ONLYIAS BY PHYSICS WALLAH

DAILY CLASS NOTES

Geography

Lecture – 39

Atmospheric Phenomenas - Thunderstorms

Atmospheric Phenomenas - Thunderstorms

4. Cyclonic Rain:

- Cyclonic Rainfall is convectional rainfall on a large scale
- The precipitation in a tropical cyclone is of convectional type while that in a temperate cyclone is because of frontal activity.

5. Monsoonal Rainfall:

- This type of precipitation is characterized by seasonal reversal of winds which carry oceanic moisture (especially the south-west monsoon) with them and cause extensive rainfall in south and southeast Asia.

World Distribution of Rainfall:

- Different places on the earth's surface receive different amounts of rainfall in a year and that too in different seasons.
- In general, as we proceed from the equator towards the poles, rainfall goes on decreasing steadily.
- The coastal areas of the world receive greater amounts of rainfall than the interior of the continents.
- The rainfall is more over the oceans than on the landmasses of the world because of being great sources of water.

- Between the **latitudes 35° and 40° North and South of the equator, the rain is heavier** on the eastern coasts and goes on decreasing towards the west.
- But, **between 45° and 65° North and South of the equator, due to the westerlies,** the rainfall is first received on the western margins of the continents and it goes on decreasing towards east.
- Wherever mountains run parallel to the coast, the rain is greater on the coastal plain on the windward side and it decreases towards the leeward side.
- On the basis of the total amount of annual precipitation, major precipitation regimes of the world are identified as follows:
  - The **equatorial belt, the windward slopes of the mountains along the western coasts** in the cool temperate zone, and the coastal areas of the monsoon land receive heavy rainfall of over 200 cm per annum.
  - **Interior continental areas** receive moderate rainfall varying from 100-200 cm per annum. The **coastal areas of the continents** receive a moderate amount of rainfall.

- The central parts of the **tropical land and the eastern and interior parts of the temperate lands** receive rainfall varying between 50 - 100 cm per annum.
- Areas lying in the **rain shadow zone of the interior of the continents and high latitudes** receive very low rainfall - less than 50 cm per annum.

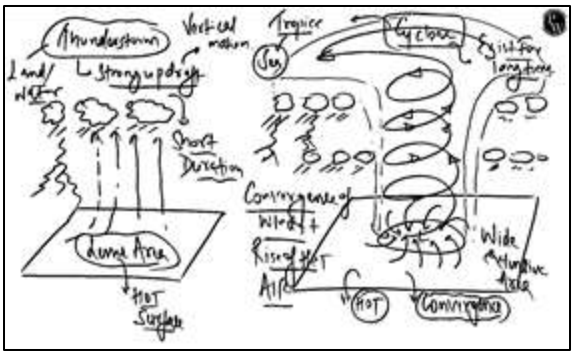
- Seasonal distribution of rainfall provides an important aspect to judge its effectiveness. In some regions, rainfall is distributed evenly throughout the year such as in the **equatorial belt** and in the **western parts of cool temperate regions.**

Latitudes	Rainfall Pattern
0-10 degrees Latitude (Doldrum)	Mainly convectional rainfall, along with lightning and thunder.
10-20 degrees Latitude (Influence of Easterlies)	Rainfall on the eastern part of the continent.
20-30 degrees Latitude (Sub tropical high-pressure belt and descending winds)	Cause minimum rainfall in the region.
30-40 degrees Latitude (Influence of Westerlies)	Rainfall on the western margin of the continent.
40-45 degrees Latitude (Mid-latitude region)	Both the Westerlies and Temperate cyclones cause rainfall.
55-65 degrees Latitude (Sub polar low-pressure zone)	Frontal rainfall
65 degrees Latitude and Beyond	Minimum rainfall, maximum precipitation in the form of snowfall.

Thunderstorm:

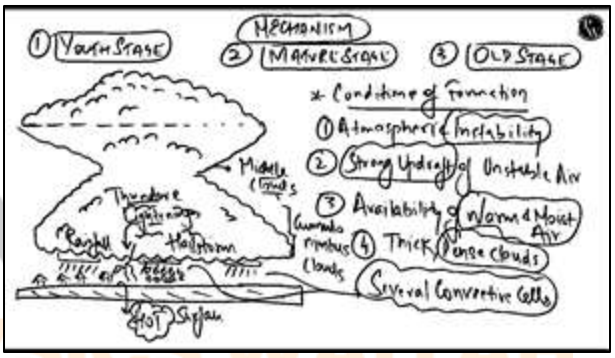
- Thunderstorms are **storms ranging several kilometers in diameter, created by the rapid lifting of moist and warm air, a**s a result of which a dense vertical tower of the cloud is created
- Thunderstorms are **associated with strong winds, hail, lightning, tornadoes, thunder, and heavy rain.**
- There are many factors that lead to the uplifting of air, like solar heating, low-pressure troughs, meeting of two different air streams, or when air is forced uphill.

- When humid air is lifted, it gets cooled and the moisture in the air condenses to form clouds. Upon further uplifting, the cloud will extend higher.
- Water droplets in the cloud continue to grow in size. As the cloud extends further upward, ice crystals may form because of the low temperature.
- A cumulonimbus cloud results when it **grows to a height of 10 to 20 kilometers.** Thunderstorms are produced by cumulonimbus clouds.



- Thunderstorms normally develop in late afternoon hours when surface heating produces the maximum number of convection currents in the atmosphere.
- Thunderstorms **mostly occur on the ground where the temperature is high.** Thunderstorms are **less frequent on water bodies due to low temperatures.**
- Worldwide, there are an estimated 16 million thunderstorms each year, and at any given moment, there are roughly 2,000 thunderstorms in progress.

Thunderstorm Life Cycle:



1. Cumulus Stage (Youth Stage):

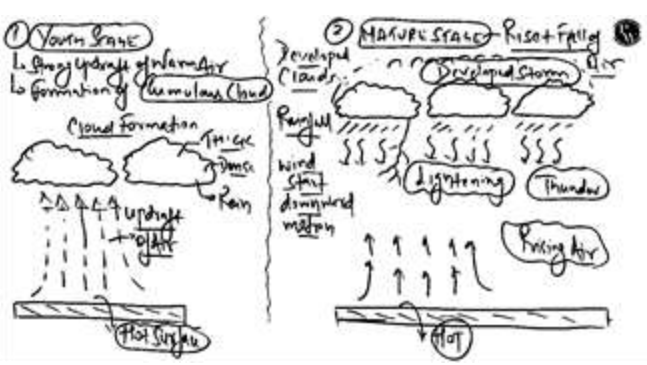
- Ground is significantly heated due to solar insolation.
- A low pressure starts to establish due to intense upliftment of an air parcel (convection).
- Air from the surroundings starts to rush in to fill the low pressure.
- Intense convection of moist hot air builds up a towering cumulonimbus cloud.

2. Mature Stage:

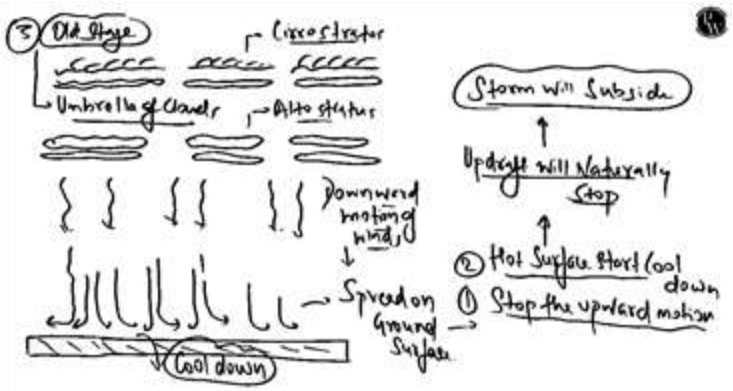
- This stage is characterized by the intense updraft of rising warm air, which causes the clouds to grow bigger and rise to a greater height.
- Later, downdraft brings down to earth the cool air and rain.
- The incoming thunderstorms are indicated by violent gusts of wind. This wind is due to the intense downdraft.
- The updraft and downdraft determine the path of the thunderstorm. Most of the time, the path is erratic.

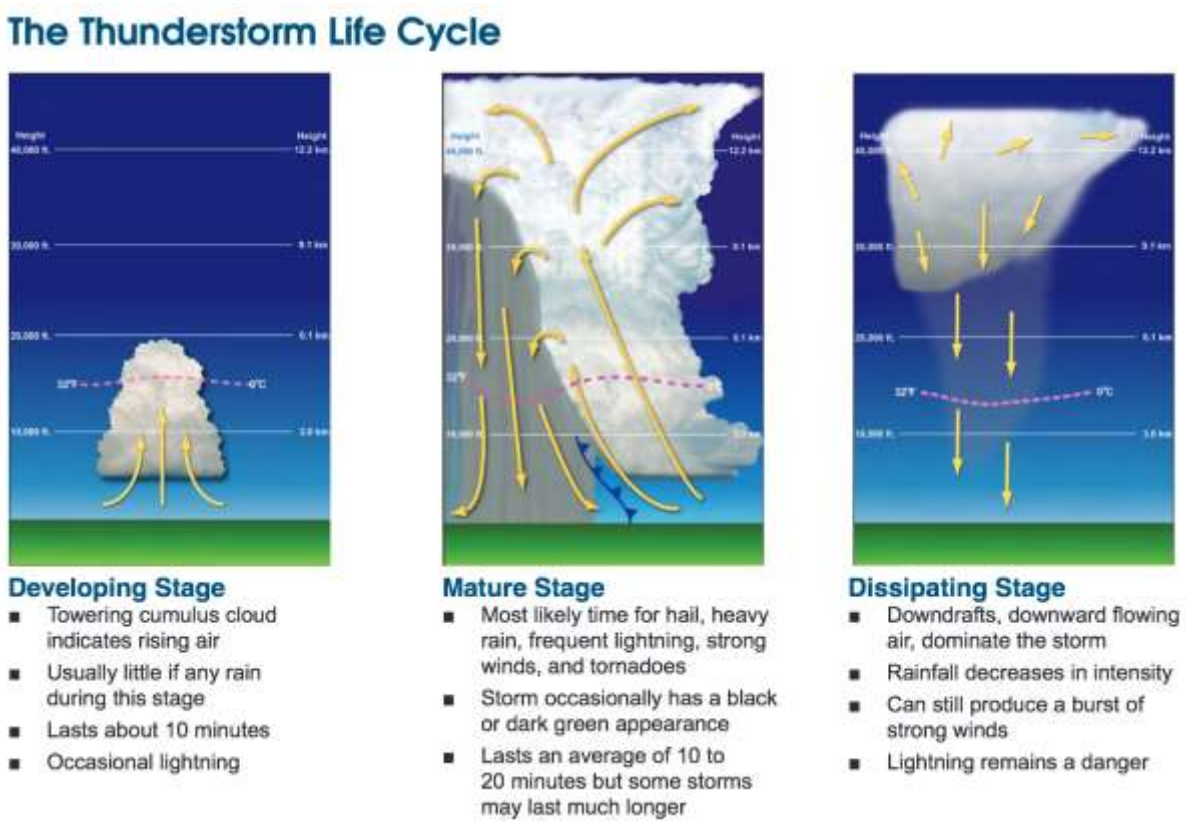
3. Dissipating Stage:

- When the clouds extend to heights where sub-zero temperature prevails, hails are formed and they come down as hailstorms. As a result, intense precipitation occurs.



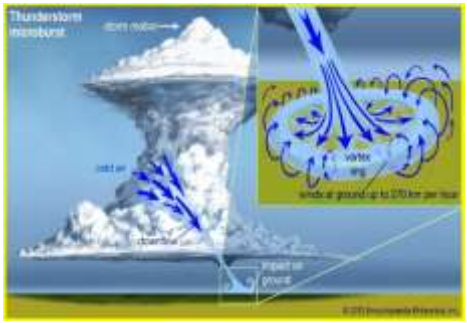
- In a matter of a few minutes, the storm dissipates and clear weather starts to prevail.



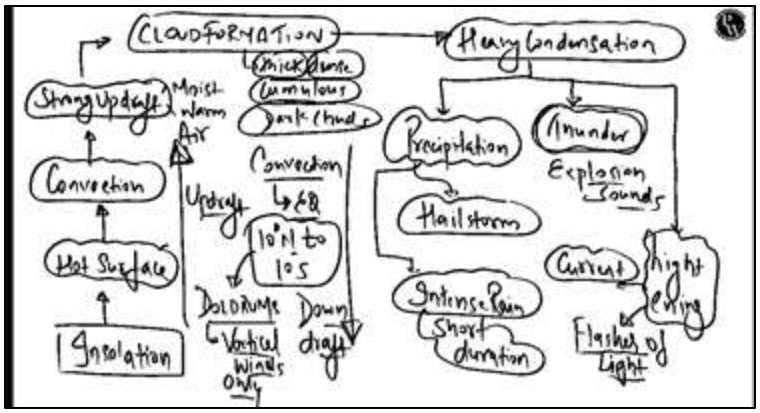


Motion of Thunderstorm:

- Motion of thunderstorms is due to interactions of its updrafts and downdrafts. Path of a thunderstorm is erratic.
- The speed of isolated storms is typically about 20 km (12 miles) per hour, but some storms move much faster.
- In extreme circumstances, a supercell storm may move 65 to 80 km (about 40 to 50 miles) per hour.

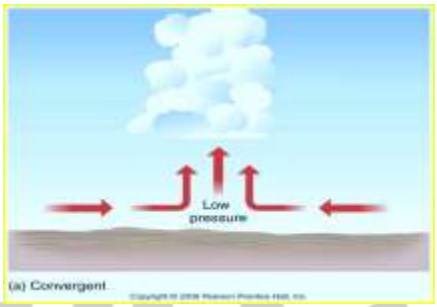


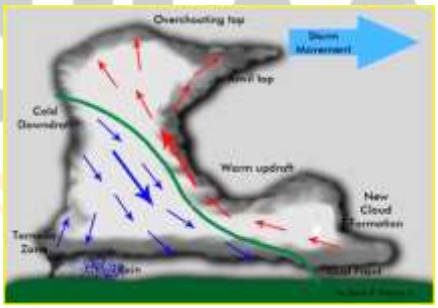
Downbursts:



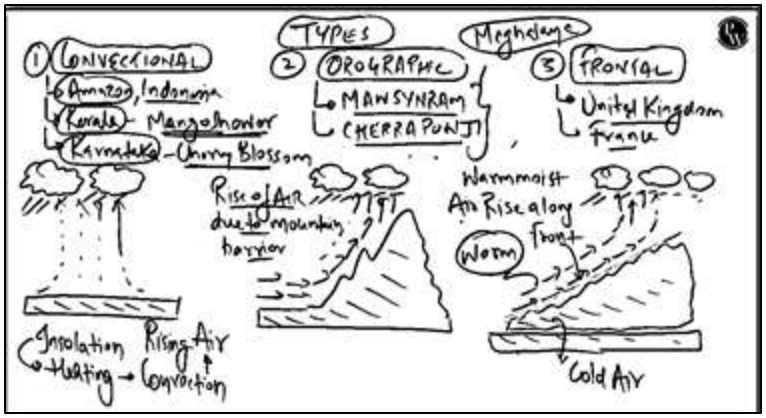
- Downdrafts are **referred to as macrobursts or microbursts.**
- **Macroburst** is more than 4 km in diameter and can produce winds as high as 60 metres per second, or 215 km per hour.
- A **microburst** is smaller in dimension but produces winds as high as 75 metres per second, or 270 km/hour
  - They are hazardous to aircraft, especially during takeoffs and landings.

Types of Thunderstorms:





1. **Thermal/Convective Thunderstorm:**
   - It is caused due to intense heating of **ground during the summer season.**
   - They are prominent in the **equatorial regions.**
2. **Orographic Thunderstorm:**
   - Forceful upliftment of warm moist air parcel when it passes over a mountain barrier creates a cumulonimbus cloud causing heavy precipitation on the windward side.
   - Orographic **'Cloud bursts'** are **common in Jammu and Kashmir, Cherrapunji, and Mawsynram.**
   - **Lake Maracaibo** is also an example where this type of thunderstorm is prominent.
3. **Frontal Thunderstorm:**
   - These are thunderstorms **occurring along cold fronts.**
   - **Example: In United Kingdom.**
4. **Advectional Thunderstorms:**
   - There is the **horizontal movement of winds.**
   - **It occurs at mid-latitude regions (35-60 degrees latitude).**



Single-cell Thunderstorm

- Single-cell thunderstorms are small, brief, weak storms that grow and die within an hour or so. They are typically driven by heating on a summer afternoon.

- Single-cell storms may produce brief heavy rain and lightning- Very common in India during summers, mostly April, and May.
- In Kerala they are called **'Mango Showers' and in Karnataka 'Blossom showers'.**
- These storms can set up a better environment for stronger storms but are themselves not often severe.
- These storms generally occur in a lower moisture environment where the storms stay more isolated from each other.
- Most of these single-cell storms are slow moving and some can be nearly stationary.

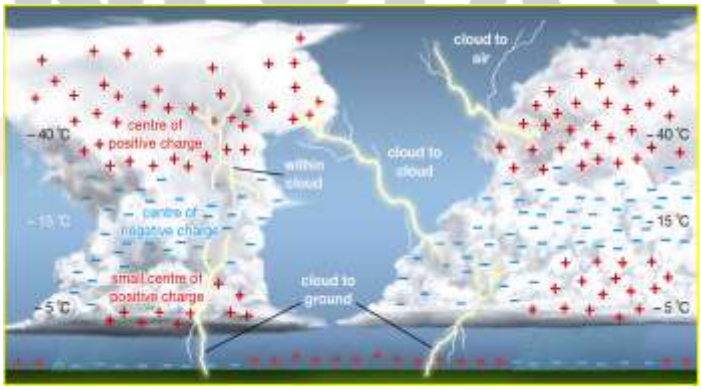
A Multi-cell Thunderstorm

- A multi-cell storm is a thunderstorm in which new updrafts form along the leading edge of rain-cooled air (the gust front).
- Individual cells usually last 30 to 60 minutes, while the system as a whole may last for many hours.
- Multicell storms may produce hail, strong winds, brief tornadoes, and/or flooding.

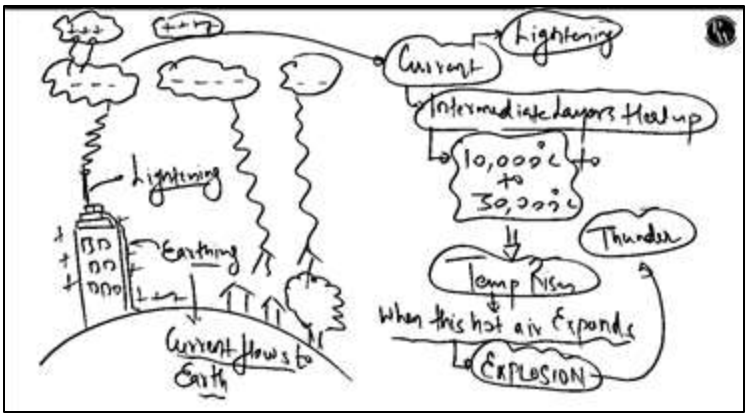
A Supercell Thunderstorm

- A supercell is a long-lived (greater than 1 hour) and highly organized storm feeding off an updraft (a rising current of air) that is tilted and rotating.
- Most large and violent tornadoes come from supercells.
- The updraft within super-cell thunderstorms can have a 10-mile diameter footprint and can extend up to 50,000 feet into the troposphere.

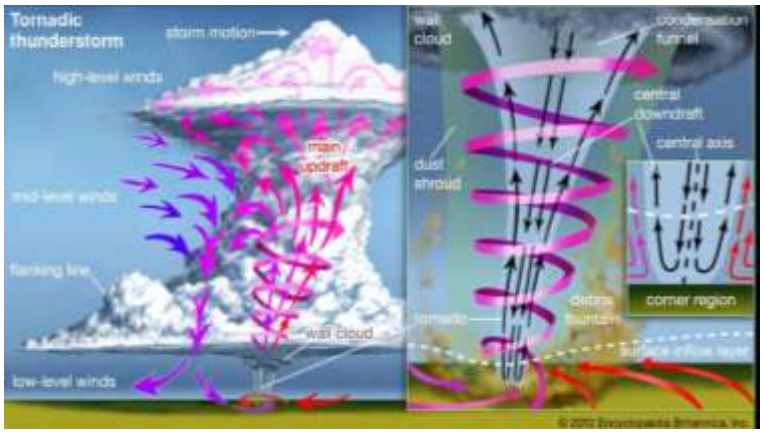
Lightning and Thunder:



- As water vapour moves upward, decreasing temperatures causes it to condense.
- The heat (the latent heat of condensation) generated in the process pushes the water molecules further up.
- As they move beyond zero degrees, water droplets change into small ice crystals.
- As they continue to move up, they gather mass until they are so heavy that they start to fall.
- This leads to a system where smaller ice crystals move up while bigger crystals come down.
- The resulting collisions trigger the release of electrons, in a process very similar to the generation of electric sparks (this is called ionization – an electron in the outer shell is peeled out of the atom and the atom becomes an ion.



- There are **two types of ions based on charge – cation and anion.**
  - **Cation:** A cation is an atom or a molecule which is positively charged, i.e. has more number of protons than electrons.
  - **Anion:** An anion is an atom or molecule which is negatively charged, i.e. has more number of electrons than protons). The moving free electrons cause more collisions and more electrons, as a chain reaction ensues.



- The process results in a situation in which the top layer of the cloud gets positively charged (cations) while the middle layer is negatively (anions) charged.
- It produces heat, leading to the heating of the air column between the two layers of the cloud.
- It is because of this heat that the air column looks red during lightning.
- The heated air column expands and produces shock waves that result in thunder.

Features of Lightning:

- Positive charge accumulates at **both higher and lower altitudes.**
- Larger and heavier cloud particles charge with a negative polarity.
- Smaller and lighter clouds particles charge with a positive polarity.
- Roughly two-thirds of all discharges occur within the cloud. The rest are between the cloud and the ground.

Lightning from Cloud to Earth

- Earth is a good conductor of electricity but is electrically neutral.
- In comparison to the middle layer of the cloud, however, it becomes positively charged.
- As a result, a flow of current (about 20-15%) gets directed towards the Earth as well.
- It is this current flow that results in damage to life and property. There is a greater probability of lightning striking tall objects such as trees, towers or buildings.
- Once about 80-100 m from the surface, lightning tends to change course to hit taller objects (guess why very tall buildings have a vertical pole above).
- This is because travelling through the air, which is a bad conductor of electricity, electrons try to find a better conductor, and also the shortest route to the relatively positively charged Earth's surface.
- Several thousand thunderstorms occur over India every year.
- Incidents of lightning have been showing an increasing trend over the last 20 years, especially near the foothills of the Himalayas.
- People are rarely hit directly by lightning. But such strikes are almost always fatal. The most common way in which people are struck by lightning are by 'ground currents'.

- The electrical energy, after hitting a tree or any other object, spreads laterally on the ground for some distance, and people in this area receive electrical shocks. It becomes more dangerous if the ground is wet, or there is conducting material like metal on it.

Prediction and Precautions

- Predicting a thunderstorm over a very precise location is not possible. Nor is the exact time that it is likely to strike.
- People are advised to move indoors in a storm.
- Moving under a tree or lying flat on the ground can increase risks.
- Even indoors, electrical fittings, wires, metal and water must be avoided.

The World's Most Electric Place

- The most lightning activity on Earth is seen on the shore of Lake Maracaibo in Venezuela.
- At the place where the **Catatumbo River falls. into Lake Maracaibo,** sees 28 lightning flashes every minute a phenomenon referred to as the **Beacon of Maracaibo or the Everlasting Storm.**
- The reason probably lies in the topography of the spot: winds blow across **Lake Maracaibo -the largest in South America** (By volume of water, **Titicaca** is the largest lake in South America.
- Lake Maracaibo has a larger surface area, though some consider it to be a large brackish bay due to its direct connection with the sea.) which is surrounded by swampy plains and connected to the Gulf of Venezuela/Caribbean Sea by a very narrow strait.
- The **Maracaibo plain** is enclosed on three sides by high mountain sides into which air masses crash.
- The heat and moisture picked from the swampy plains creates electrical charges and, as the air is destabilized at the mountain faces, thunderstorm activity characterised by almost non-stop lightning activity within clouds results.

Deadly Strikes

- **Direct Strike:** Occurs most often in open areas.
- **Side Flash (Or Side Splash):** Occurs when lightning strikes a taller object and some current jumps on to the victim, who ends up acting as a "short circuit" for the energy.
- Generally occurs when the victim is within a foot or two of the struck object. Most victims are those sheltering under a tree in a rainstorm.
- **Ground Current:** When an object is struck, much of the energy travels outward in and along the ground surface. This is 'ground current', and anyone close can be a victim.
- Ground current affects a larger area than other kinds of current and causes the most lightning deaths and injuries.
- **Conduction:** Lightning can travel long distances in wires or other metal surfaces.
- Most indoor lightning casualties and some outdoor casualties are due to conduction.

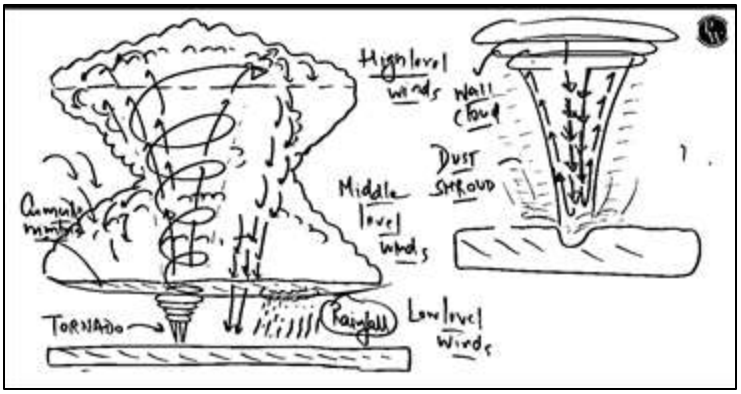
Thunder:

- Lightning creates plasma (ionized gas medium) [Temperature as high as 30,000 °C].

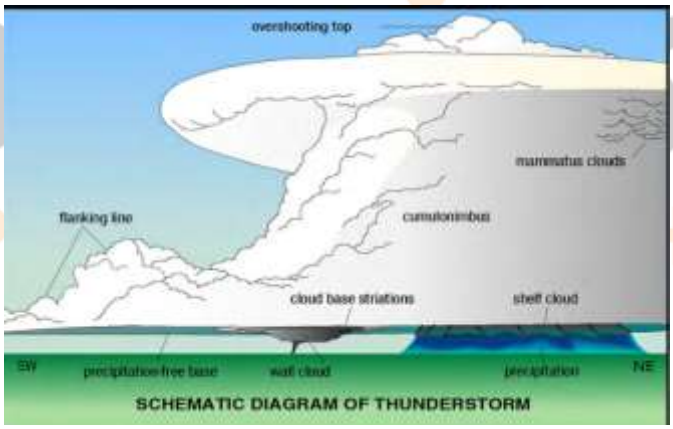
- The channel pressure greatly exceeds the ambient (surrounding) pressure, and the channel expands at a supersonic rate (speed of sound).
- The resultant shock wave decays rapidly with distance and is eventually heard as thunder once it slows to the speed of sound.

Tornado

- From severe thunderstorms sometimes spiraling wind descends like a trunk of an elephant with great force, with very low pressure at the center, causing massive destruction on its way. Such a phenomenon is called a **tornado.**

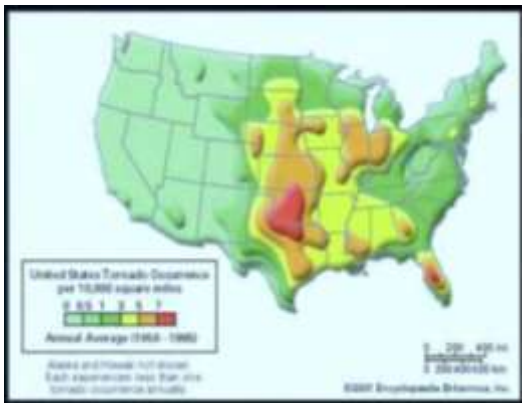


- Tornadoes generally occur in middle latitudes. The tornado over the sea is called water **sprout.**
- A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud.
- In the United States, twister is used as a colloquial term for tornadoes.
- A tornado is a rotating column of air that is in contact with both the surface of the earth and a cloud, which is generally cumulonimbus and occasionally cumulus.



- These whirling atmospheric vortices can generate the strongest winds known on Earth: wind speeds in the range of 500 km (300 miles) per hour.
- They are often referred to as twisters or cyclones.
- These violent storms are the manifestation of the atmosphere's adjustments to varying energy distribution. The potential and heat energies are converted into kinetic energy in these storms and the restless atmosphere again returns to its stable state.
- Tornado is a small-diameter column of violently rotating air developed within a convective cloud and in contact with the ground.
- Tornados occur most often in association with thunderstorms during the spring and summer in the mid-latitudes of both the Northern and Southern Hemispheres.

How are Tornadoes formed?



- First the rotating cloud base lowers.
- This lowering becomes a funnel, which continues descending while winds build near the surface, kicking up dust and other debris.
- Finally, the visible funnel extends to the ground, and the tornado begins causing major damage.

Distribution of Tornadoes

- Rare in polar regions and infrequent at latitudes higher than 50° North and 50° South.
- The temperate and tropical regions are the most prone to thunderstorms.
- Tornadoes have been reported on all continents except Antarctica.
- United States has the most violent tornadoes.
- Canada reports the second-largest number of tornadoes.
- In the Indian sub-continent, Bangladesh is the most prone country to tornadoes.
- At any moment there are approximately 1,800 thunderstorms in progress throughout the world.

How they are detected?

- Tornadoes can be detected before or as they occur through the use of Pulse-Doppler radar by recognizing patterns in velocity and reflectivity data.

What is Fujitsa and Torro Scale?

- Fujitsa scale rates tornadoes by damage caused, and has been replaced in some countries by the updated Enhanced Fujita Scale.
- FO or EFO is the weakest tornado, while F5 or EF5 is the strongest tornado.
- TORRO scale ranges from a T0 for extremely weak tornadoes to T11 for the most powerful known tornadoes.

Waterspout

- Waterspout is an intense columnar vortex (usually appearing as a funnel-shaped cloud) that occurs over a body of water.
- They are connected to a towering cumuliform cloud or a cumulonimbus cloud.
- Weaker than most of its land counterparts i.e. tornadoes.
- Most waterspouts do not suck up water; they are small and weak rotating columns of air over water.
- They are tornadoes in connection with severe thunderstorms but simply occur over water.

Damage Caused by Thunderstorms and Tornadoes

- Many hazardous weather events are associated with thunderstorms.
- Under the right conditions, rainfall from thunderstorms causes flash flooding,
- killing more people each year than hurricanes, tornadoes or lightning.
- Lightning is responsible for many fires around the world each year, and causes fatalities.
- Hail up to the size of softballs damages cars and windows, and kills livestock caught out in the open.
- Strong (up to more than 120 mph) straight-line winds associated with thunderstorms knock down trees, power lines and mobile homes.
- Tornadoes (with winds up to about 300 mph) can destroy all but the best-built man-made structures.

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