

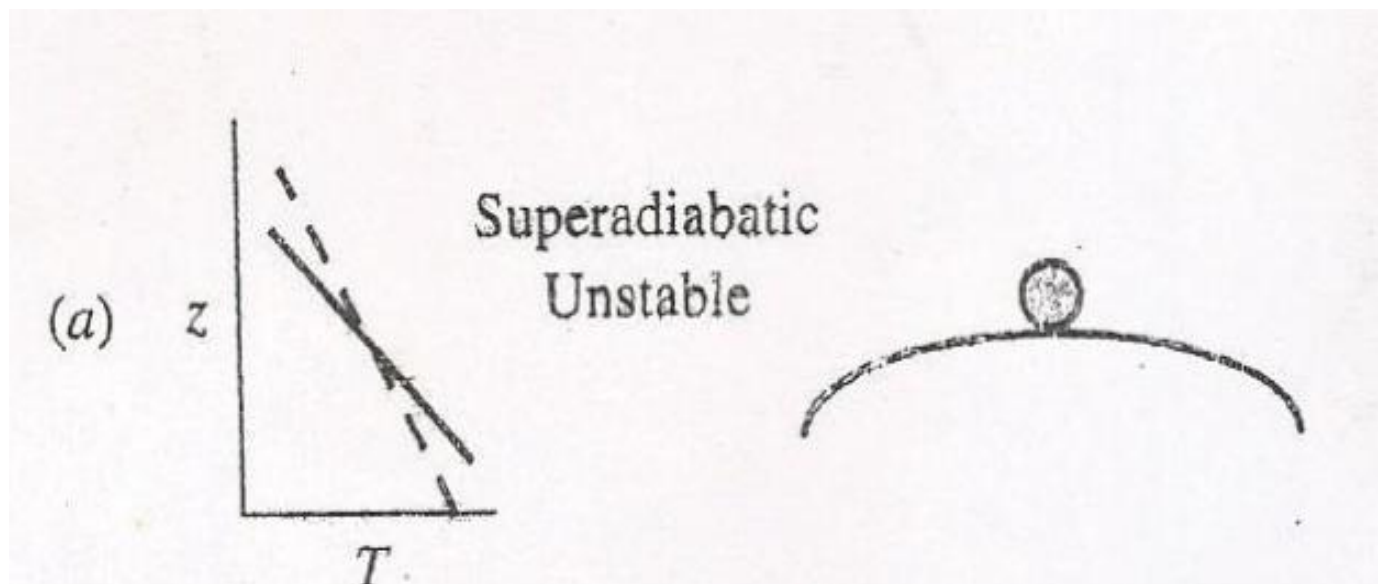
## Atmospheric Stability

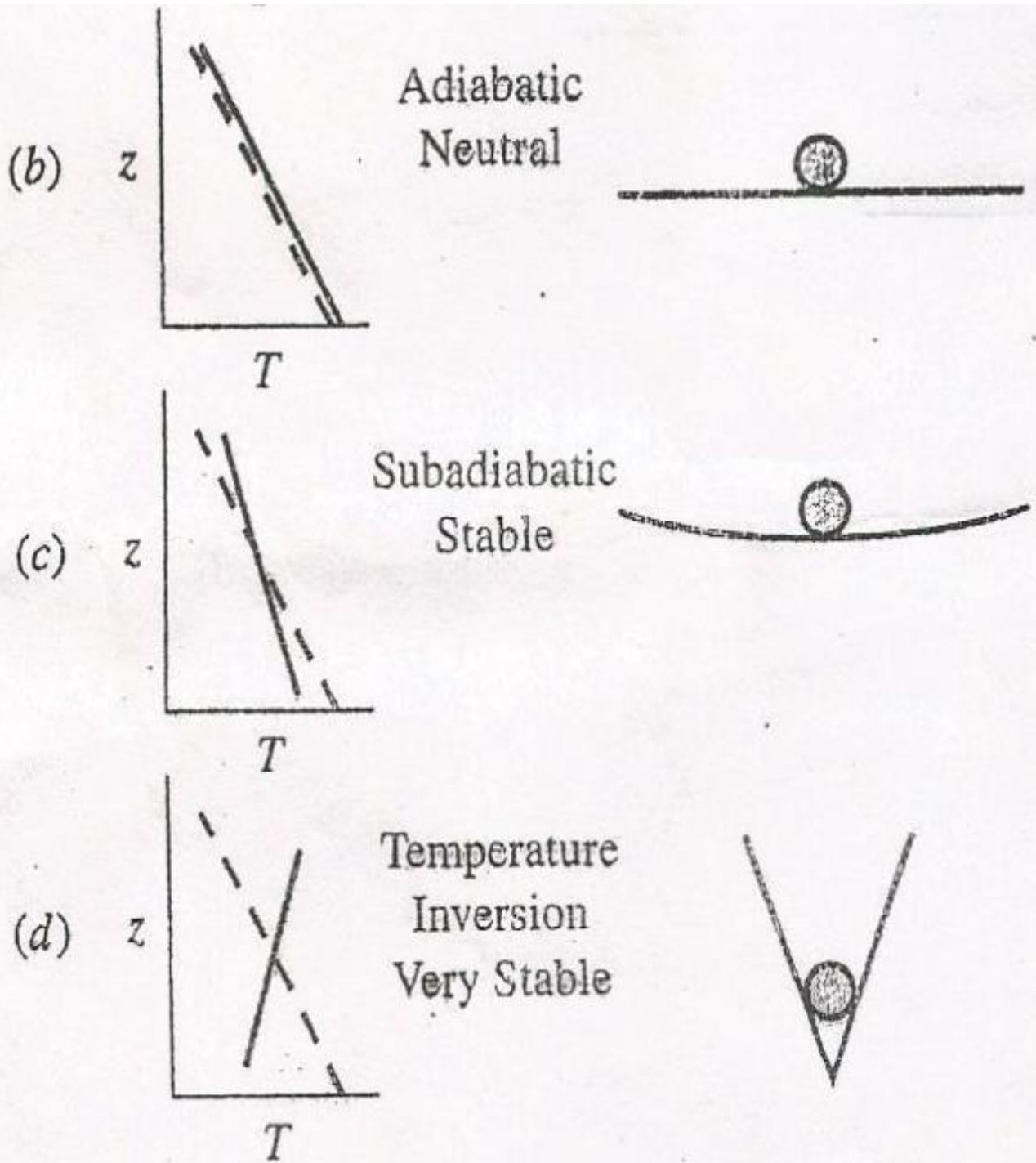
### Lapse rate:

- ✚ In well mixed air which is dry, for every 1000ft (300m) increase in altitude, the temperature decreases by about  $3.3^{\circ}\text{F}$  (about  $1.8^{\circ}\text{C}$ ).
- ✚ This vertical temperature gradient is known as the “lapse rate” and the value given is the normal lapse rate.

### Inversion:

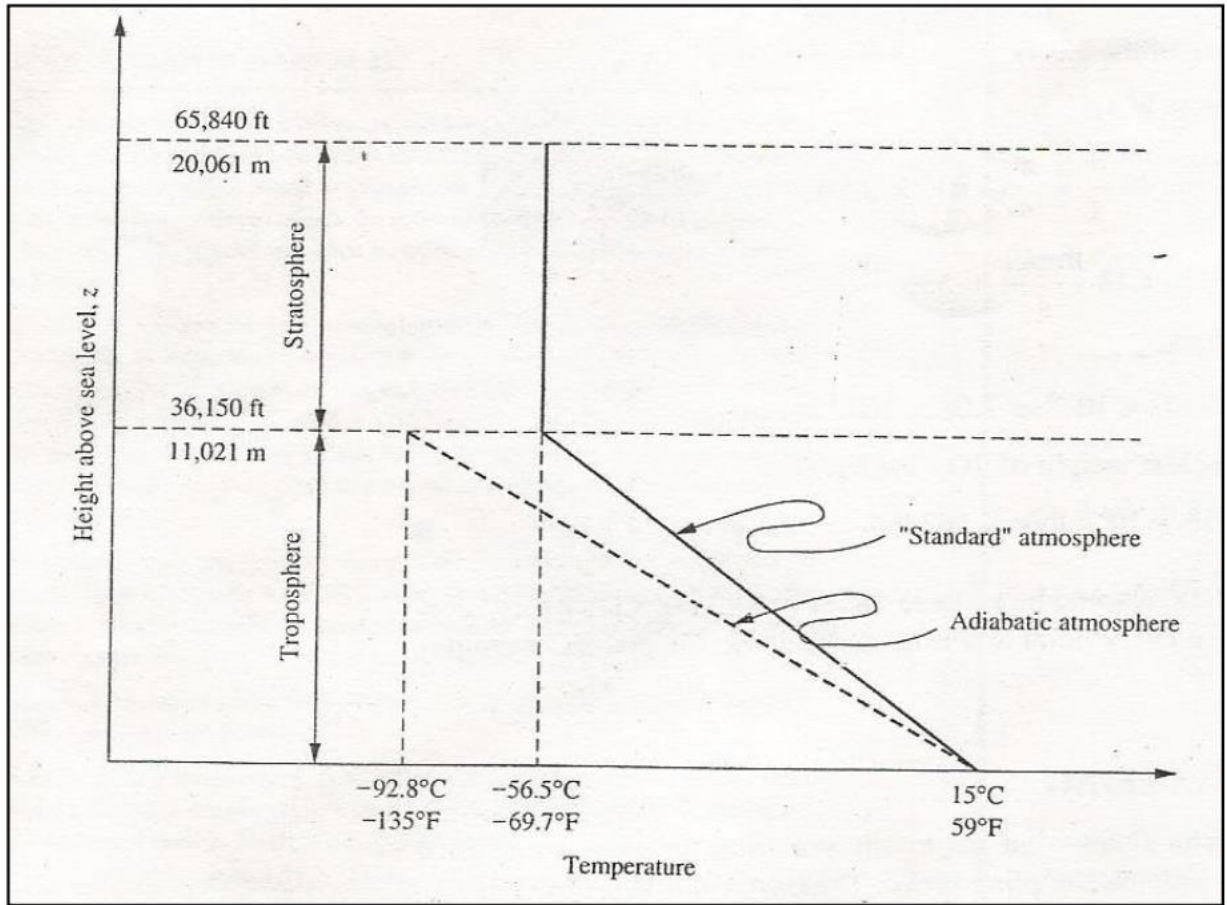
- ✚ When the reverse or negative lapse rate occurs, a dense cold stratum of air at ground level gets covered by lighter warmer air at higher level. This phenomenon is known as ‘inversion’.
- ✚ During inversion, vertical air movement is stopped and pollution will be concentrated beneath the inversion layer, i.e., in the denser air at ground level.
- ✚ As a result, during temperature inversion, the atmosphere is stable and very little turbulence or mixing takes place.
- ✚ Under such conditions, pollutants in the air do not disperse.
- ✚ Inversion is a frequent occurrence in the autumn and winter months and the accumulation of smoke and other contaminants further aggravates pollution by preventing the sun’s rays from warming the ground and the adjacent air.





Note: In all of these plots the dashed line represents the adiabatic lapse rate,  $dT/dz = -5.4^{\circ}\text{F}/1000 \text{ ft}$  ( $dz/dT = -185 \text{ ft}/^{\circ}\text{F}$ ).

**Relation between actual lapse rate, adiabatic lapse rate, and atmospheric stability**



**Comparison of the temperature elevation relations in the adiabatic atmosphere and the standard atmosphere**

- ✚ Fog is commonly associated with inversions, because the temperature of the air at ground level falls below the dew point of the water vapour in the air.
- ✚ Narrow valleys are favourable to inversions since horizontal air movement is restricted. At the time of inversions, visibility is greatly reduced and contaminants are at a maximum.

**Types of Inversion:**

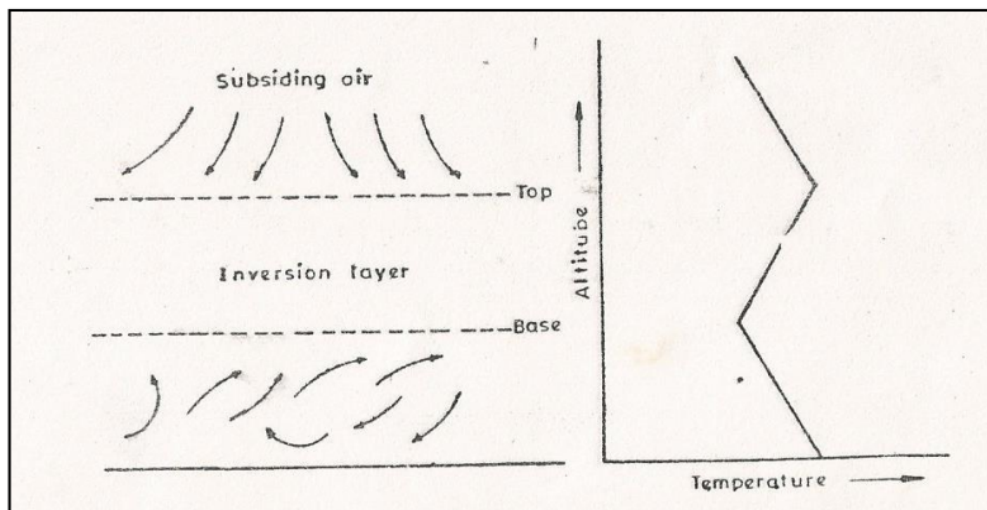
- ✓ Radiation Inversion
- ✓ Subsidence inversion
- ✓ Frontal inversion
- ✓ Advective inversion

### Radiation inversion

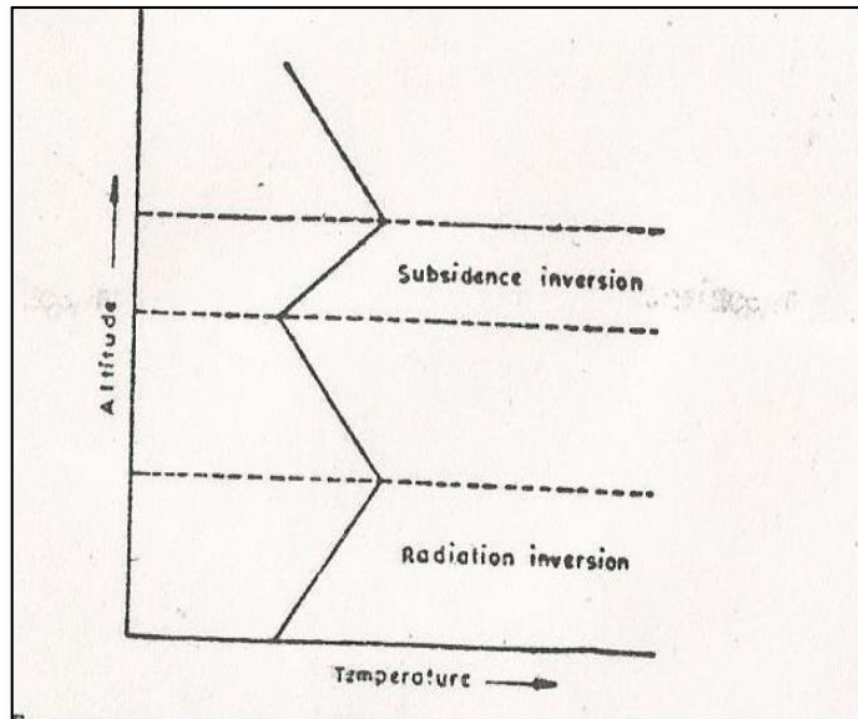
- Usually occurs at night, when the earth loses heat by radiation and cools the air in contact with it. If the air is moist and its temperature is below the dew point, fog will form. The cool air stratum is covered by warmer air, and the vertical movement is stopped until the sun warms the lower air, next morning.
- Frequently in valley areas, because of the restriction of horizontal air movement by surrounding high ground,
- In India, because of intense solar heating of the ground, inversions are broken within a few hours after sunrise.
- Simultaneous occurrence of fog or mist prolongs the duration of inversion by cutting out sunlight reaching the ground.

### Subsidence inversion

- Occurs at modest altitudes and often remains for several days.
- Caused by sinking or subsiding of air in anti-cyclones (high pressure areas surrounded by low pressure areas)
- The air circulating around the area descends slowly at the rate of about 1000m per day as the air sinks, if is compressed and gets heated to form a warm dense layer.
- This acts as a lid to prevent the upward movement of contaminants. The inversion height may vary from the ground surface to 1600m. When it drops to less than 200m, extreme pollution occurs.
- The Formation of subsidence inversion and the temperature profile is shown in Figure A. And temperature profile with subsidence and radiation inversions is shown in figure B.



**(A) Formation of subsidence inversion and the temperature profile**



**(B) Temperature profile with subsidence and radiation inversions**

Double inversion

- Sometimes both radiation inversion and subsidence inversion may occur simultaneously. Such a phenomenon is known as 'double inversion'.

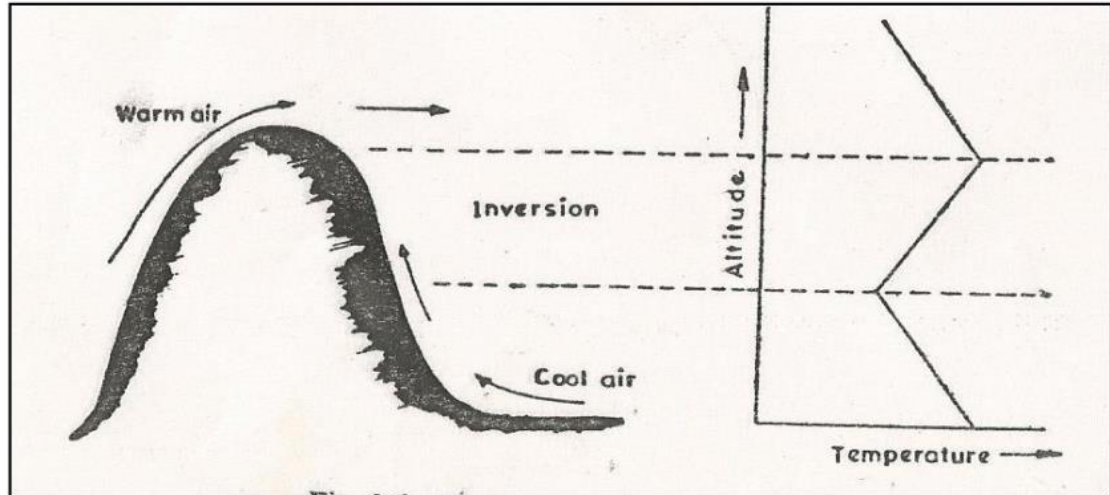
Frontal inversion

- Occurs at high altitudes and results when warm air mass overturns a cold air mass below.

Non important from a pollution control standard point.

Advection inversion

- Formed when warm air moves over a cold surface or cold air.
- The inversion can be ground-based in the former case, or elevated in the latter case.
- An example of an elevated advective inversion occurs when a hill range forces a warm land breeze to flow at high levels and a cool sea breeze flows at low level in the opposite direction. This is shown in Fig. below

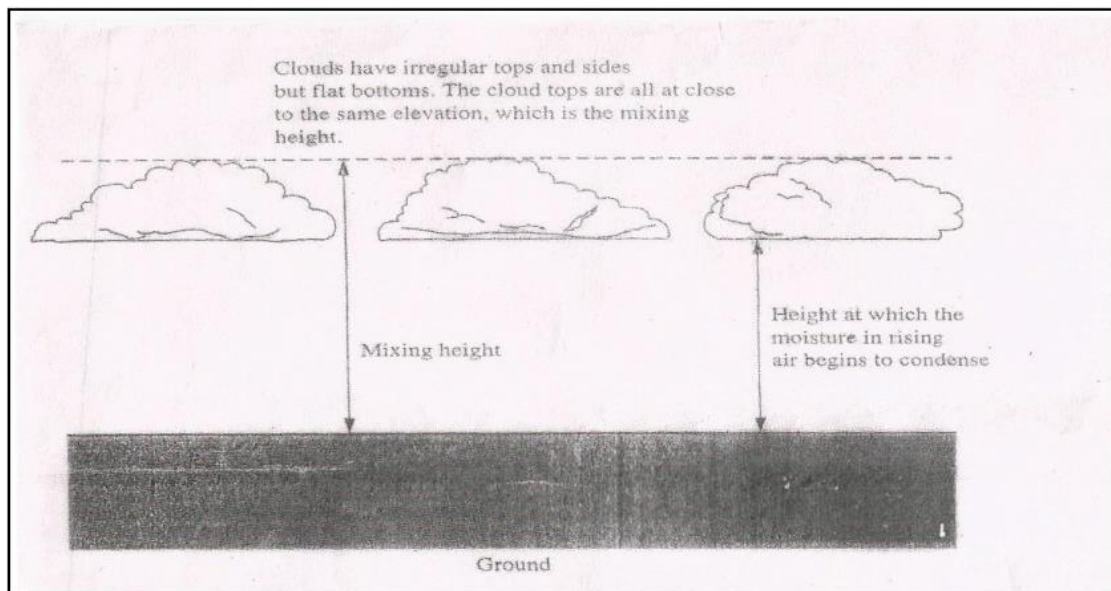


**Elevated advective inversion**

**Mixing height**

- Defined, as that height above the earth's surface to which related pollutants will extend primarily through the action of atmospheric turbulence.
- It is usually related to on or more of the three factors:
  - ✚ Wind direction
  - ✚ Wind speed
  - ✚ Wind turbulence

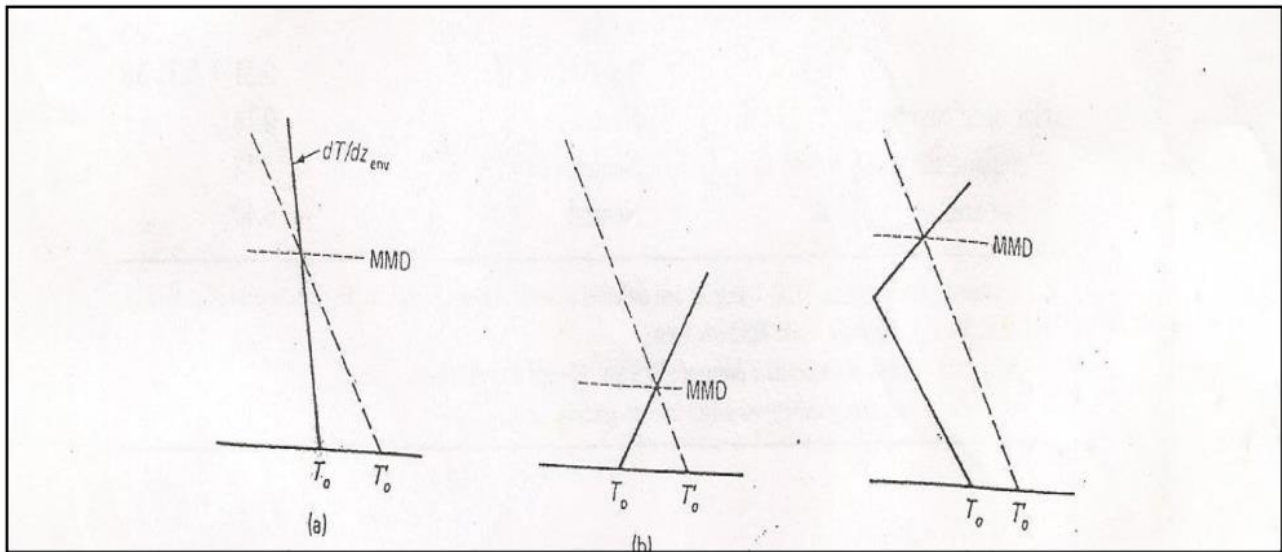
Under certain circumstances, it may be related to all three.



**During the day many small clouds with a common top elevation show the height of the mixing layer. The flat bottoms show the elevation at which condensation begins.**

Maximum mixing depth

1. Pollutants released at ground level will be mixed at mixing height not about it.
2. Maximum mixing depth defined as height to which unstable air mixes
3. Air parcel will rise till temperature is equal to local atmospheric temperature (T).
4. Values lowest at night and increases during day.
5. Value may be zero to 2000 – 3000(very severe).
6. Episode occur when value < 150.



**Establishment of the mean mixing depth (MMD) under various atmospheric conditions (adiabatic profile ....., environmental profile -----)**

- ✓ Air density changes with temperature, humidity and pressure.
- ✓ As air mass increases, ratio of temperature of air mass surface temperature decreases.
- ✓ Ratio of relative humidity of air mass to surface relative humidity increases.
- ✓ Temperature gradient (lapse rate)
- ✓ Adiabatic lapse rate (wet 6.5 C /1000m) Dry (9.8 C/1000m)
- ✓ Actual Lapse rate > Adiabatic lapse rate – Super adiabatic (unstable)
- ✓ Actual lapse rate = adiabatic lapse rate – Adiabatic (Neutral)
- ✓ Actual lapse rate < adiabatic lapse rate – sub adiabatic (stable)

### Precipitation

- ✿ Rainfall or precipitation exerts a two-fold cleansing action on the pollutants discharged into the atmosphere.
- ✿ It accelerates the deposition of particulate matter on the ground and hence its removal from the atmosphere.
- ✿ It also helps to remove the concentration of gaseous pollutants which are soluble in water.
- ✿ The washout by precipitation of air-borne radioactive wastes is a matter of particular concern.
- ✿ Precipitation can be determined by using various types of rain gauges.

### Humidity

- ✿ The moisture content of the atmosphere influences the corrosive action of the air pollutants and indicates the potentiality for fog formation in relation to the degree of air pollution.
- ✿ Of the various means by which humidity may be expressed, the relative humidity is most frequently used in air pollution studies.

### Solar Radiation

- ✿ Depending on the location, solar radiation can have a pronounced effect on the type and rate of chemical reactions in the atmosphere.
- ✿ The photochemical smog formation at Los Angeles is a typical example of the effect of solar radiation on air pollution.