Class-ix

Subject-Geography

Chapter14-Atmospheric pressure and winds

Part-II

WINDS

The horizontal movement of air related to ground surface is called a wind. This movement of air is due to the variation in atmospheric pressure caused by uneven heating of the Earth by the Sun.

- Winds always blow from the areas of high pressure to the areas of low pressure.
- The rate of change in atmospheric pressure between two places is called the pressure gradient. The greater the difference in pressure between two places, the faster the wind will blow.

Wind observations. Wind is measured in terms of direction and speed.

Wind direction. Wind is named according to the direction (compass point) from which it blows. For example. wind blowing from the south towards the north is called a south wind or southern wind.

Deflection of wind. The winds do not blow strait from high pressure to low pressure but they curve or deflect as they blow. This happens due to the rotation of the Earth. This curving motion is called the Coriolis Effect.

(a) The Coriolis Effect

- In 1935, Gustav Gaspard de Coriolis explained that winds do not move in a straight path but they deflect because of the spinning of the Earth on its axis that causes air masses to be deflected. See Fig. 15.5.
- The Coriolis Effect is absent at the Equator but increases in strength towards the Poles.

(b) Ferrel's law

- The direction of this turning effect is stated as Ferrel's law. The deflection was explained by an American scientist W. Ferrel in 1856.
- Ferrel's law states that any object or fluid moving horizontally in the Northern Hemisphere tends to be deflected to the right of its path of motion. In the Southern Hemisphere, the moving object tends to be deflected to the left of its path of motion. See Fig. 15.6.

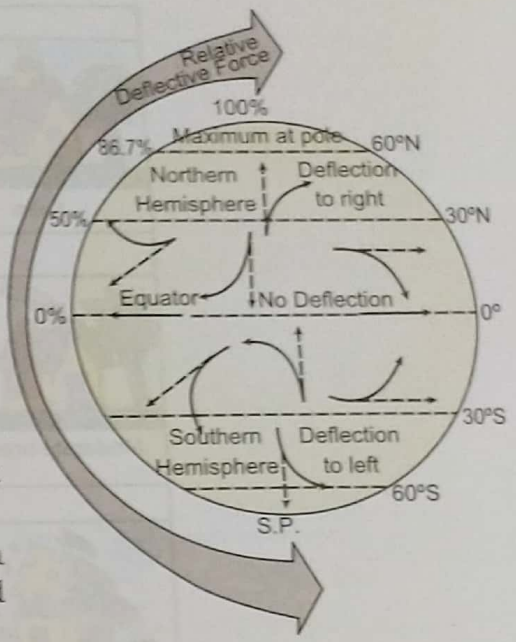

Fig. 15.6 Deflection of Winds according to the Ferrel's Law

WIND VANE

- The direction of wind is easily determined by a common instrument known as wind vane or "weather cock" for meteorological records.
- It consists of a pivoted horizontal arm or arrow rotating freely on a vertical spindle. The arm has an arrow on one side and a broad surface on the other side.
- It moves freely with the prevailing wind. The wind catches the broad surface or tail of the arrow and swings the pointer to the direction from which the wind blows. See Fig. 15.7.
- Below this, there are four fixed compass points showing direction of the moving wind.
- Wind vane should be placed at a high point where there is no obstruction created by tall buildings and trees.

Wind Speed. This is measured by an instrument called anemometer.

Anemometer

- It consists of four metal or plastic semicircular cups attached to horizontal spokes mounted on a vertical spindle.
- A dial is at the base which records the number of revolutions made by the cups in a given period because the cups move in a speed proportional to that of the wind. See Fig. 15.8.

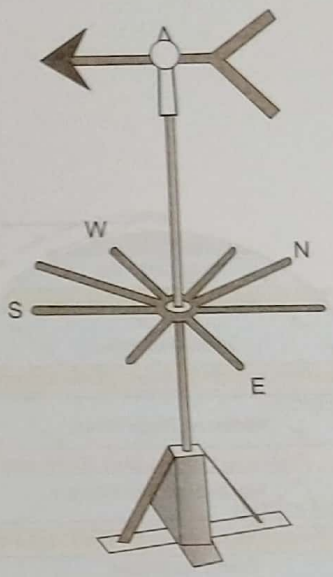

Fig. 15.7 Wind Vane

Beaufort scale

- This scale of wind strength was devised by Sir. Francis Beaufort of British navy in 1805 based on the effect of speed of wind on a sailing ship or by general observation of the moving objects.
- There are 13 levels of wind strength on this scale (0 – 12) ranging from calm to hurricanes. See Fig. 15.9.

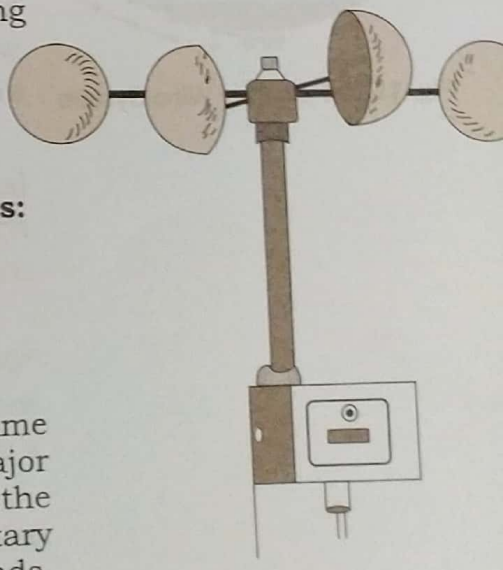

Fig. 15.8 Anemometer

TYPES OF WINDS

Winds are generally classified into the following four major types:

1. Planetary Winds or the Permanent Winds
2. Periodic Winds
3. Local Winds
4. Variable Winds

1. **Planetary Winds.** The winds which blow regularly in the same direction in certain latitudinal zones corresponding to the major pressure belts of the world are called prevailing winds or the permanent winds or the planetary winds. The major planetary winds are the trade winds, the westerlies and the polar winds. See Fig. 15.10.

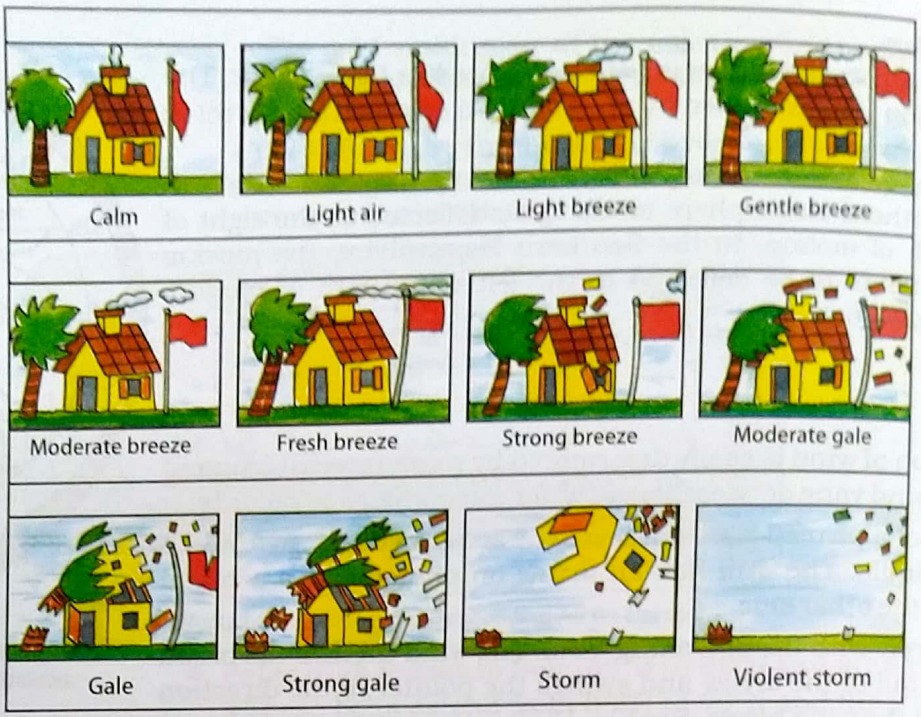

Fig. 15.9 The Beaufort scale

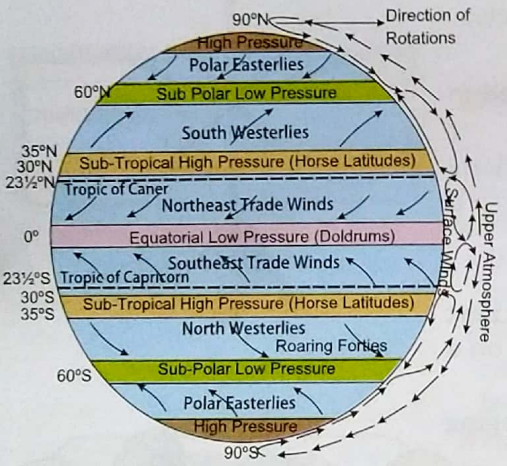

Fig. 15.10 Planetary Wind System

(a) Trade Winds

- They blow from the sub tropical high pressure belts to the equatorial low pressure belt between 30° N and 30° S latitudes.
- In the Northern Hemisphere, they blow from North-East to South West. Thus, known as North East trade winds. Whereas, in the Southern Hemisphere they blow from South East to North West. Thus, known as South East trade winds.
- The trade winds are most regular in strength and direction among the planetary winds.
- The trade winds blow regularly over Pacific and Atlantic Ocean due to vast expanse of water bodies but in the Indian Ocean and some parts of the South West Pacific Ocean, they are reversed in summer by the monsoons.
- They derive their name from a nautical expression "to blow tread" meaning to blow steadily in the same direction and in constant or regular path.
- Their name has been derived from the Latin word which means to blow in a constant direction. In ancient days, the ships used to cross the Atlantic Ocean from west European shore to the West Indies with the help of pushing action of trade winds.
- The onshore trade winds bring much rain on the eastern margins of the continents in the tropical zone, while western parts get very little rain. So, the hot deserts like Mexican, Kalahari and the Atacama are found on the western margins of the continents.
- On reaching close to the Equator, the trade winds of the Northern and Southern Hemisphere clash with one another. They rise as convectional air currents causing heavy rain in the Equatorial region.

(b) Westerlies or Anti-trade Winds

- They blow from the sub-tropical high pressure belt (horse latitude) to the sub polar low pressure belt in the temperate latitudes between 30°N and 60°N and 30°S and 60°S of the Equator.
- In Northern Hemisphere, they blow from South West to North East direction. Hence known as South Western Westerlies. Whereas, in Southern Hemisphere they blow from north west to south east direction. Hence known as North Western Westerlies.
- They are not as constant in strength and direction as the trade winds. In other words, they are variable. So, they are characterized by frequent cyclones and anti-cyclones. Thus, temperate zone experiences variable climate.
- They are more constant and stronger throughout the year in the Southern Hemisphere due to the absence of large landmasses and dominance of oceans over there. They blow with great force so are known as "Roaring Forties" (near 40°S latitude), "Furious Fifties" (near 50°S latitude) and the "Stormy Sixties" (near 60°S latitude).
- The onshore westerlies bring much rain to the western coast of the continent lying in their belt.
- The belt of the westerlies move north and south following the apparent movement of the Sun, so all the western coasts do not receive rain throughout the year.
- The Mediterranean regions receive rain by wet westerlies only in winter due to shifting of the wind system caused by shifting of world pressure belts.

(c) Polar Winds

- They blow from polar high pressure belt to sub polar low pressure belt from 90° N to 60° N and from 90° S to 60° S.
- In Northern Hemisphere, these winds blow from North East to South West direction. Hence, known as North-East Polar winds. Whereas, in the Southern Hemisphere, they blow from south-east to north-west direction. Hence, known as South-East Polar winds.
- These are variable in speed and direction due to local weather disturbances especially in the Northern Hemisphere. These winds are more regular in the Southern Hemisphere.
- The polar winds are deflected the most, as much as 90° from their normal course until they blow almost from east. The amount of deflection is so much due to the Earth's rotation.
- These winds are extremely cold and dry because they blow from polar ice caped regions.

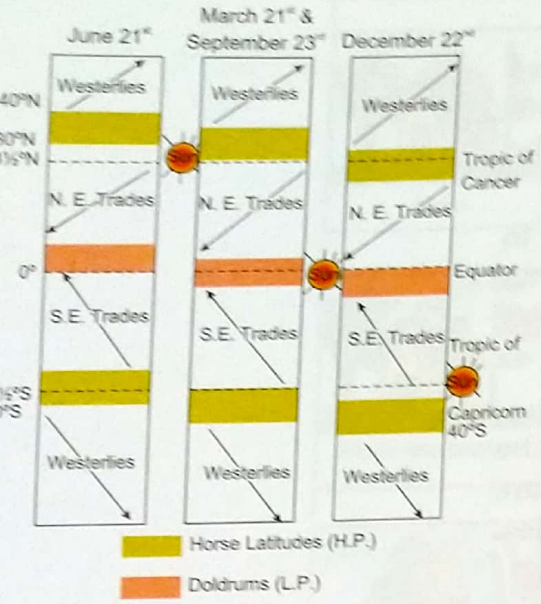

Fig. 15.11 Seasonal Shifting of World Pressure Belts

Seasonal Shifting of World Pressure and Wind Belts

- The Earth is inclined on its axis at an angle of 23.5° and it revolves on its orbit around the Sun in about 365 days. Thus, the revolution of the Earth on an inclined axis causes changes in relative position of the Earth and the Sun or an apparent migration of the Sun.
- It has already been explained that the main cause of the pressure belts is the varying amount of heat received from the Sun. So, the pressure belts follow the apparent, annual migration of the Sun to the North and South of the Equator. (Fig. 15.11. Seasonal Shifting of World Pressure Belts)
- The shifting of pressure belts and wind belts is about 5° to 10° from their average position.

(a) On 21st of March (Equinox) the Sun shines vertically over the Equator. So, all the pressure belts and wind belts remain in their average or ideal positions. After 21st of March, the Sun appears to move northwards and reaches the Tropic of Cancer on 21st of June.

(b) On 21st of June (Summer Solstice) the Sun is overhead at the Tropic of Cancer. Thus, all the pressure belts (except the Northern Polar High Pressure Belt) and the wind belts shift northwards from their average position. After 21st of June, the apparent movement of the Sun is southwards.

(c) On 23rd of September (Equinox) the Sun shines vertically again over the Equator. Consequently, all the pressure belts and wind belts are again in their average positions. After 23rd of September, the Sun appears to move south of the Equator and reaches the Tropic of Capricorn on 22nd of December.

(d) On 22nd of December (Winter Solstice) the Sun is overhead at the Tropic of Capricorn. So, all the pressure belts (except the Southern Polar High Pressure Belt) and the wind belts shift southwards from their average position.

Consequences of the Shifting of the Pressure Belts and Wind Belts

As the pressure belts and wind belts shift with seasons, consequently the belts that receive rainfall by the prevailing winds also change.

- The Mediterranean region which lies between 30°and 40° N and S has trade winds blowing during their summer season. These winds blow off-shore and are dry.
- The Mediterranean regions come under the influence of wet westerlies in winter season due to shifting of world pressure belts. So, these regions receive rainfall in winter.
- Northern Chile lies in the trade wind belt which hardly receives any rain. That is why Atacama desert is developed over there. But Central Chile comes under the influence of wet westerlies in winter and receive good amount of rainfall.

2. Periodic Winds. The winds which blow in certain periods of a day or in certain seasons only due to excessive heating or cooling of landmasses and the water bodies resulting into difference in air pressure causing winds to blow. Such winds may change their direction periodically from which they blow. So, they are called Periodic winds.

Land and Sea Breezes and Monsoon winds are typical examples of periodic winds.

(a) Land and Sea Breezes. They are experienced in the coastal areas. They develop due to different ways of heating of land and water. The daily range of temperature is lower in the coastal areas due to the occurrence of sea and land breeze, which help in keeping the climate moderate upto 2-3 km in land in the narrow coastal areas.

Day: Sea Breeze

- Land gets heated more quickly than the Sea during daytime.
- The warm air above the land rises forming a low pressure.
- Water takes more time to get heated. So, the adjoining sea is comparatively cooler. The cool air above the sea is heavy so it forms high pressure on the sea.
- Air always moves from an area of high pressure to an area of low pressure. The pressure gradient forces the wind to blow from sea to land forming sea breeze. The cooling effect of sea breeze is experienced in the coastal areas. During the day, the weather becomes pleasant. See Fig. 15.12.

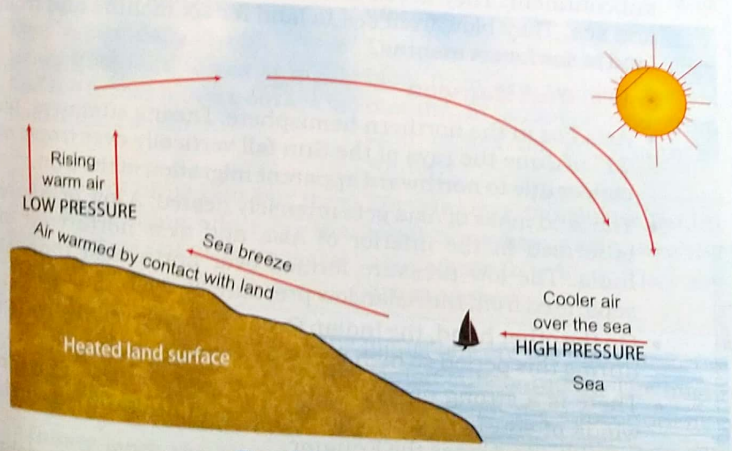

Fig. 15.12 Sea Breeze (day)

Night: Land Breeze

- Land is a good radiator of heat. So, after sunset the land radiates its heat rapidly and low pressure formed during daytime is weakened. Since the land cools down rapidly, an area of high pressure is formed on land at night.
- The sea takes more time to get cooled down so it is comparatively warmer, and an area of low pressure is formed on the sea during night. See Fig. 15.13.

• This pressure difference on land and sea causes movement of wind from high to low pressure or from land to sea as land breeze.

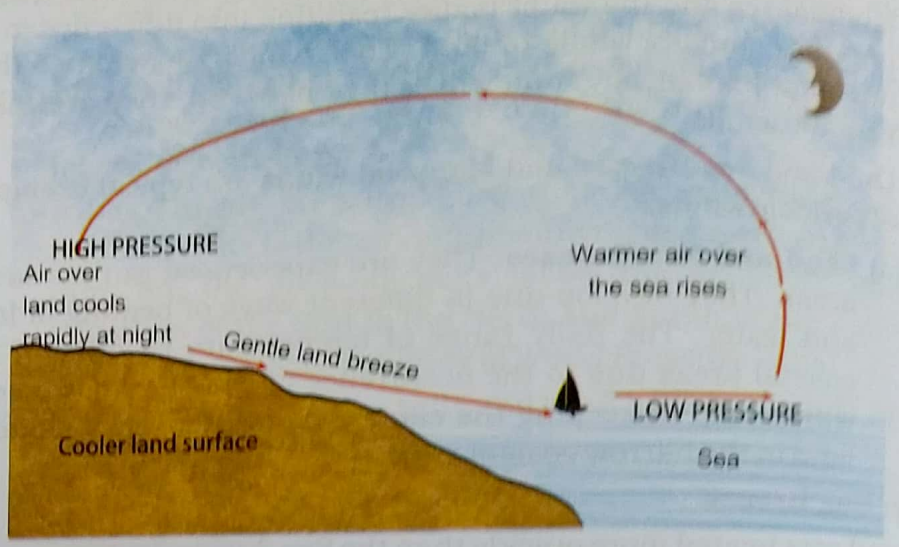

Fig. 15.13 Land Breeze (Night)

(b) Monsoon Winds. The word "Monsoon" is derived from the word "Mausim" meaning season. The monsoon is a typical example of a periodic wind. It is also similar to land–sea breeze on a large scale. Unlike land–sea breeze, monsoon winds are seasonal rather than daily phenomena. An important feature of the monsoon system of winds is the seasonal reversal of wind direction.

Monsoon winds are best developed over the Indian subcontinent. They developed due to unequal heating of land and sea. They blow from sea to land for six months and from land to sea for six months.

South–West Monsoon

- Asia lies in the northern hemisphere. During summers, on 21st of June the rays of the Sun fall vertically over tropic of cancer due to northward apparent migration of the Sun.
- The land mass of Asia gets intensely heated. A low pressure is formed in the interior of Asia and over north-west of India. The low pressure formed over north-west India is separated from the Asian low pressure by the Himalayas.
- On the other hand, the Indian Ocean remains relatively cool during this period so high pressure exists over it.
- There is a strong pressure gradient. The south-east trade winds of southern hemisphere blow from Australian high pressure and cross the Equator.
- On crossing the Equator, they are deflected towards right side as they enter the northern hemisphere. This happens due to the Coriolis Force.
- They blow as south-west monsoon winds over the Arabian Sea towards the intense low pressure of Asia and Indian subcontinent.
- As the south-west monsoon winds blow from sea to land, they are moisture laden. So, they bring good amount of rain fall in the Indian subcontinent. See Fig. 15.14.

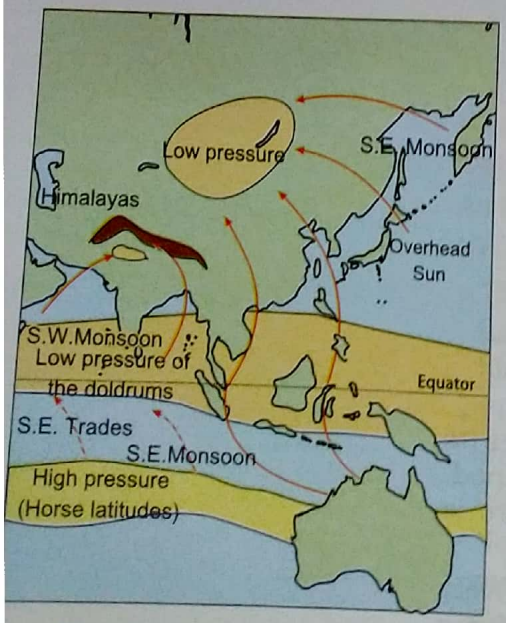

Fig. 15.14 South-West Monsoon

North-East monsoon

- During winter season, the Sun's rays fall vertically over tropic of Capricorn on 22nd of December due to apparent migration of Sun southward.
- The land mass of Asia cools down rapidly consequently an area of high pressure develops over the interior parts of Asia (central Asia) and over the north-western parts of India which are separated by the Himalayas.
- On the other hand, the Indian Ocean remains warm and centre of low pressure develops over it.
- The cold dry winds blow from the area of high pressure (land) towards the low pressure (sea). They follow the direction of prevailing trade winds of northern hemisphere, *i.e.*, north-east.
- On crossing the equator, they are deflected towards the intense low pressure formed over Australia as north-west monsoons.
- Winter monsoon are generally cold and dry as they blow from land to sea. They are weak and variable winds.
- Monsoon conditions are also experienced in north Australia and east Africa. See Fig. 15.15.

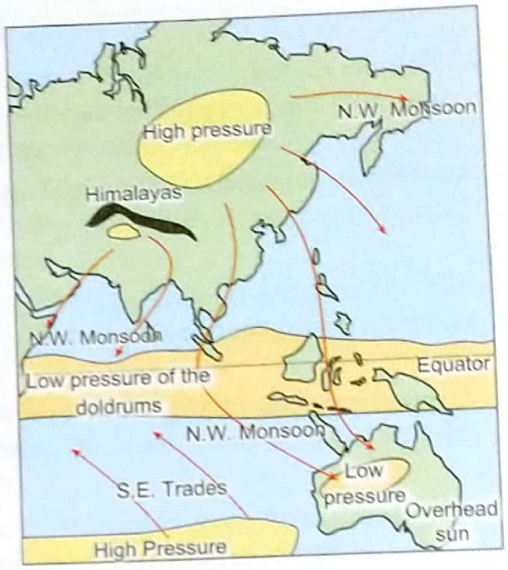

Fig. 15.15 North-East Monsoon

Land and Sea Breezes	Monsoon Winds
Land and Sea breezes are experienced along the coastal region due to local variation in temperature and air pressure between land and sea.	They are experienced over a large area of tropical region due to great contrast in temperature and air pressure between land and sea.
They occur daily. Land breeze blows from land to sea at night and sea breeze blows from sea to land during daytime.	They are seasonal winds. They blow from sea to land for six months in summer and from land to sea for six month in winter.
They do not bring rain but they have moderating effect on the temperature of the coastal areas.	The summer monsoons (south west) bring heavy rain over the area where they blow. They are dry in winter.

Importance of monsoon. The monsoons are the most important features of Asia as well as the Indian subcontinent. The mighty Himalayas trap the monsoon winds within the subcontinent so this region receives heavy amount of rainfall. India is a water thirsty land; the torrential rain associated with monsoon is a welcome relief to city dwellers and farmers after a long period of hot dry season. Rainwater is used for cultivation, irrigation and harnessing of electricity.

3. Local Winds

The winds which are caused due to the variation in local heating and cooling of smaller areas. Such winds are of local signification only. So, they are called local winds. Local winds are classified as:

(i) The Depression Winds

(ii) The Descending Winds

(i) The Depression Winds

(a) Hot winds

- The air circulation in the tropical regions is such that the air is drawn in from the tropical regions in the front of depressions. This gives rise to hot winds.
- These hot local winds are generally hot and dusty. If they cross a sea, they become humid.
- **Example.** Sirocco (Sahara desert), Leveche (Libyan desert), Khamsin (Egyptian desert), Santa Ana (California), Loo (Northern India) and Brickfielder (Central Australia).

(b) Cold winds

- In such air circulation, the air is drawn in from Polar regions in the depression giving rise to cold winds.
- These winds are usually bitterly cold and strong. Example. Mistral, Bora and Pampero. See Fig. 15.16.

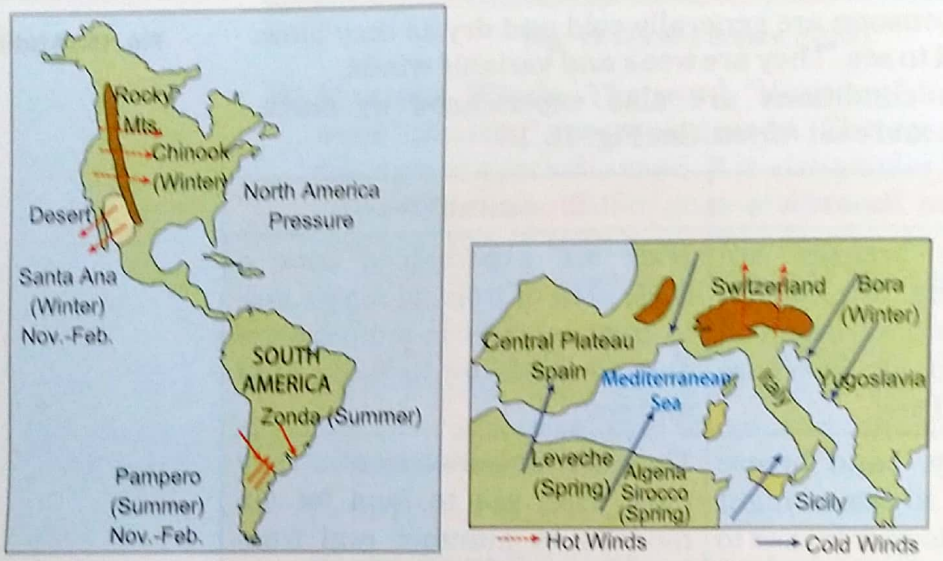

Fig. 15.16 Depression Winds

(ii) The Descending Winds

- As the air rises up the windward side of the mountain, it is unsaturated. It cools down at the rate of 1° C per 165 m (normal lapse rate). The air becomes saturated as it rises higher and condensation takes place. The latent heat is released and the air gets saturated at the rate of 0.5° C per 165 m.
- After crossing the mountain, the descending air warms as it comes down the mountain slopes. The warm air can hold more moisture. So, the air becomes unsaturated.
- It brings warming effect and relief to the lowlands and the areas over which it passes. Example. Chinook, Foehn, Berg, Nor'wester. See Fig. 15.17.

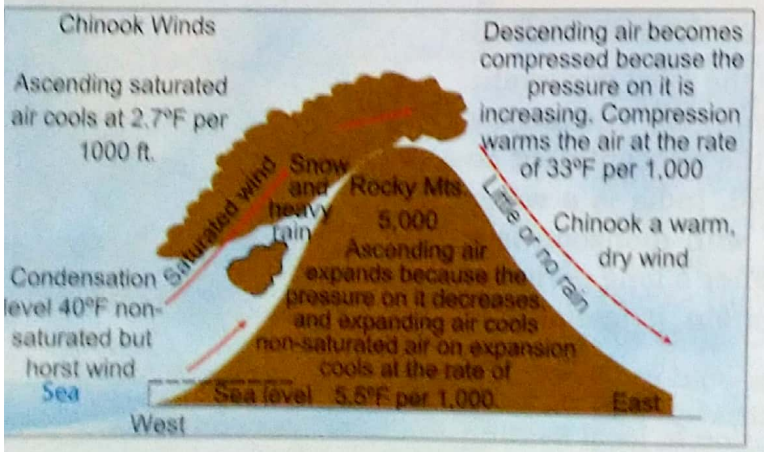

Fig. 15.17 Descending Winds

Some Important Local Winds Around the World

- **Chinook.** It is a warm dry wind that descends the eastern slopes of Rocky Mountain of North America. It is also known as "snow eater" as it brings about sudden rise in temperature in a short period of time. This sudden increase in temperature helps in melting snow in Prairies.
- **Foehn.** A hot dry wind which develops in the leeward slopes of Alps Mountain in Europe, especially in the valley of Switzerland. This descending wind helps in melting the snow in late winter and helps in animal grazing and ripening of grapes in the autumn season.
- **Loo.** It is a hot, dry, dusty wind that blows in the plains of Northern India and Pakistan in the months of May and June, usually in the afternoon. It may cause sunstroke to the people. It blows in the areas where temperature of air ranges between 40° C and 50° C.
- **Nor'westers.** These are hot winds with violent thunder storms, which blow in the hot dry season in West Bengal and Assam in India before the onset of monsoons. They are also known as "Kal Baisakhi" meaning calamity of the month of Baisakh.
- **Mistral.** It is a cold and dry wind, which blows along the coasts of France and Spain along the Mediterranean Sea. Rhone river valley gets adversely affected by this strong Mistral wind.
- **Bora.** It is a strong, cold and dry wind which blows along the Eastern coast of Adriatic Sea. It mainly blows in winter season giving clear skies and very cold dry weather.
- **Harmattan.** It is a hot, dry and dusty wind that blows over North-West Africa from Sahara Desert. It brings fine desert dust causing problems to caravan traders. Crops get damaged by such winds.

4. Variable Winds. When both the speed and direction of winds vary, they are called variable winds.

(i) Cyclones

- Cyclone is a small system of low atmospheric pressure in the centre to which winds blowing from the surrounding high pressure areas, in an anticlockwise direction in the Northern Hemisphere and in a clockwise direction in the Southern Hemisphere according to the Ferrel's law.
- Cyclones usually originate when the intense heat of the Sun stirs up humid air over oceans. The winds from the surrounding regions blow with a great speed towards the centre of the cyclone, which is known as the "eye of the storm". It is a calm region with a clear sky.
- The stormy winds spiral inwards towards the eye and the inward blowing air is forced to rise, the rising moist air gets cooled down, condenses and brings heavy rain.
- Cyclones cause dull weather, overcast skies and very heavy rainfall accompanied by thunder and lightening.
- Cyclones move in the direction of the planetary wind system. So, they move towards west in the trade wind belt while they are pushed eastwards in westerlies belt.
- There are two types of cyclones–tropical and temperate cyclones. See Fig. 15.18 and Fig. 5.19.

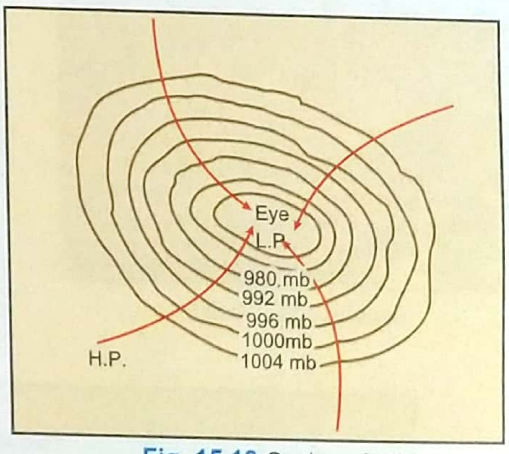

Fig. 15.18 Cyclone in the Northern Hemisphere

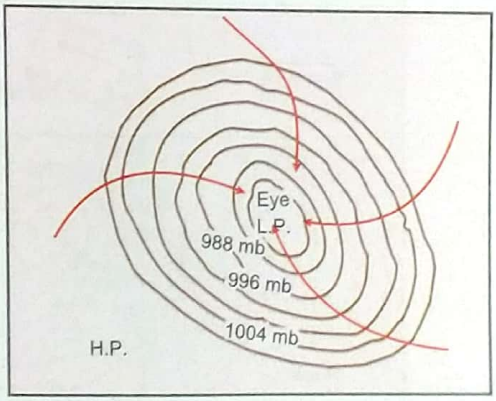

Fig. 15.19 Cyclone in the Southern Hemisphere

Tropical Cyclones	Temperate Cyclones
They originate over the western parts of the oceans between 8°. And 20°. North and South of the Equator.	They originate in the temperat latitudes.
The surface sea temperature reaches 27°C. So high temperature and high humidity of air causes low pressure.	This is the region of convergenc of warm moist westerlies and cold polar easterlies. See Fig. 15.20.
They occur during late summer season when doldrums belt of low pressure shifts far from the Equator.	These winds do not mix easily and form front. The warm air being lighter rises over cold air leads to condensation and precipitation. They are more frequent in winter.
They are usually small with diameter 100 to 500 km.	They are much larger with a diameter of 1000 to 2000 km.
On weather maps, isobars are circular with a steep pressure gradient between the center and periphery. Winds blow with a speed of 100 to 150 km per hour.	On weather maps, isobars are oval in shape with less pressure gradient between center and periphery. These winds have moderate velocity.
They travel westward in the path of trade winds.	They travel eastward in the path of westerlies.
Thick clouds and torrential rain are the characteristics of this region. They cause heavy damage to life and property.	The temperate cyclones do not cause much damage of life and property.
They are very destructive. Strong winds may uproot trees and other structures. They are more violent.	They bring wet stormy conditions with extensive clouds but they are not violent like tropical cyclones.

JET STREAMS

- Jet streams are fast flowing, narrow air currents found in the upper atmosphere or in troposphere of the Earth.
- The major jet streams, located near the tropopause, are westerly winds (flowing west to east). Their paths typically have a meandering shape.
- Jet streams may start, stop and split into two or more parts. These streams also combine into one stream, or flow in various directions including the opposite direction of most of the jet.
- The polar jets are the strongest jet streams found at around 9–12 km (30,000–39,000 ft) above sea level, and the higher and somewhat weaker subtropical jets are found at around 10–16 km (33,000–52,000 ft). Polar jet and a subtropical jet are found in both the Northern Hemisphere and the Southern Hemisphere .
- The northern hemisphere polar jet flows over the middle to northern latitudes of North America, Europe, and Asia and their Intervening oceans, while the southern hemisphere polar jet mostly circles Antarctica all year round.
- Jet streams are caused by a combination of a planet's rotation on its axis and atmospheric heating (by solar radiation and, on some planets other than Earth, internal heat). Jet streams form near boundaries of adjacent air masses with significant differences in temperature, such as the colder air near the polar region and the warmer air towards the equator.
- Other jet streams also exist. During the Northern Hemisphere summer, easterly jets can form in tropical regions. Low-level jets also are found in the various regions such as the central United States.

Importance

- Meteorologists use the location of some of the jet streams for weather forecasting.
- The main commercial importance of the jet streams is while air travel, as flight time can be dramatically affected by either flying with the flow or against the flow of a jet stream.
- Clear-air turbulence, a potential hazard to aircraft passenger safety, is often found in a jet stream's vicinity, but it does not create a substantial alteration on flight times.
- Jet Streams could determine the arrival and departure of monsoons. Western disturbances are responsible for bringing rain in North West India and Pakistan with the help of westerly jet and tropical depression are caused by easterly jet over northern India and Bangladesh.

A. Answer the following questions briefly:

1. What is meant by the term 'atmospheric pressure'?
2. Name the instrument used to measure atmospheric pressure.
3. Name the instruments used to measure the wind speed and the wind direction.
4. What are the factors which affect the atmospheric pressure of a place?
5. Name the world's pressure belts.
6. What is meant by Coriolis Force?
7. What is Ferrel's law?
8. What are doldrums? Why are they called so?
9. What are horse latitudes? Why are they called so?
10. Name the planetary winds.
11. State the main features of trade winds.
12. State the main features of westerlies.
13. What are the causes of shifting of pressure belts?
14. What are the consequences of shifting of pressure belts?
15. What are local winds? Give two examples each of hot and cold local winds.
16. What are the main causes for the development of local winds?
17. What are the basic causes of formation of land breeze and sea breeze? Explain with diagrams.
18. What are monsoon winds? How are they caused?
19. What is a cyclone? Describe the weather conditions associated with the cyclones.
20. What is an anticyclone? Describe the weather conditions associated with the anticyclone.
21. Name the areas where typhoons and hurricanes are experienced.
22. What is the importance of Jet Stream?

B. Define the following terms:

1. Winds,
2. Atmospheric pressure,
3. Coriolis Force,
4. Doldrums,
5. Horse latitudes,
6. Isobars,
7. Cyclones,
8. Anticyclones.

C. Distinguish between the following:

1. Equatorial low pressure belt and sub polar low pressure belt.
2. Trade winds and Westerlies.
3. South West Monsoon and North-East Monsoon winds.
4. Land and Sea breeze.
5. Cyclone and Anticyclone.
6. Tropical Cyclones and Temperate Cyclones.
7. Land-Sea breeze and Monsoon winds.

D. Give reasons for the following:

1. There is a low pressure belt in the Equator whereas high pressure belts in the polar region.
2. The sub tropical high pressure belt is also known as the horse latitude.
3. The winds deflect to the right in the Northern Hemisphere and to the left in the Southern Hemisphere from their original path.
4. The roaring forties and furious fifties are found in Southern Hemisphere only.
5. Monsoon winds change their direction after six months.
6. Sub Polar Regions have low pressure belts.
7. Tropical cyclones cause heavy damage to life and property.
8. The major pressure belts and winds shift pole wards during summer season.
9. South Western monsoon winds bring good amount of rain on the areas where they blow.
10. The Mediterranean Regions receive rainfall only in winter.

E. Answer the following questions in detail:

1. Explain the monsoon system of South East Asia.
2. How do land and sea breeze affect the temperature of the coastal region?
3. Explain any two factors affecting atmospheric pressure.

F. Draw and label neat diagrams of the following:

1. Planetary wind system
2. Major pressure belts of the world
3. Sea breeze and Lad breeze
4. Cyclones in both the hemispheres
5. Anticyclones in both the hemispheres.