Lecture 33 Air Pollution (EOM Ch 12)

The accumulation of unusually large amounts of some substance in the atmosphere due to human or natural sources...an age old problem

Natural: windborne dust, forest fires, volcanoes

Human:

Fixed sources: Factories, power plants, homes, etc.

Mobile sources: Motor vehicles, planes, ships, etc.

<u>England</u>

- 1273, England: Edward I forbids sooty ‘sea coal’ but coal burning increases, London’s air worsens
- 1850-1950: Stagnant London smoke-fogs (coined ‘smog’ in 1911 by British physician Harold Des Voeux) kill 700 (1873), 1150 (1911), 4000 (1952). Similar pollution episodes elsewhere in Europe
- 1956: British Clean Air act passed, and London’s air is now much cleaner.

<u>US</u>

- 1542: Spaniard Juan Rodriguez Castillo named San Pedro Bay off LA the ‘Bay of Smokes’.

- 1940: Dark smoke from coal use in cities such as Pittsburgh requires midday use of car headlights.
- Oct 26-30, 1948, Donora PA: SO_2 and particulates from this small valley-bottom town's steel mill, zinc smelter, and sulfuric acid plant trapped for 5 days in a stagnant shallow layer of radiation fog. 22 killed, 50% of 14000 inhabitants experienced ill effects.
- 1940's-1960's: Urban industry and automobiles led to dangerous pollution levels in NYC, LA.
- 1970: US Clean Air Act -national air quality standards enforced through regulation of emissions. Acute problems now less, but still $25 billion/yr damage in US to health, materials, vegetation.

Urban areas in industrializing countries continue to have acute air pollution (e. g. Mexico City or the 'Valley of Death' in Cubatao, Brazil, in which 30% of 100,000 residents suffer from respiratory disease.)

- What are principal pollutants?
- What weather conditions favor air pollution?
- Acid rain.

Principal Pollutants

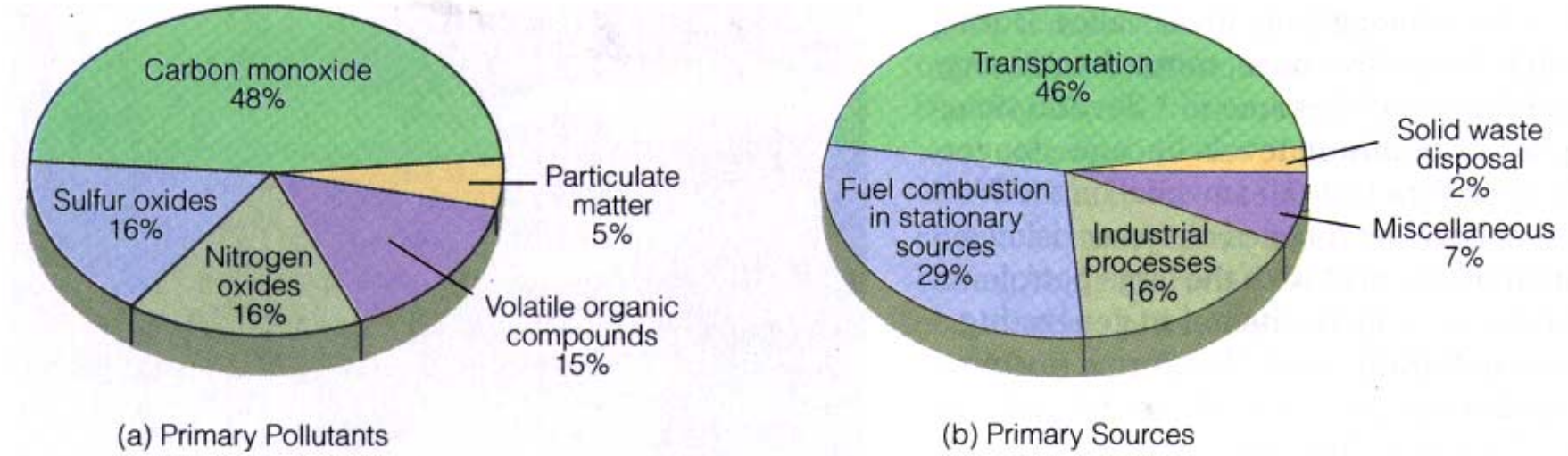


Figure 12.2 (EOM)
(a) Estimates of emissions of the primary air pollutants in the United States on a per weight basis; (b) the primary sources for the pollutants. (Data courtesy United States Environmental Protection Agency)

- 1990 US total: 120 million tons/yr (3 lb per person per day!)

Airborne particulates

- 80% from fixed sources.
- Soot, dust, pollen, asbestos fibers, lead
- Liquid droplets of sulfuric acid, oil, pesticides.
- Particles less than 1 micron in diameter are most dangerous, can stay air-borne for weeks if no rain.

Carbon Monoxide (CO)

- 60 million tons/yr (500 lb/person!), half from cars.
- Colorless, odorless, reduces blood oxygen uptake.
- Combustion also inevitably produces CO_2 (a major greenhouse gas). In US, we produce 22 tons/person/yr of CO_2(!) due to our energy-guzzling habits.

Sulfur Dioxide (SO_2)

- From less refined sulfur-containing coal and oil, burned in power plants, refineries, paper mills.
- Combines with water vapor to make corrosive sulfuric acid aerosol (a major cause of acid rain).
- Aggravates respiratory problems such as asthma.

Volatile Organic Compounds (VOC's)

- Methane, benzene, formaldehyde, CFC's
- 1/3 vehicles,rest from industry, agriculture, nature.
- Some carcinogens, increase secondary pollution

Nitrogen Oxides (NO_x)

Vehicles, power plants, waste disposal

Brown NO_2 reduces visibility

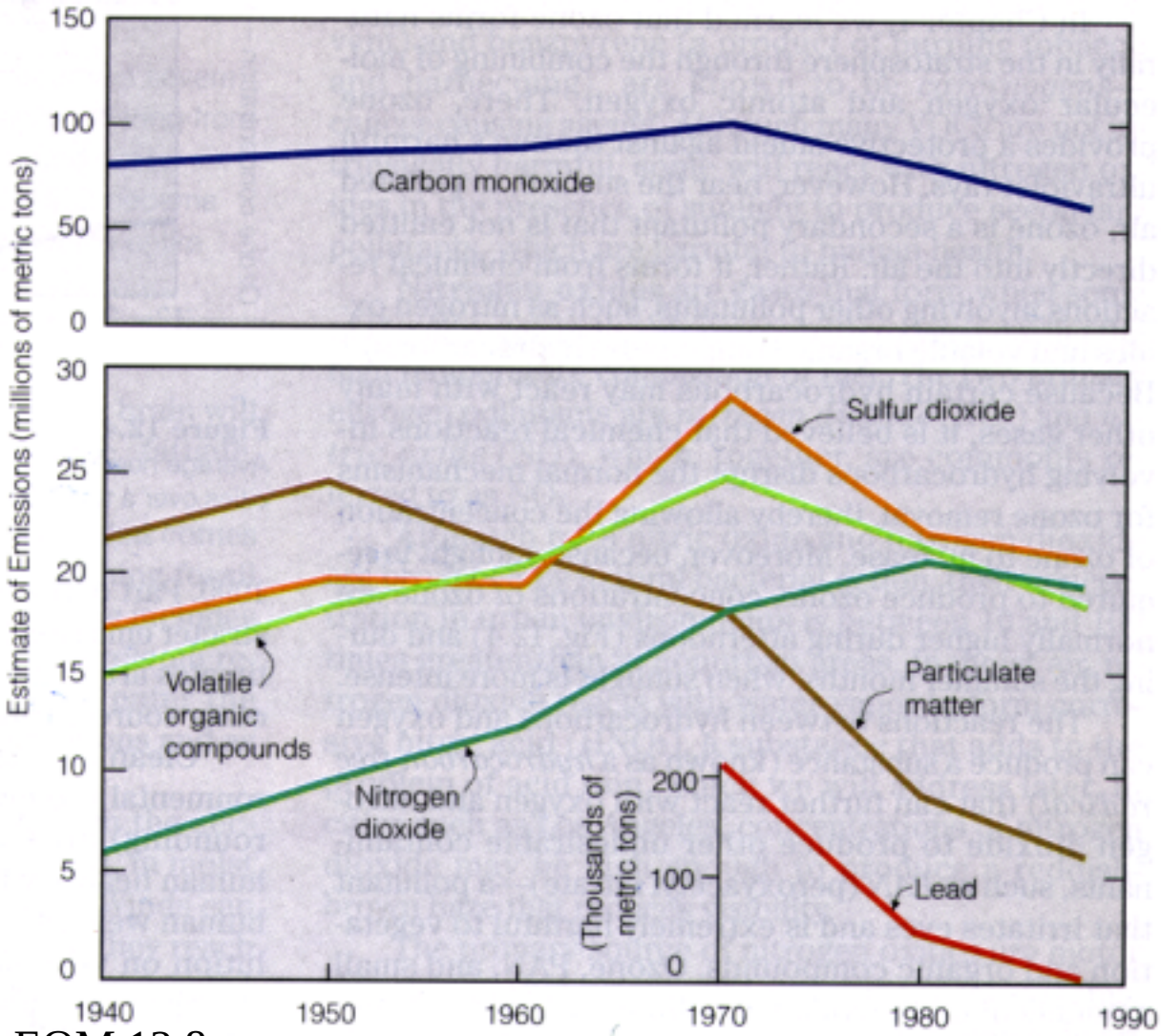
Combines with water vapor to make corrosive nitric acid aerosol (another cause of acid rain).

Reacts with sunlight to make ozone, the main component of *photochemical smog* (LA, Denver).

Ozone (O_3)

- Irritates eyes, lungs, attacks rubber, harms plants.
- Since sunlight is needed to make ozone, concentration highest in afternoon, and during summer.

Trends in Primary Air Pollutants

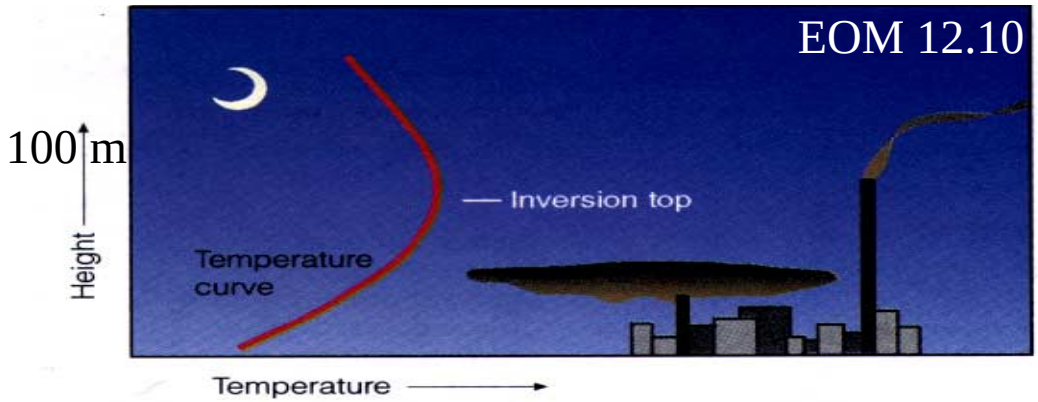


EOM 12.8

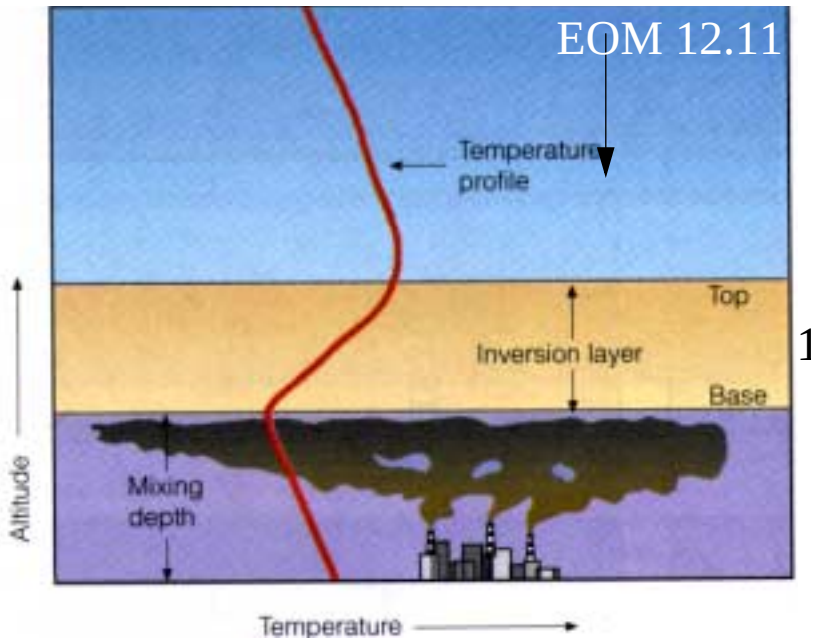
Air Pollution Weather

Smog promoted by stagnant, stable layer of air near surface, usually in a broad surface anticyclone. Promoted by trapping of stable air in a valley.

Radiation inversions. (nightly)



Subsidence inversions. (several days)



Monitoring Air Pollution

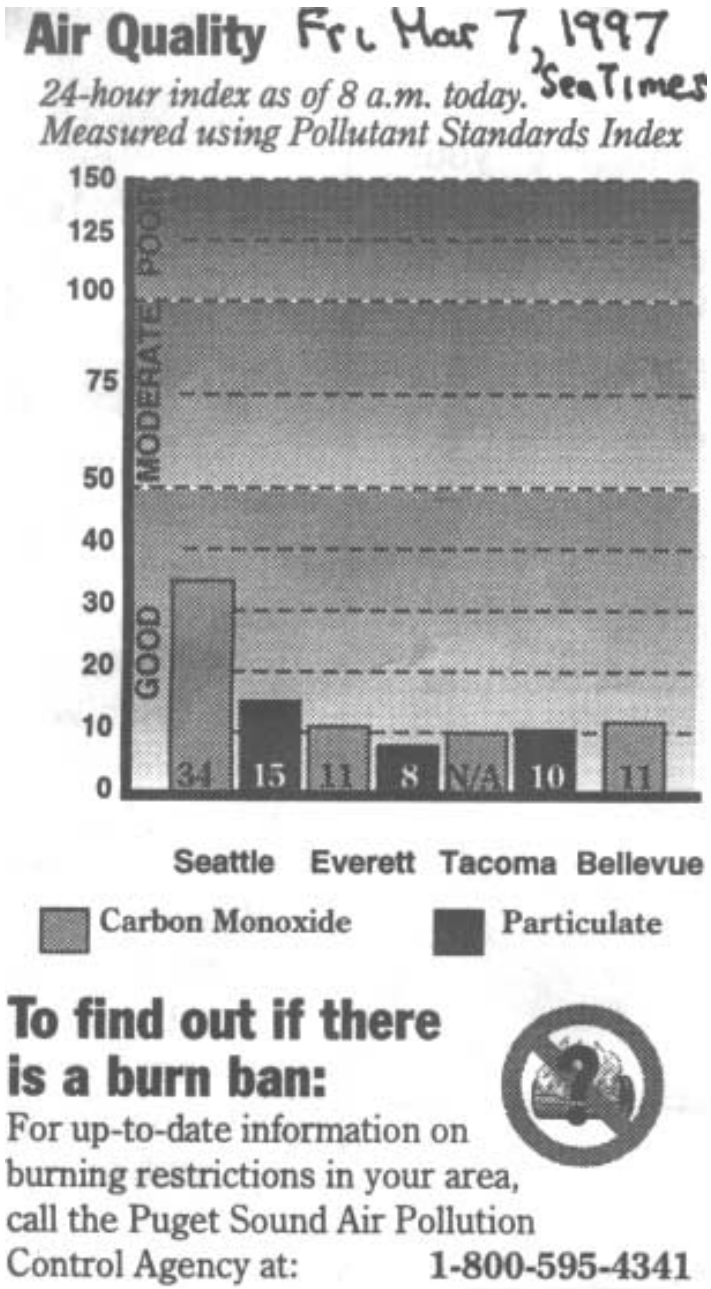
- In most urban areas, concentrations of CO, SO_2, NO_2, O_3, particulates are measured continuously, and each is expressed as a percentage of EPA's maximum healthful standard (Pollution Standard Index)

PSI	Short-term Health Effects
0-100	None
100-200	Mild respiratory irritation
200-300 (Stage 1 alert)	Considerable irritation
300-400 (Stage 2 alert)	Premature disease onset
400-500 (Stage 3 alert)	Premature death-ill/elderly

- Seattle's main pollution problems:
  - Winter - particulates (wood stoves/burn bans)
    - more recently, CO (cars)
  - Summer - ozone.
- Currently, PSI's above 100 are uncommon in Seattle, but rapid population/ auto use growth threatens our air quality.

Air Quality Info (Sea Times Weather section)

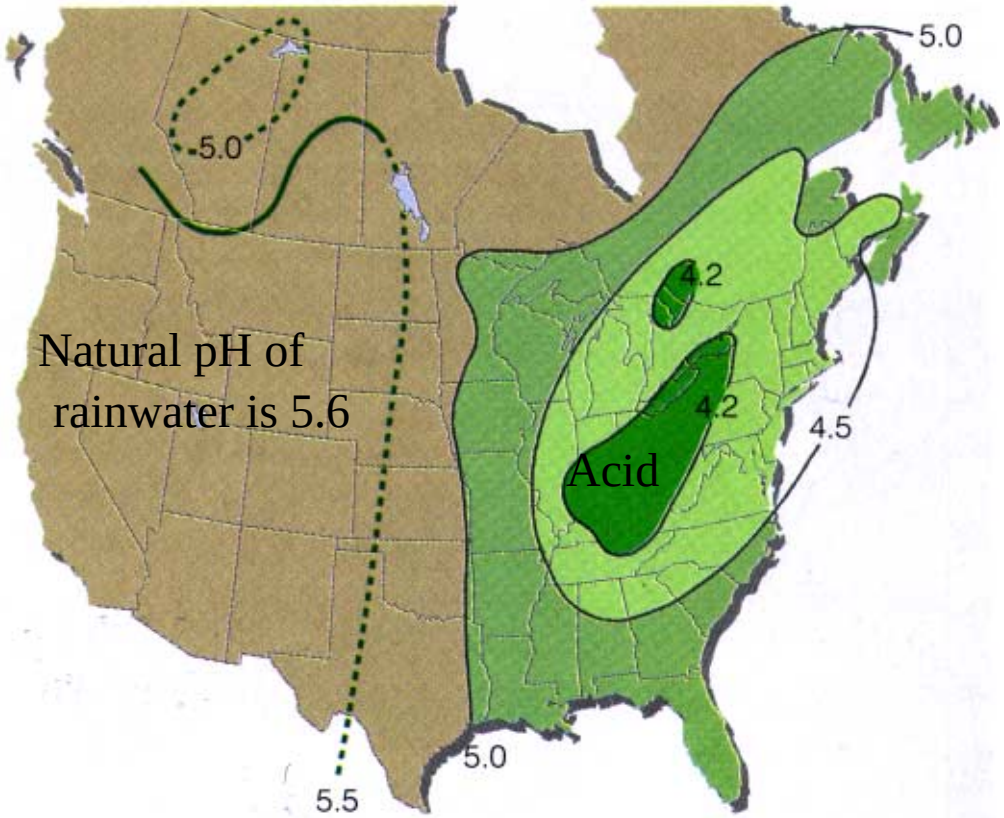
(These low levels are typical of a windy, rainy day!)



Acid Deposition

- Sulfuric and nitric acid downwind of major industrial centers.
- Wet (precip, cloud) and dry (set-tling) deposition
- Acid deposition attacks build-ings, acid rain helped cause a blight affecting 1/3 of Germany's trees.

- In LA, fog can be more acidic (pH 1.7) than lemon juice!



EOM 12.17

Figure 12.14
Annual average value of pH in precipitation weighted by the amount of precipitation in the United States and Canada for 1980.