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?

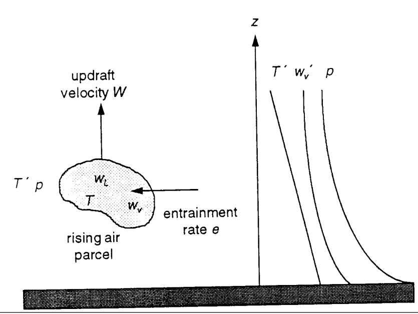
Assume
  - there exists a mass of air that may deform as it moves upward
  - exchange of air molecules across boundary << size of air parcel
  - as z increases, expansion occurs adiabatically (no heat exchange)
  - as z increases , T decreases

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

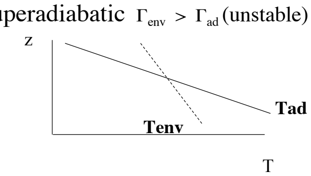


Lapse Rate

- Lapse Rate (Γ): 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

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

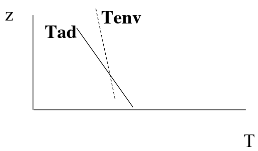


Compare T_{parcel}, T_{env} .

Compare ρ_{parcel}, ρ_{env} .

Subadiabatic

- Subadiabatic $\Gamma_{env} < \Gamma_{ad}$ (stable)

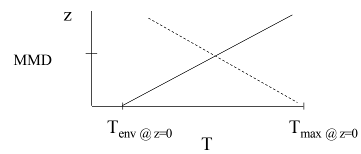


Compare T_{parcel}, T_{env} .

Compare ρ_{parcel}, ρ_{env} .

Maximum Mixing Depth

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



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

Inversions

- Subsidence Inversion
  - Position: above emission sources
  - Cause: adiabatic compression and warming of a large layer of earth as it sinks to lower altitude.
    - $dT/dP = 1/(C_p\ \rho)$, where C_p is essentially constant over T.

Inversions

- Radiation Inversion

  Position: in the range of emission sources

  Cause:
  - radiation of heat by the ground at night
  - air adjacent to the the surface has a T < layer at higher elevations

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) its transport by motions 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
  - stratosphere 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 thermally-driven updrafts, which result in simultaneous cooling and expansion; in many cases this expansion is close to adiabatic
  - fog formation and some stratus cloud formation can occur by isobaric cooling, caused by surface cooling
  - after a sufficient amount of cooling $w_v = w_{v,sat}$ and a liquid condensate is formed; this process occurs when the dew-point temperature (T_d) is reached