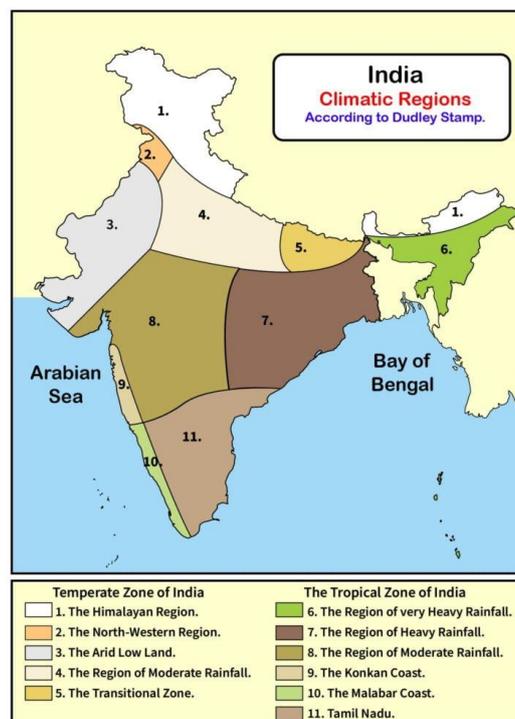


GEOGRAPHY - MODULE 3.1

CLIMATE OF INDIA

- Variety of climates in India.
- Ranging from tropical in the south to temperature and alpine in the Himalayas, north.
- The whole landmass of India lies in tropical zone.
- India’s climate – featured by seasonal reversal of wind.
- Indian climate can be mentioned as monsoon climate.
- Monsoon – Arabic term – **mausim**: seasons.
- Rhythmic change in the direction of wind.
- The Himalayas – act as barriers of the cold wind flowing down from Central Asia.
- Keep the Indian sub-continent warmer.
- Land areas in the north of the country – continental climate.



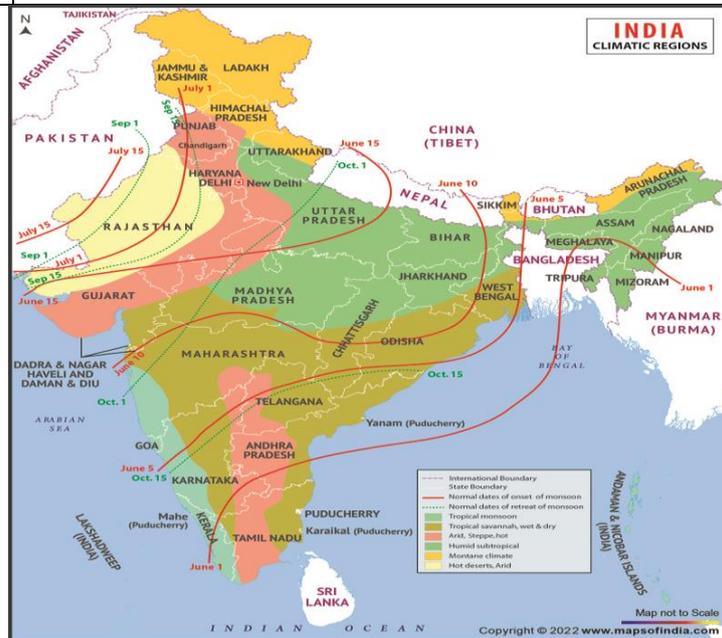
CLIMATE AND WEATHER

- Climate – defined as – total average weather conditions over a region for a greater number of years.
- Weather – defined as – characteristics of atmosphere as particular point of time.
- Climate and weather – same components of measure, observation period differ for both terms.
- Characteristic of atmospheric condition – along with components – reflect different seasons of a year of a region.

The factors which influence the Indian climate

Latitude	<p>Determines the amount of sun rays that a surface receives.</p> <p>The air temperature decreases from the equator to poles.</p> <p>As the tropic of cancer cuts India almost equally half, India experiences both Tropical and sub-tropical climate.</p>
Altitude	<p>The temperature decreases from the surface to higher altitudes as the density of air, decreases.</p> <p>As India has a diversity of landscape from coastal areas to huge mountains led to different climate patterns in different areas of the country.</p> <p>The huge mountains also influence the weather pattern by acting as a wind barrier.</p>
Pressure and wind system	<p>Distribution of temperature and rainfall depends on the pressure and wind system of an area.</p> <p>The major pressure and wind components are- pressure and surface winds, upper air circulation and the cyclones.</p>
Distance from the sea	<p>Sea influences the climate in the coastal areas.</p>

	Coastal areas have moderated climate and the interior lands have an extreme climate.
Relief	Physical features have great influence on climate with the parameters of temperature and pressure, wind direction and speed finally the rainfall distribution



WEATHER MECHANISM

Winter Season

- Cold dry wind from north of Himalayas.
- Jet streams blows over the upper troposphere – great influence on weather pattern of India.
- In winter seasons – Jet Streams travels south of the Himalayas over the Ganga plain.
- Another branch blows north of Tibetan Plateau.
- Jet Streams – high altitude, westward wind in troposphere, flow in a meandering path at high speed.
- Westerly Jet Streams.

Summer Season

- The wind circulation reverses in both at surface and atmospheric level.

ENTRI

- Inter tropical convergence zone – ITCS – low pressure, north east and south east trade wind converge.
- Shifts northward with the movement of the sun and lies south of Himalayas parallel to it.
- Southern part of Peninsula – easterly Jet Streams flows – the tropical cyclones.

Monsoon

- Seasonal change
- Strongest wind of a region over India.
- Wet and dry seasons throughout the tropics.
- Often associated with Indian ocean.
- Blow from cold to warm regions.
- Summer monsoon and winter monsoon – determine the climate of India.

Important concept on the origin of Monsoon

The thermal concept of Hailey - 1686

- Monsoon is the extended land breeze and sea breeze on large scale.
- Produced by different heating of continental and oceanic basin.
- Summer season – northern hemisphere – when sun ray is vertical over tropic of cancer – the huge landmass of Asia heats quickly and develop strong low-pressure centre near Lake Baikal and Peshwar.
- At this juncture the inter Tropical Convergence Zone also shift northwards this reinforces the thermally induced low pressure centre.
- But in comparison to this, the pressure over the adjacent water of the Indian and the Pacific Ocean is relatively high.
- Consequently, the surface air flow form from the high pressure over the oceans towards the low-pressure areas over the heated landmass
- The air coming ocean towards land is warm and moisture laden.

ENTRI

- When the moisture laden wind comes in the contact with land barriers like mountains and plateaus then they ascend and result into condensation and precipitation.

The Dynamic concept by Flohn

- Monsoon is the result of seasonal migration of planetary winds and pressure below.
- The Inter Tropical convergence zone (ITCZ) is formed due to the convergence of north -east trade winds near the equator.
- The northern and southern zone of ITCZ is called NITC (Northern Inter Tropical Convergence Zone) and SITC (Southern Inter Tropical Convergence Zone).
- There is belt of doldrums within the inter Tropical convergence, characterized by equatorial westerlies are established over these areas.
- The equatorial westerlies become south-west summer monsoons.
- Due to the Coriolis force, the trade winds of the southern hemisphere after crossing the equator, deflect towards the right side.
- Similarly, the North-East or winter monsoon does not originate only due to low pressure in the southern hemisphere during winter solstice in fact North-East monsoons or North-East trade winds which are re-established over South-East Asia due to southward shifting of pressure and wind belts.

INDIAN MONSOONS

- The monsoons are experienced in the tropical area roughly between 20°N and 20°S.
- The following **facts help in understanding the mechanism of the monsoons in India:**
 - The differential heating and cooling of land and water (land heats up and cools down faster than water) creates a pressure difference.
 - The movement is formed with high pressure to low pressure.

ENTRI

- The ITCZ positions itself over the Ganga plain in summer (normally 5°N of the equator) - called the monsoon trough.
- There is a high -pressure area, east of Madagascar, approximately at 20°S over the Indian ocean.
- The position and intensity of this high-pressure area effect the Indian monsoon.
- During summer, the Tibetan plateau heats up intensely, develops low pressure over it at about 9km above sea level and results in strong vertical air currents.
- The movement of westerly jet streams and tropical easterly jet streams also influence the monsoon of India.

SOUTERN OSCILLATIONS AND EL – NINO

The change in the pressure conditions over the southern oceans also affect the monsoon.

- Normally when the tropical eastern south Pacific Ocean experiences high pressure, the tropical eastern Indian ocean has low pressure over it.
- There is a reversal in the pressure conditions and the eastern Indian ocean has pressure in comparison to the eastern Pacific Ocean.
- This **periodic change in pressure conditions is called southern oscillations (SO)**.
- The pressure difference over Tahiti (Pacific Ocean, 18°S/149° W) and Darwin in northern Australia (Indian Ocean, 12°30 S/131°E) predict the intensity of monsoons.
- If the pressure difference is negative, it indicates below average and late monsoons.
- South oscillations are the precursor to the occurrence of an El-Nino phenomenon which is the development of a warm ocean current along the coast of Peru (in the eastern pacific) as a temporary replacement of the cold Peruvian current.
- El - Nino is a Spanish word meaning "the child".

ENTRI

- Refers to the baby Christ as these current starts flowing during Christmas.
- This El Nino phenomenon leads to an increase in sea surface temperature and therefore, weakened trade winds in the region.
- El Nino is used in India for forecasting long - range monsoon rainfall.
- In 1990-91, there was a wild El- Nino event and the onset of southwest monsoon was delayed over most parts of the country ranging from 5-12 days.

Monsoons [Onset and Withdrawal]

- The differential heating of land and sea during the summer months is responsible for the monsoon winds to drift towards the subcontinent.
1. The sun shines vertically over the tropical cancer during April and May and the large landmass in the north of the Indian ocean gets intensely heated which results in the formation of intense low pressure in the north-western part of the subcontinent.
 2. As the pressure in the Indian ocean in the south of the landmass is high (water gets heated slowly), the low-pressure region attracts the south -east trade winds across the equator.
 3. These factors help in the northward shift in the position of ITCZ. The south - west monsoon is thus the continuation of subcontinent after crossing the equator.
 4. These winds cross the equator between 40° and 60°E longitude.
 5. The shift in the position of ITCZ is also related to the phenomenon of the withdrawal of the westerly jet stream form its position over the north Indian plain - South of the Himalayas.
 6. The easterly Jet Stream sets in along 15°N latitude once the western jet stream has withdrawn itself from the region.
 7. This easterly jet stream is considered to be responsible for the burst of monsoon in India.
 8. The south - west monsoon sets in over the Kerala coast by 1st June and subsequently it proceeds into two- the Arabian branch and the Bay of Bengal branch.

E ▶ ENTRI

- The Arabian branch reaches Mumbai about ten days later (approx. 10th June)
- The Bay of Bengal branch also advances rapidly and arrives in assam in the first week of June.
- The lofty mountains cause the monsoon winds to deflect towards the west over the Ganga plains.
- By mid-June, the Arabian sea branch of the monsoon arrives over Saurashtra - Kachchh and the central part of the country.
- Both branches of the monsoons merge over the north western part of the Ganga plains.
- Delhi generally receives the monsoons showers from the Bay of Bengal branch by the end of June (approx. 29th June)
- By the first week of July, western utter Pradesh, Haryana, Punjab and eastern Rajasthan experience the monsoons. By mid-July, the monsoon reaches Himachal Pradesh and the rest of the country

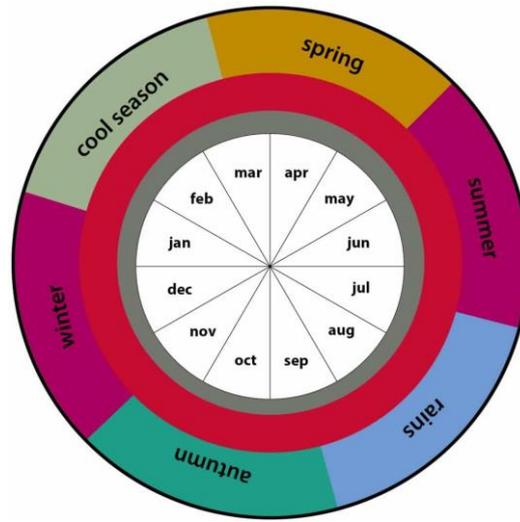
Breaks in the monsoon

- During the monsoon when it rains for a few days and then, if the rains fall to occur for one or more weeks, it is known as a break in the monsoon.
- These dry spells in different regions are due to different reason:
 - In northern India, rains are likely to fall if the rain-bearing winds are not very frequent along the monsoon through (ITCZ).
 - Over the west coast, the dry spell is associated with days when winds blow parallel to the coast.

Retreating Monsoon

- By early September, monsoon begins to withdraw from the north- western states of India.
- From the northern half of India, it withdraws completely by mid-October.
- The withdrawal from the southern half of the peninsula is fairly rapid.
- By early December, the monsoon withdraws from the rest of the country.

SEASONS IN India



- The subcontinent of India has great latitudinal dimension.
- There is different season from Kashmir to Kanyakumari.
- The meteorologists – recognize four seasons.

FOUR SEASONS
The cold weather season - Winter season
The hot weather season - Summer season
The south-west monsoon season - Rainy season
The retreating monsoon seasons

The cold weather season (winter)

- The cold weather season begins from mid-November in northern India and stays till February.
- December and January are the coldest months in the northern part of India.
- During the winter season, there is a general decrease in temperature from south to north.
- Days are warm and nights are cold.
- Frost is common in the north and the higher slopes of the Himalayas experience snowfall.

ENTRI

- Due to the moderating influence of the sea and proximity to the equator, the peninsular region of India does not have any well-defined cold weather season.
- Hardly any seasonal change in the distribution pattern of temperature in coastal region.
- Winter season – north east trade wind prevails over the country.
- Blow from land to sea – dry season in India.
- Rainfall at Tamilnadu coast blow from sea to land.
- End of December – sun shine vertically over tropic of Capricorn in the southern Hemisphere.
- Weather is normally marked – clear skies, low temperature, low humidity, feeble, winds.
- Features- cold wind over norther plains – inflow of cyclone disturbance – west and northwest.
- Originate from east Mediterranean Sea.
- Travels eastward – west Asia, Iran, Afghanistan, Pakistan.
- Rabi crop cultivation.

The hot weather seasons

- The apparent northward movement of the sun towards the Tropic of cancer in March results in the rise of temperature in north India.
- April, May and June are the summer months in north India.
- In march, the highest temperature is about 38°C, recorded on the deccan plateau.
- In April, temperature in Gujrath and Madhya Pradesh are around 42° C.
- In May, a temperature of 45°C is common in the north-western part of the country.
- In peninsular India, the moderating influence of the oceans keeps the temperatures lower than that prevailing in north India and remain between 20°C and 32° C.
- Due to, altitude the temperature in the hills of western Ghats remains below 25°C.

E ▶ ENTRI

- The inter tropical convergence zone (ITCZ) moves northwards due to increased temperature.
- This elongated low-pressure monsoon trough extends over the Thar desert in the north-west to Patna and Chotanagpur plateau in the east and south -east.
- The ITCZ attracts a surface circulation of the winds which are southwesterly on the west coast as well as along the coast of west Bengal and Bangladesh.
- They are easterly or south-easterly over north Bengal and Bihar. These currents of south-westerly monsoon are actually displaced equatorial westerlies.
- The influx of these winds by mid-June brings about a change in the weather towards the rainy season.
- A striking feature of the hot weather season is the "loo". These are strong, gusty, hot, dry winds, blowing during the day over the north and north- west India and sometimes they even continue until late in the evening.
- Dust storms in the evening are very common during may in Punjab, Haryana, eastern Rajasthan and Uttar Pradesh.
- These temporary storms bring some respite from the oppressing heat since they bring along light rains and a pleasant cool breeze.
- The season for localized thunderstorms, associated with violent winds, torrential thunderstorms, associated with violent winds, torrential downpours, often accompanied by hail.
- In west Bengal these storms are known as the "kaal Baisakhi", these showers are helpful for tea, jute and rice cultivation in Assam, these storms are called "Bardoli cheerha".
- Towards the end of summer, there are pre- monsoon showers which are common phenomena in Kerala and coastal areas of Karnataka. They are known as "Mango Sowers" as they help in the ripening of mangoes.

South - west monsoon season - Rainy season

- The low -pressure conditions over the northwestern plains get intensified due to increasing temperature.
- By early June, the low pressure attracts the trade winds of the southern Hemisphere coming from the Indian ocean.

E ▶ ENTRI

- The south-east trade winds cross the equator and follow a south-westerly direction (that is why they are known as south- west monsoons).
- These winds enter the Bay of Bengal and the Arabian sea and while passing over the equatorial warm currents they pick up moisture in abundance.
- The sudden onset of moist- laden winds together with violent thunder and lightning is often termed as the "break" or "burst" of monsoons.
- In the coastal area of Kerala, Karnataka, Goa and Maharashtra the monsoon burst occurs in the first week of June while in the interior regions of the country it may be delayed to the first week of July.
- The monsoon approaches the landmass in two branches - the Arabian sea branch and the Bay of Bengal branch.

The Arabian Sea branch - splits into three parts

-One branch of the Arabian sea - strikes the western ghats and these winds climb the slopes of western Ghats from 900 -1200 m.

-Soon, these winds become cool and the windward side of the Sahyadri and western coastal plain experiences very heavy rainfall (between 250 cm and 400cm).

-After crossing the western ghats, these winds descend and heat in which reduces the humidity in the winds.

-This leads to scanty rainfall east of the western ghats and this region is called the rain shadow area.

-The second branch of the Arabian sea - strikes the coastal north of Mumbai.

-Moving along the Narmada and Tapti River valleys, these winds cause rainfall in central India.

-The Chotanagpur plateau gets about 15 cm of rainfall form this branch.

-Thereafter, they enter the Ganga plains and merge with the Bay of Bengal branch

-The third branch - strikes the Saurashtra peninsula and the Kachchh.

-It then crosses over west Rajasthan and along the Aravalli, causing only a little rainfall.

- The Bay of Bengal branch
 - The Bay of Bengal branch hits the coast of Myanmar and parts of southeast Bangladesh.
 - The Arakan hills along the coast of Myanmar deflect a large part of this branch towards the Indian subcontinent.
 - The monsoon thus enters west Bengal and Bangladesh from south -east and not from a south westerly direction.

Bay of Bengal branch of monsoon splits into two
One branch moves in a west direction along the Ganga plain reaching as far as the Punjab plains.
The second branch moves up the Brahmaputra valley in the north and north- east, causing heavy rains.

- The maximum rainfall is received in the northern-eastern part of the country. Myanmar in the southern ranges of the Khasi hills receives the highest average rainfall in the world.
- Rainfall in the Ganga plains decreases from east to west.
- The Tamilnadu coast remains dry during this season because it is situated parallel to the Bay of Bengal branch of the south - west monsoon.
- Lies in the rain shadow area of the Arabian sea branch of the south- west monsoon.

Breaks in the monsoon

- The monsoon rains take place only for a few days at a time and are interrupted with rainless intervals.
- These breaks are related to the movement of the monsoon trough.

E ▶ ENTRI

- When the axis of the monsoon trough lies over the plains, rainfall is good in these parts and when the axis shifts closer to the Himalayas, there are large dry spells in the plains and heavy rainfall in the mountainous catchment areas of the Himalayan rivers.
- The frequency and intensity of tropical depressions too, determine the amount and duration of monsoon rains.
- These depressions are formed at the head of the Bay of Bengal and cross over to the mainland.
- The depression follows the axis of the monsoon trough of low pressure.
- Monsoons play an important role in the agrarian economy of India because over three-fourths of the total rain in the country is received during the south-west monsoon season.

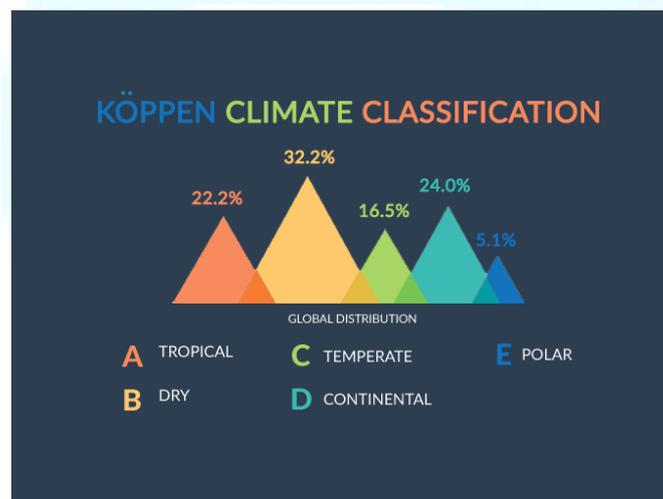
Retreating Monsoon Season

- During the months of October and November, with the apparent movement of the sun towards the south, the monsoon trough or the low-pressure trough over the northern plains become weekend.
- This gets gradually replaced by the high-pressure system.
- The southwest monsoon winds weaken and start withdrawing gradually.
- The monsoon withdraws from the northern plains by the beginning of October.
- October and November months form a period of transition from hot rainy season to dry winter season.
- The withdrawal of the monsoon is marked by clear skies and increasing temperatures.
- The land is still moist.
- Due to high temperature and humidity, the weather becomes rather oppressive during the day.
- This is commonly known as "October heat".
- In the second half of October, the mercury begins to fall rapidly in north India.
- The low-pressure trough over north-western India gets transferred to the Bay of Bengal early November.
- This shift is associated with the occurrence of cyclonic depressions, which originates over the Andaman Sea.

E ▶ ENTRI

- These cyclones generally cross the eastern coasts of India and bring heavy and widespread rainfall.
- These tropical cyclones are highly destructive.
- The densely populated deltas of the Godavari, Krishna and Kaveri are often hit by cyclones which cause great damage to life and property.
- These cyclones may also reach the coasts of Bangladesh, west Bengal and Odisha.
- The bulk of the rainfall of the coromandel coast is derived from depressions and cyclones.
- Such cyclonic storms are less frequent in the Arabian sea.

KÖPPENS CLIMATIC CLASSIFICATION



A - TROPICAL MOIST CLIMATE

A- Tropical Humid Climate	Tropical wet Tropical monsoon Tropical wet and dry	Af Am Aw	No dry season Monsoon short dry season Winter dry season
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E ▶ ENTRI

- Tropical moist climates can be found about 15 to 25 degrees latitude northwards and south wards of the equator.
- The distinctive feature of this climatic zone is that temperatures Hindi songs remains about 18 degrees Celsius all throughout the year annual precipitations in this climatic zone is usually above 1500 mm.
- With this board climatic zone, 3 minor climatic types also exist, whose classifications based on the seasonal distribution of rainfall in this climatic zone.
- Areas falling under these climatic zones usually consist of natural dense tropical forests.

- First is Af or tropical wet climate where the climate is tropical with precipitation all year around.
- Monthly variations in temperature in these regions are less than about 3 degrees C.
- The extremely high humidity and surface temperatures in these regions cause cumulus and cumulonimbus clouds to form early into the afternoons everyday resulting in a high amount of precipitation.

- The second is a tropical monsoon climate designated as Am.
- In this region the annual precipitation is nearly similar to that of a but here moat of the precipitation occures within the 7 to 9 of the warmest months of the year.
- Less rainfall occures in these regions in the rest of the year.

- The third sub division is Aw or the tropical wet and dry climate or the savanna climate.
- These climate zone experience and extended dry season during the winter season.
- During the wet season precipitation is usually less than 1000mm and occures mostly during the summer season.

B - DRY CLIMATE

B - dry climate	Subtropical Steppe	Bsh	Low latitude semi arid or dry
	Subtropical Desert	BWh	Low latitude arid or dry
	Mid- latitude Steppe	Bsk	Low latitude arid or dry
	Mid latitude desert	Bwk	Mid latitude semi-arid and or dry
			Mid latitude arid or dry

- Temperature is not as much of a factor in this climatic zone as precipitation, or rather the lack of it is this climatic zone.
- In this climatic zone evaporation and transpiration exceed at the total precipitation.
- These climatic regions extended 2235 degrees latitude northwards and southwesome equator and a present in large continental region in the mid-latitudes or enriched by mountains regions.

There are four broad subdivisions of this climatic zone

- The first is BW or dry eric climate also called the true dessert climate and covers about 12% of Earth total land area.
- Areas falling under disc climatic zone are habitats for xerophytic vegetation.
- The letters h and k are suffixed after BW to signify whether the dry arid zone is located in the subtropics of themed latitudes respectively.
- The second is BS or dry semi-arid climate also referred to as steppe climate.
- This forms a sort of grass and climate that is present on about 14% of the Earth surface.
- Regions coming under dry semi eric climate or BS receives more precipitations than the regions under the dry and climate or BW which is

E ▶ ENTRI

mainly due to mid latitude cyclones or due to the in the tropical convergence zones.

- The letters h and k are suffered in a similar way to BW zones to define the location of the climatic zone in the subtropics or in the mid latitudes respectively.

C – MOIST SUBTROPICAL MID LATITUDE CLIMATES

C - warm temperature climate	Humid subtropical	Cfa	No dry season
	Mediterranean	Cs	Dry hot summer
	Marine west coast	Cfb	No dry season warm and cool summer

- In warm temperature climate climatic zone summers are usually warm and humid while winters are mild these climatic sounds extend 30 to 50 degrees latitude northwards and south wards from the equator and the present mainly at the eastern and western extremes of most continents.
- Summers months feature many convective thunderstorms and winter month feature some mid latitude cyclones 3 sub divisions exists for this form of the climatic zone.
- The first is the humid subtropical climate or CFA wear summers are hot and humid with frequent thunderstorms.
- The windows are comparatively mild and precipitations during this period occures due to meet latitude cyclones like in the southeastern USA for example.
- The second is the CFB Marine climates that are usually found on the western coast of continents.
- The climate here is largely humid with a hot and dry summer.

E ▶ ENTRI

- Winters are mild although accompanied by heavy precipitation due to mid latitude cyclones.
- The third is the Mediterranean climatic zones or CS where rainfall mostly occurs during the mild winters due to the mild latitude cyclones.
- Precipitations during the summer month in this climatic sound can be extremely sandy.
- Areas falling under this climatic zone can include locations in Portland, Oregon, and California for example.

D- MOIST CONTINENTAL MID LATITUDE CLIMATES

D – cold snow for est climates	Humid Continental Subarctic	Df Dw	No dry season Severe winter Winter dry and very severe
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- In moist continental mid latitude climates summers are warm and can also be cool while winters are cold.
- The regions with moist continental mid latitude climates are usually located poleward from the moist subtropical mid latitude climates or C climates.
- Average temperature in the warmest months is you surely more than 10 degree C, while temperature in the coldest months can be less than minus 3 degrees C.
- Winters in these regions can be bitterly cold with strong winds and snow storms that flow the continental polar and the Artic air masses.

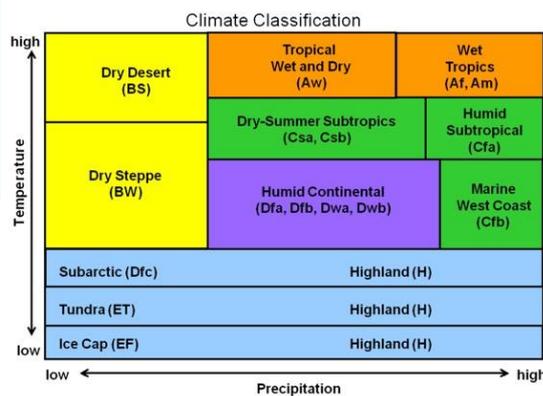
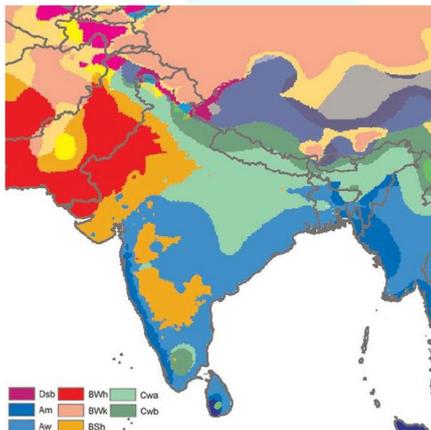
There are three subdivisions in this form of Koppen's climate classification.

- Dw with dry winters
- Ds with dry summers and
- Df with precipitation all year round

E – POLAR CLIMATES

E - cold climates	Tundra polar ice cap	ET EF	No true summer Perennial ice
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- In polar climate temperature are low all year round with the warmest month having temperatures less than 10 degrees C.
- Polar climate occurs in the Northern coastal areas of Asia.
- Europe and North America and on Greenland and Antarctica polar climate have two subdivisions.
- The first is ET or polar Tundra in which soil occurs as permanently frozen as permafrost extending hundreds of meters in depth.
- Most vegetation found here occurs in the form of dwarf trees would be shrubs, lichens and mosses.
- The second is EF or polar ice caps, lock which have a surface that is permanently covered with ice or snow.



Pros of Koppen classification

- Quantitative - easier to understand and measure.
- Coincides with vegetation pattern.
- Give importance to effective precipitations evapotranspiration.

Cons of Koppen classification

- Too much emphasize on average value.

Koppen based his classification of the mean monthly values of temperature and precipitation.

By the statistics the most important factor of precipitation can only be estimated rather than measured accurately.

This makes comparison from one locality to another rather difficult

- Ignore precipitation intensity amount of cloud and daily temperature variation number of rainy days.

- Koppen did not take into account such weather elements as winds precipitation intensity amount of cloudiness and daily temperature extremes for the sake of making his classification generalized and simple.

- Ignore the role of air masses.

It is empirical and the four is based on facts and observations.

The causative factors of climate have been totally ignoring this the air masses which form the very basic modern climatology could not find any place in Koppen classification.

- Was not a genetic classification.

CODE CLIMATIC TYPE REGIONS OF India

CODE	CLIMATIC TYPE	REGIONS OF INDIA
Aw	Tropical Savanna	Most of the Peninsular Plateau. South of the tropic of cancer.
Amw	Tropical monsoon with short dry seasons.	West coast of India, South of Goa
As	Tropical moist	Coromandel Coast of Tamilnadu
BShw	Semi-arid steppe	North western Gujarat,

		Parts of Rajasthan, Punjab
Bwhw	Hot desert	Extreme western Rajasthan
Cwg	Monsoon with dry winter	Ganga plain, Eastern Rajasthan, Northern Madhya Pradesh, North East India
Dfc	Cold humid winter with shot summer	Arunachal Pradesh
E	Polar type	Jammu and Kashmir, Himachal Pradesh, Uttarakhand

