Content

Credits

The latest Indian Edition of Certificate Physical and Human Geography has been referred while preparing this PDF notes. All the facts, information and data has been taken from the textbook itself. The facts, information and data has been organised in a reading friendly manner for students so that they can understand it easily.

Chapter 13 – Weather

The Difference Between Weather and Climate:

- **Climate** mean the **average** atmospheric conditions of an area over a considerable time whereas climate mean the average atmospheric conditions of an area over a minimum period of 35 years is desirable.
- This involves the systematic observation, recording and processing of the various elements of climate such as rainfall, temperature, humidity, air pressure, winds, clouds and sunshine before any standardization of the climatic means or averages can be arrived at.
- The **degree of variability** in the climate or weather of a country also differs, the climate of temperate latitudes is far more variable than that of the tropics.

The Importance of Climate and Weather:

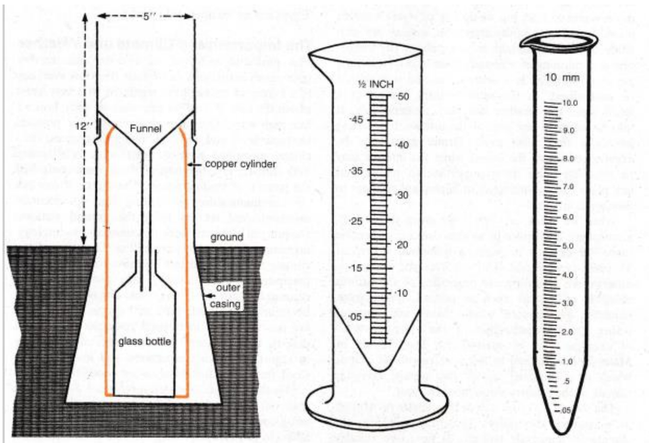
- Forces of nature have regulated to a very great extent the sort of food we eat, what we wear, how we live and work. Our mental alertness, our physical characteristics and even our racial differences when closely examined have at least some relationship with climate.
- The direction of winds once controlled the pattern of trading routes. The safety of modern air communications is closely tied to accurate meteorological reports from the ground stations.
- Conditions of temperature, precipitation and humidity may promote or dis-courage the growth of fungus and diseases which may be injurious to both men and crops.
- Death rates are normally high in tropical countries and low in deserts, because germs are not transmitted readily in regions of high temperature and low humidity. Cool, fresh mountain air is always good for health.
- Though men are still unable to tame the forces of natures such as floods, droughts, typhoons or hurricanes, a sound knowledge of the trends or the weather system can often help to avoid or reduce the seriousness of the calamities.
- Professional meteorologists are able to **forecast** the weather fairly accurately from local observation.
- To-day farmers are becoming more and more depend ant upon meteorological services. A knowledge of the likely weather of a place will be useful for a farmer to plan his work for the season or the year.
- Frequent agricultural bulletins issued by the Meteorological Office will assist farmers to take due precautions against frosts, hail, heavy snowfall or a period of possible drought.
- Modern air transport, military operations, geographical expeditions, even important games and outings, often take due consideration of meteorological reports. A fair knowledge of the weather is not only useful but often essential.

The Elements of weather and climate:

To collect various climatic data and to prepare maps and charts of them, the following elements of climate are normally observed and measured by weather instruments:

1. Rainfall:

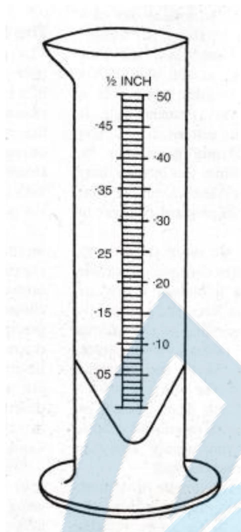
- Rainfall including other forms of **precipitation** (snow, sleet and hail) is always measured by a metal instrument called a **Rain gauge.**



(a) A rain gauge (b) Ordinary measuring cylinder (c) A calibrated taper measure

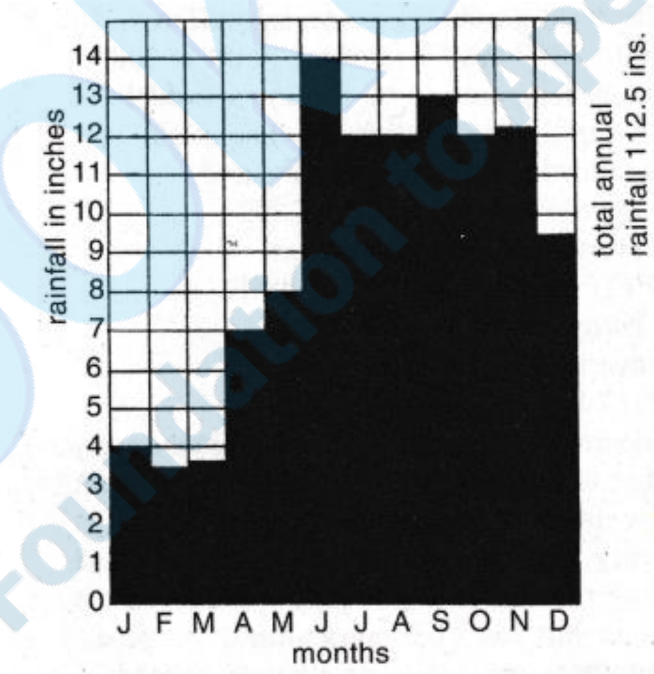
- It consists of a copper cylinder with a metal funnel either 5 inches or 8 inches in diameter, which leads into a smaller copper container or a glass bottle.

- The hole in the funnel that leads down to the container is very small so that evaporation of the collected rain is minimised.
- The gauge should be at least one foot above the ground and firmly fastened, to avoid splashing. The instrument should be sited well away from tall buildings, high trees and other objects which would shelter it.
- The measurement of the rainfall is done by removing the funnel, emptying the rain in the container into a **graduate cylinder** with a 1 $^1/_2$ inch diameter.
- The reading should be done at eye-level and to an accuracy of 0.01 inch. For greater accuracy, a special kind of **taper measure**, which tapers bottom may be used.



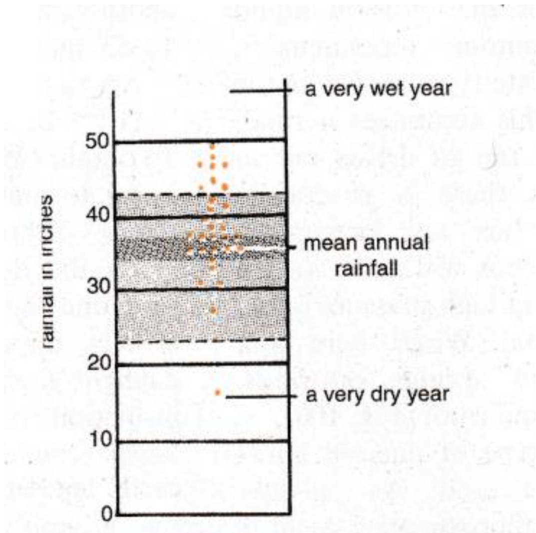
(b) Ordinary measuring cylinder

- It gives an accuracy up to 0.005 inch. An inch of rainfall means the amount of water that would cover the ground to a depth of 1 inch, provided none evaporated, drained off or percolated away.
- For meteorological recording, a rain-day is reckoned as a period of 24 hours with at least 0.01 inch or more rain being recorded. If the amount exceeds 0.04 inch, it is considered a wet day.
- The rain gauge must be examined every day. In temperate regions, snowfall is carefully melted by warming the funnel and then measured. For all practical purposes 10 to 12 inches of snow may be considered as equivalent to 1 inch of rain.
- The daily records of rainfall will be added at the end of the month to find the total rainfall for that month. The total for each month is again added at the end of the year to find the annual rainfall.
- The **mean annual rainfall** is obtained from the averages of annual rainfall taken over a long period of say 35 years.
- For plotting in rainfall maps, places having the same mean annual rainfall are joined by a line called an **isohyet,** as shown in many atlases.
- Rainfall can also be graphically depicted as shaded rainfall columns, one for each month of the year, illustrates the monthly rainfall regime over a year for 35 years.



A rainfall histogram showing the monthly rainfall of Kota Kinabalu, E. Malaysia

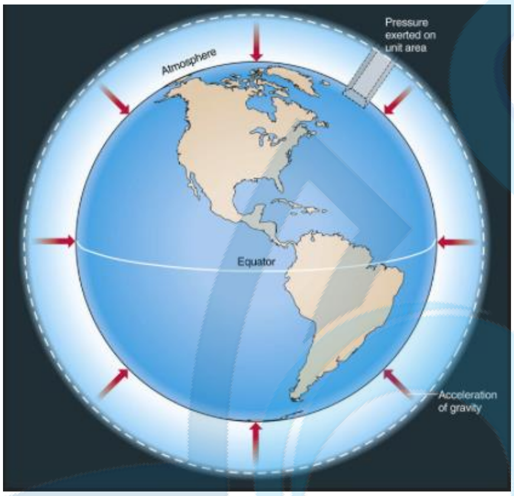
- In dispersal diagrams, one dot for each year for as many years as possible, shows at a glance the range of dry and wet years for 35 years.



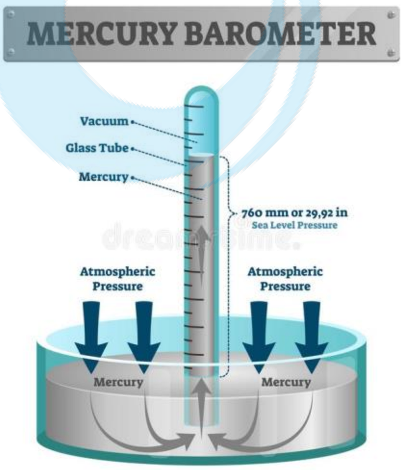
A rainfall dispersal diagram for Gibraltar for 35 years

2. **Pressure:**

- Air is made up of a number of mixed gases and has weight. It therefore exerts a pressure on the earth's surface which varies from place to place and from time to time.

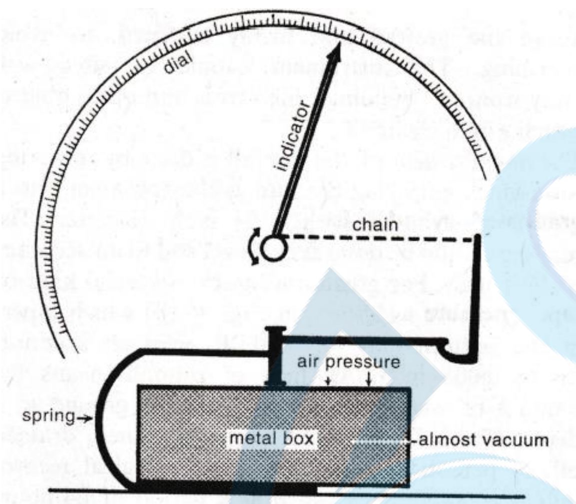


- The instrument for measuring pressure is a **Barometer,** invented by the scientist Galileo and his assistant Torricelli in 1643.



- The ordinary mercury barometer consists of a long glass tube, sealed at the upper and open at the lower end. The lower end is inverted in a bowl of mercury whose surface is exposed to the air.
- Variations in the atmospheric pressure on the mercury surface are balanced by the column of mercury in the glass tube.
- This gives the pressure of the air and can be read off quickly from the scale on the glass tube. Any liquid could be used for this purpose, but mercury has been chosen because it is the heaviest liquid known.
- If ordinary water were used, the corresponding column for normal atmospheric pressure would be 34 feet! At sea level, the mercury column is 2g.g inches, or 760mm.
- If the pressure increases, the air pressing on the surface will force up the mercury column to about 31 inches (high pressure). When the pressure decreases, as less air presses on the surface, the mercury column will drop about 28 inches (low pressure).
- As pressure is a **force**, it is more appropriate to measure it in terms of a unit of force. A new unit known as the **millibar(mb)** was adopted by meteorological stations in 1914.
- A normal atmospheric pressure equivalent to 14.7 lb. per square inch in weight or a reading of 29.9 inches of mercury in the column is 1013 millibars.
- on maps places of equal pressure are joined by lines called **isobars.** In temperate latitudes, pressure changes are very rapid in the formation of cyclones and anticyclones. In normal circumstances, they vary from 960 mb. to 1,040 mb.
- Pressure readings vary with a number of factors. A sea-level reading of 30 inches will be halved on mountainous regions of 3.5 miles above sea level.
- This is because as on **ascends** there is less air above and so the weight, or **pressure Is less.**
- The barometer is also sensitive to gravitational forces at different **latitudes.** The mercury itself also expands with an increase in **temperature.**

- Since a mercury barometer that dips in liquid mercury is inconvenient for outdoor measurement, a more portable but less accurate type known as the **aneroid barometer** is used.
- This comprises a small metal container, with most of the air driven out to form almost a vacuum.
- As there is practically no pressure at all inside the box, any increase in pressure on the outside of the box will cause the lid to move inwards thus registering high pressure by an indicator on the revolving dial.
- When there is a decrease in pressure, the lid springs outwards, registering low pressure by the indicator.

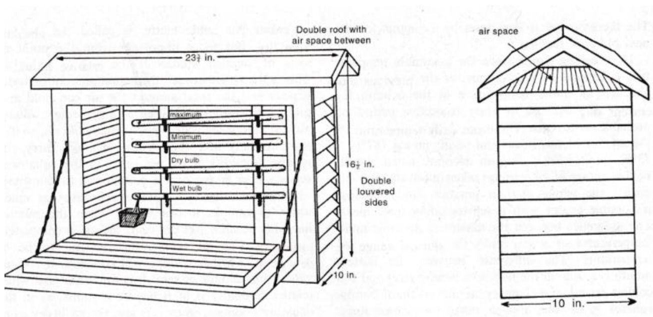


An aneroid barometer

- In aeroplanes, a modified type of aneroid barometer called an **altimeter** is used.
- As pressure decreases with altitude at an approximate rate of 1 inch drop in the mercury reading for every 900 feet ascent, the altimeter gives the reading in feet for height attained instead of millibars or inches.
- With this, the pilot will be able to tell the altitude of the plane above sea level. For a continuous record of pressure changes, as is sometimes required, the self-recording **barogram** is used.

3. **Temperature:**

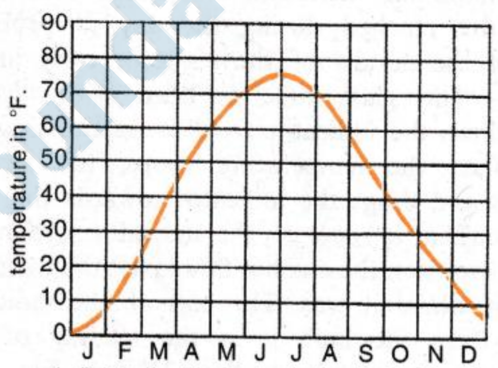
- Temperature is a very important element of climate and weather. The instrument for measuring temperature is the **Thermometer** which is a narrow glass tube filled with mercury or alcohol. It works on the principle that mercury expands when heated and contracts when cooled.
- on thermometers, temperatures are marked in one of two ways. In °F (Fahrenheit) the freezing-point is 32°F and the boiling-point is 212°F.
- For most scientific purposes the Centigrade °C scale is preferred. Its freezing-point is 0°C and its boiling-point is 100°C.
- As the degree of 'hotness' varies tremendously from one place to another, the **siting** of the instrument is very important.
- A temperature taken in open daylight is very high, because it measures the direct insolation of the sun. It is better described as 'temperature in the sun'.
- For agricultural purposes, **earth temperature** is taken at various depths in the ground. The thermometer is enclosed in a special glass tube and the bulb is embedded in paraffin wax, so that they are less sensitive to abrupt temperature changes.
- To assess the possible damages done by ground frosts to crops in temperate latitudes, **grass temperatures** are also taken.
- But the temperatures that we are so accustomed to in climatic graphs are shade temperatures, that is the temperatures of the **air.**
- Precautions therefore must be taken to exclude the intensity of the sun's radiant heat. This is done by placing the thermometers in a standard' meteorological shelter known as the **Stevenson Screen.**



A Stevenson Screen

- It consists of a white wooden box raised 4 feet above the ground on stilts. The roof is double-layered with an intervening air space to exclude much of the direct rays of the sun. The sides of the box are louvred like 'venetian blinds' to allow free circulation of the air.

- One side of the screen is hinged to serve as a door which can be opened and closed to give access to the instruments kept inside. The floor of the screen is also louvred.
- The Stevenson Screen normally carries maximum and minimum thermometers, dry and wet bulb thermometers. Larger ones may also contain a self-recording **Thermogram and Hygrogram.**
- Maximum and minimum temperatures are measured by the **Maximum and minimum thermometer.**
- They are either in the form of separate thermometers or joined in a U-shaped glass tube as in the Six's thermometer.
- The maximum thermometer records the **highest temperature** reached during the day. The mercury in the closed glass tube expands when the temperature rises. It pushes a metal indicator up the tube and this stays at the maximum level when the temperature drops
- The end of the indicator nearest the mercury, gives the reading of the maximum temperature, which is 87°F. in this case. To reset the mercury for the next day's reading, swing it hard or draw the indicator back by a magnet.
- The minimum thermometer records the **lowest temperature** reached during the day, it Probably occurs in the middle of the night or early in the morning.
- The glass tube is filled with **alcohol** which allows the indicator to slide freely along the tube. When the temperature drops, the alcohol contracts and drags the indicator towards the bulb by the surface tension of the indicator.
- When the temperature rises, the alcohol flows past the indicator leaving it where it was. The end of the indicator farthest from the bulb gives the reading of the minimum temperature, which is 73°F. The thermometer is then reset by a magnet for the next 24 hours' reading.
- In recording temperature, the maximum temperature is entered in the column for the **previous day** and the minimum temperature in the column for **current day** because of their respective period of probable occurrence.
- The **mean daily temperature** the average of maximum and minimum e.g., (87°F+73°F)/2 = 80°F. But an accurate mean should be the average of 24 reading taken at hourly intervals during the whole day. In practice this is almost impossible except with a self-recording instrument.
- The difference between the maximum and minimum temperatures of a day gives the **diurnal range** of temperature.
- The difference between the hottest month (i.e., July in the northern hemisphere) and the coldest month (i.e., January in the northern hemisphere) gives the annual range of temperature.
- In diagrammatic representations, monthly mean temperatures are shown in simple temperature graphs or in temperature distribution maps as **isotherms.**



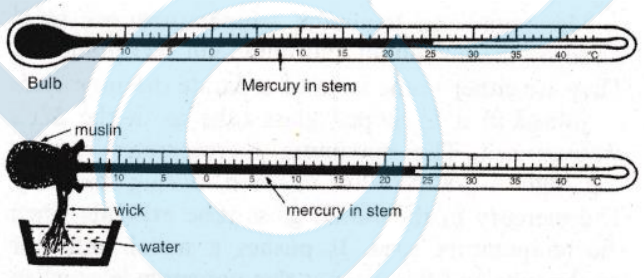
J F M A M J J A S O N D Range
F°. 8 14 30 47 60 71 77 75 61 48 29 14 69°
Statistical data of temperature of Mukden
(Mean monthly temperatures from January to December)
Mean annual temperature is 44°F.

A temperature graph of Mukden, Manchuria (42°N., 123°E.)

- For these maps temperatures are **reduced to sea level-** that is shown as if the recording station were at sea level.
- Temperatures decrease at the rate of 1°F. drop in temperature for 300 feet ascent in altitude, so for highland stations a higher temperature is shown than was actually recorded.

4. Humidity:

- Humidity is a measure of the **dampness of** the atmosphere which varies greatly from place to place at different times of day.
- The actual amount of water vapour present in the air, which is expressed in grams per cubic metre, is called the **absolute humidity.** But more important from the point of view of weather studies is the **relative humidity.**
- This is the ratio between the actual amount of water vapour and the total amount the air can hold at a given temperature, expressed as a percentage.
- Warm air can hold more water vapour than cold air, so if it contains only half the amount it could carry, the relative humidity is 50 per cent.
- In the equatorial regions, over 80 per cent is common in the morning, which means the air contains four-fifths as much water vapour as it can carry.
- When the relative humidity reaches 100 per cent, the air is completely **saturated**. The air temperature is said to be at **dew-point.**
- Further cooling will condense the water vapour into clouds or rain. It is thus clear that when relative humidity is high the air is moist, as in the equatorial regions; when it is low, the air is dry as in the deserts.
- The instrument for measuring relative humidity is the **Hygrometer,** which comprises **wet and dry bulb thermometer** placed side by side in the Stevenson Screen.

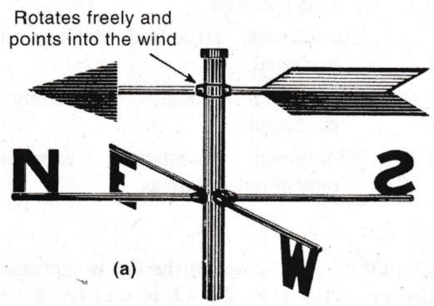


The hygrometer consisting of wet and dry bulb thermometers

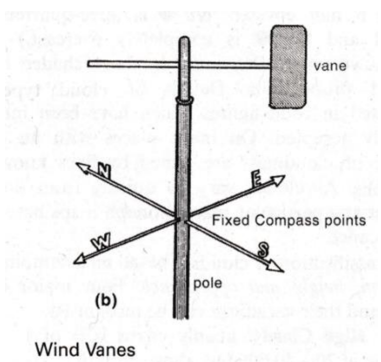
- The dry-bulb is, in fact, the ordinary thermometer that measures the shade temperature mentioned earlier. The wet-bulb is kept wet by a wick that dips into a reservoir of distilled water.
- When there is not saturated evaporation, which produces a **cooling effect**, takes place from the moist wick.
- The wet bulb therefore always shows a lower reading than the dry bulb. With reference to prepared tables for calculating relative humidity, under the difference column of the dry and wet bulb reading, the relative humidity can be obtained as a percentage.
- Normally a large difference indicates a low R.H. and a small difference a high R.H. If both have the same reading, R.H. is 100 per cent; the air is saturated.

5. Winds:

- Wind is **air in motion** and has both direction and speed. Unlike other elements in climate such as rain, snow or sleet, winds are made up of a series of gusts and eddies that can only be felt but not seen.
- The instrument widely used for measuring **wind direction** is a **wind vane** or weather cock. As wind direction is always blocked by trees and tall buildings, weather cocks and wind vanes need to be erected in an exposed position, to get a true direction.
- It is made up of two parts (a) and (b). One part is an arrow or vane on the top, which is free to move with the prevailing wind.

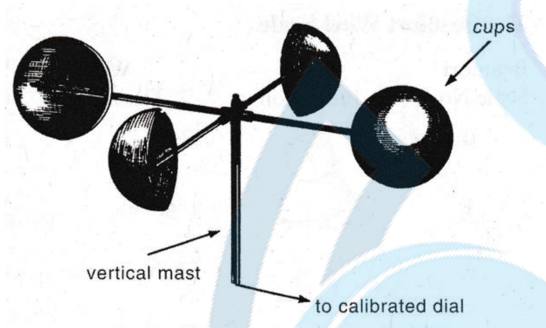


- The other part with the four compass points is stationary and shows in which direction the wind is moving.



Wind Vanes

- Winds are always named **from the direction they blow,** an east wind is one that blows from east to west and a south-west wind is one that blows from the south-west.
- Most of the weather cocks that we see on church spires and country buildings seldom give a correct indication of wind directions.
- They are either too low or are blocked by taller structures nearby. The direction of smoke-drift or flag movements in fairly open spaces provides the most reliable indication of wind direction.
- Sometimes a piece of woven cloth with a tail is fixed to the top of a high pole and drifts freely in mid-air. This is another way of indicating wind direction.
- The speed of wind is usually measured by an **anemometer.** It consists of three or four semi-circular cups attached to the ends of horizontal spokes mounted on a high vertical spindle.



Simplified sketch to illustrate the main features of a wind anemometer

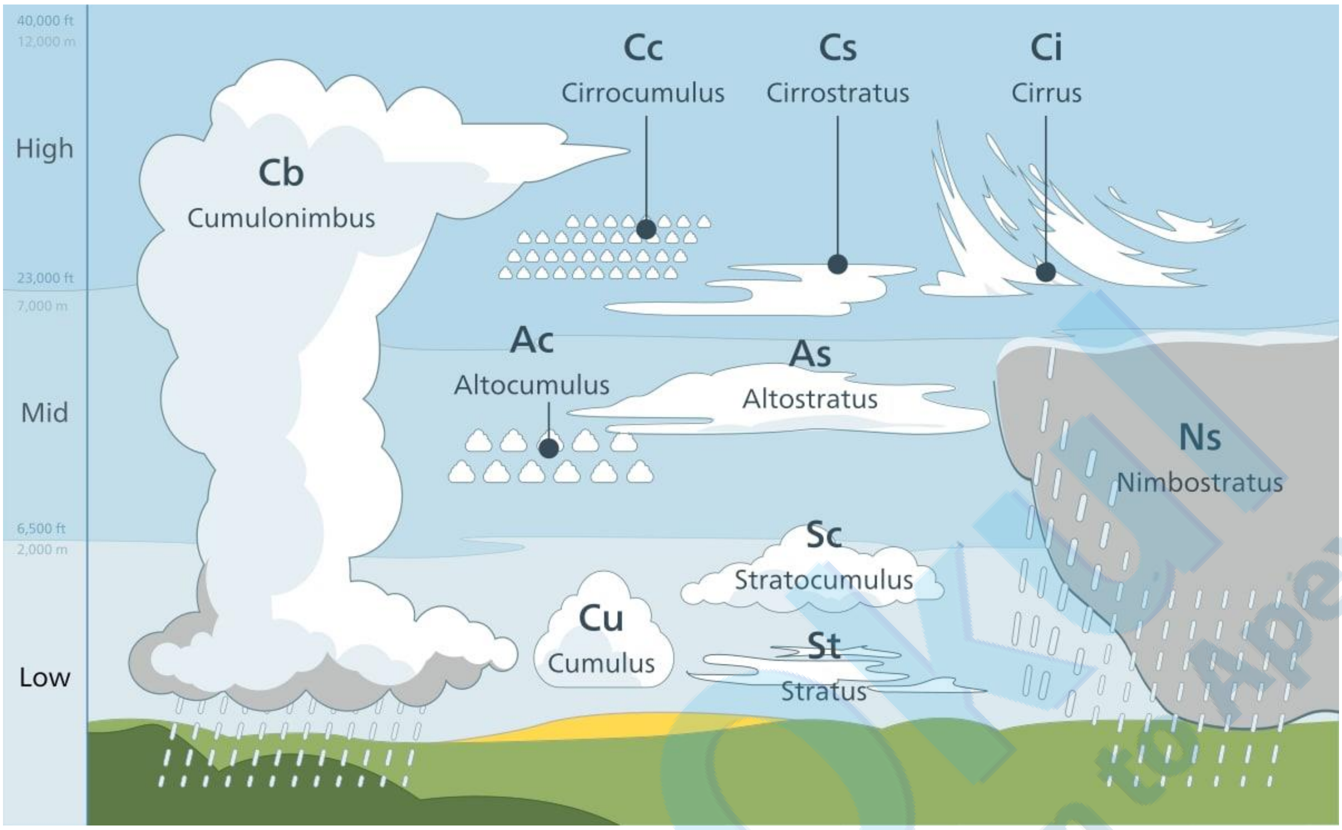
- As the concave sides of the cups offer greater resistance to the winds, the horizontal spokes will rotate, moving a central rod which transmits the velocity (speed) of the wind in miles per hour to an electrically operated dial.
- But the speed recorded is not absolutely accurate because after the winds have abated, the rotation continues due to its own momentum. With some modifications, the anemometer can also record wind directions.
- Since an anemometer is not easily available, a little practice of local wind observations will help us to assess the speed of winds.
- The best guide is obtainable from the **Beaufort wind scale** which was devised by Admiral Beaufort in 1805 for estimating wind speed.

6. Sunshine:

- The amount of sunshine a place receives, depends on the seasons, a factor determined by latitude and by the position of the earth in its revolution around the sun.
- In the meteorological station, sunshine duration is recorded by a **sun-dial,** 4 Inches in diameter, through which the sun's rays are focussed upon a sensitized card, graduated in hours.
- A line is made on the card when it is sufficiently heated, but not when the rays are faint. on maps places with equal sunshine duration are joined by **isohels.**

7. Clouds:

- when air rises, it is cooled by expansion. After dew-point has been reached cooling leads to **condensation of water vapour** in the atmosphere.
- Tiny droplets of water vapour which are too small to fall as rain or snow (less than 0.001 cm., approximately 0.0005 inches in radius) will be suspended in the air and float as **clouds.**
- For meteorological purposes, the amount of **clouds-cover** in the sky is expressed in **eights or oktas** (e.g., 2/8 ◔ is quarter covered, 4/8 ◑ is half covered, 6/8 ◕ is three-quarters obscured and 8/8 ● is completely overcast.
- Details of **cloud type** are indicated in code figures which have been internationally accepted. On maps places with an equal degree of cloudiness are joined by lines known as **isonephs.**
- The **classification of clouds** is based on a combination of form, height and appearance. Four major cloud types and their variations can be recognised:



1. **High clouds**: mainly cirrus (Ci) of feathery form at 20-40,000 feet above ground.

a) **Cirrus (Ci)** This looks fibrous and appears like wisps in the blue sky; it is often called 'mares' tails'. It indicates fair weather, and often gives a brilliant sunset.

b) **Cirrocumulus (Cc)** This appears as white globular masses, forming ripples in a 'mackerel sky'.

c) **Cirrostratus (Cs):** This resembles a thin white sheet or veil, the sky looks milky and the sun or moon shines through it with a characteristic 'halo'.

2. **Medium clouds**: mainly alto (Alt) or middle-height clouds at 7-20,000 feet.

a) **Altocumulus (Alt-Cu)**: These are woolly, bumpy clouds arranged in layers and appearing like waves in the blue sky. They normally indicate fine weather.

b) **Altostratus (Alt-St):** These are denser, greyish clouds with a 'watery' look. They have a fibrous or striated structure through which the sun's rays shine faintly.

3. **Low clouds:** mainly stratus or sheet clouds below 7,000 feet.

a) **Stratocumulus (St-Cu):** This is a rough, bumpy cloud with the waves more pronounced than in altocumulus. There is great contrast between the bright and shaded parts.

b) **Stratus (St):** This is a very low cloud, uniformly grey and thick, which appears like a low ceiling or highland fog. It brings dull weather with light drizzle. It reduces the visibility of aircraft and is thus a danger.

c) **Nimbostratus (Ni-St):** This is a dark, dull cloud, clearly layered, and is also known as a 'rain cloud'. It brings continuous rain, snow or sleet.

4. **Clouds with great vertical extent**: mainly cumulus or heap clouds with no definite height (2-30,000 feet).

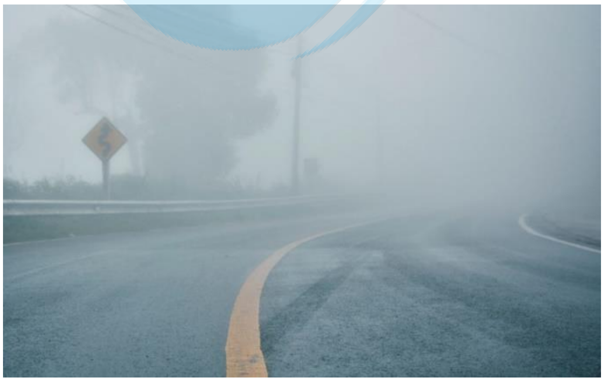
a) **Cumulus (Cu):** This is a vertical cloud with a rounded top and horizontal base, typical of humid tropical regions, associated with up-rising convectional currents. Its great white globular masses may look grey against the sun but it is a 'fair weather cloud'.

b) **Cumulonimbus (Cu-Ni):** This is an overgrown cumulus cloud, extending for a tremendous vertical height from a base of 2,000 feet to over 30,000 feet. Its black and white globular masses take a fantastic range of shapes. Its cauliflower top often spreads out like an anvil. This is frequently seen in tropical afternoons. It is also referred to as a 'thunder-cloud' and brings convectional ram, accompanied by lightning and thunder.

Other Elements pertaining to visibility: other elements affecting visibility include haze, mist and fog.

c) **Haze:** This is caused by smoke and dust particles in industrial areas or may be due to unequal refraction of light in air of different densities in the lower atmosphere. The term is usually used in connection with the **reduction of visibility** in regions of **low humidity,** less than 75 per cent. when visibility is less than 1 1/4 miles, haze is present.

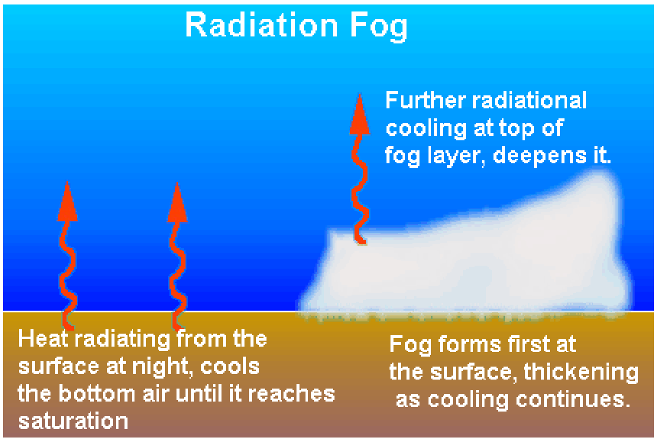
b) Mist: The condensation of water vapour in the air causes small droplets of water to float about forming clouds at ground level called **Mist.** It reduces visibility to about 1,000 metres or 1,100 yards. Unlike haze, mist occurs in **wet air,** when the relative humidity is over 75 per cent.



c) Fog: ordinary fog is due to water condensing on dust and other particles like smoke from houses and factories. It only occurs in the **lower starta** of the atmosphere as a sort of dense 'ground cloud'. The visibility in fog is even less than 1,000 metres.

In industrial areas, like those of the Black Country and northern England, very thick **smoky fog** is formed, called **Smog.** The visibility may be reduced to 220 yards or even less.

- Fogs that occur on hills are called **hill fogs.** They are most common in the morning, even in the tropics, and disperse when the sun rises.
- In temperate lands, when days are hot and nights are clear and still, fogs may also result from cooling of the land surface by radiation.
- The lower layers of the air are chilled and water vapour in the atmosphere condenses to form **radiation fog or land fog.**



- When the cooling surface is over the sea or when a damp air stream is brought into contact with a cold current **sea fog** is formed.
- It varies in depth and thickness. Some sea fogs are so shallow and light that the masts of ships can be seen protruding above them.

Generally speaking, fogs are more common overseas than lands, and are most prevalent over coastal areas. The dry interiors experience haze or mist. Dense fogs are more likely to occur in the high and middle latitudes rather than the tropics.

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Chapter 14 – Climate

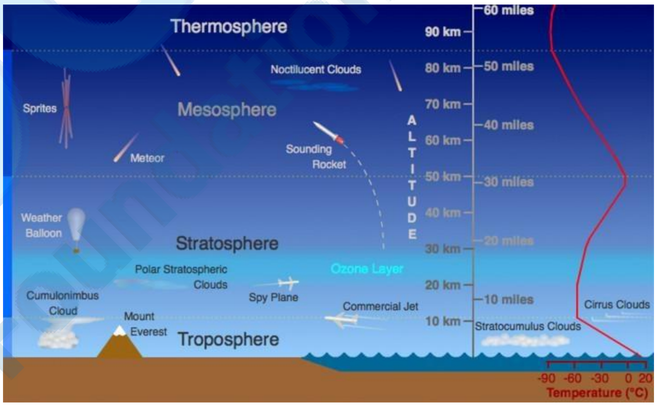
The Atmosphere

- The atmosphere is made up of gases and vapour, and receives incoming solar energy from the sun' giving rise to **climate.**
- We live at the bottom of this indefinite layer of atmosphere where the air is densest. On moving further up, the air becomes lighter. The end boundary of atmosphere is still not clearly defined.
- The lowest layer, in which the **weather** is confined, is known as the **troposphere.** It extends from the earth's surface for a height of 6 miles, and within it, temperature normally falls with increasing altitude.
- The climatic elements such as temperature, precipitation, clouds, pressure and humidity within the troposphere account for the great variations in local climate and weather that play such a great part in our daily lives.
- From analyses, it is found that the lower part of the atmosphere contains a consistent proportion of certain gases: 78 per cent of nitrogen, 21 per cent of oxygen, 0.03 per cent of carbon dioxide and minute traces of argon, helium and other rare gases.

Permanent Gases of the Atmosphere

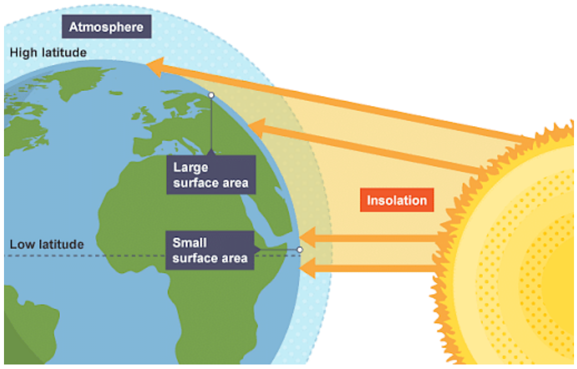
Constituent	*Formula*	*Percentage by Volume*
Nitrogen	N_2	78.08
Oxygen	O_2	20.95
Argon	Ar	0.93
Carbon dioxide	CO_2	0.036
Neon	Ne	0.002
Helium	He	0.0005
Krypto	Kr	0.001
Xenon	Xe	0.00009
Hydrogen	H_2	0.00005

- In addition, it has an unpredictable proportion of **water,** existing either as a **gas** like water vapour, a **liquid** like rain, clouds and sleet or a **solid** like snow and hailstones, as well as other solid particles like smoke and dust.
- It is because of the variable water content of the atmosphere that we have such great contrasts in weather and climate over different parts of the world.
- Above the troposphere lies the **stratosphere** or the upper layer of the atmosphere. It extends upwards for another 50 miles or even more.
- It is not only very cold, but cloudless, with extremely thin air and without dust, smoke or water vapour but there are marked seasonal temperature changes.
- Beyond the stratosphere is the **ionosphere** which goes several hundred miles up. It has electrically-conducting layers which make short-wave radio transmission possible over long distances.
- Modern artificial satellites, launched in the upper strata of the atmosphere, as well as balloons are used to transmit back to earth valuable information regarding the conditions of the atmosphere.

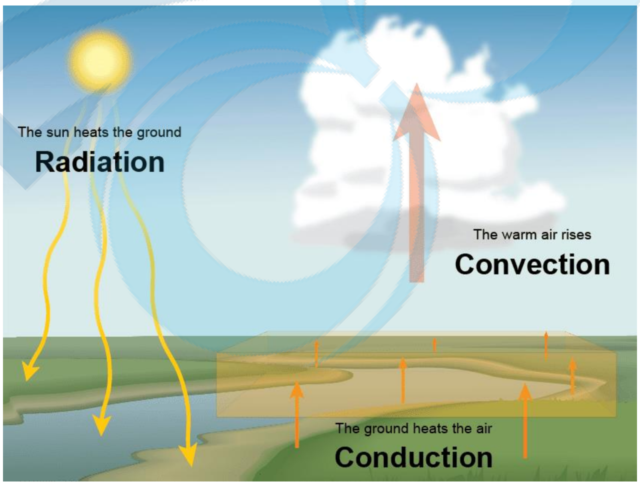


Insolation:

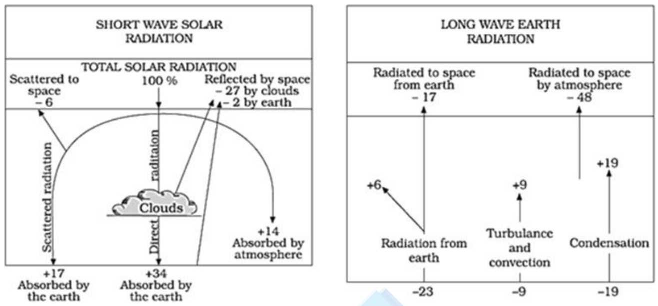
- The only **Source of energy** for the earth's atmosphere comes from the **Sun** which a surface temperature of more than 10,800°F.
- This energy travels through space for a distance of 93 million miles and reaches us as **solar energy or radiant energy** in the process called **insolation.**



- This radiation from the sun is made up of three parts, the visible **'white' light** that we see when the sun shines and the less visible **ultra-violet and infra-red rays.**
- The visible 'white' light is the most intense and has the greatest influence on our climate. The ultra-violet rays affect our skin and cause sun-burn when our bare body is exposed to them for too long a period.
- The infra-red rays can penetrate even dust and fog and are widely used in photography. Only that part of the sun's radiation which reaches the earth is called insolation.
- It is estimated that of the total radiation coming to us, 35 per cent reaches the atmosphere and is directly **reflected** back to space by dust, clouds and air molecules. It plays practically no part in heating the earth and its atmosphere.
- Another 14 per cent is **absorbed** by the water vapour, carbon dioxide and other gases.
- Its interception by the air causes it to be 'scattered' and 'diffused' so that the visible rays of the spectrum between the ultra-violet and infra-red give rise to the characteristic **Blue sky.**
- The remaining 51 per cent reaches the earth and warms the surface. In turn the earth warms the layers of air above it by direct contact or **conduction,** and through the transmission of heat by upward movement of air currents or **convection.**



- This **radiation** of heat by the earth continues during the night, when insolation from the sun cannot replace it. The earth-surface therefore cools at night.



- The rate of heating differs between land and water surfaces. Land gets heated up much more quickly than the water.
- Because water is transparent heat is absorbed more slowly and because it is always in motion, its absorbed heat is distributed over a greater depth and area. Thus, any appreciable rise in temperature takes a much longer time.
- On the other hand, the opaque nature of land allows greater absorption but all the radiant heat is concentrated at the surface, and temperature rises rapidly. Because of these differences between land and water surfaces land also cools more quickly than water.

Elements of Climate and Factors Affecting them:

- Of the various climatic elements, temperature, precipitation, pressure and winds are the most important because of their far-reaching global influences.
- These elements and their distribution, whether horizontal from equatorial to polar regions, or vertical from ground to atmosphere, are in one way or another affected by some or all of the climatic factors: latitude, altitude, continentality, ocean currents, insolation, prevailing winds, slope and aspect, natural vegetation and soil.

Temperature

The Importance of Temperature:

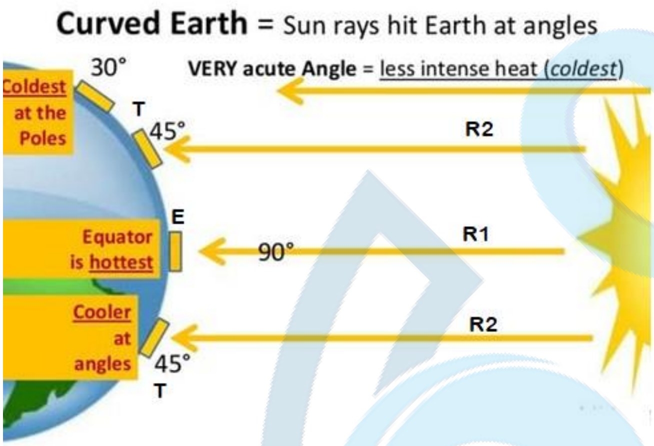
1. Temperature influences the actual amount of **water vapour** present in the air and thus decides the moisture-carrying capacity of the air.
2. It decides the rate of **evaporation** and **condensation,** and therefore governs the degree of stability of the atmosphere.

3. As **relative humidity,** is directly related to the temperature of the air, rt affects the nature and types of **cloud formation and precipitation.**

Factors influencing Temperature:

1. **Latitude:**

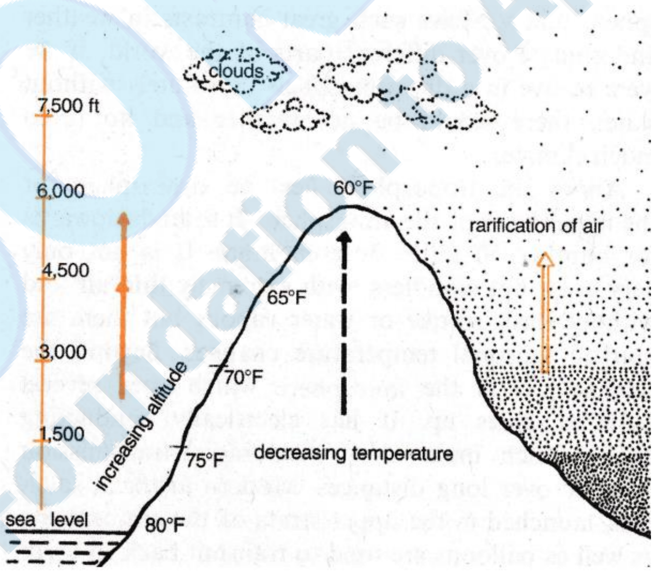
- Due to the earth's inclination, the mid-day sun is almost over-head within the tropics but the sun's rays reach the earth at an angle outside the tropics. Temperature thus diminishes from equatorial regions to the poles.
- It shows two bands of rays coming from the sun to two different latitudes on the earth's surface. Band R1 falls **vertically** over the equatorial latitudes on surface E. Band R2 falls **obliquely** over the temperate latitudes on surface T.



- R1 travels through a **shorter distance** and its concentrated solar insolation heats up a smaller surface arca; temperature is thus high.
- on the other hand, R2 travels through a **longer distance** and much of its heat is absorbed by clouds, water vapour and dust particles. Its oblique ray has to heat up a large area, temperature is therefore low.

2. **Altitude:**

- Since the atmosphere is mainly heated by conduction from the earth, it can be expected that places nearer to the earth's surface are warmer than those higher up. Thus temperature decreases with increasing height above sea level.
- This **rate of decrease with altitude (lapse rate)** is never constant, varying from place to place and from season to season. But for all practical purposes, it may be reckoned that a fall of 1°F. occurs with an ascent of 300 feet or 0.6°C. per 100 metres. It is usually more in summer than in winter.
- For example, in temperate latitudes, in summer, an ascent of only 280 feet will cause the temperature to drop by 1°F., whereas in winter it requires 400 feet.
- Similarly, the lapse rate is greater by day than at night, greater on elevated highlands than on level plains. In tropical countries where the sea level temperature is 80°F., a town that is located at a height of 4,500 feet.



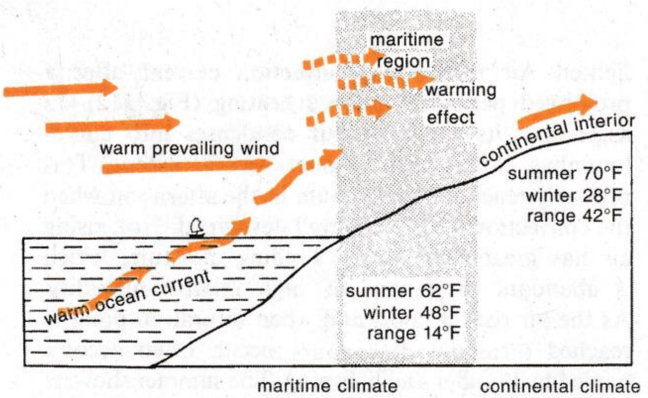
The lapse rate. The effect of altitude on mean annual temperature in a tropical area

3. **Continentality:**

- Land surfaces are heated more quickly than water surfaces, because of the higher specific heat of water.
- In other words, it requires only one-third as much energy to raise the temperature of a given volume of land by 1°F. as it does for an equal volume of water.
- This accounts for the warmer summers, colder winters and **greater range** of temperature of continental interiors as compared with maritime districts.

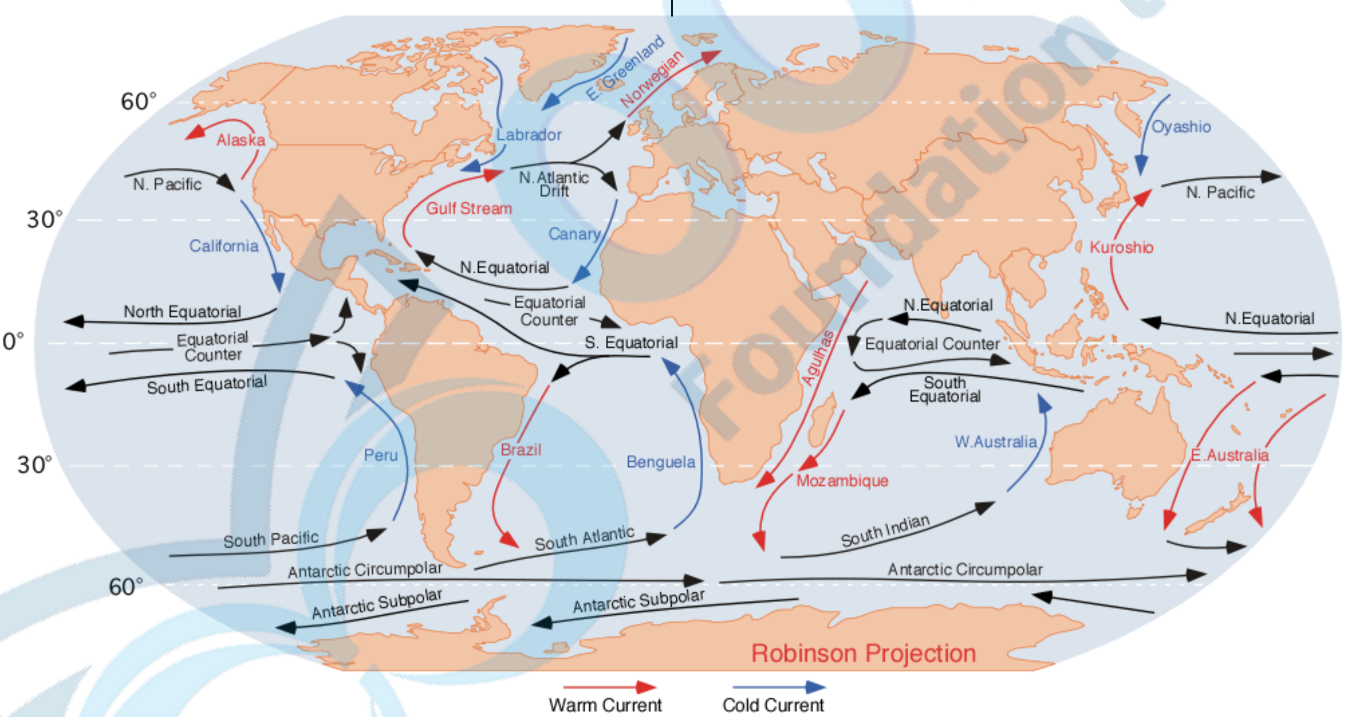
4. Ocean currents and winds:

- Both ocean currents and winds affect temperature by **transporting** their heat or coldness into adjacent regions.



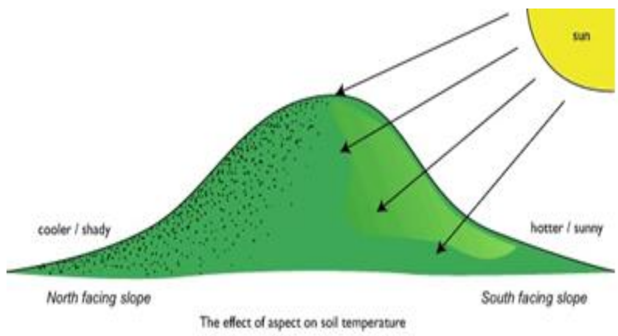
The warming effect of warm ocean currents and prevailing winds on coastal regions with a Maritime climate in temperate latitudes

- Ocean currents like the Gulf Stream or the North Atlantic Drift warm the coastal districts of western Europe keeping their ports ice-free.
- Ports located in the same latitude but washed by cold currents, such as the cold Labrador Current off north-east Canada, are frozen for several months.
- Cold currents also lower the summer temperature, particularly when they are carried landwards by on-shore winds.
- On the other hand, on-shore Westerlies, convey much tropical warm air to temperate coasts, especially in winter. The Westerlies that come to Britain and Norway tend to be cool winds in summer and warm winds in winter and are most valuable in moderating the climate.
- Local winds, e.g., Fohn, Chinook, Sirocco, Mistral, also produce marked changes in temperature.

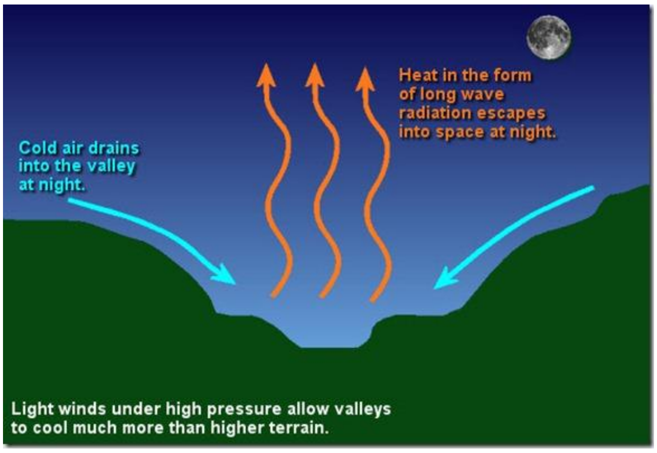


5. Slope, shelter and aspect:

- A **steep slope** experiences a more rapid change in temperature than a gentle one.
- Mountain ranges that have an east west alignment like the Alps show a higher temperature on the south-facing 'sunny slope' than the north facing 'sheltered slope.
- The greater insolation of the southern slope is better suited for vine cultivation and has a more flourishing vegetative cover.
- Consequently, there are more settlements and it is better utilised than the 'shady slope'



- In hilly areas a hot day followed by a calm, cloudless night during which the air cools more rapidly over the higher ground may induce cold, heavy air to flow down the slope and accumulate at the valley bottom pushing the warmer air upwards. The temperature may then be lower in the valley than higher up as the slopes. A reversal of the lapse rate has taken place. This is called a **temperature inversion.**



6. **Natural vegetation and soil:**

- There is a definite difference in temperature between forested regions and open ground.
- The thick foliage of the Amazon jungle cuts off much of the in-coming insolation and in many places, sunlight never reaches the ground.
- It is, in fact, cool in the jungle and its shade temperature is u few degrees lower than that of open spaces in corresponding latitudes.
- During the day trees lose water by evapo-transpiration so that the air above is cooled. Relative humidity increases and mist and fog may form.
- Light soils reflect more heat than darker soils which are better absorbers. Such soil differences may give rise to slight variations in the temperature of the region.
- As a whole, dry soils like sands are very sensitive to temperature changes, whereas wet soils, like clay, retain much moisture and warm up or cool down more slowly.

Precipitation

Types of Precipitation:

- If air is sufficiently cooled below dew-point, tiny drops of water vapour will **condense** around dust particles.
- When they float about as masses of minute water droplets or ice crystals at a considerable height above sea level, they form **clouds- cirrus, cumulus or stratus.**
- when condensation occurs at ground level without necessary resulting in rain**, haze, mist or fog** are formed.
- In higher latitudes or altitudes, where condensation of water vapour may take place in the atmosphere at temperatures below freezing-point, **snow** falls, either as feathery flakes or individual ice crystals.

- If the moist air ascends rapidly to the cooler layers of the atmosphere, the water droplets freeze into ice pellets and fall to the earth as **hail or hailstones.**

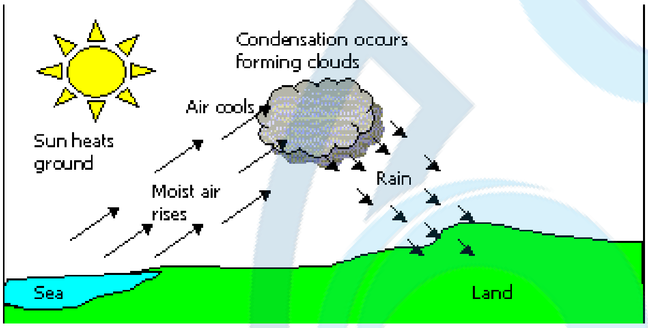
- As more and more super-cooled water drops accumulate around a hailstone, it increases steadily in size, some of them weigh as much as two pounds. In a severe hail-storm the hailstones do great damage to crops and buildings.
- Very often, the ice-pellets exist as frozen rain-drops, melting and re-free zing on their way down; this form **sleet.** It is only when the droplets in clouds coalesce into larger drops between 0.2mm. and 6mm., that **rains** falls.

Rainfall:

Types of Rainfall: There are three major types of rainfall:

1. **Convectional rainfall:**

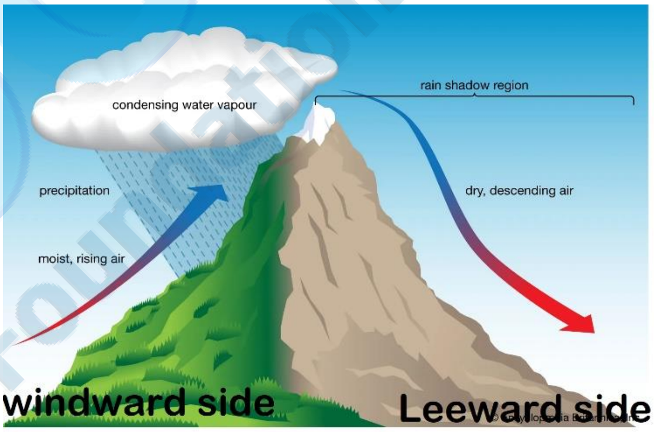
- This type of rainfall is most common in regions that are intensely heated, either during the **day,** as in the tropics, or in the **summer,** as in temperate interiors.
- When the earth's surface is heated by conduction, moisture-laden vapour rises because heated air always expands, and becomes lighter.



- Air rises in a **convection current** after a prolonged period of intense heating. In ascending, its water vapour condenses into cumulonimbus clouds with a great vertical extent. This probably reaches its maximum in the **afternoon** when the convectional system is well developed.
- Hot, rising air has great capacity for holding moisture, which is abundant in regions of high relative humidity. As the air rises it cools and when saturation point is reached **torrential downpours** occur, often accompanied by thunder and lightning.
- The summer showers in temperate regions are equally heavy with occasional thunderstorms. These downpours may not be entirely useful for agriculture because the rain is so intense that it does not sink into the soil but is drained off almost immediately.

2. **orographic or relief rain:**

- It is formed wherever moist air is forced to ascend a **mountain barrier**. It is best developed on the **windward slopes** of mountain where the prevailing moisture-laden winds come from the sea.
- The air is compelled to rise and is thereby **cooled** by expansion in the higher altitudes and the subsequent decrease in atmospheric pressure.
- Further ascent cools the air until the air is completely saturated (relative humidity is 100 per cent). condensation takes place forming clouds and eventually rain. Since it is caused by the relief of the land, it is also known as **relief rain.**



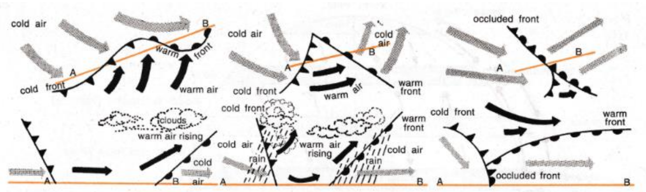
- On descending the **leeward slope,** a decrease in altitude increases both the pressure and the temperature, the air is compressed and **warmed.** Consequently, the relative humidity will drop. There is evaporation and little or no precipitation. The area in the lee of the hills is termed the **rain shadow area.**

3. **Cyclonic or frontal rain:**

- This type of rainfall is independent of relief or convection. It is purely associated with **cyclonic activity** whether in the temperate regions (depressions) or tropical regions (cyclones).
- Basically, it is due to the **convergence(meeting)** of two different air

masses with different temperatures and other physical properties.

- As cold air is denser, it tends to remain close to the ground. The warm air is lighter and tends to rise over the cold air.
- In ascent, pressure decreases, the air expands and cools, condensation takes place and light showers called cyclonic or **frontal rain** occur.
- The heavier and colder air masses eventually push up the warmer and lighter air and the sky is clear again.

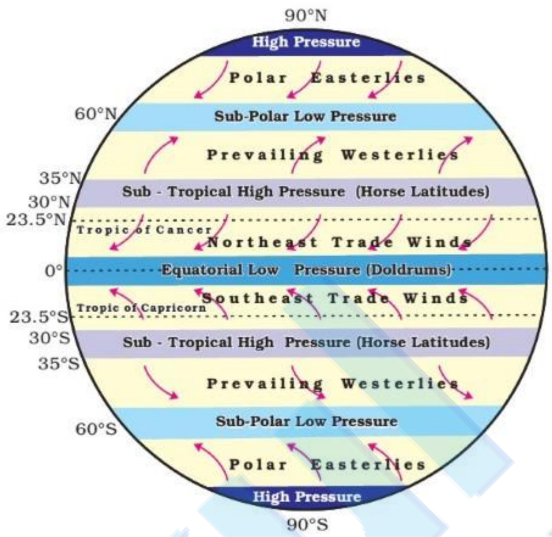


114 Cyclonic or frontal rain (depression) (a) The convergence of warm and cold air
(b) Warm air rises over cold air, cyclonic rain occurs
(c) Cold air eventually pushes up warm air and the sky is clear again

Pressure and Planetary Winds:

World pressure belts:

- Same as circulation of waters in the oceans in a regular pattern, flowing from the poles equator-wards and from the equator pole-wards.
- In the same way there is also a circulation of air over the surface of the earth caused by the differences in pressure.
- Along the equator and within 5 degrees north and south, is the Equatorial Low-Pressure Belt, where there is intense heating, with expanding air and ascending convection currents. This equatorial belt is often termed the **Doldrums,** because sailors in the olden days often found themselves becalmed here. It is a zone of **wind convergence.**



Major Pressure Belts and Wind System

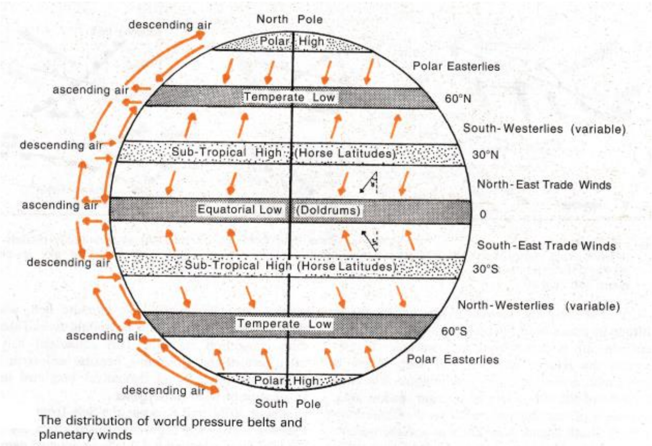
- About 30°N. and S. occur the Sub-Tropical High-Pressure Belts where the air is comparatively dry and the winds are calm and light. It is a region of descending **air currents or wind divergence** and anticyclones. It is frequently referred to as the **horse latitudes.**
- Around the latitudes 60'N. and S. are two Temperate Low-Pressure Belts which are also zones of **convergence** with cyclonic activity.
- The sub-polar low-pressure areas are best developed over the oceans, where temperature differences between summer and winter are negligible.
- At the North and South Poles 90°N. and S. where temperatures are permanently low, are the Polar High-Pressure Belts.
- Unlike the water masses of the high latitudes in the southern hemisphere, high pressures of the corresponding latitudes in the northern hemisphere are a little complicated by the presence of much land. Some pressure differences between summer and winter can be expected.

The planetary winds:

- Within this pattern of permanent pressure belts on the globe, **winds tend to blow from the high-pressure belts to the low-pressure belt as planetary winds** as the planetary winds.
- Instead of blowing directly from one pressure belt to another, however, the effect

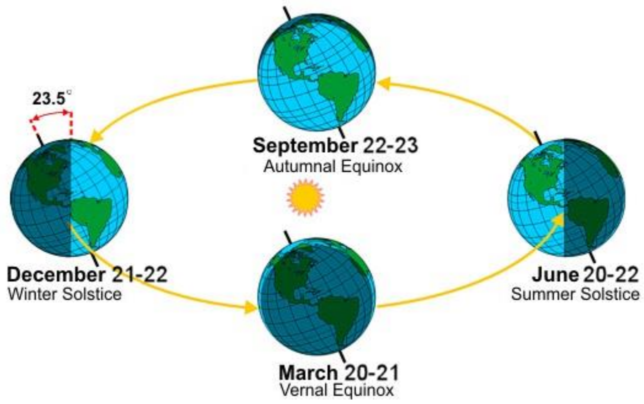
of the **rotation of the earth** (Coriolis Force) tends to **deflect** the direction of the winds.

- In the northern hemisphere, winds are deflected to their right, and in the southern hemisphere to their left. This is known as **Ferrel's low of Deflection**.



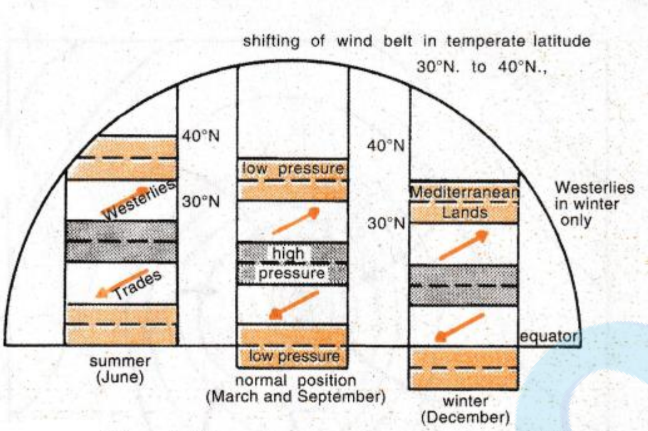
The distribution of world pressure belts and planetary winds

- The Coriolis Force is absent along the equator but increases progressively towards the poles. For this reason, winds blowing out from the Sub-Topical High-Pressure Belt in the northern hemisphere towards the Equatorial Low become North-East Trade Winds and those in the southern hemisphere become the South-East Trade winds.
- These **trade winds** are the most regular of all the planetary winds. They blow with great force and in a constant direction.
- They were thus helpful to early traders who depended, on the wind when sailing the high seas; hence the name 'trade winds'.
- Since they blow from the cooler sub-tropical latitudes to the warmer tropics, they have great capacity for holding moisture.
- In their passage across the open oceans, they gather more moisture and bring **heavy rainfall** to the **east coasts** of continents within the tropics.
- As they are off-shore on the west coast, these regions suffer from great aridity and form the Trade Wind Hot -Deserts of the world.
- From the sub-Tropical High-Pressure Belts, winds blow towards the Tempe rate Low pressure Belts as the variable **Westerlies.**
- Under the effect of the Coriolis Force, they become the South-Westerlies in the northern hemisphere and the North-Westerlies in the southern hemisphere. They are more **variable** in the northern hemisphere, but they play a valuable role in carrying warm equatorial waters and winds to western coasts of temperate lands.
- This **warming effect** and other local pressure differences have resulted in a very variable climate in the temperate zones, dominated by the movements of cyclones and anticyclones.
- In the southern hemisphere where there is a large expanse of ocean, from 40°S. to 60°s., Westerlies blow with much greater force and regularity throughout the year.
- They bring **much precipitation** to the **western coast** of continents. The weather is damp and cloudy and the seas are violent and stormy. It is thus usual for seafarers to refer to the Westerlies as the **Roaring Forties, Furious Fifties and Shrieking or Stormy Sixties**, according to the varying degree of storminess in the latitudes in which they blow.
- It must be pointed out that not all the western coasts of the temperate zone receive Westerlies throughout the year. Some of them like California, Iberia, central Chile, southern Africa and south-western Australia receive Westerlies only in winter.
- This is caused by the 'shifting of the wind belts' of such regions which lie approximately between the latitudes 30" and 40°N. and S.
- Due to the earth's inclination, the sun is overhead at midday in different parts of the earth at different seasons. The entire system of pressure and wind belts follows the movement of the midday sun.



- In June when the overhead sun is over the Tropic of Cancer, all the belts move about 5°-10° north of their average position.

- The 'Mediterranean' parts of the southern continents then come under the influence of the Westerlies and receive rain in June (winter in the southern hemisphere).
- In the same manner, when the sun is overhead at the Tropic of Capricorn in December, all the belts swing 5°-10° south of their average position.
- The 'Mediterranean' parts of Europe and California then come under the influence of the Westerlies and receive rain in December (winter in the northern hemisphere).



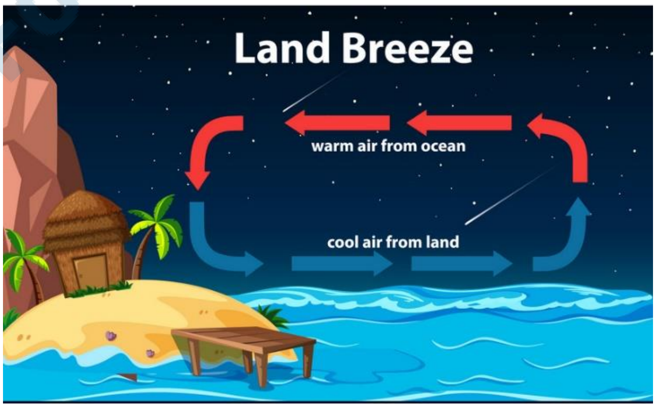
The shifting of the pressure and wind belts in the northern hemisphere—showing their positions in summer and winter and at the equinoxes

- The Polar Easterlies which blow out from the Polar High-Pressure Belts towards the Temperate Low-Pressure Belts.
- These are extremely cold winds as they come from the tundra and ice-cap regions. They are more regular in the south than in the north.

Land and Sea Breezes and Monsoons:

- Land and sea breezes ate, in fact, monsoons on a smaller scale. Both are basically caused by **differential heating** of land and sea, the former in a **diurnal** rhythm and the latter in a seasonal rhythm.
- During the day, the land gets heated up much faster than the sea. Warm air rises forming a region of local **low pressure.** The sea remains comparatively cool with a higher pressure so a **sea breeze** blows in from sea to land.
- Its speed or strength is between 5-20 m.p.h. and it is generally stronger in tropical than temperate regions. Its influence does not normally exceed 15 miles from the coast. It is most deeply felt when one stands facing the sea in a coastal resort.

- At night the reverse takes place. As the land cools down much faster than the sea, the cold and heavy air produces a region of local **high pressure.** The sea conserves its heat and remains quite warm. Its pressure is comparatively low.
- A **land breeze** blows out from land to sea. Fishermen in the tropics often take advantage of the out-going land breeze and sail out with it. They return the next morning with the in-coming sea breeze, complete with their catch.



- In the same way**, monsoons** are caused. Rapid heating in the hot **summer** over most parts of India for example induces heated air to rise. The South-West Monsoon from the surrounding ocean is attracted by the low pressure over the land and blows in, bringing torrential rain to the sub-continent.
- Similarly, in **winter** when the land is cold, the surrounding seas remain comparatively warm. High pressure is created over Indo-Pakistan and the North-East Monsoon blows

out from the continent into the Indian Ocean and the Bay of Bengal.

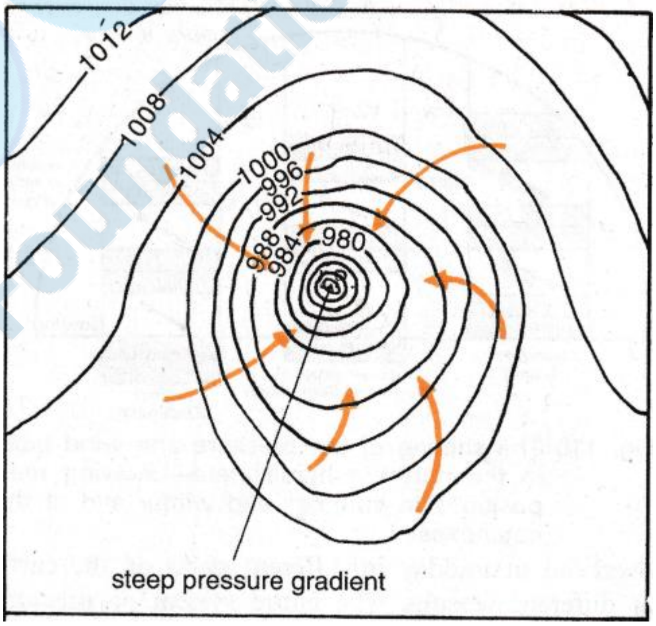
Fohn Wind or Chinook Wind:

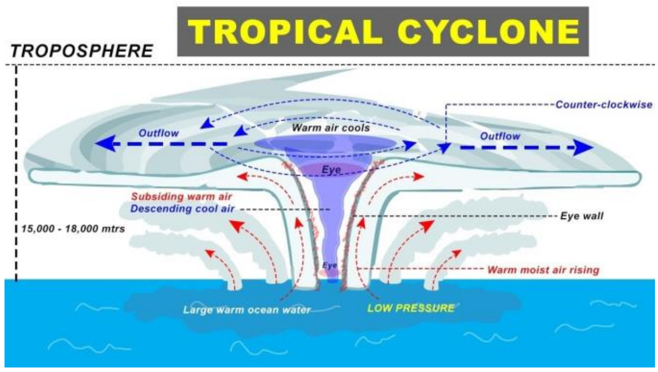
- Both the Fohn and Chinook winds are **Dry winds** experienced on the leeward side of mountains when descending air becomes compressed with increased pressure.
- The Fohn wind is experienced in the valleys of the northern Alps, particularly in Switzerland in spring. Chinook winds are experienced on the eastern slopes of the Rockies in U.S.A. and Canada in winter.
- Air ascending the southern slopes of the Alps **Expands and cools.** Condensation takes place when the air is saturated. Rain and even snow fall on the higher slopes.
- In descending the northern slope, the wind experiences an increase in pressure and temperature. The air is **compressed and warmed.**
- Most of its moisture is lost and the wind reaches the valley bottom as a dry, hot wind-the Fohn. It may raise the temperature by 15° to 30°F., within an hour. It melts snow and causes avalanches. In North America it is called Chinook, meaning 'the snow-eater'.
- But it has its blessings too, it hastens the growth of crops and fruits and thaws the snow-covered pastures.
- In the Rockies, the Chinook has been known to raise temperature by 35°F. within 15 minutes. The occurrence of frequent Chinooks means winter is mild.

Cyclonic Activity:

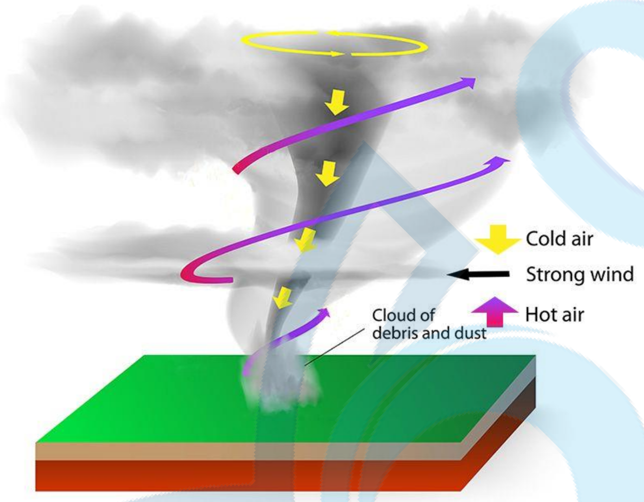
Tropical cyclones, typhoons, hurricanes and tornadoes:

- All these are different kinds of tropical cyclones. They are well-developed **low-pressure systems** into which violent winds blow.
- Typhoons occur in the China Sea, tropical cyclones in the Indian ocean, hurricanes in the West Indian islands in the Caribbean, tornadoes in the Guinea lands of West Africa and the southern U.S.A. in which the local name of Whirl-wind is often applied, and willy-willies occur in north-western Australia.
- **Typhoons** occur mainly in regions. between 6° and 20° north and south of the equator and are most frequent from July to October.
- In extent, they are smaller than temperate cyclones and have a diameter of only 50 to 200 miles, but they have a much steeper pressure gradient.
- Violent winds with a velocity of over 100 m.p.h. are common. The sky is overcast and the torrential downpour is accompanied by thunder and lightning.
- The other tropical cyclones have similar characteristics and differ, perhaps, only in intensity, duration and locality.
- **Hurricanes** have **calm, rainless centres** where the pressure is lowest (about 965 mb.) but around this 'eye', the wind strength exceeds force 12 of the Beaufort Scale (75 m.p.h.)

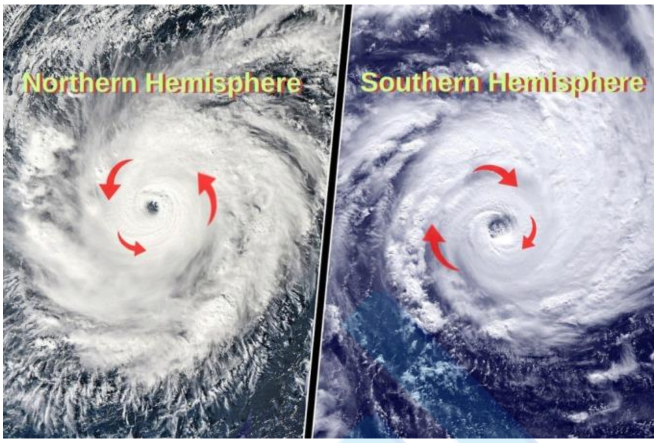




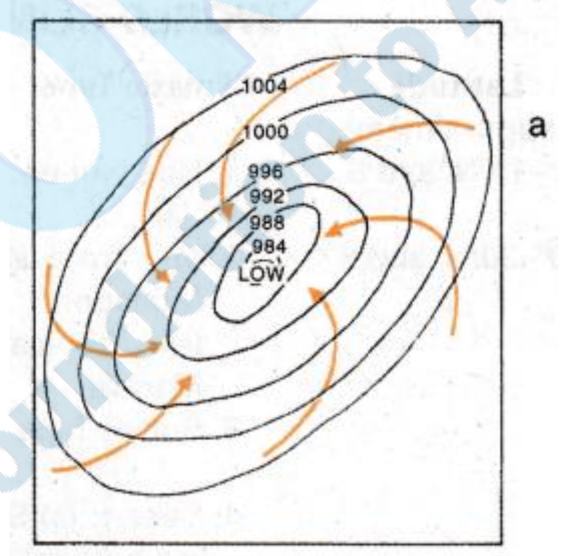
- Dense dark clouds gather and violent stormy weather lasts for several hours.
- **Tornadoes** are small but very violent tropical and sub-tropical cyclones in which the air is spiralling at a tremendous speed of as much as 500 m.p.h.
- A tornado appears as a dark **funnel cloud** 250 to 1,400 feet in diameter. As a tornado passes through a region, it writhes and twists, causing complete devastation within the limits of its passage.
- There is such a great difference in pressure that houses virtually explode. Tornadoes are most frequent in spring but can occur at almost any time.
- Fortunately, they are not common in many countries and their destructive effects are confined to a small area. Tornadoes are most typical of the IJ.S.A. and occur mainly in the Mississippi basin.



- **Cyclones.** These are better known as **depressions** and are confined to temperate latitudes. The lowest pressure is in the centre and the isobars.
- Depressions vary from 150 to 2,000 miles in extent. They remain quite stationary or move several hundred miles in a day. The approach of a cyclone is characterised by a fall in barometric reading, dull sky oppressive air and strong winds.
- Rain or snow falls and the weather is generally bad. Winds blow **inwards** into regions of **low pressure** in the centre, circulating in anticlockwise direction in the northern hemisphere and clockwise in the southern hemisphere.



- Precipitation resulting from cyclonic activities is due to the convergence of warm tropical air and cold polar air. Fronts are developed and condensation takes place, forming either rain, snow or sleet.

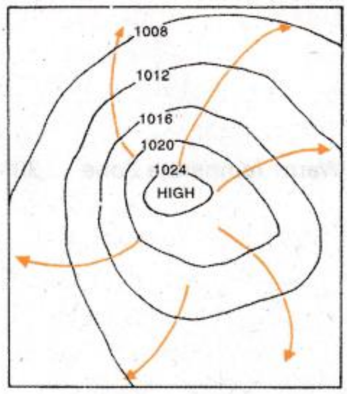


(a) A cyclone in the northern hemisphere (close isobars, anti-clockwise winds)

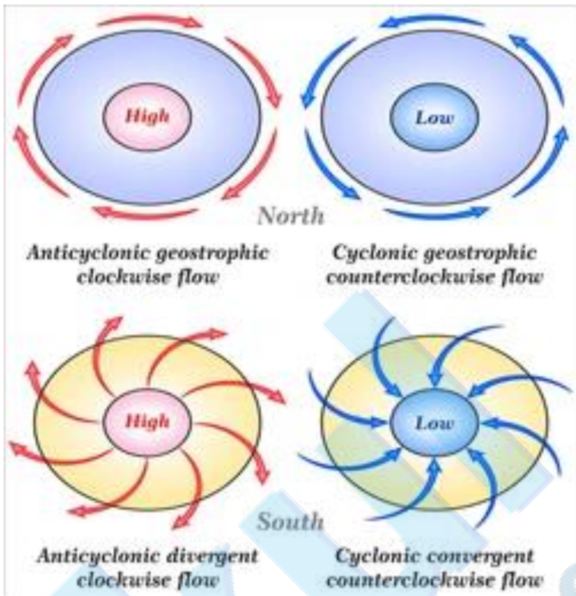
- **Anticyclone.** These are the opposite of cyclones with **high pressure** in the centre and isobars far apart.
- the pressure gradient is gentle and winds are light. The pressure gradient is gentle and wind are light.
- Anticyclones normally herald fine weather. Skies are clear, the air is calm and temperature are high in summer but cold in winter.
- In winter intense cooling of the lower atmosphere may result in thick fogs. Anticyclonic conditions may last for days or weeks and then fade out quietly.
- Winds in anticyclone blow **outwards** and are also subject to deflection, but they blow

clockwise in the northern hemisphere and anticlockwise in the southern hemisphere.

b

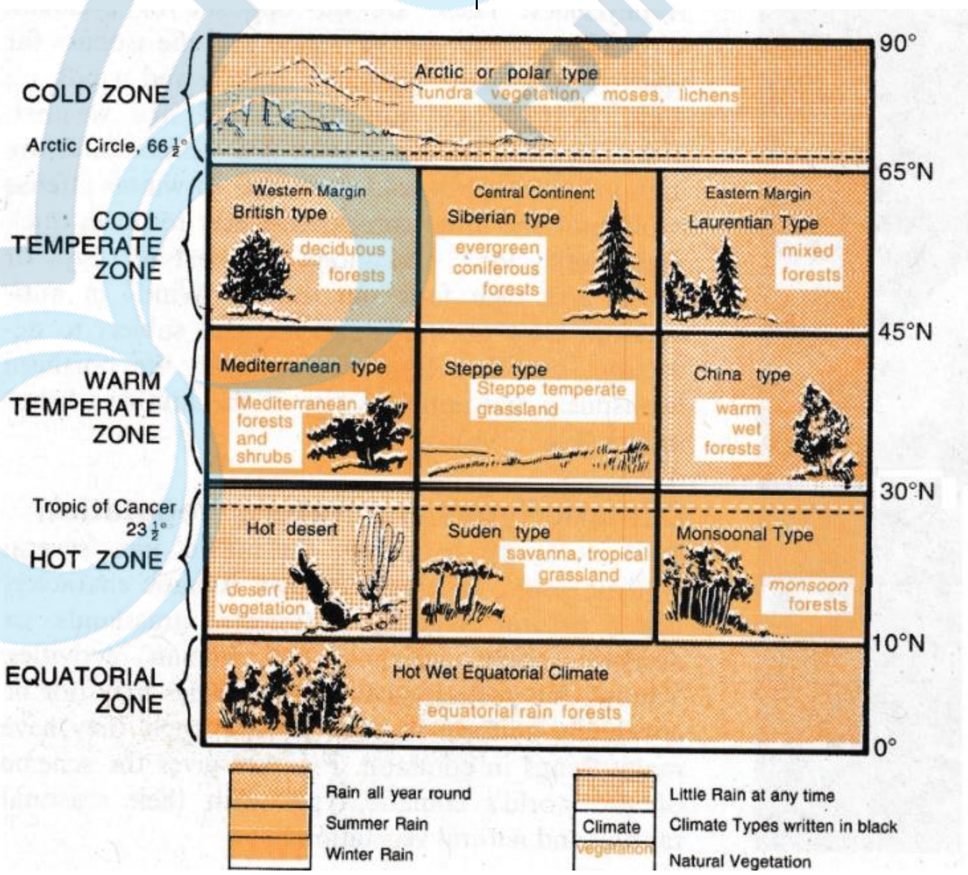


(b) An anticyclone in the northern hemisphere (well-spaced isobars, winds blow in clock-wise direction)



Climate type and natural vegetation:

- it is necessary to divide the world into several **climatic zones,** each with its own climatic characteristics, natural vegetation (forest, grasslands or deserts), crops, animals and human activities.
- Though the geographical characteristics may not be absolutely uniform in each climatic type, they have many things in common.



Scheme of the world's climatic types (with seasonal rainfall and natural vegetation also indicated)

World Climatic Types

Climatic Zone	*Latitude (Approximate)*	*Climatic Type*	*Rainfall Regime (with approx. total)*	*Natural Vegetation*
Equatorial Zone	0°-10°N and S	1. Hot, wet equatorial	Rainfall all year round : 80 inches	Equatorial rain forests
Hot Zone	10°-30°N and S	2. a) Tropical Monsoon b) Tropical Marine 3. Sudan Type 4. Desert: a) Saharan type b) Mid-latitude type	Heavy summer rain: 80 binches Much summer rain: 70 inches Rain mainly in summer: 30 inches Little rain: 5 inches	Monsoon forests Savanna (tropical grassland) Desert vegetation and scrub
Warm Temperate Zone	30-°40°N & S	Western Margin (Mediterranean type) 6. Central Continental (Steppe type) 7. Eastern Margin: a) China type b) Gulf type c) Natal type	Winter rain: 35 inches Light summer rain: 20 inches Heavier summer rain : 20 inches	Mediterranean forests and shrub Steppe or temperate grassland Wawrm, wet forests and bamboo
Cool Temperate Zone	45°-65°N & S	8. Western Margin (British type) 9. Central Continental (Siberian type) 10. Eastern Margin (Laurentian type)	More rain in autumn & winter : 30 inches Light summer rain: 25 inches Moderate summer rain : 40 inches	Decidous forests Evergreen coniferous forests Mixed forests (coniferous and deciduous)
Cold Zone	65°-90° N & S	11. Arctic or Polar	Very light summer rain : 10 inches	Tundra, mosses, lichens
Alpine Zone		12. Mountain climate	Heavy rainfall (variable)	Alpine pastures, confiers, fern, snow

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END OF PREVIEW...

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