity of the winds in the southern hemisphere remains high. These winds are called 'Roaring Forties' between 40° to 50° latitude , called 'Furious Fifties near 50 °south latitude, 'Shrieking or Screaming Sixties' near 60° south latitude because of its intensity.

The margins of these winds become unstable near the poles and these winds cause disturbance in the weather conditions.

Polar winds

The winds blowing from the polar high pressure belt towards the subpolar low pressure belts in both the hemispheres are called polar winds. These winds blow from North East to south west direction in the Northern hemisphere and from South East to North West direction in the southern hemisphere. As these winds blow from the polar regions, they are very cold and dry. These winds have lesser capacity to hold moisture as their temperature is low. The polar winds are called Nor'easter in the Northern hemisphere as they blow with very high intensity. These winds affect North Eastern Canada and USA.

Periodical winds

The winds that change their course according to season or time are called periodical winds. They are as follows-

A) Monsoon Winds
B) Land Breeze and Sea Breeze
C) Mountain Breeze and Valley Breeze

A) Monsoon Winds

The term monsoon has been derived from the Arabic word 'mausin' meaning 'season'. Thus the monsoon winds are those winds that change their direction according to the change of season. The theories regarding the origin of monsoon winds are

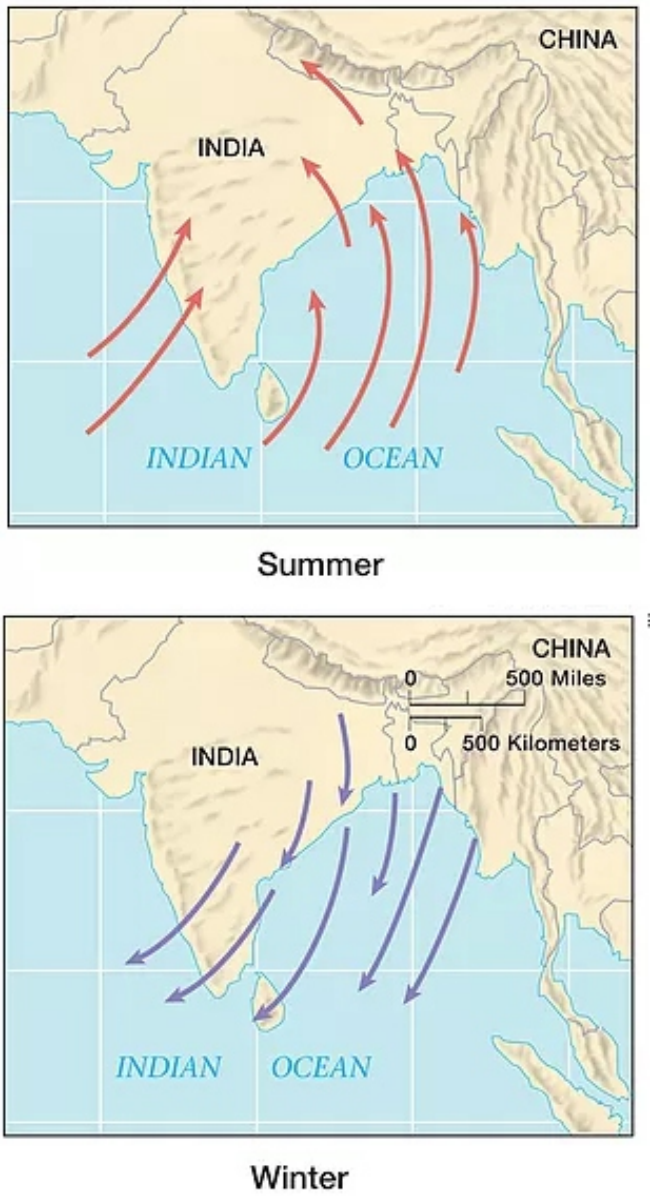

Fig. 13.4 : Monsoon winds

as follows-

Thermal concept

According to this theory the origin of monsoon is due to uneven distribution of land and sea and their contrary nature of heating and cooling. During summers due to excessive solar radiation ,the land becomes much hotter than the seas this causes development of low pressure areas. Due to this, the wind blows from sea towards land. This situation is reversed during the winters land becomes the centre of high pressure and sea

becomes the centre of low pressure. This results in the winds blowing from land towards sea and is called winter monsoon. It is also called North East monsoon. (Fig 13.4)

Dynamic concept of Flohn

Flohn rejected the thermal concept of origin of monsoon and proposed his Dynamic concept of origin of monsoons.

According to him the origin of monsoon winds is due to the shifting of winds and air pressure belts. As the two trade winds clashe near the equator, it develops Convergence. It is called Inter-Tropical Convergence ITC. It's northern margin is called NITC and its southern margin is called as SITC. The Doldrum belt exists between these ITC in which equatorial westerlies winds blow. During the summer solstice ITC shifts and extends till 30° north latitude , which covers south east Asia.Therefore, the doldrums equatorial westerly winds blow in these regions , during summers these become south west monsoon winds. In the same way , during Winter Solstice, the NITC shifts away from south east Asia, and north east trade winds re-establishes. These are called North East monsoon winds.

Modern concept

It's also called 'Jet Stream' theory. Jet stream is a stream of fast moving air from west to east usually found in South Asia in the upper troposphere at a height of about 12 km. It is also called Sub tropical West Jet Stream here. The height of Jet Stream is about 9 to 10 km at 60° north latitude and its height gradually decreases towards the pole. Due to mechanical barrier of the Himalayas and Tibetan plateau, the upper westerly jet stream is divided during winters in northern hemisphere.

It's northern branch blows from west to east in north of Tibetan plateau, and it's main branch blows in South of Tibet plateau and Himalaya from west to east direction. The main branch follows a cyclonic pattern over Afghanistan and Pakistan. This causes the origin of winter monsoon. After 21st of March during summers when the sun is in summer solstic,due to which the polar surface high air pressure weakens.

As the higher level Polar vortex shifts towards north, the high level Westerly Jet stream also shifts towards north. This Jet stream disappeares completely from India by mid of June. The Jet stream now blow in opposite direction of winter path over the north of Tibetan plateau.The path of high-level crystal jet stream over the northern part of Afghanistan and Iran is in cyclic form (in anticlock direction), which develops low pressure and cyclonic conditions in troposphere. This low pressure extends over North Western India and Pakistan. Thermal low already exists below this on the surface.

During these conditions the winds rises from lower pressure area and upper strata low pressure attracts them to higher parts, due to which there is sudden burst of Southwest monsoon.

(B) Land and Sea Breeze

These winds are miniature form of monsoon winds which change their direction twice during 24 hours. The main cause of land and sea breeze is the differential heating and cooling of land and water bodies. These winds are experienced daily on the coastal regions or the margins of the lakes.

Land Breeze

During night the heat loss is rapid due to terrestrial radiation on land in comparison to the water bodies , due to this land becomes cooler than

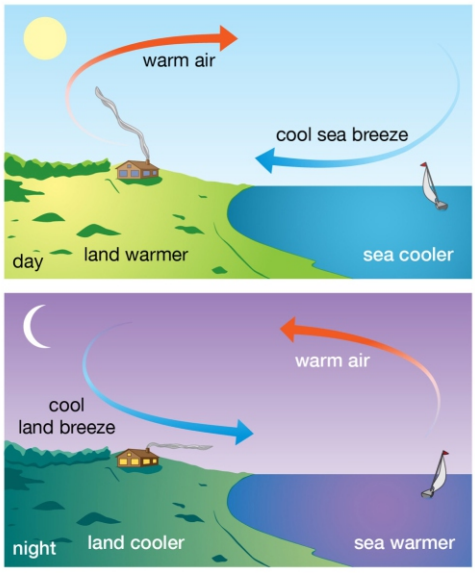

Fig. 13.5 : Land and sea breeze

water bodies.

This causes development of high pressure over land and low pressure over sea. Due to this ,the winds blows from land towards the sea and are called land breeze. These are dry winds. The coastal margins are similarly affected by these winds. This is the main reason why the climate of Kolkata, Mumbai, Chennai and other coastal cities in India experiences moderate type of climate which is neither too hot nor too cold.

Sea Breeze

During daytime, land mass gets more heated in comparison to the water bodies, resulting the devlopment of low pressure over land and high pressure over sea. This results in the blowing of the winds from sea towards land which is called sea breeze. These winds begins by 10:00 am to 11:00 am in the morning and reaches its maximum velocity around 1:00 pm to 2:00 pm and almost diminishes by 8:00 pm in night. These winds cause decrease in the temperature of about 5° to 7°degree celsius in just 15 to 20 minutes in the coastal margins of tropical regions.

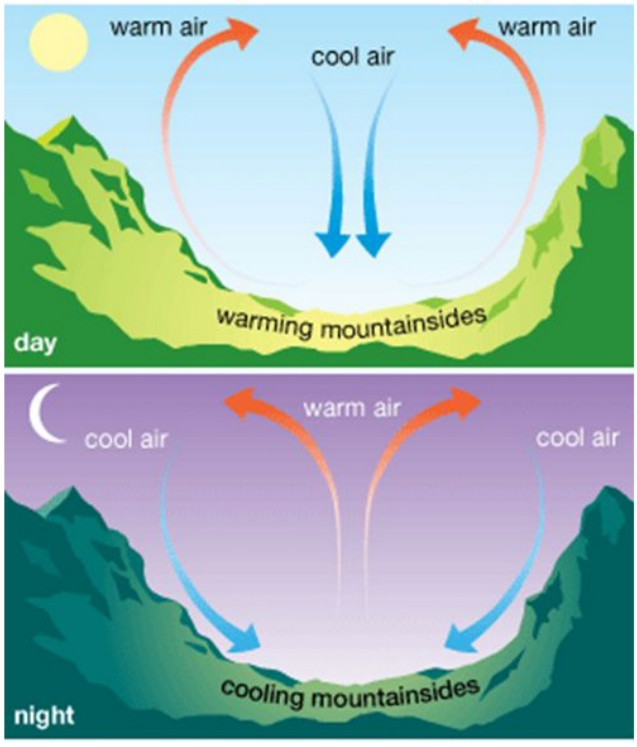

Fig. 13.6 : Valley and Mountain breeze

This causes weather to be pleasant and healthy. These winds also causes rainfall in the coastal regions. These winds prevails only during the day in summer season.

(C) Mountain and Valley breeze

During the day, the slopes of the mountain become much warmer than lower region of valley, due to this low pressure develops on mountain slopes and higher pressure develops in valley floor. Due to this difference in pressure conditions the winds blow from Valley floor towards the mountain slopes. These winds are called Valley breeze. The conditions are reversed after the sunset. During night the slope of the mountains loose it's heat due to Terrestrial radiation. Due to this high pressure area develops over mountain slopes and lower pressure in the valley floors. The cold and heavier wind blows towards low pressure areas of the valley bottom. These winds are called mountain breeze.
These winds create the position of inversion of temprature, This causes frost during night in the valley floors where as the upper parts are free from the frost . Similar conditions exist in Himachal Pradesh in India.

Local winds

The winds which develop as a result of local differences in temperature and pressure conditions are called local winds. These winds are of opposite nature to the prevailing winds in the region. The characterstics of these winds varies according to the local regions, they may be warm, cold, dusty, snowy and many other different types. These winds have favourable as well as unfavourable effects on the regions where they prevail. The major winds are Chinook, Foehn, Bora, Sirroco, Harmattan, Mistral, Brickfielder Willy-willy etc.

Chinook and Foehn

The dry and warm winds which blow down the mountain slopes are called 'Chinook' in USA and Foehn in Europe. The effect of these winds can easily be observed on the Prairie region of USA. These winds mostly blow in winter season. During this season,when these dry and warm winds cross over extensive Rockies mountains and enter eastern

Prairie grasslands, they melt the snow. It is the reason that they are also called as Snow Eaters.

Foehn have characteristics similar to Chinook. It ascends over southern slopes of Alps mountain and descends on from the northern side. These winds causes sudden increase in temperature of about 8° to 10° Celsius. Due to increase in temperature the snow melts and pasture lands are created, and cultivation is started. Its maximum impact is on Switzerland, where these winds blow mostly in Spring and Autumn season.

Sirocco

These are dry,warm and dust laden winds which blow from Sahara desert to north of Mediterranean sea and affect Italy, Spain etc. These winds carry red sand in ample quantity. These winds pick up moisture as they cross over Mediterranean sea. They causes rain as these winds with red sand descends down in southern Italy. This type of rain is also called "Blood Rain". As these winds descend down along atmosphere slopes of Atlas Mountains they become more dry and warm. These winds are known by different names in different places. Sirocco in Italy, Simmom in Sahara, Gibli in Libya, Chili in Tunisia, Leveche in Spain. The dry and hot wind that prevails in Arabian desert is called Simoom. These winds have devastating effects on vegetation, agriculture and orchards.

Harmattan

These winds which are dry, hot and blow in the eastern part of Sahara desert of Africa from North-East to west are called Harmattan. These are high velocity winds. The Western coastal regions of Africa is hot and humid due to which the weather remains unhealth. The weather becomes dry and pleasant with the arrival of Harmattan winds. Therefore these winds are also called 'Doctor winds' in the Guinea coastal area of Western Africa .

Similarly dry and hot winds blow in the Victoria region of Australia, which are called Brickfielder.

Mistral

These are cold dry and high velocity winds, which blow in north-west direction of mediterranean sea, and affect Spain and France. These winds blow with an average speed of 56 to 64 km per hour but some times it becomes 128 km per

Fig. 13.7 : Local winds of the world

hour. This high speed adversely affects the air flights. In order to reduce the impact of these winds, orchards and shrubs are planted at right angles of their flow direction. With the arrival of these winds there is a sudden drop in the temperature below freezing point.

Bora

These winds are cold and dry which blow along the eastern margins of Adriatic sea.

The northern part of Italy is specially affected by these winds. The high velocity of these winds uproots the trees and blows off the roofs of many houses. Sometimes these winds blow continuously for sevral days. These winds also causes rainfall as they carry moisture.

Blizzard

These winds are also called thunderstorm. These winds are prevalent in USA, Canada & Siberia. The average velocity of these winds varies from 80-96 km per hour. These winds have snow particles which hampers the visibility. The arrival of these winds causes sudden decrease in temperature and the entire region is covered with snow. These winds reache USA and affect the extensive plains of the Southern states of USA, as there is absence of any east-west, mountain barrier in USA. These are called Northern in southern USA and 'Buran' in Siberia.

Loo

These hot and dry winds blow during summer season specially after noon in the plains of Northern India and Pakistan from western direction. These winds are called Loo. The temperature of these winds varies from 40° to 50° Celsius. These winds causes heat stroke. The regions which are affected by these winds observe troublesome weather conditions.

Important points

1. The pressure exerted by the layers of the atmosphere on the earth's surface is measured by Barometer. The factors that affect the air pressure include temperature , height above sea level, rotation and revolution of the earth and water vapours etc.
2. The air pressure belts changes according to the change in seasons. The air pressure decreases with the increase in height.
3. The factors that affect the direction and speed of the winds are temperature, rotation and revolution of the earth, relief features.
4. The winds like Westerlies, Trade winds and Polar winds are Permanent winds and seasonal winds are monsoon land, sea breeze and Valley - mountain breeze. The theories regarding origin of monsoon include thermal theory dynamic, theory of Flohn and modern hypothesis.
5. Chinook, Foehn,Siricco, Mistral, Harmattan, Mistral, Bora, Blizzards,Loo are examples of Local Winds

Exercise
Multiple choice questions

1. Who discovered air pressure?
   (A) Twewartha
   (B) Ferrel
   (C)Guerick
   (D) Finch

2. What is the extension of equatorial low pressure belt?
   (A)5° North to 5° South latitudes
   (B) 30°to 35° North and South latitudes
   (C) 60 ° to 65° North and south latitudes
   (D) None of these

3. The hot and dry winds which blow in the plains of North India and Pakistan are called....
   (A) Chinook
   (B) Loo
   (C) Mistral
   (D) Bora

4. The winds that blow in a particular direction for the whole year are called....
   (A) Uncertain winds
   (B) Seasonal winds
   (C) Prevailing winds

(D) Local winds

5. The belt of 'Doldrums' are found in ...
   (A) Near equater
   (B) Near Tropic of Cancer
   (C) Near Tropic of Capricorn
   (D) Near Arctic circle

Very short type questions

6. What is the most popular unit to measure air pressure?
7. Where does Mistral winds prevail?
8. Which winds blow in Alps mountains?
9. Give the extension of equatorial low pressure belt.
10. What is wind?

Short type questions

11. What is air pressure?
12. What are Doldrums?
13. What are Prevailing Winds?
14. What is Loo?
15. Name the factors that affect the air pressure.

Essay type questions

16. What is air pressure ? Describe the air pressure belts.
17. What is wind ? What are the different types of winds ? Explain
18. Examine critically the theories about the origin of monsoon winds.

Answer Key

1.C. 2.A. 3.B. 4.C. 5.A