Lecture Ch. 7b

- Effects of Meteorology on Pollution
  - Stability (review)
  - Atmospheric structure (review)
  - Water vapor structure (review)
  - Inversions (review)

Curry and Webster, Ch. 7, 8
For Thursday: Ch. 12

Effects of Meteorology on Pollution

- T is not constant as z increases in the troposphere!
- What is the relationship between T and z?
  Assume
  - there exists a mass of air that may deform as it moves upward
  - exchange of air molecules across boundary << size of air parcel
  - as z increases, expansion occurs adiabatically (no heat exchange)
  - as z increases, T decreases

Atmospheric Structure

- Structure of the atmosphere
  - Decreasing temperature with altitude
  - Decreasing pressure with altitude
  - Changes in water vapor (“mixing ratio”) with altitude
- Temperatures in meteorology
  - Potential temperature (meteorologists’ entropy)
  - Virtual (potential) temperature
  - Equivalent (potential) temperature

- Describing the atmospheric structure
  - Example: Skew-T log P plot
  - Example: Tephigram

Updrafts

- Lapse Rate ($\Gamma$): helps to define the stability of the atmosphere.
- Degree of stability relates to the atmosphere’s ability to disperse pollutants.
- Stability:
  - Superadiabatic (unstable)
    - $\Gamma_{env} > \Gamma_{ad}$
  - Subadiabatic (stable)
    - $\Gamma_{env} < \Gamma_{ad}$
  - Neutral
    - $\Gamma_{env} = \Gamma_{ad}$

Superadiabatic

$\Gamma_{env} > \Gamma_{ad}$ (unstable)

Compare $T_{parcel}$ vs. $T_{env}$.
Compare $\rho_{parcel}$ vs. $\rho_{env}$.
Subadiabatic

- Subadiabatic $T_{\text{par}} < T_{\text{ad}}$ (stable)

\[ z \begin{array}{c} T_{\text{ad}} \ \ \ \ \ \ \ \ \ \ \ T_{\text{env}} \end{array} \]

Compare $T_{\text{par}} - T_{\text{env}}$.

Compare $\rho_{\text{par}} - \rho_{\text{env}}$.

Maximum Mixing Depth

- Maximum Mixing Depth (MMD): the limit of the convective mixing layer where $T_{\text{par}} = T_{\text{surrounding environment}}$

\[ z \begin{array}{c} T_{\text{env}} \ \ T_{\text{ad}} \ \ T_{\text{max}} \end{array} \]

Inversions

- Inversion: A condition of strong stability characterized by a positive temperature gradient.

- Effects of inversion:
  - reduced vertical dispersion of pollutants
  - increased local concentration of pollutants

Water Vapor in the Atmosphere

- the Earth's surface is the primary source of water vapor for the atmosphere
- the amount of water vapor in the atmosphere depends on:
  - (1) the amount which enters the atmosphere through evaporation and sublimation,
  - (2) transport by motion of various scales throughout the troposphere and the lower stratosphere,
  - (3) the amount which leaves the atmosphere intermittently as rain, hail and snow

- $w_{v,sat}$, the amount of water vapor in air at saturation on a mass-per-mass basis, decreases with decreasing temperature.
  - the amount of water in an air parcel consequently decreases with altitude, reaching a minimum in the lower stratosphere a few kilometers above the tropopause.
  - atmosphere has very low water content

- clouds and fogs form by cooling of moist air

- cloud formation is driven by the rise of moist air due to thermal advection and expansion, which results in simultaneous cooling and expansion; in many cases this expansion is close to adiabatic.

- fog formation can occur by radiative cooling caused by surface cooling when a sufficient amount of cooling $w_{v,sat}$ and a liquid condensate is formed; this process occurs when the dew-point temperature is reached.