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Distance Learning Programme (DLP)

WORLD GEOGRAPHY

(UPSC PRELIMS)

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WORLD GEOGRAPHY

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CHAPTER

PRESSURE & WIND SYSTEMS

The weight of a column of air contained in a unit area from the mean sea level to the top of the atmosphere is called the air or atmospheric pressure. The atmospheric pressure is expressed in units of millibar. At sea level the average atmospheric pressure is 1,013.2 millibar. Due to gravity, the air at the surface is denser and hence, has higher pressure. Air pressure is measured with the help of a mercury barometer or the aneroid barometer. The pressure decreases with height. At any elevation it varies from place to place and its variation is the primary cause of air motion, i.e., wind which moves from high pressure areas to low pressure areas.

Distribution of Pressure on Earth's Surface

- Horizontal distribution of air pressure on the earth's surface is closely related to that of temperature because the factors which control the distribution of temperature on the earth's surface equally govern the distribution of pressure as well.
- Unequal distribution of insolation over the surface, differential heating of land and water and different albedo of the earth's surface are the main factors which affect the distribution of pressure on the earth's surface. However, one more factor comes into play during the development of the pressure belt, which is Coriolis force due to the rotation of earth.

Pressure Belts

Based on the distribution pattern of surface pressure on a rotating earth with uniform surface (In order to eliminate the effect of altitude on pressure, it is measured at any station after being reduced to sea level), there are seven alternate low and high pressure belt on the earth's surface.

The pressure belts are not permanent in nature. They oscillate with the apparent movement of the sun. In the northern hemisphere in winter they move southwards and in the summer northwards.

The seven Pressure Belts are:

- Equatorial low pressure belt
- Subtropical high pressure belt – Northern hemisphere
- Subtropical high pressure belt – Southern hemisphere
- Subpolar low pressure belt – Northern hemisphere
- Subpolar low pressure belt – Southern hemisphere
- Polar high pressure belt – Northern hemisphere
- Polar high pressure belt – Southern hemisphere

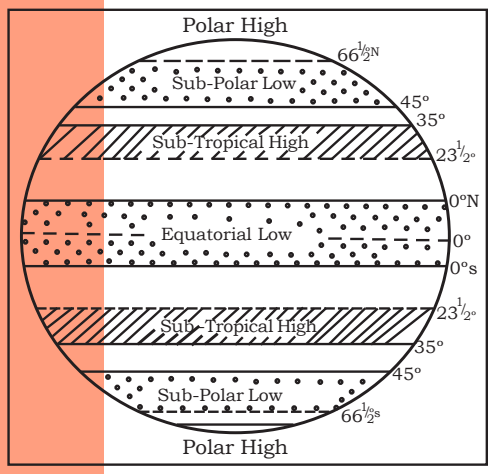


Fig: *Major Pressure Belts*

Equatorial Low Pressure Belt

- Equatorial Low Pressure Belt exists between 10°N to 10°S latitude. It is a thermally induced belt caused by high insolation and the convective rise of air (updraft).
- This region observes vertical cloud like
- Cumulonimbus with thunder & lightning and afternoon shower between 2 to 4 pm, followed by atmospheric stability with absolute calm.
- Equatorial Low Pressure Belt region is also referred to as doldrums due to the absence of air movement and generation of intense low pressure. It is believed that the ships sailing through doldrums get stuck for weeks if they do not have enough sail power to move forward. This belt represents the zone of convergence of N-E and S-E Trade winds.

Sub Tropical High Pressure Belt

- It exists between 25° to 35° latitudes in both the hemisphere. It is dynamically induced high pressure zone. This is caused by the subsidence of cold and dry air (downdraft) due to the mechanical force produced by air accumulated aloft.
- The air accumulation is caused by air coming from the equatorial region, which descends after becoming heavy.
- Coriolis force and geostrophic effect are contributing factors for accumulation of air. Hot tropical deserts are developed in the western side of continents in this zone as subsiding air is warm and dry that discourage rainfall.
- This zone of high pressure is called 'Horse Latitude' because of the prevalence of frequent calms. In ancient times, the merchants carrying horses in their ships had to throw out some of the horses while passing through this zone of calm in order to lighten their ships. This is why this zone is called 'Horse Latitude'

Sub Polar Low Pressure Belt

- It exists along 60° to 65° latitude in both the hemisphere. It is dynamically induced pressure belt, but thermal factors cannot be ignored.
- It is a zone of convergence of warm and cold air masses and also known as the temperate convergence zone.
- Development of fronts as well as temperate cyclone and frequent change in weather conditions are the common phenomena observed here.

Polar High Pressure Belt

- It exists near the poles between 75° to 90° latitude in both the hemispheres. It is thermally induced pressure belt, but the role of dynamic factors cannot be denied.
- The region observes the subsidence of cold and dry air, which causes the high pressure. The subsiding air is converted into anti cyclone due to the Coriolis effect and leads to the outflow of air in the form of gale. These gales are known as blizzard in North America and buran in Siberia.

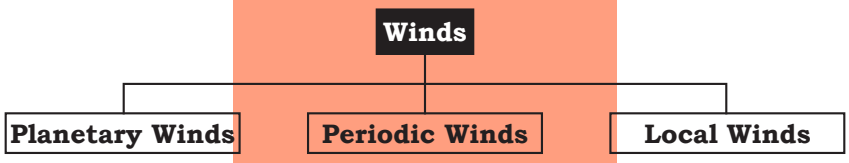
Winds

- The horizontal motion of air parallel to the pressure gradient force and perpendicular to the isobar is called wind.
- It always blows from high pressure to low pressure and acts as a medium for the transfer of heat and moisture from one place to another.

Forces Affecting Velocity and Direction of Wind

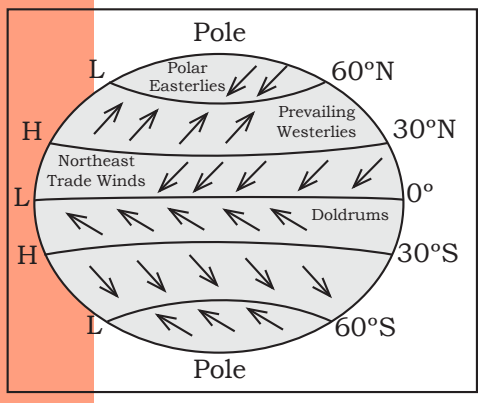
- Air is set in motion due to the differences in atmospheric pressure. The air in motion is called wind. The wind at the surface experiences friction.
- Rotation of the earth also affects the wind movement. The force exerted by the rotation of the earth is known as the Coriolis force.
- The horizontal winds near the earth's surface respond to the combined effect of three forces – the pressure gradient force, the frictional force and the Coriolis force. In addition, the gravitational force acts downward.
  - **Pressure Gradient Force:** It originates due to the difference in the pressure between two places and acts perpendicular to the isobar. Narrowly spaced and widely spaced isobars indicate steep pressure gradient force and gentle pressure gradient force respectively.
  - **Frictional Force:** It is a retarding force exerted by surface in the direction opposite to the direction of wind. It also reduces the Coriolis force.
  - **Coriolis Force:** It is an apparent force produced due to the rotation of earth. This phenomenon was first discovered by the French scientist Coriolis and hence the name. The quantity of the force keeps increasing with increasing distances from the equatorial belt. It deflects the wind rightward in the northern hemisphere and leftward in the southern hemisphere. Due to its deflective power it can also produce gyratory motion. The Coriolis force is directly proportional to the angle of latitude. It is maximum at the poles and is absent at the equator.

Classification of Winds



Planetary Winds

The winds blowing throughout the year from one latitude to another in response to latitudinal differences in air pressure are called "planetary or prevailing winds".



They are global in nature and are the result of the global pressure distribution. Latitudinal variation of atmospheric heating, emergence of pressure belts, the migration of belts following the apparent path of the sun, the distribution of continents and oceans and rotation of earth are the main factors responsible for the origin of the planetary winds.

These winds prevail throughout the year in a constant direction and, transport energy as well as maintain the global heat balance. The planetary winds blowing on the surface of the earth are:

- **Trade Winds:**
  - Trade Winds are extremely steady winds blowing from sub-tropical high pressure areas (30°N and S) towards the equatorial low pressure belt.
  - Trade Winds should have blown from the north to south in the Northern Hemisphere and south to north in the Southern Hemisphere, but, they get deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere due to Coriolis effect and Ferrel's law. Thus, they blow as north eastern trades in the Northern Hemisphere and south eastern trades in the Southern Hemisphere.
  - Trade winds are on shore along the eastern margin of continents and thus harbinger maritime condition especially during summer. These winds converge near equator & form ITCZ. Here these winds rise & cause heavy rainfall.

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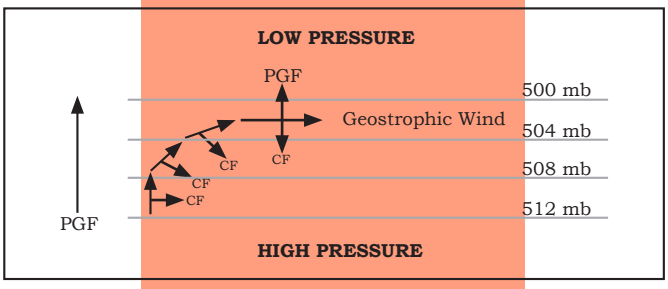
Inter Tropical Convergence Zone (ITCZ)

It is the zone of convergence of the trade winds and the tropical air masses. It is fluctuating and oscillating line characterized by low pressure, rainfall and cloudiness. It is known to shift with the apparent migration of the sun. It shifts by 25° to 30° over the continent and 10° to 15° over the oceanic surface in summer time. It is called NITCZ in the northern hemisphere and SITCZ in the southern hemisphere.

- **Westerly Winds:**
  - Westerly Winds also originate from the subtropical high pressure belt and move towards the subpolar low pressure belt and, prevail between 35° to 60 ° latitudes.
  - Westerly winds are also permanent, but more intense during winters. They transport warm and moist air toward the pole.
  - Westerly Winds cause formation of fronts along sub polar low pressure zone and the transport cyclone toward the western margin.
  - The British type of climate or the western European type of climate is produced by the westerly which causes rainfall throughout the year.
  - In the southern hemisphere, they are uninterrupted and blow with gale force. They are known as roaring forties along 40°S, furious fifties along 50°S and shrieking sixties along 60°S.
- **Polar Easterlies:**
  - The Polar easterlies blow from the Polar high pressure area to the Temperate low pressure area. On their equator ward journey, they are deflected westward to become North easterlies in the Northern hemisphere and South easterlies in the Southern hemisphere.
  - These are extremely cold winds that come from the Tundra and Icecap regions of the poles. The Polar Easterlies are more regular in the southern hemisphere in comparison to the northern hemisphere. These polar cold winds converge with the warm easterlies near 60° latitudes and form the Polar front or Mid Latitude front. This mid-latitude front becomes the centre of the origin of the Temperate Cyclones.

Geostrophic Wind

The upper atmosphere, 2-3 km above the surface, is free from frictional forces and the direction as well as speed of wind is controlled by the pressure gradient force and the Coriolis force only.



When isobars are straight and when there is no friction, the pressure gradient force is balanced by the Coriolis force and the resultant wind blows parallel to the isobar. This wind is known as the geostrophic wind.

Periodic Winds/Seasonal Winds

Periodic winds change their direction periodically with the change in season, e.g., Monsoons, Land and Sea Breezes, Mountain and Valley Breezes.

- **Monsoon Winds:**
  - These are seasonal winds and refer to wind systems that have a pronounced, seasonal reversal of direction.
  - According to 'Flohn', monsoon is a seasonal modification of the general Planetary Wind System. Monsoons cause wet and dry seasons throughout much of the tropics. Monsoons always blow from cold to warm regions. It blows from sea to land during summers & land to sea during winters, due to differential heating of continents & oceans.
  - According to Halley's law, in summers, sun shines vertically over the Tropic of Cancer resulting in high temperature & low pressure in central Asia, while pressure is sufficiently high at the Bay of Bengal & Arabian Sea. This induces air flow from Sea to land & induces heavy rainfall in India & neighbouring countries. In winters, sun shines vertically over the Tropic of Capricorn, hence N-W part of India grows colder than Arabian Sea & Bay of Bengal which results in reversal of monsoon in India. Above theory of differential heating was replaced by shifting of the ITCZ for monsoon in India & neighbouring countries.
- **Land Breeze and Sea Breeze**
  - The land and sea absorb and transfer heat differently due to the difference in their specific heat. The land heats up faster during the day and becomes warmer than the sea. Therefore, warm air rises over the land, giving rise to a low pressure area, whereas the sea is relatively cool and the pressure over the sea is relatively high. The pressure gradient emerging from sea to land due to the difference in the pressure between sea and land during day time triggers the wind to blow from sea to land. This wind is called sea breeze.

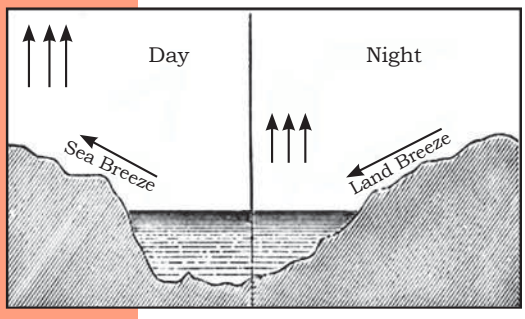


Fig: *Land Breeze and Sea Breeze*

  - During the night, the land loses heat faster and becomes cooler than the sea. Now the pressure gradient is from the land to the sea, which triggers the wind to blow from land to sea. This wind is known as land breeze.

- **Valley and Mountain Breeze**
  - In mountainous regions, the slopes get heated up during the day and air moves upslope. And the wind from the valley blows up the valley to fill the resulting gap. This wind is known as the valley breeze.
  - The upslope winds driven by warmer surface temperatures on a mountain slope than the surrounding air column are known as anabatic winds.
  - During the night, the slopes of mountains get cooled and air over these slopes becomes dense. This dense air descends into the valley which is known as the mountain breeze.
  - The cool air, of the high plateaus and ice fields draining into the valley is called katabatic wind.

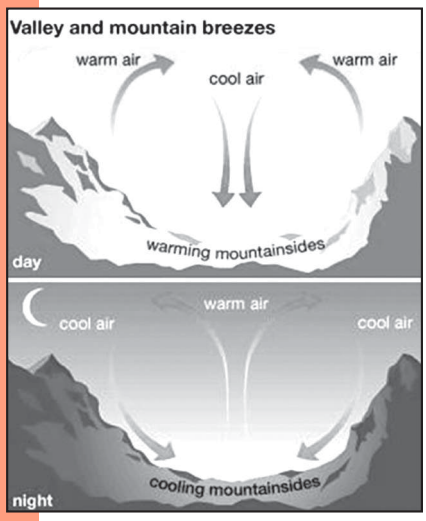


Fig: *Valley and Mountain Breezes*

Local Winds

Local winds are confined to a specific location and are diurnal or monthly in nature. They are characterized by diurnal reversal or appear for a short period of time.

Local winds are produced either due to physiographic features such as mountain & valley or due to distribution of land and sea. They bring diurnal variation in the weather conditions. There are many such winds around the world, some of them cold, some warm, some wet, some dry. There are many hazards associated with these winds as well.

Some of the local winds have been discussed below:

- **Loo:**
  - Loo prevails in the plains of northern India and Pakistan and blows from the west in the months of May and June, usually in the afternoons.
  - Sometimes, it is very hot and dry as its temperature invariably ranges between 45°C and 50°C.
  - Loo is a harmful wind and may cause sunstroke to people.
- **Fohn/Foehn:**
  - Foehn is a hot local wind, which originates during descends of air on the leeward side of a mountain range in the Alps. It is a strong, gusty, dry and warm wind. The temperature of the wind varies between 15°C and 20°C.
  - Fohn is a beneficial wind, which helps animal grazing by melting snow and aids the ripening of grapes.
- **Chinook:**
  - Chinook is a hot and dry wind just like fohn and prevail in USA and Canada along the eastern slopes of the Rockies. They are more common in winter and early spring.
  - Chinook is beneficial to ranchers as it keeps the grasslands clear of snow during much of the winter.
- **Mistral:**
  - Mistral is a cold northwest wind that blows from the Alps over France towards the Mediterranean Sea, channelled through the Rhine valley.

- Mistral is very cold and dry blows with high speed. It is a harmful wind and brings snow storms into southern France.

■ **Sirocco:**
- Sirocco is a hot, dry and dusty winds blowing from the Sahara Desert over central Mediterranean and engulfing North Africa and Southern Europe as well.
- Sirocco arises from a warm, dry, tropical air mass that is pulled northward by low-pressure cells moving eastward across the Mediterranean Sea.
- Sirocco is a harmful wind, which causes dusty dry conditions along the northern coast of Africa, storms in the Mediterranean Sea, and cool wet weather in Europe.

■ **Bise:**
- Bise is a cold, dry wind which blows from the north-east, north or northwest in the mountainous regions of south eastern France and western Switzerland in winter months.
- The bise is accompanied by heavy cloud.

■ **Bora:**
- The bora is a strong, cold and gusty north-easterly wind, which descends to the Adriatic Sea from the Dinaric Alps, the mountains behind the Dalmatian coast (the coast of Croatia).
- The bora begins suddenly and without warning and the cold air typically descends to the coast so rapidly that it has little time to warm up.
- The bora can reach speeds of more than 100 km/h and has been known to overturn vehicles and blow people off their feet.

■ **Harmattan:**
- Harmattan is a dry and comparatively cool wind which blows from the east or north-east on the coast of North Africa between Cape Verde and the Gulf of Guinea during the dry season (November to March).
- Harmattan brings dust and sand from the Sahara Desert, often in sufficient quantity to form a thick haze which hinders navigation on rivers.
- Dust and sand are sometimes carried many hundreds of kilometres out to sea by these winds.

■ **Khamsin:**
- Khamsin is a hot, dry, dust-laden, southerly wind over Egypt, the Red Sea and eastern parts of the Mediterranean Sea ahead of eastward-moving depressions.
- Khamsin occurs during the period February to June, being most frequent in March and April.
- The Khamsin is a Sirocco wind, whose name comes from the Arabic word for 'fifty', which is approximately the length of time the wind blows for. In the nineteenth Century, the plague was worst in Egypt when the Khamsin was blowing.

■ **Pampero:**
- Pampero is the name given to severe line squalls in Argentina and Uruguay, particularly in the Rio de la Plata area.
- Pampero are associated with marked cold fronts and are usually accompanied by rain, thunder and lightning, a sharp drop in temperature and a sudden change of wind direction from northerly or north-westerly to southerly or south-westerly.
- Pampero are most likely to occur during the period June to September.