Altitude

- Mountains in the North of India have an average height of about 6000 m. On the other hand, the vast coastal area of India has the maximum elevation only about 30 m.
- The Indian sub-continent experiences milder winters as compared to Central Asia because of the Himalayas which prevent the cold winds from entering the sub-continent.

Pressure and Winds

The following atmospheric conditions govern the climate and associated weather conditions in India

(i) Pressure and surface winds
(ii) Upper air circulation
(iii) Western cyclonic disturbances and tropical cyclones

Pressure and Surface Winds

- India lies in the region of the North-Easterly surface winds. These winds originate and blow over land during winter from the sub-tropical high-pressure belt of the Northern hemisphere.
- These winds blow Southwards and get deflected to the right due to the **Coriolis force** and move towards the equatorial-low pressure region.
- Coriolis force is apparent force caused by the earth's rotation. The Coriolis force is responsible for deflecting winds towards the right in the Northern hemisphere and towards the left in the Southern hemisphere. This is also known as Ferrel's Law.
- The North Easterly surface winds carry very little moisture as they originate and blow over land. Therefore, they bring no rain or very little rain.
- During winter, there is a high-pressure area North of the Himalayas. This causes cold dry winds blow from this area towards low-pressure areas over the oceans to the South.
- In summer, due to high temperature, a low-pressure area develops over interior Asia and over North-Western India. Air moves from the high-pressure area over the Southern Indian Ocean in a South easterly direction. It then crosses equator and turns right towards this low pressure region over the Indian subcontinent. This results in complete reversal of wind direction during summer. These winds are known as the **South-West Monsoon winds**.
- These winds blow over the warm oceans, gather large moisture and bring widespread rainfall over the mainland of India.

Upper Air Circulation

- The upper air circulation of the Indian sub-continent is dominated by a Westerly flow, governed by **Jet stream**.
- Jet streams are a narrow belt of high altitude (above 12,000 m) westerly winds in the troposphere. Their speed varies from about 110 km/h in summer to about 184 km/h in winter. A number of separate jet streams have been identified. The most constant are the mid-latitude and the sub-tropical Jet stream.
- Jet streams are located over 27°-30° N latitude, due to which they are known as **sub-tropical westerly jet streams.**
- They blow south of the Himalayas, throughout the year except in summer.

Western Cyclonic Disturbances and Tropical Cyclones

- The Western cyclonic disturbances are weather phenomena of the winter months. These are brought in by the westerly flow from the Mediterranean region. They usually influence the weather of the North and North-Western regions of India.
- Tropical cyclones occur during the monsoon as well as in October-November. These are part of the easterly flow. These disturbances affect the coastal regions of the country.
- In summer, the sub-tropical westerly jet stream moves North of the Himalayas due to apparent shifting of the Sun.
- An easterly jet stream, called sub-tropical easterly jet stream, blows over peninsular India approximately over 14° N during the summer months.

The Indian Monsoon

The Arabs, who had come to India as traders named the seasonal reversal of the wind system 'monsoon'.

The monsoon winds strongly influence the climate of India. The monsoons are experienced in the tropical area roughly between 20° N and 20° S.

Mechanism of Monsoon

The following facts are important to understand the mechanism of the monsoons

- **The differential heating and cooling of land and water creates low pressure on the landmass of India. On the other hand, the seas around this landmass experience comparatively high pressure.**

- **The Inter Tropical Convergence Zone** (ITCZ) in summer season shifts its position over the Ganga plain. ITCZ is normally positioned about 5°N of the equator. ITCZ is the **equatorial trough**[7] but it is also known as the **monsoon trough** during the monsoon season.
- The Inter Tropical Convergence Zone (ITCZ) is a broad trough of low pressure in equatorial latitudes. There is where the Northeast and the Southeast **trade winds**[8] converge. This convergence zone lies more or less parallel to the equator but moves North or South with the apparent movement of the Sun.
- The **high-pressure area in the East of Madagascar** (approximately at 20°S over the Indian Ocean) affects the Indian monsoon due to the intensity and position of this high-pressure.
- The **Tibetan plateau gets intensely heated** during summer. This results in strong vertical air currents and the formation of low pressure over the plateau at about 9 km above sea level.
- The **movement of the westerly Jet stream** to the North of the Himalayas and the presence of the tropical easterly Jet stream over the Indian peninsula during summer.

Monsoon and the Southern Oscillation

- Changes in the pressure conditions over the Southern oceans also affect the monsoons. When the tropical Eastern South Pacific Ocean experiences high pressure, the tropical Eastern Indian Ocean experiences low pressure.
- However, in the past few years, there is a reversal in the pressure conditions and the Eastern Pacific has lower pressure in comparison to the Eastern Indian Ocean. This periodic change in pressure conditions is known as the **Southern Oscillation** (SO).
- The difference in pressure over Tahiti (Pacific Ocean, 18°S/149°W) and Darwin in Northern Australia (Indian Ocean, 12°30'S/131°E) is analysed to predict the intensity of the monsoons.
- If the pressure differences were negative, it would mean below average and late monsoons.

EL Nino Southern Oscillations (ENSO)

- The EL Nino phenomenon is a feature connected with the Southern Oscillation. In this, a warm ocean current flows past the Peruvian Coast, in place of the cold Peruvian current. It occurs at the interval of 2 to 5 years.
- The changes in pressure conditions are connected to the EL Nino. Hence, the phenomenon is referred to as ENSO (EL Nino Southern Oscillations).

The Onset and Withdrawal of the Monsoon

The monsoon winds are affected by different atmospheric conditions over the warm tropical seas. The duration of the monsoon is between 100-120 days from early June to mid September.

At the time of arrival of monsoon, rainfall increases suddenly. It continues constantly for several days.

This phenomenon is called as **Burst of monsoon**. It is different from pre-monsoon showers.

Onset of Monsoon

- Monsoon generally reaches the Southern tip of the Indian peninsula during the first week of June. Then it is divided into the **Arabian Sea branch** and the **Bay of Bengal branch** which move rapidly.
- The Arabian Sea branch advances North along the Western Ghats, reaching Mumbai about ten days later on approximately the 10th of June. By mid-June this branch arrives over Saurashtra Kachchh and central most part of the country.
- The Bay of Bengal branch reaches rapidly to Assam in the first week of June. It then gets deflected towards the West by the lofty mountain ranges, thus, giving rainfall to the Ganga plains.
- Both the branches again merge over the North-Western part of the Ganga plains.
- Delhi receives rainfall from Bay of Bengal branch by the end of June (tentative date is 29th June).
- By the first week of July, monsoon covers Western Uttar Pradesh, Punjab, Haryana and Eastern Rajasthan.
- By mid-July, the monsoon reaches Himachal Pradesh and the rest of the country.

Withdrawal of Monsoon

- Withdrawal or the retreat of the monsoon is a more gradual process. It begins by early September in North-Western states.
- By mid-October, it withdraws completely from the Northern half of the peninsula monsoon withdraw from the Southern half of the peninsula quickly.

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7 **Equatorial Trough** It is a belt of low pressure lying between the subtropical high pressure belts of the Northern and Southern Hemispheres

8 **Trade winds** Winds that blow steadily from East to West towards the equator over most of the Equatorial Zone. These are caused by hot air rising at the equator, with cool air moving in to take its place from the North and from the South.

- By early December, the monsoon has withdrawn from the rest of the country.

Onset and Withdrawal of Monsoon in the Indian Islands

- The Indian islands receive the very first monsoon showers from the last week of April to the first week of May.
- The withdrawal takes place progressively from South to North from the first week of December to the first week of January. By this time, the rest of the country is already under the influence of the winter monsoon.

Check Point 02

1. The average elevation of the mountains in the North is _____.
2. The ITCZ stands for _____.
3. Which line divides India into two halves?
4. Where does sub-tropical easterly jet stream blow in India?

The Seasons

There are basically four seasons identified in India. These are

1. The Cold Weather Season

The cold weather season (winter) begins from mid-November and stays till February. In the Northern parts of India December and January are the coldest months.

The temperature decreases from South to North. For example, the average temperature of Chennai, on the Eastern coast, is between 24°–25°C while in Northern plains, it ranges between 10°–15°C.

Days are warm and nights are cold during this season. Frost commonly occurs in the Northern plains and snow falls in the high mountainous regions of the Himalayas.

During this season, the North-East trade winds prevail over the country. They blow from land to sea and hence for most part of the country, it is a dry season.

Some amount of rainfall occurs on the Tamil Nadu coast from these winds as, here they blow from sea to land.

In the Northern part of the country, a high-pressure region develops, with light winds moving outwards from this area. These winds are influenced by the relief and blow through the Ganga valley from the West and the Northwest.

Features of Cold Weather Season

The characteristic features of cold weather season are

- Clear sky, low temperatures and low humidity and weak variable winds are the characteristics of the weather during this period.
- Over the Northern Plains, there is an inflow of cyclonic disturbances from the West and the North-West. These low-pressure systems have originated over the Mediterranean sea and Western Asia and move into India, alongwith the westerly flow.
- The low pressure systems cause very important winter rains locally known as Mahawat over the plains and snowfall in the mountains. The total amount of Mahawat (winter rainfall) is small, but they are important for the cultivation of 'rabi' crops.
- The peninsular region has moderating effect from the sea and hence, it doesn't have well-defined cold season. Due to this effect, there is no change in temperature pattern during winters.

2. The Hot Weather Season

Due to the apparent Northward movement of the Sun, the global heat belt shifts Northwards. As a result, from March to May, it is hot weather season (summer) in India.

Features of Hot Weather Season

The characteristic features of hot weather season are

- The temperature of the Northern part of India goes up and the atmospheric pressure comes down.
- Towards the end of May, an extended low-pressure area develops in India. It extends from Thar Desert in North-West to Patna and Chotanagpur plateau in the East and South-East. This results into beginning of air circulation around this trough.
- A strong, hot, gusty and dry wind, locally known as Loo blows during this season over the North and North-Western India. It is the salient feature of this season. Sometimes, it even continues until late in the evening. Direct exposure to loo may prove to be fatal (deadly).
- Dust storms are very common in the Northern India in the month of May. They bring temporary relief from the heat by lowering the temperature and may also cause light rain and cold breeze.

- Localised thunderstorms also occur during summer. They may have high speed winds, torrential down pours[9], and even precipitate hail[10]. Such thunderstorms are called Kaal Baisakhi in West Bengal.
- In the end of summer, there may be pre-monsoon showers. These are called Mango Showers which are common in Kerala and Karnataka. These help in the early ripening of the mango fruit.

Temperature Variation During Hot Weather

- The influence of the shifting of heat belt can be seen from temperature recordings taken during March to May at different latitudes.
- In March, the highest temperature is about 38°C, recorded in Deccan Plateau. In April, temperature in Gujarat and Madhya Pradesh is around 42°C.
- In May, North-Western parts of the country experience temperature around 45°C. Due to moderating influence of the oceans, temperature remains lower in the Peninsular India.

3. Advancing Monsoon

The low pressure area over the Northern plains intensifies by early June. It attracts the South-east trade winds of the Southern hemisphere. These trade winds originate over the warm sub-tropical ocean.

After crossing the equator, these blow in a South-Westerly direction and enter the Indian Peninsula as South-West monsoon.

As these winds blow over warm oceans, they bring abundant moisture to the sub-continent. These winds are strong and blow at an average velocity of 30 km per hour. They cover the entire sub-continent except extreme North-West in just over one month.

Rainfall in Western Ghats, Deccan Plateau and North-East region

- The windward side[11] of the Western Ghats receives very heavy rainfall, more than 250 cm in the early season. While the rain shadow area, the Deccan Plateau and parts of Madhya Pradesh also receive some amount of rainfall.
- The maximum rainfall of this season is received in the North-eastern part of the country.

- Mawsynram in the Southern ranges of the Khasi hills receives the highest average rainfall in the world.
- Mawsynram is the wettest place on the Earth which is also famous for its stalagmite and stalactite caves.
- Rainfall in the Ganga valley decreases from the East to the West. Rajasthan and parts of Gujarat get scanty rainfall.

Distribution of Rainfall

- Annually, parts of Western coast and North-Eastern India receive over about 400 cm of rainfall. However, it is less than 60 cm in Western Rajasthan and adjoining parts of Gujarat, Haryana and Punjab.
- Rainfall is equally low in the interior of the Deccan Plateau and East of the Sahyadris.
- Another area of low precipitation is around Leh in Jammu and Kashmir.
- The rest of the country receives moderate rainfall. Snowfall occurs only in the Himalayan region.
- The annual rainfall is highly variable from year to year. Variability is high in the regions of low rainfall, such as parts of Rajasthan, Gujarat and the leeward side of the Western Ghats.
- Areas of high rainfall are greatly affected by floods. On the other hand, areas which receive low rainfall are usually affected by drought like condition.

Features of Advancing Monsoon

Features of advancing monsoon are as follows

- Wet and Dry Spells Monsoon in India does not bring continuous rainfall. It has wet and dry spells i.e. 'breaks' in rainfall. In other words, the monsoon rains take place only for a few days at a time they are (scattered) with rainless intervals. These breaks in monsoon are related to the movement of the monsoon trough.
- Monsoon Trough The trough and its axis keep on moving Northward to Southward and determines the spatial distribution of rainfall. When the axis of the trough lies over the plains, the region gets good rainfall. On the other hand, when the axis of trough lies closer to the Himalayas, the plains gets longer dry spells and widespread rains occur in the mountainous catchment areas of the Himalayan rivers. These heavy rains bring devastating floods causing damage to life and property in the plains.

9 Torrential Down pour It is any amount of rain that is considered especially heavy.
10 Hail It is a form of solid precipitation.
11 Windward Side It is the side or direction of a mountain from which the wind is blowing and pour its moisture in the form of heavy rain.

- **Tropical Depression** frequency and intensity of tropical depressions determine intensity and distribution of the monsoon. These depressions form at the head of the **Bay of Bengal** and move west to mainland. These depressions follow the axis of the 'monsoon trough of low pressure'.
- The monsoon is known for its uncertainties. The alternation of dry and wet spells differ in intensity, frequency and duration.
- Monsoon causes heavy floods and also responsible for causing drought in some regions. It is often irregular in its arrival and its retreat. Hence, it sometimes disturbs the farming schedule of millions of farmers all over the country.

4. Retreating/Post Monsoon Season

When the Sun starts shifting towards the South during October-November, the low pressure trough or monsoon trough over the Northern plains becomes weaker.

It is gradually replaced by a high pressure system. This is followed by the withdrawal of South-West monsoon winds which also become weaker.

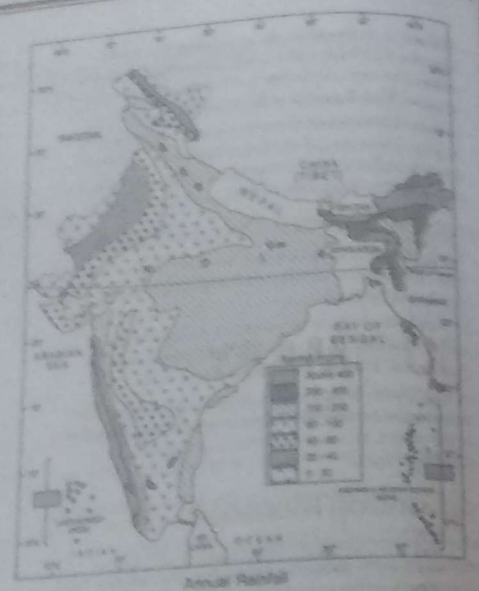
The monsoon withdraws from the Northern plains by the beginning of October, and dry winter conditions prevail by the end of November.

The months of October-November form a period of transition from hot rainy season to dry winter conditions.

Features of Retreating Monsoon

The characteristic features of retreating monsoon are

- The period is marked by clear skies and rise in temperature.
- The day temperatures are high but nights are cool and pleasant.
- Due to the high temperature and humidity, the weather becomes oppressive (humid), during the day time. This phenomenon is known as 'October heat'. In the second half of October, the temperature begins to fall rapidly in the Northern India.



Cyclonic Depression and Tropical Cyclone

The low pressure conditions over North- Western India, get shifted to the Bay of Bengal by early November. This shift is associated with the occurrence of cyclonic depressions which originate over the Andaman sea.

These cyclones generally cross the Eastern coast of India causing heavy and widespread rain. Often they cause a lot of destruction. Sometimes, these cyclones arrive at the coasts of Odisha, West Bengal and Bangladesh.

These cyclones frequently strike the populated deltas of the Godavari, the Krishna and the Kaveri. The Coromandel coast gets its maximum monsoon rainfall mostly during October and November from the cyclones and also by the retreating monsoon which takes its moisture from the Bay of Bengal.

Monsoon as a Unifying Bond

- The Northern India has uniformly higher temperatures than other areas on the same latitudes because the Himalayas protect it from the extremely cold Central Asian winds.
- The Peninsular plateau has moderate temperatures due to the influence of the sea on three sides. Despite such moderating influences, there are great variations in the temperature conditions.

- The seasonal alteration of wind systems and the associated weather conditions provide a rhythmic cycle of seasons.
- Even the uncertainties of rain and uneven distribution are very much typical of the monsoons.
- The Indian landscape, its animals and plant life, agricultural activities and the life of the people all are dependent on the effects of the monsoon.
- The monsoon provides the water to wet agricultural activities in motion and hence, the arrival of the monsoon is awaited eagerly.
- The river valleys which carry this water also unite as single river valley unit.

Check Point 03

1. Dust storms are common in North India in the month of _____.
2. During cold weather season the average temperature of Chennai is between _____.
3. Name any one region which receives low rainfall.
4. In month of _____ the low pressure conditions, get transferred to the Bay of Bengal.

SUMMARY

- Climate is the sum total of the weather conditions (including variations) over a large area for a long period of time (more than 30 years).
- Weather refers to the state of the atmosphere over an area at any point of time.
- The elements of weather and climate are the same i.e. temperature, atmospheric pressure, wind, humidity and precipitation.
- The climate of India is described as monsoon type.
- The word monsoon is derived from Arabic word 'mausim'. Monsoon refers to the seasonal reversal in wind direction throughout the year.
- There are six major controls of the climate of any place which are latitude, altitude, pressure and wind system, distance from the sea, ocean currents and relief features.
- The atmospheric conditions which govern the climate and associated weather conditions in India are- pressure and surface winds, upper air circulation, Western cyclonic disturbances and tropical cyclone.
- South-West monsoon winds are South-East trade winds of southern hemisphere which after crossing equator, be come South-Western trade winds (due to rightward deflection by Coriolis force). As they blow over warm ocean, they cause rainfall in Indian sub-continent.
- The western cyclonic disturbances are weather phenomena of the winter months. These are brought in by the westerly flow from the mediterranean region. They usually influence the weather of the North and North-Western regions of India.
- **The Inter Tropical Convergence Zone** (ITCZ) is a listed trough of low pressure in equatorial latitude. This is where the North-East and South-East trade winds converge.
- In the past few years, there is a reversal in the pressure conditions and the Eastern Pacific has lower pressure in comparison to the Eastern Indian Ocean. This periodic change in pressure conditions is known as the Southern Oscillation (SO).
- The El-Nino phenomenon is a feature connected with the Southern Oscillation. The changes in pressure conditions are connected to El- Nino, hence, the phenomenon is referred to as ENSO (El- Nino Southern Oscillation).
- Monsoon generally reaches the Southern tip of the Indian peninsula during the first week of June. Then it is divided into the Arabian Sea branch and the Bay of Bengal branch which move rapidly.
- The Arabian Sea branch advances North along the Western Ghats. By mid-June, this branch arrives over Saurashtra Kachchh and central most part of the country.
- The Bay of Bengal branch reaches rapidly to Assam in the first week of June. It then gets deflected towards the west by the hilly mountain ranges, thus, giving rainfall to the Ganga plains.
- Both the branches merge over the North-Western part of the Ganga plains.
- There are basically four seasons identified in India such as the cold weather season, the hot weather season, advancing monsoon and retreating post monsoon season.
- Clear sky, low temperatures and low humidity and weak variable winds are the characteristics of the weather during this period.
- The hot weather season is associated with loo, Kaal Baisakhi and Mango showers.
- Features of advancing monsoon are wet and dry spells, monsoon trough and tropical depression.
- Mawsynram in the southern ranges of the Khasi hills receives the highest average rainfall in the world.
- The months of October-November form a transition period from hot rainy to dry winter conditions. This period is known as Retreating/Post monsoon season.
- The seasonal alteration of wind systems and the associated weather conditions provide a rhythmic cycle of seasons.
- The Indian Landscape, its animals and plant life, agricultural activities and the life of the people all are dependent on the effects of the monsoon.
- The monsoon withdraws from the Northern plains by the beginning of October and dry winter conditions prevail by the end of November.

CHAPTER

04

Climate

Concept

Climate is the sum total of the weather conditions (including variations) over a large area for a long period of time (more than thirty years).

Weather refers to the state of the atmosphere over an area at any point of time. The elements of weather and climate are the same i.e. **temperature, atmospheric pressure, wind, humidity** and **precipitation**[1].

On the basis of generalised monthly atmospheric conditions, the year is divided into seasons such as **winter, summer** and **rainy seasons.**

The world is divided into a number of climatic regions. The climate of India is described as **monsoon** type. This type of climate is also found in South Asia and South-Eastern countries.

The word monsoon is derived from the Arabic word **'mausim'** which literally means season. 'Monsoon' refers to the seasonal reversal in the wind direction during a year.

Regional Climatic Variations in India

There is an overall unity in the general climatic pattern in India but there are also some regional variations in climatic conditions within the country.

Temperature

In India, there is much variation in the temperature of different parts of the country even in the same season.

For example, on a summer day the temperature in Rajasthan desert may be 50°C but on the same day it will be around 20°C in Pahalgam in Jammu and Kashmir.

On a winter night, temperature at Drass in Jammu and Kashmir may be as low as minus 45°C. On the other hand, Thiruvananthapuram may have a temperature of 22°C.

1 Precipitation A deposit of rain, hail, mist, sleet or snow on the Earth.

Chapter Syllabus

- Concept
- Climatic Controls
- Factors Influencing India's Climate
- The Indian Monsoon
- Distribution of Rainfall
- Monsoon as a Unifying Bond

There is also a wide difference between night temperature in some parts. For example, in Thar desert the day temperature may rise upto 50°C and drops down to 15°C on the same night.

There are the regions such as Andaman and Nicobar islands or Kerala where there is not much variation in day and night temperature.

Coastal areas experience less contrasts in temperature conditions.

Precipitation

There is a wide variation in seasonal distribution amount types and forms of precipitation.

For example, Upper parts of Himalayas receive precipitation in the form of snow, while it rains over the rest of the country.

The annual precipitation varies from over 400 cm in Meghalaya to less than 10 cm in Ladakh and Western Rajasthan.

Most parts of the country receive rainfall from June to September, but the Tamil Nadu coast gets most of its rain during October and November.

Seasonal contrasts are more in the interior of the country. There is decrease in rainfall generally from East to West in the Northern Plains.

Climatic Controls

Permanent factors which govern the general nature of the climate of any location on the earth are called factors of Climatic Controls. There are six major controls of the climate of any place which are given below

- **Latitude**[2] Due to **curvature**[3] of the Earth, the amount of solar energy received varies with latitude. As a result, air temperature generally decreases from the equator towards the poles.
- **Altitude**[4] With increase of height from the Earth surface, the temperature decreases and air becomes less dense. Therefore, hilly regions are cooler in summer.
- **Pressure and Wind System** It depends on the latitude and altitude of a place. It influences the temperature and rainfall pattern of the area.
- **Continentality**[5] **or Distance from the Sea** The sea exerts a moderating influence on the climate. As the distance from the sea increases its moderating influence decreases then weather conditions become more extreme. This condition is known as continentality. i.e. very hot during summers and very cold during winters.
- **Ocean Currents** Alongwith onshore winds, the ocean currents (warm or cold) affect the climate of the coastal areas. For example, cold onshore currents bring coolness in coastal areas.
- **Relief Features** High mountains act as a barrier for cold or hot wind. These high mountains may also cause precipitation if they are enough high and lie in the path of rain bearing winds. The **leeward side**[6] of mountains is relatively dry.

Check Point 01

1. The type of climate found in India is .....
2. There are ..... major controls of climate of any place.
3. What are the various forms of precipitation in India?
4. Which region has wide fluctuation between day and night temperature?
5. Which Indian state gets most of its rain in October and November?

Factors Affecting India's Climate

The major factors which affect India's climate are given below

Latitude

- The Tropic of Cancer (23°30' N) divides the country into almost two equal halves as the **tropical zone** (South of this line) and the **sub-tropical zone** (North of this line). The Tropic of Cancer passes through the middle of the country.
- It runs from the Rann of Kachchh (West) to Mizoram (East). So, India's climate has characteristics of tropical as well as sub-tropical climates.

2 Latitude The angular distance of a location from the equator in North-South direction is called latitude.
3 Curvature The fact of being curved or the degree to which something is curved.
4 Altitude It refers to the height above the mean sea level.
5 Continentality It is a measure of the difference between continental and marine climates, characterised by the increased range of temperatures that occurs overland compared with water, e.g. very hot during summer and very cold during winters.
6 Leeward Side The side of a mountain which receives less rainfall as windward side already received much of its part.