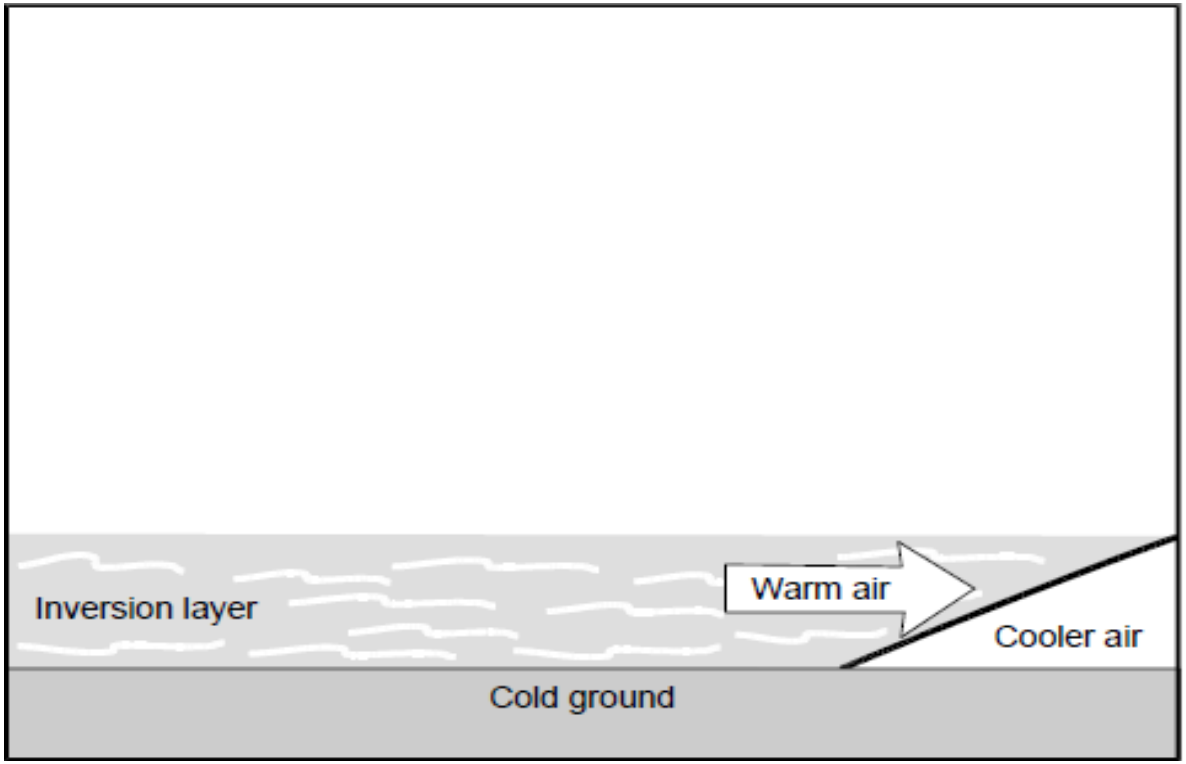
Lecture 11

Lapse Rate and Inversion

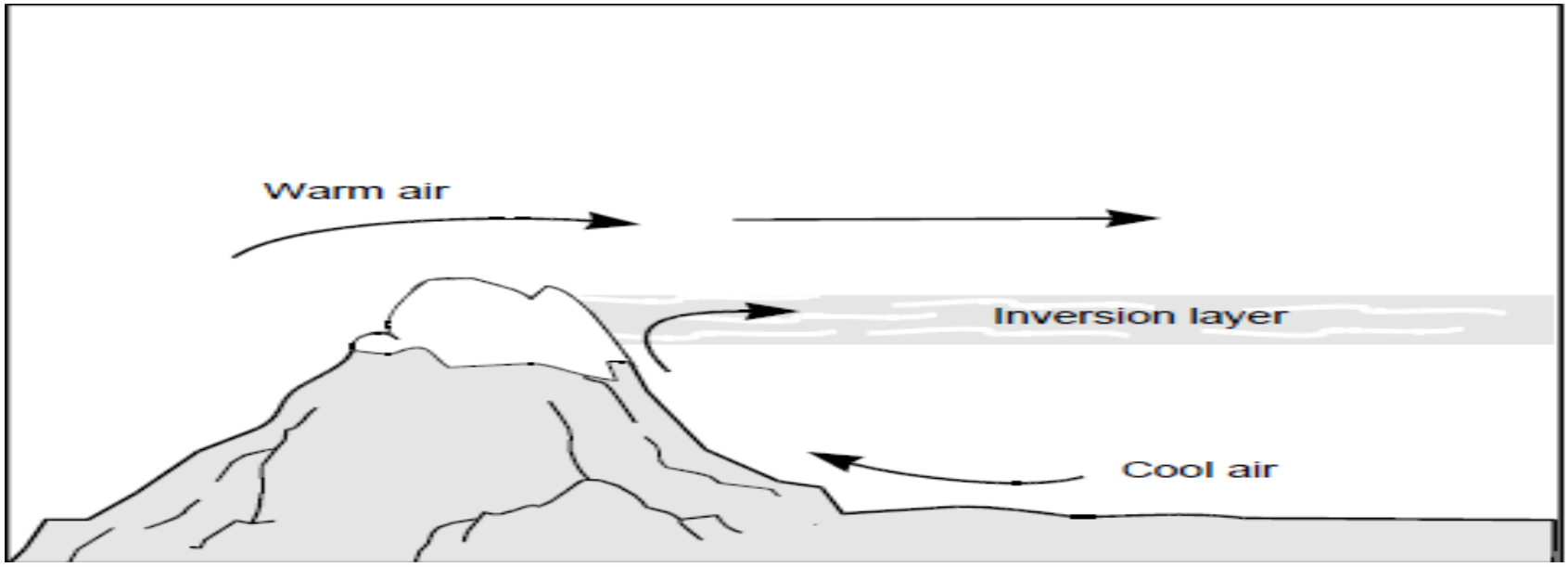
Advective Inversion

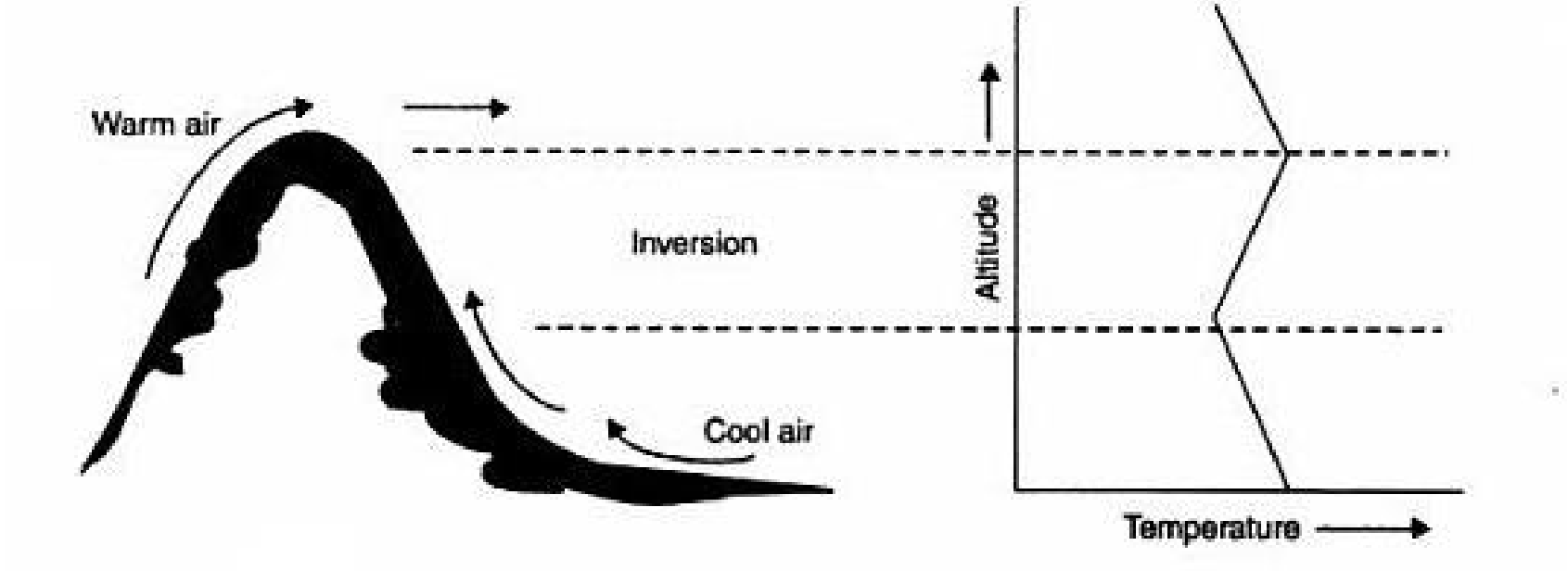
- Advection inversions are associated with the horizontal flow of warm air.
- Is formed when warm air moves over a cold surface or cold air.
- conduction and convection cools the air closest to the surface, causing a surface-based inversion
- The inversion can be ground based in the former case, or elevated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

- This inversion is most likely to occur in winter when warm air passes over snow cover or extremely cold land.



- Another type of advection inversion develops when warm air is forced over the top of a cooler air layer.
- This kind of inversion is common on the eastern slopes of mountain ranges, where warm air from the west overrides cooler air on the eastern side of the mountains.
- Denver often experiences such inversions. Both kinds of advection inversions are vertically stable but may have strong winds under the inversion layer.

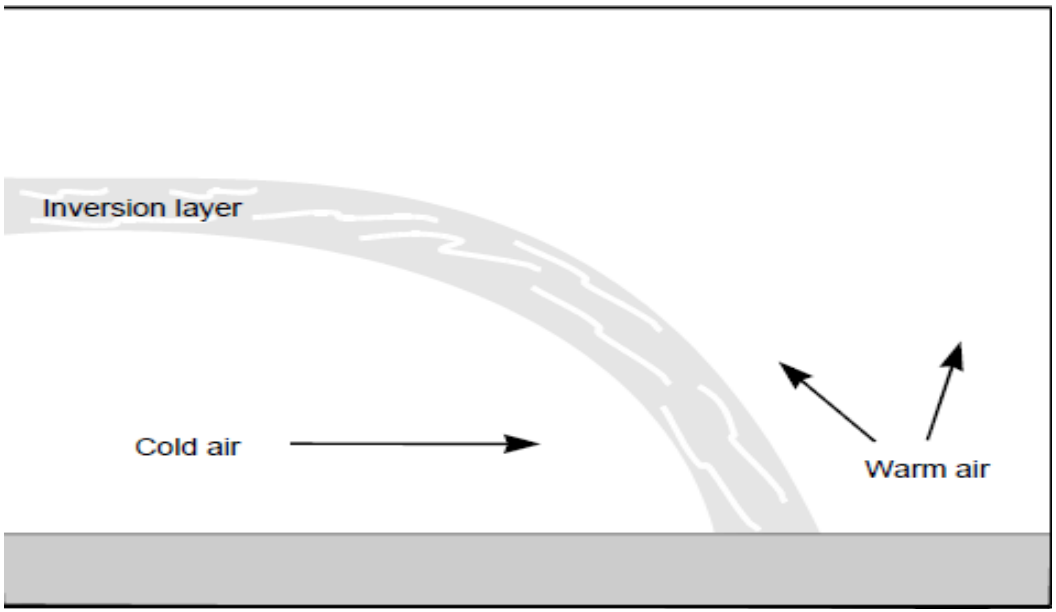

Warm air
Inversion layer
Cool air


Warm air
Inversion
Cool air
Altitude
Temperature

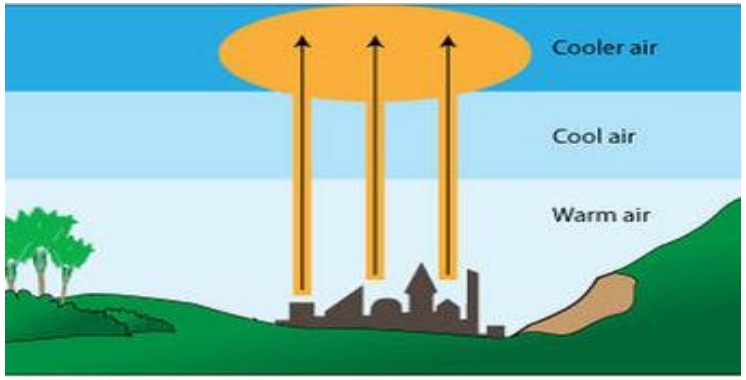
Frontal Inversion

- frontal trapping, the inversion that is usually associated with both cold and warm fronts.
- At the leading edge of either front, the warm air overrides the cold, so that little vertical motion occurs in the cold air layer closest to the surface.
- The strength of the inversion depends on the temperature difference between the two air masses.

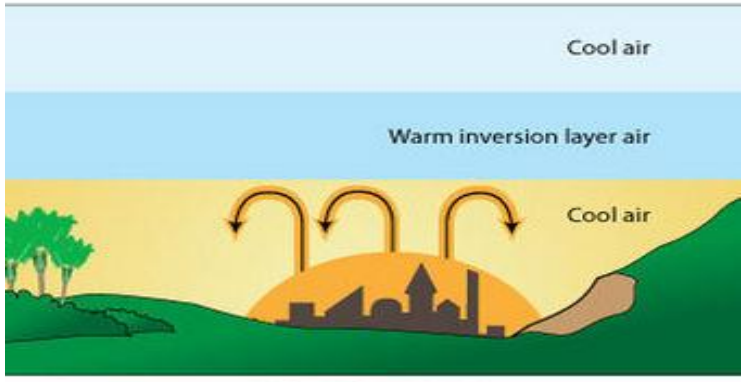
- Because fronts are moving horizontally, the effects of the inversion are usually short-lived, and the lack of vertical motion is often compensated by the winds associated with the frontal passage.



Temperature Inversion



Normal pattern



Thermal inversion

In normal condition the temperature decrease at rate of 6.4 ^{0}C per kilometer.

At normal cycle there is unstable air mass.

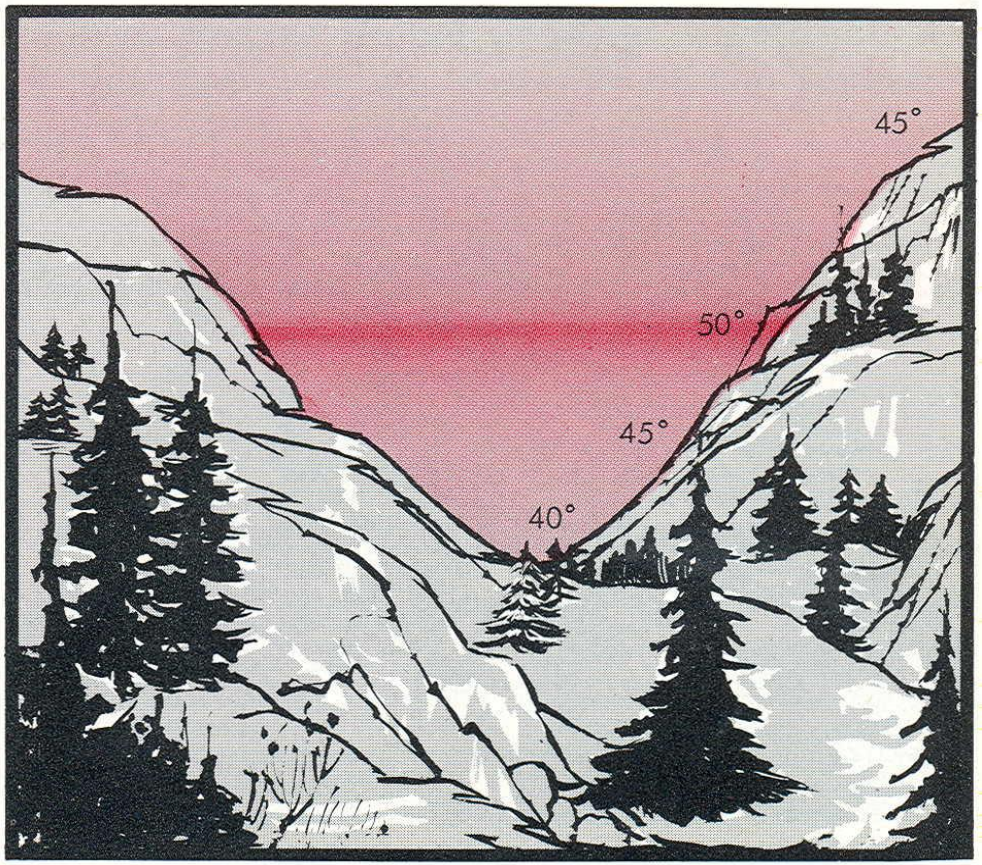
But during the inversion the temperature increases with increase in altitude.

These acts as cap over the cold air which stops mixing so these inversion layer is called the **Stable layer.**

Radiation Inversion

- It occurs at night when the earth loses heat by radiation and cools the air in contact with it.
- Cold air flows downward.
- Layer of warm air above forms thermal belt.
- Inversions becomes stable, calm and if the air is moist and its temperature is below the dew point the fog will form.
- The vertical moment is stopped until the sun warms the lower air, next morning.

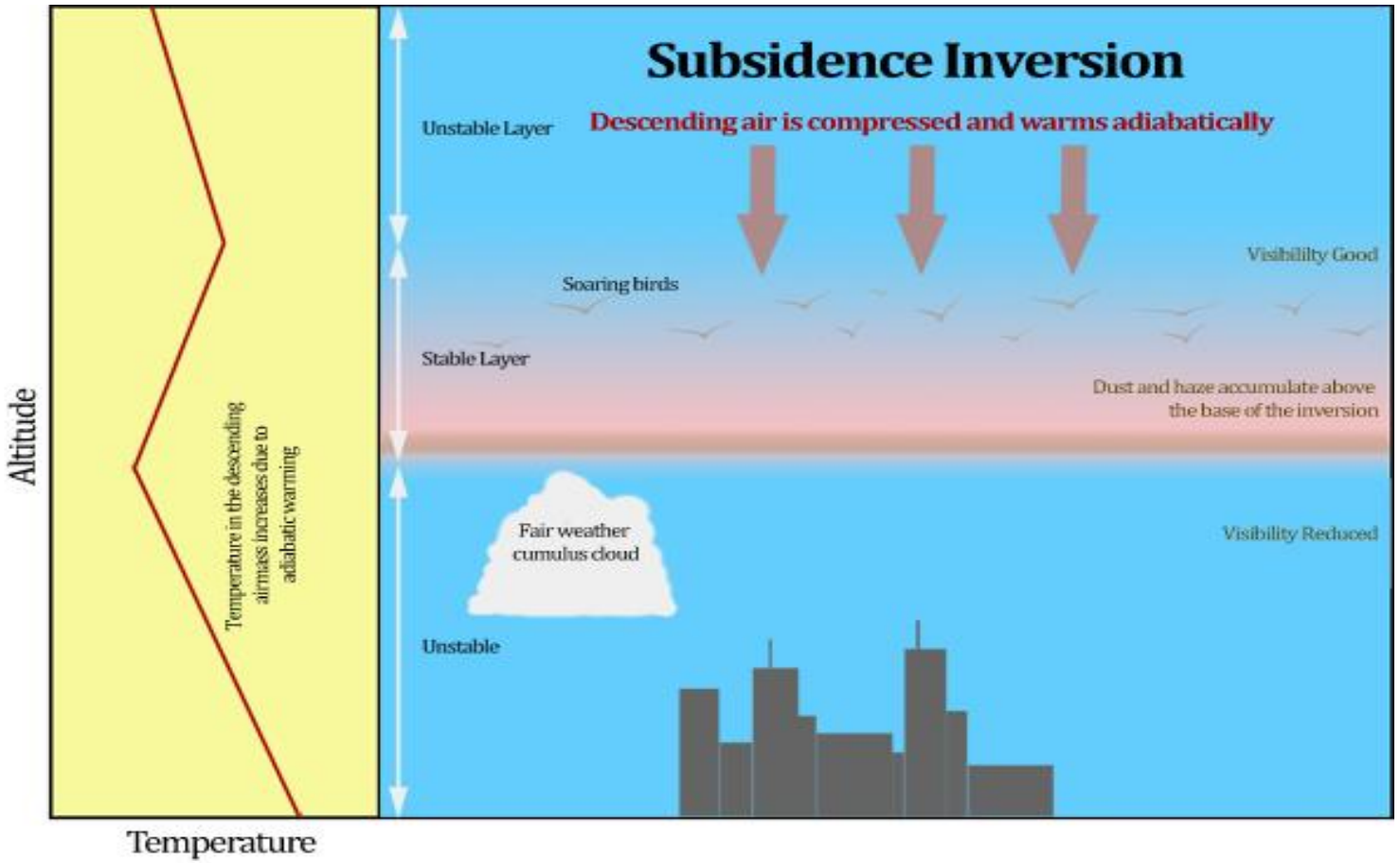
Night Radiation Inversion



Morning Fog due to Night Inversion

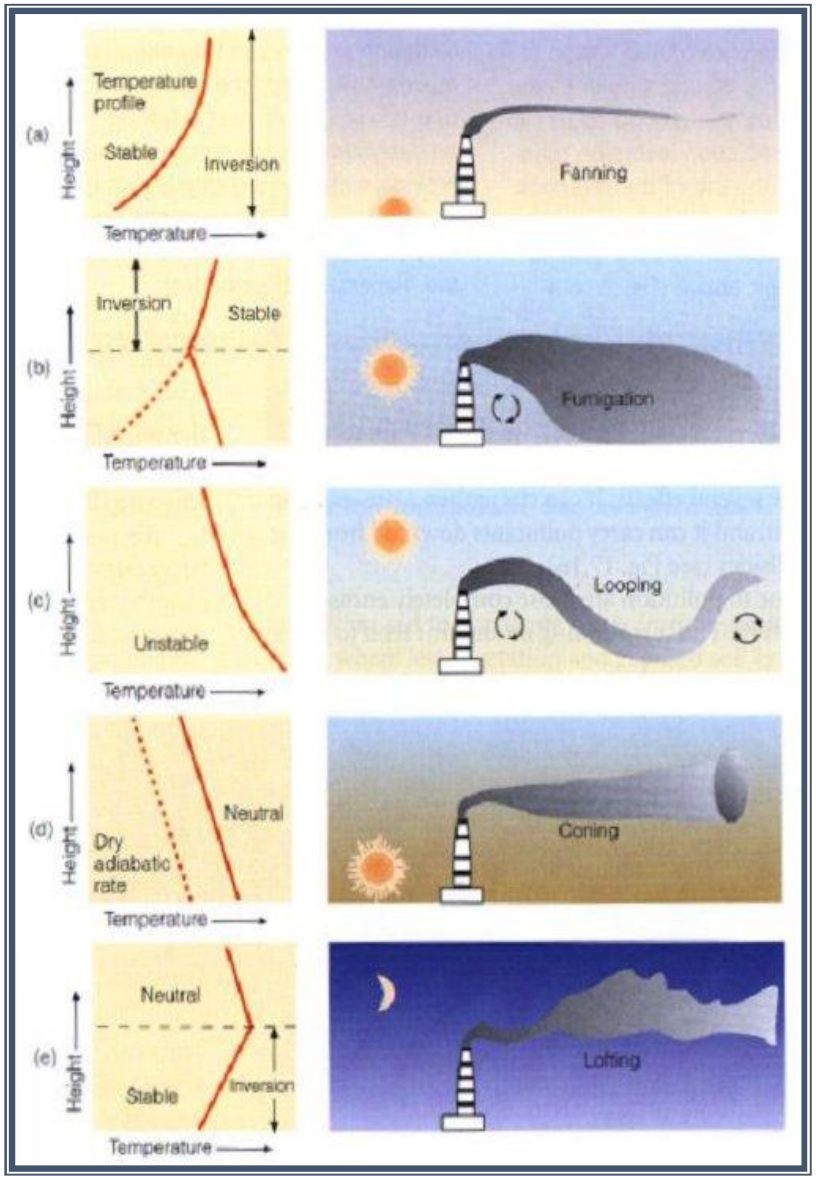
Subsidence Inversion

- It occurs at modest altitude and often remain for several days.
- It is caused by sinking of air.
- The air circulating around the area descends slowly at rate of 1000 m per day.
- As air sinks, it compressed and get heated to forms warm dense layer.
- These acts as lid to prevent the upward movement of contaminants.
- When both radiation and subsidence inversion occurs it is known as **‘double inversion’.**


Subsidence Inversion
Descending air is compressed and warms adiabatically
Unstable Layer
Visibility Good
Soaring birds
Stable Layer
Dust and haze accumulate above the base of the inversion
Fair weather cumulus cloud
Visibility Reduced
Unstable
Temperature in the descending airmass increases due to adiabatic warming
Altitude
Temperature

General Characteristics of Stack Plumes

- Dispersion of pollutants
  - Wind – carries pollution downstream from source
  - Atmospheric turbulence - causes pollutants to fluctuate from mainstream in vertical and cross-wind directions
- Affect plume dispersion differently

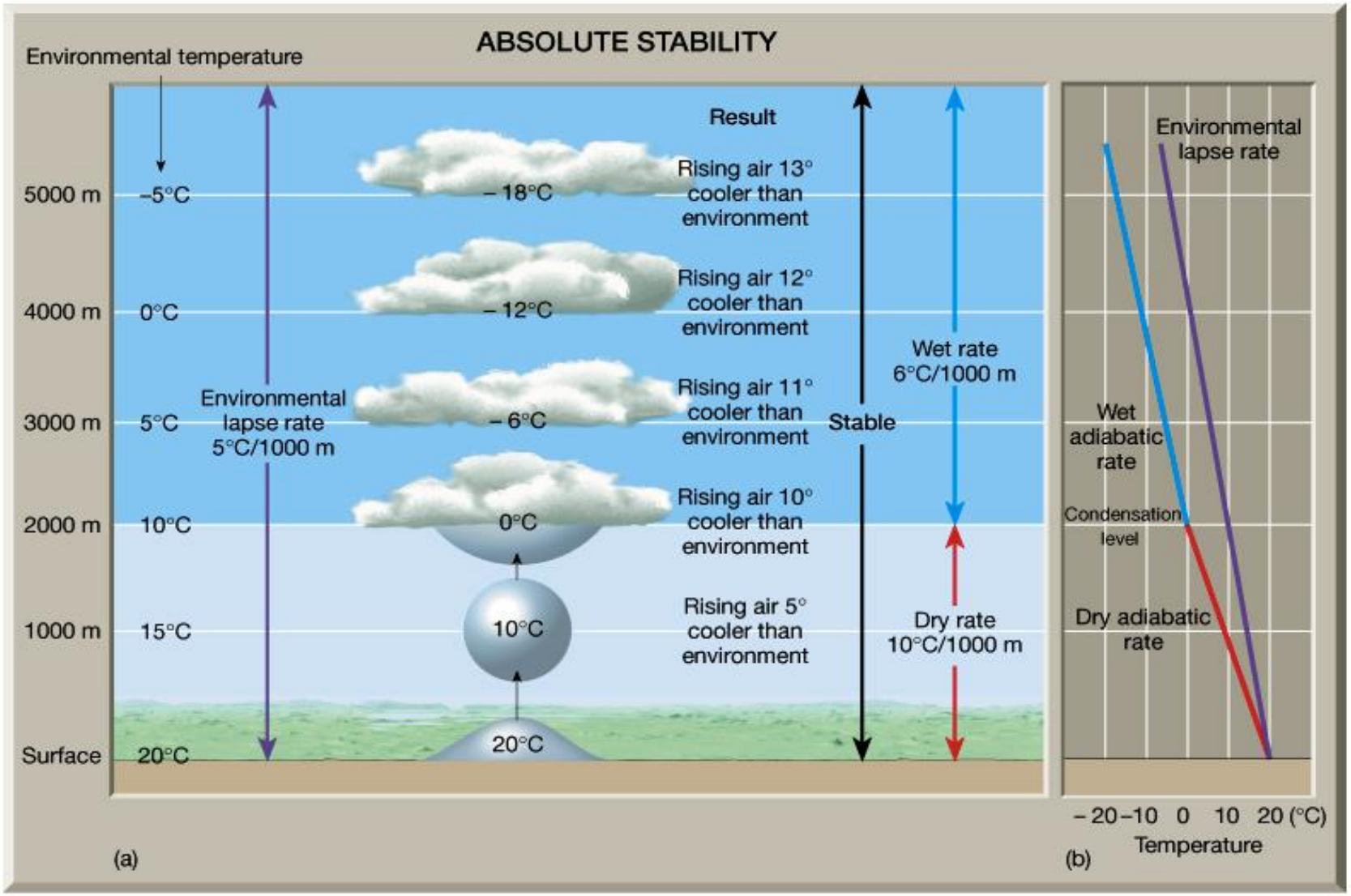


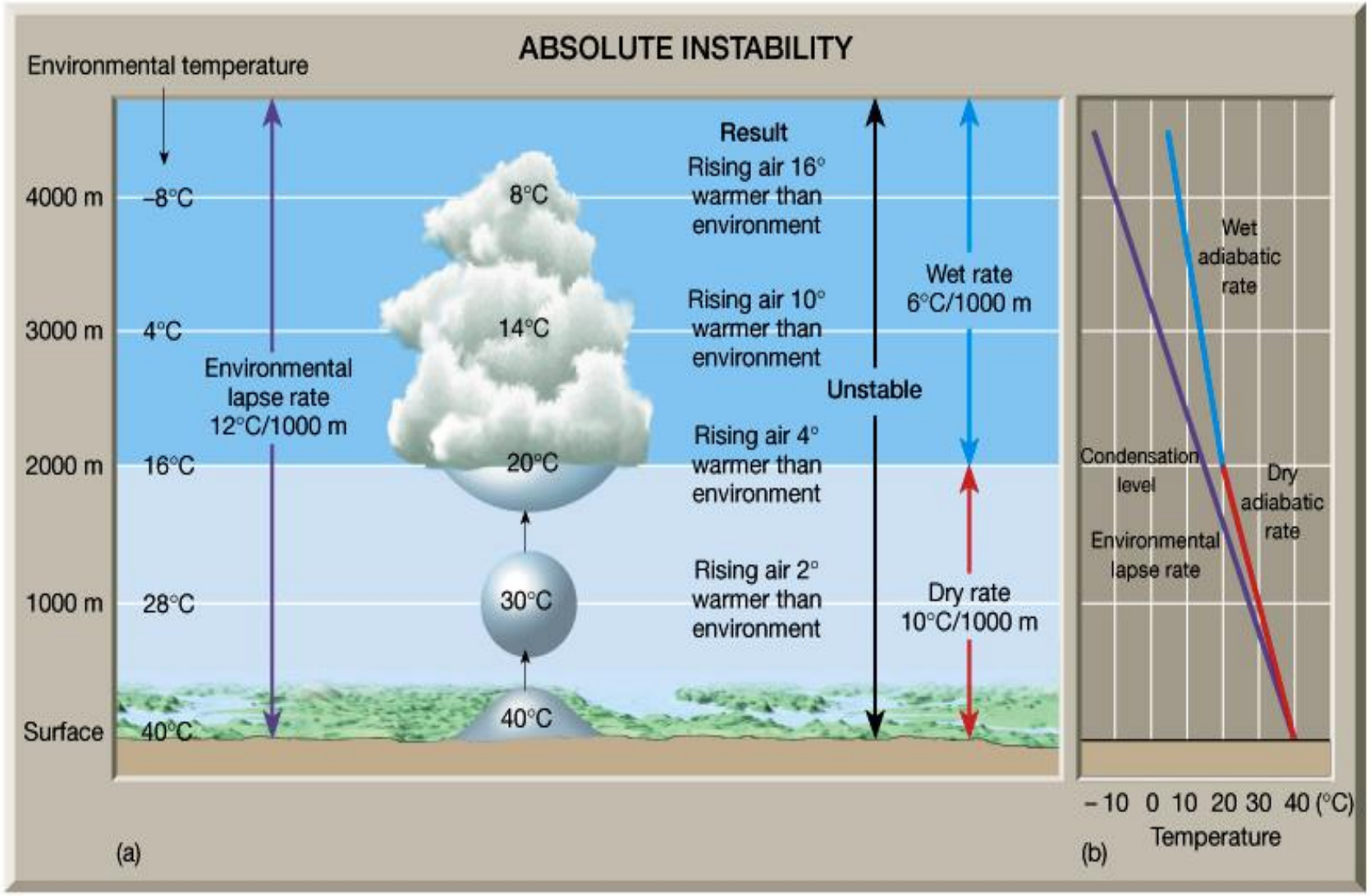
- Environmental lapse rate (ELR)
- Dry adiabatic lapse rate (DALR)

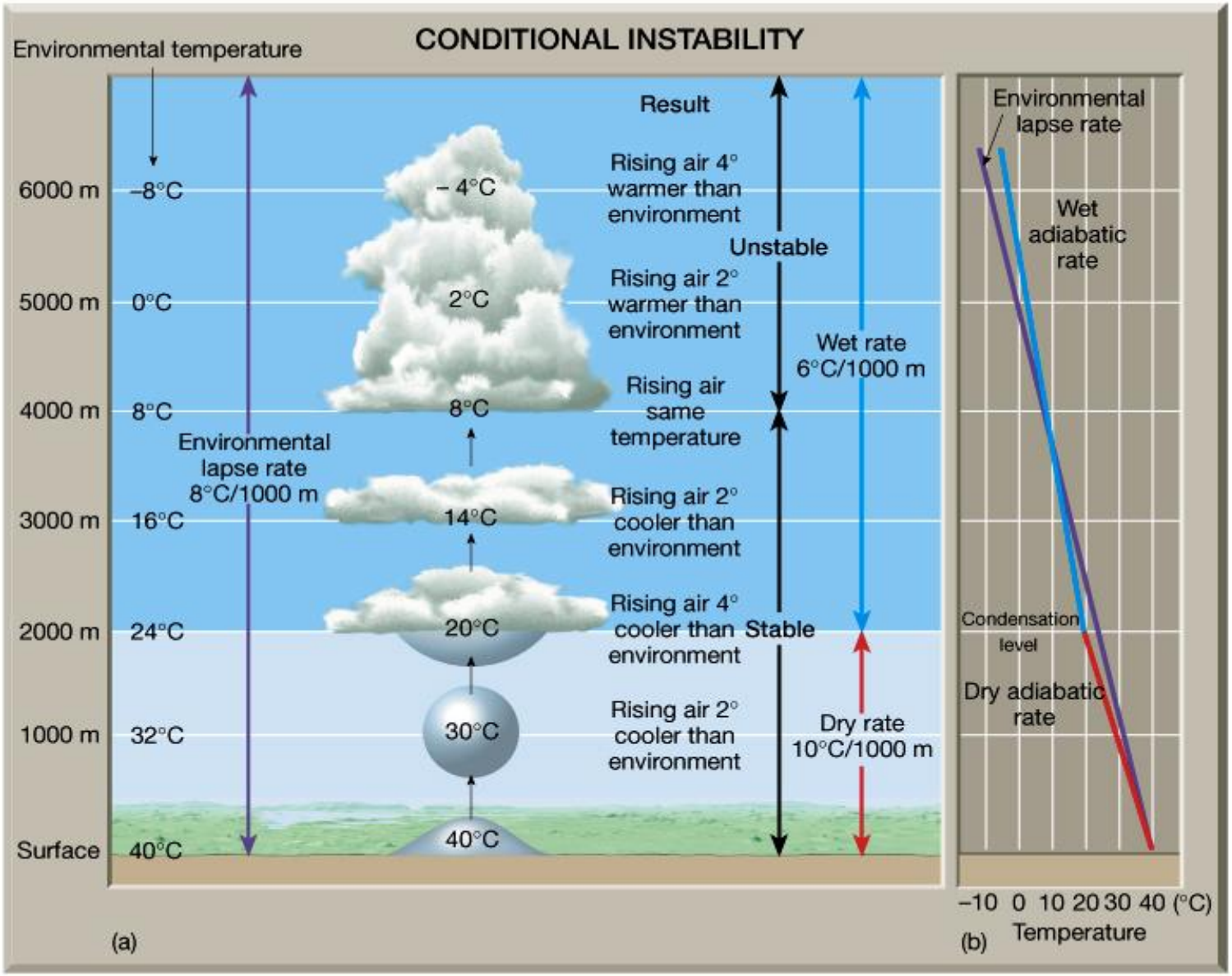
If,

- ELR > DALR =sub adiabatic condition, atmosphere is stable.
- ELR >> DALR= Inversion conditions. Very stable atmosphere.
- ELR= DALR= atmosphere is neutral.
- ELR< DALR = super adiabatic condition, atmosphere is unstable.

Shapes of plumes depends upon atmospheric stability conditions.


ABSOLUTE STABILITY
Environmental temperature
Result
5000 m
4000 m
3000 m
2000 m
1000 m
Surface
–5°C
0°C
5°C
10°C
15°C
20°C
– 18°C
– 12°C
– 6°C
0°C
10°C
Rising air 13° cooler than environment
Rising air 12° cooler than environment
Rising air 11° cooler than environment
Rising air 10° cooler than environment
Rising air 5° cooler than environment
Environmental lapse rate 5°C/1000 m
Stable
Wet rate 6°C/1000 m
Dry rate 10°C/1000 m
(a)
Environmental lapse rate
Wet adiabatic rate
Condensation level
Dry adiabatic rate
– 20 –10 0 10 20 (°C)
Temperature
(b)


ABSOLUTE INSTABILITY
Environmental temperature
4000 m
3000 m
2000 m
1000 m
Surface
–8°C
4°C
16°C
28°C
40°C
Environmental lapse rate 12°C/1000 m
8°C
14°C
20°C
30°C
40°C
Result
Rising air 16° warmer than environment
Rising air 10° warmer than environment
Rising air 4° warmer than environment
Rising air 2° warmer than environment
Unstable
Wet rate 6°C/1000 m
Dry rate 10°C/1000 m
(a)
Wet adiabatic rate
Condensation level
Dry adiabatic rate
Environmental lapse rate
– 10 0 10 20 30 40 (°C)
Temperature
(b)


CONDITIONAL INSTABILITY
Environmental temperature
6000 m
5000 m
4000 m
3000 m
2000 m
1000 m
Surface
–8°C
0°C
8°C
16°C
24°C
32°C
40°C
– 4°C
2°C
8°C
14°C
20°C
30°C
40°C
Environmental lapse rate 8°C/1000 m
Result
Rising air 4° warmer than environment
Rising air 2° warmer than environment
Rising air same temperature
Rising air 2° cooler than environment
Rising air 4° cooler than environment
Rising air 2° cooler than environment
Unstable
Stable
Wet rate 6°C/1000 m
Dry rate 10°C/1000 m
(a)
Environmental lapse rate
Wet adiabatic rate
Condensation level
Dry adiabatic rate
–10 0 10 20 30 40 (°C)
Temperature
(b)