ATMO 102 Pacific Climates and Cultures

Lecture: Air Pollution Intro

What do you consider Pollution?

- Smoke
- Dust
- Factory Emissions
- Pollen and Tree Emissions
- Automobile and Truck Emissions
- Sea Salt from Sea Spray
- Smog
- Ozone
- Carbon Monoxide
- Sulfur Dioxide
- Volcanic Ash







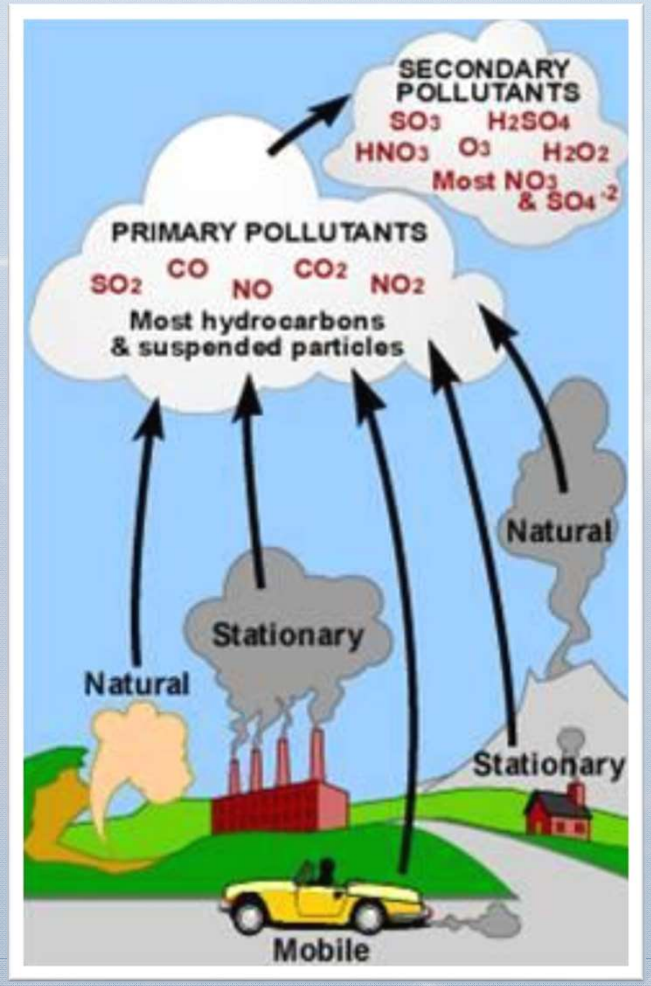



Air Pollution: How do YOU define it?

- **Air Quality?**
  - Hard to breathe, smells bad, looks dirty?
- **Urban/City Pollution?**
  - Health concerns
    - Decreased life expectancy (1.8-3.1 years)
    - Premature deaths (4000 per year)
- An ***Anthropogenic*** (people) Problem
- A ***Natural*** Problem….
- Related to **ATMOSPHERIC STABILITY**!

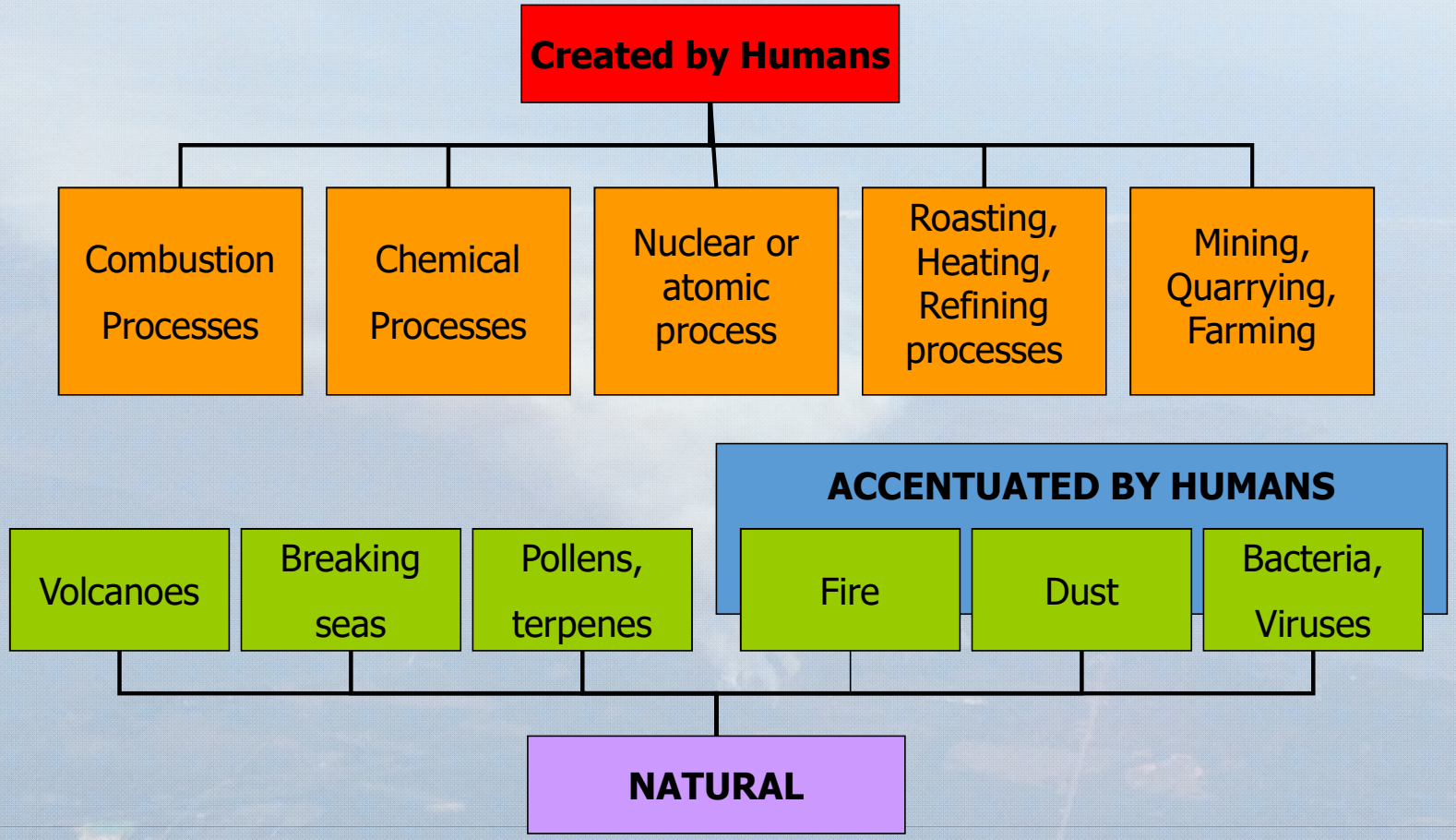
Air is NEVER Perfectly Clean!!!

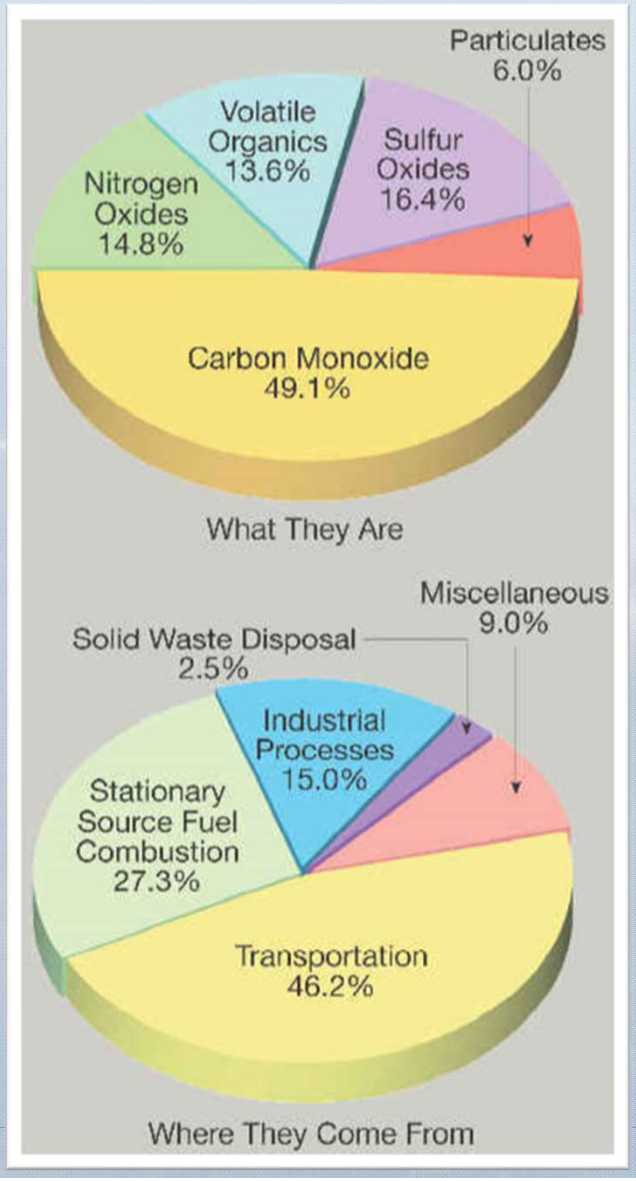
Sources and Types of Air Pollution



- **Air pollutants**
  - Airborne **particles** and **gases** that occur in concentrations that endanger the health and well-being of organisms.
- **Primary Pollutants**
  - **Emitted directly** from the identifiable source
  - Pollutes the air immediately after being emitted
- **Secondary Pollutants**
  - Are produced in the atmosphere by **chemical reactions** between primary pollutants (i.e. smog)

Sources of Primary Pollutants



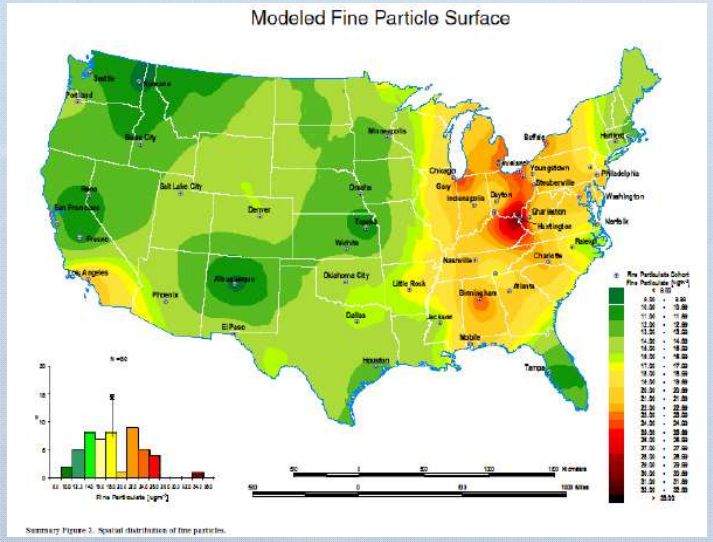


Primary Pollutants

- **Particulate Matter (solid and liquid)**
  - *Fine* are 2.5 micrometers (µm) or less (PM 2.5)
  - *Coarse* are 10 µm or greater (PM 10)
- **Sulfur Dioxide** (SO_2)
- **Nitrogen Oxides** (NO_x) – includes NO_2 and NO
- **Volatile Organic Compounds** (VOCs)
- **Carbon Monoxide** (CO)
- **Lead** (Pb)

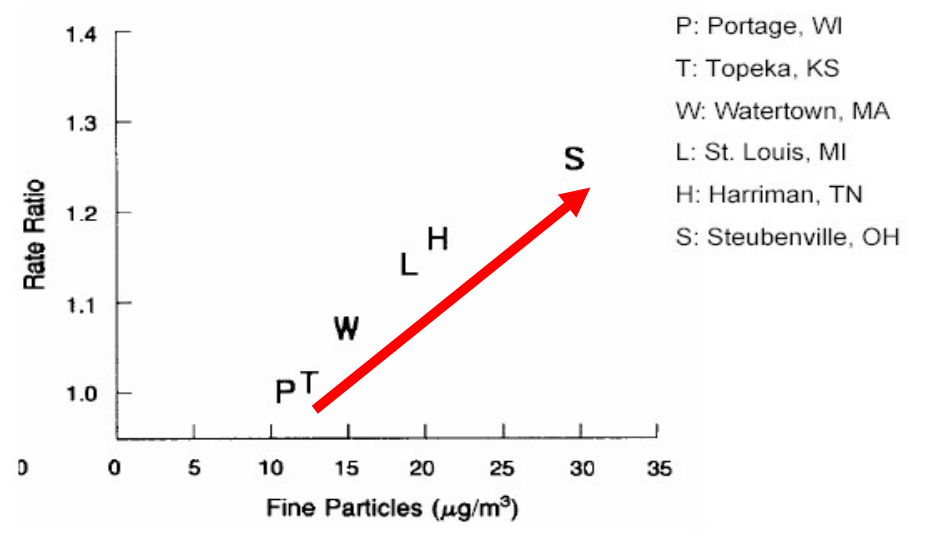
Primary Pollutants – Particulate Matter

- **Particulate Matter (solid and liquid)**
  - ***Fine* are 2.5 µm or less (PM 2.5)**
    - Fuel combustion, fireplaces, wood stoves
    - Get deep into lungs, cause serious health problems
    - Can cause premature death
  - ***Coarse* are 10 µm or greater (PM 10)**
    - Crushing and grinding operations, dust, soot
    - Aggravate asthma and other respiratory conditions
  - Main cause for **REDUCED VISIBILITY** in US.



- Midwest is a big problem due to regions with a lot of industry
  - Lots of coal burning power plants cause a problem because they emit SO_2 which turns into fine particles.

Primary Pollutants - Effects of PM 2.5



- **Six Cities Study**
  - They found that PM2.5 correlated very strongly with increased mortality. That's not to say that other pollutants aren't harmful; they just don't lead to shortened life-spans.

- Many scientific studies have linked breathing PM to a series of significant health problems, including:
  - Aggravates asthma
  - Increases in respiratory symptoms like coughing and difficult or painful breathing
  - Chronic bronchitis
  - Decreased lung function
  - Premature death [see Six Cities Study]

Primary Pollutant – Particulate Matter: Dust

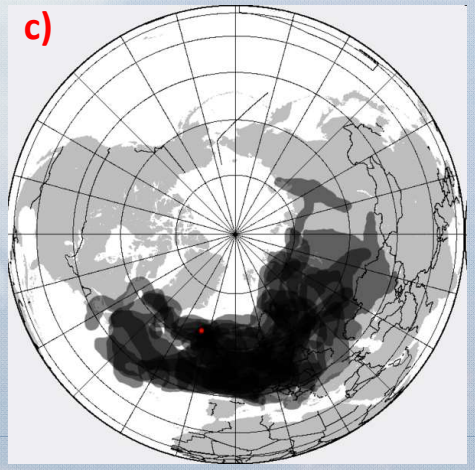
- Visibility reduction
- Breathing issues

Dust Bowl in US 1930s

Primary Pollution – Particulate Matter: Volcanic Ash

- Ash reflects sunlight back to space (cools Earth)
- Dangerous to breathe
- Covers the land surface
- Can cause issues with air travel

All Below: **Eyjafjallajökull, Iceland**. a) the plume is clearly different than the clouds, b) it can cause thunderstorms (surface heating from lava), c) plumes of ash covering Europe, red dot is the volcano, d) plume got very high above the regular cloud deck

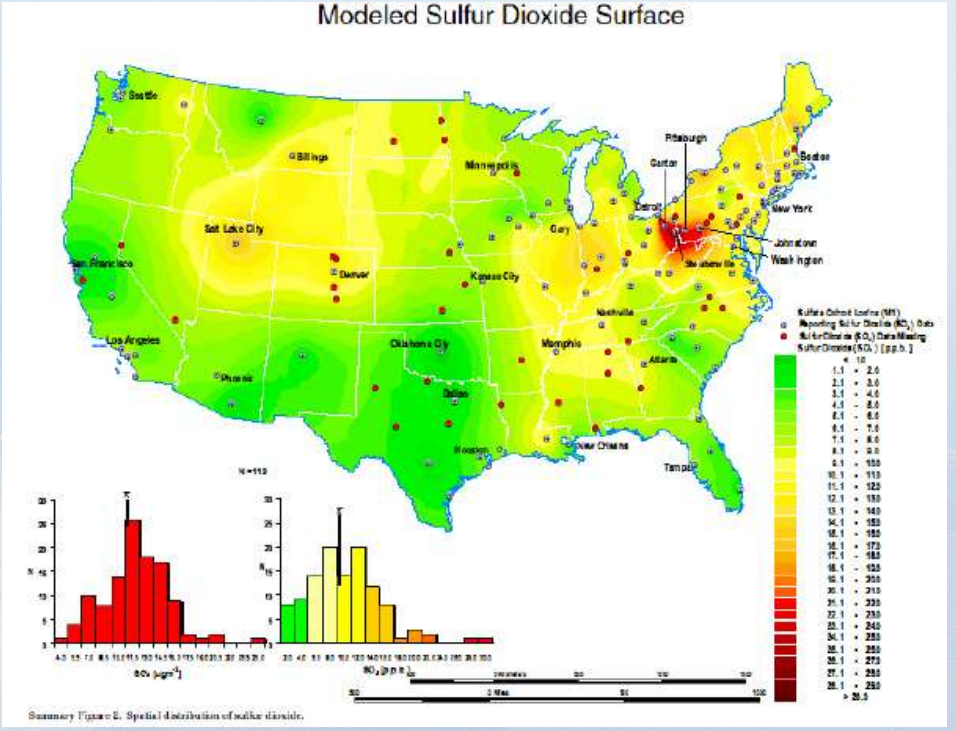


Primary Pollutant – Sulfur Dioxide

- **Is a colorless and corrosive gas**
  - Originates from combustion of sulfur containing fuels (like COAL and OIL)

- **Sources include:**
  - Power plants
  - Smelters
  - Petroleum refineries
  - Pulp and paper mills

- Through chemical reactions in the atmosphere can ultimately form **ACID RAIN (sulfuric acid)**.



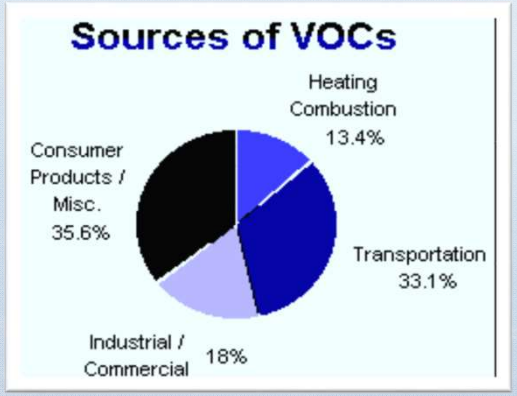
- **Midwest** is BAD.
- There is also the problem of **transport**:
  - The pollution itself may not be produced in the areas that are affected
  - The pollution can be blown/carried with the wind.
  - Affects both the US and Canada

Primary Pollutants - Nitrogen Oxides (NO_x)

- **Formation:**
  - Form during the high-temperature combustion of fuel when nitrogen reacts with oxygen.
- **Acid Rain:**
  - NO_x can react with other substances in the air to form acids which fall to earth as rain, fog, snow or dry particles. Some may be carried by wind.
- **Toxic Chemicals:**
  - In the air, NO_x reacts readily with common organic chemicals and even ozone, to form a wide variety of toxic products, some of which may cause biological mutations.

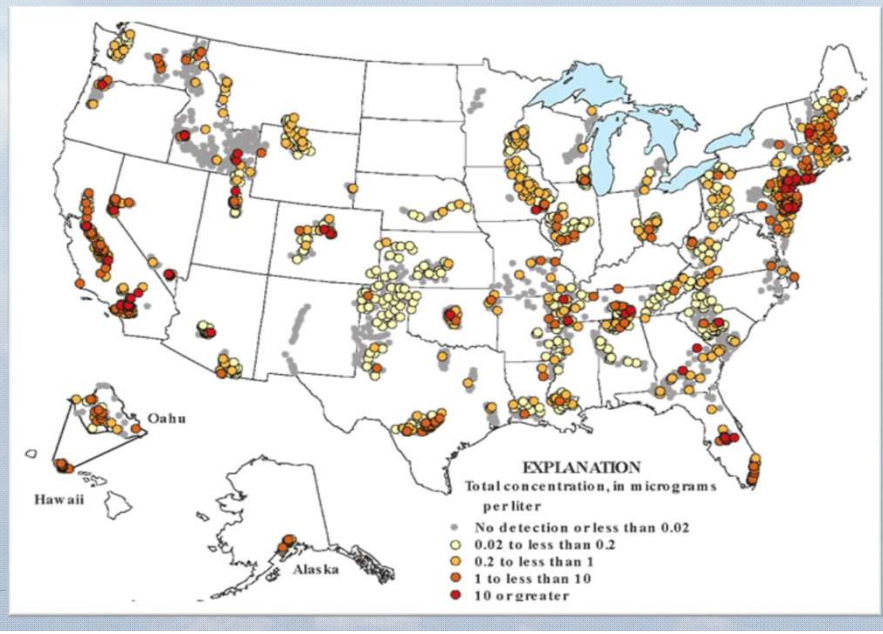
- **Sources include:**
  - Motor vehicles
  - Power plants
  - Some bacteria

Primary Pollutant - Volatile Organic Compounds



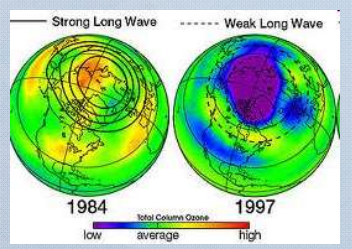
- **Also called *hydrocarbons***
  - *Solid, liquid and gaseous forms*

- **Sources include:**
  - Large quantities occur naturally (CH_4 = methane)
  - In cities incomplete combustion of gasoline
- **Hazard?**
  - by themselves they tend to be harmless…
- **Reactions in the atmosphere:**
  - If they react with other chemicals in the atmosphere they can produce harmful *secondary pollutants*.



Tropospheric Ozone – "Bad" Ozone vs. "Good" Ozone

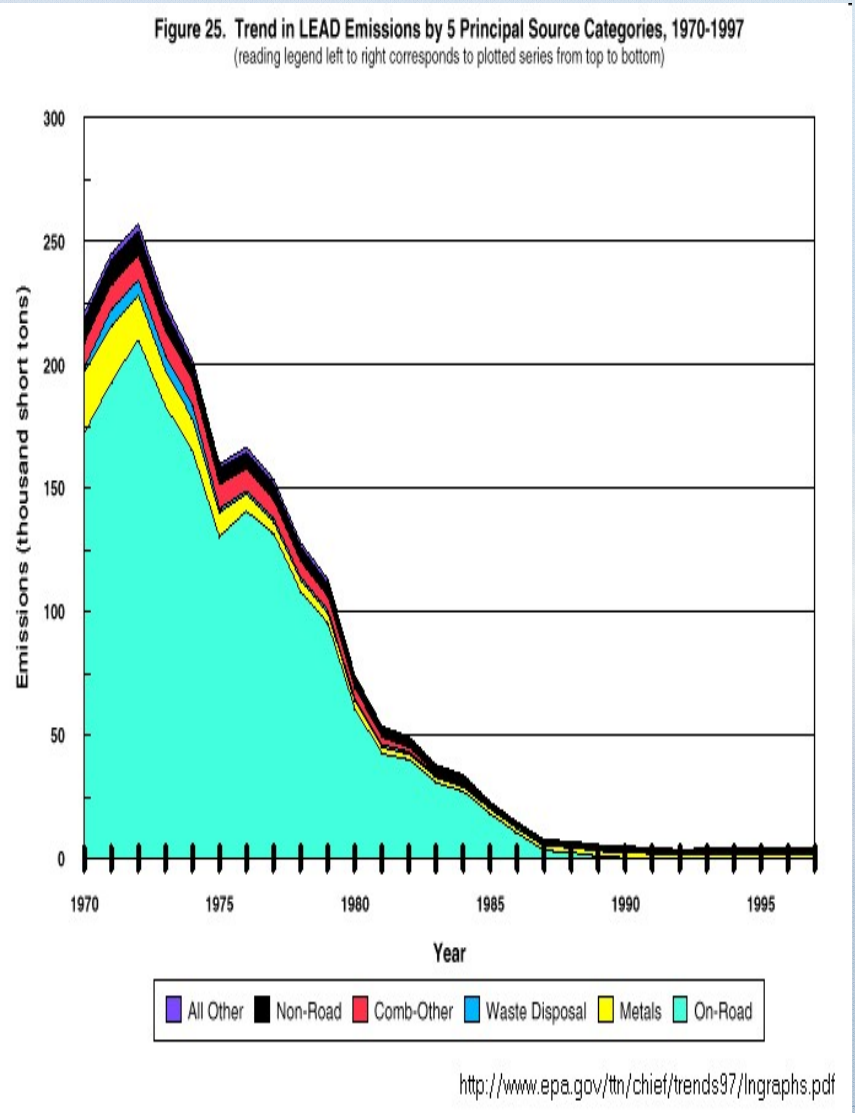
- **BAD Ozone is found in the troposphere**
  - Caused by reactions with "smog" and nitrogen gases including NO_2 and NO:
- **Urban air pollution causes ozone formation.**
  - Sunlight breaks apart NO_2 to produce NO and a free oxygen atom, which reacts with regular oxygen (O_2) to form ozone (O_3)
  - Ozone is an irritant to lungs and is dangerous to those with lung conditions or who are very young or very old.



- **Good Ozone is found in the Stratosphere**
  - Makes the temperature in this layer increase
  - Protects life from harmful UV radiation
  - Is destroyed by chemical reactions involving CFCs (chlorofluorocarbons)
    - Reduced the Ozone layer in the mid 1970 – 1990
    - Problem remediated by international political and scientific cooperation: **Montreal Protocol (1990)**

Primary Pollutant - Carbon Monoxide (CO)

- Is a colorless, odorless and poisonous gas produced by **incomplete burning of carbon in fuels**
- It is the **MOST** abundant primary pollutant
- **Sources include:**
  - In cities incomplete combustion of gasoline or gas used in fireplaces and stoves
- **Central Nervous System Effects:**
  - People who breathe high levels of CO can develop vision problems, reduced ability to work or learn, reduced manual dexterity, and difficulty performing complex tasks.
- **At extremely high levels, CO is poisonous and can cause death.**

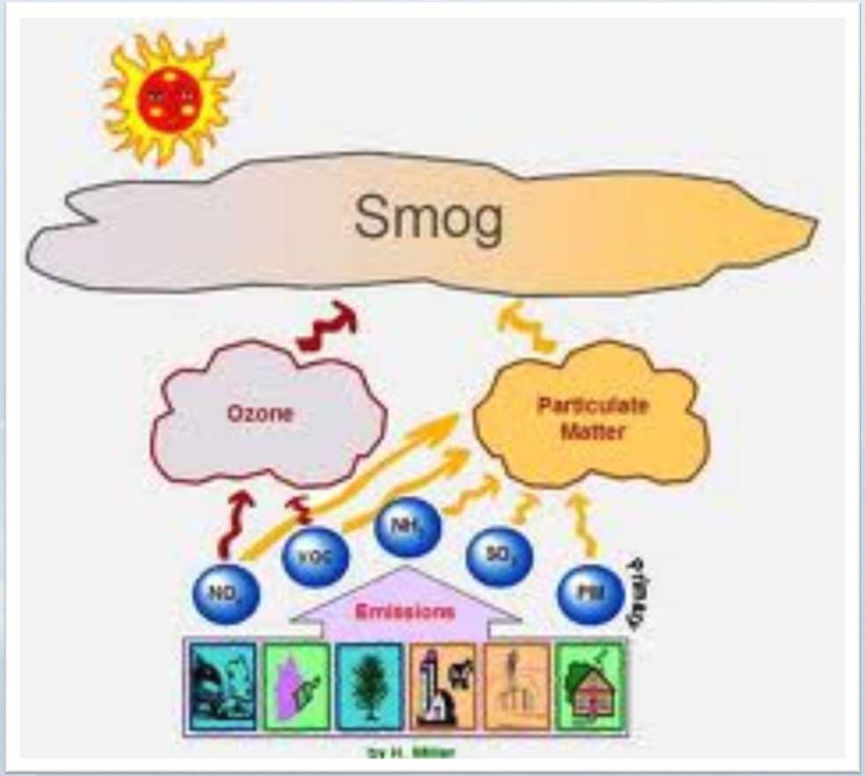


Primary Pollutant – Lead

- **Used to come from Automotive sources**
  - There used to be lead in gasoline!!!
  - That's why we have "unleaded gas" nowadays
- **Damages organs:**
  - Lead causes damage to the **kidneys, liver, brain and nerves, and other organs**. Exposure to lead may also lead to osteoporosis (brittle bone disease) and reproductive disorders.
- **Affects the brain and nerves:**
  - Excessive exposure to lead causes seizures, behavioral disorders, memory problems, and mood changes. Low levels of lead damage the brain and nerves in fetuses and young children, resulting in learning deficits and **lowered IQ**.

Secondary Pollutants

- Not emitted **directly** to the atmosphere
- Result from **chemical reactions between primary pollutants**.
- For Example: **SMOG!!** – Cities like Los Angeles and Mexico City are prone to SMOG!



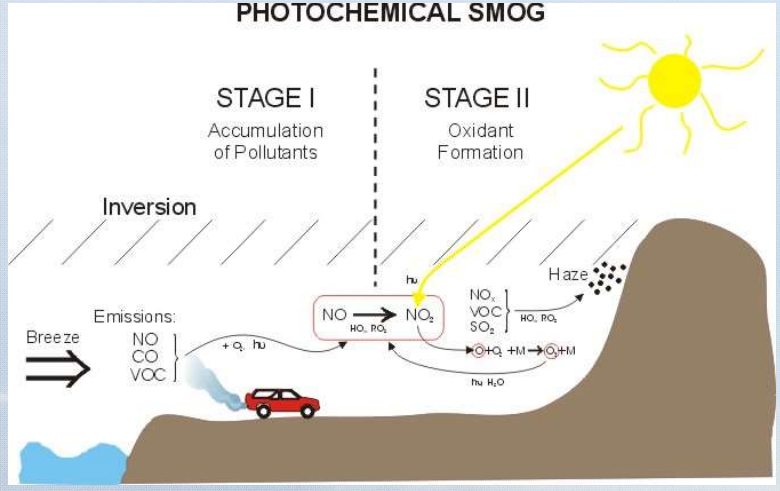
- Different types of reactions produce different types of secondary pollutants
  - **Industrial Smog**
  - **Photochemical Smog**

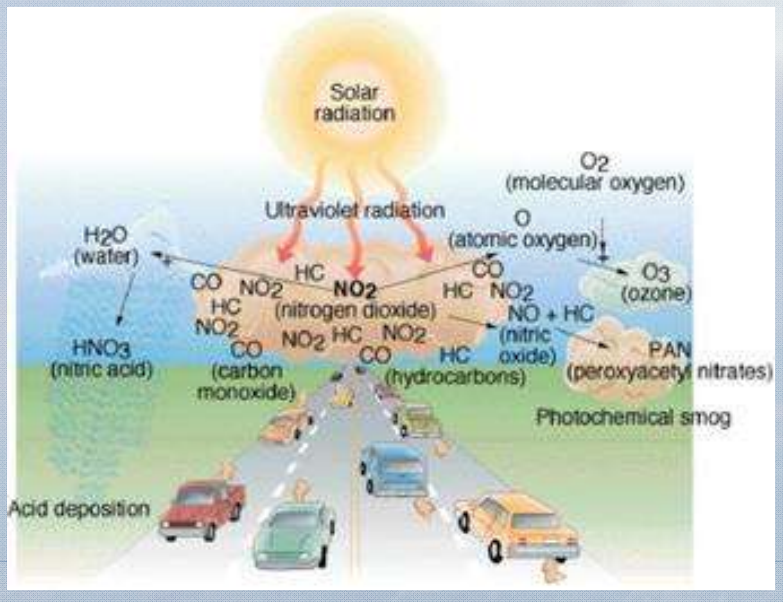
Secondary Pollution - Smog from Industry

- **Where is this?**
  - London, England
  - The 1952 Smog Disaster Killed 4,000 people!

- **Industrial Smog**
  - coal or oil is burned, some portion is completely combusted, forming CO_2, some partially combusted producing CO, and some unburned that is released as soot, or particles of carbon.
  - With reactions in the atmosphere some sulfur containing compounds are made.

Secondary Pollutants – Photochemical Smog





- **Photochemical Reactions**
  - "Photo" → photons & energy from the sun
  - "Chemical" → the compounds in the atmosphere

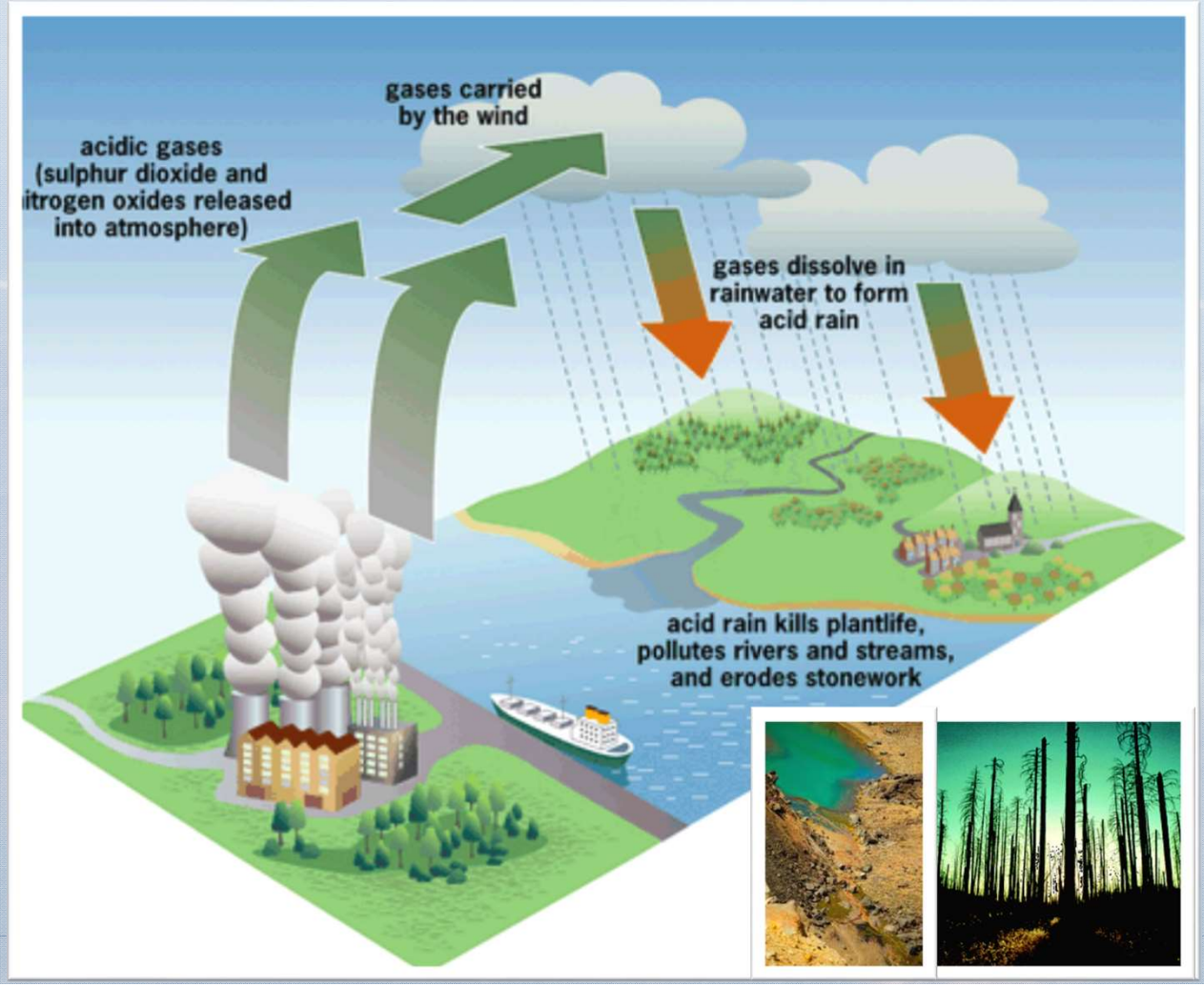
- Can result in "**Photochemical Smog**"
  - Ex: Nitrogen oxides absorb solar radiation causing chemical reactions to occur.

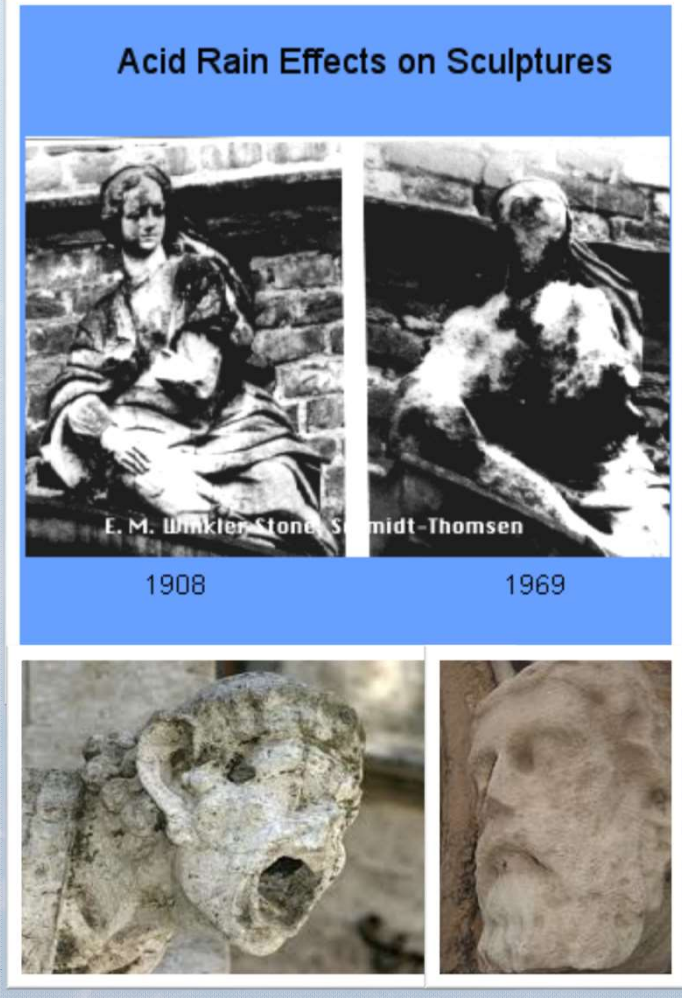
  - If certain **VOCs** are present, other more dangerous and toxic compounds can be formed.

Acid Precipitation

- Fossil fuel burning releases tons of sulfur and nitrogen oxides
- **These pollutants can be converted into acids** (like sulfuric acid)
- They leave the atmosphere by:
  - **Wet deposition (rain)**
  - **Dry deposition (dust/smoke)**
- **Effects:**
  - Damage and Kill Trees
  - Damage and "melt away" stone statues and structures
  - Changes the pH of lakes and rivers
    - Kills fish and other wildlife

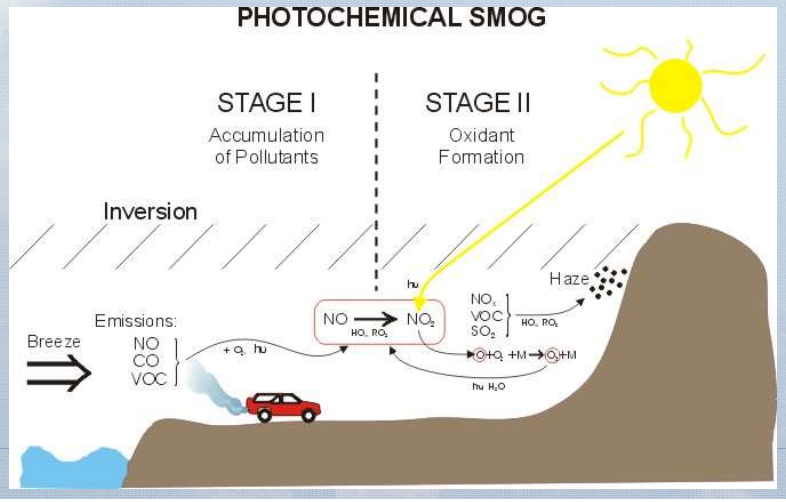
Acid Rain Formation & Effects



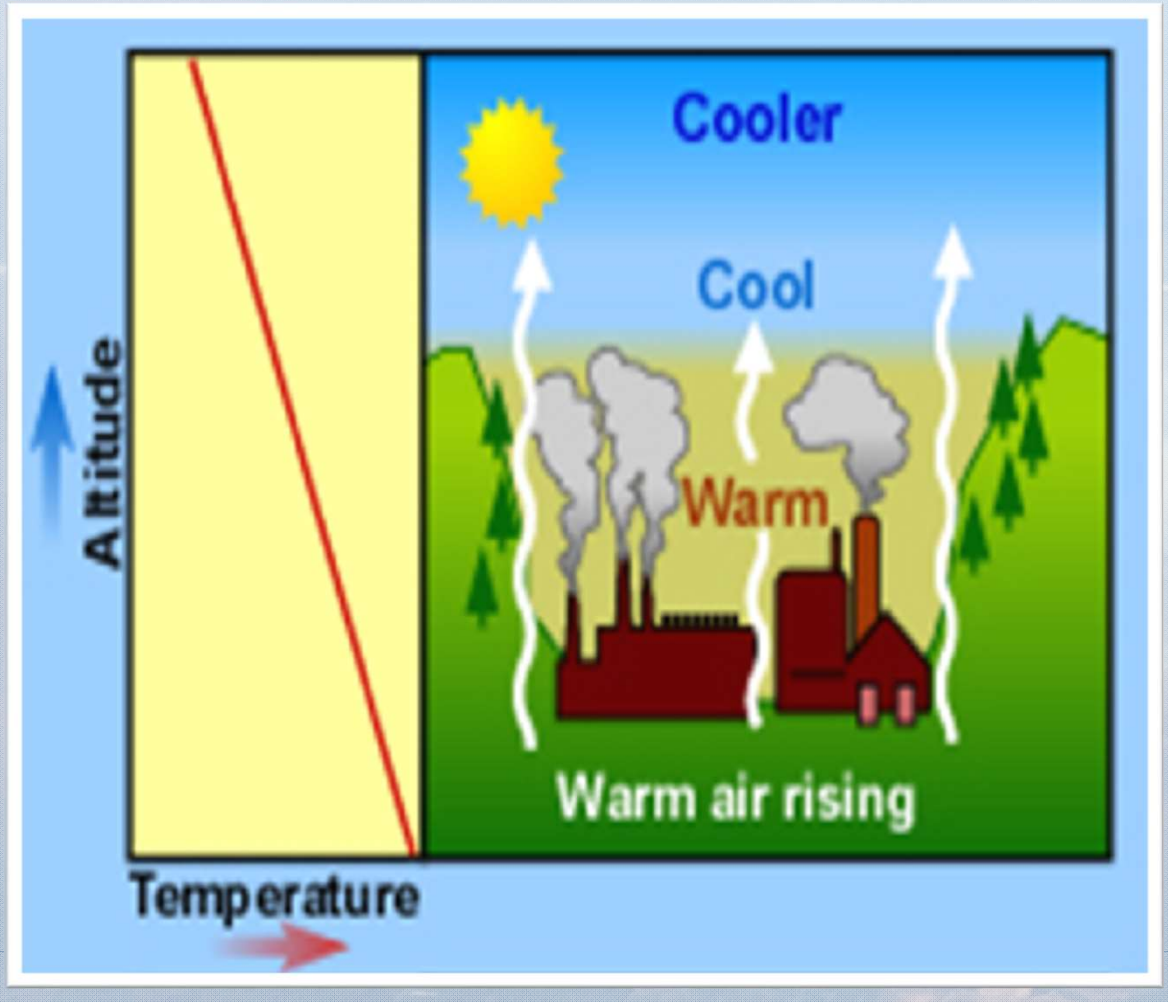


The Role of Weather in Pollution

- **Wind**
  - **Speed**
    - Determines the concentration of pollution
    - Determines how turbulent the air is
    - How fast the plume moves and is mixed with “clean” air
  - **Direction**
    - What area (near people or not) is affected
- **Atmospheric Stability**
  - Determines the extent to which vertical motions will mix the pollution with cleaner air above.
- **An increase in air temperature with height.**
  - Often simply called an inversion
  - Warm air over cooler air
  - Acts as a **lid** and can trap pollution
  - This is why LA and Mexico City have such bad pollution problems!!!!



Without a Temperature Inversion



- Here we have **warmer temperatures by the surface and cooler air on top** with **mixing in the atmosphere**.
- The temperature decrease with height is represented by the red line.
- The decrease is known as the **environmental lapse rate** and is approximately 6.4 ºC/1000m (3.5 ºF/ 1000ft)

With a Temperature Inversion

- Here we have **cool air trapped below a warmer layer**.
- The height at which the temperature increase occurs corresponds to where the pollution gets stopped.
- **Your rising warm air is inhibited by the inversion.**