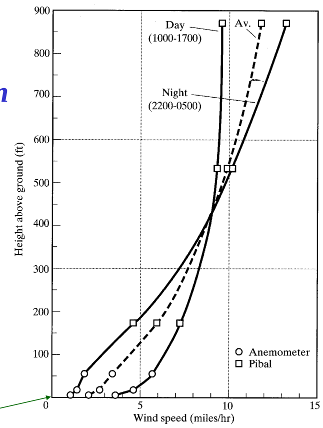
Meteorology

- *Wind*
- *Sun*
- *Buoyancy*
- *Atmospheric stability*

Variation of wind speed with elevation

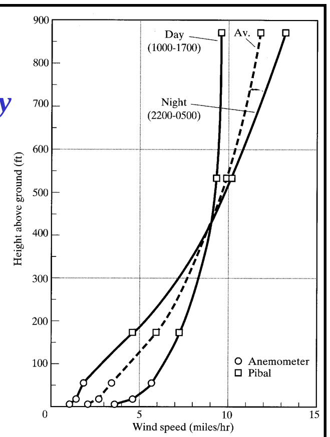
- Wind speed increases with altitude.
- The velocity profile is called a ***boundary layer***.

No-slip boundary condition at the ground.



Variation of wind speed during the day

- Solar radiation affects wind conditions.
- Wind generally varies between night and day.



Example - fumigation in building wake

Fig. 3.20—A photograph of a smoke plume released from the top of a building during neutral conditions.

Buoyancy of plumes

- A hot plume will rise rapidly, out of the way. (That's good!)
- A hot plume wastes a lot of energy. (That's bad!)

Buoyancy of plumes (continued)

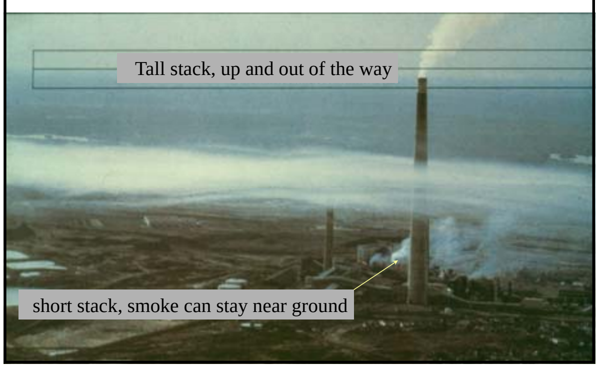
- A cool plume does not waste a lot of energy. (That's good!)
- A cool plume does not rise well, and may even fall - downwash. (That's bad!)

Example of insufficient buoyancy, downwash

Buoyancy of plumes (continued)

- Hot plumes rise rapidly, but waste energy.
- Cool plumes save energy, but do not rise well.
- Bottom line - ***Must compromise between energy savings and plume buoyancy***.
- Taller stacks help.

Example of tall stack: discharge away from problems



Lapse rate

- The negative of the temperature gradient with elevation is called the ***lapse rate***,

lapse rate = - dT/dz = - (change in T)/(change in z)

- The ***standard*** (***normal*** or ***average***) ***lapse rate*** is about 6.5 $^{\circ}$C per kilometer, i.e., T drops by about 6.5 $^{\circ}$C for every 1 km of elevation.
- In English units, T drops by about 19 $^{\circ}$F for every 1 mile of elevation.

Dry adiabatic lapse rate

- The ***dry adiabatic lapse rate*** corresponds to a ***neutrally stable*** atmosphere.
- In other words, mixing is neither promoted nor inhibited.

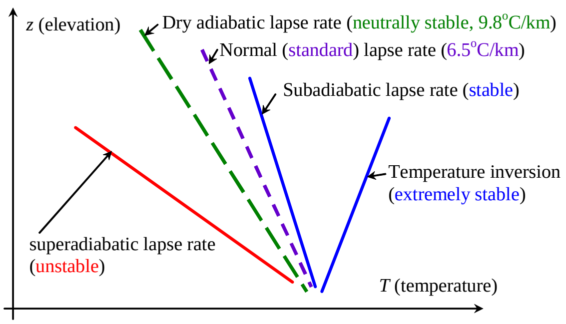
dry adiabatic lapse rate = 9.8 $^{\circ}$C/km

dry adiabatic lapse rate = 28 $^{\circ}$F/mile

Atmospheric stability

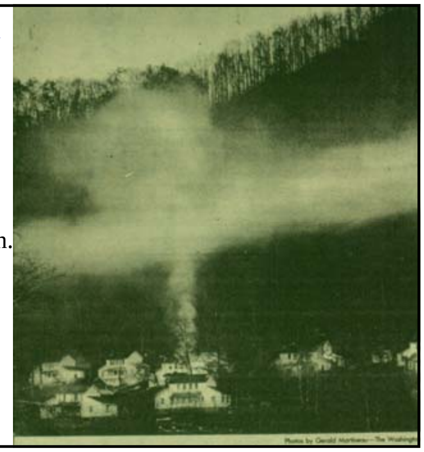
- Stability of the atmosphere is determined by comparing ***actual lapse rate*** to ***dry adiabatic lapse rate***.
  - If the actual lapse rate is ***greater*** than the dry adiabatic lapse rate, the atmosphere is ***unstable*** - mixing is enhanced (***superadiabatic***).
  - If the actual lapse rate is ***equal to*** the dry adiabatic lapse rate, the atmosphere is ***neutrally stable*** - mixing is neither inhibited nor enhanced (***adiabatic***).
  - If the actual lapse rate is ***less*** than the dry adiabatic lapse rate, the atmosphere is ***stable*** - mixing is inhibited (***subadiabatic***).

Atmospheric stability (continued)



Example of a temperature inversion

- Smoke trapped by the inversion.
- Typically seen on cold winter mornings.

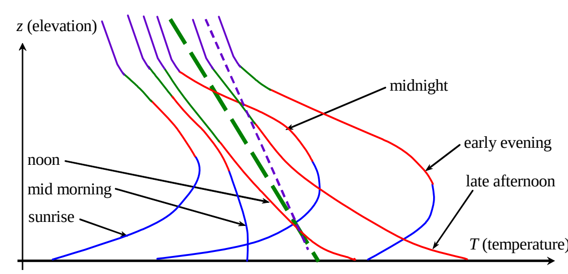


Example of a temperature inversion

- Cool, foggy morning
- Fog trapped in a thin layer near the ground

Diurnal temperature variations

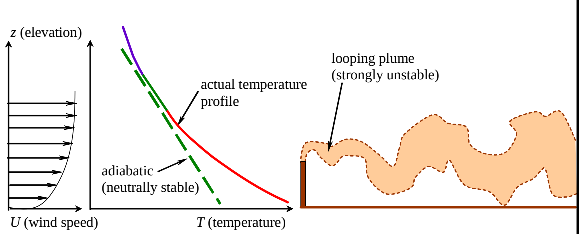
(change in temperature profile throughout a 24-hour period)



Atmospheric stability (continued)

Superadiabatic conditions

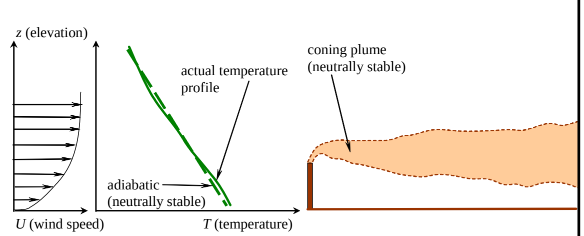
(very unstable - looping plume):



Atmospheric stability (continued)

Nearly adiabatic conditions

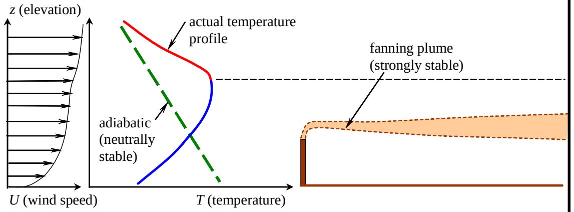
(neutrally stable - coning plume):



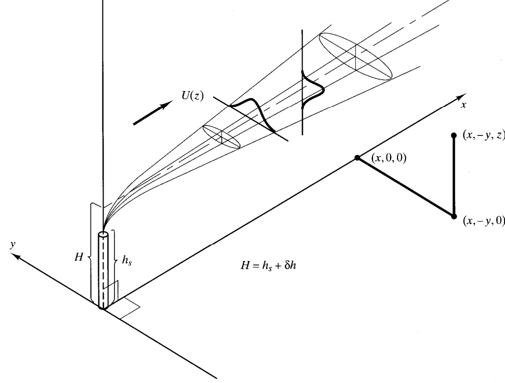
Atmospheric stability (continued)

Ground-based temperature inversion and <u>short</u> stack

(very stable - fanning plume):



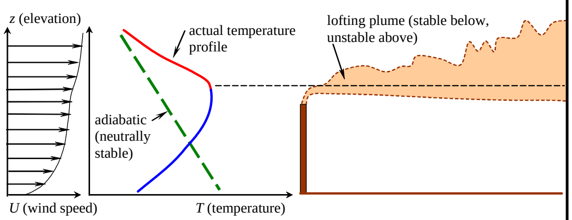
Fanning plume



Atmospheric stability (continued)

Ground-based temperature inversion and <u>tall</u> stack

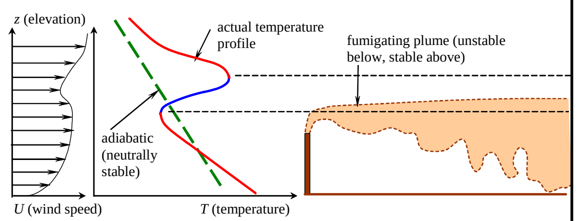
(stable below, unstable above - lofting plume):



Atmospheric stability (continued)

Elevated temperature inversion and <u>short</u> stack

(unstable below, stable above, - fumigating plume):



Atmospheric stability (continued)

Ground-based <u>and</u> elevated temperature inversions

(stable below, stable above, - trapping plume):