Atmospheric Pressure

Atmospheric pressure

The atmospheric pressure is the weight of the air, which lies vertically above a unit area centered at a point. The weight of the air presses down the earth with the pressure of 1.034 gm / cm^2. It is expressed in millibar (mb) equal to 100 N/m^2 or 1000 dynes/cm^2. Unequal heating of the earth and its atmosphere by the sun and rotation of the earth bring about differences in atmospheric pressure.

Isobars: The distribution of pressure is represented on maps by 'isobars'. Isobars are defined as the imaginary lines drawn on a map to join places having the same atmospheric pressure.

Diurnal and seasonal variation

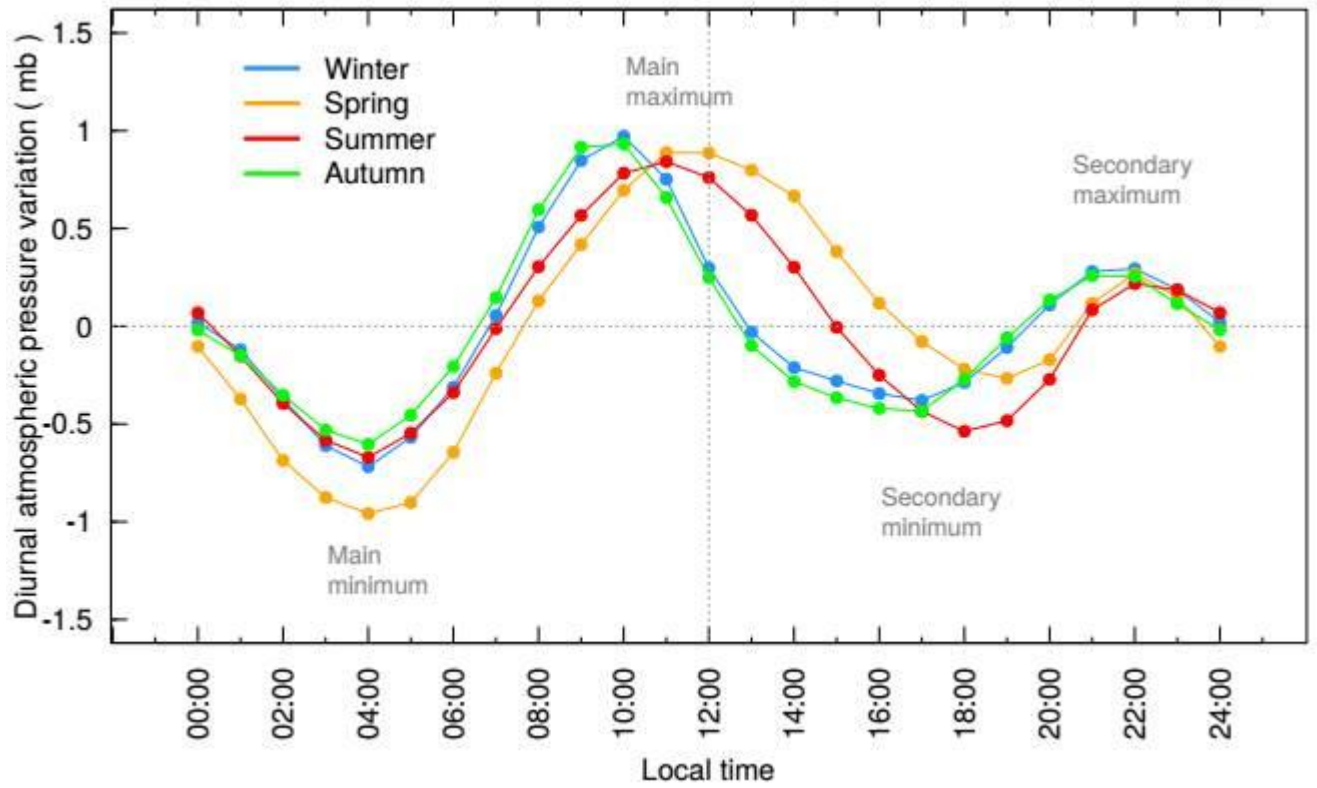
(a) Diurnal pressure variation

a. There is a definite rhythm in the rise and fall of the pressure in a day.
b. Radiational heating (air expansion) and radiational cooling (air contraction) are the main reasons for diurnal variation in the air pressure.
c. Diurnal variation is more prominent near the equator than at the mid latitudes.
d. The areas closer to sea level record relatively larger amount of variation than in land areas.
e. Equatorial regions absorbs more heat than it loses while the polar region gives up more heat than they receive

b) Seasonal pressure variation

a. Due to the effect caused by annual variation in the amount of insolation, distinct seasonal pressure variations occur.
b. These variations are larger in the tropical region than the mid latitude and polar regions.
c. Usually, high pressures are recorded over the continents during the cold season and over the oceans during the warm season.

Diurnal variation of Atmospheric Pressure



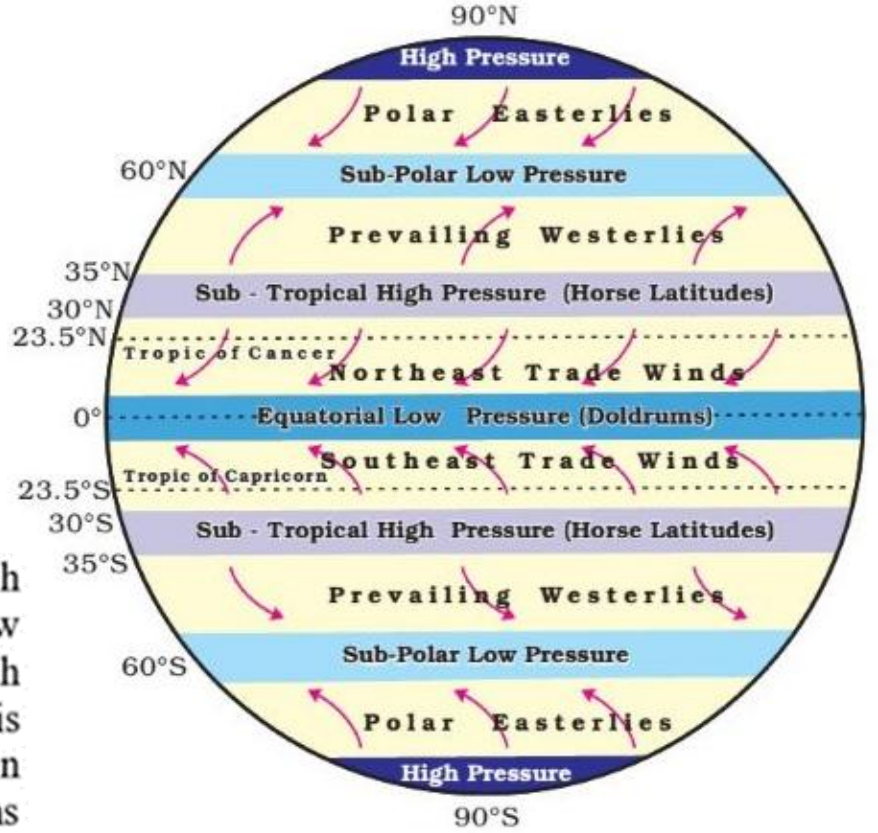
- Surface pressure exhibits semi-diurnal characteristic
- First Maximum at ~10 AM and second Maximum at ~10 P.M.
- First Maximum at ~4 AM and second Maximum at ~6 P.M.

Pressure systems of the world

The shape of the earth is not uniform and subjected to uneven distribution of solar radiation, when it revolves around the sun. The uneven distribution of solar radiation over different regions of the globe leads to contrast in surface air temperature. This results in variations of surface atmospheric pressure systems, which are known as standard atmospheric pressure systems / belts. There are altogether seven alternating low and high pressure belts on the earth's surface. They are as follows:

i. Equatorial trough of low pressure (between 5°N and 5°S)
ii. Subtropical high pressure belt (Northern hemisphere) (25° and 35°N)
iii. Subtropical high pressure belt (Southern hemisphere) (25° and 35°S)
iv. Subpolar low pressure belt (Northern hemisphere) (60° and 70°N)
v. Subpolar low pressure belt (Southern hemisphere) (60° and 70°S)
vi. Polar high (Northern hemisphere)
vii. Polar high (Southern hemisphere)

The equatorial region receives more solar radiation and thus the surface air temperature is high, which creates lighter air near the ground compared to higher latitudes. The above condition leads to low atmospheric pressure over the equatorial region while sub tropical high pressure belts develop in both the hemispheres between 25 and 35 degree latitudes due to relatively low surface air temperature. It is due to low solar radiation received due to inclined sun's rays over the subtropical region when compared to the equatorial belt. Like wise alternate low and high atmospheric pressure belt systems are developed across the globe from the equator to the poles.



Major Pressure Belts and Wind System

c) Water vapour

The water vapour content is lighter in cold area than in air which is dry with the result that moist air of a high temperature exerts a less pressure when compared to cold air.

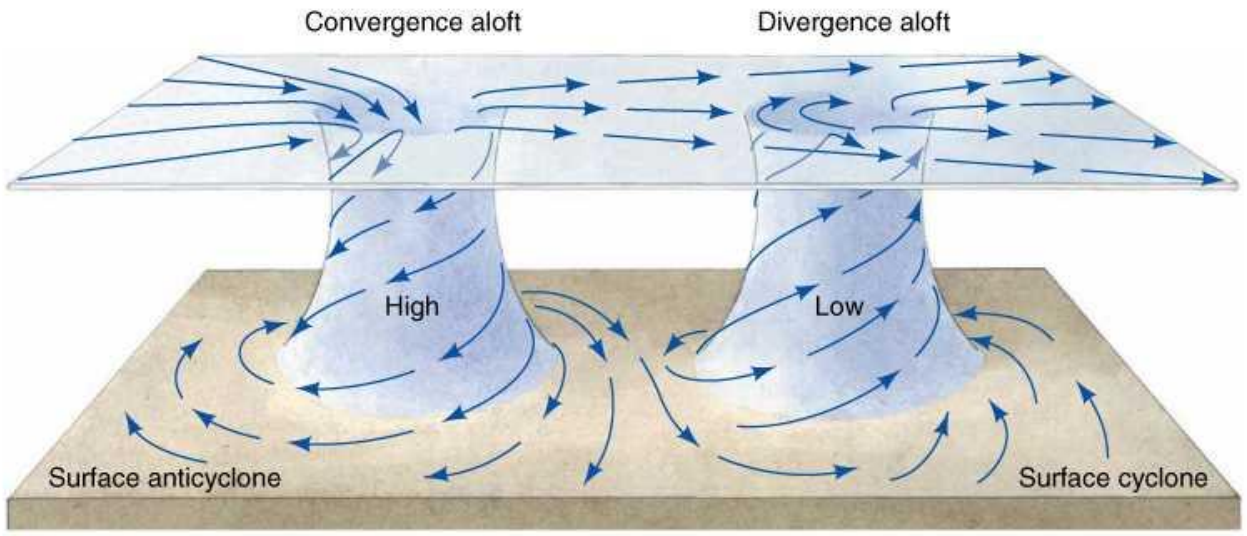
d) Rotation of the earth

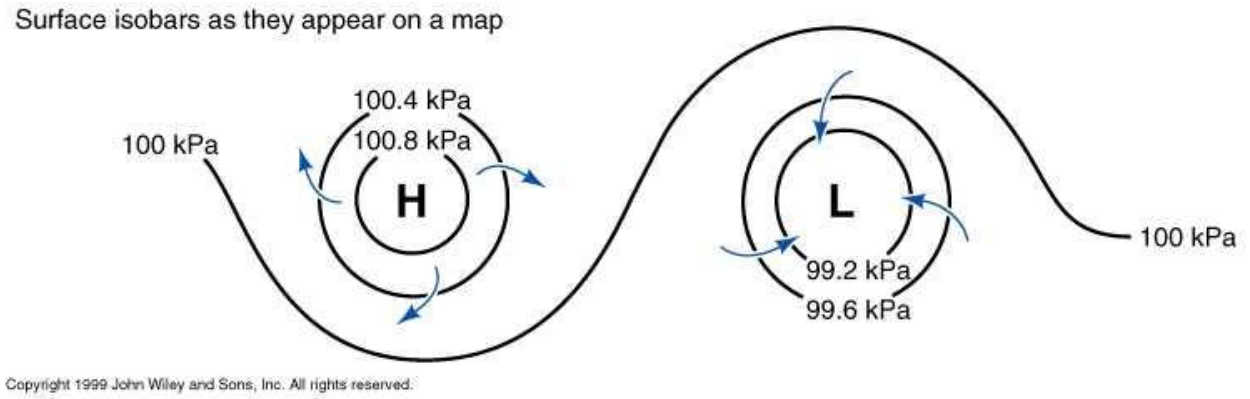
On account of rotation of the earth, the pressure at 60-70°N and S becomes low. The rotation of the earth near sub-polar belts, makes the air to escape from these belts which move towards the horse latitude (30° - 35°N and 30 – 35°S). These latitudes absorb the air from sub polar belts making the pressure high.

Causes of Atmospheric Pressure

- The atmospheric pressure is primarily caused by the weight of the air above a given location and is influenced by several factors. Here are the key causes of atmospheric pressure:
- ***Gravity:*** The force of gravity pulls the Earth's atmosphere towards its center, resulting in the weight of the air exerting pressure on the surface below. The higher the column of air above a location, the greater the atmospheric pressure.
- ***Altitude:*** Atmospheric pressure decreases with increasing altitude. As one moves higher in the atmosphere, there are fewer air molecules above, leading to lower atmospheric pressure. This is because the weight of the air decreases with altitude.
- ***Temperature:*** Temperature variations affect atmospheric pressure. Warmer air tends to expand and become less dense, leading to lower pressure. Conversely, cooler air contracts and becomes denser, resulting in higher pressure.
- ***Air Masses:*** Differences in temperature and moisture content between air masses contribute to variations in atmospheric pressure. When warm air rises and forms a low-pressure area, surrounding air flows towards it, causing a drop in pressure. Conversely, when cool air sinks and forms a high-pressure area, surrounding air diverges and results in increased pressure.
- ***Rotation of the Earth:*** The rotation of the Earth induces the Coriolis effect, which influences wind patterns. The Coriolis effect causes air to deflect from its original path, creating areas of low and high pressure.
- ***Solar Heating:*** Unequal heating of the Earth's surface by the Sun leads to variations in temperature. This, in turn, affect atmospheric pressure. The equatorial regions receive more direct sunlight, resulting in warmer air and lower pressure. The polar regions receive less sunlight and have cooler air, leading to higher pressure.

Cyclones and Anti-cyclones





Low/Depression/Cyclone:

- Isobars are circular or elliptical in shape, and the pressure is lowest at the center, such a pressure system is called ‘Low’ or ‘Depression’ or ‘Cyclone’.
- The movement will be anti-clockwise in the Northern hemisphere while it is clockwise in the Southern hemisphere.

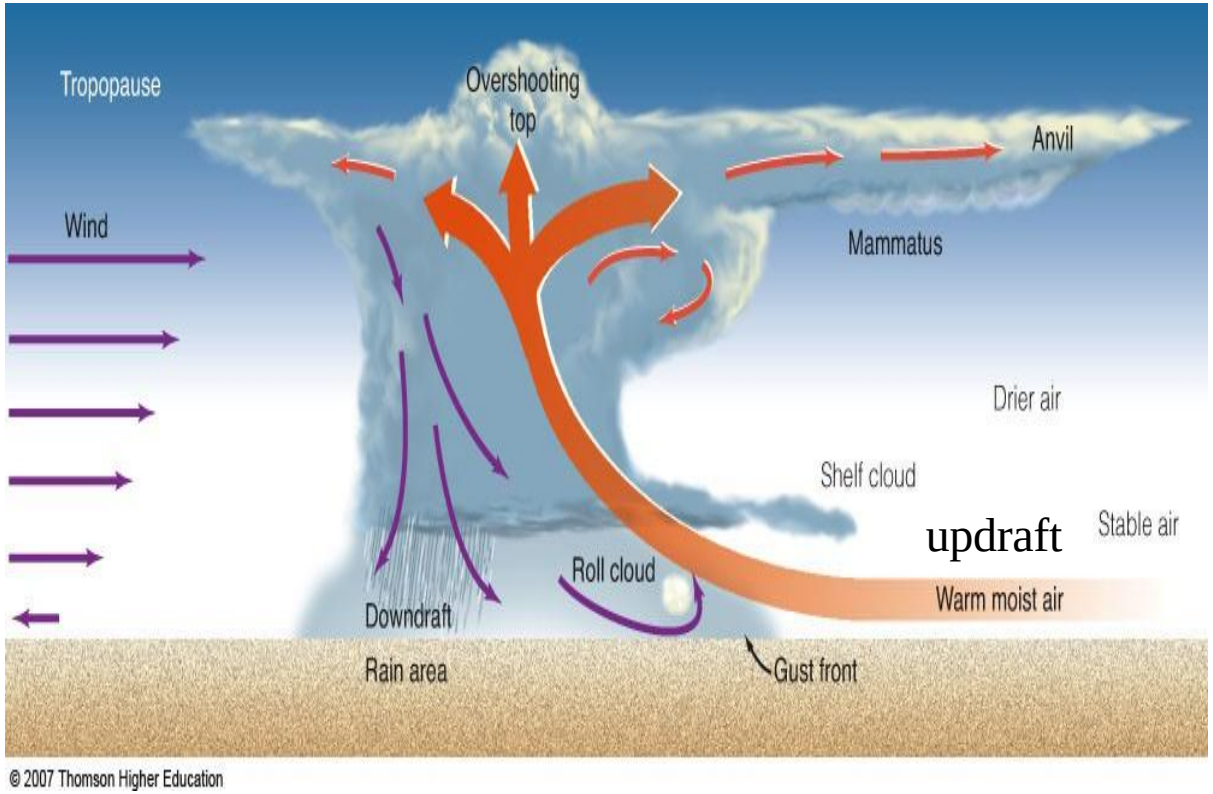
Anticyclone:

- Isobars are circular or elliptical in shape, and the pressure is highest at the center, such a pressure system is called ‘High’ or ‘Anticyclone’.
- Isobars are elliptical rather than circular system is called as ‘Ridge‘ or ‘Wedge’.
- The movement will be clockwise in the Northern hemisphere while it is anti-clockwise in the Southern hemisphere

Thunderstorms

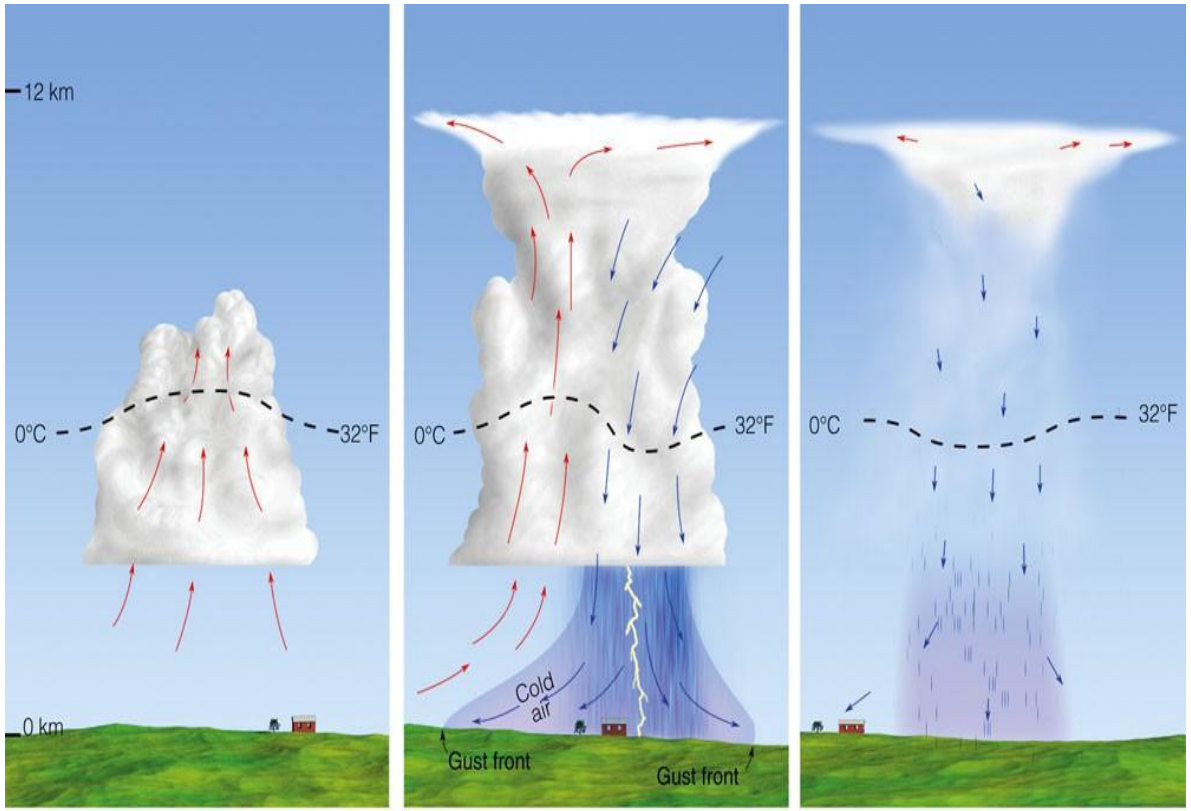
- Produced by cumulonimbus clouds and are accompanied by lightning and thunder.
- Occurs when the atmosphere becomes unstable—when a vertically displaced air parcel becomes buoyant and rises on its own.
- The ideal conditions include warm, moist air near the surface and a large change in temperature with height (large lapse rate)
- They extend as high as 12 km to 25 km from the surface
- Thunderstorms/tornados produce heavy rain, and hail and gusty winds of 160 km per hour
- Unstable lapse rate of temperature: a rapid decrease of temperature with height.
  - This large lapse rate can be forced by warming below or cooling above.
- Sufficient low-level moisture

Major Thunderstorm Structures



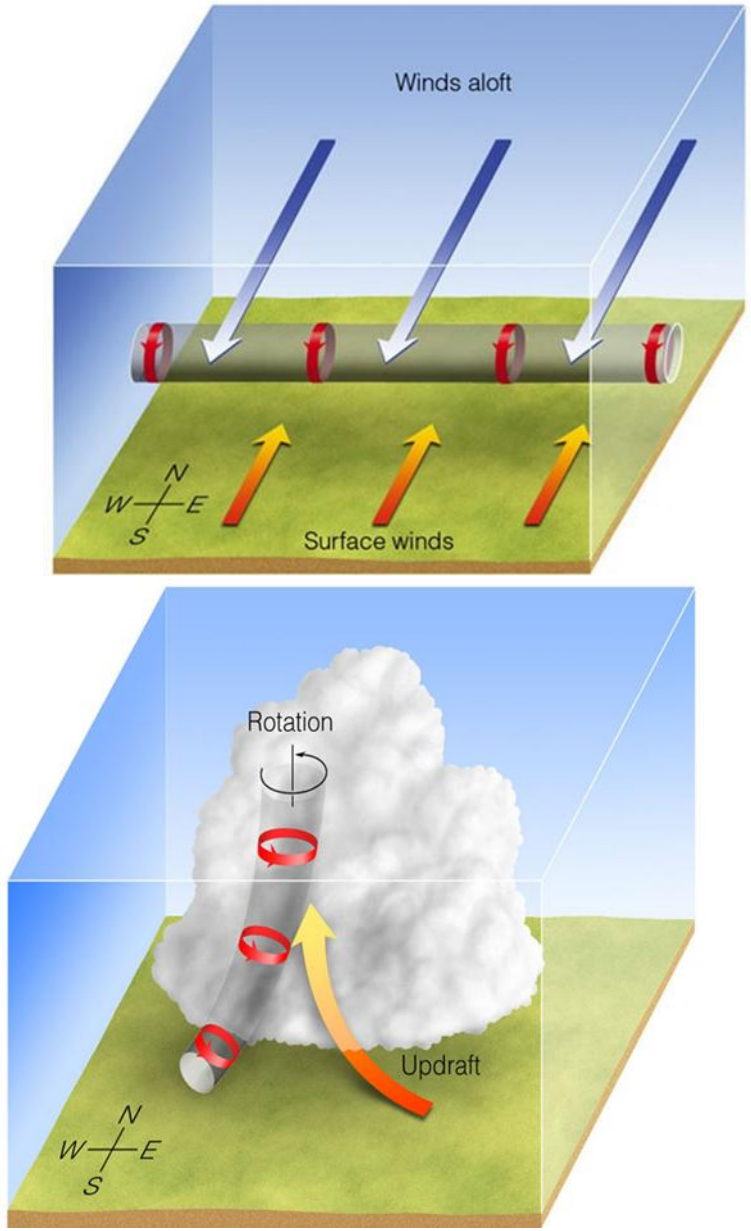
Cirrus Anvil, Gust Front, Updraft, Downdraft

Single Cell Thunderstorm

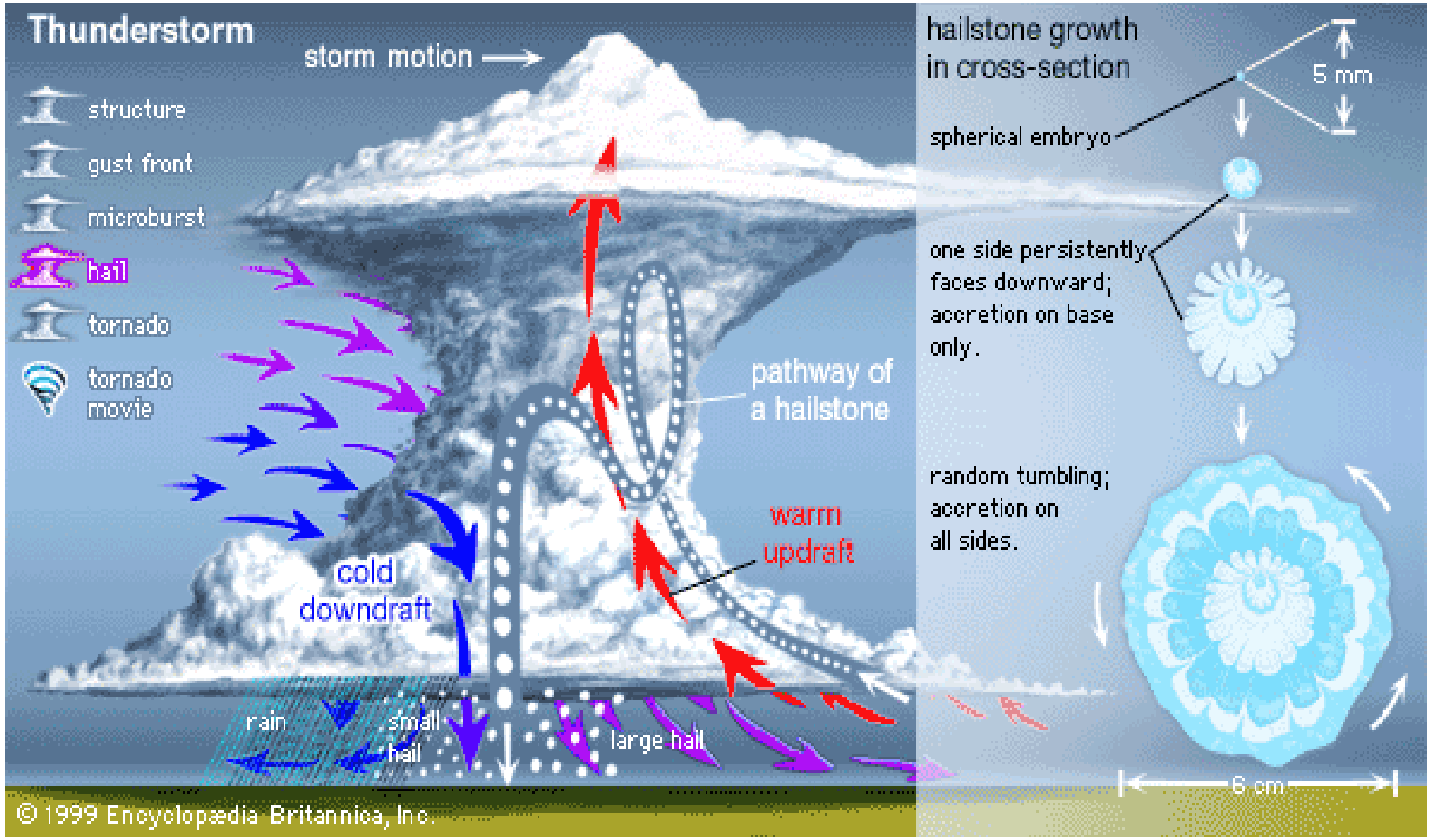


Cumulus Mature Dissipating

Meso-cylonic circulation



Hail Occurs in Strong Thunderstorms with Very Large Upward Velocities



Wind Systems – Effect on Crop Production

Wind: Air in horizontal motion is known as wind. Vertical movement is noticed but negligibly small compared to horizontal movement as the height of the atmosphere is only for few kilometers. However vertical movement or uplift of air only causes significant weather changes in cloud formation and rain.

Wind systems of the world

The wind belts found on earth's surface in each hemisphere are:

a. Doldrums
b. Trade wind belt
c. Prevailing westerlies
d. Polar easterlies

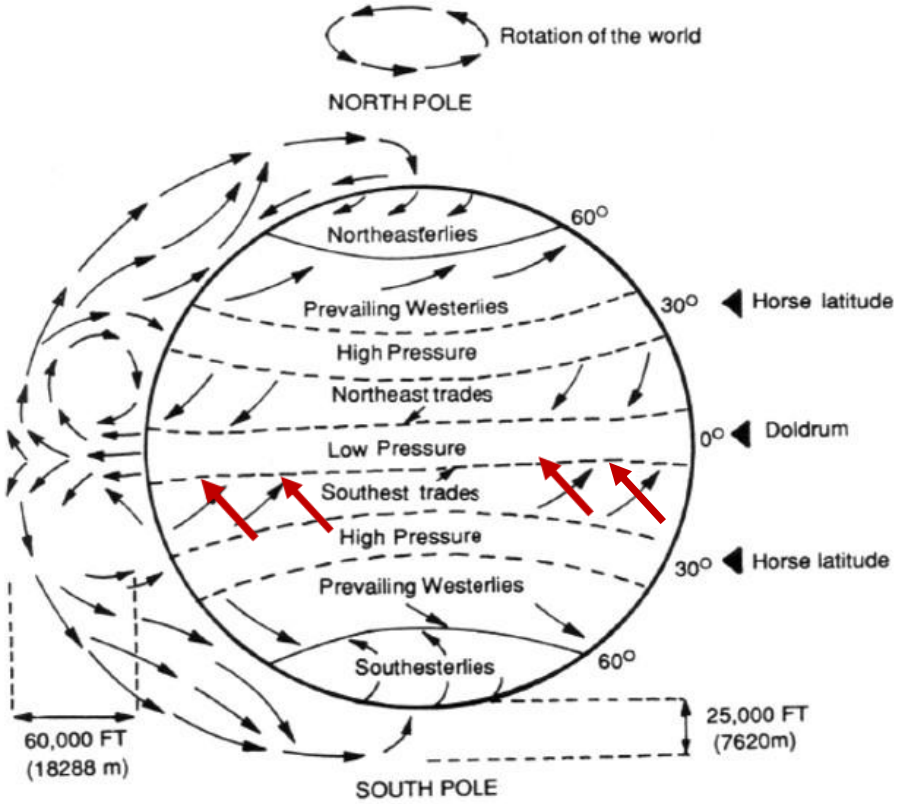
1. Doldrums

Owing to continuous heating of the earth by insolation, pressures are low and winds converge and rise near the equator. This intertropical convergent zone is known as 'Doldrums'.

a) These are the equatorial belts of calms and variable winds.
b) The location is 5°S and 5°N latitudes.
c) Wind is light due to negligible pressure gradient.
d) Mostly, there are vertical movements in the atmosphere.
e) The atmosphere is hot and sticky.

2. Trade winds (Tropical Easterlies)

a) The regular high temperature at the equator results in a high pressure forming in the upper levels of the equator.



GLOBAL WIND CIRCULATION

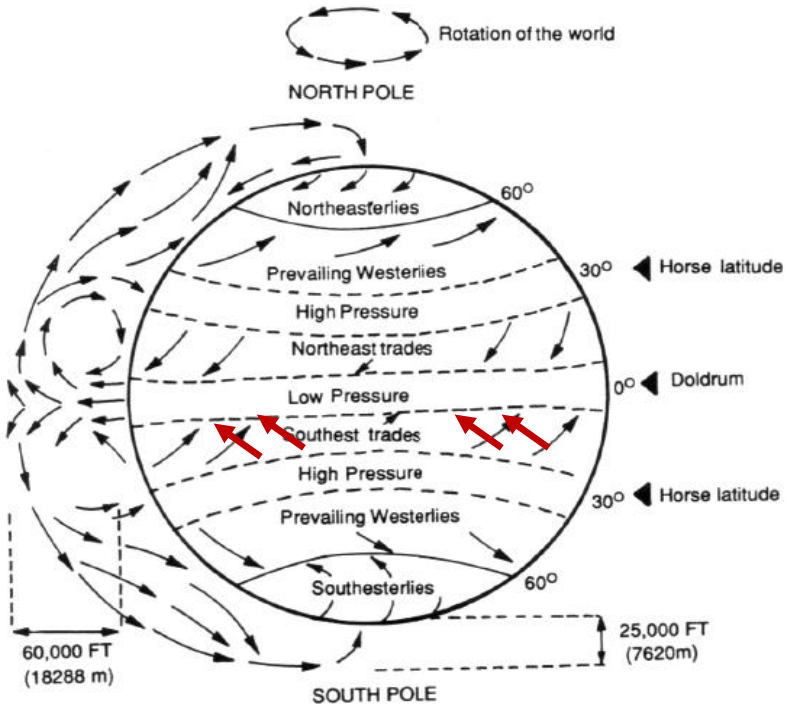
b) Then, the air is transferred to the northward and southward directions until 35° North and South in both the hemisphere.
c) Due to this reduction in surface pressure on the equator (doldrums) there is an increase in pressure at 35°N and 35°S which are known as horse latitude (sub-tropical high).
d) As a result, the winds flow from the horse latitude to the equatorial region.
e) While moving, these winds are deflected by Coriolis force to the right in northern hemisphere and to the left in southern hemisphere.
f) These winds flow from 35°N to the equator in NE direction in the northern hemisphere and from 35°S to the equator in SE direction in the southern hemisphere. These are known as 'Trade winds'. These are known as 'Tropical easterlies'.
g) These are most constant winds in force and direction and flow over nearly half the globe.

3. Anti-trade winds

a) This is a supplementary wind system of the earth which is effective at higher levels.
b) This system works in opposite direction to the surface winds.
c) The anti-trade winds mostly flow from land to ocean and brings no rain.

4. Prevailing Westerlies

a) The winds that flow from sub-tropical high to the low-pressure area about 60-70° latitudes in both the hemispheres are known as 'Prevailing westerlies'.
b) In the northern hemisphere the direction of Prevailing westerlies is SW and in southern hemisphere NW.



GLOBAL WIND CIRCULATION

c) These winds are forceful and are irregular as compare to the trade winds in the tropical regions.
d) High precipitation zone

5. Polar Easterlies / Polar winds

b) A permanent high pressure exists on the poles.
c) From these high pressure polar regions, cold winds flow to areas at about 60-65° latitudes in both the hemispheres.
d) The winds flow in NE direction in the northern hemisphere and in SE direction in the southern hemisphere.

Mountain winds

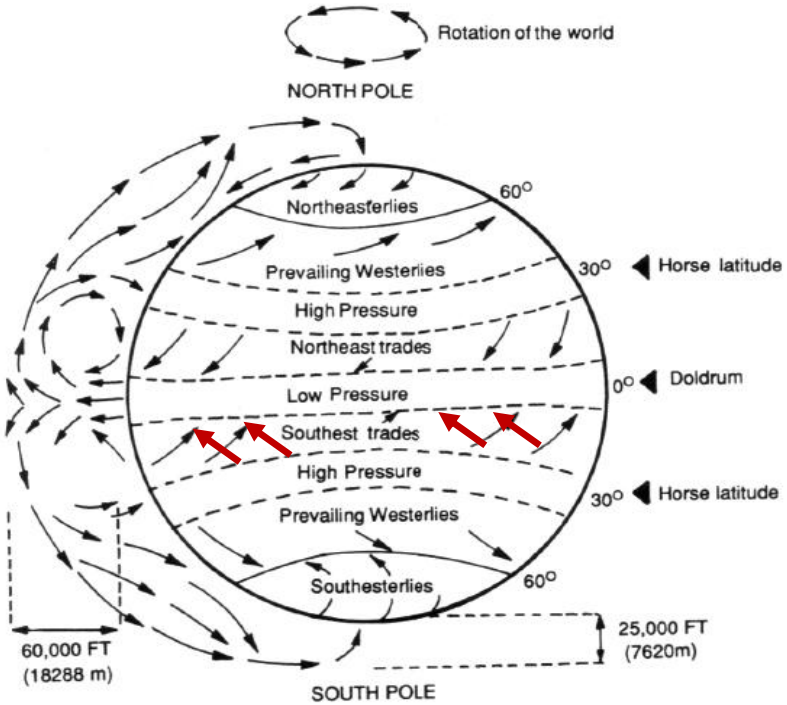
a) Blows from mountain up slope to base
b) Occurs during night time
c) Cooling of air close to slope takes place
d) Adiabatic heating decreases this phenomenon
e) Also known as 'Katabalic winds'

Valley winds

a) Blow from valley base to up slope.
b) Occurs during day time
c) Over heating of air adjacent to slope takes place
d) Adiabatic cooling decreases this phenomenon
e) Also known as 'Anabatic winds'

Sea breeze

During the daytime, more so in summer, land is heated more than the adjacent body of water. As a result warmed air over the land expands producing an area of low pressure. The isobaric surfaces bend upward as a result of which the cooler air starts moving across the coast line from sea to land. This is the 'Sea breeze; or 'On shore breeze'.



GLOBAL WIND CIRCULATION

Land breeze

At night because of nocturnal radiation land is colder than adjacent sea and the pressure gradient is directed from land to sea. There is a gentle flow of wind from land to sea. This 'off-share' wind is called 'Land breeze'.

Sl.	Sea Breeze	Land Breeze
1.	Occurs in day time	Occurs in night time
2.	Flows from sea	Flows from land
3.	Have more moisture than land breeze	Do not have more moisture
4.	Occurrence depends on topography of coast to grater extent	Occurrence depends on topography of land to little extent
5.	Modifies weather on hot summer afternoon	Produces cooler winters and warmer summers
6.	Stronger than land breeze	Weaker than sea breeze

Effect of wind on crop plants

1) Transports heat in either sensible or latent heat form from lower to higher altitudes
2) Wind affects the plant directly by increasing transpiration and the intake of CO_2 and also causes several types of mechanical damage.
3) Wind helps in pollination and dispersal of seeds.
4) Light and gentle winds are helpful for cleaning the agricultural produce.
5) Hot dry winds frequently do much damage to vegetation in the growing crops by promoting excessive water loss.
6) Wind has powerful effect on humidity.
7) Long, continued warm, dry winds injured blossoms by evaporating the secretion of the stigma.
8) Provides moisture which is necessary for precipitation
9) Wind prevents frost by disrupting atmospheric inversion
10) Causes soil erosion

Wind speed in different season

Winds represent air in motion. The primary cause of all winds is regional differences in temperature, producing regional differences in pressure. When these pressure differences persist for several hours, the rotation of the earth modifies the direction of motion, till the winds blow along lines of equal pressure. Wind direction and speed are modified frequently due to seasonal variation in solar radiation and differential heating of the earth's surface.

Wind Speed The winds are generally measured over level, open terrain at **10** meters above ground. Yet, a general idea of the distribution of the mean daily wind speed, on an annual basis as well as on a monthly basis, would be useful. The mean daily wind speed is the value obtained by averaging the wind speed (irrespective of direction) for a whole day. This averaged for all the days of a month is the mean daily wind speed for that month. The daily values averaged for all the 365 days of the year is the annual mean daily wind speed.

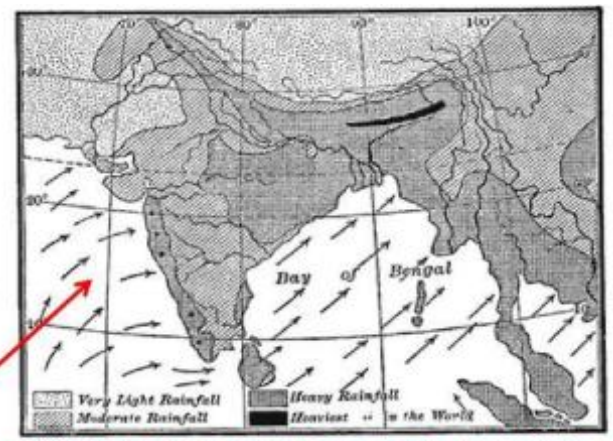
Wind Direction Winds are always named after the direction they come from. Thus, a wind from the south, blowing towards north is called south wind. The wind vane is an instrument used to find out the direction of the wind. Windward refers to the direction wind comes from, and leeward refers to the direction it blows to. When a wind blows more frequently from one direction than from any other, it is called a prevailing wind.

South West Monsoon wind direction: During South West Monsoon period of June to September, the westerly winds prevail on the west of Kerala and south winds on the west of northern Circars, Orissa and Bengal. During April and May the region of high temperature is shifted to north viz., upper Sind, lower Punjab and Western Rajasthan. This area becomes the minimum barometric pressure area to which monsoon winds are directed.

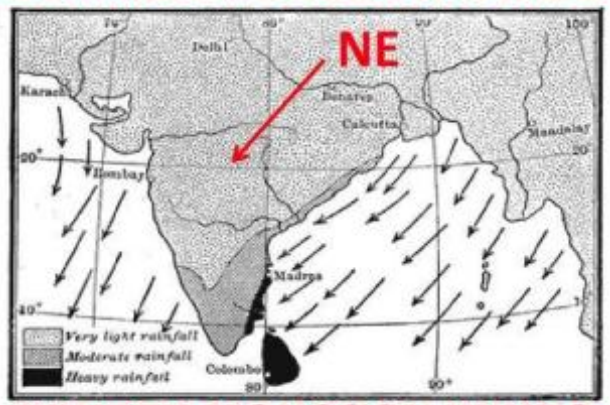
North East Monsoon wind direction: During North East Monsoon period of October to December, on account of the increase in barometric pressure in Northern India, there is a shift in the barometric pressure to the South East and North Easterly winds begin to flow on the eastern coast, by the end of September. These changes bring on heavy and continue rainfall to the Southern and South Eastern India.

The Summer Wet Monsoon

Winds blowing from the southwest between May and September bring rain.



SUMMER MONSOON WINDS



WINTER MONSOON WINDS

The Winter Dry Monsoon

Winds blowing from the northeast between October and April bring dry winds that can cause major droughts.

Humidity – Its effect on Crop Production

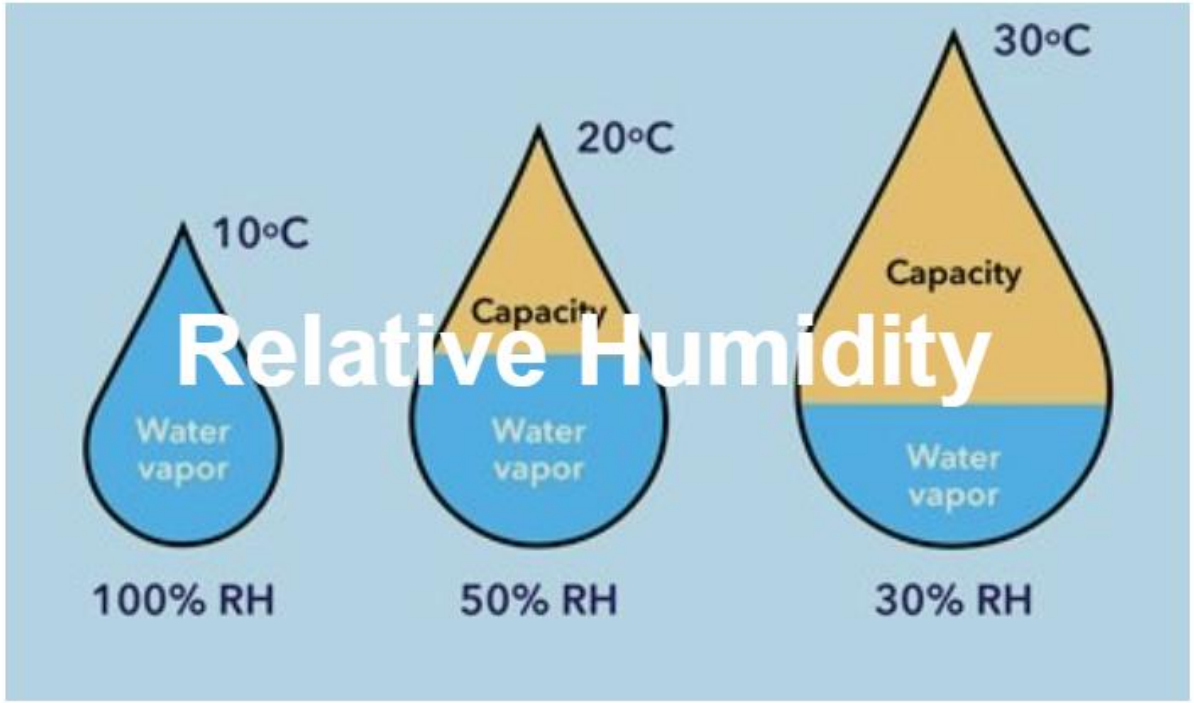
Humidity: Humidity is the amount of water vapour present in the air at a given moment. Water vapour is the vapour phase of water, which is invisible to us because it is totally transparent. The humidity is responsible for situations such as precipitation, dew, and fog. A saturated atmosphere has the maximum amount of water vapour that is can hold. Moreover, the amount of water vapour required for the saturation increases with the increase of temperature.

Absolute Humidity: It is the total water vapour content in the atmosphere. It gives the total mass of water vapor in a given volume of air (sometimes we consider the mass of air in place of volume). The unit for the measurement is gram per cubic meter (g/m^3). The equation for this relationship is as follows.

Specific Humidity: It refers to the weight (amount) of water vapour contained in a unit weight (amount) of air (expressed as grams of water vapour per kilogram of air **g/kg**). Absolute and specific humidity are quite similar in concept.

Relative humidity (RH): The ratio between the amount of water vapour present in a given volume of air and the amount of water vapour required for saturation under fixed temperature and pressure and it is expressed as percentage. The relative humidity gives only the degree of saturation of air. The RH of saturated air is 100 percent.

Dew point temperature: The dew point is the temperature the air needs to be cooled to (at constant pressure) in order to achieve a relative humidity (RH) of 100%. At this point the air cannot hold more water in the gas form. If the air were to be cooled even more, water vapour would have to come out of the atmosphere in the liquid form, usually as fog or precipitation.



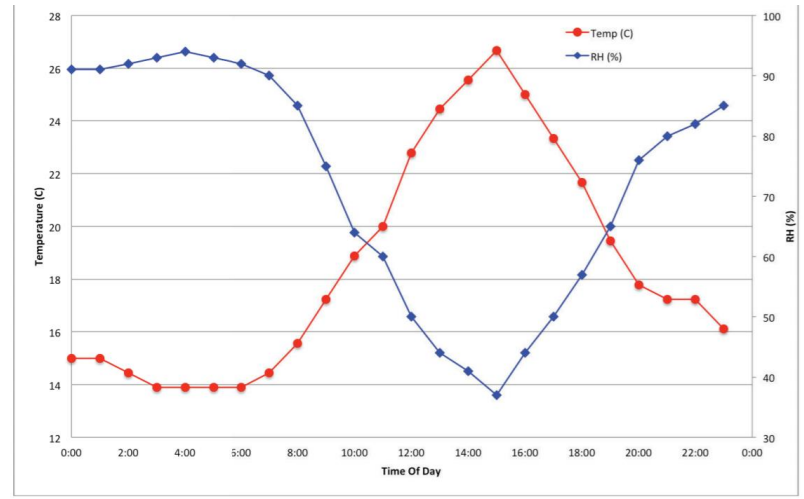
If you take an average spring day at 22°C and 55% relative humidity (RH) you would have an absolute humidity of 9 g/kg.

- when the moisture content remains constant and temperature increases, relative humidity decreases.
- Example, if we have air at 22°C and 55% RH, we would have an absolute humidity level of 9 g/kg.
- Warmer air can hold more humidity. So, if we increase the temperature to 30°C but keep the absolute humidity the same (9 g/kg) then RH would now be 34%.
- Similarly, if we decrease the temperature from 22°C to 12 °C and kept the absolute humidity the same we would now have a relative humidity of 100%.

Importance of Humidity on crop plants

The humidity is not an independent factor. It is closely related to rainfall, wind and temperature. It plays a significant role in crop production.

1. The humidity determines the crops grown in a given region.
2. It affects the internal water potential of plants.
3. It influences certain physiological phenomena in crop plants including transpiration
4. The humidity is a major determinant of potential evapotranspiration. So, it determines the water requirement of crops.
5. High humidity reduces irrigation water requirement of crops as the evapotranspiration losses from crops depends on atmospheric humidity.
6. High humidity can prolong the survival of crops under moisture stress. However, very high or very low relative humidity is not conducive to higher yields of crops.
7. There are harmful effects of high humidity. It enhances the growth of some saprophytic and parasitic fungi, bacteria and pests, the growth of which causes extensive damage to crop plants. Eg: a. Blight disease on potato. b. The damage caused by thrips and jassids on several crops.
8. High humidity at grain filling reduces the crop yields.
9. A very high relative humidity is beneficial to maize, sorghum, sugarcane etc, while it is harmful to crops like sunflower and tobacco.
10. For almost all the crops, it is always safe to have a moderate relative humidity of above 40%.



Variation in Humidity:

1. Absolute humidity is highest at the equator and minimum at the poles.
2. Absolute humidity is minimum at sunrise and maximum in afternoon from 2 to 3 p.m. The diurnal variations are small in desert regions.
3. The relative humidity is maximum at about the sunrise and minimum between 2 to 3 p.m.
4. The behaviour of relative humidity differs a lot from absolute humidity. At the equator it is at a maximum of 80 per cent and around 85 per cent at the poles. But, near horse latitudes it is around 70 per cent.