L-14
Types of inversions and wind velocity profile

Air Pollution and Control

(Elective- I)

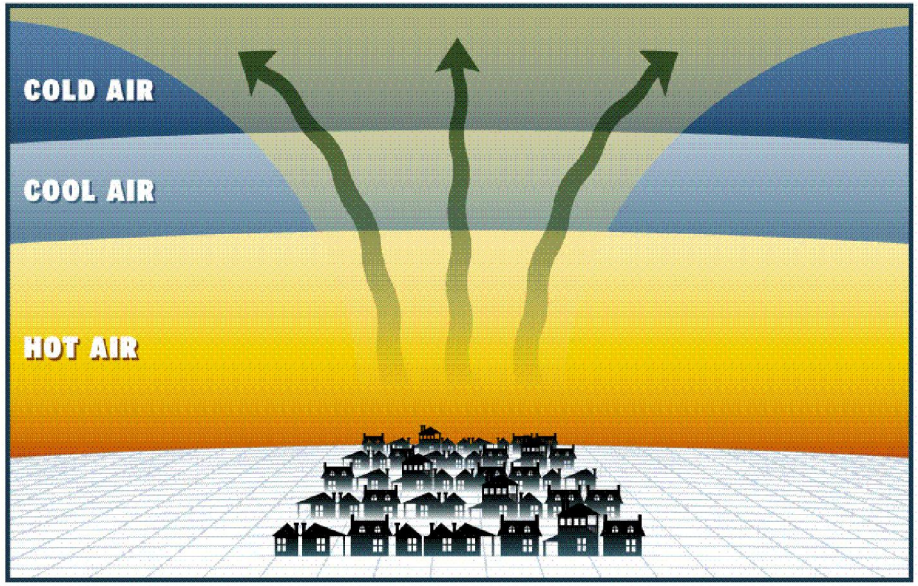
Temperature Inversion

- **A temperature inversion is when a layer of warmer air covers the colder air at ground level.**

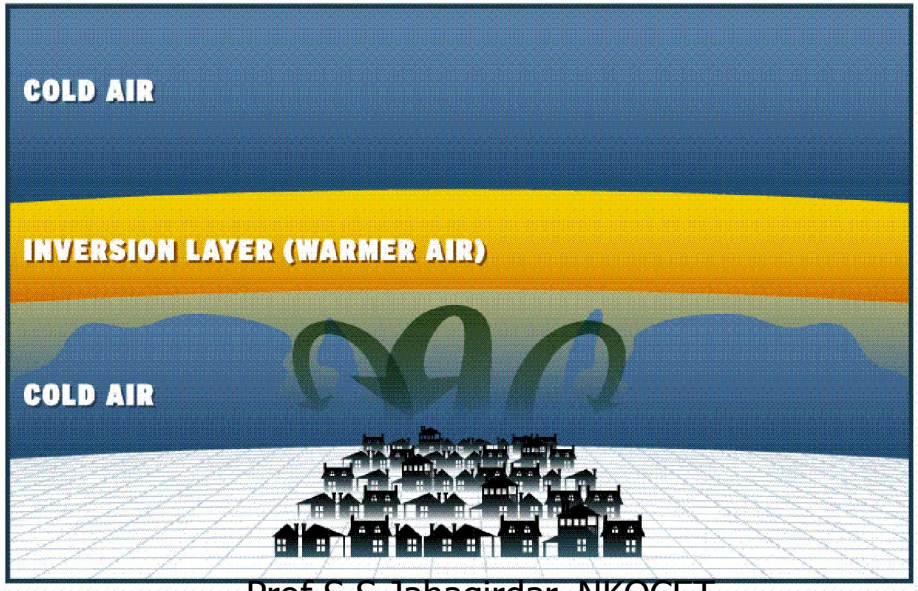
Temperature Inversion

- **It forms when the ground level air is kept cold by the cold ground.**
- **Then a warm air mass comes from another area and covers the cold air.**
- **The inversion acts like a lid over the cold ground level air**

NORMAL SITUATION



TEMPERATURE INVERSION



The Air Gets Dirty!

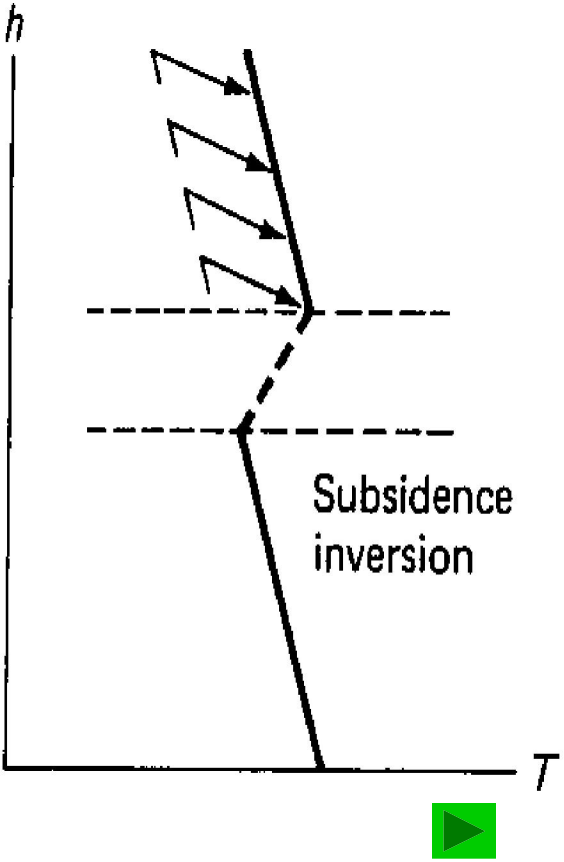
Real Dirty!

Temperature Inversion

Inversion

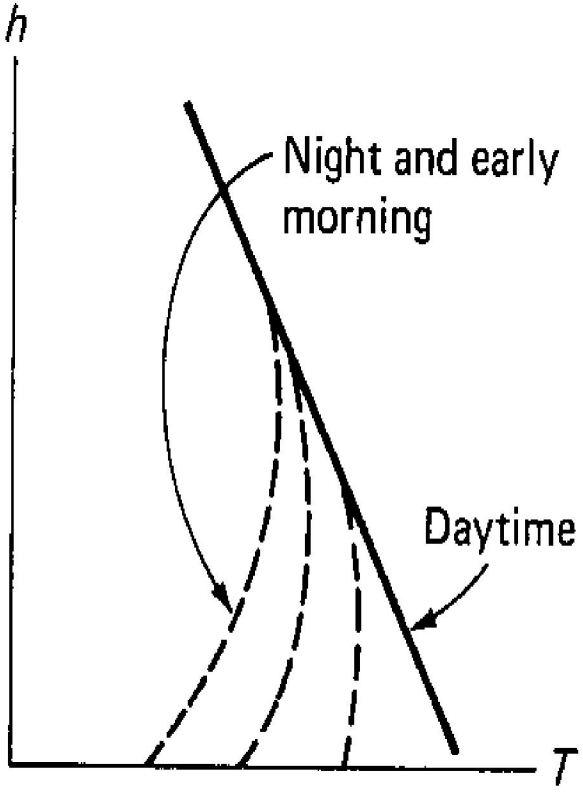
- Inversion is defined as increase in temperature with respect to altitude. It is also known as negative lapse rate.
- Two major types of inversion:
  1. **Subsidence Inversion**
  2. **Radiation Inversion**
  3. **Combination of subsidence and radiation**

1. Subsidence inversion



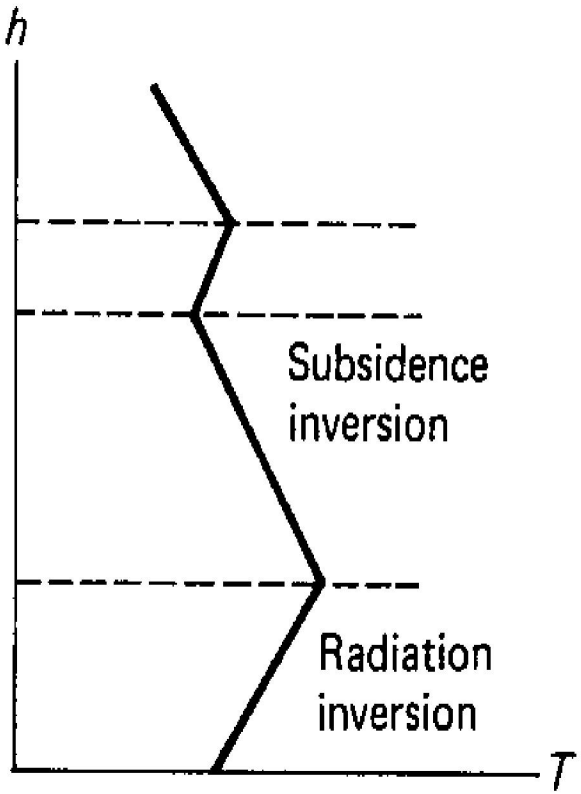
(a)

2. Radiation inversion



(b)

3. Combination of radiation and Subsidence inversion

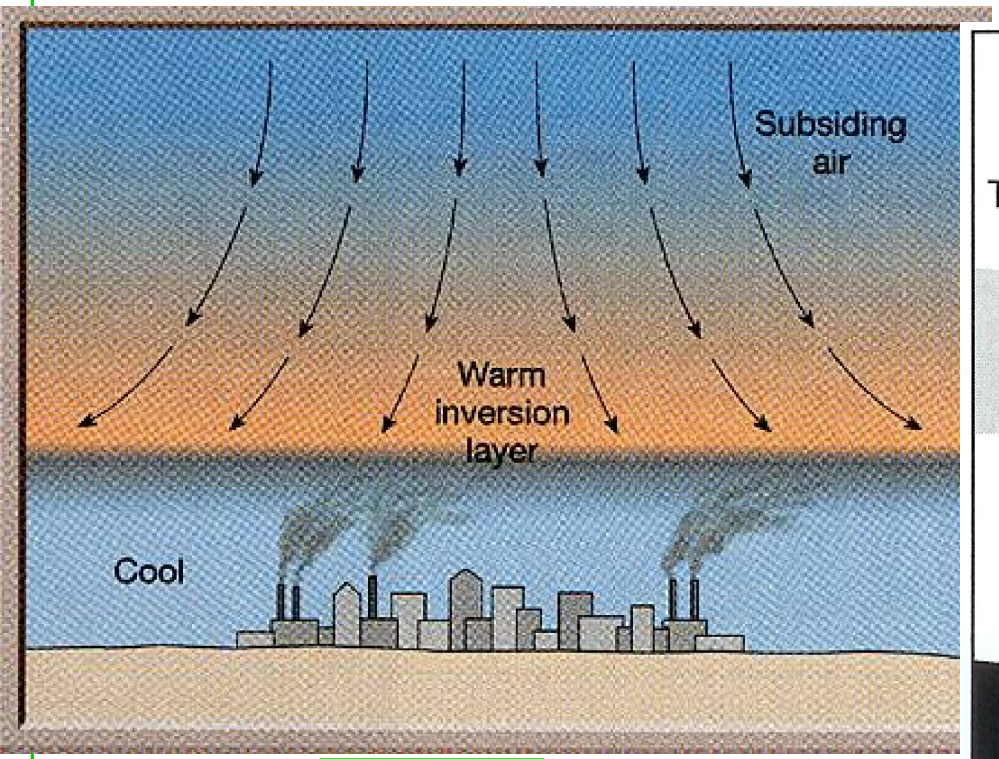


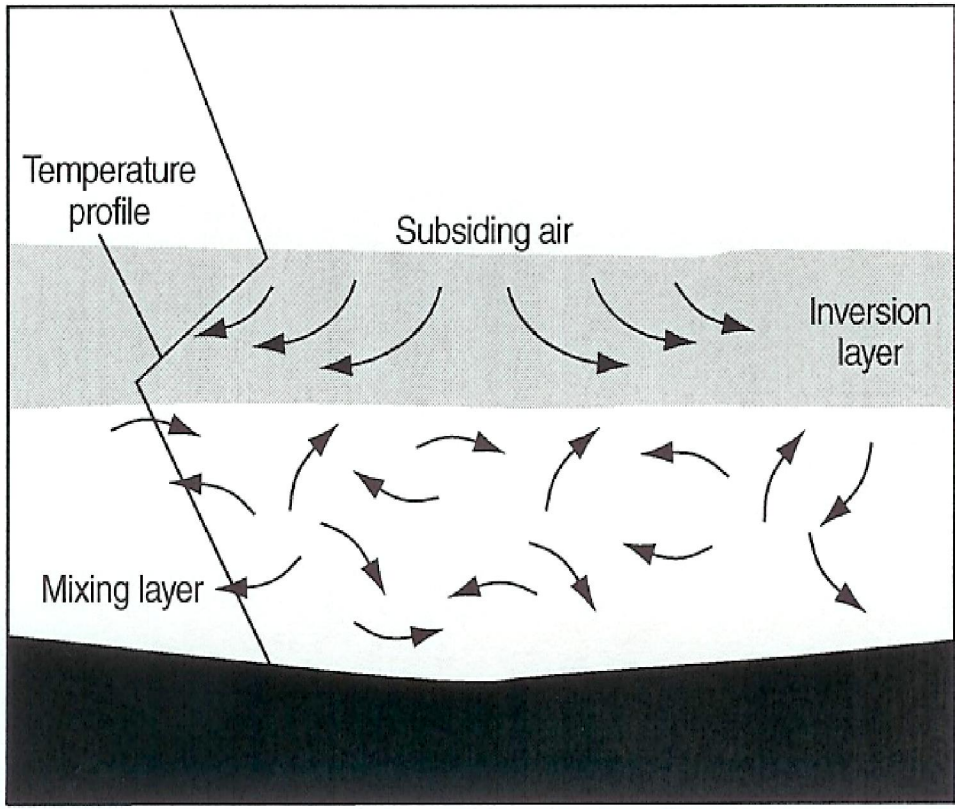
(c)

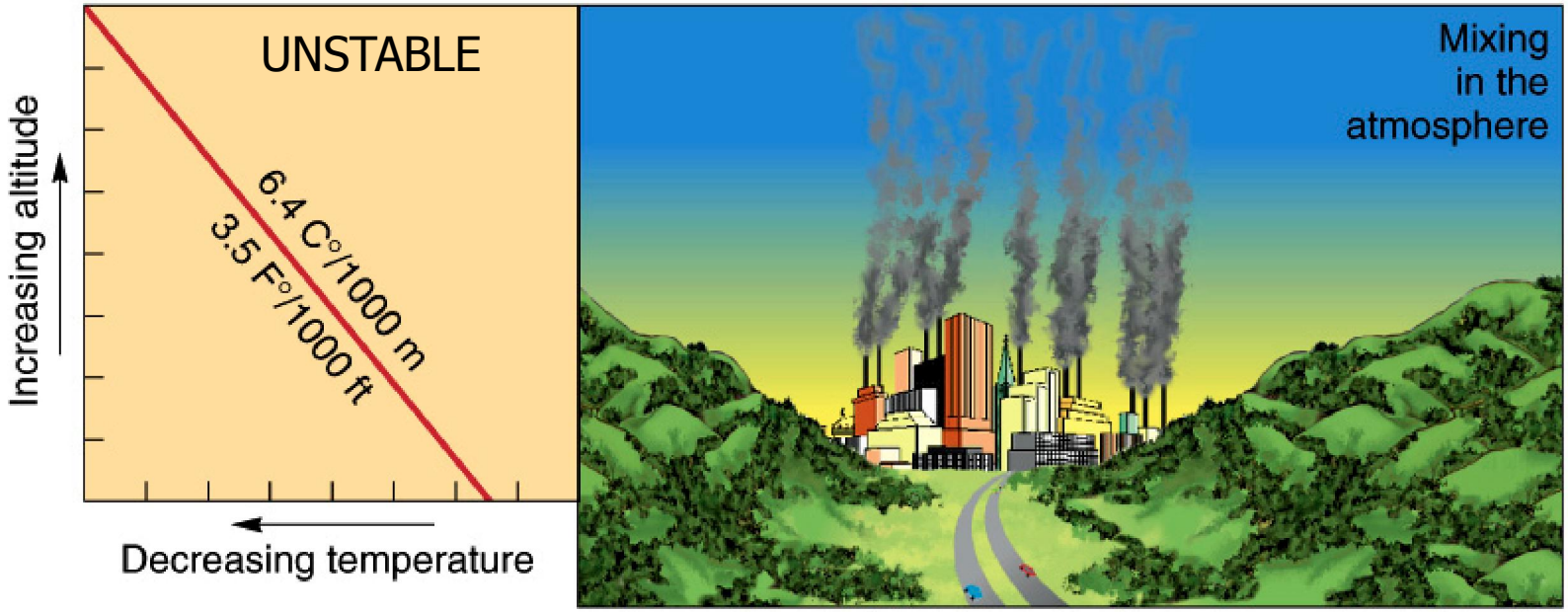
1. Subsidence Inversion

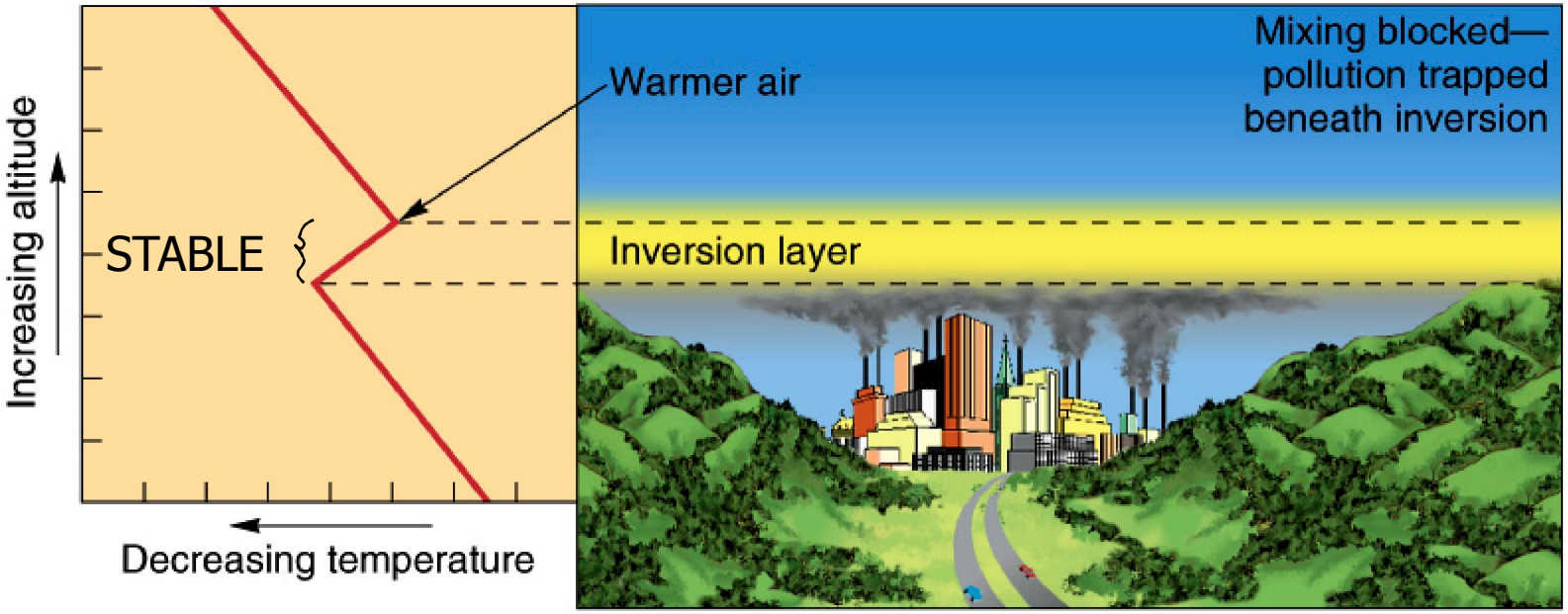
- Occurs high above emission sources.
- Associated with high-pressure systems
- Inversion layer is formed aloft
- Covers hundreds of thousands of square kms
- contribute to long term air pollution problems.
- Persists for several days and greatly contribute to long term accumulation of pollutants.
- Gets broken by strong winds at that altitude.

•Elevation of base of inversion varies from about 200m to around 1000m.



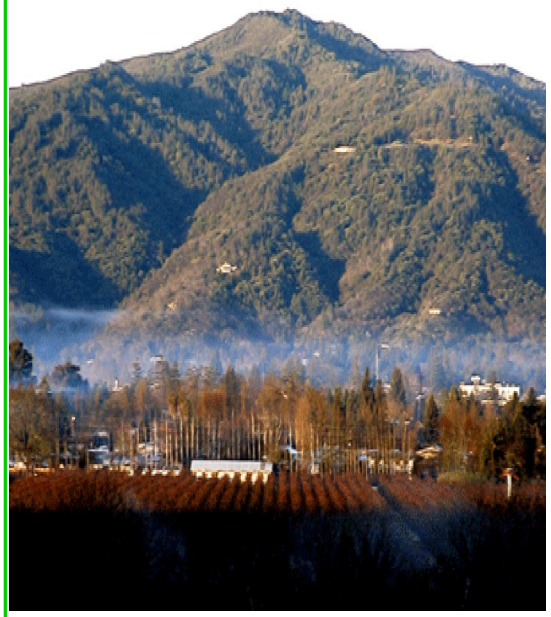


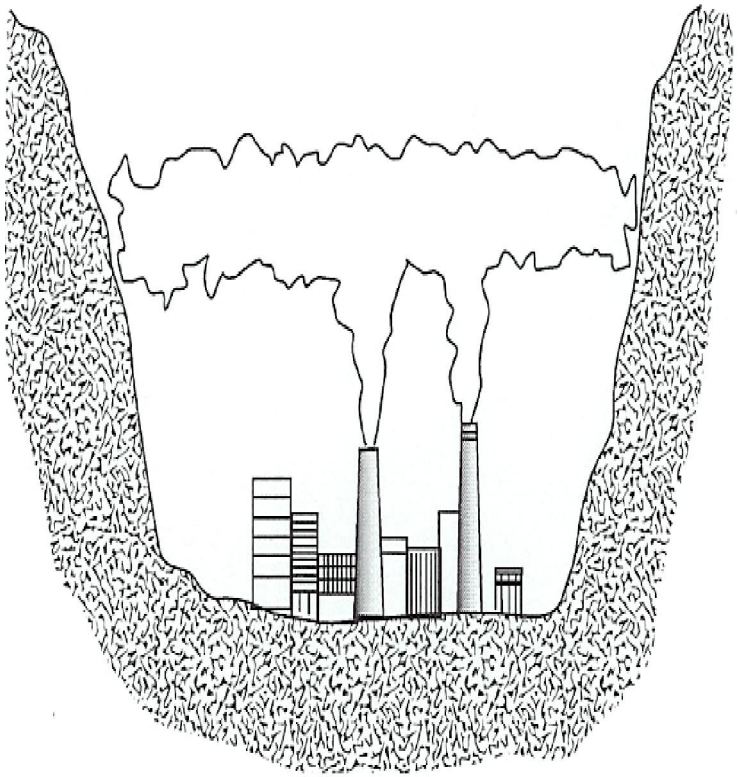

UNSTABLE
Increasing altitude
6.4 C°/1000 m
3.5 F°/1000 ft
Decreasing temperature
Mixing
in the
atmosphere

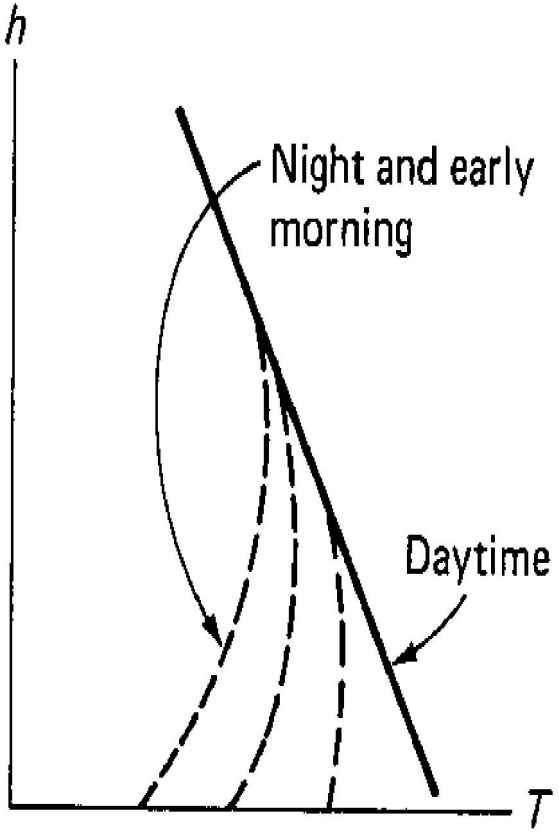

Increasing altitude
STABLE
Warmer air
Decreasing temperature
Mixing blocked—
pollution trapped
beneath inversion
Inversion layer

2. Radiation Inversions

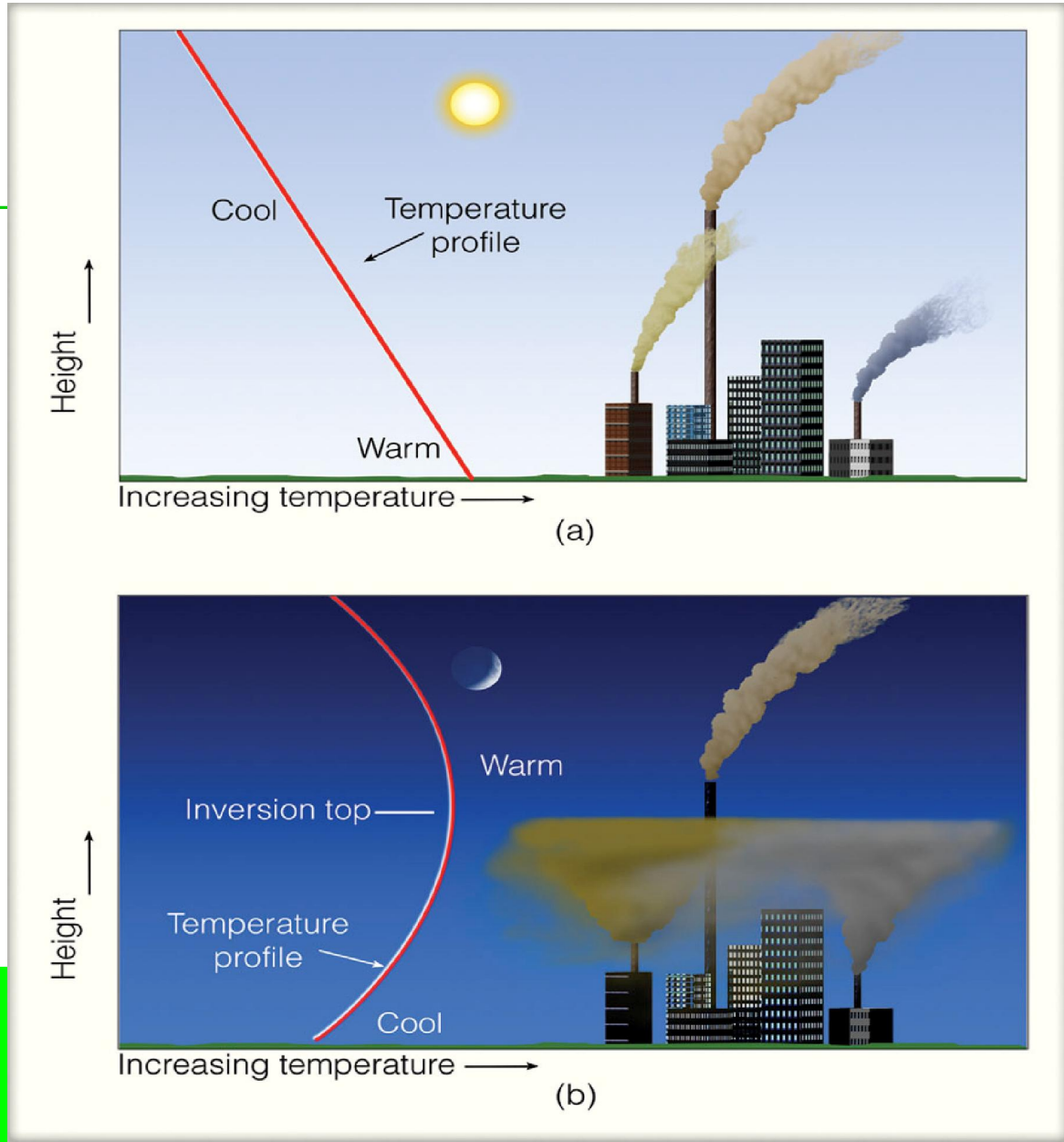
- Surface layers of the atmosphere during the day receive heat by conduction, convection and radiation from the earth's surface and are warmed.
- This results in temperature profile in the lower atmosphere that is represented by a negative lapse rate.
- These types of inversions are intensified in river valleys.
- Cause pollutants to be "trapped".






h
Night and early morning
Daytime
T

- Breakup after sunrise.
- Occurs in winter season in India.
- Most likely to occur during windless and cloudless nights.



3. Combination of radiation and Subsidence inversion

- It is possible for subsidence and radiation inversions to appear in the atmosphere at the same time.
- Joint occurrence of these two types of inversions leads to a special phenomena called **'Trapping of plume'.**

WIND VELOCITY PROFILE

Wind Velocity Profile

- Friction retards wind movement
- Friction is proportional to surface roughness
- Location and size of surface objects produce different wind velocity gradients in the vertical direction
- Area of atmosphere influenced by friction – few hundred m to several km above earth's surface

Wind Velocity Profile

- Wind speed varies by height
- International standard height for wind-speed measurements is 10 m
- Dispersion of pollutant is a function of wind speed at the height where pollution is emitted
- But difficult to develop relationship between height and wind speed

Wind

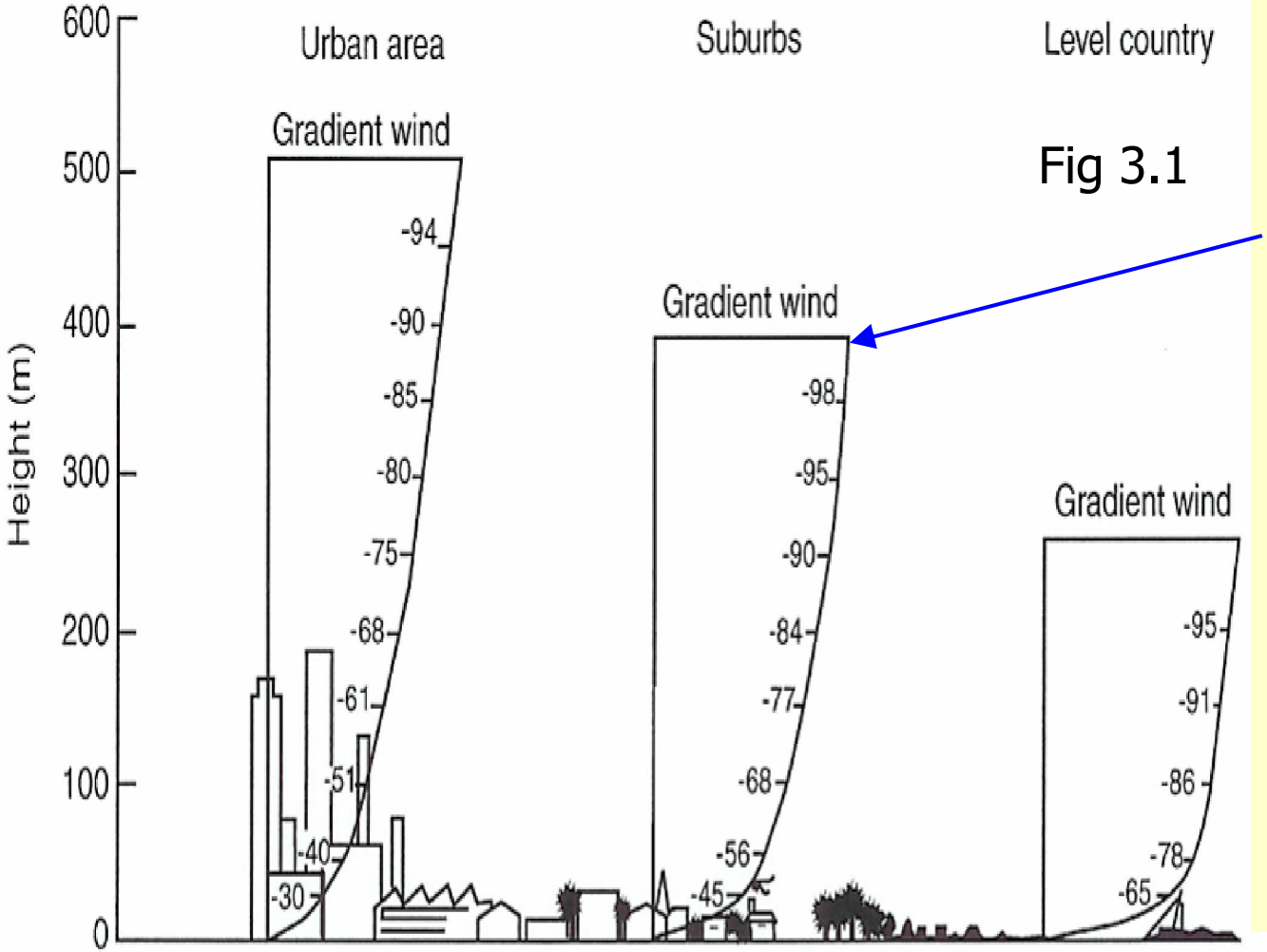


Fig 3.1

Maximum height of wind profiles indicate where effects of surface roughness end and where gradient wind begins

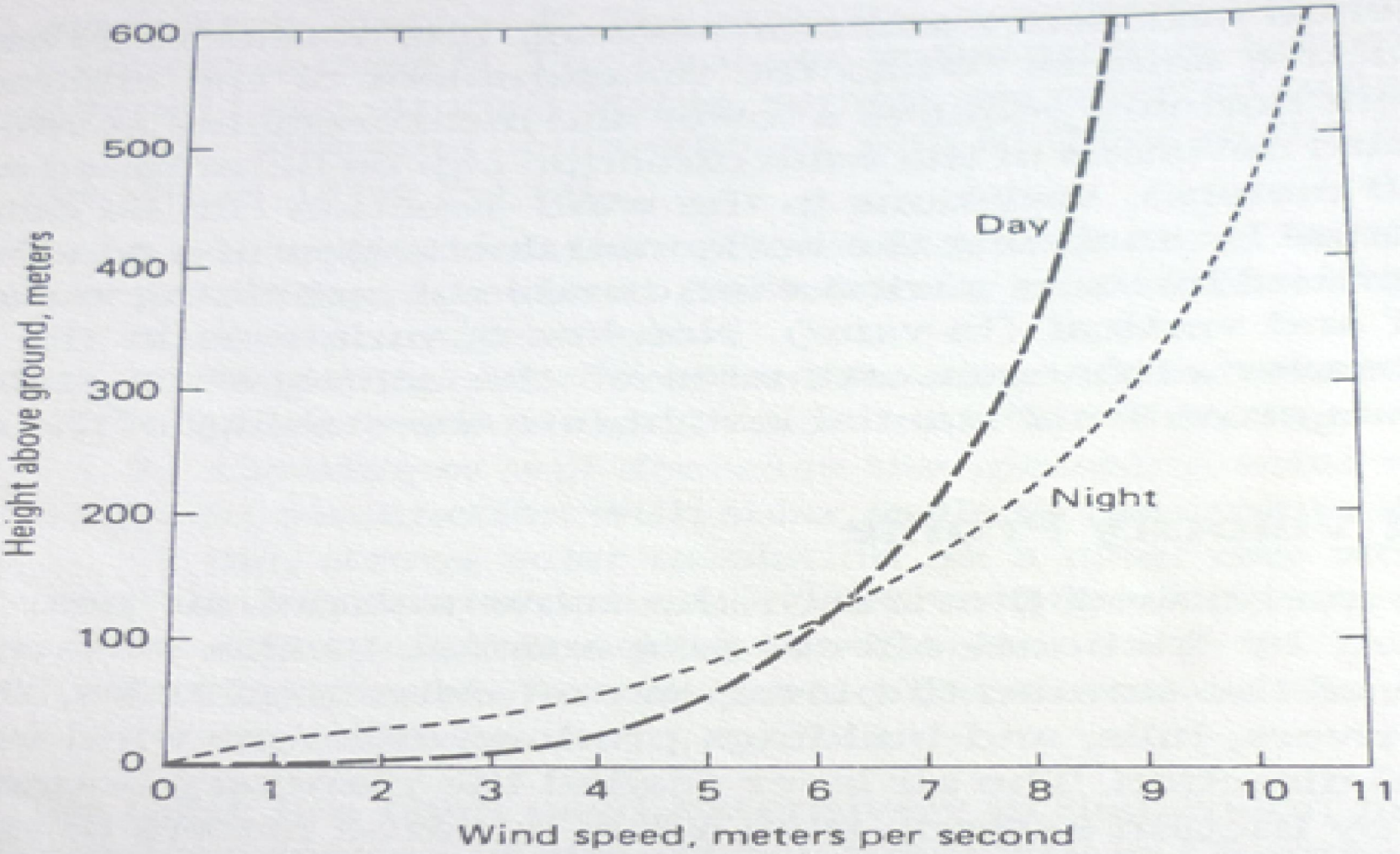
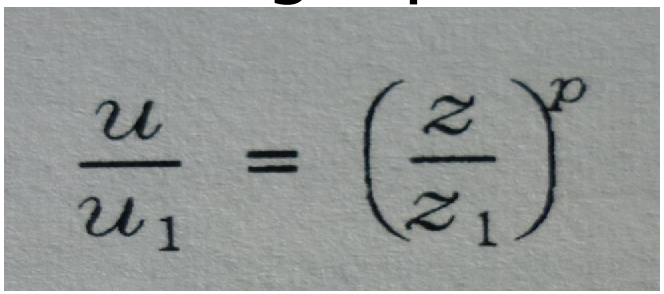


FIGURE 3-12 Change of wind-speed profile with stability. (Source: D.B. Turner. *Workbook for Atmospheric Dispersion Estimates.* Washington, D.C., HEW, 1969.)

Calculating Effective Stack Height Wind Speed: Deacons' power law

- The surface wind speed is different at the effective stack height, which is used in the Gaussian model. At elevation z1, wind speed u_1 is given by the following equation and table.



$$\frac{u}{u_1} = \left(\frac{z}{z_1}\right)^p$$

- Where:
- u = wind speed at altitude z, m/s
- z_1 = effective stack height or altitude at which wind speed is needed, m
- z= height above surface at which wind speed is measured, m (usually 10 meters)
- p = exponent is a function of atmospheric stability class

Value of p for Deacons power law irrespective of type of terrain

Table 2. Relationship between the Stability Parameter and Atmospheric stability [a]

Stability condition	p
Large lapse rate (Classes A, B, C)	0.20
Zero or small lapse rate (Class D)	0.25
Moderate inversion (Class E)	0.33
Strong inversion (Classes F and G)	0.50

[a] From Wark and Warner (1986).

Problems

1. The wind speed at 10 m altitude is 5m/s. Find the wind speed at 250 m altitude for the following stability conditions.

1. Large lapse rate
2. Zero or small lapse rate
3. Moderate inversion
4. Large inversion

2. Wind speed at 10 m altitude is 2m/s. Find the wind speed at 200 m altitude for following cases

1. Large lapse rate
2. Zero lapse rate
3. Moderate inversion
4. Large inversion

3. The ground level wind velocity at 10 m elevation is 5.2 m/sec in a city. What would you estimate the velocity to be at 125m elevation in moderately stable atmosphere?

Objective Questions

Q1. Radiation inversion gets broken by _____.

Q2. Subsidence inversion persist for _____.

Q3. As per Deacon's power law, Wind speed at any height is given by _____.

Q4. Stability class ___ refers to neutral stability condition.

Q5. _____ stability class refers to most unstable condition.

Q6. . _____ stability class refers to most stable condition.

Q7. In Deacons law value of exponent p in rough terrain, for neutral stability condition is _____. *(similar objective questions for all values).*

Q8. An _____ acts as a lid on vertical air movement.

Q9. When the earth's surface cools rapidly, such as between late night and early morning under clear skies, a _____ inversion is likely to occur.

Theory Questions

Q1. Discuss in detail three types of inversions with neat sketches.

Q2. What is power law of Deacon? What is its use?

Summer Inversion

Winter Inversion