Unit 2 Air Pollution

Meteorology

Meteorology is the scientific study of the **atmosphere** and **weather**. It involves understanding and predicting how atmospheric conditions (such as temperature, humidity, pressure, wind, and precipitation) change over time and affect the Earth's environment.

Key Aspects of Meteorology:

1. **Weather**: Meteorology is most commonly associated with weather forecasting. It involves predicting short-term atmospheric conditions (hours, days, and weeks) in a specific area. This includes things like temperature, rainfall, wind patterns, and storms.
2. **Atmosphere**: The atmosphere is the layer of gases surrounding the Earth. Meteorologists study the physical processes, such as the movement of air masses, formation of clouds, and the role of the sun's energy in weather patterns.
3. **Climate**: Meteorology also relates to studying long-term weather patterns in a region (this is sometimes called "climatology"), although climate science is more focused on longer-term trends (years or decades).
4. **Weather Systems**: Meteorologists analyze large-scale weather systems such as high and low-pressure areas, fronts, cyclones, anticyclones, and jet streams to understand how they influence local and global weather patterns.
5. **Tools and Technology**: Meteorologists use advanced tools like satellites, radar, weather balloons, and computer models to track and predict weather events. These technologies help them understand atmospheric behavior and make forecasts.

Why Meteorology is Important:

- **Public Safety**: Meteorology helps predict dangerous weather conditions like hurricanes, tornadoes, and severe storms, allowing people to prepare and stay safe.
- **Agriculture**: Weather forecasts are crucial for farmers to determine the best times for planting, irrigation, and harvesting.
- **Transportation**: Pilots, ship captains, and drivers rely on weather predictions to make safe decisions during travel.
- **Climate Change**: Meteorologists study how climate is changing due to human activities and natural processes, helping policymakers address environmental concerns.

Basic Meteorological Concepts:

- **Temperature**: How hot or cold the air is.
- **Pressure**: The weight of the air pushing down on the Earth's surface, which affects wind and weather patterns.

- **Humidity**: The amount of moisture in the air.
- **Wind**: Moving air, which affects temperature and precipitation.
- **Precipitation**: Any form of water (rain, snow, sleet, hail) falling from the atmosphere.

In short, **meteorology** is the study and prediction of the Earth's atmosphere and weather, which plays a critical role in our daily lives.

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Temperature lapse rate & stability

The **temperature lapse rate** explains how temperature drops as you go higher in the atmosphere. As you go up in altitude, the air gets cooler. This drop in temperature is measured in **degrees Celsius per kilometer** (°C/km). There are three main types of lapse rates, which describe how the temperature changes under different conditions:

1. **Environmental Lapse Rate (ELR)**:
    - This is the actual rate at which temperature changes with altitude at a specific place and time. It can change based on factors like the weather, time of day, and location. For example, on a sunny day, the temperature might decrease more slowly compared to a cloudy or rainy day.
2. **Dry Adiabatic Lapse Rate (DALR)**:
    - This refers to how quickly the temperature of **unsaturated air** (air that isn't holding all the moisture it can) cools as it rises. The typical rate is about **10°C per kilometer**. This means that if a dry air parcel goes up 1 kilometer, its temperature will drop by 10°C. This happens because as air rises, it expands and cools, but there's no moisture involved to slow the cooling down.
3. **Moist Adiabatic Lapse Rate (MALR)**:
    - This is the rate at which **saturated air** (air that is fully humid, or has 100% moisture) cools as it rises. The typical rate is about **6°C per kilometer**, but it can vary depending on how much moisture the air contains. The cooling happens slower than the dry air because, as the air rises, the water vapor in it starts to condense, releasing heat (called **latent heat**), which helps to keep the air warmer. So, the temperature doesn't drop as quickly.

4) super adiabatic:ELR is greater than ALR

In simple terms:

- **ELR** is the actual change in temperature you see at a specific place.
- **DALR** is how fast dry air cools when it rises.
- **MALR** is how fast moist air cools when it rises, but it cools slower than dry air because of the heat released by moisture.

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wind velocity & turbulence

Wind velocity and **turbulence** are key concepts in understanding how air moves through the atmosphere. Here's an explanation in simple terms:

1. Wind Velocity:

- **Wind velocity** refers to the **speed** and **direction** of the wind. It tells us how fast the air is moving and in which direction. It's usually measured in meters per second (m/s) or kilometers per hour (km/h).
- **Wind Speed**: The rate at which the wind moves. Higher wind speeds generally mean stronger winds.
- **Wind Direction**: The direction from which the wind is blowing, typically measured using a compass (e.g., from the north, east, south, or west).
- **Example**: If the wind is blowing from the north at 20 km/h, the wind velocity is 20 km/h from the north.

2. Turbulence:

- **Turbulence** refers to irregular or chaotic air movement, where the flow of air becomes **swirling** or **disordered**.
- In the atmosphere, turbulence occurs when air moves in **uneven** patterns, causing eddies (small whirlpools) and **fluctuating wind speeds**. This can make wind gusty or unpredictable.
- Turbulence can be caused by:
    - **Obstacles**: Mountains, buildings, or other objects can disrupt the smooth flow of air, causing turbulence.
    - **Changes in temperature or pressure**: When warm air rises and cool air sinks, or when there are sudden changes in air pressure, turbulence can occur.
    - **Wind shear**: A sudden change in wind speed or direction with altitude can lead to turbulence.
- **Example**: When you're flying in an airplane and feel sudden, bumpy movements, it's caused by turbulence in the air.

How Wind Velocity and Turbulence Are Related:

- **Wind velocity** can change due to **turbulence**. For example, in turbulent conditions, wind speed may rapidly increase or decrease, leading to gusts (short bursts of wind) or uneven wind flow.
- The higher the **turbulence**, the more **unstable** the wind velocity will be, causing a mixture of fast and slow winds in different directions.

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The **Adiabatic Lapse Rate (ALR)** refers to the rate at which the temperature of a parcel of air changes as it moves vertically in the atmosphere without exchanging heat with its surroundings. This concept is crucial in meteorology and atmospheric science for understanding atmospheric stability, cloud formation, and weather patterns.

Types of Adiabatic Lapse Rates:

1. **Dry Adiabatic Lapse Rate (DALR)**:
    - The rate at which the temperature of a **dry air parcel** (unsaturated air, i.e., relative humidity < 100%) decreases as it rises or increases as it descends.
    - Dry air cools at a constant rate of approximately **9.8°C per kilometer (5.4°F per 1,000 feet)** as it ascends.
2. **Saturated Adiabatic Lapse Rate (SALR)**:
    - The rate at which the temperature of a **saturated air parcel** (air containing water vapor and at 100% relative humidity) decreases as it rises.
    - Saturated air cools at a slower rate, typically **4°C to 7°C per kilometer (2.2°F to 3.8°F per 1,000 feet)**, because latent heat is released during condensation as water vapor turns into liquid droplets.
    - The exact rate varies depending on the amount of moisture in the air and the atmospheric pressure.

Why Does This Happen?

- When air rises, the **pressure decreases**, causing the air parcel to expand. Expansion requires energy, and since the air parcel does not exchange heat with its surroundings in an adiabatic process, the energy for expansion comes from the internal energy of the parcel itself, leading to a **decrease in temperature**.
- Conversely, when air descends, the **pressure increases**, compressing the air parcel, which raises its temperature.

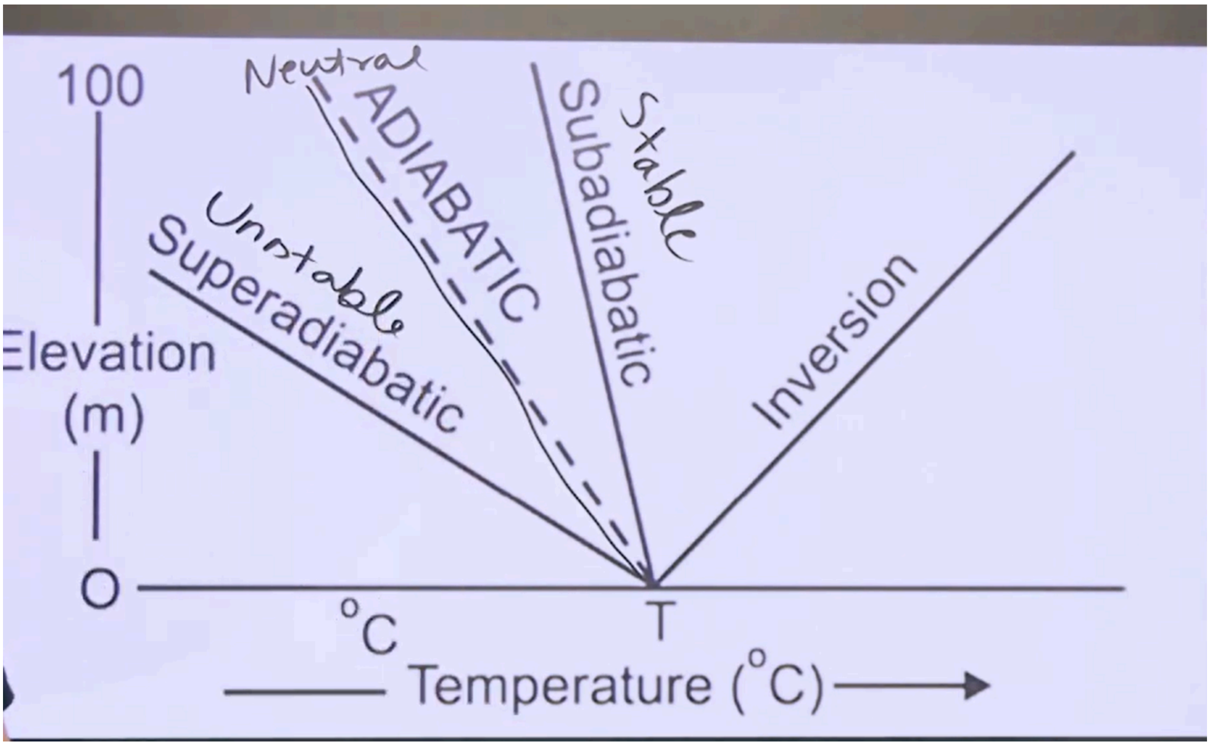
Importance of the Adiabatic Lapse Rate:

1. **Cloud Formation**:

    - As air rises and cools, it may reach its **dew point** (temperature where water vapor condenses), forming clouds. The SALR becomes relevant here as condensation occurs.
2. **Atmospheric Stability**:
    - The lapse rate helps determine whether the atmosphere is **stable, unstable, or neutral**:
        - **Stable**: If the environmental lapse rate is less than the SALR, the air resists upward motion.
        - **Unstable**: If the environmental lapse rate exceeds the DALR, the air continues to rise.
        - **Neutral**: If the environmental lapse rate matches the DALR or SALR.
3. **Weather Patterns**:
    - Understanding lapse rates is essential for predicting thunderstorms, turbulence, and other weather phenomena.

Summary:

- **Adiabatic Lapse Rate** describes temperature changes in rising or descending air parcels due to pressure changes, without heat exchange.
- **Dry Adiabatic Lapse Rate**: ~9.8°C/km.
- **Saturated Adiabatic Lapse Rate**: ~4°C to 7°C/km, varying with moisture content and pressure.
- Plays a critical role in atmospheric stability, cloud formation, and weather forecasting.



(i) ELR > ALR ⇒ Unstable ⇒ mixing

super-ad.

(ii) ELR < ALR = Stable/

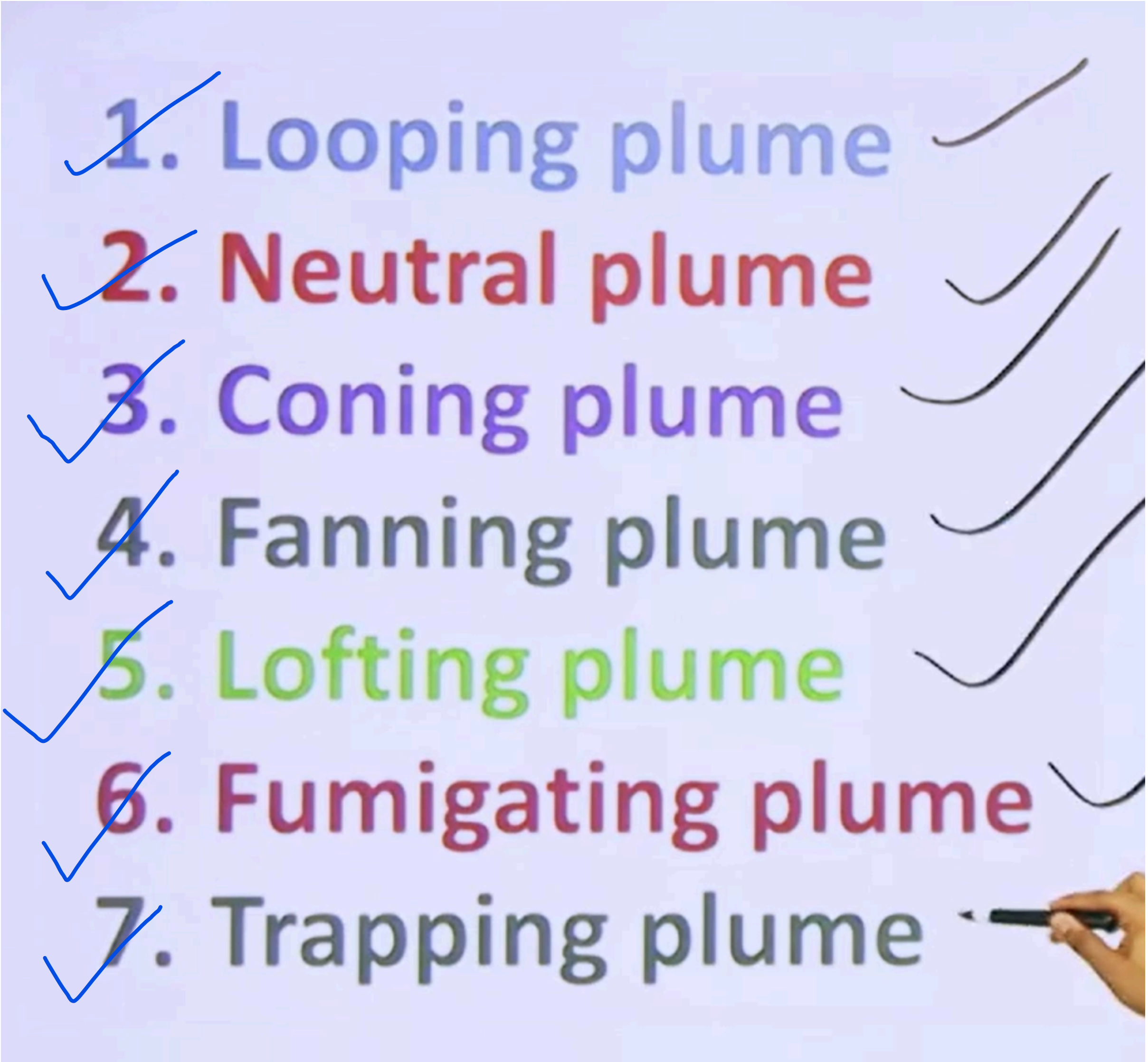
Sub-adiabatic

(iii) ELR = ALR = Nutral En

(iv) NLR = Inversion

Plume behaviour

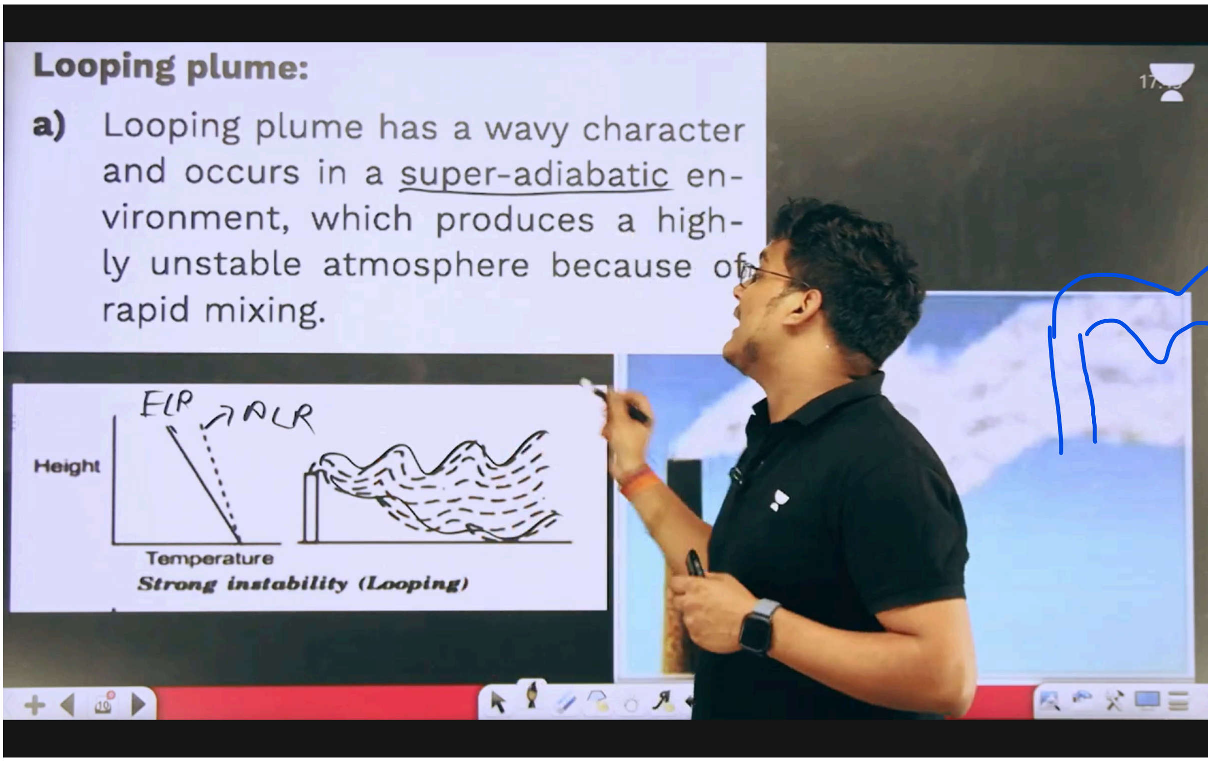
- **Plume –** the emitted pollutants either gases/ smoke from a source
- **Stack –** source of origin of pollutants
- The diffusion of pollutants in atmosphere considered as **plume behaviour**. It is governed by environmental lapse rate and adiabatic lapse rate.

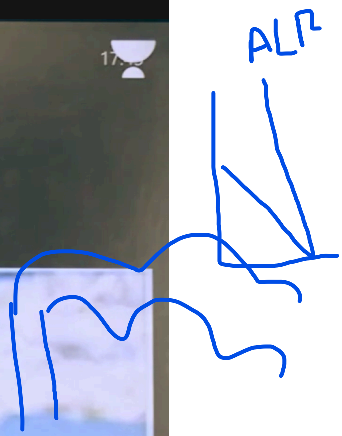


Types of Plume Behavior

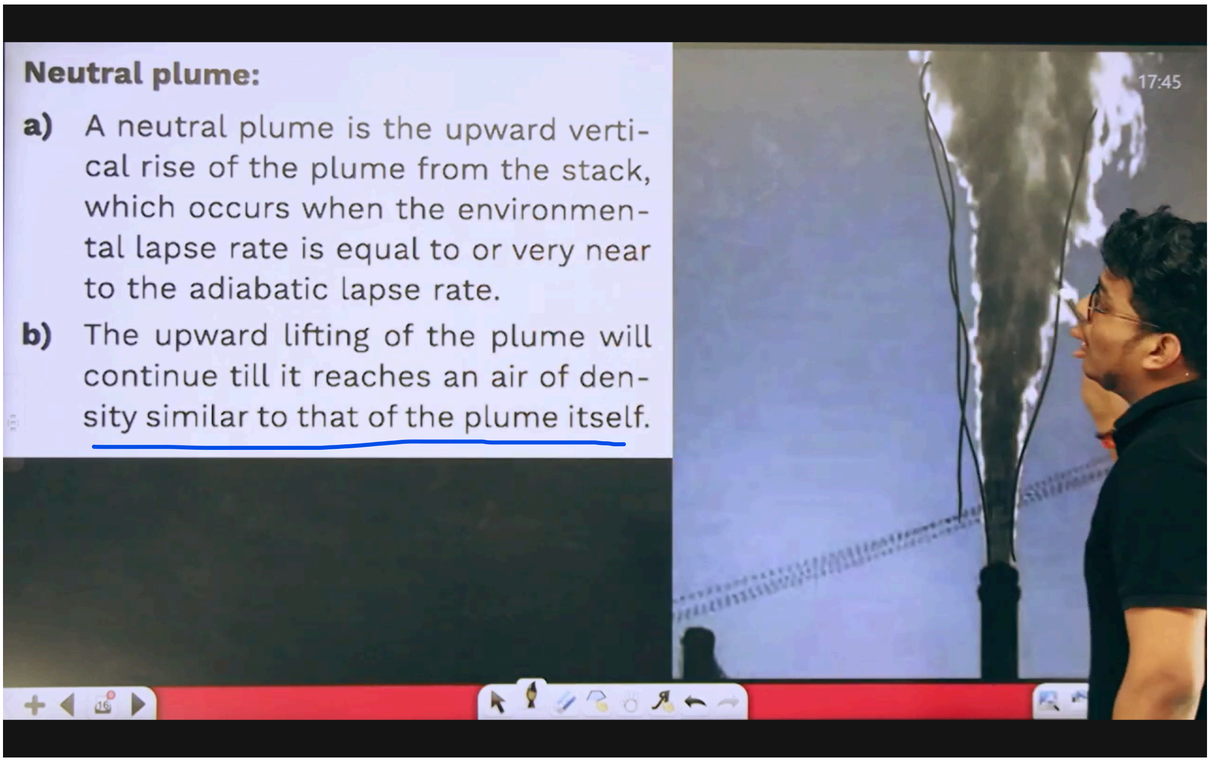
1. Looping Plume

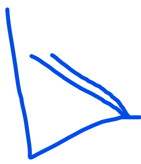
- **Description**: The plume exhibits a wavy, irregular pattern as it rises and falls, caused by turbulence.
- **Conditions**:
  - Highly unstable atmosphere with significant vertical mixing.
  - Usually occurs on sunny days with strong surface heating.
- **Impacts**:
  - Pollutants disperse widely but unpredictably.
- **Example**: Seen near industrial areas during hot afternoons.





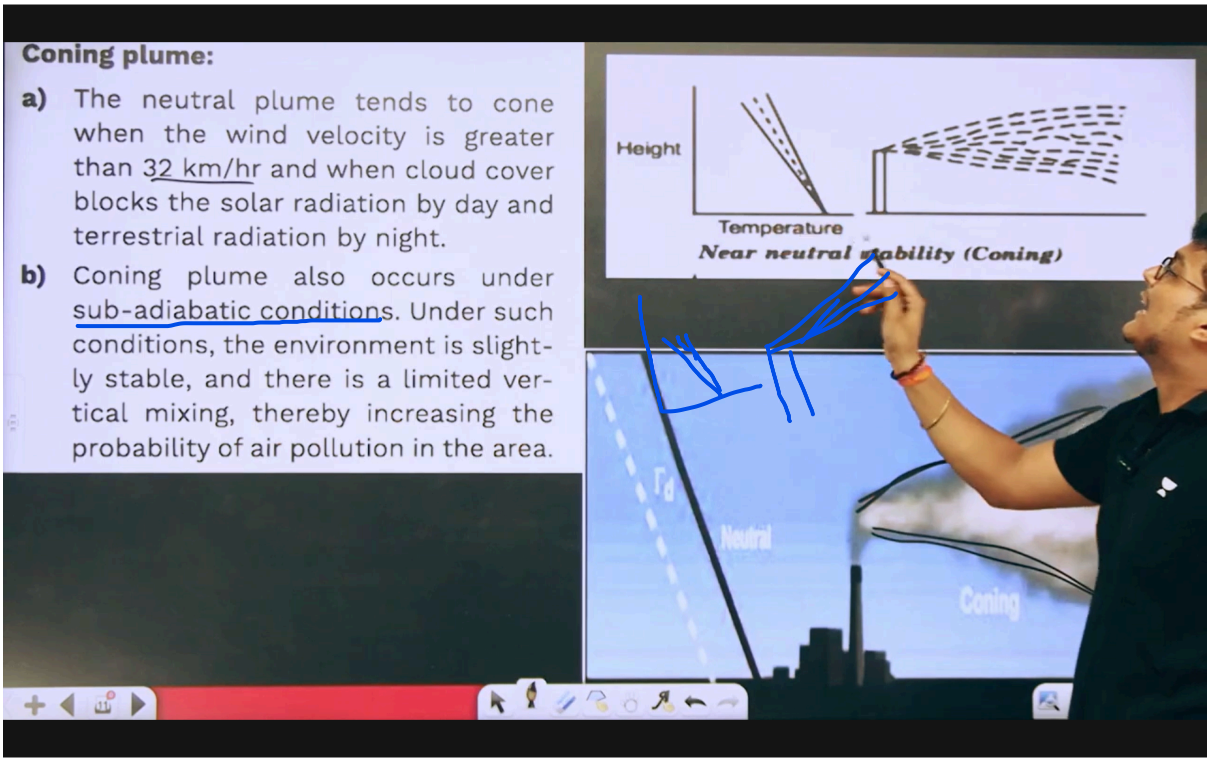
2.Neutral Plume





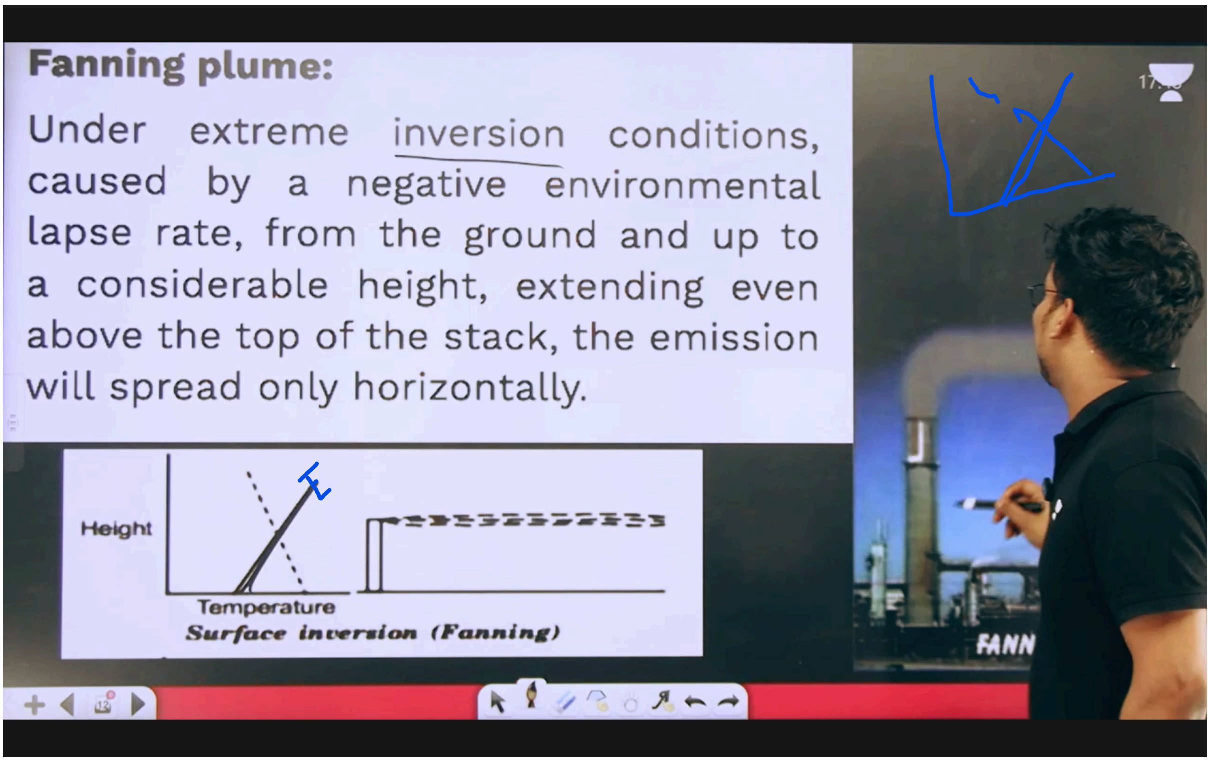
3. Coning Plume

- **Description**: The plume forms a cone shape, with pollutants evenly spreading upward and downward.
- **Conditions**:

- Neutral atmospheric stability, often under overcast skies or moderate wind conditions.
- **Impacts**:
  - Pollutants spread over a large area but remain relatively concentrated.
- **Example**: Common during cloudy days or at dusk.
- 

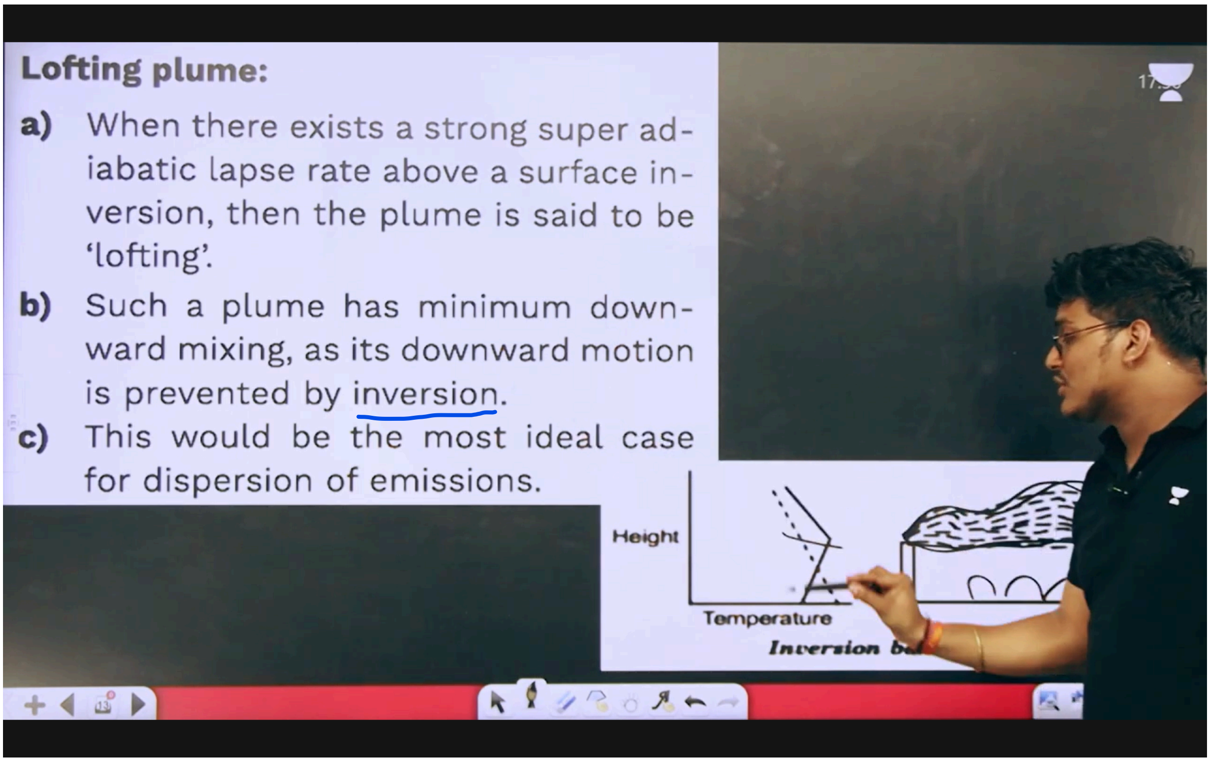
4. Fanning Plume

- **Description**: The plume spreads horizontally but shows little vertical movement.
- **Conditions**:
  - Stable atmospheric conditions, typically during temperature inversions.
  - Occurs when warm air traps cooler air below.
- **Impacts**:
  - Pollutants remain confined near the ground, potentially causing high local concentrations.
- **Example**: Seen at night or early morning in urban areas.



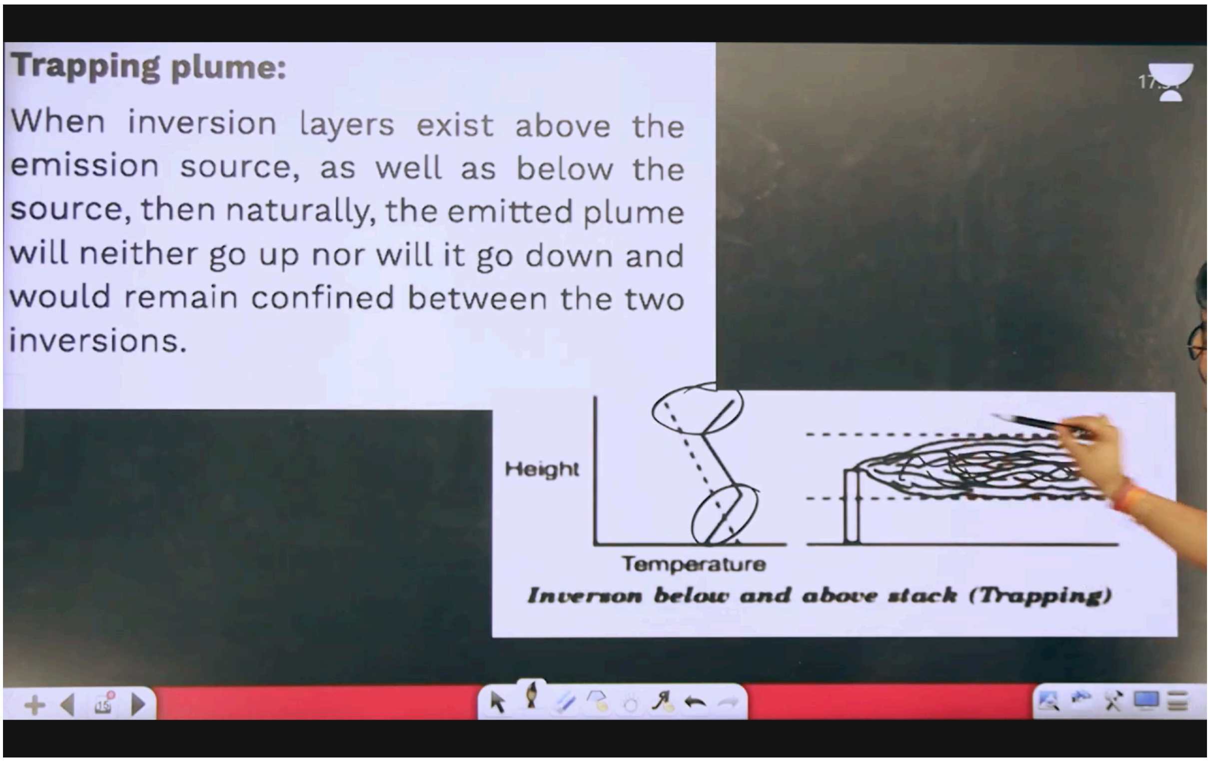
5. Lofting Plume

- **Description**: The plume rises and disperses upward, avoiding ground-level dispersion.
- **Conditions**:
  - Occurs when the air is unstable above the source but stable below (temperature inversion at the ground level).
- **Impacts**:
  - Minimal ground-level pollution; pollutants disperse into the upper atmosphere.
- **Example**: Common during late afternoons when the ground begins cooling.

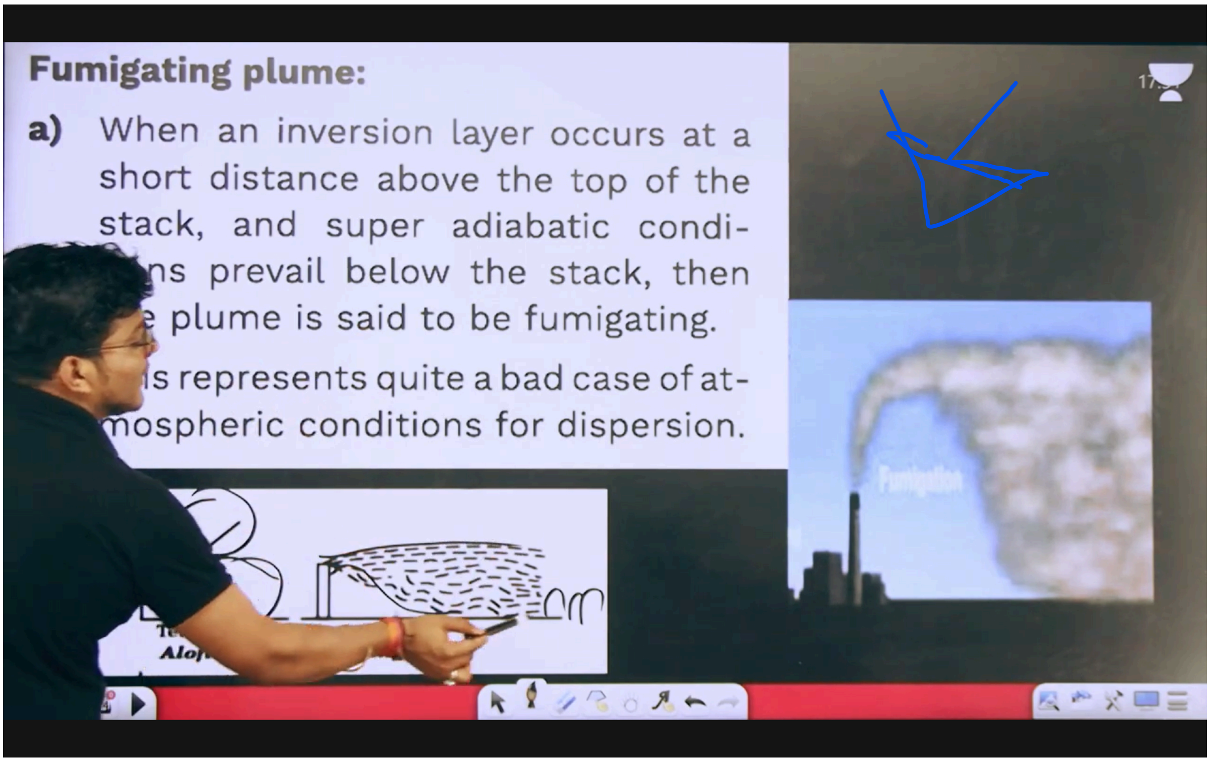


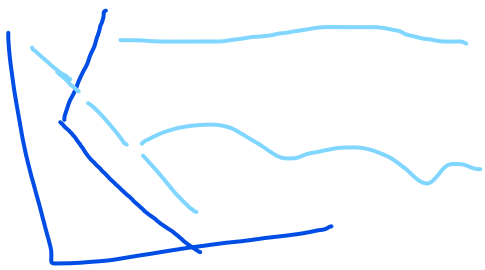
5. Trapping Plume

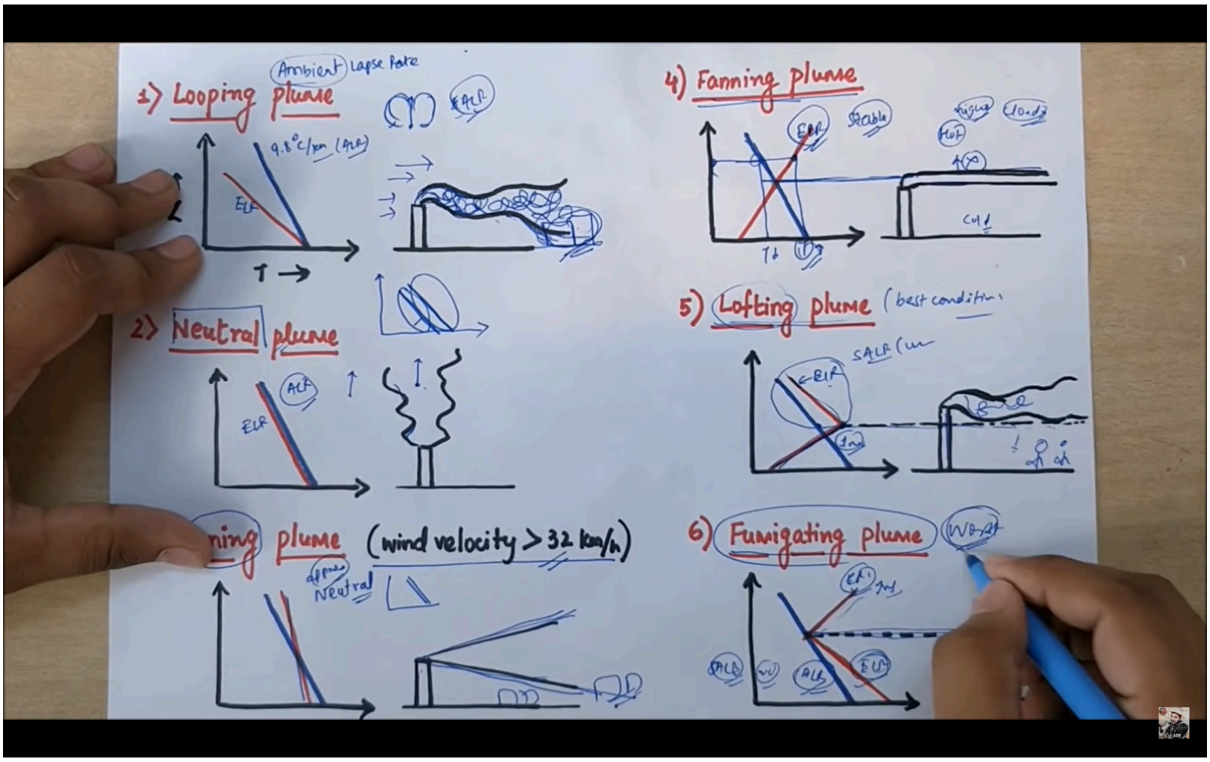
- **Description**: The plume becomes confined between two stable atmospheric layers.
- **Conditions**:
  - Occurs when there is a temperature inversion both above and below the plume release point.
- **Impacts**:
  - Pollutants accumulate in a narrow atmospheric band, leading to high concentrations over specific areas.
- **Example**: Found in industrial zones during prolonged periods of calm weather.



6)Fumigating







Visual Comparison of Plume Types

Plume Type	Vertical Mixing	Horizontal Dispersion	Atmospheric Stability	Example Conditions
Looping	High	Moderate	Unstable	Hot afternoons, strong sun
Coning	Moderate	Moderate	Neutral	Overcast skies, steady winds
Fanning	Low	High	Stable	Early mornings, calm weather
Lofting	High (Upward Only)	Moderate	Inversion below, unstable above	Late afternoons
Trapping	Low	Low	Stable layers above and below	Industrial zones, calm nights
Stacking	Moderate	High at specific altitudes	Stable above, neutral below	Tall smokestacks

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measurement of meteorological variables

1) wind direction Recorder
2) wind speed recorder
3) Humidity measurement
4) Temperature measurement
5) solar radiation measurement

Wind Direction Recorder:

- **Definition**: A wind direction recorder is an instrument that measures the direction from which the wind is coming. It is typically used in meteorology to understand air movement patterns and predict how pollutants will spread.
- **Functionality**: The wind direction is usually expressed in degrees, with 0° indicating wind coming from the north, 90° from the east, 180° from the south, and 270° from the west. Wind direction recorders help identify the source and movement of pollutants in the air. By tracking wind direction, meteorologists can predict where pollutants will go, how they disperse, and if they will accumulate in certain areas (e.g., near mountains or valleys).
- **Common Instruments**:
  - **Wind Vane**: A simple device that points in the direction from which the wind is blowing. It is often mounted on a rotating shaft and has an arrow or fin that moves to align with the wind direction.
  - **Digital Wind Direction Sensor**: Modern instruments use electronic sensors to measure wind direction with more precision. These sensors are often coupled with data loggers to store the data over time.

2. Wind Speed and Direction Recorder:

- **Definition**: A wind speed and direction recorder is an integrated device that measures both the speed and direction of the wind. It provides comprehensive data about air movement.
- **Functionality**: This instrument is essential in meteorology for understanding the dynamics of the atmosphere. The speed component is important because it helps determine the dispersion of pollutants; stronger winds will spread pollutants over a wider area, while light winds can cause pollutants to accumulate. The direction

component allows scientists to track where the pollutants are coming from and where they might move.

- **Common Instruments**:
  - **Anemometer**: Measures wind speed, often using cups or blades that rotate with the wind. The speed of rotation is converted into a wind speed reading.
  - **Combined Anemometer and Wind Vane**: These devices combine an anemometer for measuring speed and a wind vane for measuring direction, providing comprehensive wind data in one instrument.

3. Humidity Measurement:

- **Definition**: Humidity measurement refers to the process of determining the amount of water vapor present in the air. It is an important parameter as humidity affects air quality and the behavior of pollutants in the atmosphere.
- **Functionality**: Humidity is usually expressed as relative humidity, which is the percentage of water vapor present in the air compared to the maximum amount of water vapor the air can hold at a given temperature. High humidity can enhance the formation of secondary pollutants like ozone and can also contribute to the growth of fine particulate matter (PM2.5). Humidity measurement helps predict the likelihood of pollutants sticking to surfaces or condensing into droplets (creating aerosols).
- **Common Instruments**:
  - **Hygrometer**: The basic instrument for measuring humidity. There are different types of hygrometers:
    - **Mechanical Hygrometer**: Measures humidity by the expansion or contraction of materials that change with moisture levels, such as hair or certain types of fibers.
    - **Digital Hygrometer**: Uses electronic sensors like capacitive or resistive sensors to measure humidity with greater accuracy and ease of reading.
    - **Psychrometer**: A type of hygrometer that uses two thermometers, one with a dry bulb and one with a wet bulb, to calculate humidity based on the difference in temperatures.

4. Temperature Measurement:

- **Definition**: Temperature measurement refers to determining the heat level of the atmosphere at a specific point. Temperature affects air pollution by influencing chemical reactions in the atmosphere and controlling how pollutants are dispersed or trapped.
- **Functionality**: Temperature has a direct effect on the behavior of pollutants. For instance, high temperatures can increase the production of ground-level ozone by accelerating chemical reactions. Conversely, cooler temperatures can trap pollutants close to the surface, especially in the case of temperature inversions. Accurate temperature readings help in forecasting pollution levels and understanding atmospheric conditions.
- **Common Instruments**:
  - **Thermometer**: The basic tool for measuring temperature, which can be:

        - **Mercury Thermometer**: A liquid-filled thermometer where the liquid expands or contracts with temperature changes.
        - **Digital Thermometer**: Uses electronic sensors, such as thermistors or thermocouples, to measure temperature with higher accuracy and to display the result digitally.
        - **Infrared Thermometer**: Measures temperature from a distance by detecting infrared radiation emitted by an object or surface.

5. Solar Radiation Measurement:

- **Definition**: Solar radiation measurement refers to the quantification of the sun's energy that reaches the Earth's surface, which is crucial for understanding atmospheric processes like the formation of pollutants and the role of sunlight in chemical reactions.
- **Functionality**: Solar radiation plays a vital role in the formation of secondary air pollutants like ozone. It provides the energy required for photochemical reactions that produce pollutants such as ozone (O_3) and other photochemical smog components. Measuring solar radiation helps assess the intensity of these reactions and can be used to predict high pollution days or the likelihood of smog formation.
- **Common Instruments**:
    - **Pyranometer**: A device that measures the total solar radiation (both direct and diffuse) reaching the Earth's surface. It typically contains a thermopile sensor that converts radiation into an electrical signal.
    - **Pyrheliometer**: A more specialized instrument used to measure the direct solar radiation (from the sun's rays) in a specific direction. It is typically used in more controlled environments or for precise studies.

Summary of Functionality:

- **Wind Direction Recorder**: Measures the direction of wind flow, helping track pollutant sources and dispersion.
- **Wind Speed and Direction Recorder**: Provides both wind speed and direction, essential for understanding pollutant movement.
- **Humidity Measurement**: Measures the amount of water vapor in the air, influencing the formation of pollutants and aerosols.
- **Temperature Measurement**: Monitors air temperature, which impacts chemical reactions and the behavior of pollutants.
- **Solar Radiation Measurement**: Quantifies the sun's energy, which drives photochemical reactions that produce pollutants like ozone.

Each of these instruments is essential for monitoring and predicting air quality and understanding the dynamics of how pollutants spread and behave in the atmosphere.

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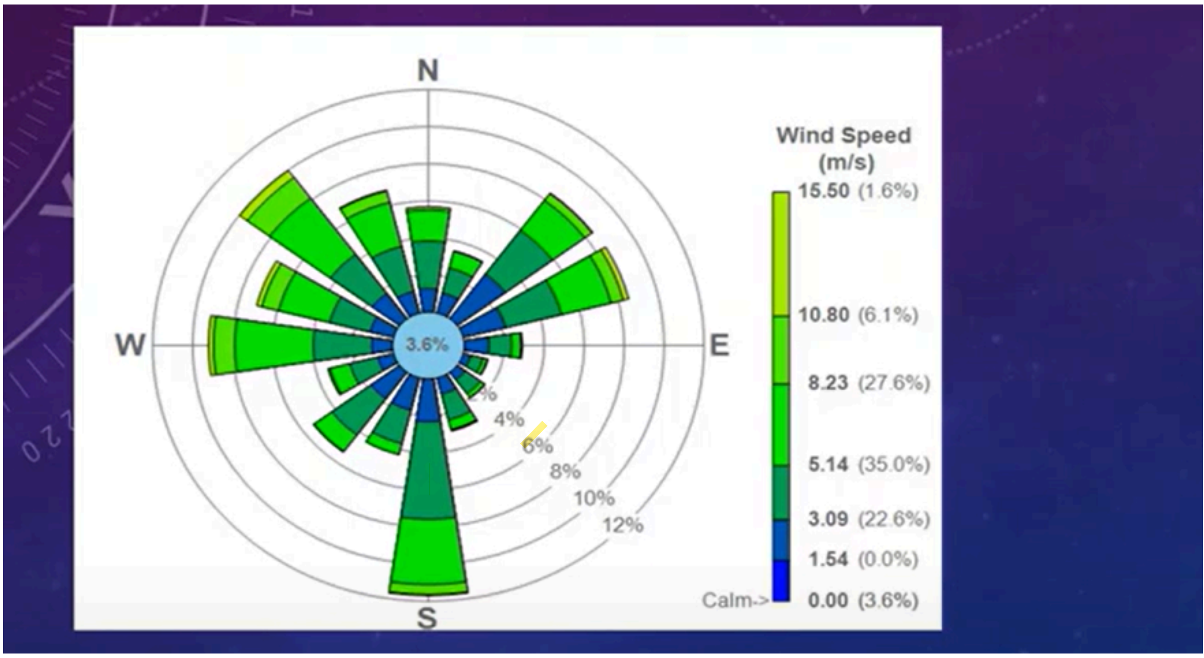
A **wind rose diagram** is a graphical representation that shows the distribution of wind directions and speeds at a specific location over a given period of time. It is used extensively in meteorology, environmental science, and air pollution studies to visualize wind patterns and understand how they affect the dispersion of pollutants, as well as general weather trends.

Key Features of a Wind Rose:

- **Wind Direction**: The diagram typically displays the direction from which the wind is blowing (i.e., wind direction). The center of the diagram represents the observation point, and the various spokes or segments represent different directions (e.g., north, northeast, east, etc.).
- **Wind Speed**: The length of each spoke or section can represent the frequency of wind speeds in that direction. For instance, longer spokes represent stronger winds, while shorter spokes represent lighter winds. In some versions of the wind rose, the width of the sections is used to represent wind speed categories or the frequency of occurrence of different wind speeds.
- **Compass Points**: A wind rose is divided into compass points (8, 16, or 32 segments), where each segment represents a specific wind direction. The most common types are:
    - **8-point wind rose**: North, North-East, East, South-East, South, South-West, West, North-West.
    - **16-point wind rose**: This includes intermediate directions like NNE (North-North-East), ENE (East-North-East), etc.
    - **32-point wind rose**: This divides each of the 16 points further for more detailed analysis.
    - 

Components of a Wind Rose:

1. **Spokes**: Each line or "spoke" extending from the center of the wind rose represents a specific direction. These spokes typically point to one of the cardinal directions (North, East, South, West) or intercardinal directions (e.g., North-East, South-West).
2. **Rings or Circles**: Concentric circles around the center indicate the frequency of wind occurrences. The outer rings may show more frequent occurrences or stronger winds, while inner rings represent less frequent or lighter winds.
3. **Scale**: The scale of the wind speed is often placed around the diagram. The length of the spokes can be proportional to the wind speed, and sometimes, color coding is used to distinguish wind speeds.

How to Read a Wind Rose Diagram:

- **Wind Directions**: The direction from which the wind is blowing is shown along each spoke. For example, a spoke pointing to "North" means the wind is coming from the north.
- **Frequency of Wind Directions**: The length or thickness of each spoke represents the frequency of wind coming from a particular direction. A longer spoke indicates that the wind predominantly comes from that direction during the observation period.
- **Wind Speeds**: The distance from the center of the diagram to the tip of the spoke shows the wind speed in that direction. Some wind roses use color codes or additional markings to represent different wind speed ranges (e.g., light, moderate, strong, etc.).

Example:

Imagine you have a wind rose for a specific city over a month. If the diagram shows that the longest spoke points towards the south, it indicates that the most frequent winds during that month came from the south. If the outer rings indicate strong winds in the south direction, it suggests that these winds were not only frequent but also strong.

Applications of Wind Rose Diagrams:

1. **Air Pollution Studies**: By tracking wind patterns, a wind rose can help predict how pollutants will disperse. For instance, if a factory emits pollutants and the prevailing winds are from the west, the wind rose can show the likely areas where the pollutants will accumulate.
2. **Environmental Studies**: Wind roses are useful in understanding local weather patterns and environmental conditions, such as where wildfires or air pollution are likely to spread.
3. **Engineering**: Wind rose diagrams are used in designing buildings, ventilation systems, and other infrastructure, particularly to understand prevailing winds and optimize airflow.
4. **Agriculture**: Wind roses can help farmers determine the best planting strategies based on prevailing wind patterns, which can affect things like pollen dispersal or irrigation methods.

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Plume behavior refers to the way a plume of air or gas (such as smoke, pollutants, or exhaust) moves and disperses in the atmosphere after being released from a source, like a factory chimney or vehicle exhaust. Understanding plume behavior is important in environmental science, air pollution control, and meteorology, as it helps predict how pollutants spread in the air and where they might settle.

Key Factors Affecting Plume Behavior:

1. **Wind Speed and Direction**: The wind plays a major role in determining the direction and spread of the plume. The plume will generally move in the direction of the wind, and its shape will stretch out along the wind path.
2. **Atmospheric Stability**: This refers to how stable the air is in the atmosphere:
    - **Stable Atmosphere**: The air is calm, and pollutants tend to stay close to the ground, not dispersing much. This can lead to pollution accumulating in certain areas.
    - **Unstable Atmosphere**: Warm air rises, and pollutants disperse more easily into the atmosphere. This leads to better mixing and quicker diffusion of the plume.
3. **Temperature**: The temperature of the air and the emitted gas affects how the plume behaves. If the plume is hotter than the surrounding air, it will rise due to convection. If it’s cooler, it may sink and spread out.

Types of Plume Behavior:

1. **Neutral Plume**: In this case, the plume rises to a certain height, but because of wind, it spreads evenly and does not rise or fall significantly.
2. **Looping Plume**: This happens in unstable atmospheric conditions when the plume rises rapidly and then falls back toward the ground. It appears as loops or spirals in the sky.
3. **Coning Plume**: A conical shape forms when the plume rises and spreads out evenly, creating a shape like an upside-down cone. This is typically seen in relatively stable atmospheric conditions.
4. **Fanning Plume**: When the plume is released at high altitudes in strong winds, it spreads widely in a fan-like shape. The plume may not rise much but may instead spread horizontally.
5. **Elevated Plume**: If the plume is emitted from a high point, it may rise and disperse, depending on the wind conditions and temperature of the air.

Simple Words

Plume behavior refers to how a cloud of smoke or pollutants moves and spreads in the air after being released from a source like a factory or chimney. It depends on factors like:

1. **Wind Speed and Direction**: The wind blows the plume in a specific direction.
2. **Atmospheric Stability**: Stable air keeps the plume close to the ground, while unstable air lets it rise and spread.
3. **Temperature**: Hot plumes rise, while cooler ones stay lower.
4. **Topography**: Hills or valleys can affect the movement of the plume.
5. **Source Height**: Higher sources make the plume spread more evenly.

Types of plume behavior include **neutral** (even spread), **looping** (rises and falls), **coning** (spreads out like a cone), and **fanning** (widely spread).

Simple Description Types of lapse rates(main)

The **environmental lapse rate (ELR)** is the rate at which the temperature of the atmosphere decreases with an increase in altitude. It is a crucial concept in meteorology and atmospheric science, as it determines atmospheric stability and weather conditions. There are several types of lapse rates, each associated with different atmospheric conditions:

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1. Environmental Lapse Rate (ELR)

- **Definition**: The actual rate at which temperature decreases with altitude in the atmosphere at a given time and location.
- **Value**: Varies widely, depending on local conditions like humidity, pressure, and surface heating. The average ELR is approximately **6.5°C per kilometer**.
- **Significance**: Used as a reference to determine the stability of the atmosphere when compared to other lapse rates.

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2. Dry Adiabatic Lapse Rate (DALR)

- **Definition**: The rate at which the temperature of a parcel of **dry air** (unsaturated) decreases as it rises or increases as it descends in the atmosphere.
- **Value**: Approximately **10°C per kilometer**.
- **Significance**:

    - Applies when the air is unsaturated (relative humidity < 100%).
    - Important for understanding convection and atmospheric stability.

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3. Moist (or Saturated) Adiabatic Lapse Rate (MALR)

- **Definition**: The rate at which the temperature of a **saturated air parcel** (relative humidity = 100%) decreases as it rises.
- **Value**: Varies between **4°C to 9°C per kilometer**, depending on the amount of water vapor present and the latent heat released during condensation.
- **Significance**:
    - Applies to rising air that has reached its dew point and condensation is occurring.
    - Typically slower than the DALR because latent heat release during condensation offsets cooling.

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4. Superadiabatic Lapse Rate

- **Definition**: When the temperature decreases with height **faster than the DALR** (greater than 10°C per kilometer).
- **Significance**:
    - Indicates extreme instability in the atmosphere.
    - Common near the Earth's surface during intense heating, leading to strong convection and turbulence.

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5. Subadiabatic Lapse Rate

- **Definition**: When the temperature decreases with height **slower than the MALR** (less than 4°C per kilometer).
- **Significance**:
    - Indicates a stable atmosphere.
    - Inhibits vertical air movement and convection.

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6. Isothermal Lapse Rate

- **Definition**: When the temperature remains **constant with altitude** (0°C per kilometer).
- **Significance**:
    - Indicates a neutral atmosphere.
    - Common in specific atmospheric layers, such as parts of the stratosphere.

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7. Inversion Lapse Rate

- **Definition**: When the temperature **increases with altitude** (negative lapse rate).
- **Significance**:
  - Indicates a temperature inversion, which creates stable conditions that inhibit vertical mixing.
  - Common during the night or in regions with significant cooling of the ground.