Lecture 10

Lapse Rate and Inversion

Lapse Rate and Inversion

Lapse rate:

- The decrease in temperature with increase in altitude.
- In mixed air which is dry, for every 1000 ft increase in altitude, the temperature decreases by 3.3°F (1.8 C).

Inversion: When the reverse or negative lapse rate occurs, where the temperature increase as altitude increase, a dense cold stream of air at ground level gets covered by lighter warmer air at higher level.

- These phenomenon is known as **"Temperature Inversion"**.

Lapse Rate and Inversion

- Due to these the vertical air movement is stopped and pollution will be concentrated beneath the inversion layer.

- **So during the temperature inversion, the atmosphere is stable and very less turbulence or mixing takes place.**

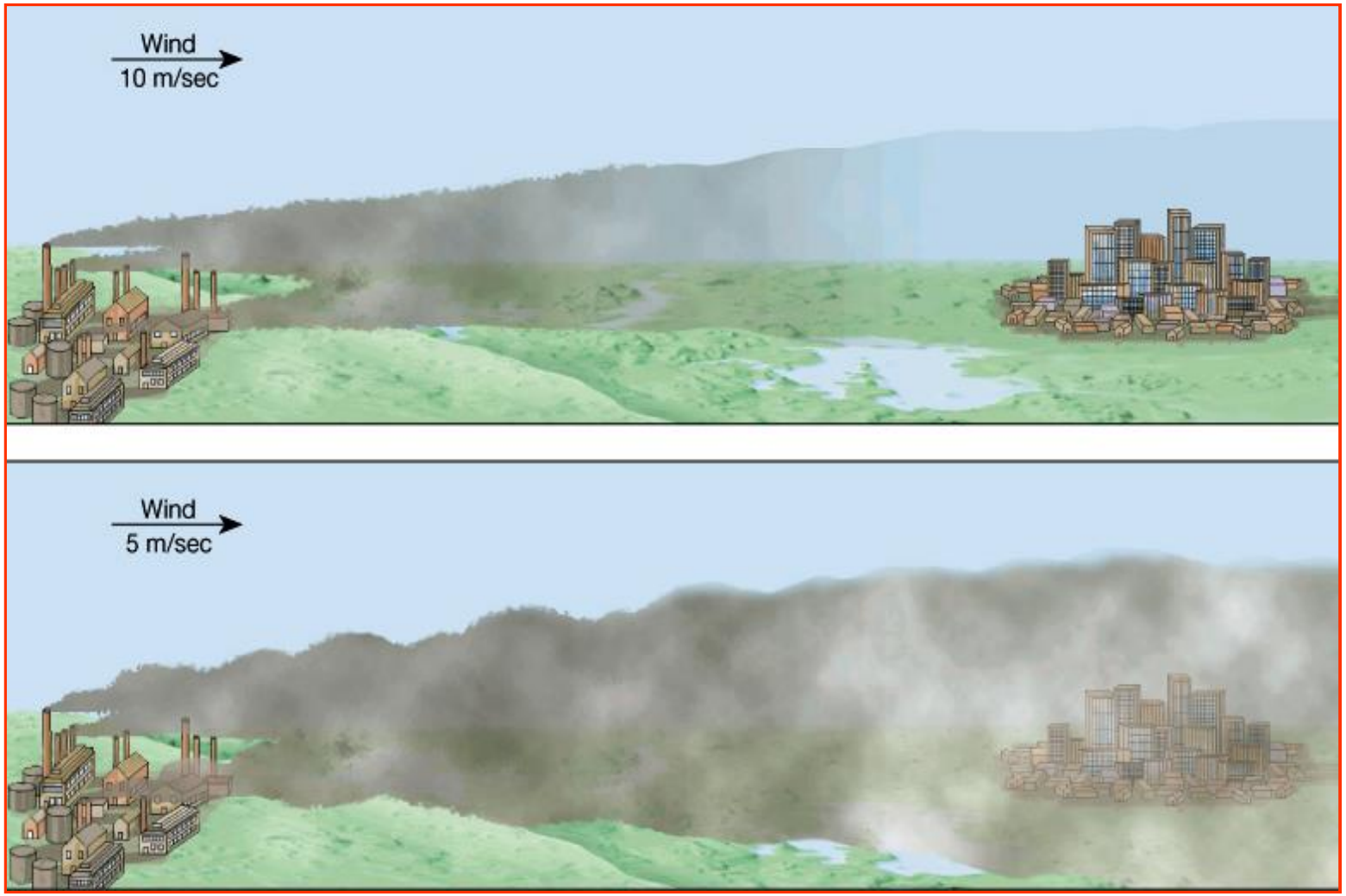
Inversions

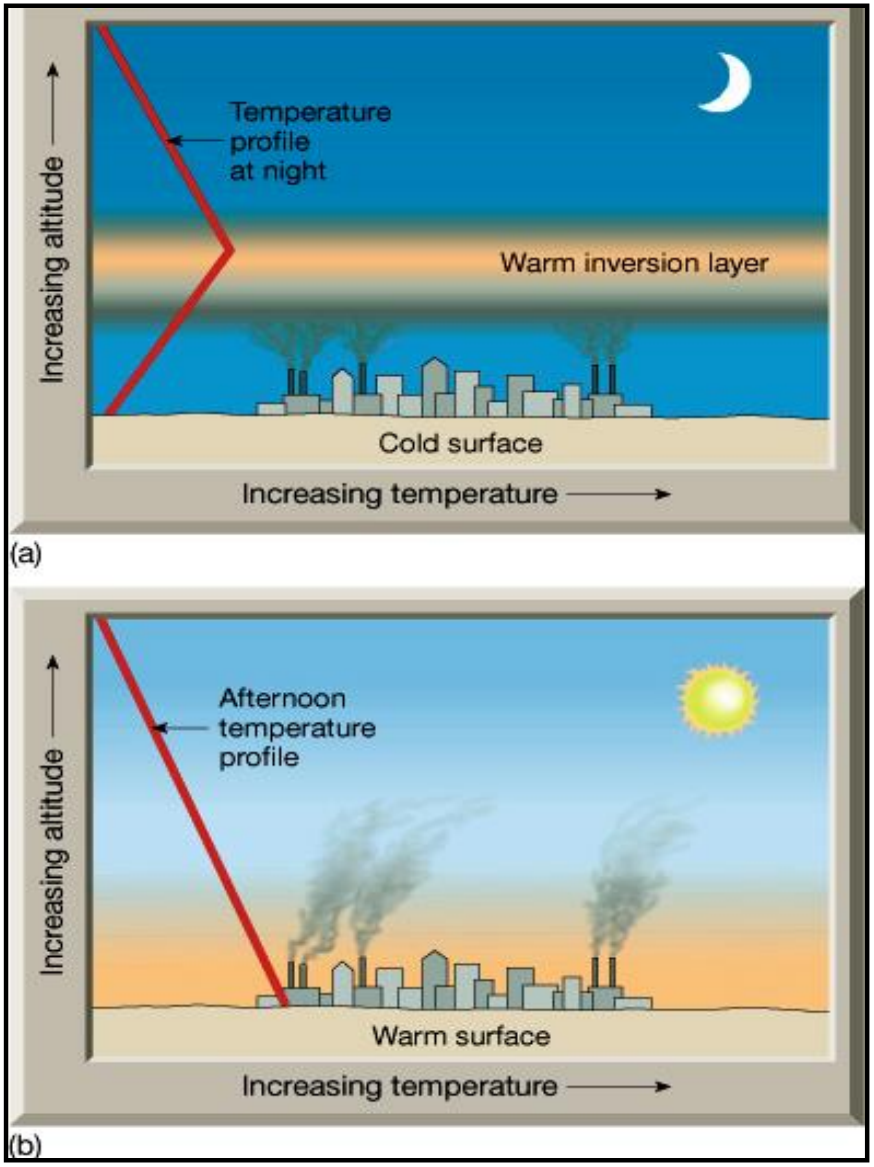
- An inversion occurs when air temperature increases with altitude. This situation occurs frequently but is generally confined to a relatively shallow layer.
- Plumes emitted into air layers that are experiencing an inversion (inverted layer) do not disperse very much as they are transported with the wind.
- Plumes that are emitted above or below an inverted layer do not penetrate that layer, rather these plumes are trapped either above or below that inverted layer.

- Atmospheric inversions influences the dispersion of the pollutants by restricting vertical mixing.
- There are several ways by which inversion layers can be formed.
  - SUBSIDENSE INVERSION
  - RADIATION INVERSION
  - ADVECTIVE INVERSION
  - FRONTAL INVERSION

- **Temperature inversions** represent a situation in which the atmosphere is very stable and the mixing depth is significantly restricted.
- When an inversion exists and winds are light, diffusion is inhibited and high pollution concentrations are to be expected in areas where pollution sources exist.
- **Surface temperature inversions** form because the ground is a more effective radiator than the air above.
- **Inversions aloft** are associated with sinking air that characterizes centers of high air pressure (anticyclones).

Inversion



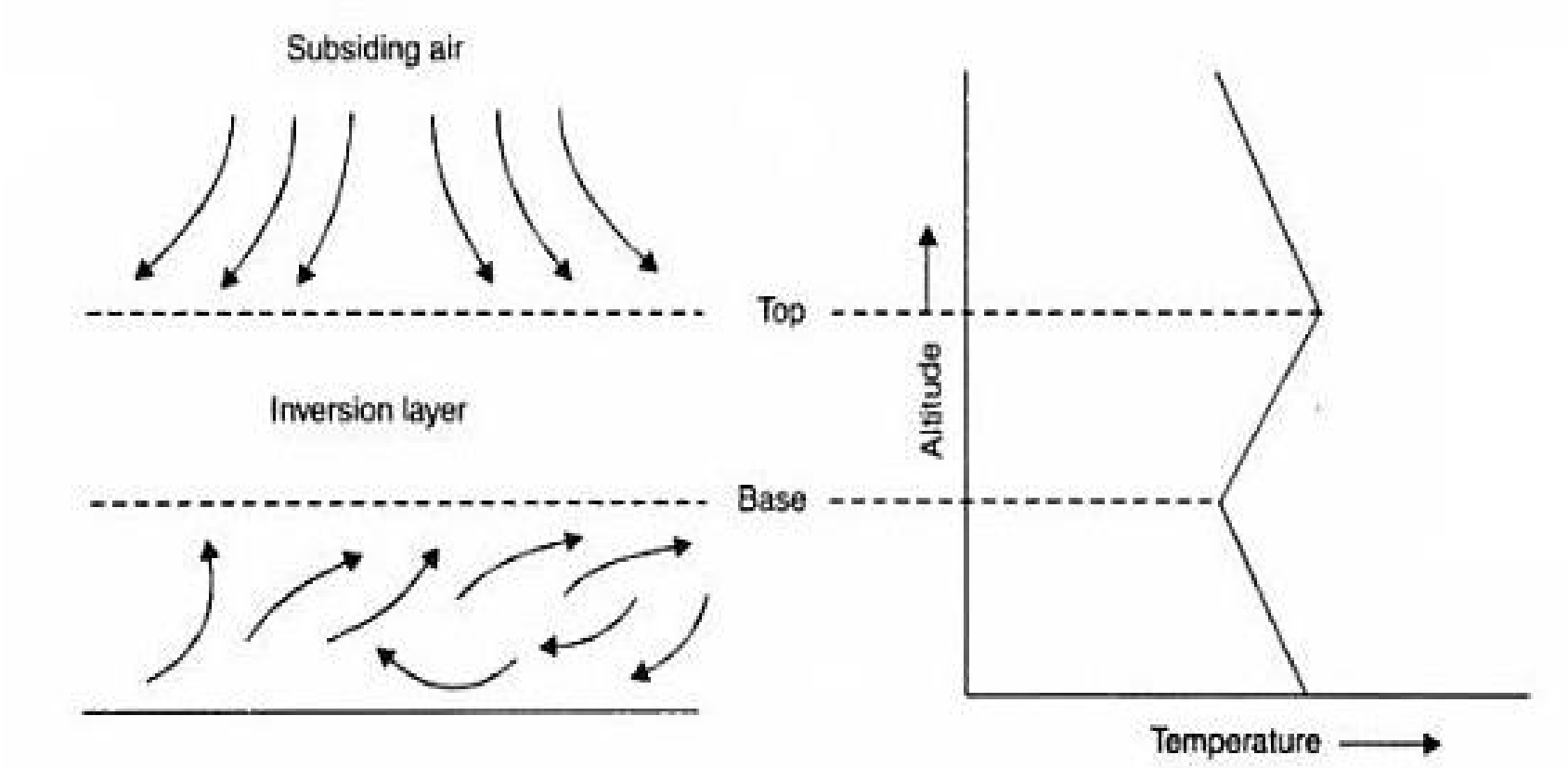


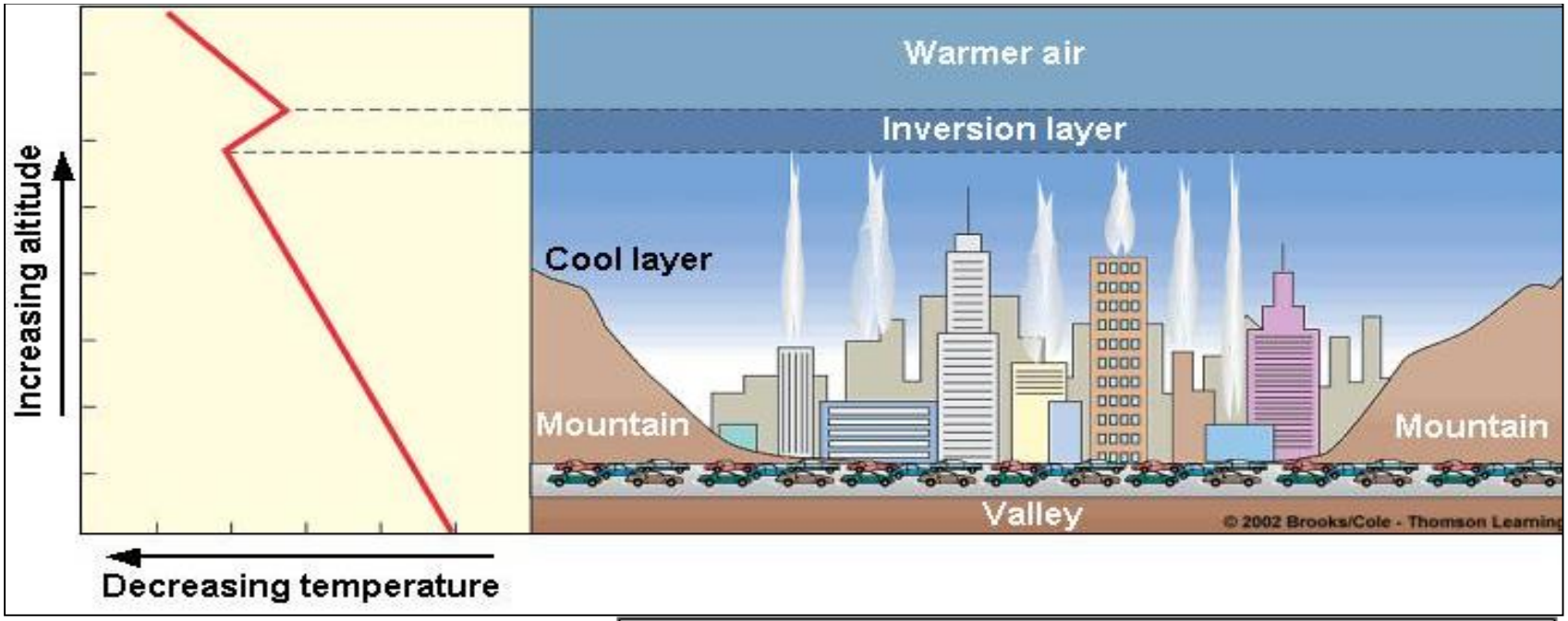
This is an example of a generalized temperature profile for a surface inversion.

Temperature-profile changes in bottom diagram after the sun has heated the surface.

Subsidence Inversion

- This is usually associated with subtropical anticyclone where the air is warmed by the compression as it descends in a high pressure system and achieves temperature higher than that of the air underneath.
- If temperature increase is sufficient, an inversion will result
- It is caused by air flowing down to replace air which has flowed out of the pressure region.
- The inversion layer thus formed is often elevated several hundred meters above the surface during the day.


Subsiding air
Top
Inversion layer
Base
Altitude
Temperature


Warmer air
Inversion layer
Cool layer
Mountain
Mountain
Valley
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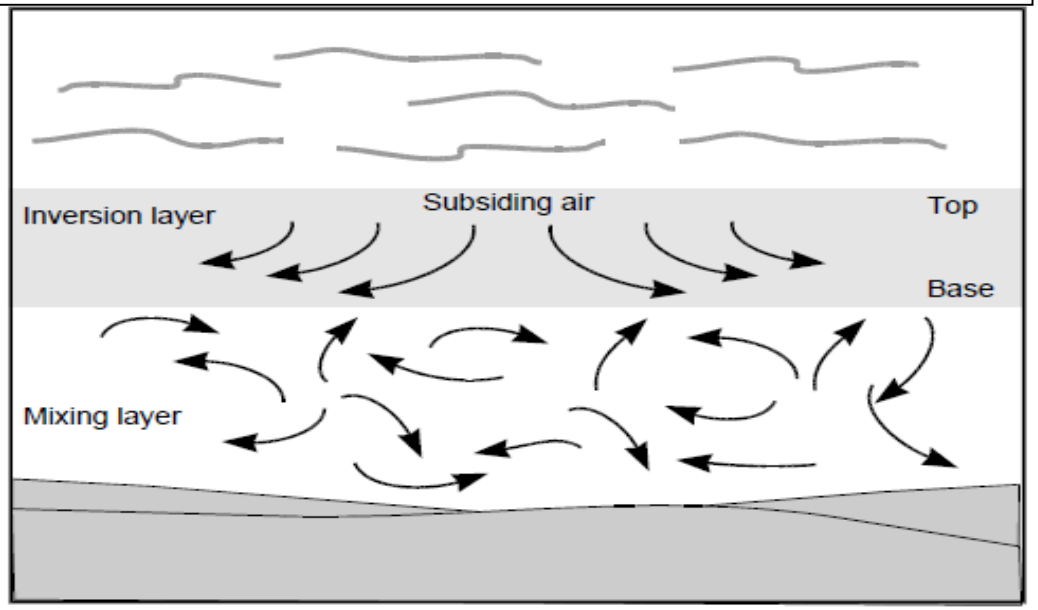
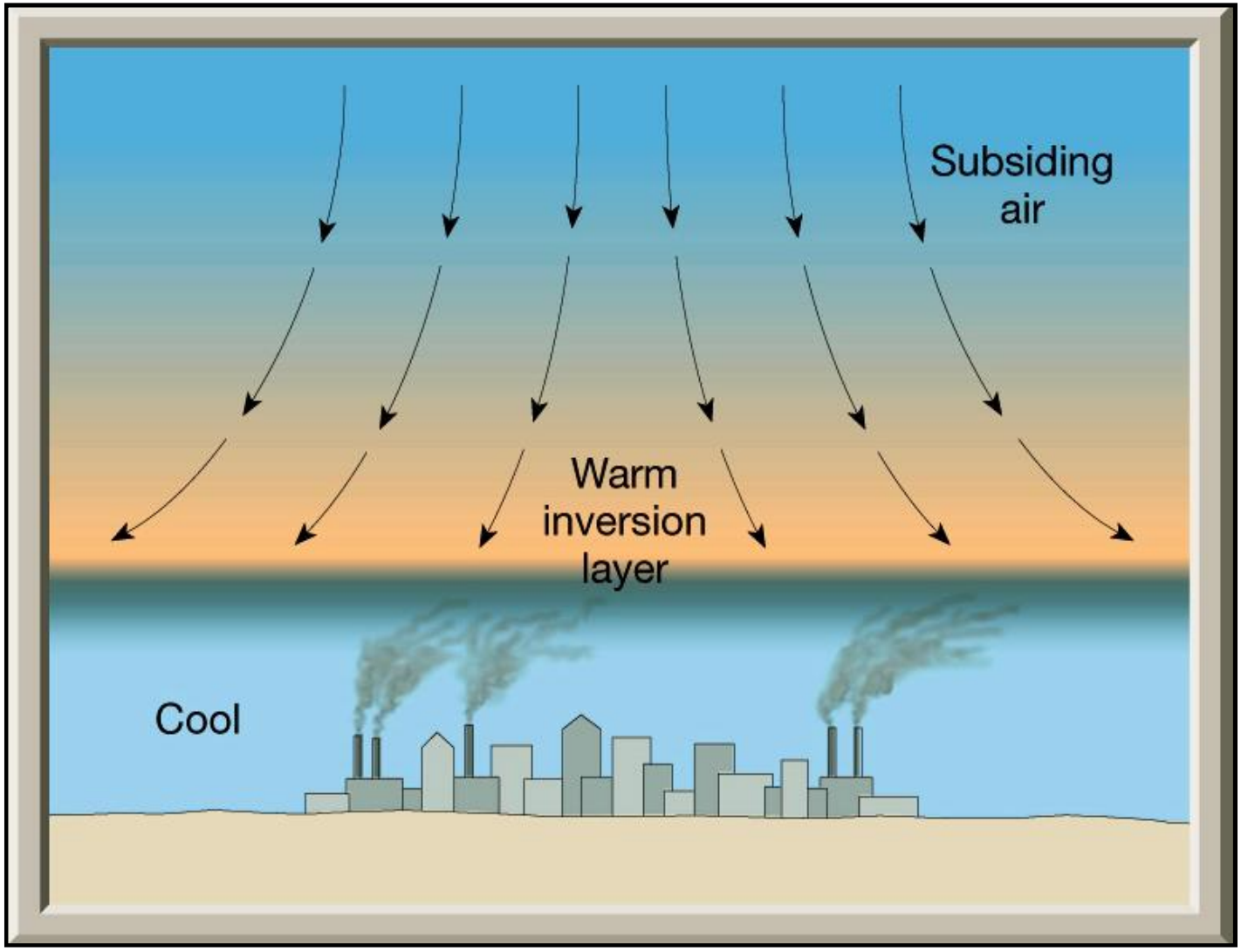
Increasing altitude
Decreasing temperature


Inversion layer
Subsiding air
Top
Base
Mixing layer

An Inversion Aloft

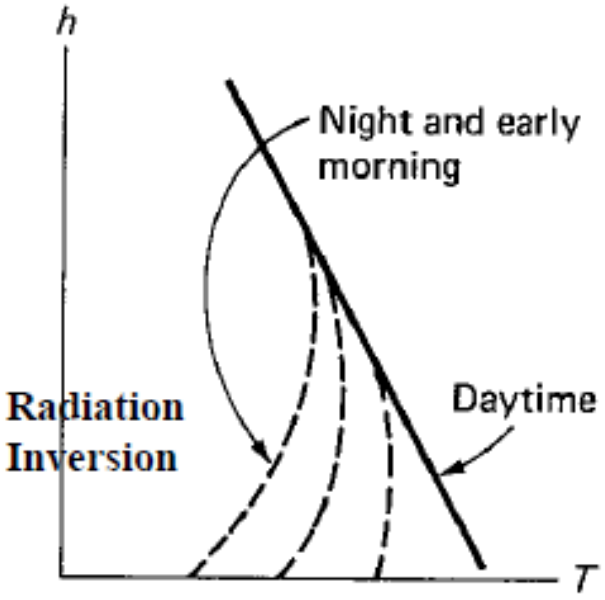


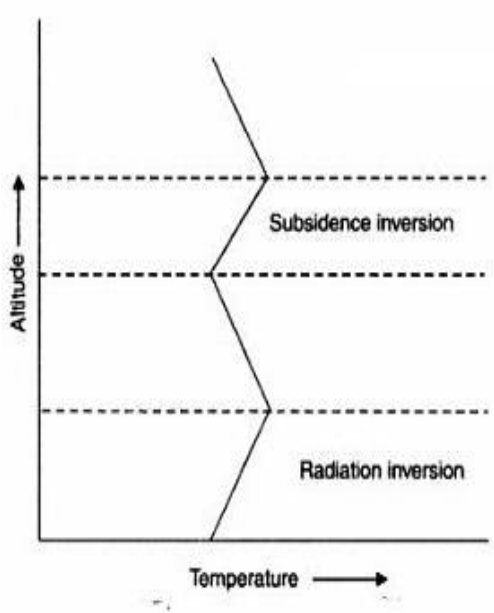
- When an anticyclone stagnates, pollutants emitted into a mixing layer cannot be diluted.
- As a result, over a period of days, pollutant concentrations may rise.
- The most severe air pollution episodes in the United States have occurred either under a stagnant migratory anticyclone (for example, New York in November, 1966 and Pennsylvania in October, 1948) or under the eastern edge of the Pacific semipermanent anticyclone (Los Angeles).

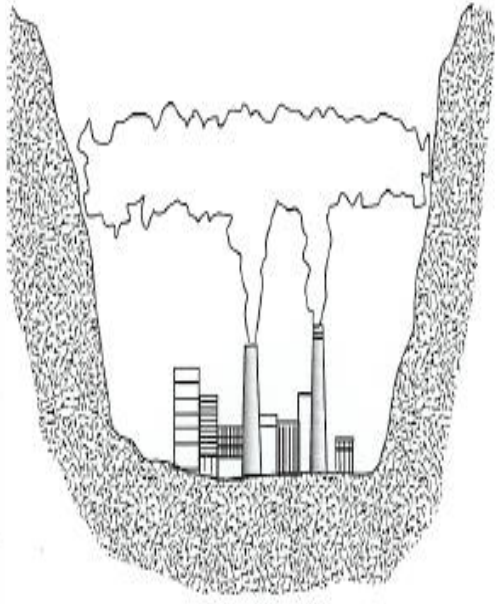
Radiational Inversion

- The **radiation inversion is the most common form of surface inversion and** occurs when the earth's surface cools rapidly.
- This results from the normal diurnal cooling cycle.
- After sunset, the ground cools quickly by radiational heat transfer and the lowest layer of air in the contact with the surface loses sensible heat through conduction and small scale mixing.
- Consequently, a temperature inversion is set up between the cool low level air and the warmer air above, in first few hundred meters above the surface.

Radiation inversions usually occur in the late evening through the early morning under clear skies with calm winds, when the cooling effect is greatest







- Valleys and low lying areas are particularly affected by this type of inversions because of denser, cold air trends to sink down beneath the warmer air.
- The next day sunlight destroys the inversion as the earth is warmed and the air previously stratified by inversion is overturned by convective currents.
- The subsidence inversion is potentially more serious than radiation inversion because later usually dissipates quite rapidly after sunrise.

- Radiation inversions are important in another context besides air pollution.
- Fruit growers in place like California have long known that their crops are in greatest danger of frost damage on winter nights when skies are clear and radiation inversion sets in.
- Since the air even a few meters up is warmer than the air at crop level, one way to help protect sensitive crops on such nights is simply to mix the air with large motor driven fans.

- In locations where radiation inversions are common and tend to be relatively close to the surface, tall stacks that emit pollutants above the inversion layer can help reduce surface-level pollutant concentrations.

Advective Inversion

- Advection inversions are associated with the horizontal flow of warm air.
- Is formed when warm air moves over a cold surface or cold air.
- conduction and convection cools the air closest to the surface, causing a surface-based inversion
- The inversion can be ground based in the former case, or elevated in the later case. An example of a warm land breeze to flow at high levels in the opposite direction.