1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 02 (Class XI, Semester - 2)
Module Name/Title	Monsoon Climate: Unity and Diversity in India – Part 1
Module Id	kegy_20401
Pre-requisites	Basic Concept about size and location of India, location of the different physiographic units such as the Himalayas, location of the Indian ocean, Arabian sea and Bay of Bengal.
Objectives	After reading this lesson, learners will be able to: • Differentiate between weather and climate. • Understand the seasonal and diurnal variation in India in terms of temperature and rainfall. • Acquire knowledge and understanding about the different factors determining the climate of India.
Keywords	Weather, climate, Monsoon, land breezes, sea breezes, southwest monsoon, retreating monsoon, air pressure, upper air circulation, western disturbances.

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Introduction

In the previous modules you have read about the location, structure and physiography of India. Based on that knowledge you can understand that the location, structure and physiography of the country has played a decisive role in making India's climate unique. The presence of the Indian Ocean in the south and the Himalayas in the north have along with the oscillation in the solar radiation and pressure belts significantly impacted the climate of India.

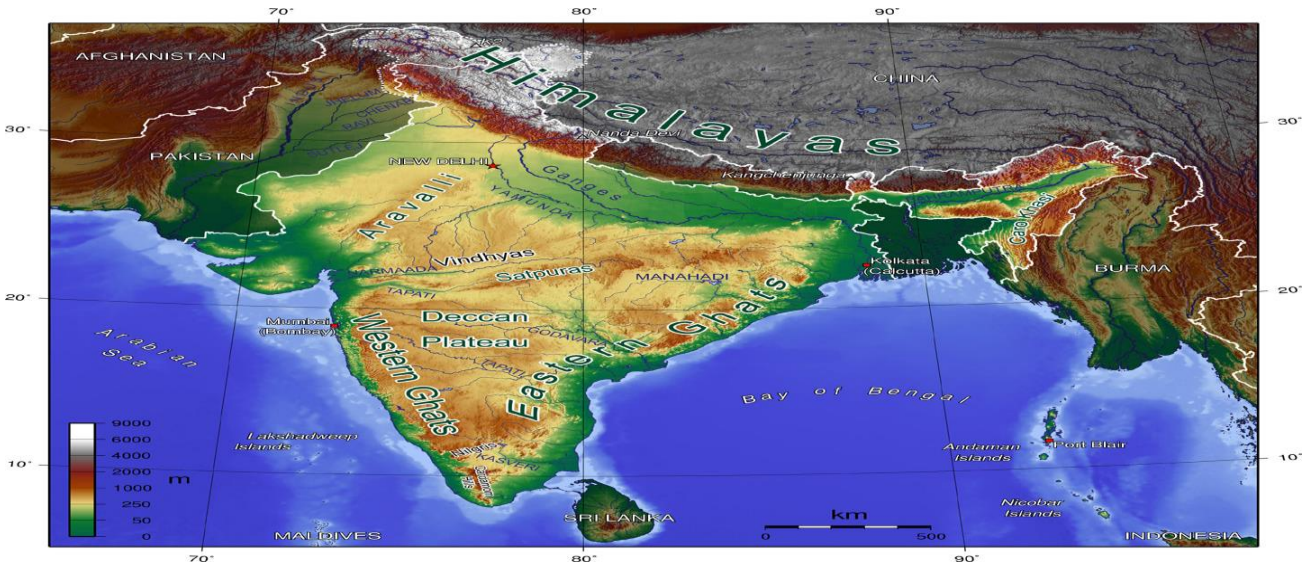


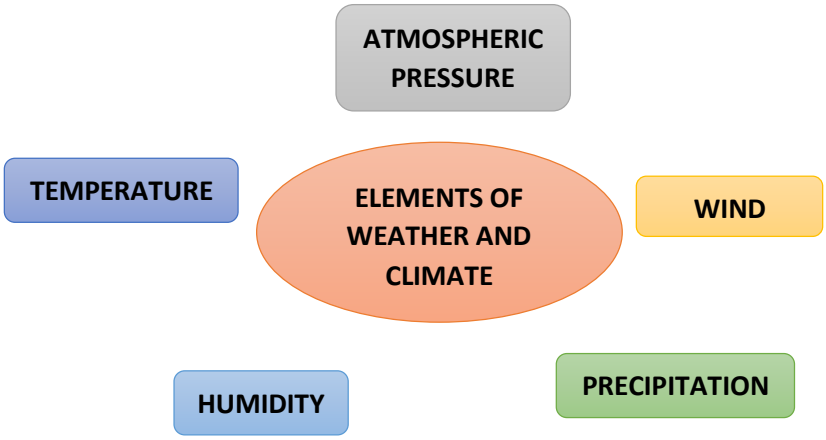
Fig 1: India: Size and Location

Source: https://upload.wikimedia.org/wikipedia/commons/7/7a/India_Geographic_Map.jpg

We drink more water during summers. Your uniform during the summer is different from the winters. Why do you wear lighter clothes during summers and heavy woollen clothes during winters in north India? In southern India, woollen clothes are not required. In northeastern states, winters are mild except in the hills. There are variations in weather conditions throughout the country during different seasons. These changes occur due to the changes in the elements of weather.

Weather and Climate

Weather is the momentary state of the atmosphere for a small area over a short period of time while climate refers to the average of the weather conditions for a large area over a longer period of time (more than 30 years). Weather changes quickly, may be within a day or week but climate changes imperceptively and may be noted after 50 years or even more. The elements of weather and climate are the same, i.e. temperature, atmospheric pressure, wind, humidity and precipitation.



On the basis of the generalised monthly atmospheric conditions, the year is divided into seasons such as winter, summer, rainy seasons and retreating monsoon as per the IMD. India has Monsoon type of climate. The word monsoon is derived from the Arabic word 'Mausim' which literally means season. Monsoon connotes the climate associated with seasonal reversal in the direction of winds. In Asia, this type of climate is found mainly in the south and the south-eastern part. Despite an overall unity in the general pattern, there are perceptible regional variations in climatic conditions within the country. Let us take two important elements – temperature and precipitation, and examine how they vary from place to place and season to season.

Unity and Diversity in the Monsoon Climate

The monsoon regime emphasises the unity of India with the rest of Southeast Asian region. This view of broad unity of the monsoon type of climate should not, however, lead one to ignore its regional variations which differentiate the weather and climate of different regions of India.

Regional variation

For example, the climate of Kerala and Tamil Nadu in the south are so different from that of Uttar Pradesh and Bihar in the north, and yet all of these have a monsoon type of climate. The climate of India has many regional variations expressed in the pattern of winds, temperature and rainfall, rhythm of seasons and the degree of wetness or dryness. These regional diversities may be described as sub-types of monsoon climate. Let us take a closer look at these regional variations in temperature, winds and rainfall.

While in the summer the mercury occasionally touches 55°C in the western Rajasthan, it drops down to as low as minus 45°C in winter around Leh. Churu in Rajasthan may record a

temperature of 50°C or more on a June day while the mercury hardly touches 19°C in Tawang (Arunachal Pradesh) on the same day. On a December night, temperature in Drass (Jammu and Kashmir) may drop down to minus 45°C while Thiruvananthapuram or Chennai on the same night records 20°C or 22°C.

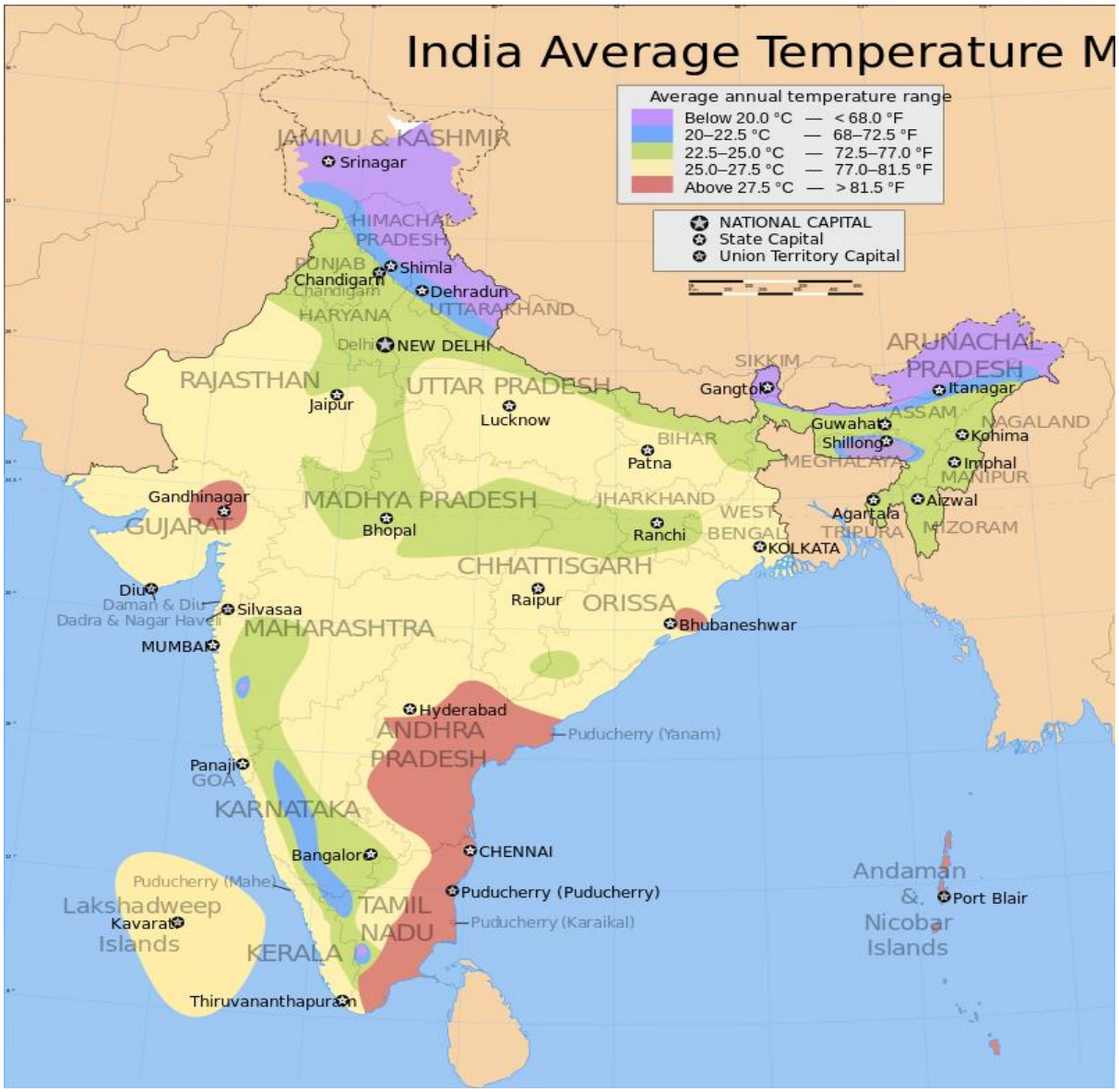


Fig 2: Map: Variation in Temperature

Source:
https://en.wikipedia.org/wiki/Climate_of_India#/media/File:India_average_annual_temperature_map_en.svg

Now, let us see the regional variations in precipitation in terms of its type, amount and form. While snowfalloccurs in the Himalayas, it only rains over the rest of the country. Similarly, variations are noticeable not only in the type of precipitation but also in its amount. While Cherrapunji and Mawsynram in the Khasi Hills of Meghalaya receive rainfall over 1,080 cm in a year, Jaisalmer in Rajasthan rarely gets more than 9 cm of rainfall during the same period.

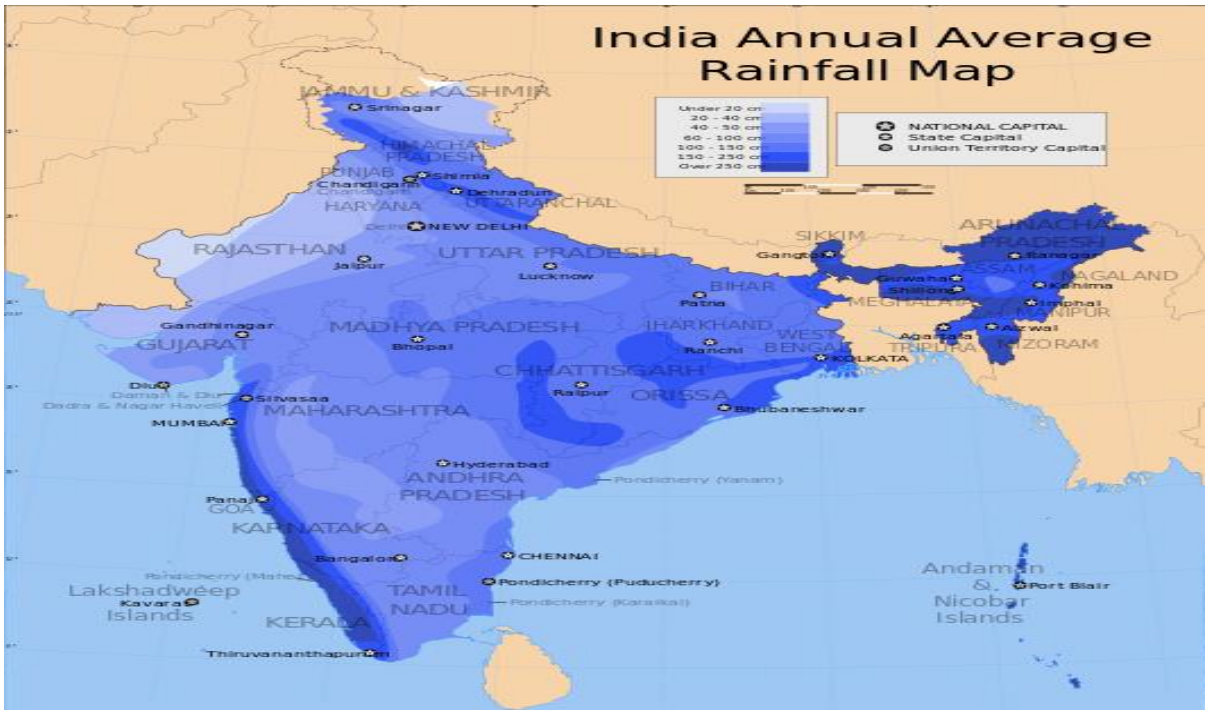


Fig 3: Map Variation in Rainfall

Source: https://commons.wikimedia.org/wiki/File:India_annual_rainfall_map_en.svg

Tura situated in the Garo Hills of Meghalaya may receive an amount of rainfall in a single day which is equal to 10 years of rainfall at Jaisalmer. While the annual precipitation is less than 10 cm in the northwest Himalayas and the western deserts, it exceeds 400 cm in Meghalaya.

The Ganga delta and the coastal plains of Odisha are hit by strong rain-bearing storms almost every third or fifth day in July and August while the Coromandal coast, a thousand km to the south, goes generally dry during these months. Most parts of the country get rainfall during June-September, but on the coastal areas of Tamil Nadu, it rains in the beginning of the winter season.

These examples confirm that there are seasonal variations in temperature from place to place and from region to region in India. Not only this, if we take only a single place and record the temperature for just one day, variations are no less striking.

Diurnal variation

Diurnal variation means changes noticed within a day i.e., 24 hours. In Kerala and in the Andaman Islands, the difference between day and night temperatures may be hardly seven or eight degree Celsius. But in the Thar Desert, if the day temperature is around 50°C, at night, it may drop down considerably up to 15°to 20°C. On the other hand, there is hardly any difference in day and night temperatures in the Andaman and Nicobar Islands or in Kerala.

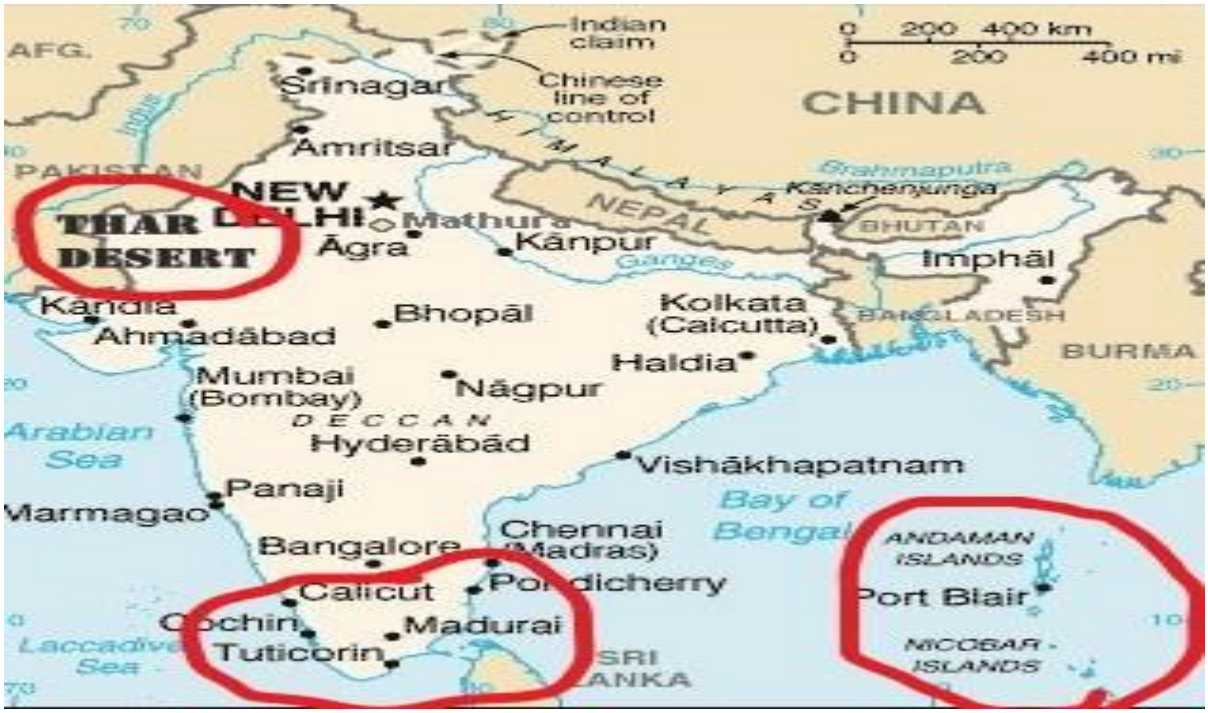


Fig 4: Map Areas Showing Diurnal Variation

In spite of these differences and variations, the climate of India is monsoonal in rhythm and character.

Factors Determining the Climate of India

India's climate is controlled by a number of factors which can be broadly divided into two groups:

A. Factors related to location and relief, and

B. Factors related to air pressure and winds.

FACTORS CONTROLLING THE CLIMATE OF INDIA

FACTORS RELATED TO LOCATION AND RELIEF

1. **Latitude**
2. **Altitude**
3. **The Himalayan Mountains**
4. **Distribution of land and water**
5. **Distance from sea**
6. **Relief**

Factors related to air pressure and winds

1. **Distribution of air pressure and winds on the surface of the earth**
2. **Upper air circulation**
3. **Inflow of western cyclones**

A. Factors related to Location and Relief: -

Latitude, altitude, the Himalayas, distance from sea, distribution of land and water and relief are some of the important factors that we will discuss below in detail.

1. **Latitude:** India is a vast country. Lying entirely in the Northern hemisphere. The main land extends between latitudes 8°4'N and 37°6'N and between 68°7'E and 97°25'E longitudes. You also know that the Tropic of Cancer passes through the central part of India in east-west direction from the Rann of Kuchchh in the west to Mizoram in the east.

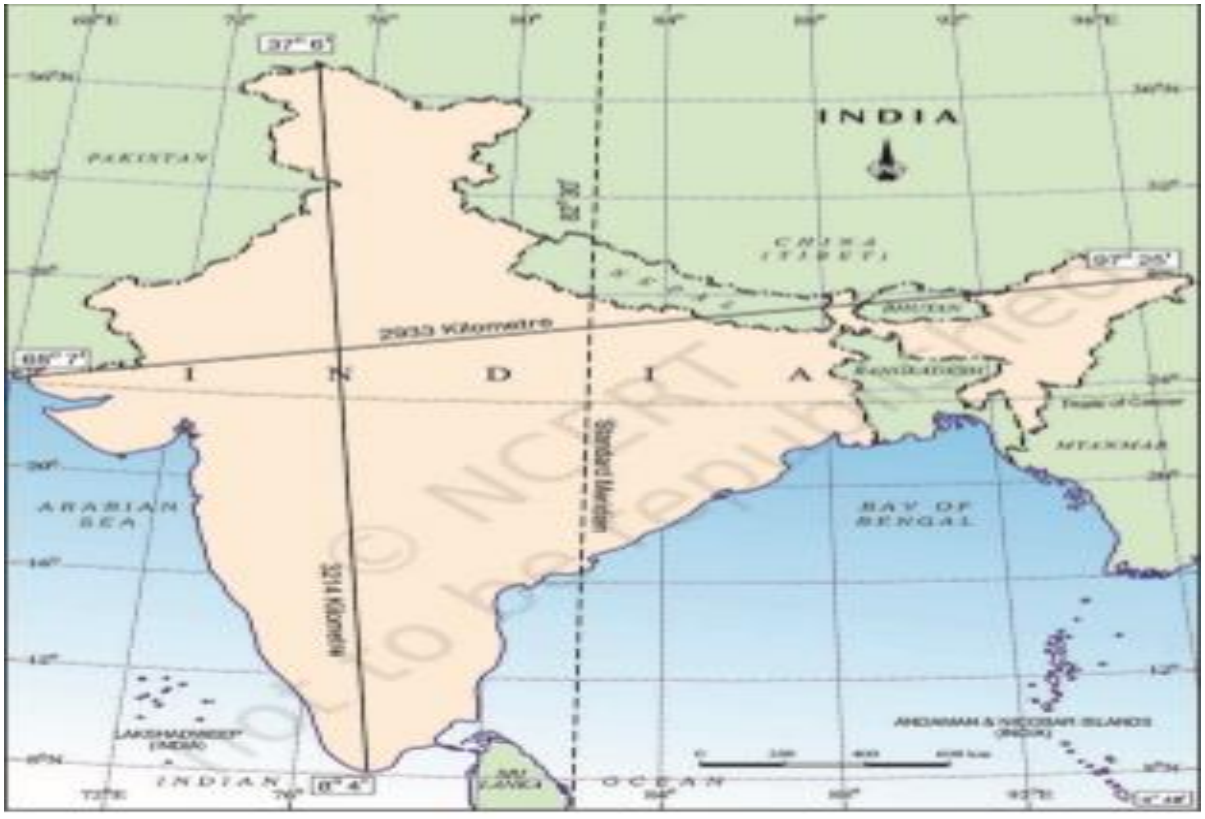


Fig 5: Map: Latitudinal and Longitudinal extent of India

Source: NCERT Geography textbook class 9th

Thus, the tropic of cancer broadly divides the country into two different climatic zones. The northern part of the India lies in sub-tropical and temperate zone and therefore have sub-tropical and temperate climate. The part of India lying south of the Tropic of Cancer falls in the tropical zone and therefore have tropical climate.

Due to the curvature of the earth, the amount of solar energy received varies according to latitude. As a result, air temperature generally decreases from the equator towards the poles. The tropical zone being nearer to the equator, experiences high temperatures throughout the year with small daily and annual range. Area north of the Tropic of Cancer being away from the equator, experiences extreme climate with higher daily and annual range of temperature.

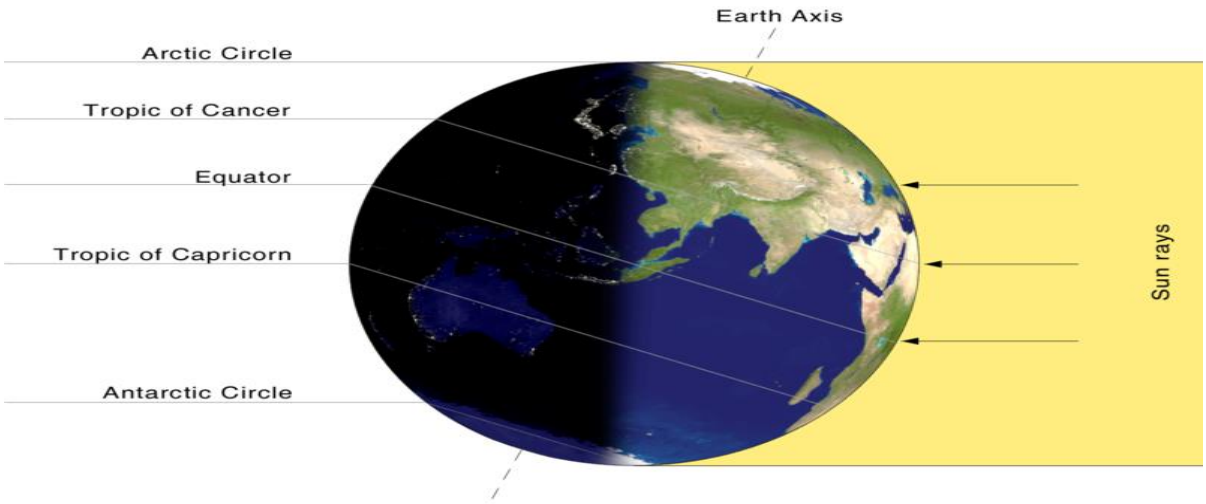


Fig 6: Solar energy received by the earth at different latitude

Source:https://commons.wikimedia.org/wiki/File:Earth-lighting-summer-solstice_EN_-_corrected.png

2. **Altitude:** Altitude means height (from the sea level). There is an inverse relationship between altitude and temperature (upto a certain altitude). Temperature decreases with increasingaltitude. As one goes from the surface of the earth to higher altitudes, the atmosphere becomes less dense and temperature decreases. The hills are therefore cooler during summers. Due to thin air, places in the mountains are cooler than places on the plains. For example, Agra and Darjiling are located on the same latitude, but temperature of January in Agra is 16°C whereas it is only 4°C in Darjiling.

Fig 7: Map Location of Agra and Darjiling

Source:https://commons.wikimedia.org/wiki/File:Map_of_British_India_anachronous.png

There is great altitudinal variation in India. India has mountains to the north, which (Greater Himalayas) have an average height of about 6,000 metres. India also has a vast coastal area where the maximum elevation is about 30 metres. The Himalayas prevent the cold winds from Central Asia from entering the subcontinent. It is because of these mountains that this subcontinent experiences comparatively milder winters as compared to central Asia.

3. **The Himalayan Mountains:** The Himalayas, is a mountain range in Asia separating the plains of the Indian subcontinent from the Tibetan Plateau. The range has many of Earths highest peaks, including the highest, Mount Everest. The Himalayas include over fifty mountains exceeding 7,200 m (23,600 ft) in elevation, including ten of the fourteen 8,000-metre peaks.

Fig 8: Map The Himalayas

India is bounded by the young fold mountains in the northwest, north and northeast. The lofty Himalayas in the north along with its extensions in the north eastern states of India act as an effective climatic divide. The Himalayas play a decisive role in determining the climate of India. By virtue of their high altitude, length and direction, they effectively intercept the southwest monsoons coming from the Bay of Bengal and Arabian Sea and cause precipitation in the form of rain. The Himalayas trap the monsoon winds, forcing them to shed their moisture within the subcontinent. The towering mountain chain provides an invincible shield to protect the subcontinent from the cold northern winds. These cold and chilly winds originate near the Arctic Circle and blow across central and eastern Asia. It is because of these mountains that this subcontinent experiences comparatively milder winters as compared to central Asia.

4. **Distribution of Land and Water:** India is flanked by the Ocean on three sides Indian Ocean in the south, Arabian Sea in the west and Bay of Bengal in the east. The Himalayas form a high and continuous mountain-wall in the north. As compared to the landmass, water heats up or cools down slowly. The differential heating and cooling of land and water creates low pressure on the landmass of India while the seas around experience

comparatively high pressure. This differential heating of land and sea creates different air pressure zones in different seasons in and around the Indian subcontinent. Difference in air pressure causes the reversal in the direction of monsoon winds.

The surface of the sea warms up more slowly than the land. As the temperature of the surface of the land rises, the land heats up the air above it by convection. The warming air expands and becomes less dense, decreasing the pressure over the land near the coast. The air above the sea has a relatively higher pressure, causing air near the coast to flow towards the lower pressure over land as sea breeze. The strength of the sea breeze is directly proportional to the temperature difference between the land and the sea. If a strong offshore wind is present (that is, a wind greater than 8 knots (15 km/h)) and opposing the direction of a possible sea breeze, the sea breeze is not likely to develop.

Fig 9: Sea Breeze

Source: https://commons.wikimedia.org/wiki/File:Land_and_Sea_Breezes.gif

At night, the land cools off faster than the ocean, and hence the land becomes cooler than the adjacent sea surface temperature. The air pressure over the sea surface will be lower than that of the land, setting up a land breeze blowing from the land to the sea. If there is sufficient moisture available, the land breeze can cause showers, or even thunderstorms, over the water.

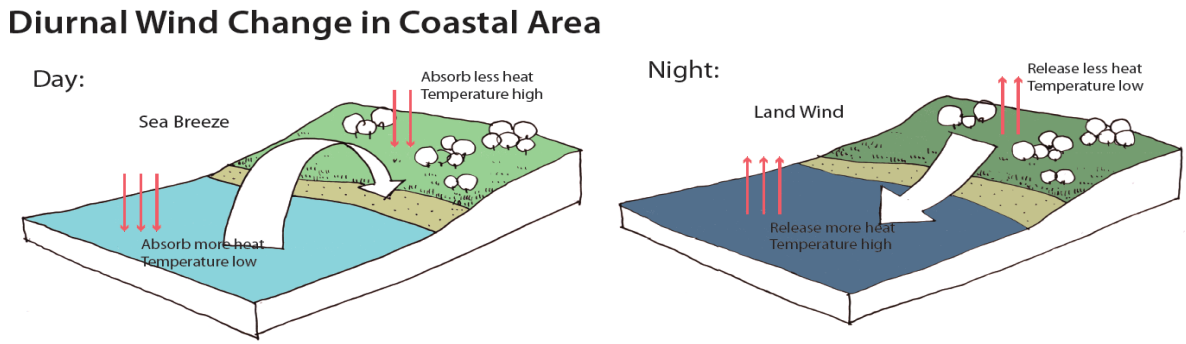


Fig 10: Sea and Land Breeze

Source: https://upload.wikimedia.org/wikipedia/commons/f/fd/Diurnal_wind_change_in_coastal_area.png

5. **Distance from the Sea:** India has a land boundary of about 15,200 km and the total length of the coastline of the mainland, including Andaman and Nicobar and Lakshadweep, is 7,516.6 km. As the distance from the sea increases, its moderating influence decreases and the people experience extreme weather conditions. This condition is known as continentality (i.e. very hot during summers and very cold during winters).

With a long coastline, large coastal areas have an equable climate. Areas in the interior parts of India are far away from the moderating influence of the sea. Such areas have extremes of climate. That is why, the people of Mumbai and the Konkan coast have hardly any idea of extremes of temperature and the seasonal rhythm of weather. On the other hand, the seasonal contrasts in weather conditions in the interior of the country such as in places like Delhi, Kanpur and Amritsar affect the entire sphere of life.

For instance, the **Climate of Mumbai** is a tropical, wet and dry climate. Mumbai's climate can be best described as moderately hot with high level of humidity. Its coastal nature and tropical location ensures temperatures do not fluctuate much throughout the year. The mean average temperature is 27.2 °C and average precipitation is 242.2 cm. The mean maximum average temperatures are about 32 °C in summer and 30 °C in winter, while the average minimums are 25 °C in summer and 18 °C in winter.

The **climate of Delhi** is an overlap between monsoon-influenced subtropical and semi-arid, with high variation between summer and winter temperatures and precipitation. Delhi's version of a subtropical climate is markedly different from many other humid subtropical cities such as Sao Paulo, New Orleans and Brisbane. Delhi features dust storms (something more commonly seen in a desert climate) and wildfire haze (something seen in a tropical climate during the dry season) due to its semi-arid climate and interior location.

Fig 11: Map Location of Mumbai and Delhi from sea

Source: https://upload.wikimedia.org/wikipedia/commons/1/18/India_Map.gif

Summer is certainly not the best time to visit Delhi. It starts in early April and peaks in late May or early June, with average temperature of nearly 38 °C although occasional heat waves can result in highs close to 45 °C on some days and therefore higher apparent temperature. The monsoon starts in late June and lasts until mid-September, with about 797.3 mm of rain. The average temperatureis around 29 °C, although it can vary from around 25 °C on rainy days to 32 °C during dry spells. The monsoons recede in late September, and the post-monsoon season continues till late October, with average temperatures sliding from 29 °C to 21 °C. Winter starts in November and peaks in January, with average temperatures around 6–7 °C.

6. **Relief:** too plays a major role in determining the climate of a place. High mountains act as barriers for cold or hot winds; they may also cause precipitation if they are high enough and lie in the path of rain-bearing winds. This type of rainfall is called orographic rainfall. The leeward side of mountains remains relatively dry. The physiography or relief of India also affects the temperature, air pressure, direction and speed of wind and the amount and distribution of rainfall.

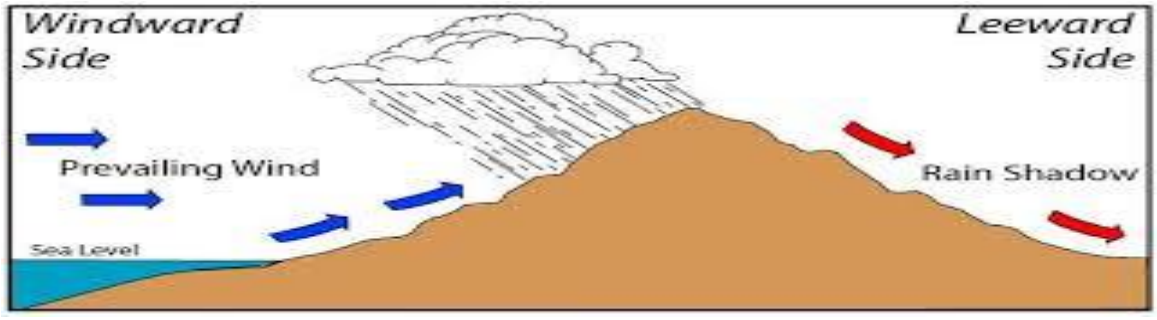


Fig 12: Windward and Leeward Side of a Mountain

Source: https://www.flickr.com/photos/megstewart/8644087724

The windward sides of Western Ghats and Assam receive heavy rainfall during June-September whereas the southern plateau remains dry due to its leeward situation along the Western Ghats.

B. Factors Related to Air Pressure and Wind

To understand the differences in local climates of India, we need to understand the mechanism of the following three factors:

(i) **Distribution of air pressure and winds on the surface of the earth**:

India lies in the region of north easterly trade winds. These winds originate from the subtropical high-pressure belt of the northern hemisphere. They blow southwards, get deflected to the right due to the Coriolis force, and move towards the equatorial low-pressure area. Generally, these winds carry little moisture as they originate and blow over land.

[Coriolis force: An 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 'Ferrell's Law'.]

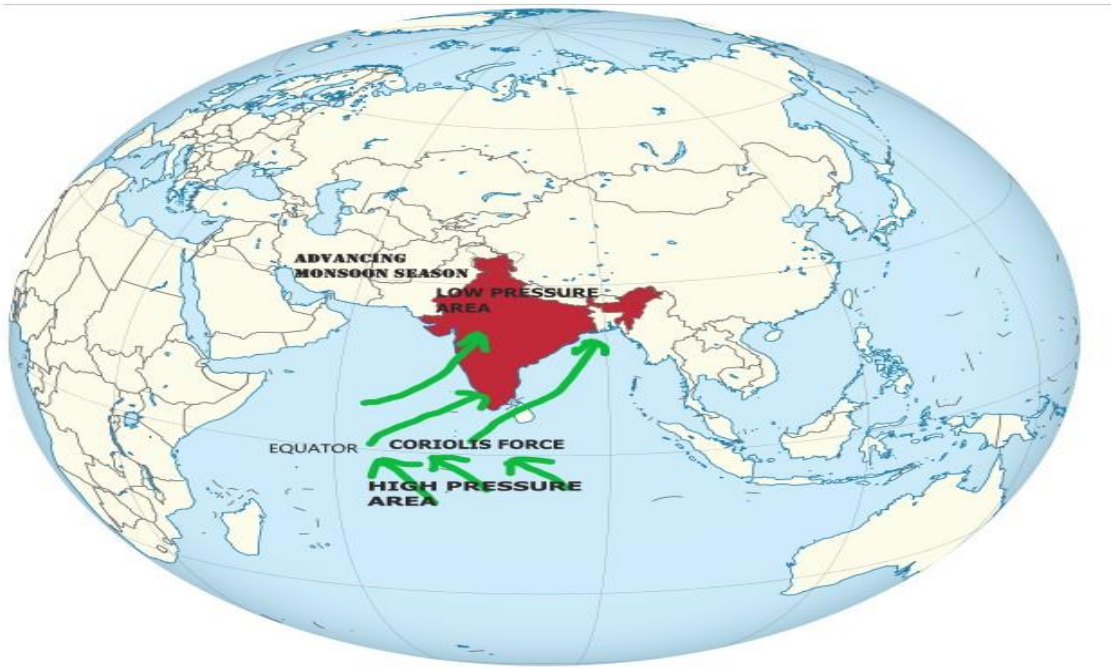
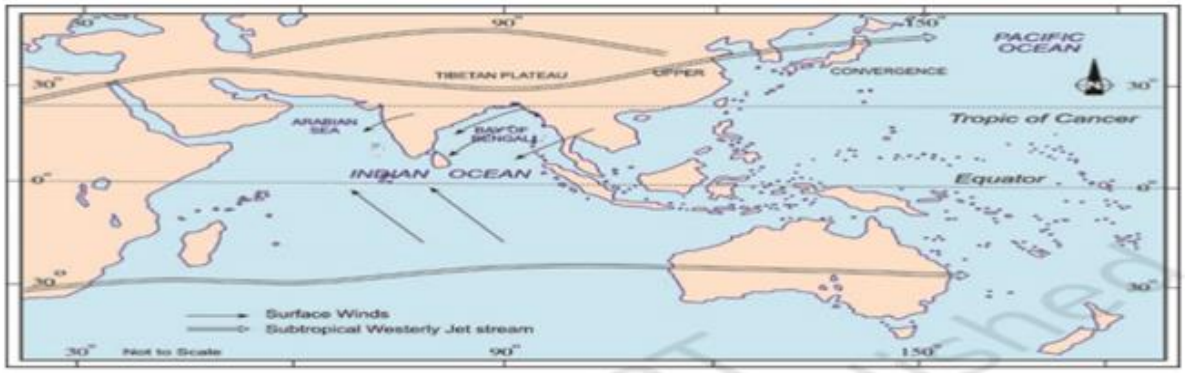


Fig 13: Coriolis Effect

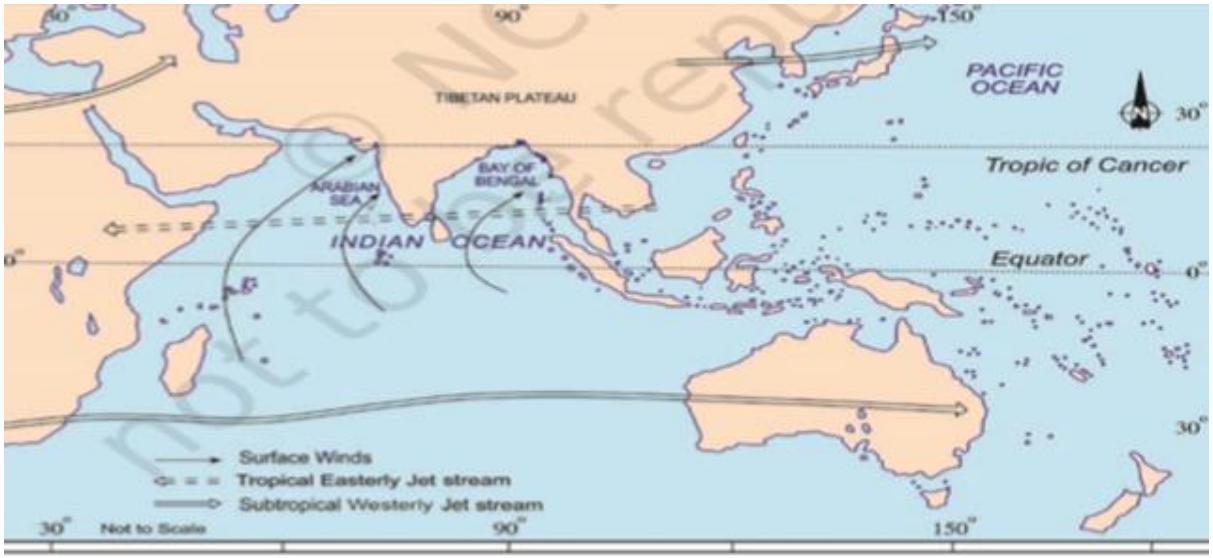
Source: https://es.m.wikipedia.org/wiki/Archivo:India_on_the_globe_(India_centered).svg

The pressure and wind conditions over India are unique. During winter, there is a high-pressure area to the north of the Himalayas. Cold dry winds blow from this region to the low-pressure areas over the oceans to the south. During summer, a low-pressure area develops over interior Asia, as well as, over north-western India. This causes a complete reversal in the direction of

wind during summer. Air moves from the high-pressure area over the southern Indian Ocean, in a south-easterly direction, crosses the equator, and turns right towards the low-pressure areas over the Indian subcontinent. These are known as the Southwest Monsoon winds. These winds blow over the warm oceans, gather moisture and bring widespread rainfall over the mainland of India.



Atmospheric Conditions over the Indian Subcontinent in the Month of January



Atmospheric Conditions over the Indian Subcontinent in the Month of June

Fig 14: Atmospheric Condition over the Indian Subcontinent in the Month of January & June

(ii) **Upper air circulation:** - caused by factors controlling global weather and the inflow of different air masses and jet streams. The upper air circulation in this region is dominated by a westerly flow. An important component of this flow is the jet stream. These jet streams are located approximately over 27°-30° north latitude, therefore, they are known as subtropical westerly jet streams. Over India, these jet streams blow south of the Himalayas, all through the year except in summer. The western cyclonic disturbances experienced in the north and north-western parts of the country are brought in by this westerly flow. In summer, the subtropical westerly jet stream moves north of

the Himalayas with the apparent movement of the sun. An easterly jet stream, called the sub-tropical easterly jet stream blows over peninsular India, approximately over 14°N during the summer months.

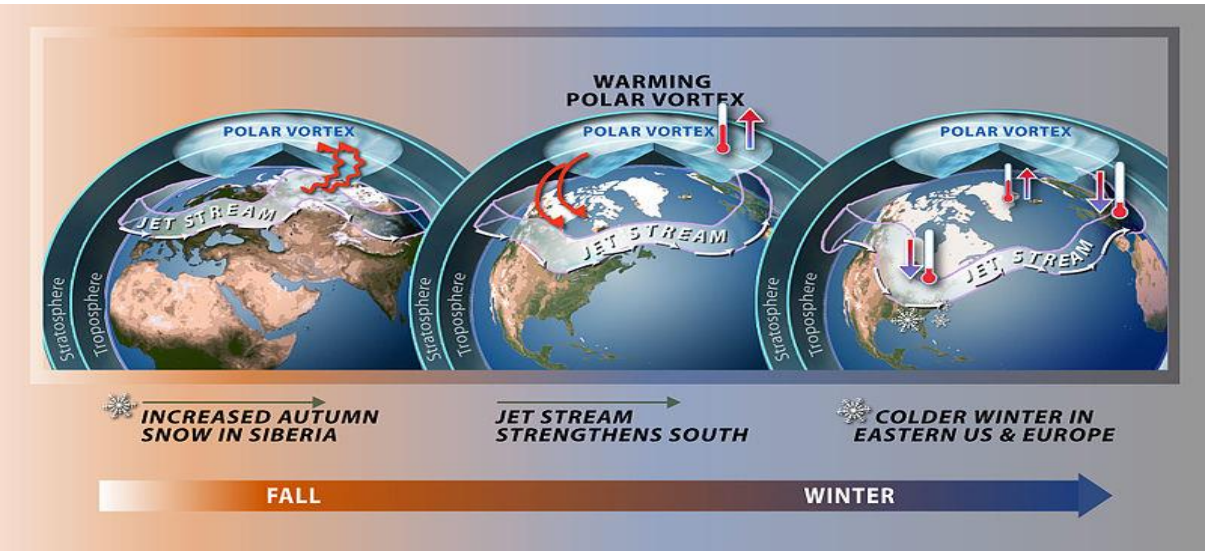


Fig 15: Jet Stream

Source: https://commons.wikimedia.org/wiki/File:Polarvortexwinter.jpg

Jet stream: These 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.

(iii) **Inflow of western cyclones: -** generally known as disturbances during the winter season and tropical depressions during the south-west monsoon period into India, creating weather conditions favourable to rainfall. The western cyclonic disturbances are weather phenomena of the winter months 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, and are part of the easterly flow. These disturbances affect the coastal regions of the country.

Fig 16 Map inflow of Western Cyclones

Source**:** https://mapswire.com/world/physical-maps/

The mechanism of these three factors can be understood with reference to winter and summer seasons of the year separately and that we will discuss in the next module.

In the end of this module it can be summarized that weather and climate are the two different aspects of atmosphere but having same elements. In India great regional and diurnal variations can be noticed in terms of temperature, pressure and precipitation. India has monsoon type of climate which is found in south and south-east Asia. Factors related to location and relief, and Factors related to air pressure and winds plays a detrimental role in making the climate of India unique.