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 what we call climate. We actually live at the bottom of this indefinite layer of atmosphere where the air is densest. Higher up, the air thins out and it is still a matter of conjecture where the atmosphere ends. One estimate puts this limit at about 600 miles above sea level. 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 taken in different parts of the globe, 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. 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. If we were to live in a dry atmosphere, absolutely without water, there would be no weather and not even much climate.

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 has 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.

What matters most is the effect of the atmosphere upon the incoming solar radiation. 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 that we see above us. 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, it affects the nature and types of cloud formation and precipitation.

Factors Influencing Temperature

1. **Latitude.** As explained in Chapter 1, due to the earth's inclination, the mid-day sun is almost overhead 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. This is illustrated in Fig. 107. It shows two bands of rays coming from the sun to two different latitudes on the earth's surface. Band RI falls vertically over the equatorial latitudes on surface E. Band R2 falls obliquely over the temperate latitudes on surface T. RI travels through a *shorter distance* and its concentrated solar insolation heats up a smaller surface area; 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.

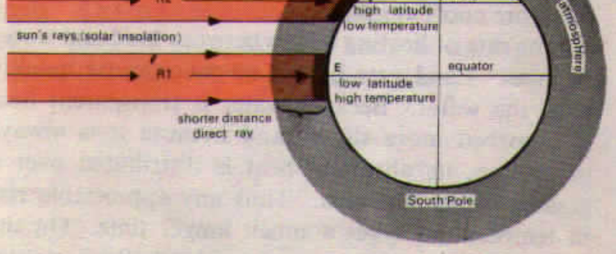


Fig. 107 The effect of latitude on solar insolation. This shows why temperatures are lower in higher latitudes than in the tropics

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 (shown as X in Fig. 108) will record a mean temperature of 65°F.

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

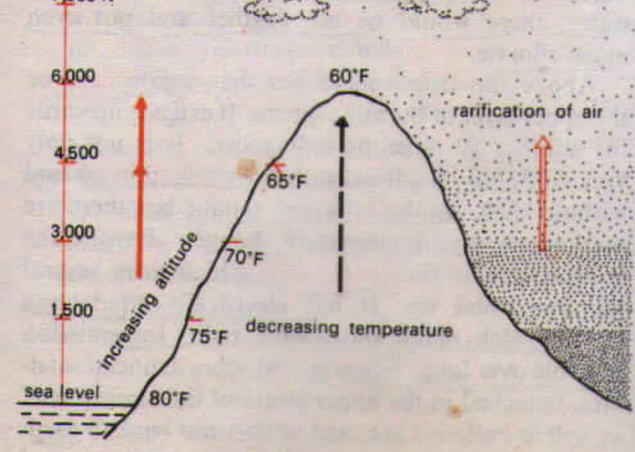


Fig. 108 The lapse rate. The effect of altitude on mean annual temperature in a tropical area

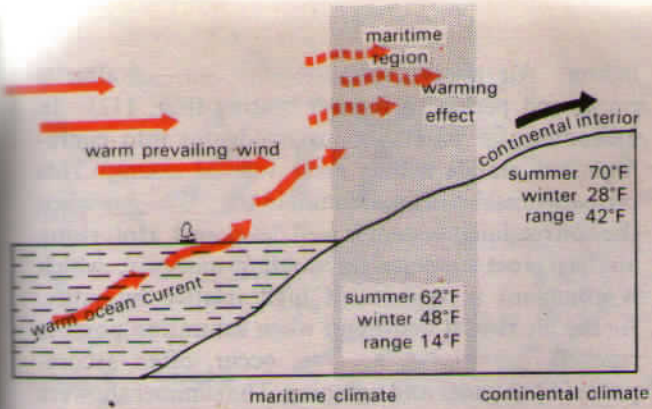


Fig. 109 The warming effect of warm ocean currents and prevailing winds on coastal regions with a Maritime climate in temperate latitudes

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 (Fig. 109). 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' (Fig.110). 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

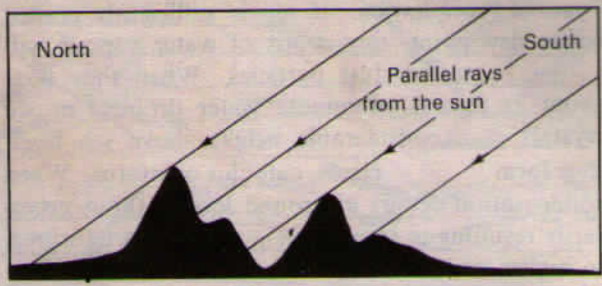


Fig. 110 South-facing slopes are more sunny

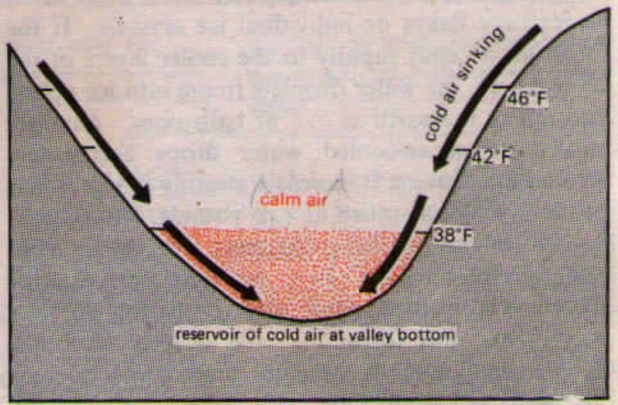


Fig. 111 Temperature inversion at valley bottom on a calm, still night e.g. an Alpine valley in spring

may then be lower in the valley than higher up as the slopes as show in Fig. 111. 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 a 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 necessarily 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-freezing on their way down; this forms sleet. It is only when the droplets in clouds coalesce into larger drops between 0.2 mm. and 6 mm., that rain 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 (Fig. 112). 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. Unlike convectional rain which is caused by convection currents, orographic rain is formed wherever moist air is forced to ascend a mountain barrier. It is best developed on the windward slopes of mountains where the prevailing moisture-laden winds come from the sea. The air is compelled to rise as shown in Fig.113, 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. Much of the precipitation experienced on the windward slopes of the north-east of West Malaysia, western New Zealand, western Scotland and Wales and the Assam hills of the Indian sub-continent, is relief rain.

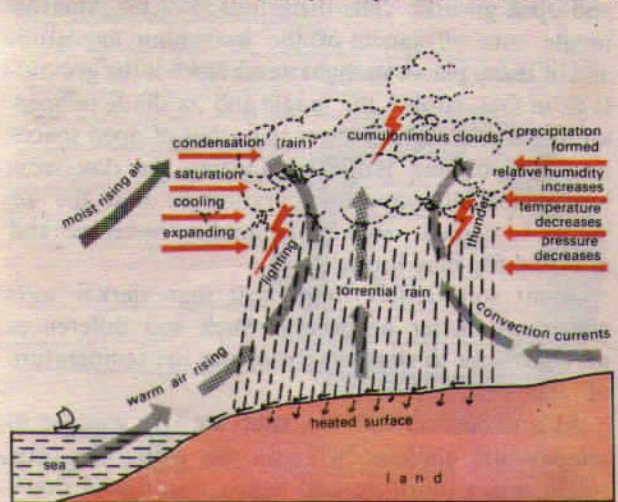


Fig. 112 Convection rainfall

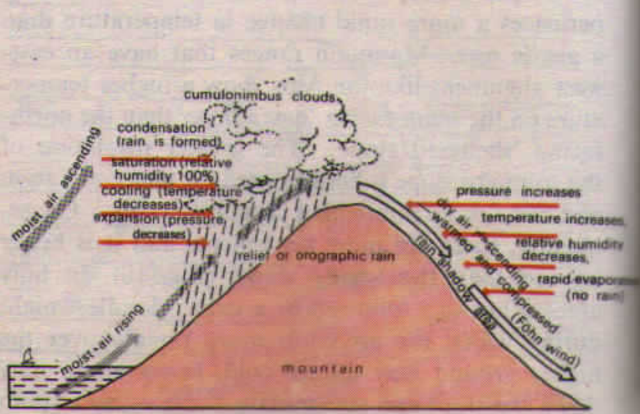


Fig. 113 Orographic or relief rain

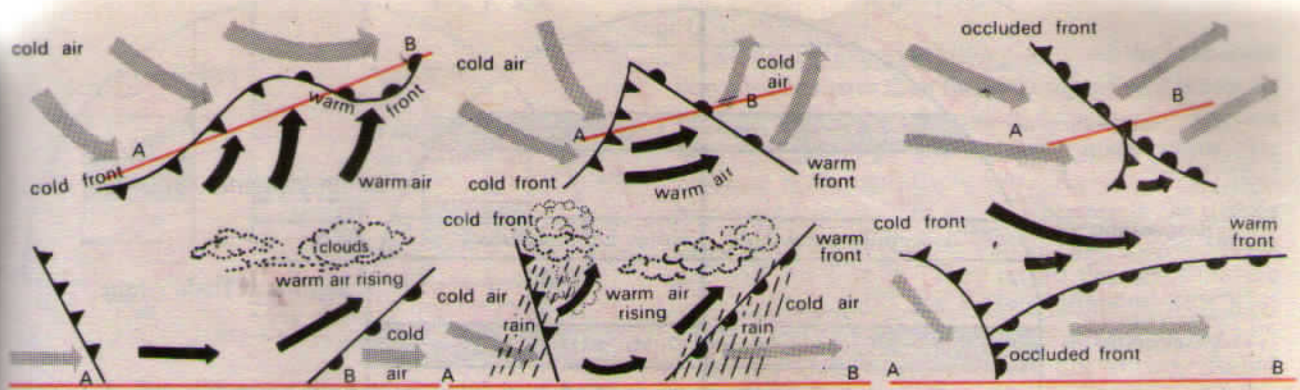


Fig. 114 Cyclonic or frontal rain (depression) (a) The convergence of warm and cold air (b) Warm air rises over cold air, cyclonic rain occurs (c) Cold air eventually pushes up warm air and the sky is clear again

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. The effects of rain shadow are felt on the Canterbury Plain of South Island, New Zealand and the western slopes of the Northern and Central Andes and in many other areas.

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 as shown in Fig. 114. 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 pushes up the warmer and lighter air and the sky is clear again.

Pressure and Planetary Winds

World pressure belts. We studied in Chapter 11 the circulation of waters in the oceans and noted that they follow a regular pattern, flowing from the poles equatorwards and from the equator polewards. 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.

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 belts 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 as shown in Fig. 115. This is know as Ferrel's

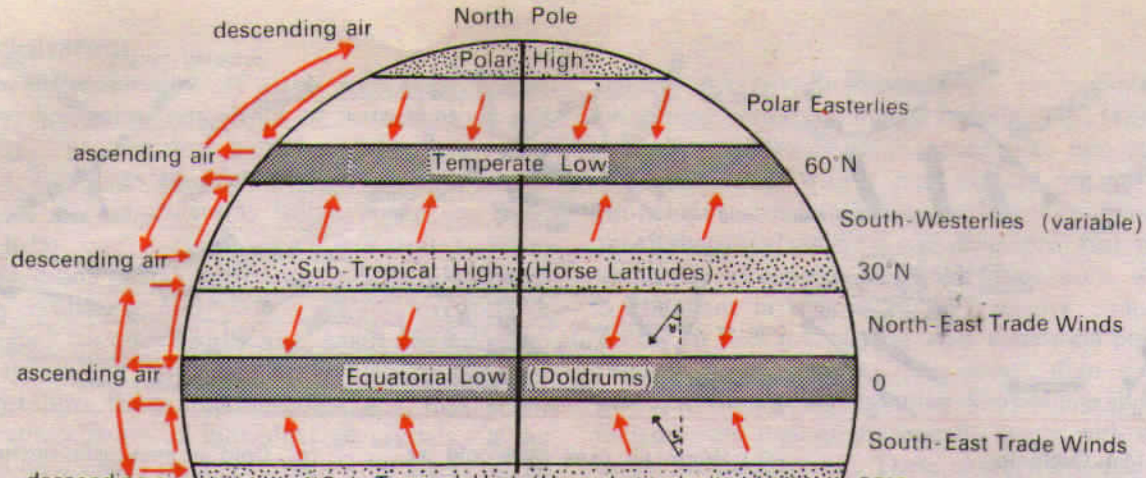


Fig. 115 The distribution of world pressure belts and planetary winds

Law of Deflection. The Coriolis Force is absent along the equator but increases progressively towards the poles.

For this reason, winds blowing out from the Sub-Tropical 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, e.g. the Sahara, Kalahari, Atacama and the Great Australian Deserts.

From the Sub-Tropical High Pressure Belts, winds blow towards the Temperate 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 coasts of continents. The weather is damp and cloudly 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, as explained in Chapter 1, the sun is

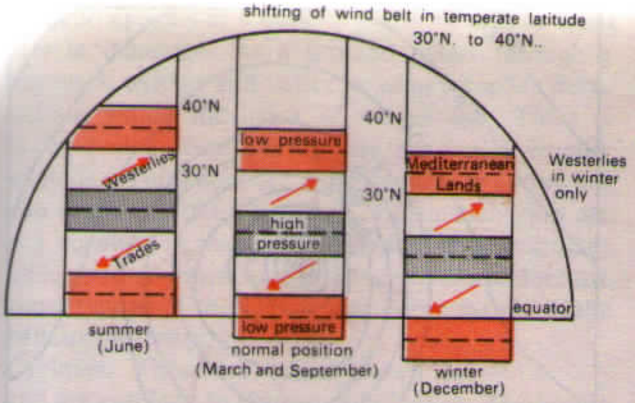


Fig. 116 The shifting of the pressure and wind belts in the northern hemisphere—showing their positions in summer and winter and at the equinoxes

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). This is illustrated in Fig.116.

Lastly, mention must be made of 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 are, 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 thus 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. Land and sea breezes are illustrated in Fig.117.

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.

As illustrated in Fig. 113 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.

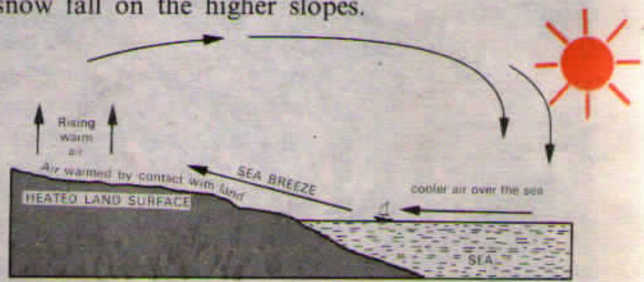
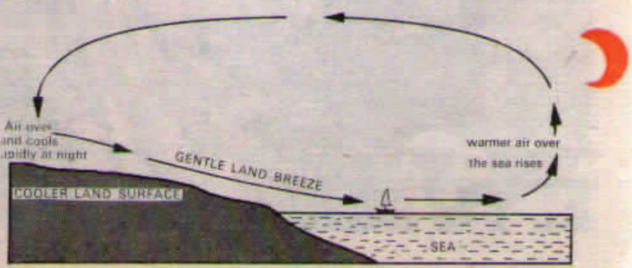


Fig. 117 (a) Sea breeze (day)



(b) Land breeze (night)

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

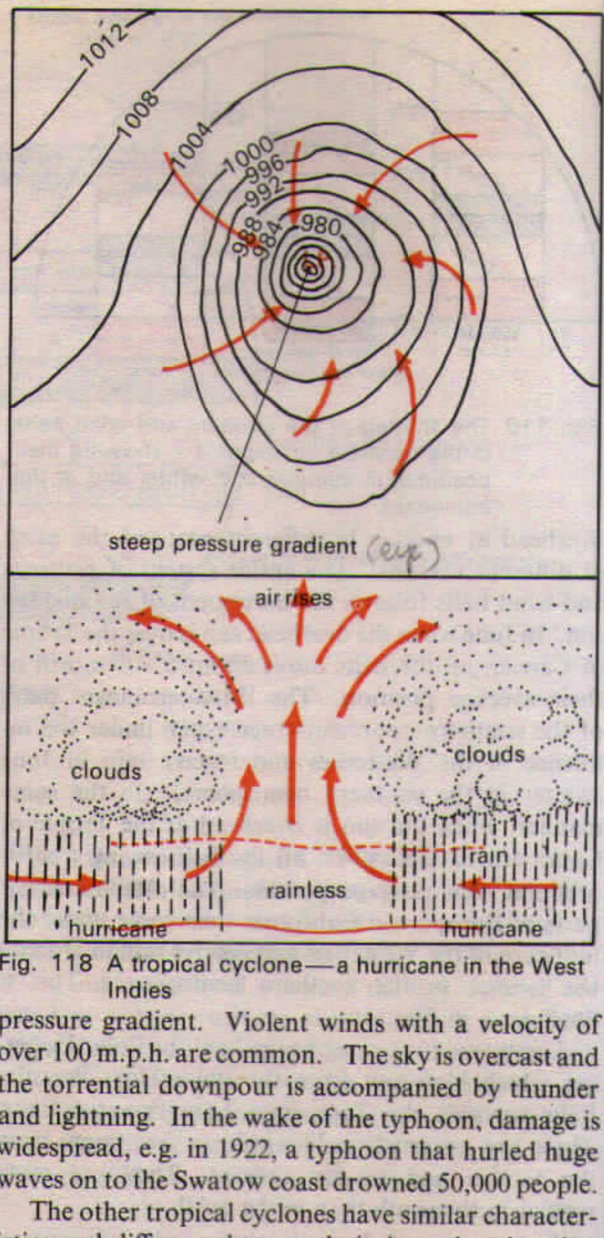


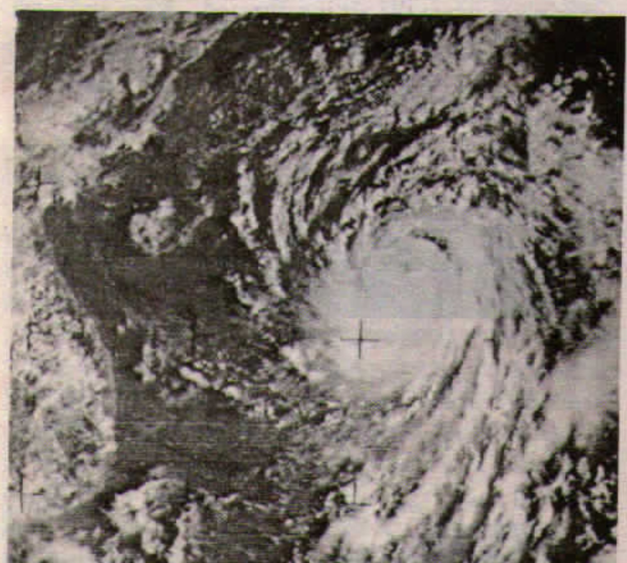
Fig. 118 A tropical cyclone—a hurricane in the West Indies

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. In the wake of the typhoon, damage is widespread, e.g. in 1922, a typhoon that hurled huge waves on to the Swatow coast drowned 50,000 people.

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.) (Fig.118). Dense dark clouds gather and violent stormy weather lasts for several hours. A terrible hurricane struck Barbados in the West Indies in 1780, which nearly destroyed the whole island, tearing down buildings and uprooting trees. About 6,000 inhabitants were reported dead.

Tornadoes are small but very violent tropical and sub-tropical cyclones in which the air is spiraling at a tremendous speed of as much as 500 m.p.h.! A

Tropical storm Judy off South East Asia *Royal Observatory Hong Kong*



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 U.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, as shown in climatic charts, are close together. 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 (Fig.119a)

Chaos caused by a typhoon in Hong Kong *Government Information Services Hong Kong*

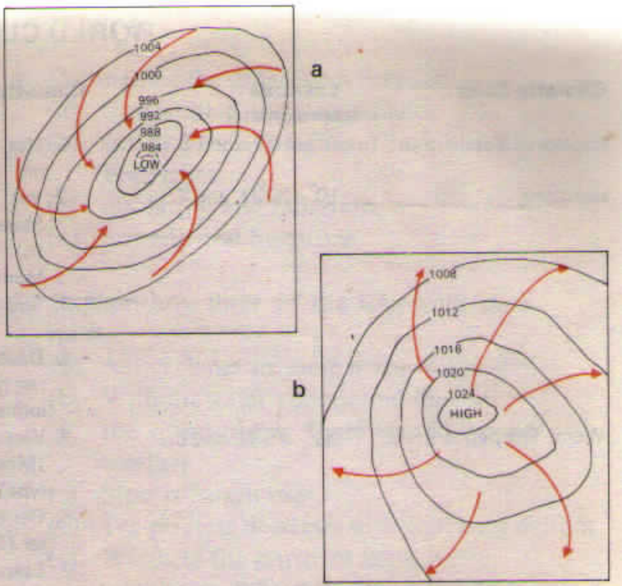


Fig. 119 (a) A cyclone in the northern hemisphere (close isobars, anti-clockwise winds)
(b) An anticyclone in the northern hemisphere (well-spaced isobars, winds blow in clock-wise direction)

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.

Anticyclones. These are the opposite of cyclones, with high pressure in the centre and the isobars far apart. The pressure gradient is gentle and winds are light. Anticyclones normally herald fine weather. Skies are clear, the air is calm and temperatures 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 anticyclones blow outwards and are also subject to deflection, but they blow clockwise in the northern hemisphere and anticlockwise in the southern hemisphere (Fig. 119b).

Climatic Types and Natural Vegetation

It is necessary to divide the world into several climatic zones, each with its own climatic characteristics, natural vegetation (forests, 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. Fig. 120 gives the scheme of the world's climatic types with their seasonal rainfall and natural vegetation.

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	Heavy summer rain: 60 inches	Monsoon forests
		(b) Tropical Marine	Much summer rain: 70 inches	
		3. Sudan Type	Rain mainly in summer: 30 inches	Savanna (tropical grassland)
		4. Desert: (a) Saharan type (b) Mid-latitude type	Little rain : 5 inches	Desert vegetation and scrub
Warm Temperate Zone	30°–45°N. and S.	5. Western Margin (Mediterranean type)	Winter rain: 35 inches	Mediterranean forests and shrub
		6. Central Continental (Steppe type)	Light summer rain: 20 inches	Steppe or temperate grassland
		7. Eastern Margin: (a) China type (b) Gulf type (c) Natal type	Heavier summer rain: 45 inches	Warm, wet forests and bamboo
Cool Temperate Zone	45°–65°N. and S.	8. Western Margin (British type)	More rain in autumn and winter: 30 inches	Deciduous forests
		9. Central Continental (Siberian type)	Light summer rain: 25 inches	Evergreen coniferous forests
		10. Eastern Margin (Laurentian type)	Moderate summer rain: 40 inches	Mixed forests (coniferous and deciduous)
Cold Zone	65°–90°N. and S.	11. Arctic or Polar	Very light summer rain: 10 inches	Tundra, mosses, lichens
Alpine Zone		12. Mountain climate	Heavy rainfall (variable)	Alpine pastures, conifers, fern, snow.

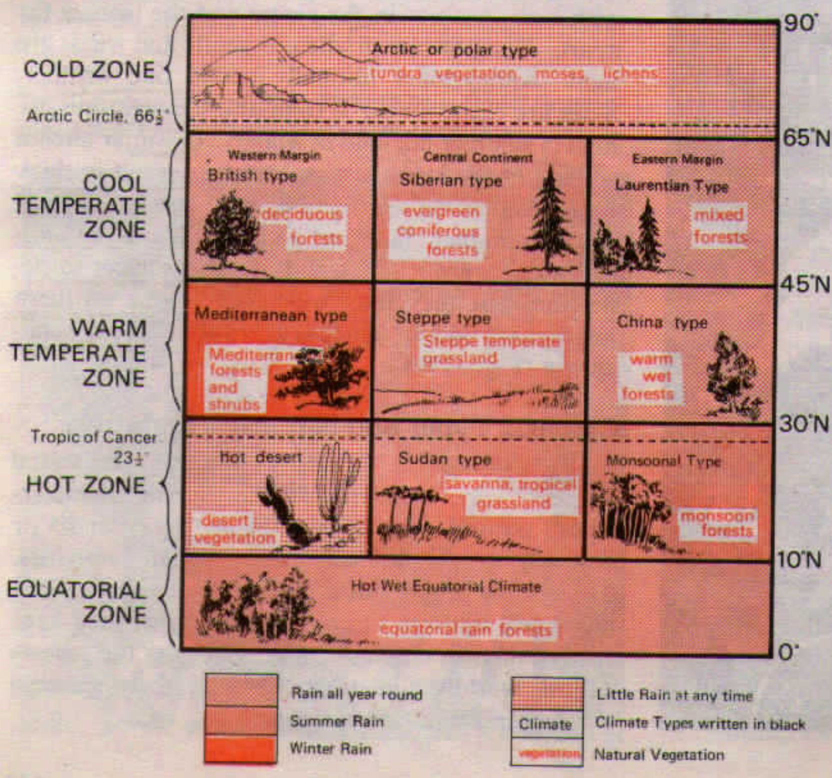


Fig. 120 Scheme of the world's climatic types (with seasonal rainfall and natural vegetation also indicated)

QUESTIONS AND EXERCISES

1. There are many ways in which rain may be caused. Name any three of them and with the aid of annotated diagrams, describe how each of them occurs.

2. Attempt to explain the role played by temperature in climate. What are the various factors that affect the distribution of temperature in the world?

3. Account for the occurrence of any three of the following. Make use of any relevant sketches.
   (a) the planetary winds
   (b) land and sea breezes
   (c) frontal rain
   (d) extremes of temperature in continental interiors
   (e) Horse Latitudes

4. Distinguish the differences between
   (a) troposphere and stratosphere
   (b) steady Trade Winds and variable Westerlies
   (c) insolation and radiation
   (d) tornado and hurricane

5. Explain any three of the following statements.
   (a) Anticyclones are more frequent in summer.
   (b) Without water vapour and dust in the atmosphere, there would be no weather.
   (c) Sleet is frozen rain.
   (d) Temperature decreases with increasing altitude.
   (e) Winds in the northern hemisphere are always deflected to their right.

SELECTED QUESTIONS FROM CAMBRIDGE OVERSEAS SCHOOL CERTIFICATE PAPERS

1. (a) Explain how you would:
   i. read and record maximum and minimum temperatures at a school weather station.
   ii. calculate the mean temperature for a particular month.

   (b) Describe and account for the temperature conditions experienced in:
   i. cool temperate western margin (N.W. European) and;
   ii. tropical interior (Sudan) types of climate, as illustrated by the figures given below:

		Mean monthly temperature	
	Altitude	**Lowest**	**Highest**
i. **Valentia** (52°N. 10°W.)	30 ft.	February: 44°F. (6.7°C.)	July: 59°F. (15°C.)
ii. **Kayes** (14°N. 12°W.)	197 ft.	January: 77°F. (25°C.)	May: 96°F. (35.6°C.)

(1968)

2. Temperature, humidity and wind direction are facts which are recorded at school weather stations.
   (a) For any *two* of these, describe with the aid of annotated diagrams the instruments used and show how to read them correctly.
   (b) Explain clearly the ways in which the school can make use of such records. (1963)

3. (a) Name *three* different types of rainfall and, with the aid of diagrams, show clearly how the rainfall is caused in each case.
   (b) Describe the instrument used to measure the rainfall of a place, and the way in which the information so obtained is used to calculate the mean annual rainfall. (1962)

4. Give reasons for the following:
   (a) Fog at sea often experienced near the Californian coast.
   (b) Many of the hot deserts of the world lie on the west side of a continent either between 20°N. and 30°N. or between 20°S. and 30°S.
   (c) The surface waters in the north-west Atlantic are cooler than surface waters in the north-east Atlantic. (1968)

5. With the aid of diagrams, and by reference to actual examples, describe *three* of the following and state clearly how *each* of the three has been caused:
   (a) land and sea breezes.
   (b) a rain shadow area.
   (c) Fohn (Chinook) winds.
   (d) hurricanes (typhoons). (1967)