

Credit III

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Meaning & significance of climatology

The word climatology is compounded of two Greek words, *Klima* & *logos*; klima means slope of the earth & logos means discourse of the study here the slope of the earth refers to latitude of the earth. Climatology is one of the important branch of physical geography and focuses on the study of weather & climate or in simple words short & long term atmospheric conditions on the earth's surface, its structure, composition & various processes & phenomena. Climatology studies the different climatic controls weather & climate of a particular place & different types of climate. Climatology also takes into consideration the impact of various climatic attributes on human beings, human activities & total environment & vice-versa. At present climatology is a broad & diverse field. in brief climatology may be defined as the scientific study of climate. It is the study of the varieties of climates found on the earth & their distribution over its surface.

According to *Critchfield*, climatology is the science that seeks to describe & explain the nature of climate, how it differs from place to place, & how it is related to man's activities.

Riley & Spolton define the science of climatology as the study of weather conditions over a longer period.

Austin Miller Views Climatology as that branch of science which discusses the average conditions of weather

Thornwaite broadens the scope of climatology when he suggests that the study of atmosphere as well as that of the earth's surface form the core of this discipline. It is because of the fact that each & every characteristics of climate is determined by the exchange of heat, moisture, & momentum between the earth's surface & the atmosphere.

The term climatology is correctly applied to the study of the following five growing fields: climatological record, theory of climate, energy & moisture balances of the earth, study of climate as the environment of living organisms & study of climate as the direct environment of man.

Since geography studies the earth as a habitat of human societies, it is naturally concerned with the study of climate as the dominant element in the natural element. *Franklyn.W* argues has remarked that through exercise of his intellect man reigns supreme among the animals in his knowledge of environmental change. As *Riley & Spolton* put it, the distribution of atmospheric phenomena over the earth is differentiated by latitude, topography, altitude, distribution of land, sea, & ice caps & also to some extent by forests & great cities. All these influences are geographical. The geographers, among other social scientists, are engaged in long term acquisition & application of environmental change.

Climatology according to *Kenneth* is an integral part of physical geography, perhaps closer to the centre than any other. At the same time it has also been described as a major aspect of meteorology from which it must be drawn its fundamental principles. The geographer is interested in the study of climate simply because there are climatic regions found on the earth's surface, & each climatic regions, despite its different geographical setting, is characterized by certain degree of uniformity. The boundaries of these climatic regions are so well marked that they can be easily defined on the basis of soil groups, different types of land forms & various plant communities, they can be easily defined on the basis of climatic numerical data. Since climate is said to be the key to regional variations, the geographer is therefore naturally interested in the science of climatology .similarities or differences found in different landscape are the resultant effects of diversities in climate. A particular type of climatic conditions give rise to a specific landscape.

Climatology is further subdivided into three distinct sub branches which are listed below;

Physical climatology: - studies the various factors responsible for spatial & temporal variations in climate & climatic elements as well as different elements of weather & climate such as temperature, pressure, clouds, wind, humidity & precipitation.

Regional climatology: - study the different types of climates prevailing in different parts of the world, their distribution pattern & characteristics

Applied Climatology: - is concerned with the application of diverse climatic knowledge to offer solutions. It analyses the relationship of climatology to other sciences in applied climatology. The main purpose is to find out ways & means to make use of our knowledge of climatic elements for the betterment of human life on the earth. The practical application of the discoveries & techniques to various types of human activities is growing day by day. Knowledge of weather & climate is being applied to the solution of such problems as plant & animal production, transportation & communication, industry structural designs & construction activities, atmospheric pollution & many other activities of man. Besides there are various economic activities of man which have highly specialized climatic requirements.

Insolation & Global energy budget

The word *insolation* is a contraction of incoming solar radiation. It consists of a bundle of rays of radiant energy of different wavelengths. Insolation is a measure of solar radiation energy received on a given surface area and recorded during a given time. It is received in the form of short waves which are electromagnetic in nature. Our earth intercepts only a tiny portion of total solar output that is 0.0005%. This radiation is partly absorbed by the constituents of the atmosphere particularly water vapors greenhouse gases & a part reaches the earth's surface. Again a part of this radiation is reflected & a part is absorbed by the earth's surface. The absorbed portion of radiation is also radiated back by the earth's surface in the form of long wave radiation. The earth's surface receives this insolation at the rate of 1.96 calories per cm²/minute. This amount of insolation received by the earth is known as solar constant. However this insolation is not evenly distributed on the earth's surface rather it varies in time & space. There are some areas which receive abundant insolation & at the same time some areas receive small amount of solar radiation. This uneven distribution is governed by certain factors.

Angle of incidence: - the altitude of the sun i.e. the angle between its rays & a tangent to the earth's surface at the point of observation, controls the amount of insolation received at the earth's surface. The angle of incidence of sun's rays determines the amount of solar radiation which a particular place on the earth's surface receives. A smaller angle means that the same amount of radiation will have to serve a larger area on the earth & the intensity will be less concentrated. A larger angle means that sun's rays will be nearly vertical over place of incidence & the radiation will have to serve smaller area as a result radiation will be more concentrated. Besides this, vertical ray will have to pass through less thickness of the atmosphere while as a ray with low angle of incidence will have to move through the atmosphere resulting into more interaction with the constituents of the atmosphere depends upon duration of day or sunshine. At the equator where the duration of sunshine is 12 hours daily the amount of radiation is more as compared to high altitude areas where duration of sunshine is less.

Tilt of the earth: - earth's surface is tilted & forms an angle of 23.5° with its polar axis. Because of this tilt of earth's axis at winter solstice (22 Dec.) the southern hemisphere faces

sun & receives more energy , while as at summer solstice (21 June) the northern hemisphere faces sun & thus receives more solar radiation.

Transparency of atmosphere: - transparency of the atmosphere is an important control on the amount of insolation which reaches the earth's surface. Reflection from cloud, dust, salt & smoke in the air is an important mechanism for returning shortwave solar radiation to space. Volcanic dust associated with volcanic eruptions sometimes persists for several years in the stratosphere & cause reduction in the energy transfer .if wavelength of radiation is more than the radius of obstructing particle, radiation gets scattered. If wavelength is less than the obstructing particle, total reflection of solar radiation takes place. If the obstructing particle happens to be water vapour, ozone, carbon dioxide, or any other greenhouse gas the solar radiation is absorbed.

Slope aspect:-slope direction & slope angle- control the amount of solar radiation received locally. Slopes exposed to sun receive more solar radiation than those away from sun rays.

Distance from the sun: - Earth's orbit around the sun is elliptical thus the distance between the two varies & produce variations of upto 6% in the receipt of solar energy. The receipt of solar energy is least on 4 July at aphelion when the earth happens to be 52.5 million km away from the sun. On the other hand energy receipt is highest on 3 Jan. at perihelion when earth is 47.5 million km away from the sun. The maximum value of energy received is $2.01 \text{ cal./cm}^2/\text{min}$. at perihelion & least value of $1.88 \text{ cal. /cm}^2/\text{min}$ at aphelion

Global energy budget

J.E.Hobbs (1980) pointed out that the total solar radiation reaching a horizontal surface on the ground is called global radiation. It comprises the shortwave radiation direct from the sun, plus the diffuse radiation scattered by the atmosphere. The gains & losses of earth's heat energy by way of incoming & outgoing radiation is known as earth's global energy budget or simply earth's heat budget. The earth receives a certain amount of insolation & gives back heat in to the space by outgoing terrestrial radiation. Through its heat energy budget the earth maintains a constant temperature.

To understand this phenomena we assume that the total energy received is 100 units as solar radiation reaching the outer atmosphere , about 34 units are returned to space without heating the atmosphere .of the total 34 units returned to space, 25 units are reflected to space by clouds, 2 units are directly reflected to space by the earth's land sea surface & 7 units are scattered by molecules of air & fine dust .Of the remaining 66 units , 19 units are absorbed within the atmosphere (17 units by the gases in the atmosphere & 2 units by clouds). The remaining 47 units are transmitted through the atmosphere & absorbed at the land sea surface, out of which 19 units are received at the surface as direct sunlight, 23 units as diffused radiation through clouds & 5 units as scattered radiation. The incoming solar radiation absorbed directly by the earth's land & sea surface forms. The largest percentage of the total solar energy intercepted by the entire earth atmosphere system. In all 66 units absorbed by the atmosphere & the earth's surface become effective in heating the atmosphere. Obviously, the atmosphere gets a larger part of its heat indirectly. Since factors like the amount of cloudiness & contrasts in the reflective power of different land surfaces

are characterized by temporal & regional variations. Besides the land & water surface serves as a great heat reservoir, because large amount of incident solar radiation is absorbed & stored there to be released consequently to the atmosphere.

Atmospheric pressure & winds (planetary, periodic & local winds)

Atmospheric Pressure:-

Atmospheric pressure is basically the "weight" of the air. It is used primarily by meteorologists to monitor developing storms that can seem to come out of nowhere. While typically considered an aspect of weather, certain regions of the world exist in zones where changing atmospheric pressures form part of the predictable climate. Because of their proximity to large bodies of water (a major factor in atmospheric pressure changes) takes places like coastal regions and islands experience severe storms on a regular basis

Pressure = density \times temperature \times constant

Wind A wind can be defined as the stream of air in a fairly well defined direction. Winds are generated due to difference in pressure from one place to the other. Winds are the mechanism by which uneven distribution of pressure is balanced globally.

Types of winds:-

On the earth's surface, certain winds blow constantly in a particular direction throughout the year. These are known as the 'Prevailing Winds'. They are also called the Permanent or the Planetary Winds. Certain winds blow in one direction in one season and in the opposite direction in another. They are known as Periodic Winds. Then, there are Local Winds in different parts of the world.

Planetary or Permanent Winds

The planetary wind system of the world accompanies the presence of the High and Low-Pressure Belts. We know that winds tend to blow from the high-pressure centres to the low-pressure centres. The effect of the earth's rotation (Coriolis Force) tends to deflect the direction of these winds. The deflection in the direction of these winds take place according to Ferrel's Law. Two sets of surface winds, the Trades and the Westerlies are the main planetary winds of the world.

Trade Winds

North and South of the Equatorial Belt of Calms, are the Trade Winds covering roughly the zone lying between 5° and 30° North and South. In other words they cover almost the entire area between 30°N and 30°S latitudes on both sides of the equator. The Trade Winds are a result of a pressure gradient from the Sub-Tropical Belt of High Pressure to the Equatorial Belt of Low Pressure. In the Northern Hemisphere, the wind moving equatorward, is

deflected by the earth's rotation to flow south-westward. Thus, the prevailing wind there is from the North-East, and it has been named as the 'North-East Trades'. In the Southern Hemisphere, deflection of the wind is towards the left, this causes the 'South-East Trades'. Trade Winds are noted for their steadiness and persistent direction. But the system of Doldrums and trades shifts seasonally north and south, through several degrees of latitudes, as do the pressure belts that causes them. The trades are best developed over the Pacific and the Atlantic Oceans, but are upset in the Indian Ocean because of nearness of the great Asian landmass. They are named after the Latin word 'trado' which means blowing steadily in a constant direction; hence, the name Trade Winds. As these Trade Winds blow from the warmer, sub-tropical latitudes to the hot tropics, they have a great capacity for holding water-vapour or moisture. When they cross the open oceans, they pick up a lot of moisture. They bring heavy rainfall to the eastern coasts of continents lying within the tropics because they blow on-shore. On the western coasts of continents, these Trade Winds do not bring any rainfall. It is because here there are 'off-shore' winds or winds blowing just parallel to the shores, as they blow off-shore. As such, the western areas within the tropics suffer from aridity. The great deserts of the Sahara, Kalahari, Atacama and the Great Australian Deserts all lie on the western margins of the continents, lying within the tropical latitudes.

Westerlies

The Westerlies or the Prevailing Westerly Winds blow between 35° and 60° North and South latitudes from the Sub-Tropical High-Pressure Belts towards the Sub-Polar Low-Pressure Belts. We know that the high-pressure belt is a zone of divergence for these outgoing winds. In the Northern Hemisphere, the Westerlies generally blow from the south-west to the north-east, and in the Southern Hemisphere from the north-west to the south-east. These are on-shore winds on the west coasts and off-shore winds on their east coasts. The on-shore winds bring rainfall while the off-shore winds are lacking in it. These winds are not as constant in strength and direction as the Trade Winds. They are rather stormy and variable though the main direction remains from west to east. But as their general direction is from the west, they are called the "Westerlies". They are also known as "Anti-Trade Winds", because their movement is in the opposite direction from that of the Trade Winds. In the Northern Hemisphere, land-masses cause considerable disruption in the westerly winds. But in the Southern Hemisphere, between 40°S and 60°S, the westerlies gain great strength and persistence because of the vast expanse of oceans in their belt. This made the mariners of old call them the "Roaring Forties", the "Furious Fifties" and the "Screaming Sixties". In olden days, sailing vessels had to face great danger while sailing in the opposite direction in the face of the prevailing westerly winds. It is to be noted that the westerlies bring warmth and rainfall throughout the year to all the western coasts of the Temperate Zone. But the areas, which lies in the Mediterranean type of region, get rainfall only in winter. At that time, in December, the Mediterranean parts of Europe and California (U.S.A.) come under the influence of the westerlies and receive rainfall. In the Southern Hemisphere, in this month, the Mediterranean regions (Central Chile, Southern Africa, S.W. Australian coast) do not receive any rainfall, as they shift away from the influence of the westerlies. In June, the Mediterranean parts of the southern continents come under the influence of the westerlies and

receive rainfall. At that time, the Mediterranean areas of the Northern Hemisphere do not receive any rainfall from the westerlies, because they shift away from their influence.

Polar Winds

The winds blowing in the Arctic and the Antarctic latitudes are known as the Polar Winds. They have been termed the 'Polar Easterlies', as they blow from the Polar High Pressure Centres towards the Sub-Polar Low-Pressure Belts. In the Northern Hemisphere, they blow in general from the north-east, and are called the North-East Polar Winds; and in the Southern Hemisphere, they blow from the south-east and are called the South-East Polar Winds. As these winds blow from the ice-capped landmass, they are extremely cold. They are more regular in the Southern Hemisphere than in the Northern Hemisphere.

Periodic Winds

Land and sea breezes and monsoon winds are winds of a periodic type. Both are caused by the unequal heating of land and sea. Land and sea breezes occur daily, whereas the occurrence of monsoon winds is seasonal.

Sea Breeze

During the day, the greater heating of the land causes the air to ascend, causing a low pressure over land and the cool heavy air from the sea moves in to take its place. The strength of the sea breeze depends on the topography of the coast and the regions.

Land Breeze

During the night the land cools quickly so that it is colder than the sea. A low pressure area is caused over the sea and the cooler heavier air from the land begins to flow towards the sea. The general effect of the contrast in heating of land and sea is to produce cooler winters and warmer summers in the centres of continents than along coasts.

Monsoons

Monsoon winds are seasonal winds. For six months they blow from land to sea, and for the other six months from sea to land. Thus, they may be regarded as land and sea breezes on a large-scale in which the period is a year instead of a day. The word 'monsoon' has been derived from the Arabic word 'Mousim', which means 'season'. These seasonal winds greatly disturb the belted system of the earth's permanent winds.

Summer Monsoons

In summer the continents get more heated than the sea, hence there develops a centre of low pressure. This may be called a "heat-low" or a "thermal low". Over the adjoining sea, the air is comparatively cool and heavy, and a high pressure area develops there. This causes the

wind to blow from the sea to the land. It is the 'Summer Monsoon'. In May, June and July, the huge plains of India and China are intensely heated by the vertical rays of the Sun. The intense heat develops a continental low pressure area over hot land-mass of Central Asia and north-western Indian Sub-continent. During these months, over the Indian Ocean, where the air is comparatively cool and heavy, a high pressure area develops. So, the winds blow from the Indian Ocean northward and north-westward into Asia, passing over Indian Sub-continent, Indo-China, southern China and south-eastern Asia. As they blow from the sea to the land, they bring heavy rainfall to South-East Asia. The summer monsoon winds blow south-west; so they are known as the 'South-West Summer Monsoon'.

Winter Monsoons

In winter, conditions are reversed. The continents become rapidly cool, and the air above it becomes cool and heavier. Because of this, an area of high-pressure develops over the land. Over the sea, because of the comparatively higher temperature, a centre of low pressure develops. This causes the wind to blow from the land to the sea. It is known as the 'Winter Monsoon'. In South-East Asia, the winter monsoon travels southward and southeastward towards the Indian Ocean. As the winds blow from the land to the sea, they bring cold dry weather. They are incapable of giving rain. But sometimes these winds blow over seas and then pass over the adjoining land. In such a situation, they bring some rainfall to that area. The Southern Coromandel Coast (Tamil Nadu) in India and the Vietnamese Coast and the west coast of Japan get sufficient rainfall from winter monsoons. The winter monsoon winds blow north-east; so the monsoon is known as the 'North-East Winter Monsoons'. Besides the South-East Asian countries, monsoons are also experienced in Northern Australia, Malagasy Republic, Ghana and Nigeria, but there they have modified type of monsoon winds.

Local Winds

Local winds are the result of a variety of causes. The mountain and valley winds follow a daily alteration of direction in a manner like the land and sea breezes. During the day, when slopes are intensely heated by the Sun, the air moves from the valleys upward over rising mountain slopes towards the summits. This is known as a **Valley Wind**. It decreases the cold of the areas on higher summits. At night, when the same slopes have been cooled by radiation from ground to the air, the air moves valley wards down the ground slopes and reduces the temperature of the valleys. These winds, thus, respond to local pressure gradients, caused by the heating or cooling of the ground.

Katabatic Type of local winds flow, under the influence of gravity, from higher to lower regions. In winter, a cold and dense air may accumulate over highland and flow out upon adjacent lowlands as a strong cold wind. The **Bora** of the northern France are well known examples of this type.

Foehn and Chinook are still other types of local winds, passing over a mountain range, are forced to descend on the leeward side with the result that the air is heated and dried.

Loo: loo is a hot & dry wind which blows over the plains of India & Pakistan during day time in hot weather season.

Chinook: chinook is a warm & dry wind which blows down the leeward slope slopes of Rockies in USA & Canada.

Harmattan: harmattan is a warm & dry wind which blows in the eastern parts of Sahara desert (Africa). harmattan is known as doctor of Guinea because it brings weather conditions favorable to human beings there.

Sirocco: sirocco is also a warm, dry & dusty wind which blows from North Africa across Mediterranean Sea to Sicily, Southern Italy, Spain & southern France.

Brick fielder: it is a hot & dry wind of Australia. It is rather extremely hot wind with its temperatures high as 38°C . It blows from the interiors of Australia towards the south eastern coastal islands.

Shamal : shamal is a hot & dry wind which blows in Tigris-Euphrates plains, Iraq & Persian gulf.

Khamsin: khamsin (Arabic term) is extremely hot wind having temperatures high as $40-50^{\circ}\text{C}$. It blows in Egypt & Arabia.

Simoom: simoom is also extremely hot wind having a temperature of 50°C . It blows in northern Sahara & Arabian Desert.

Santa Ana: santa ana is a hot and dry wind blowing down in the western slopes of Rockies in California.

Zonda : zonda a hot and dry wind which blows down the leeward slopes of Andes in Argentina and Uruguay during winter

Karaburan : karaburan is a hot and dry wind of Tarim basin (China) haboob; haboob is the name given to warm dust storms experienced in Sudan

Winds blow in every corner of the earth's surface from a region of high pressure to a region of lower pressure. They are named according to the direction from which they come. A wind coming from the west is said to be a westerly wind, those blowing from the east called easterlies. The Earth's rotation deflects winds to the right of their flow in the Northern Hemisphere and to the left of their flow in the southern Hemisphere.

Precipitation Types of Precipitation & the global distribution pattern of precipitation.

Precipitation is any product of the condensation of atmospheric water vapor that falls under gravity. The main forms of precipitation include drizzle (sometimes called mist - especially "Scotch mist"), rain, sleet, snow, graupel and hail. Precipitation occurs when a local portion

of the atmosphere becomes saturated with water vapour, so that the water condenses and "precipitates". Thus, fog and mist (except when the terms are used to mean "drizzle") are not precipitation but suspensions, because the water vapour does not condense sufficiently to precipitate. Two processes, possibly acting together, can lead to air becoming saturated: cooling the air or adding water vapour to the air.

Types of precipitation

1. Convective precipitation: when heated air becomes light it is carried upwards. Where, due to low temperature it cools down & in presence of moisture, condensation occurs. The condensed particles fall down as precipitation since this involves an upward movement of air this type of precipitation is known as convective precipitation. This process releases latent heat of condensation which further heats the air to go further up. Convective precipitation is heavy but a short duration, highly localized & associated with minimum amount cloudiness. It occurs mainly during summer & is common over equatorial doldrums in the Congo basin, the Amazon basin & the islands of South East Asia.

2. Orographic precipitation: this type of precipitation occurs when the warm, humid air strikes an orographic barrier (a mountain range) head on. Because of the initial momentum the air is forced to rise & condensation takes place. The surplus moisture falls down as orographic precipitation along the windward slopes. The windward slopes of barrier receive more precipitation than the leeward because the air moves down the slopes & gets warmed up. Hence the leeward slope is drier & is known as rain shadow area

3. Frontal precipitation: when two air masses with different temperature characteristics meet, turbulent conditions are produced. Along the front convection occurs & cause precipitation e.g. in North Western Europe continental air & warm oceanic air converge & cause heavy rainfall in the adjacent areas.

4. Cyclonic precipitation: this type of precipitation is caused when ascent of air takes place due to horizontal convergence of air streams in low pressure cells within a cyclone. The precipitation in a tropical cyclone is of convective while that in a temperate cyclone is because of frontal activity.

5. Monsoonal precipitation: this type of precipitation is characterized by seasonal reversal of winds which carry oceanic moisture with them & cause extensive rainfall in South & South East Asia.

Global distribution: Different places receive different amount of precipitation that too in different seasons. Nevertheless the main features can be explained with the help of global wind & the pressure system, land water distribution & the nature of relief features. In general high latitudes having high pressure associated with subsiding air & diverging winds experience rather dry conditions. On the other hand the equatorial belt with high temperature, low pressure, high humidity converging & unstable winds & ascending air receives ample

precipitation. Besides wind, pressure system the inherent nature of the air involved is also an important factor in determining the potential for precipitation. Since, cold air has lower capacity to hold moisture than warm air, a general decrease in precipitation is revealed with the increase in distance from the equator towards poles.

Besides the latitudinal variation, the land water distribution complicates the global precipitation pattern. Large land masses in middle latitudes generally experience decrease in precipitation towards their interiors. Further the mountain barriers alter the ideal precipitation pattern that one would expect from global wind systems. Windward mountain slopes receive abundant precipitation while as the leeward slopes & the lowlands fall in the rain shadow zone.

Areas receiving heavy precipitation of 200 cm per year include windward slopes of the mountains along the western coasts in temperate zone. A moderate rainfall of 100-200cm per year occurs over areas adjacent to the high precipitation zone. The coastal areas in the warm temperate zone also receive moderate amount of rainfall. The central parts of the tropical lands & the eastern parts & interiors of the temperate lands receive in adequate precipitation varying between 50-100cm per year.

Areas lying in the rain shadow zones, the interiors of the continents & high latitudes receive low precipitation of less than 50cm per year. The western margin of the continents in the tropical lands & the arid deserts fall in this category

Atmospheric disturbance: Tropical & Temperate cyclones

The general circulation of the atmosphere as induced by the thermal & dynamic effects, as represented by the zones & wind belts, give rise to secondary circulations which produce the most noticeable changes in the weather. Even though the secondary circulation includes such atmospheric phenomena as monsoons circulation, air masses fronts & upper level vortices it is particularly applied to the travelling disturbances which originate in the middle & high latitudes as well as within the tropics. Tropical cyclones & extra tropical cyclones (temperate cyclone) offer best example. Atmospheric disturbances play a vital role in the complex process of exchange of heat between different latitude zones. The maximum control of these disturbances on the day to day weather is seen in the middle latitudes. The travelling cyclones & anticyclones make the weather highly variable, because there is an element of uncertainty in their time of arrival as well as frequency.

Cyclones

Cyclones are centers of low pressure surrounded by closed isobars having increasing pressure outward & closed air circulation from outside towards the central low pressure in such a way that air blows inward in anticlockwise in the northern hemisphere clockwise in the southern hemisphere. They are characterized by swirling wind movement around the low pressure. This closed circulation is induced by atmospheric disturbances over & above the earth's surface, coupled with the earth's rotation which imparts whirling motion pattern to these disturbances. Their general form are circular elliptical to v-shaped. When the wind velocity increases to such an extent that they attain gale force. The atmospheric disturbances or

cyclones are called as *cyclonic storms*. Cyclones are classified into two types on the basis of their source region are as follows;

Temperate cyclones

Temperate cyclones develop over the mid latitude zone & exercise powerful influence over the climate & weather conditions there. The ideal latitudinal zone for their breeding is 35° - 65° lat.in both the hemisphere due to convergence of two contrasting air masses e.g. Warm, moist & light tropical air mass& cold, dense polar air masses. Temperate cyclones, also called as *extra tropical cyclone* or *wave cyclone* or simply *depressions*

Origin & development of temperate cyclone no commonly acceptable theory of the origin of temperate cyclones could be propounded yet. The first pioneer serious attempt was put forwarded by Fitzory in 1863. The important theories regarding the origin & development of temperate cyclones are as below

Polar front theory by Bjerkenes

This theory is also called as *frontal theory* or *wave theory*. This theory was advocated by V.Bjerkens & j.Bjerkens in 1918. This theory advocates that the warm humid air masses from tropics meet the dry cold air masses from the poles & thus polar front is formed as a surface of discontinuity. Such conditions occur over subtropical highs, sub polar lows& along the tropause. The cold air pushes the warm air mass upwards from underneath. Thus a void is created because of lessening of pressure. The surrounding air rushes in to occupy this void & coupled with earth's rotation, a cyclone is formed which advances with westerlies.

Thermodynamic theory of Lampert & Shaw

This theory advocates that in sub-tropical areas an overcrowding of vertical currents releases the surplus energy upwards which after meeting upper cool air converts into an eddy. This eddy tends to settle down as inverted 'V' shaped cyclone.

The temperate cyclones develop mostly in the winter season, late autumn & spring. They are generally associated with rainstorms & cloudy weather conditions.

Shape & size of temperate cyclone

The temperate cyclones are asymmetrical & shaped like circular semicircular elliptical elongated or an inverted "V". They stretch from 150-3000 km or more across & are highly diverse on account of their size & some giant sized temperate cyclones may occupy lakhs of km^2 area. Extensive temperate cyclones develop in particular over North America during winters. The vertical extent of an average tropical cyclone is 10-12km from surface.

Wind velocity: since there is a low pressure in the center of temperate cyclone & air pressure increases outward & hence winds blow from the periphery towards the Centre but these winds don't reach the Centre rather they cut the isobars at an angle of 20° - 40° due to friction & coriolis force & thus wind direction becomes anti-clockwise in the northern hemisphere & clockwise in the southern hemisphere. The wind speed is more in eastern & southern

portions of the cyclone, it is more in the North America than Eurasia. Wind velocity increases with approach of the cyclone & subsides after the passage of it.

Orientation: As mentioned above temperate cyclones move with westerlies thus they are oriented east-west. If the storm front is east-west the Centre moves swiftly eastwards. If the storm is directed northwards then the Centre moves towards northwards then the Centre moves towards north but after two or three days the pressure differences is reduced & the cyclone dissipates. In case the storm front is directed southwards then the Centre move quite deep southwards up to Mediterranean region.

Arrival & associated weather: the approach of a temperate cyclone is marked by a fall in temperature, wind shifts & development of hollow around sun & moon, drop in air pressure a thin veil of clouds appears. Heavy down pour is preceded a light drizzle .once warm front approaches these conditions are checked & brings a halt in precipitation. Now clear weather prevails till the arrival of cold front which again results in dropping temperature, cloudiness & rainfall accompanied by thundering. Temperate cyclones yield more rainfall when their movement is slow & there is marked difference in temperature & precipitation.

Distribution temperate cyclones extent over following areas during their favorite breeding seasons & influence weather conditions of these regions;

- Over USA & Canada , extending over Siberia Nevada, Colorado, eastern Canadian Rockies & great lakes region
- Gulf of Mexico
- The region extending from Iceland to Barents sea, continuing over Russia & Siberia
- Winter storms over Baltic sea
- Mediterranean basin extending up to Russia & even up to India during winters
- The Antarctic frontal zone

During summer, all the paths of temperate cyclones shift northwards & there is no temperate cyclone over subtropics & the warm temperate zone, although high concentration of storms occur over Bering strait, USA & Russian arctic & sub-arctic zone

Tropical cyclones

Geographically, the tropical atmosphere lies between the tropic of cancer & the tropic of Capricorn .but from meteorological point of view, the boundaries of the tropical atmosphere are determined by the high pressure cells of the subtropics in both the hemisphere. Tropical cyclone is a large spinning wind system that develops over warmer oceans & seas near the equator. Tropical cyclones are intense low pressure areas in the atmosphere around which strong winds blow & they have thermal origin. In tropical seas & oceans local convective currents acquire a whirling motion due to the impact of coriolis force & thus develop into a cyclone. The ideal conditions for the development of tropical cyclone are;

= Quiet air

= High temperature

= High saturated atmospheric conditions

All these favorite conditions prevail over equatorial doldrums especially over the western margins of the oceans & seas. Blowing trade winds continuously replace the saturated air there. Listed below are some favorite breeding grounds of tropical cyclones on the earth's surface;

1. South East Caribbean region where tropical cyclones are called "hurricanes"
2. Philippines islands, eastern China & Japan where they are called "typhoons"
3. Bay of Bengal & Arabian Sea where they are called as "cyclones"
4. Around South East African coast & Madagascar- Mauritius islands
5. North Western Australia where they are called "whilly willies"

Shape & size of tropical cyclones

Tropical cyclones possess symmetrical elliptical shape with steep pressure gradients they vary considerably on account of their size & their average diameters vary between 80-300 km.

Wind velocity tropical cyclones are characterized by threatening fast speeds especially over water bodies but their speed is reduced considerably when it strikes land surface. Their speed may go as high as 120 km/hour more violent outwards & low around Centre. Tropical cyclones after originating start with westward movement turn northwards around 20° lat., north eastwards around 25° lat. & then eastwards around 30° lat. Afterwards they lose energy & dissipate. Tropical cyclones follow a parabolic path with their axis parallel to the isobars.

Structure: tropical cyclones have a differentiated core region & periphery. The core or "eye" of the cyclone is characterized by low barometric pressure & a patch of clear sky with quiet conditions. The periphery is characterized by high pressure, cirrus clouds, still outwards they give way to dense nimbus clouds which give occasional torrential downpour & thunder storms. Tropical cyclones are highly unpredictable because of frequently changing thermal conditions over tropical oceans.

Associated weather: tropical cyclones are associated with destructive weather conditions especially at the frontal zone. The approach of a tropical cyclone is marked by cirrus clouds of the eye overtaken by dense & dark nimbus clouds followed by heavy downpour. The downpour is evenly distributed around the core region & lasts till the arrival of tail & then prevails clear weather

Tropical cyclones are divided into following categories on the basis of their wind speed;

- Depression : wind speed between 32-50 km/hour
- Deep Depression: wind speed between 51-61 km/hour
- Cyclonic storm: wind speed ranges between 62-88 km/hour
- Severe cyclonic storm: wind speed between 89-117 km/hour

- Severe cyclonic storm with the core of hurricane winds :wind speed above 117km/hour

Anticyclones

The concept of anticyclones was first introduced by Galton in 1861 to describe the cells of high pressure which were having roughly concentric isobars & their characteristics opposite to those of cyclones. They are also known as *rainless phenomena* in an anticyclone, winds diverge, spiraling downward & outward. Anticyclones are high pressure centers surrounded by low pressure periphery. They are characterized by outwards blowing of winds from the high pressure core towards the low pressure surroundings. The wind movement is clock wise in the northern hemisphere & anti clockwise in the southern hemisphere. Anticyclonic wind system are common in sub tropical high pressure belts & are absent in equatorial. Anticyclones are associated with fair & rainless weather conditions. Anticyclones are generally circular shape but sometimes they may acquire "V" shape & they are far extensive than tropical & temperate cyclones in areal dimension's. The high pressure Centre of anticyclones is a function of descending air & it is that descending air which brings stability in weather. However temperature of anticyclones fluctuates with fluctuating seasonal temperature & during winters they are associated with cold conditions & during summer high temperature. Generally anticyclones follow cyclones with variable & unpredictable trajectory. One more characteristics of anticyclones is the absence of fronts in short that anticyclones are opposite of cyclones in all aspects except their shape.

Climatology: - The scientific study of climates, including the causes and long-term effects of variation in regional and global climates. Climatology also studies how climate changes over time and is affected by human actions.

Weather:- weather refers to the state of atmosphere at any given time denoting the short term variations of atmosphere in terms of temperature, pressure, wind, moisture cloudiness precipitation & visibility it is constantly changing from hour to hour or day to day.

Climate: - Climate (from Ancient Greek word *klima*, meaning inclination) is commonly defined as the weather averaged over a long period. The standard averaging period is 30 years, but other periods may be used depending on the purpose. Climate also includes statistics other than the average, such as the magnitudes of day-to-day or year-to-year variations.

Atmospheric pressure: - Ans. Since air has mass, it also has weight. The pressure of air at a given place is defined as the force exerted in all directions by virtue of the weight of all the air above it.

Wind: - The horizontal movement of air along the earth's surface is called a Wind. Winds are the mechanism by which uneven distribution of pressure is balanced globally.