Lecture Ch. 8a

- Review of Ch.7 Concepts
  - Homework Ch. 7, Prob. 3
- Cloud Classification
- Precipitation Processes

Curry and Webster, Ch. 8
Please complete online evaluations!

Atmospheric Structure

- Structure of the atmosphere
  - Decreasing temperature with altitude
  - Decreasing pressure with altitude
  - Change in water vapor with altitude
- Temperature in meteorology
  - Potential temperature (meteorologists' entropy)
  - Virtual (potential) temperature
  - Equivalent (potential) temperature
- Describing the atmospheric structure
  - *Example: Skew-T log P plot*
  - *Example: Tephigram*

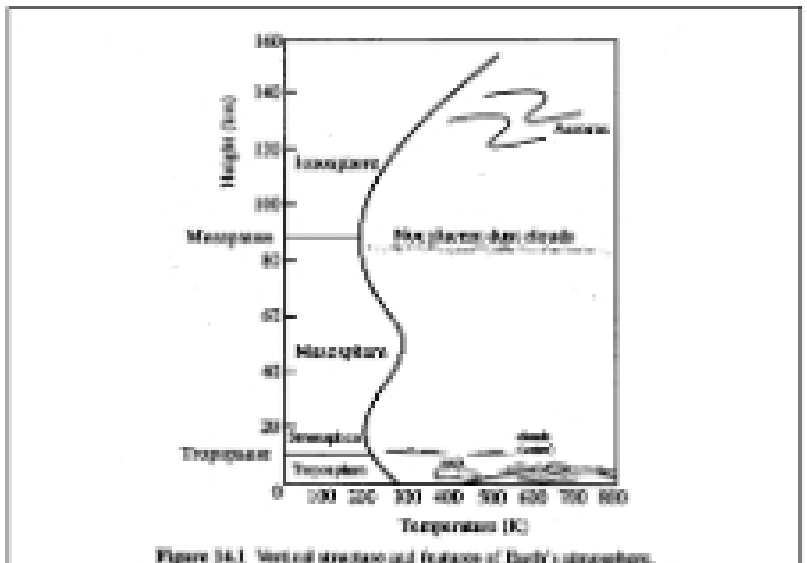


Figure 14.1 Vertical structure and features of Earth's atmosphere.

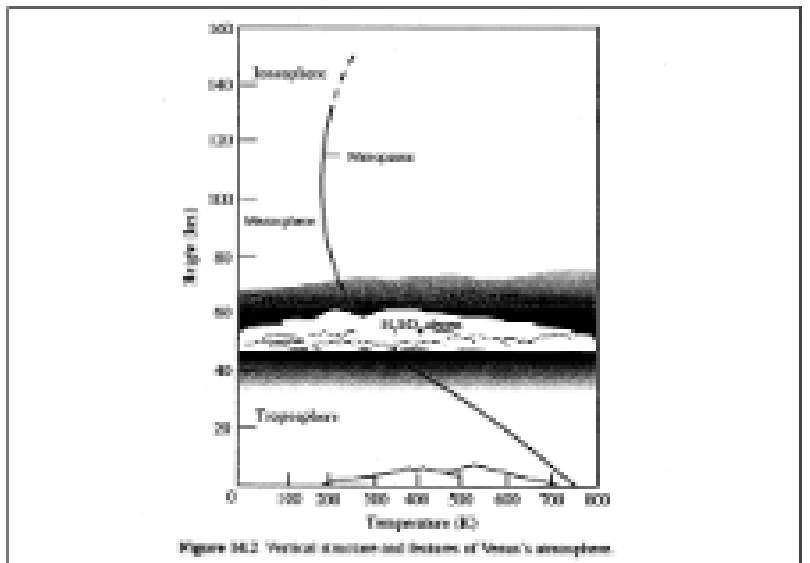


Figure 14.2 Vertical structure and features of Venus's atmosphere.

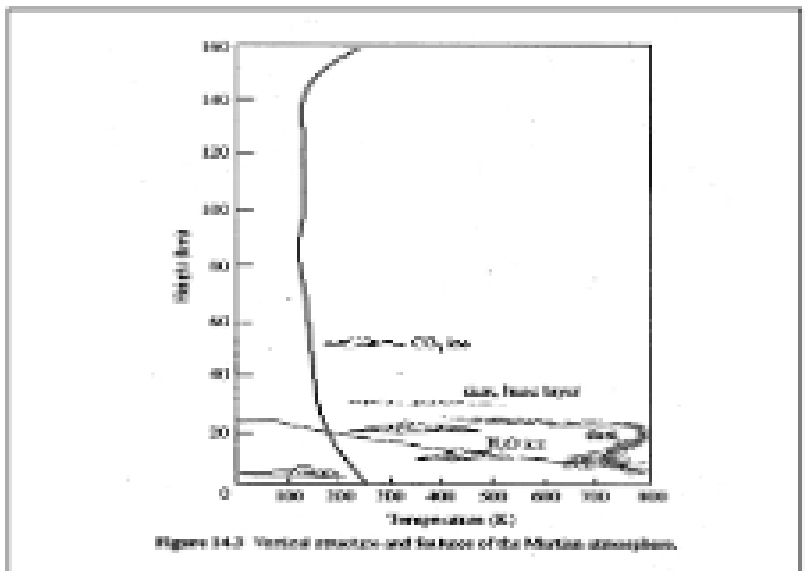


Figure 14.3 Vertical structure and features of the Martian atmosphere.

Inversions

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

Subsidence Inversions

- Subsidence Inversion
  - 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.

Radiation Inversions

- Radiation Inversion

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

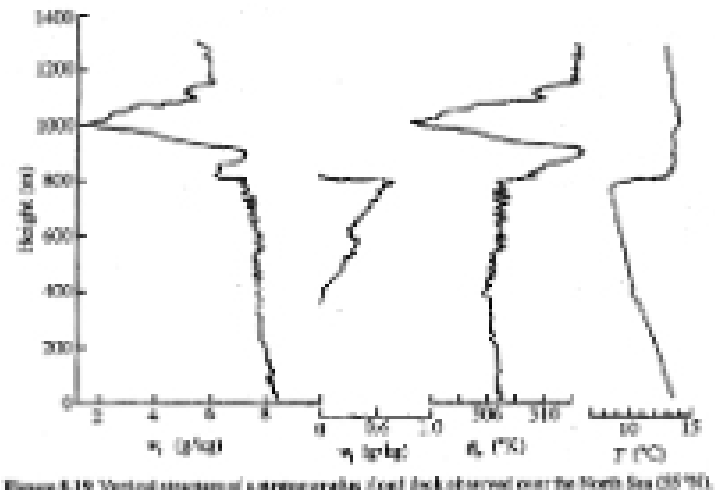


Figure 8.19 Vertical structure of a stratocumulus cloud deck observed over the North Sea (55°N). Over the depth of the boundary layer, the total water mixing ratio and the potential temperature are nearly constant, indicating a well-mixed layer. The cloud base is at about 400 m. (After Nicholls, 1984.)

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 conveniently as rain, hail and snow.
- q_{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 little water vapor
- 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 results in simultaneous cooling and expansion; in many cases this expansion is close to adiabatic
  - fog formation and some stratus cloud formation are driven by radiative cooling, assisted by surface cooling
  - after a sufficient amount of cooling to $q = q_{sat}$ and a liquid cloud/fog is formed, this process occurs when the dew point temperature (T_d) is reached

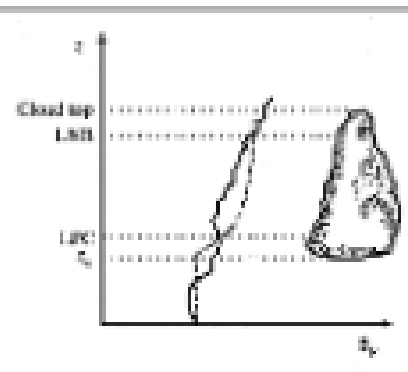
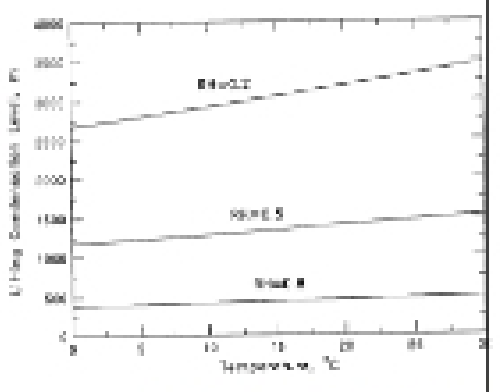


Figure 8.21 Typical temperature profiles in a convective environment. The solid profile represents the environmental temperature; the dashed profile corresponds to the temperature within the cloud. The cloud base forms near the lifting condensation level, z_b. Near the cloud base, the temperature increases more rapidly with height in the cloud than in the surroundings, resulting in a relatively large temperature difference between the environmental temperature and the (cooler) cloud temperature. A cloud that reaches the level of free convection (LFC) will accelerate upwards until it reaches the level of neutral buoyancy (LNB), where the environmental temperature is equal to the interior cloud temperature.

Lifting Condensation Level

- Lifting condensation level varies with initial relative humidity and is a weak function of initial temperature



Seinfeld and Pandis, Fig. 15.11

Cloud Classification

Clouds are also distinguished by the heights above ground level at which they form:

1) high clouds whose bases are higher than 6 km in the tropics and 3 km in the polar regions (prefix: *cirro*),
2) middle clouds whose bases lie between 2 and 8 km in the tropics and 2 and 4 km in the polar regions (prefix: *alto*);
3) low clouds whose bases lie below 2 km;
4) clouds of vertical development.

The prefix *nimbo* or the suffix *nimbus* indicates the presence of rain.

Cumulus Clouds

Swelling Cumulus

Active heaped-up cloud with flat bottom and growing cauliflower top. [http://www.fox8wghp.com/spacious.htm]

Cumulonimbus Clouds

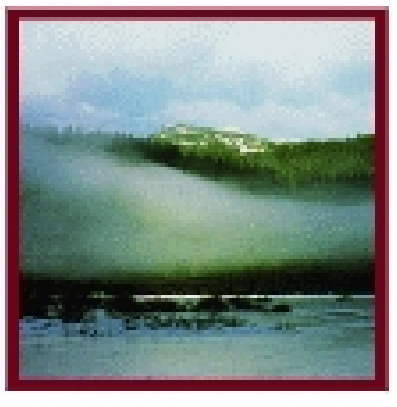
Cumulonimbus

Massive cloud system producing heavy showers, sometimes with hail. Most active clouds may have lightning and thunder. A few spawn tornadoes. [http://www.fox8wghp.com/spacious.htm]

Stratus Clouds

Stratus

Low lying layer of cloud (called fog if on the ground) with no structure. [http://www.fox8wghp.com/spacious.htm]



Cirrus Clouds

Cirrus

An ice crystal cloud, wispy in appearance. May produce ice crystal snow in winter or in mountains. [http://www.fox8wghp.com/spacious.htm]

Altostratus Clouds

Altostratus

Thickly layered water droplet cloud. Sun seen as through ground glass. [http://www.fox8wghp.com/spacious.htm]