Wet Deposition

- Wet Deposition is a process in which atmospheric chemicals are accumulated in rain, snow, fog-mists and are then deposited onto soils-water and or vegetation-other non-biotic structures.
- Wet deposition removes from the atmosphere many chemicals-including gases-that are not deposited by gravitational settling, impaction or absorption or have low rates of deposition.
- Incorporation of chemicals into water droplets-occurring in clouds-is called **rainout**.
- When the incorporation occurs below a cloud-as precipitation falls through it- it is called **washout**.

Wet Deposition of Gases and Vapors

- Gases and vapors in the atmosphere are removed first by dissolution into raindrops.
- At equilibrium the [chemical] is given by Henry's Law where;

C water = C air/H so the chemical concentration in the water droplet is equal to the concentration in air divided by the chemicals dimensionless Henry's Law constant.

- We generally assume equilibrium conditions occur if the rain forms in contact with air (rainout) or if the rain falls through some 10's of meters of an air mass (washout).

Wet Deposition Continued

- The ratio of C water/ C air , which is equal to the reciprocal of the dimensionless Henry's Law constant is called the washout ratio or W. Of course each specific chemical has a unique value of W.
- The flux density of a gas or vapor associated with falling rain is given by;

$$J = C\ water * I = C\ air*I/H = C\ air* W*I$$

I is the rainfall rate [L/T] and W is the washout ratio (dimensionless). The term I/H has dimensions of [L/T] so it can be termed a deposition velocity.

- See Table 4-10 for values of Washout Ratios (W) for various chemicals.

Wet Deposition of Particles

- The major mechanism of particulate removal from the atmosphere for wet deposition is through their action as ***nucleation sites.***
- If nucleation sites are not available- water droplets would not form unless the air temperature were significantly below the dew point.
- Silver Iodide is used as a condensation nuclei to help form ice crystals in cloud seedings.
- Particles are also incorporated into water droplets through collision processes.

Particles Removed by Both Collision and Nucleation Processes

- So; d C air/dt = -λ C air where λ is here a single scavenging coefficient for both processes in $[T^{-1}]$. This than gives-
- $C_{air,t} = C_{air,0} * e^{-\lambda t}$ where $C_{air,0}$ is the initial [chemical], $C_{air,t}$ is the air concentration after some time t, λ is the scavenging coefficient but it is usually more poorly known because it depends on the particle size distribution in the cloud and internal cloud dynamics.
- Removal of particles by wet deposition-is more effective than dry deposition.

Particle Washout Ratios

- Particles, unlike gases, do not partition between air and water in a predictable way.
- But researchers have constructed particle washout ratios as the ratio of the measured particle concentration in near surface participation to the average measured concentration of particles in near surface air.See Table 4-11, page 365.
- The amount of mass removed from air by precipitation is more easily measured by collection and analysis of precipitation than is dry deposition. (See Figure 4-33)

Chemical Transformations in the Atmosphere

- Transformations can remove or create atmospheric pollutants-note the production of photochemical smog by reactions of hydrocarbons,, nitrogen oxides and oxygen (see figure 4-35, page 370).
- Most atmospheric chemical reactions are driven by sunlight-directly or indirectly.
- Most air pollutants are oxidized in atmospheric chemical reactions as you would expect with such high O2 levels (20%).
- There are reactions that occur in the dark but they are a result of reactive species previously made photochemically. The rates of these reactions are directly proportional to temperature. See 4-31 and 4-31b on page 366.