Atmosphere

Monday, April 9 2012, 4:38 PM

Composition & Structure

1. Hygroscopic nuclei: They are the dust particles around which the water vapor condense to form clouds.
2. Normal lapse rate: 1ºC fall in temperature with every 165 m advance in troposphere.
3. Tropopause: Height of tropopause is highest @ equator (18 km) compared to poles (8 km). The temperature is also lowest @ equator (-80ºC) as compared to poles (-45ºC). This is because convectional currents are strongest @ equator.
4. Stratosphere: It extends from tropopause to 50 km. From 20 km height, the temperature starts rising due to presence of O_3. The air movements are almost horizontal.
5. Mesosphere: It extends from 50 km to 80 km. Temperature decreases with height again and reaches up to -100ºC.
6. Thermosphere: Its lower layer is called ionosphere where temperature rises with height again due to proximity to sun. It reflects radio waves.

Insolation & Temperature

1. @ 45º latitude, insolation is ~75% of that @ equator. @ 66.5º latitude it is ~50% and @ poles it is ~40% of that @ equator.
2. Isotherms: They are straighter and more widely spaced in S hemisphere than in N hemisphere because of more water.
3. Temperature anomaly: The difference between mean temperature of a place and the mean temperature of its latitude is called temperature anomaly. +ve anomaly means local temperature > latitude temperature. Above 40º N, continents have -ve anomaly and oceans have +ve anomaly for the year as a whole and vice versa for oceans.
4. Temperature inversion: This happens when earth surface is able to radiate solar energy directly into space. Clear sky and dry still air is necessary for it. When such a thing happens, the air near the surface becomes cool due to conduction and settles. The air above it remains warm as convectional currents are not possible. Such a thing often happens on intermontane valleys when during long winter nights, mountain slopes radiate energy quickly. The air cools, becomes dense and descends on the valley thus freezing it. The warm air of the valley is pushed up, so while valley freezes, the mountain slopes remain warm. This is also called a katabatic process. Temperature inversion may occur @ frontal situations when warm air climbs above the cool air mass. Finally in anti-cyclonic conditions over cold regions, when air descends it may get katabatically heated up before reaching the surface while the surface air remains cold.
5. Sub-solar point and Sun's declination: The point on earth where the sun is directly overhead @ a given point of time is called sub-solar point. The latitude of the sub-solar point is called Sun's declination.
6. Albedo: This is the amount of insolation reflected by the body. Earth's albedo is ~ 30-35%. In tropics it is as low as 20-40% and in poles it reaches 80%. When sun is overhead albedo is less.

Heat Budget

1. 35% is radiated by atmosphere (27% from clouds, 2% from ice), 14% is absorbed by it. Rest 51% reaches earth's surface which is absorbed by it and later radiated back.
2. 34% is absorbed by atmosphere again (19% via latent heat of condensation) while 17% is radiated directly to space. Atmosphere together radiates back 48% to the space.

Latitudinal Heat Balance

1. @ latitudes below 40º, insolation is ≥ that radiated back. @ latitudes above 40º, insolation is ≤ that radiated back. ~80% of the latitudinal heat transfer takes place via atmosphere and 20% via ocean currents.
2. Temperature contrast between continents and oceans are greater during winters than in summers.

Air Pressure

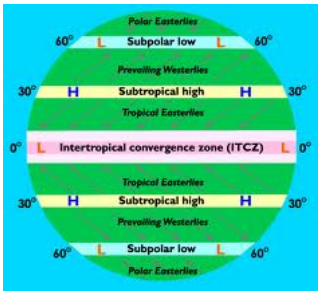
1. The atmospheric pressure is 1013.25 mb = 76 cm of Hg column. It normally falls @ a rate of 34 mb per 300 meters of ascent.

Pressure Belts
Headley's Model

1. His model assumed only one cell in each hemisphere. Low pressure @ equator and high pressure @ pole with air from pole flowing towards equator.
2. It assumed a non-rotating earth and uniform earth surface.

Ferrel's Model

1. The cell between equator low pressure belt and sub-tropical highs is called Headley cell, the one between sub-tropical high and sub-polar low is called Ferrel cell and the one between sub-polar low and poles is called polar cell.
2. It assumes a rotating earth, uniform surface (i.e. either land or water throughout) and sun being stationary overhead @ equator.



1. Equatorial low: 10º N - 10º S. Calm conditions persist here despite the low pressure because as the air from sub-tropical high pressure belt reaches the margins of this belt, it warms up and ascends vertically instead of flowing horizontally. Thus only vertical currents are found in this belt. So it is also called doldrums.
2. Sub-tropical highs: 23.5º - 35º latitudes. There is subsidence and piling up of air leading to calm conditions and hence known as horse latitudes (30º - 35º latitudes).
3. Season shift of pressure belts: The shift is less in S hemisphere due to abundant water. The shift of the pressure belts is also higher in lower latitudes than in higher ones. The ITCZ can shift ~ 20º N and only 10º S of equator.
4. Air current: The vertical or nearly vertical movement of air is called air current.

Reasons for sub-tropical high belt

1. As the warm air of equator low pressure rises, it cools. Upon reaching upper layers it begins to move towards poles. It further cools down, becomes dense and by 25-35º latitude it begins to subside.
2. Due to Coriolis effect, in these latitudes the movement of air becomes effectively west to east instead of going north. This produces a blocking effect and the dense air begins to subside heavily.

Wind Types

Planetary Winds

1. Trade winds: They blow from sub-tropical highs (30º latitudes) towards equatorial low pressure. They are extremely steady. In N hemisphere they get deflected towards right and in S hemisphere towards left.
2. Westerlies: Westerlies of S hemisphere are stronger and more consistent in direction due to predominance of water.

Periodic Winds

1. Valley breeze and mountain breeze: During day mountain slope gets heated up more than the valley floor. So air from the valley begins to flow up the slope. This is the valley breeze. During night, mountain slope cools faster than the valley. So the cold slope air begins to descend on the valley from higher slope. This is called mountain breeze.

Local Winds

1. Foehn & Chinook: Due to pressure gradient, winds get pulled up from the windward side to the leeward side. After causing precipitation on the windward side, as it descends on the leeward side, it becomes warm and increases the temperature of the surrounding. In Alps it is called foehn and in Rockies it is called Chinook.
2. Mistral: Cold winds descending from snow capped mountains into the valley are called mistral in the Alps.

Jet Streams

1. They blow from west to east near tropopause @ very high speeds (120 kmph in winters and 50 kmph in summers). They are embedded in the prevailing westerlies and encircle the globe.
2. Sub-tropical jet stream: They prevail over the lower latitudes of westerlies. It is produced by the rotation of earth and its spherical shape. The air over equator has the highest velocity (Coriolis effect). As it rises and moves towards north, it has a higher velocity than the air @ lower altitude prevailing @ same latitude. So it begins to flow from west to east around 30º latitude.
3. Mid-latitude or polar front jet stream: It is more variable and is produced by a temperature difference. In summers its position shifts towards poles and in winters towards equator.

Air Masses

1. Source region: The region where an air mass is produced. Necessary conditions are large scale subsidence of air over the source region. The subsiding air acquires the properties of the source region.
2. Classification of air masses: They are classified based on the source region and air mass modification. Thus there can be tropical maritime air mass, tropical continental air mass, polar maritime air mass and polar continental air mass.
3. Thermodynamic modification in air mass: When the air mass is heated or cooled from the surface below, it is a thermodynamic change. When a warm air moves over a cold surface, temperature inversion results which inhibits further vertical cooling. If a cold air mass moves over a warm surface, convectional currents are formed. This leads to formation of vertical clouds (cumulus) and air turbulence. Addition or loss of latent heat also is an example of thermodynamic modification.
4. Dynamic modification in air mass: These modifications are independent of surface heating or cooling. Examples are subsidence caused by anti-cyclones or cyclones. Surface friction adds to the turbulence of air flow aiding the upward transfer of the effect of thermodynamic modifications.
5. Warm front and cold front: When warm air mass rises above a cold air mass it is warm front. When the cold air mass forces its way under the warm air mass it is the cold front.

Air Moisture

Humidity

1. Absolute humidity: It is the weight of water vapor per unit volume of air. Since the volume may be impacted by a change in temperature or pressure, such factors affect absolute humidity.
2. Specific humidity: It is the weight of water vapor per unit mass of air. Since it is the mass of the air now, it is not impacted by change in temperature or pressure.
3. Relative humidity: Proportion of actual water vapor to the water vapor carrying capacity.
4. Hygrometer is an instrument used to measure humidity. Psychrometer is a hygrometer with one dry bulb thermometer and one wet bulb thermometer. The difference between the two readings gives the humidity.

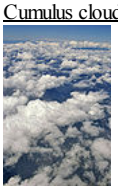
Condensation

1. Dew point: Temperature @ which the sample of air becomes saturated.
2. Dry adiabatic rate vs wet adiabatic rate: As air rises, it expands and cools adiabatically. However, the rate of cooling depends on the water vapor content of the air. Higher the water vapor present, lower the rate of cooling due to release of latent heat of condensation. Rate of cooling in a saturated air sample is called wet adiabatic rate and that in an unsaturated air sample is called dry adiabatic rate. Wet adiabatic rate is ~2x the dry adiabatic rate.
3. White frost: When under dew forming conditions, the dew point of the air is $\leq 0^{\circ}$ C, water vapor condenses as minute ice. This is called white frost.
4. Radiation fog, advection fog and frontal/precipitation fog: Radiation fog results when the ground cools rapidly due to radiation and the adjacent air too cools and its water vapor condenses. Such fog is not very thick. Advection fog is formed when moist warm air moves horizontally over a cold surface. Such fogs are thick and persistent. Frontal fog occurs when warm air mass is forced to rise over the cold air mass. It cools, condensation and precipitation takes place. If the cold air below is near the due point, its temperature falls further (as some water from the rain gets converted into water vapor thus absorbing latent heat of evaporation) and excess moisture condenses as fog. It is formed @ convergence zone.

Clouds

1. Cirrus clouds: They are high (6-12 km), thin, white clouds made of ice crystals.

2. Cumulus clouds: They are dome like, cauliflower shaped clouds.



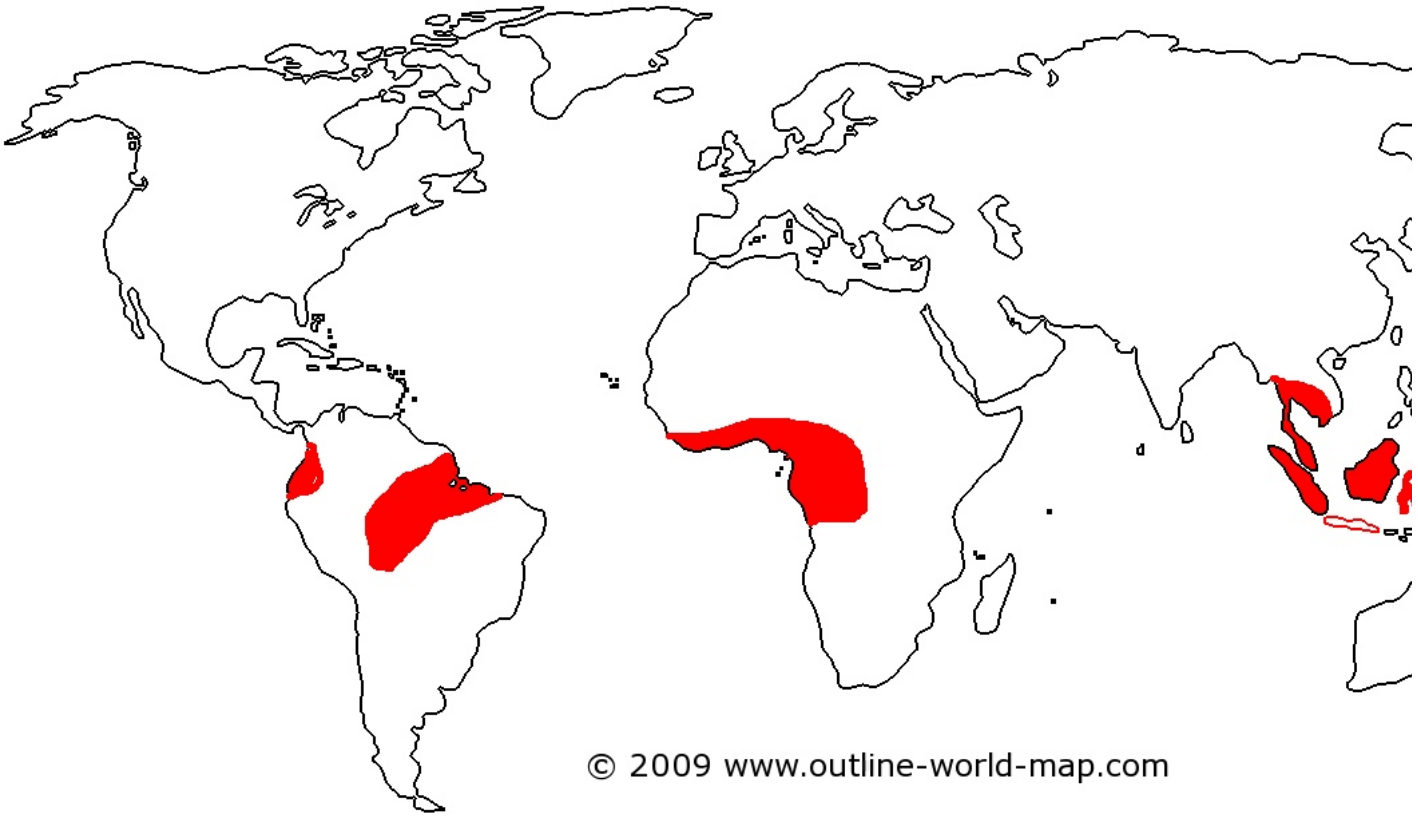
3. Stratus clouds: They represent sheets of layers which cover almost whole of sky.
4. Alto clouds: It is a prefix/suffix used to specify medium height clouds (2-6 km).
5. Nimbo clouds: It is a prefix/suffix used to specify low height clouds (0-2 km).
6. Thus various types of clouds possible according to height are: (a) Low clouds - stratocumulus, stratus, nimbostratus, cumulus, cumulonimbus. (b) Medium clouds - altocumulus, altostratus. (c) High clouds: cirrus, cirrostratus, cirrocumulus.
7. Collision - coalescence hypothesis of precipitation: This explains precipitation in tropical areas where the temperature in clouds is too high for the formation of ice. So water droplets condense, positive charge attracts negative charge, they come together, become big and fall.
8. Ice crystal hypothesis / Bergeron - Findesein hypothesis: Saturation vapor pressure is lower over ice than over water surface. Initially a cloud may contain both ice and water. Since vapor pressure is lower over ice, it attracts more water vapor in the cloud. Thus the vapor present in the cloud begins to decrease and the water droplets evaporate to replenish the diminishing vapor. So ice crystals grow @ the expense of water droplets. As they descend, they may melt and form as rain else snow.
9. Smog: Smog refers to photochemical fog haze produced when insolation reacts with hydrocarbons, nitric oxides and PAN (peroxy acetyl nitrates) present in the air.

Precipitation

1. Sleet: They are refrozen ice. Lets say condensation and precipitation happens @ higher levels below freezing temperature and snow falls. If there is a layer of warm air between the cold layers above and below it, then as snow passes through this layer, it will melt. As it leaves the layer and enters cold layer again, it will refreeze. Thus precipitation takes place in form of sleet.
2. Hail: Precipitation in form of hard round pellets. Sometimes strong ascending currents take water vapor to great heights where it condenses and precipitates as snow. As it comes down, it melts but strong currents push them up again increasing the size. Thus size keeps on increasing until it becomes very hard and big.

Climate

Equatorial Climate



Distribution

1. Main regions are Amazon belt, Congo, SE Asia between 10º N-S. Further away from equator, the influence of trade winds leads to monsoonal influences.

Temperature

1. Consistently high, annual range < 2º C. Even on highlands the annual range of temperature < 2º C.

Rainfall

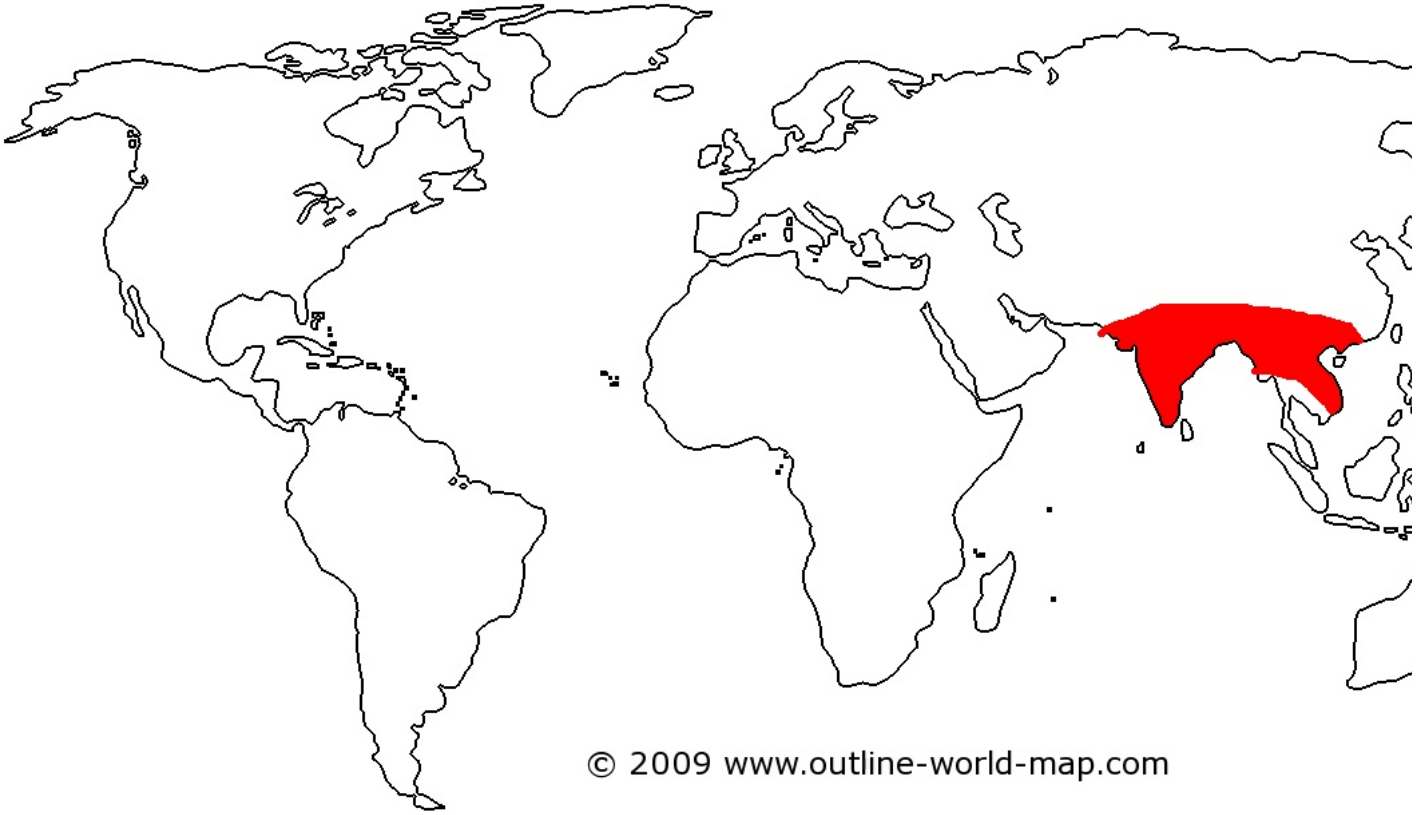
1. No month is without range. Rainfall has twin monthly peaks - in March and September (equinoxes) because the sun is directly overhead during these times and rainfall is convectional. Rainfall is least on solstices.
2. As one goes north from the equatorial regions, the rainfall pattern starts to get disturbed by monsoon winds.

Vegetation

1. Tropical rain forests (called selvas in Amazon) are found. Growing season is entire year and no distinct season of seeding, flowering, shedding of leaves.
2. Epiphytes: They are plants that grow upon other plants non-parasitically. They usually derive only physical support and not nutrition from their host. They use photosynthesis for energy obtain moisture from the air or from dampness on the surface of their hosts.

1. Forest is arranged in 3 canopy layers vertically. So many species of trees are intermixed and hardwood logs sink in water so that commercial logging is not feasible.
2. Main crops are plantation crops like rubber (SE Asia), cocoa (W Africa - Ghana & Nigeria), coconuts, sugar, coffee, tobacco, spices, banana.
3. *Belukar* is the secondary forest growing as a result of shifting cultivation activities in Malaysia.
4. Agriculture and developmental activities are difficult because thick grass and undergrowth grows as soon as the forest is cut.

Tropical Monsoon Climate



Distribution

1. South and SE Asia and N Australia. Outside this zone the climate is modified by the onshore trade winds and rainfall is distributed more evenly throughout the year (tropical marine climate).

Seasons

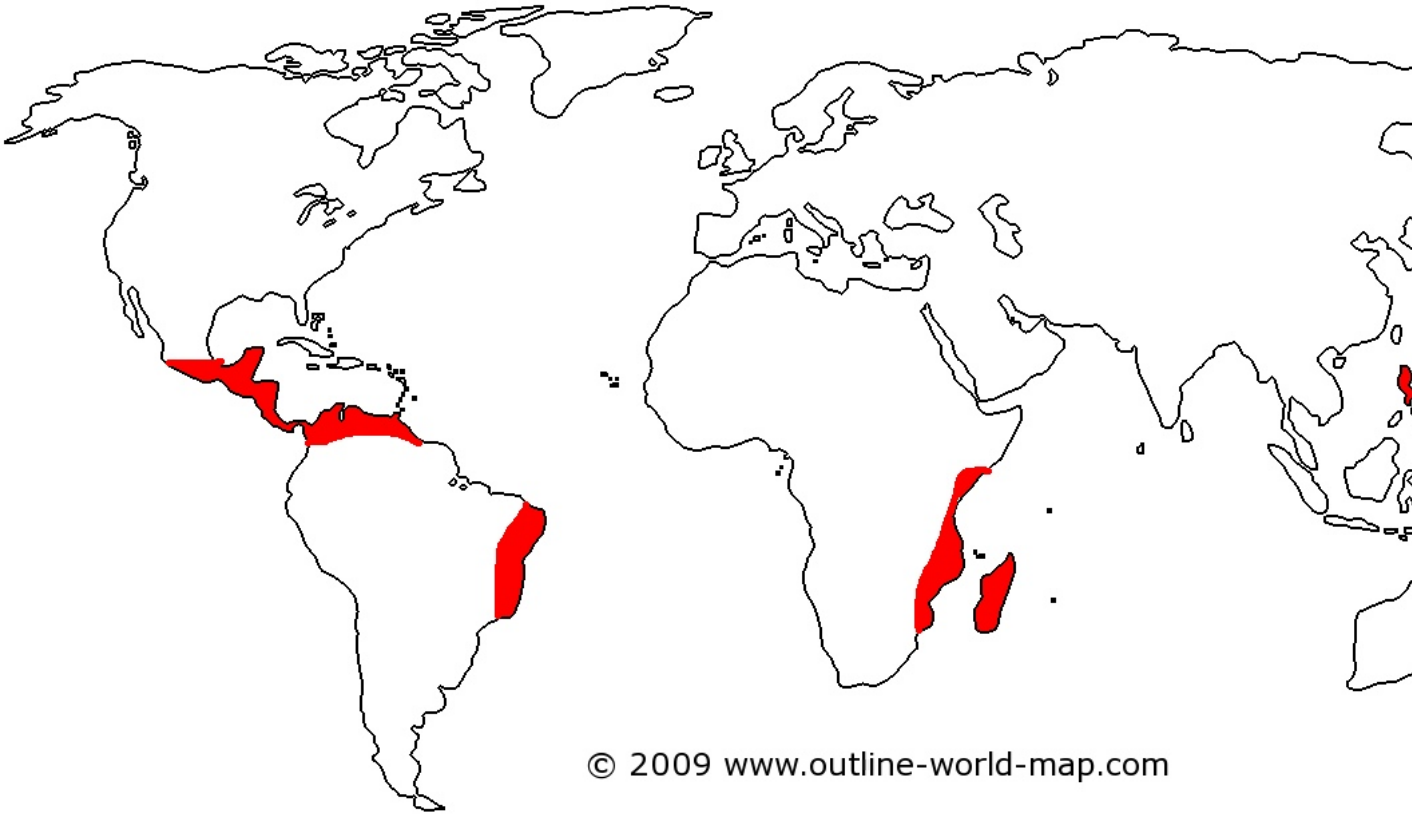
1. Cool, dry winters (October - February).
2. Hot, dry summers (March - June).

3. Rainy season (June-September). Orographic rainfall.

Vegetation

1. It is deciduous due to marked dry season during which leaves are shed. Forests are generally logged but the vegetation differs with the rainfall.
2. Main crops are rice, sugar, jute (hemp in Manilla), cotton. Coffee is grown in Brazil. Tea requires modest temperatures (15 - 20ºC), heavy rainfall (150 cm) and well drained slopes.

Tropical Marine Climate



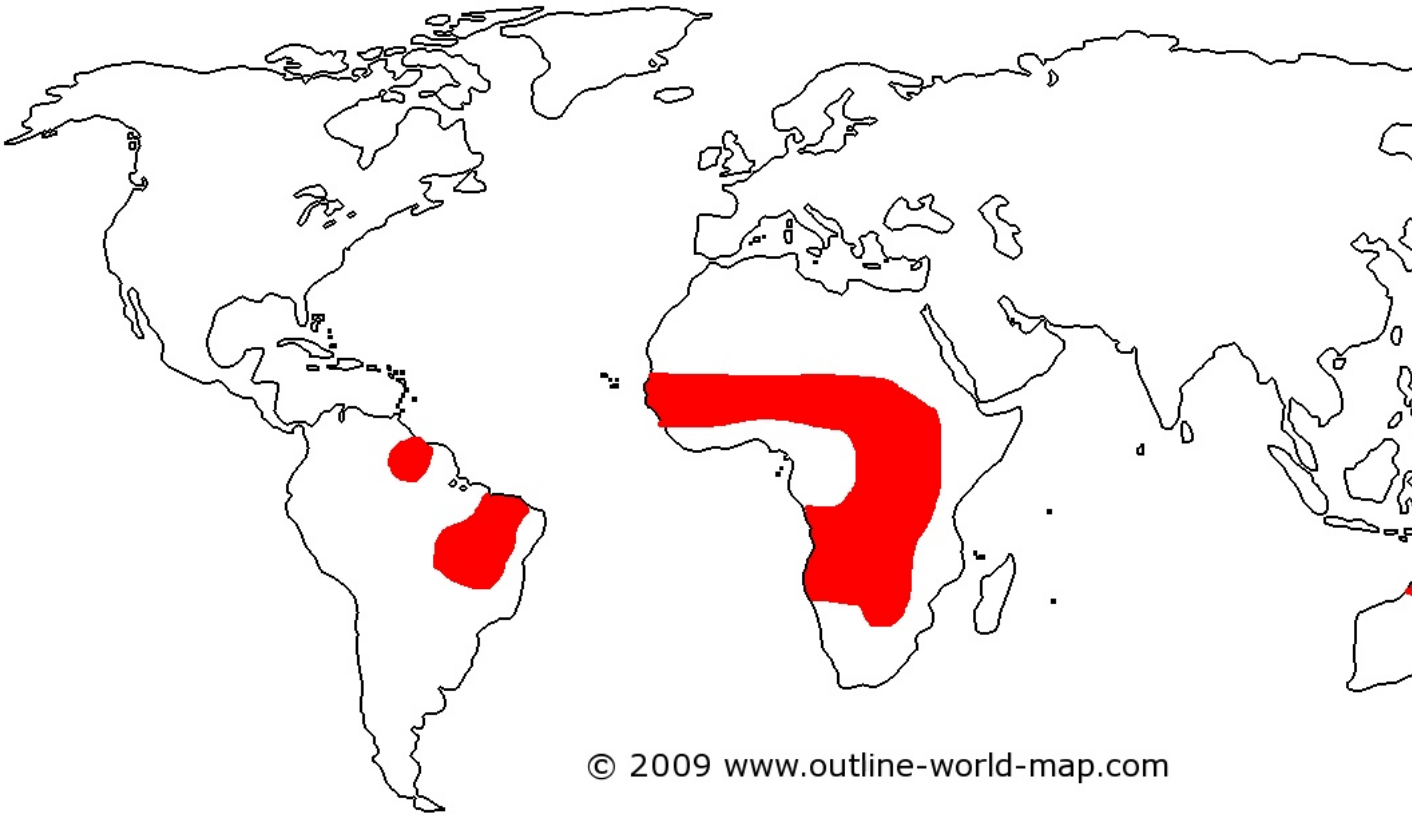
Distribution

1. Occurs on the easter casts in tropics under the influence of trade winds. Philippines, central america, NE Australia, Madagascar, east Africa and east Brazil.

Rainfall

1. It is both orographic and convectional. It is maximum in summer season but without any distinct dry season.
2. It is prone to severe tropical storms and typhoons.

Tropical Savanna / Sudan Climate



Distribution

1. It is found between equatorial forests and the trade wind hot deserts. The grasses are called *llanos* in Orinoco basin and *campos* in Brazil.

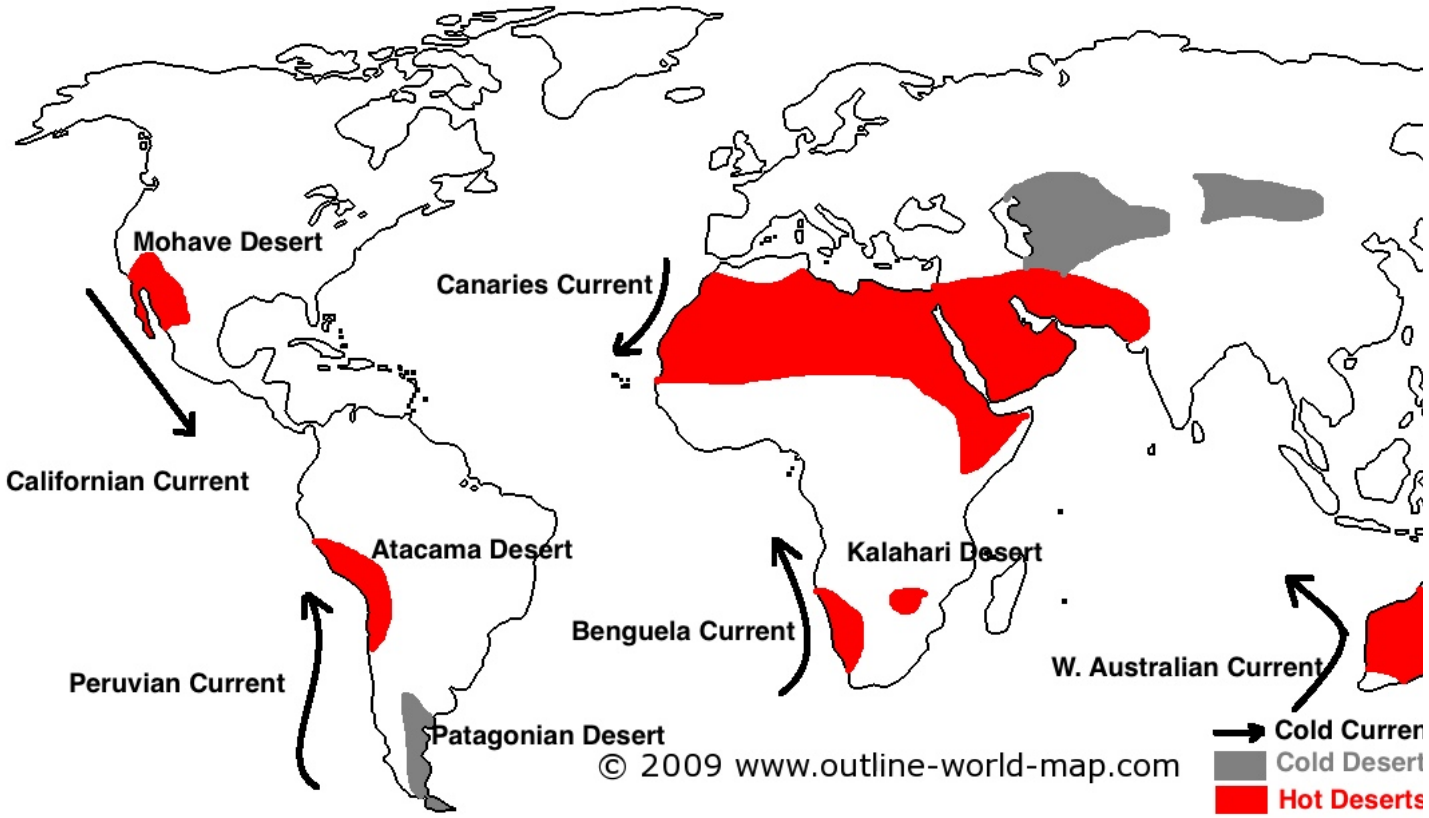
Seasons

1. Hot, rainy season (May - September in N hemisphere, October - March in S hemisphere). The amount of rainfall and the length of the rainy season decreases from equator to polewards towards the desert fringes. Trade winds bring rains to the eastern coasts but become dry by the time they reach interiors of the continents.
2. Cool, dry season.
3. Annual range of temperature is ~ 10ºC and the range increases as we move polewards. Highest temperatures don't coincide with period of highest sun but fall just below the onset of rains. Daily range of temperature is also high.
4. *Harmattan* (the doctor) are the north east trades which blow from interior Africa to the Atlantic coast in Guinea. They come from deserts and humidity rarely exceeds 30%. It is called the doctor because it gives relief from moist sea winds.

Vegetation

1. Tall savanna grasses. Grasses have deep roots. It lays dormant during cool, dry season.
2. Trees decrease in height and density polewards. Some trees are deciduous shedding their leaves in cool, dry season to prevent water loss. Some trees have broad trunks with water storing devices. Many trees are umbrella shaped exposing only a narrow edge to the winds.
3. Heavy rainfall in hot, wet season lead to intense leaching of the soil and all the nutrients are washed away.
4. Domestication of animals is popular in Australia.

Desert Climate



Distribution

1. Aridity of hot deserts is mainly due to off-shore trade winds. Aridity of cold deserts is because of off-shore westerlies or leeward side effects. Cold deserts are also generally located on high plateaus. Major hot deserts are located on the west side of continents in 15 - 30º latitude range. Atacama / Peruvian desert is the driest of all deserts (< 1.25 cm p.a.).
2. Apart from this, the hot deserts lie in the horse latitude belt where the air is subsiding - a condition least favorable to precipitation. Further winds blow from cooler to hotter regions, hence the lack of water content.
3. Cold currents have the effect of cooling the air. When this comes in contact with the hot air on the land mass, relative humidity drops further.

Rainfall

1. Whatever occurs, occurs mostly because of convectional rainfall and with thunderstorms.
2. In cold deserts in Asia, whatever rainfall happens occurs because of occasional western disturbances and in form of snow.

Temperature

1. Coastal deserts generally have less temperature than interiors due to cold currents. Ranges are also high in interiors.
2. Annual range of temperature is higher in cold deserts compared to hot deserts. Mostly because they are located in mid-latitudes where variation in insolation is highest and because they are located deep inside continents.

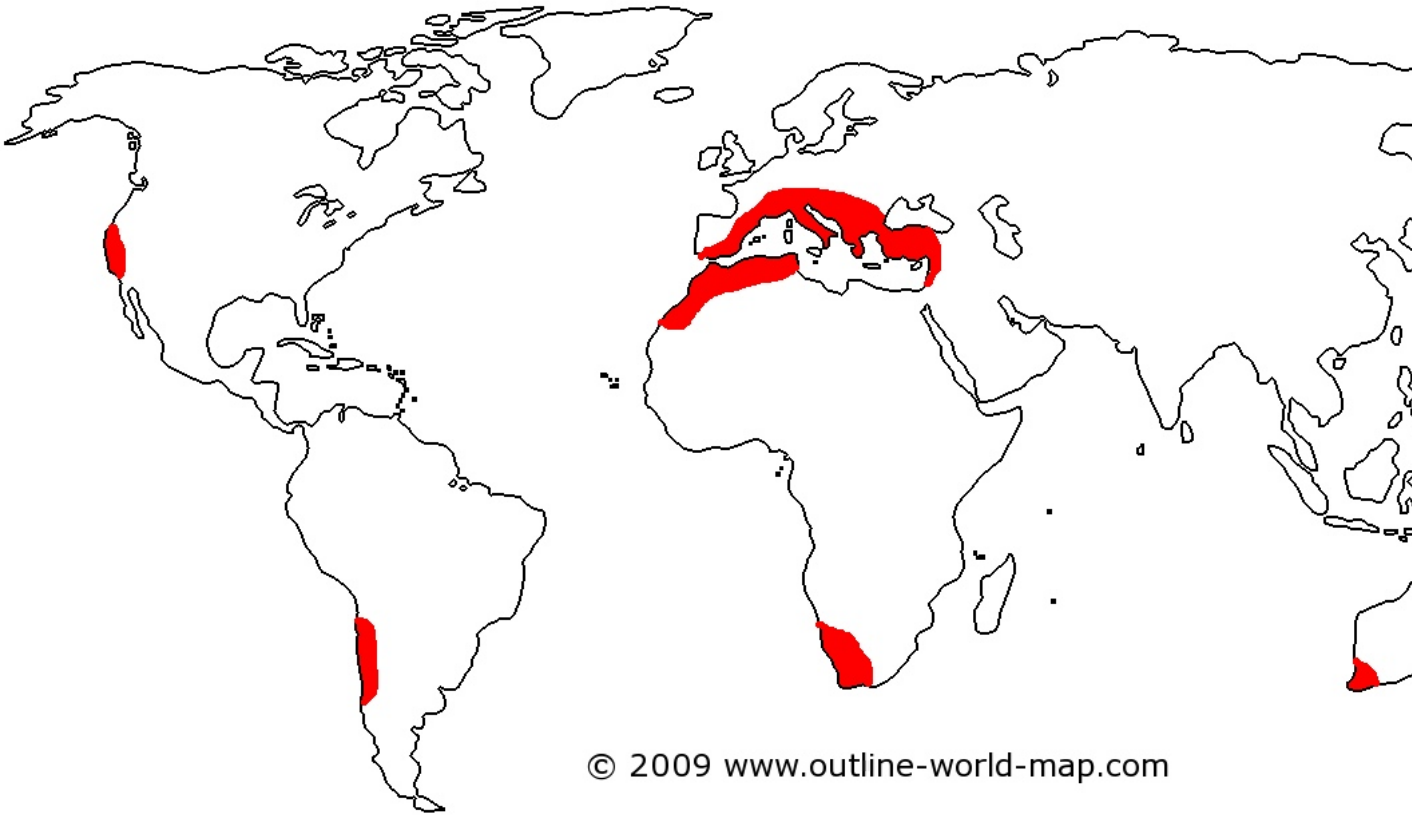
Vegetation

1. Shrubs remain dormant for years waiting for rainfall. They also have long roots, modified leaves and stems. Seeds have thick tough skins and lie dormant until it rains.
2. High evaporation means salts are brought upwards and they accumulate on the surface forming hard pans. Soil is also deficient in humus.

Minerals

1. Gold is mined in Australia, diamonds and copper in Kalahari desert, copper and nitrates in Atacama desert.

<u>Warm Temperate / Mediterranean Climate</u>



Distribution

1. It is confined between 30 - 45º latitudes on the western margins of the continents. It is caused by shifting of pressure belts and comes under the effect of trade winds during summers (continental trades and hence dry) and westerlies during winters (onshore winds and hence wet).

Temperature

1. Highest temperatures are experienced as we move inland away from maritime influence.

Rainfall

1. Cyclonic rainfall is prevalent from westerlies. The rain comes as heavy showers and only on few days with bright sunny intervening days.

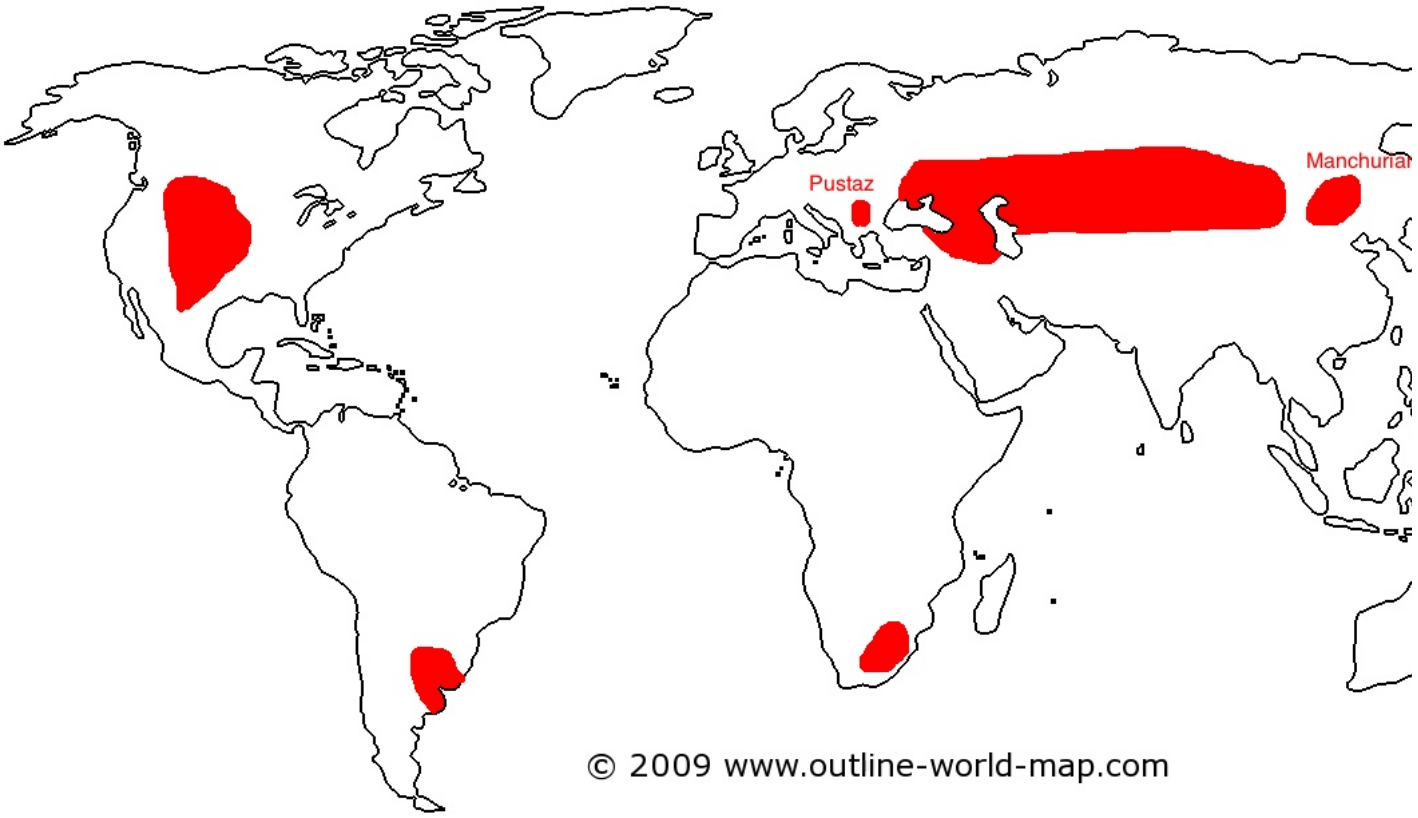
Local Winds

1. Sirocco: They are the south-westerlies blowing from Sahara desert into the mediterranean climate. They are hot and dry and remain dry even after passing above Mediterranean sea. It is most frequent during spring and is bad for crops.
2. Mistral: It is a cold wind from north in Alps region which rushes down in winter into the valleys to fill the low pressure towards the sea.It is fast and may take the temperature below the freezing point.
3. Bora: In the Adriatic coast, the cold winds blowing from the continent to the sea in winters are called Bora. They are very fast.

Vegetation

1. Mediterranean evergreen forests: They are found in regions of high rainfall. Cork oak trees are common in Europe while eucalyptus are grown in Australia.
2. Evergreen coniferous forests: They are found in highlands.
3. Mediterranean shrubs: They are the dominant vegetation.
4. Orchard farming: Fruit trees have long roots enabling them to fetch water in hot summer season as well. The thick leathery skin of the fruits also prevents transpiration.

Temperate Continental Grasslands / Steppe Climate



Distribution

1. They border the deserts and lie in the interiors of the continents in N hemisphere and near the oceans in S hemisphere. Though they lie in the westerly belt, they are far removed from the maritime influence.
2. Grasslands in S hemisphere are less continental due to proximity to oceans. They have less extreme temperatures (milder winters and less annual range) and rainfall is higher as well.

Temperature

1. Warm summers and cold winters. Extreme variation of temperature.

Rainfall

1. Annual precipitation is light with maximum rainfall in summers. Winters get occasional rains from western disturbances and in the form of snow.
2. Annual precipitation is higher in S hemisphere due to proximity to ocean and warm ocean currents.

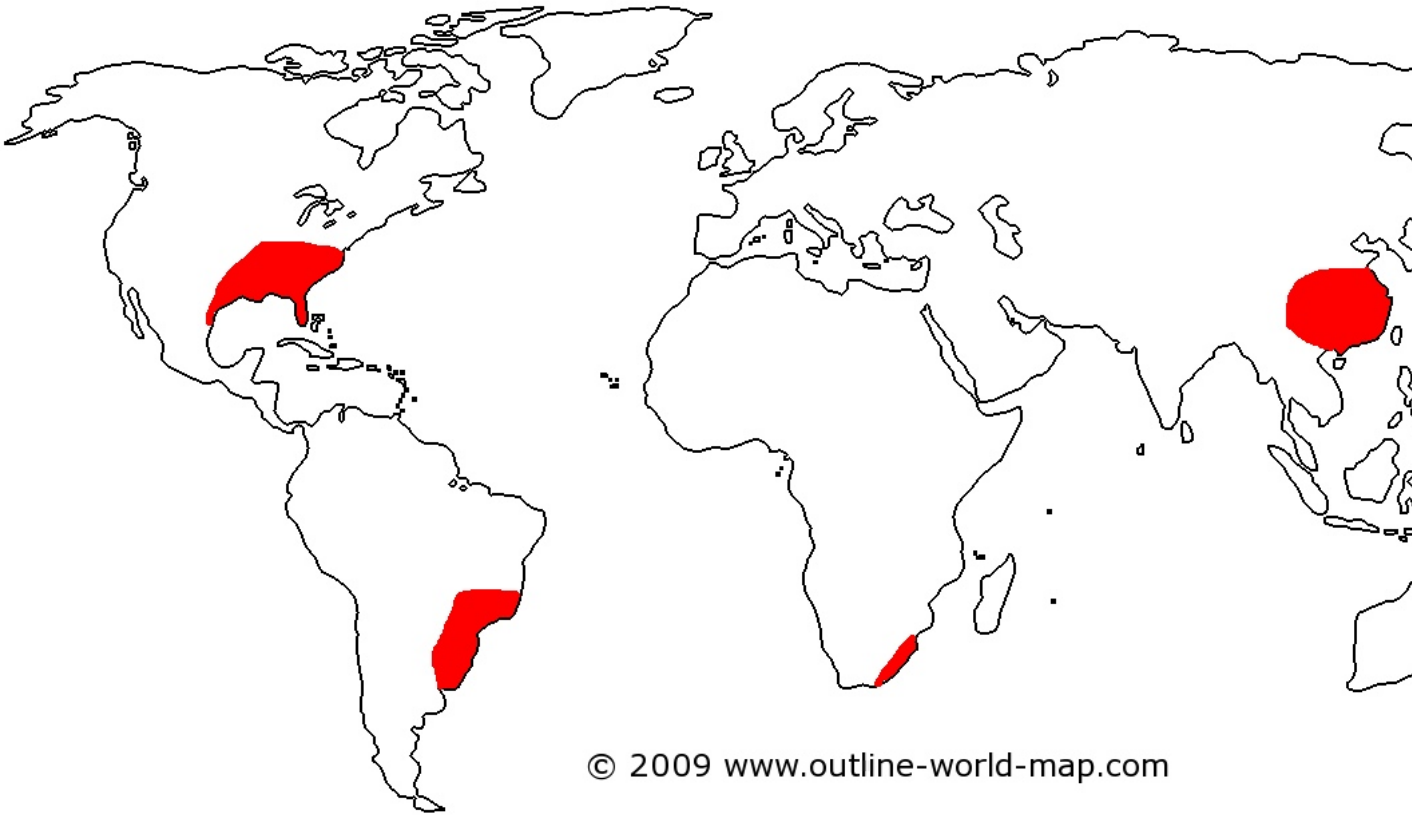
Local Winds

1. Chinooks: They are south-westerly winds pulled over from the Rockies. They are hot winds and can raise the temperatures by 20º C in 20 minutes.

Vegetation

1. The grasses lie dormant in the winters and become active in the spring when the temperature is hot enough. In summers they get scorched but in autumn they grow again.
2. Polewards, an increase in precipitation gives way to coniferous trees while equatorward they merge with desert shrubs.

Warm Temperate / China Climate



Distribution

1. China type: East and central China. Trade winds take the warm current moist air inside and causes rain in summers. In winters however there is a reversal of wind direction due to cooling of Asian land mass and temperatures plummet. So annual range of temperature is high. Typhoons are carried in by the trades.
2. Gulf type: SE US. The monsoonal characteristics are less here as the pressure gradient between continental N America and the Atlantic ocean is never high enough to reverse the wind direction completely. Rainfall has summer maximum.
3. Natal type: In southern hemisphere. These lands have no monsoonal climate due to thinness of the land masses which is not sufficient to cause any wind change. So annual range of temperature is less, rainfall is more and distributed throughout the year.

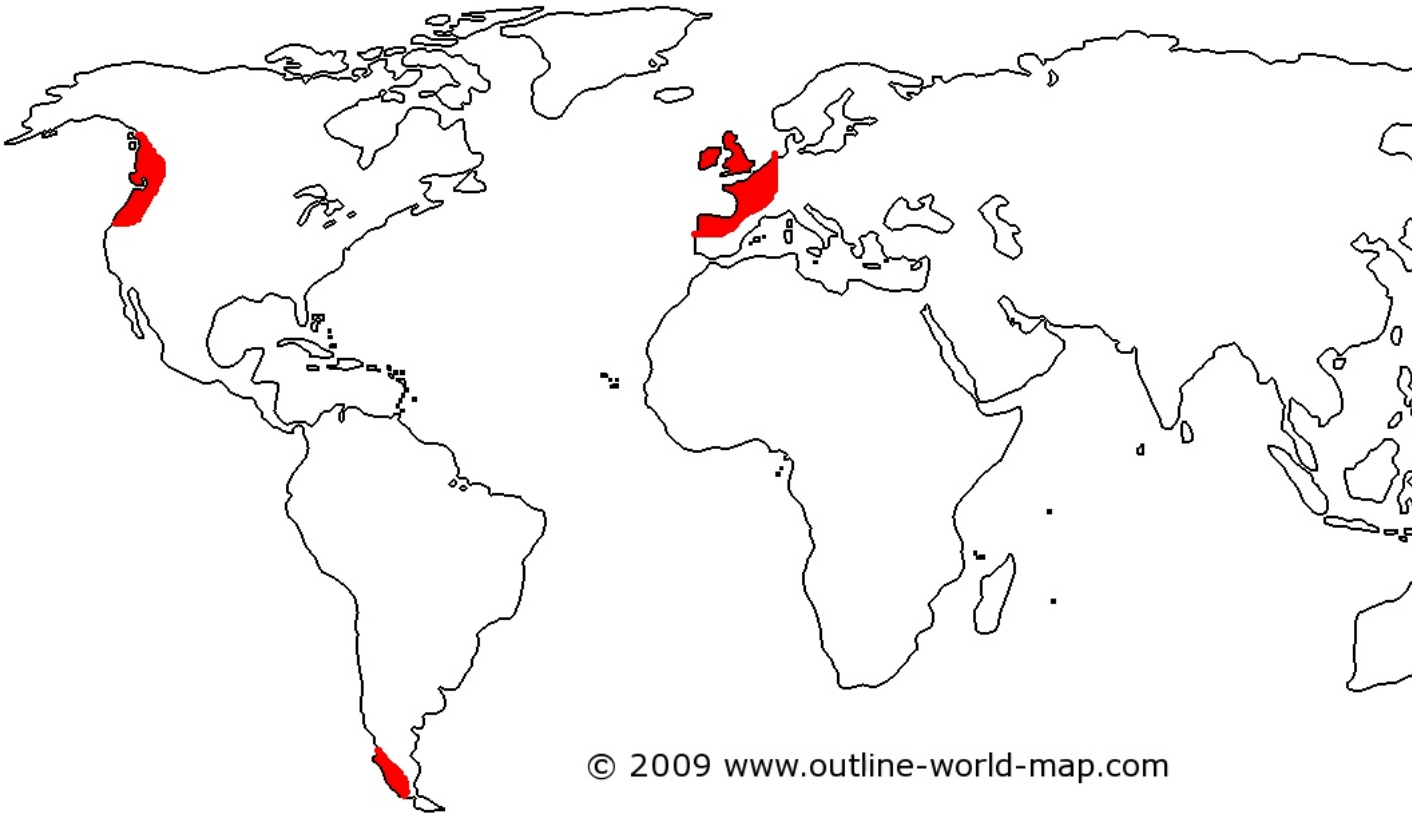
Rainfall & Temperature

1. It has more rainfall than Mediterranean climates for same latitude because of influence of warm currents. They are under the influence of trade winds.
2. Summers are warm and winters are cool. Rainfall varies from 60 - 150 cm.

Vegetation

1. Eastern margins get more rainfall and hence more luxuriant vegetation. Such regions have evergreen and deciduous forests. The perennial plant growth is not checked wither by cold or a dry season.
2. Crops grown are rice, maize, cotton, tobacco. Cotton needs 200 days frost free and moderate rainfall. Tobacco needs humid atmosphere and well drained soils.

Cool Temperate Western Margin / £ Climate



Distribution

1. They are under the influence of westerlies all through the year but westerly influence is blocked by Rockies and Andes in N and S America respectively.

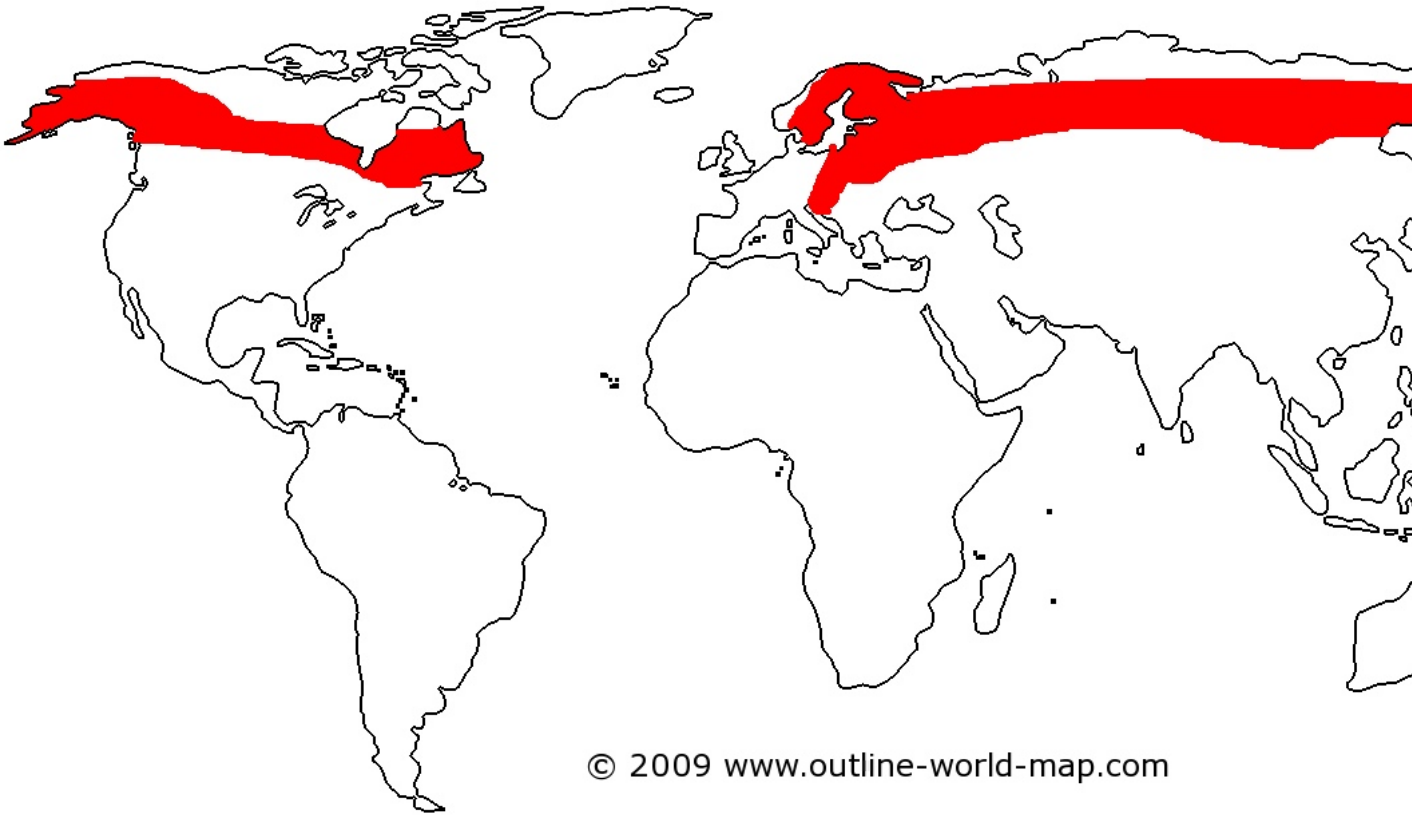
Temperature & Rainfall

1. Low annual range of temperature. Summers are never very warm.
2. Rainfall is throughout the year with winter or autumn maximum because of cyclonic conditions.

Vegetation

1. Deciduous forests are found and they shed their leaves in autumn to prepare for the cold season.

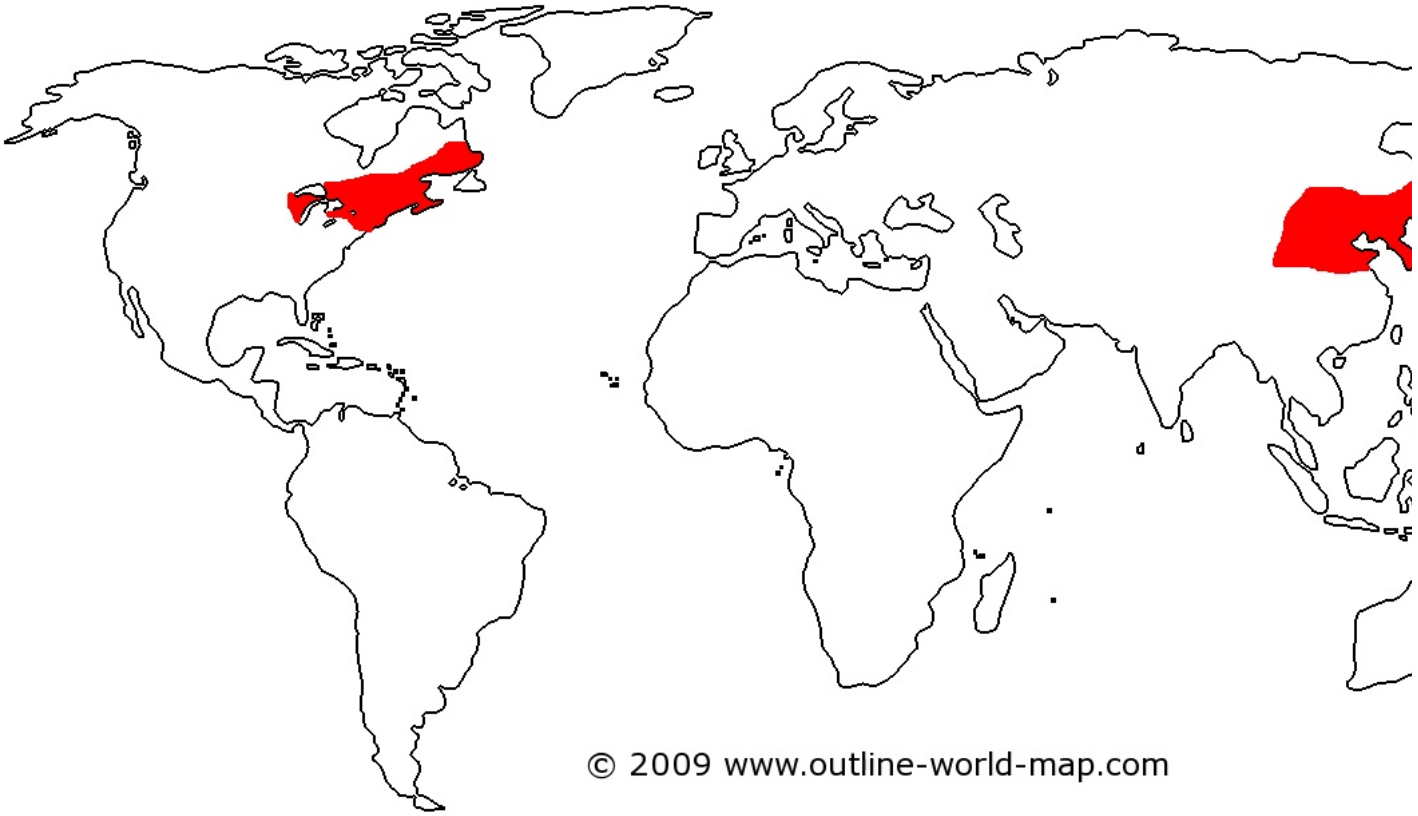
Cool Temperate Continental / Taiga Climate



Distribution

1. It has tundra towards the north and steppes towards the south. Taiga is the Russian name.

Cool Temperate Eastern / Laurentian Climate



Distribution

1. It is the intermediate types and has both maritime and continental traits.

Rainfall and Temperature

1. Winters are cold and dry while summers are warm and wet. Summers would be warmer but for the cold continental winds.
2. Rainfall has summer maximum due to easterlies from the ocean but occurs throughout the year. Gulf Stream and Oya Shio keeps it warm.