Welcome

APTI 452
Principles and Practices of
Air Pollution Control

Administrative

- Facilities
  - Rest Rooms
- Schedule/breaks
- Cell Phones
- Lunch
- Sign-In Sheet

Administrative

To receive credit for the class you must:

1) Sign in every day
2) Take the pre test
3) Take the final exam

Materials

- Registration Form
- Notebooks/Agenda
- Evaluation form - online

Ground Rules

- Ask questions
- Participate
- Provide the benefit of your experience
- Be on Time
- Feedback on Evaluations

Audience Profile

1. Agency
2. No. of Years/Months/Days
3. Work unit (permitting, enforcement)
4. No. of Inspections Yearly

Pre - Test

Make sure your name is legible

Overview of Air Quality Management

The Heart of the Process

U.S. Air Quality Management Process

Federal-Regional-State Roles

FEDERAL

- National standards, rules, and enforcement
- Consistency of policies and programs
- Technical guidance
- Reports on progress in reducing air pollution
- Ultimate authority & accountability

Federal-Regional-State Roles

REGIONAL

- Conduct assessment and characterization
- Help develop multi-state strategies and trading programs
- Regional planning/coordination for implementation of national programs

Federal-Regional-State Roles

STATE

- State rules
- Source Permits
- Compliance & enforcement
- Implementation Plans
- Implement national rules & guidance
- Monitoring, modeling, emission inventories

National Ambient Air Quality Standards (NAAQS)

- Clean Air Act requires primary NAAQS that "are requisite to protect the public health"
  - including sensitive subgroups

- Different considerations apply
  - Setting NAAQS (EPA): health and environmental effects
  - Achieving NAAQS (states): account for cost, technical feasibility, time needed to attain

[redacted]

Some Major Issues

- Regional and international transport of air pollution
- Effective market-based approaches for reducing air pollution
- Evaluating, communicating, and reducing risk to public health from air toxics
- Multi-pollutant effects
- Multi-media approaches
- Balancing “carrot and stick“ in our regulations & programs

Citizen Involvement

- Public Participation
  - Hearings on Rules/Permits
  - Comment Periods on Proposed Rules
  - Workshops
- Administrative Review
  - Agency Review Boards
- Legal Review
  - State Courts
  - Federal Courts

Economic Growth & Environmental Improvement

■ **Power Plant SO_2 Emissions (million tons)**

□ **Power Plant NOx Emissions (million tons)**

GDP

Summary

- Air Quality Standards/Goals and Timelines are key
- Technical Tools and Information are essential
- Air Quality Management Process is iterative and adaptable
- Transparency is important to maintain credibility
- Focus on results not just process

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 1:

Control Program History

Chapter Overview

- Control Program History
- Air Pollution Control Programs
- Hierarchy of Government Responsibilities
- Air Pollution Management
- Future Focus of Responsibilities

Air Pollution Control Programs

- Air Pollution Episodes
- Improvements in Science
- Changes in Society and Economy
- Environmental Activism and Public Awareness

Air Pollution Episodes

- 1930 Meuse, Belgium, 63 people died
- 1948 Donora PA, 22 people died
- 1952 London, England, 4,000 people died
- 1953 New York City, 200 people died
- 1984 Bhopal, India 3,700-16,000
- 1980's – Present – China/India

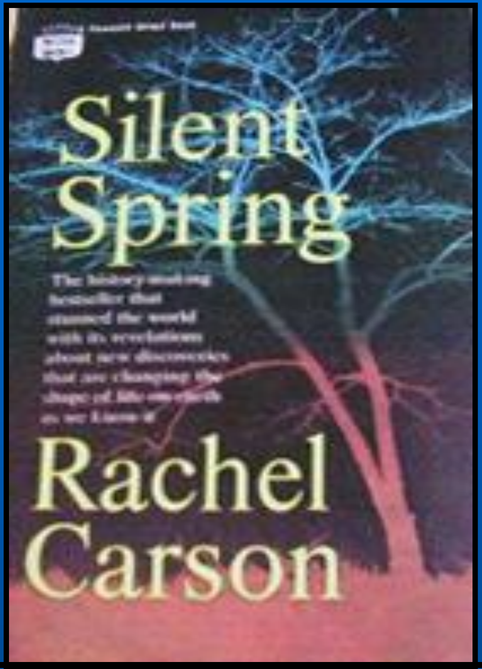
Improvements in Science

- In the 1950s, Professor A.J. Haagen-Smith showed that under ultraviolet irradiation, organic compounds and oxides of nitrogen react to produce smog
- In 1963 data indicated increased mortality with levels of high sulfur dioxide and/or smoke.
- By 1980, air pollution meteorology came of age.

Changes in Society and Economy

- Longer Life Span
- Costs of a Higher Standard of Living

Environmental Activism and Public Awareness



Earth Day

Sierra Club
Founded 1892

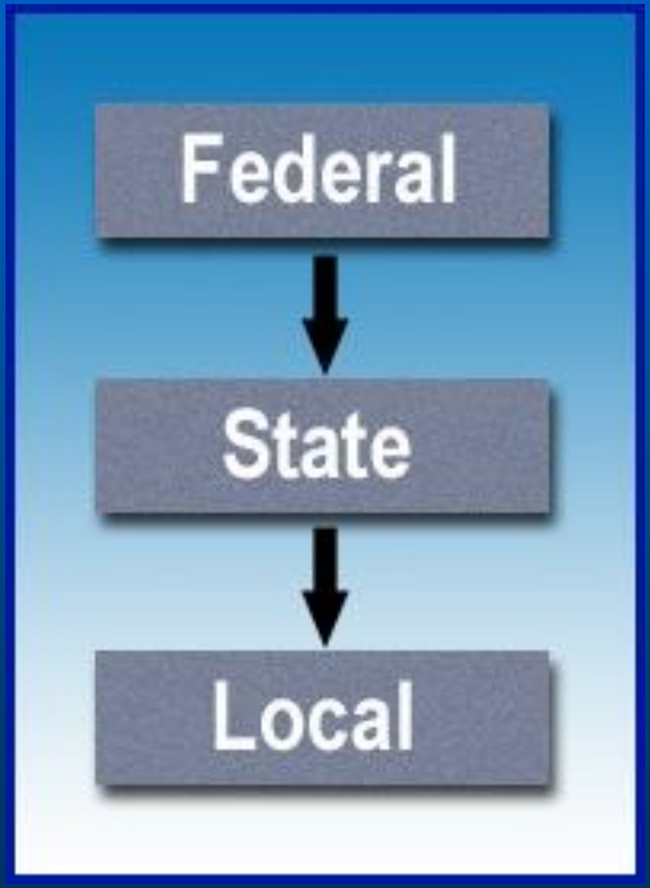
NRDC

The Nature Conservancy®
Saving the Last Great Places

National Wildlife Federation

Friends of the Earth International

Hierarchy of Government Responsibilities



Federal Legislative Landmarks

1955

Air Pollution Control Act of 1955

Federal Legislative Landmarks

1955

1963

Clean Air Act of 1963

Federal Legislative Landmarks

Motor Vehicle Air Pollution Control Act 1965

Federal Legislative Landmarks

Air Quality Act of 1967

Federal Legislative Landmarks

1955 1965 **1970**

1963 1967

Clean Air Act Amendments of 1970

Clean Air Act Amendments of 1970

- Goal of 90% reduction in vehicle emissions in 5 years
- National Ambient Air Quality Standards (NAAQS) and required states to produce a plans to meet NAAQS.
- National Emission Standards for Hazardous Air Pollutants (NESHAPs), to identify and regulate "hazardous air pollutants."
- Empowered EPA to establish New Source Performance Standards (NSPS) for significant sources of air pollution

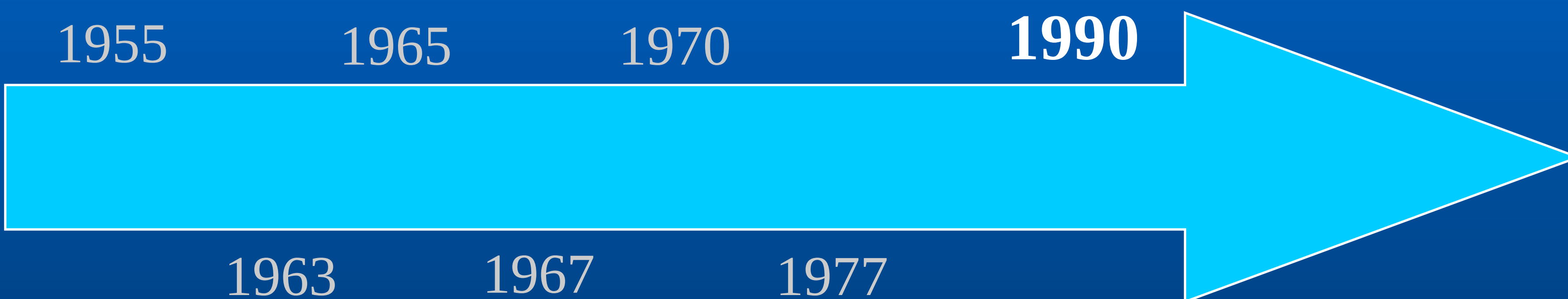
Federal Legislative Landmarks

Clean Air Act Amendments of 1977

Clean Air Act Amendments of 1977

- "Prevention of Significant Deterioration" (PSD) and "Nonattainment" Provisions.
- New Source Review program for construction and modification of new major sources.
- Provided a much longer and realistic time frame achieve compliance with the NAAQS.
- Strengthened auto emission standards
- Regulated chemicals that damage the stratospheric ozone layer.

Federal Legislative Landmarks



Clean Air Act Amendments of 1990

1990 Clean Air Act Amendments

- The air quality in several urban regions had only marginally improved.
- Overhauled the HAPs program, strengthened nonattainment provisions, and added the operating permit, acid rain and ozone depletion programs.
- Greatly expanded federal enforcement provisions; criminal penalties expanded to include felony provisions
- EPA administrative powers significantly increased via "administrative penalty orders."

Federal Regulatory Landmarks

- 1993 Schedule to end CFC's
- 1994 New HAP standards for Chemical plants
- 1996 Lead out of Gasoline Rule
- 1999 Regional Haze Rule
- 1999 New Tailpipe Emissions Rule
- 2004 Off Road Vehicle
- 2005 Clean Air Interstate Rule

Federal Regulatory Landmarks

2006 NAAQS For Particulates

2009 Greenhouse Gas Rule

2011 New Boiler Regs

Mercury Regs

Cross-State Air Pollution Rule

2012 Oil and Nat. Gas Rule (Fracking)

2013 Power Plant Carbon Rule

2014 New Ozone Standards (late 14)

Air Pollution Management

- Strategies
- Implementation

Strategies: A Comparison

Table 1-1. Comparison of Air Quality Management Strategies

Strategies	Cost	Simplicity	Enforceability	Flexibility	Adaptability
Air Quality Management	Good	Poor	Fair	Fair	Fair
Emission Standards	Terrible	Excellent	Excellent	Poor	Fair
Emission Taxes	Fair	Excellent	Excellent	Unnecessary	Good
Cost-benefit Analysis	Excellent	Terrible	Unknown	Unknown	Good

(Source: A.C. Stern, *Air Pollution* Vol. V (Academic Press: New York, 1977), p. 33.

Implementation

- National Ambient Air Quality Standards (NAAQS)
- Air Monitoring
- Source Inventories
- Air Pollution Modeling
- Enforcement

Future Focus of Responsibilities

- Current Situation - Control
- New Strategies - Prevention
- Other Issues

Chapter Summary

- Control Program History
- Why Air Pollution Control Programs?
- Hierarchy of Government Responsibilities
- Air Pollution Management
- Future Focus of Responsibilities

Review Questions

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 2:

Human Health and Environmental Effects

Of Air Pollution

Chapter Overview

- Hazardous Effects of Air Pollutants on the Human Body Systems
- Criteria Pollutants
- Toxic Air Pollutants
- Environmental Effects of Air Pollution
- Risk Assessment

Hazardous Effects of Air Pollutants on the Human Body Systems

- Pollutant Movement Through the Body
- Upper Respiratory System
- Lower Respiratory System

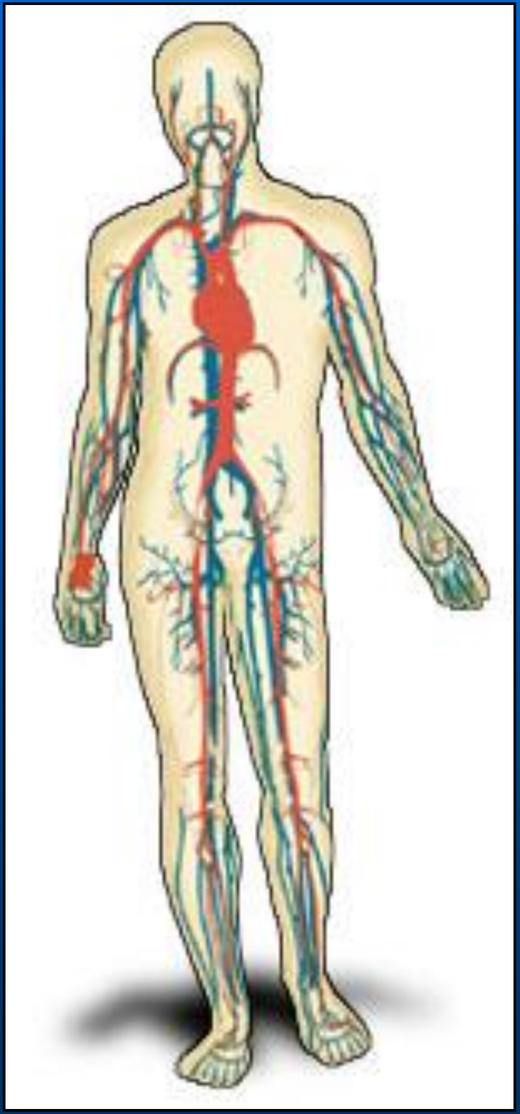
Pollutant Movement Through the Body

- Entry Points
  - Mouth/nose
  - Skin
  - Ingestion

- Susceptible Groups
  - elderly, infants, pregnant women, and those with chronic lung or heart disease.

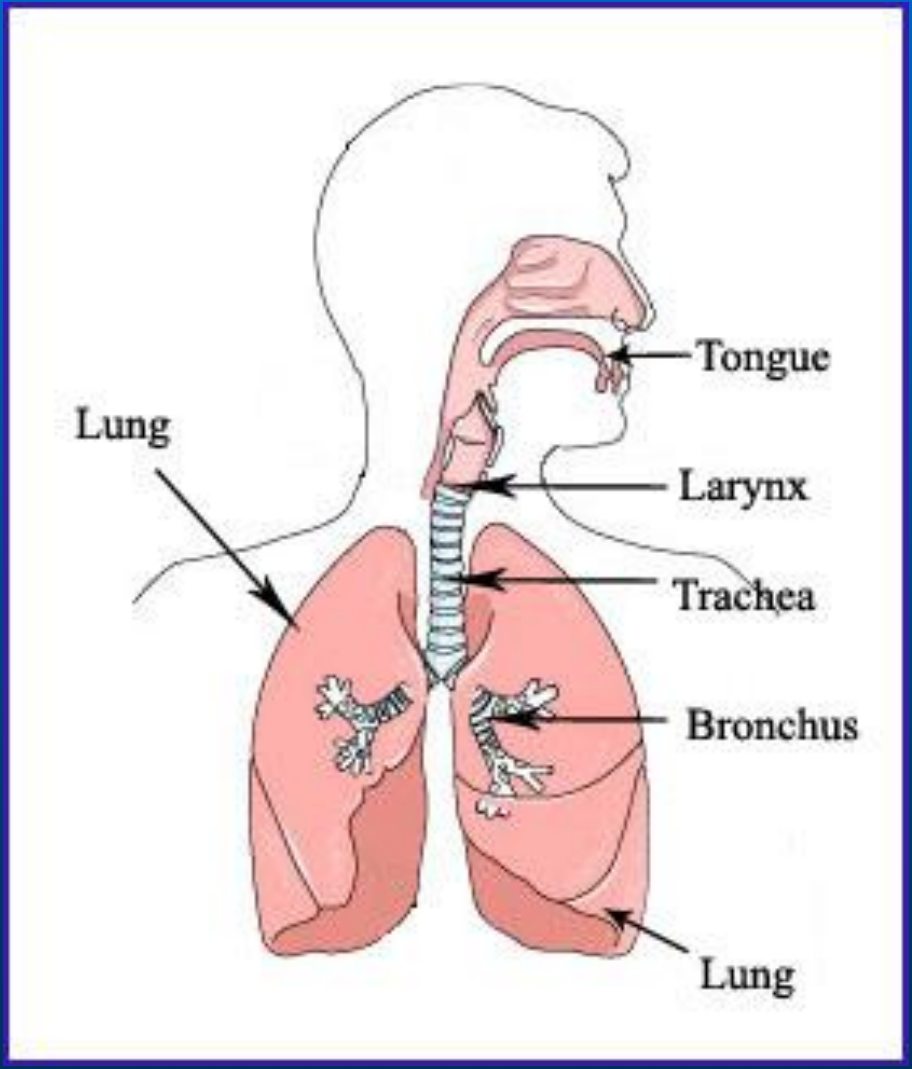
Basic Health Effects of Pollutants

- Pollutants interfere is by altering the chemical reactions that take place within individual cells.
- Manifests as either an acute (short-term) or chronic (long-term) health effect.



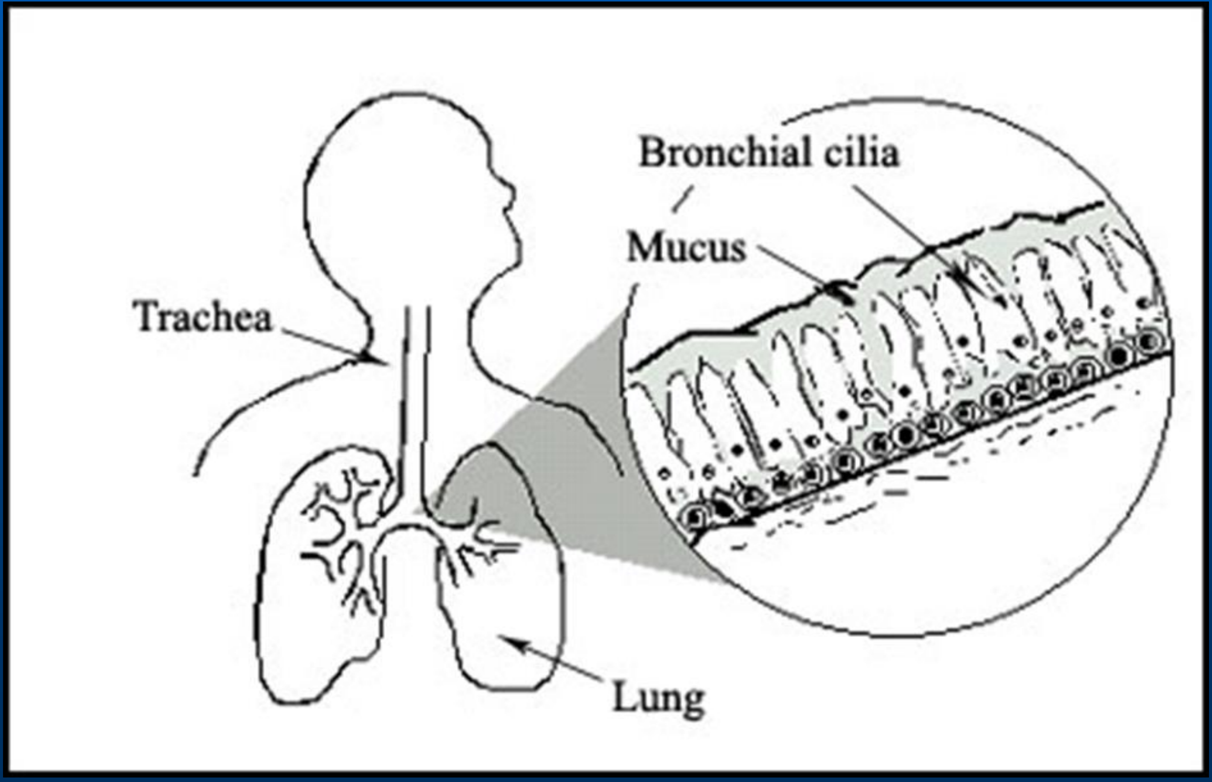
Pollutants and the Upper Respiratory System

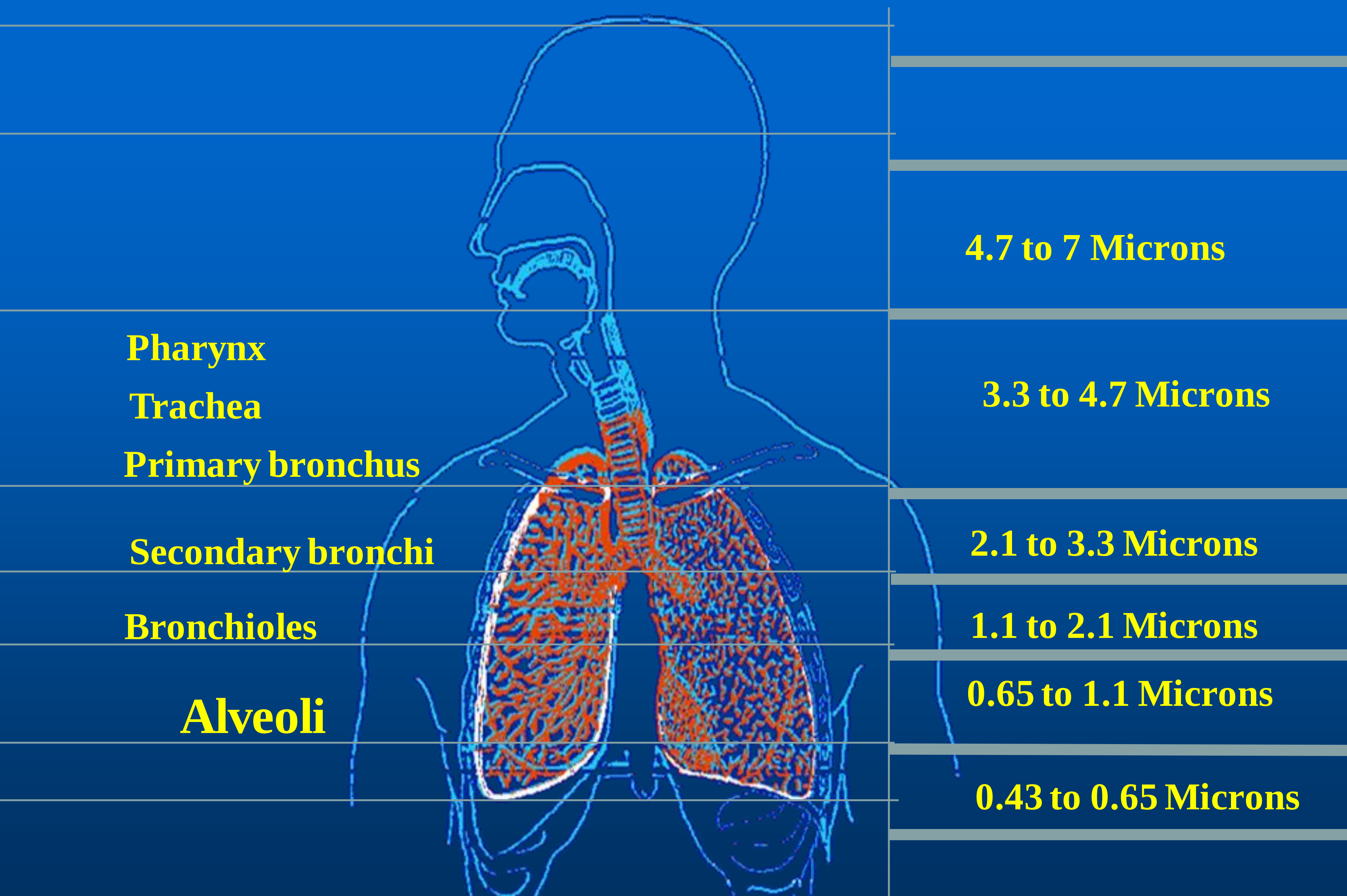
- Entry
- Defenses
  - Cilia
  - Nasal hairs
  - Mucus membrane



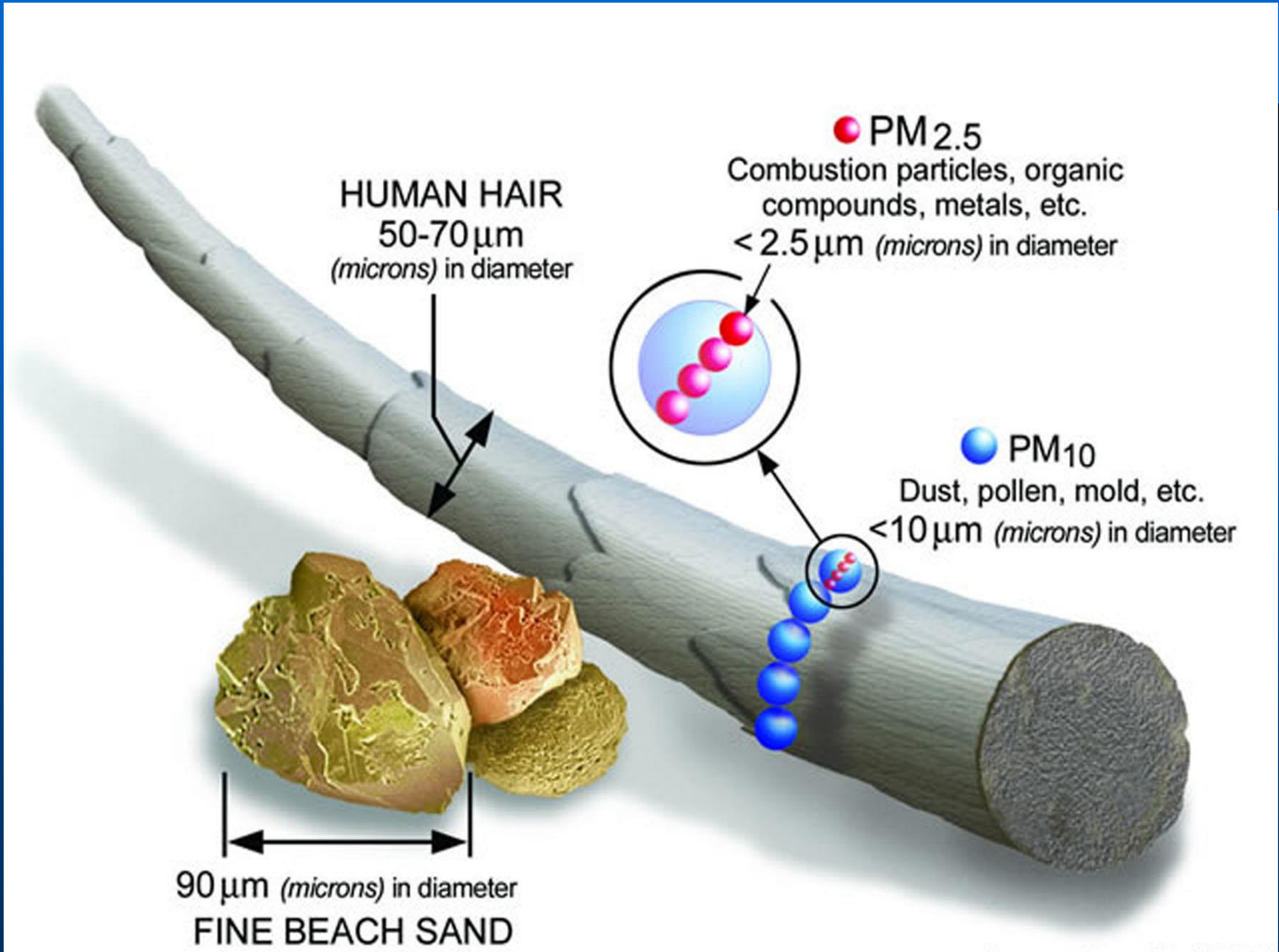
Pollutants and the Upper Respiratory System

- Smaller particles (<10 microns) can escape defense mechanisms

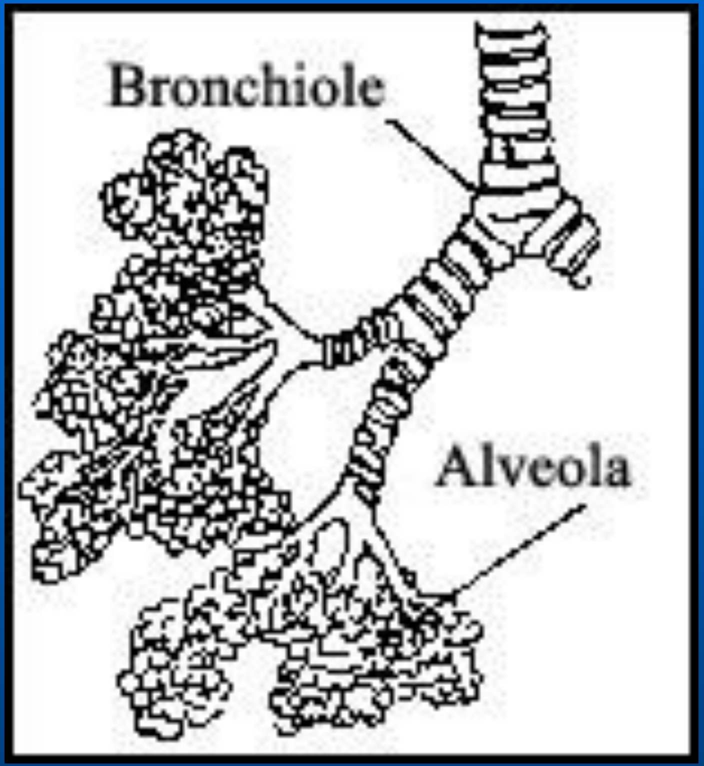




Respiratory System Penetration vs. Particle Size


HUMAN HAIR
50-70 µm
(microns) in diameter
PM2.5
Combustion particles, organic compounds, metals, etc.
< 2.5 µm (microns) in diameter
PM10
Dust, pollen, mold, etc.
<10 µm (microns) in diameter
90 µm (microns) in diameter
FINE BEACH SAND

Lower Respiratory System



Each bronchus subdivides into smaller tubes called the bronchioles.
The bronchioles end in millions of tiny air sacs called alveoli.

Heath Effects of Criteria Pollutants

O_3: Ozone

CO: Carbon Monoxide

NOx: Oxides of Nitrogen

SOx: Oxides of Sulfur

PM_{10}: Particulate Matter $\leq$ 10 microns

Pb: Lead

Criteria Pollutants

The NAAQS have “Primary” and “Secondary” categories.

Primary is based on human health and welfare

Secondary is based on property and agricultural crop dam

Particulate Matter (PM)

- A general term used for a mixture of solid particles and liquid droplets found in the air
- Natural, mobile and industrial sources
- Impacts the respiratory system

Lead (PB)

- Enters through ingestion and inhalation
- Bioaccumulates
- Impacts the central nervous system
- Sources are
  - Historical (leaded gasoline and paint)
  - Brakes
  - Gun ranges
  - Speedways
  - Airports

Sulfur Dioxide (SO_2)

- Irritation and inflammation of tissue that it directly contacts.
  - Asthma

- Sources are combustion processes

Carbon Monoxide (CO)

- Absorbed by the lungs and reacts with hemoglobin reduces the oxygen carrying capacity

- Can cause
  - Mental impairment
  - Aggravation of heart disease
  - Death
- Sources are motor vehicles, marine engines, heaters and stoves

Nitrogen Dioxide (NO_2)

- A reddish brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO).

- Impacts airway responsiveness and lung function
- Sources are high-temperature combustion processes

New NASA Images Highlight U.S. Air Quality Improvement | NASA

http://www.nasa.gov/content/goddard/new-nasa-images-highlight-us-air-quality-improvement/#.U8a-VI1dVBY

Ozone (O3) Formation

- Reactive (non-methane) hydrocarbons and NOx accumulate in the atmosphere and are exposed to the ultraviolet component of sunlight, the formation of new compounds, including ozone.
- Absorption of ultraviolet light energy by NO2 results in its dissociation into nitric oxide and an oxygen atom. The oxygen atoms react with atmospheric molecular oxygen to form ozone.

Ozone (O_3) Formation

Ozone (O_3)

- Decreases in lung function and increased respiratory symptoms.
- At-risk groups include outdoor workers and athletes
- Ozone is formed by the reaction of VOCs and NOx in the presence of heat and sunlight.
- VOCs are emitted from motor vehicles, chemical plants, refineries, factories, and consumer products.
- Nitrogen oxides are emitted from motor vehicles, power plants, and other sources of combustion.

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month average	0.15 $\mu g/m^3$ (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.075 ppm (3) (0.07ppm)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution Dec 14, 2012	$PM_{2.5}$	primary	Annual	12 $\mu g/m^3$	annual mean, averaged over 3 years
		secondary	Annual	15 $\mu g/m^3$	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

as of October 2011

Heath Effects of Criteria Pollutants

CRITERIA POLLUTANT	BODY SYSTEM	HEALTH EFFECTS	
Particulate Matter ($PM_{2.5}$ and PM_{10})	**Lower respiratory system.**	▪ Asthma ▪ Bronchitis ▪ Reduced lung function	▪ Cancer ▪ Heavy metal poisoning
Lead (Pb)	**Organs and soft tissue.**	▪ Anemia ▪ High blood pressure ▪ Cancer	▪ Neurological disorder ▪ Intellectual function
Carbon Monoxide (CO)	**Circulatory system.**	▪ CO poisoning ▪ Angina pectoris ▪ Neurological dysfunction	▪ Brain damage ▪ Fetal abnormalities ▪ Asphyxiation
Nitrogen Dioxide (NO_2)	**Respiratory system.**	▪ NO_2 poisoning ▪ Asthma ▪ Lowered resistance to infection	
Sulfur Dioxide (SO_2)	**Respiratory system.**	▪ Asthma ▪ Bronchial constriction ▪ SO2 poisoning	▪ Heart attack
Ozone (O_3)	**Respiratory system.**	▪ Lung inflammation ▪ Reduced lung elasticity ▪ Transient cough	▪ Chest pain ▪ Throat irritation ▪ Nausea

Toxic/Hazardous Air Pollutants

- Toxic or hazardous air pollutants (HAPs) are those pollutants that may cause cancer or other serious health effects or adverse environmental and ecological effects and are not covered by NAAQs.
- There are 187 HAPs.
- NESHAPS are emission standards for HAPs.

Toxic Air Pollutants (cont.)

- National Toxics Inventory (NTI) tries to estimate and track national emissions trends for the 188 HAPs

Environmental Effects of Air Pollution

- Environmental Issues
- Acid Rain
- Visibility
- The Greenhouse Effect
- Stratospheric Ozone Depletion

Environmental Issues

- Ecosystem
- Property Damage
- Quality of Life

Acid Rain

- Nature and Source of the Problem
- Health and Environmental Effects

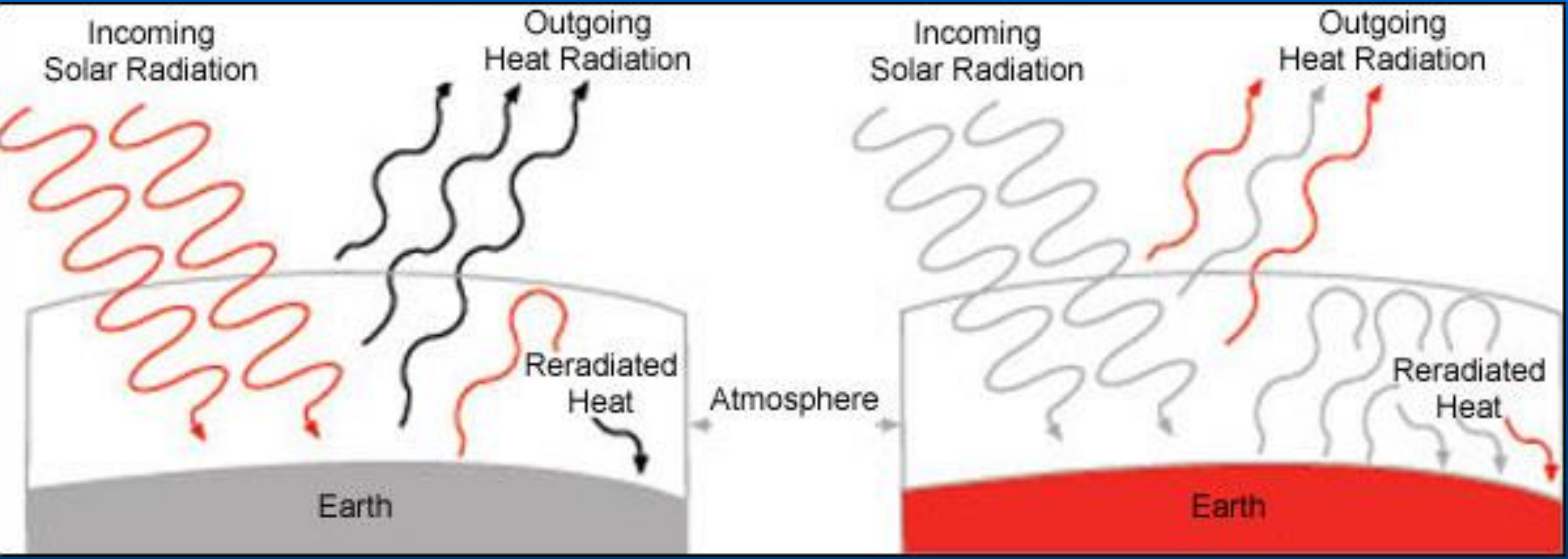
Visibility

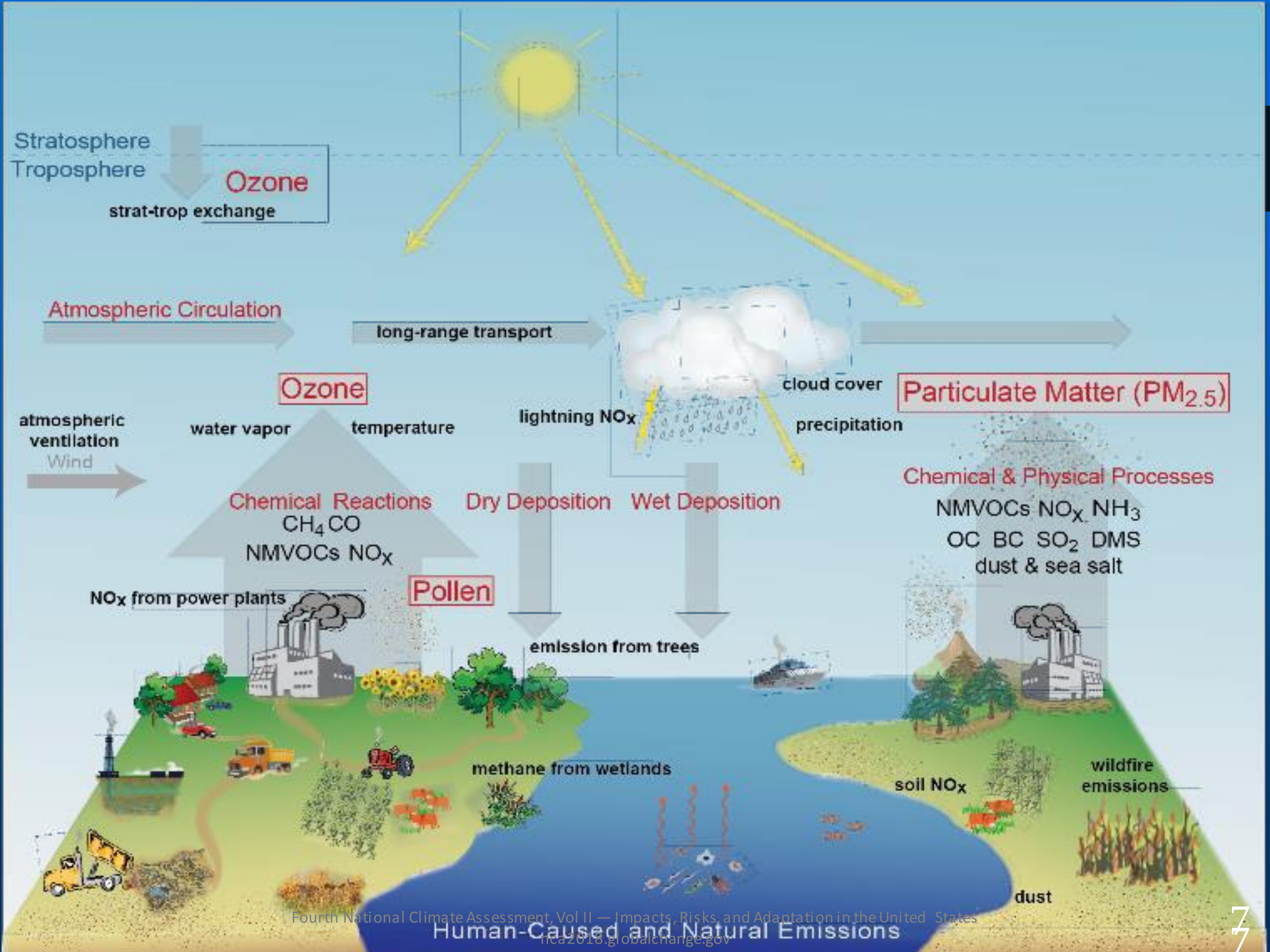
- Nature and Source of the Problem

The Greenhouse Effect

- Nature and Source of the Problem
- Health and Environmental Effects
- International Developments

The Greenhouse Effect (cont.)




Stratosphere
Troposphere
Ozone
strat-trop exchange
Atmospheric Circulation
long-range transport
Ozone
atmospheric ventilation
Wind
water vapor
temperature
lightning NOx
cloud cover
precipitation
Particulate Matter (PM2.5)
Chemical & Physical Processes
NMVOCs NOx NH3
OC BC SO2 DMS
dust & sea salt
Chemical Reactions
CH4 CO
NMVOCs NOx
Dry Deposition
Wet Deposition
NOx from power plants
Pollen
emission from trees
methane from wetlands
soil NOx
wildfire emissions
dust
Human-Caused and Natural Emissions

The Greenhouse Effect (cont.)

- Climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life.

The Greenhouse Effect (cont.)

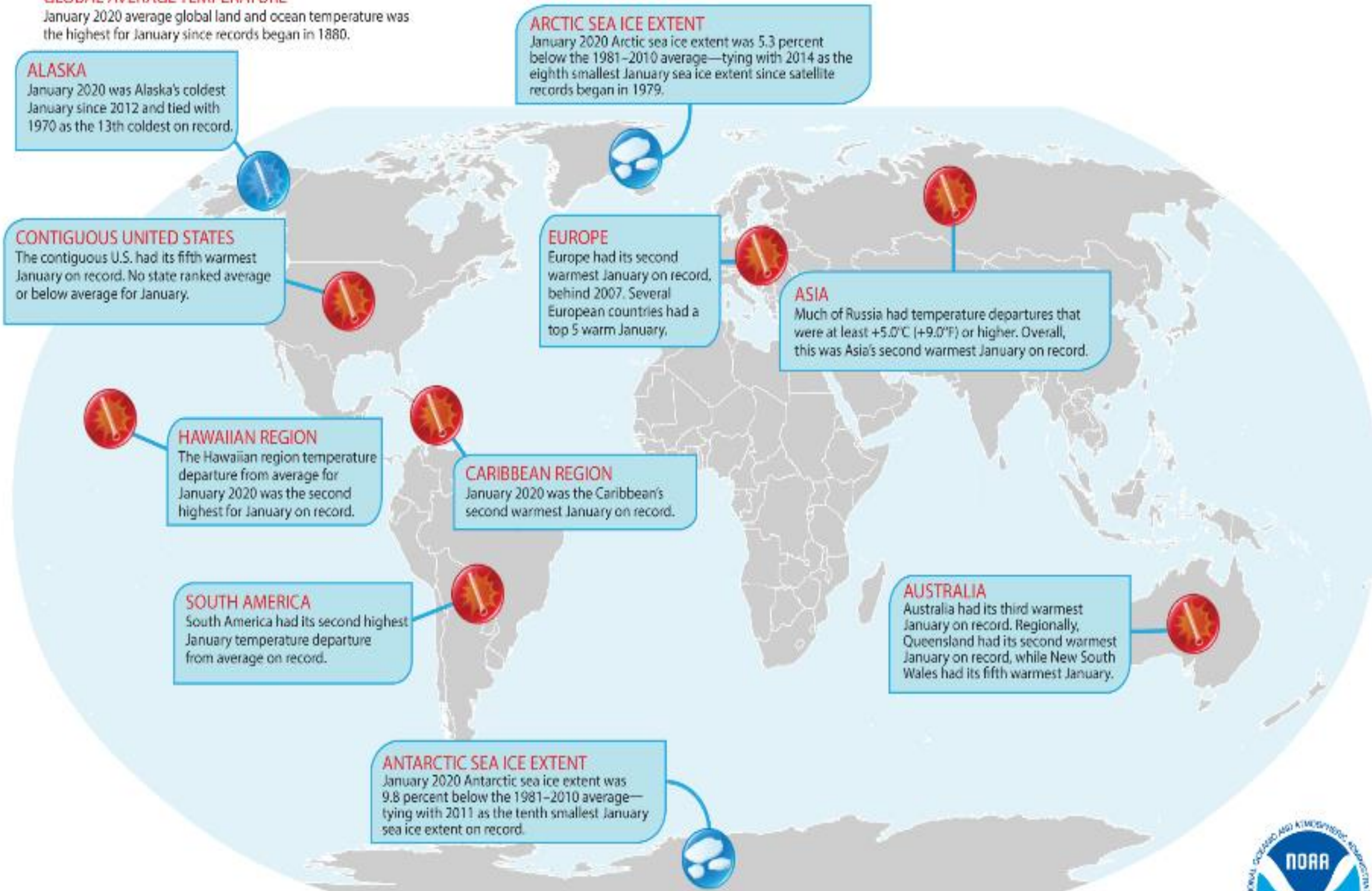
- State of the Climate in 2019

http://www.climate.gov

- Kyoto Protocol included greenhouse gas emission targets for industrialized countries for 2008–2012.
- Paris Agreement 2015 targets a 55% reduction of ghg

Selected Significant Climate Anomalies and Events: January 2020

GLOBAL AVERAGE TEMPERATURE
January 2020 average global land and ocean temperature was the highest for January since records began in 1880.

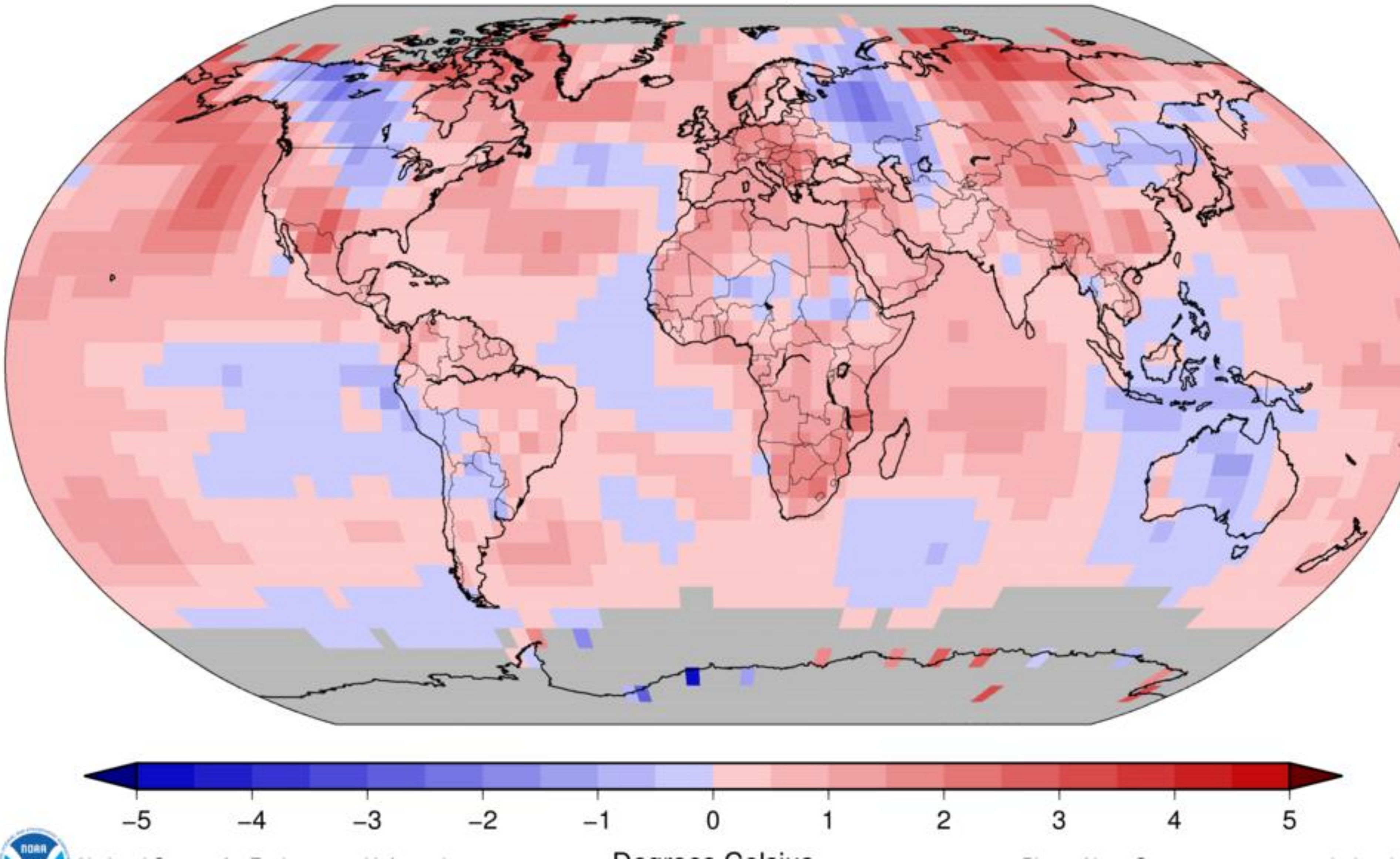


Please note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: http://www.ncdc.noaa.gov/sotc

Land & Ocean Temperature Departure from Average Aug 2019

(with respect to a 1981–2010 base period)

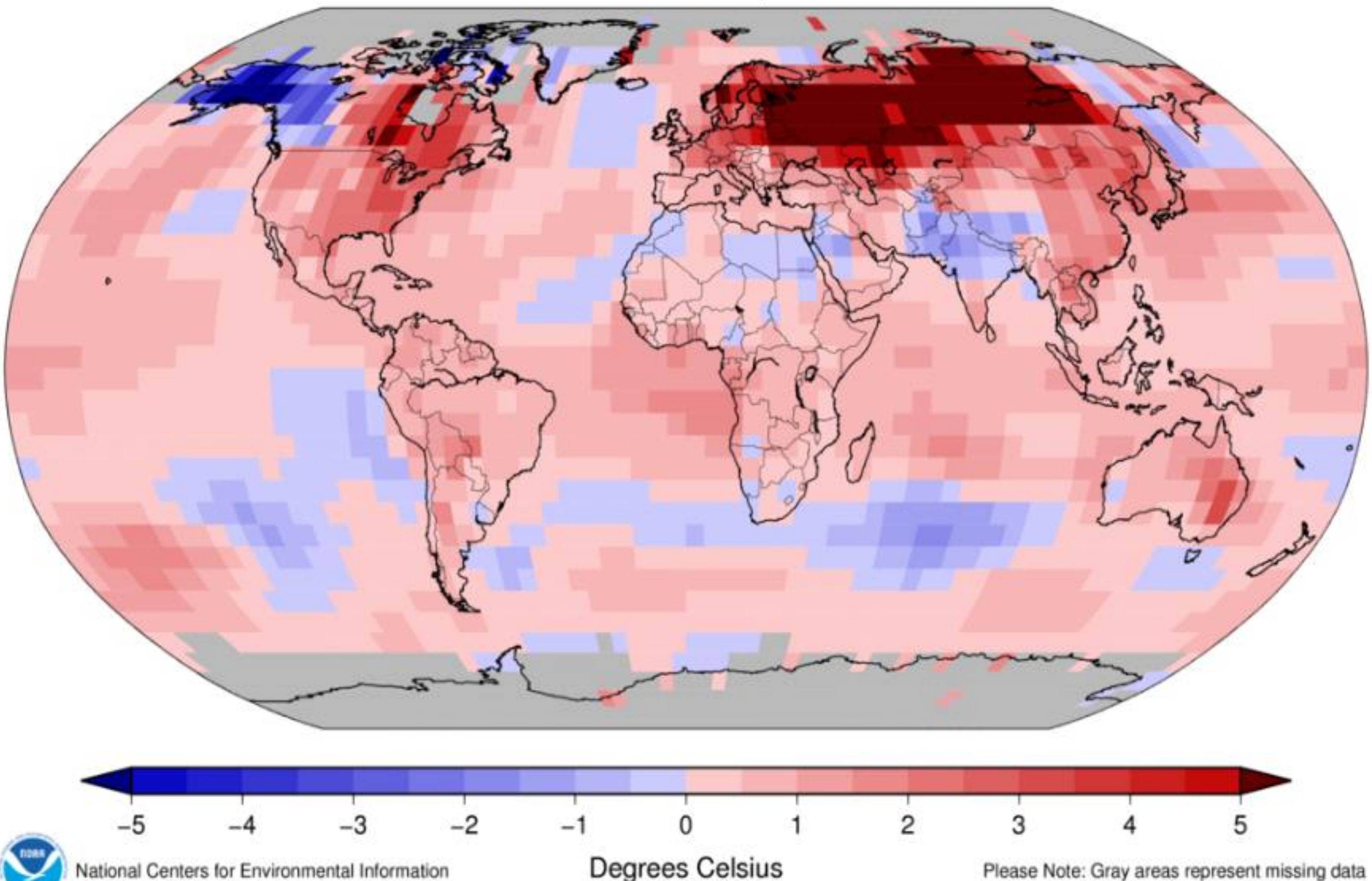
Data Source: NOAAGlobalTemp v5.0.0–20190908



Land & Ocean Temperature Departure from Average Jan 2020

(with respect to a 1981–2010 base period)

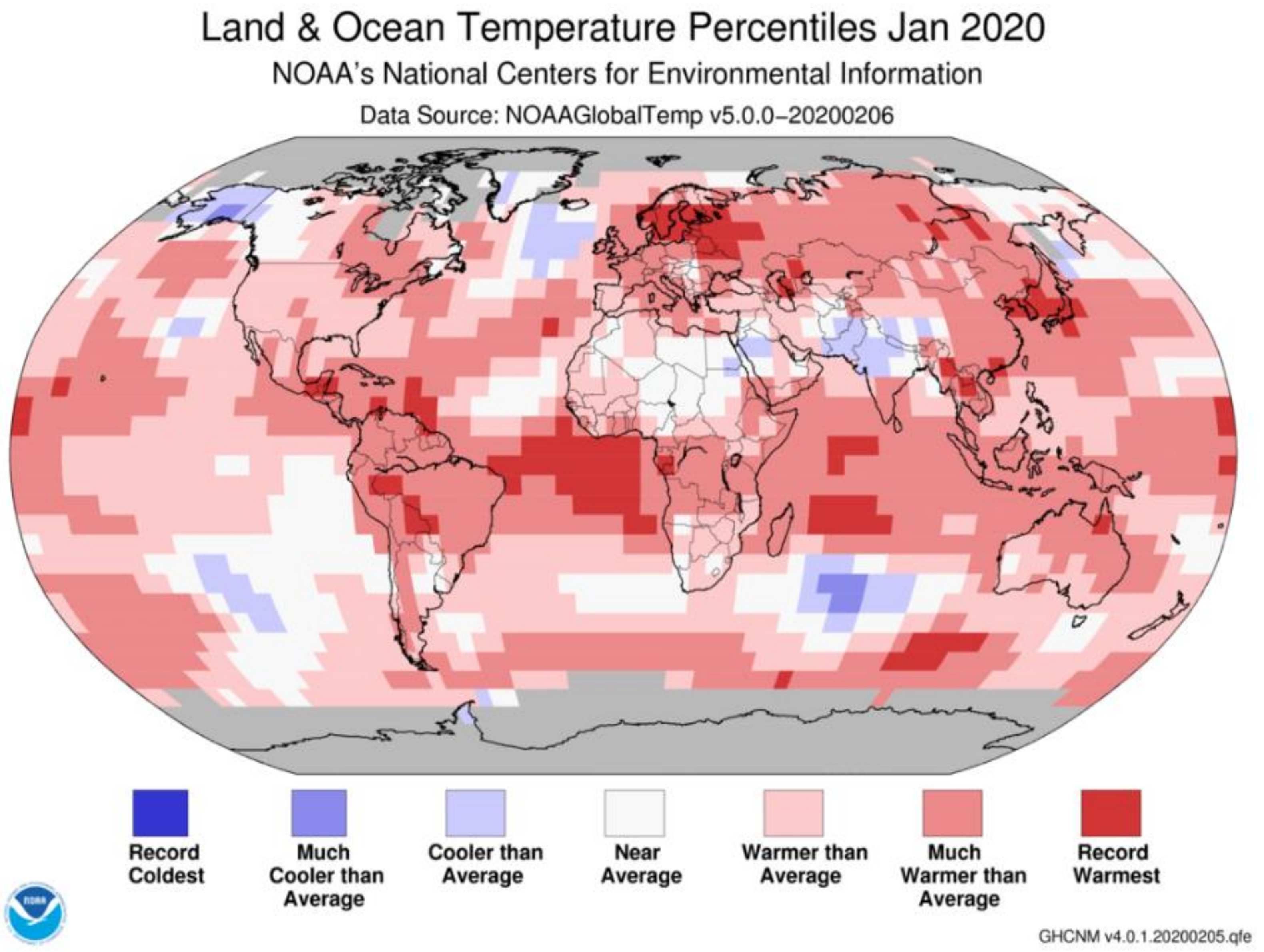
Data Source: NOAAGlobalTemp v5.0.0–20200206



National Centers for Environmental Information
GHCNM v4.0.1.20200205.qfe

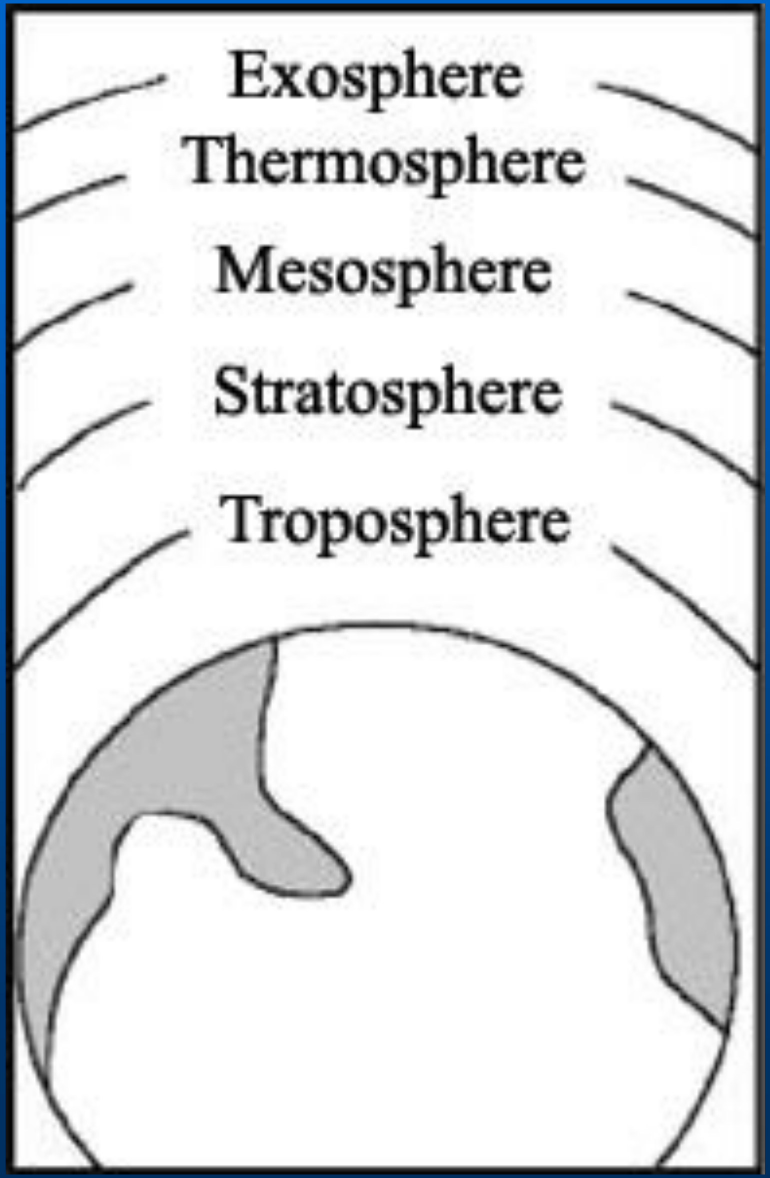
Please Note: Gray areas represent missing data
Map Projection: Robinson

January 2020 Temperature



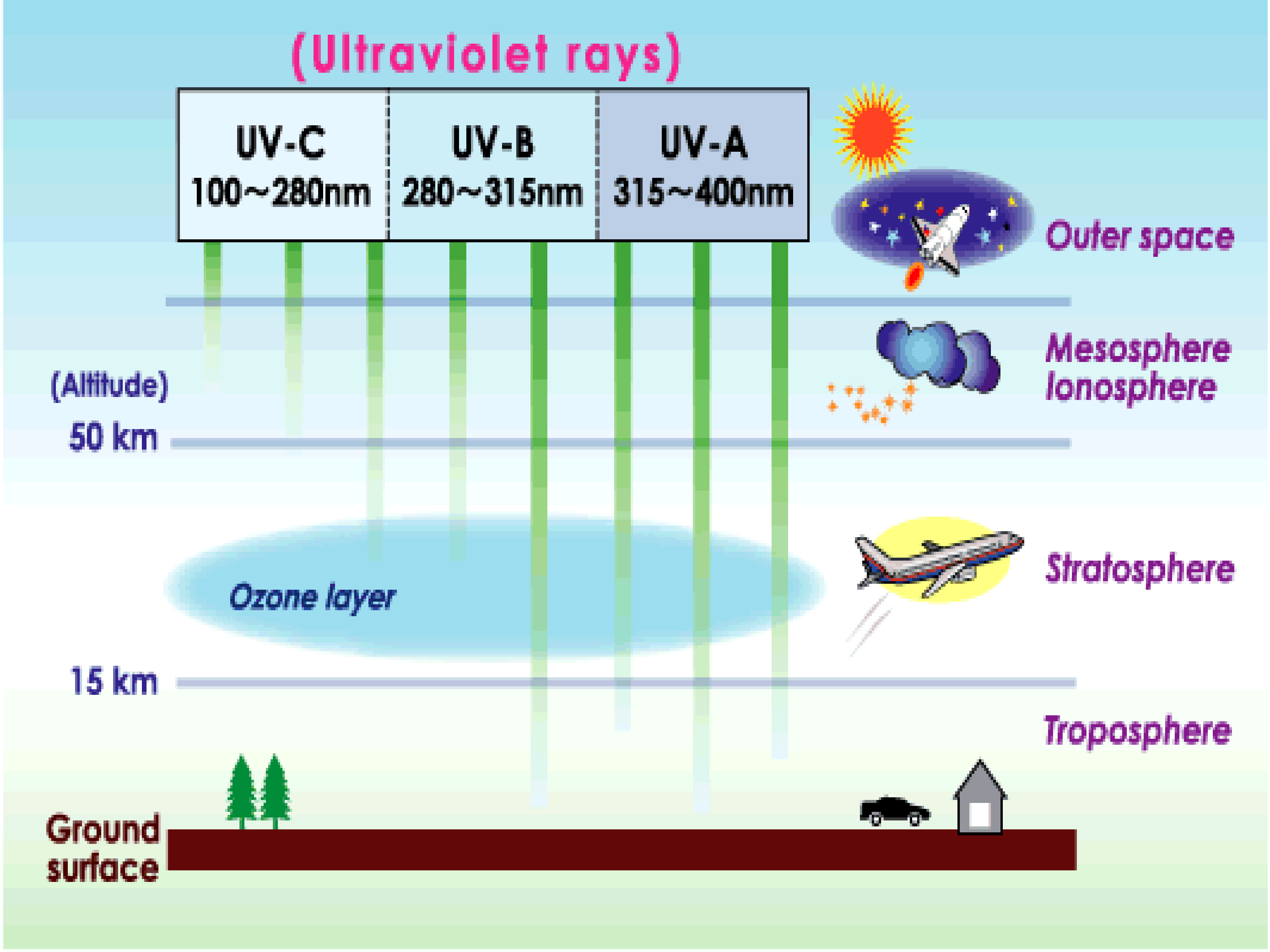
Stratospheric Ozone Depletion

- Stratosphere, 6 to 30 miles above the Earth, contains a layer of ozone gas that protects living organisms from harmful ultraviolet radiation.
- Each year, an "ozone hole" forms over the Antarctic.

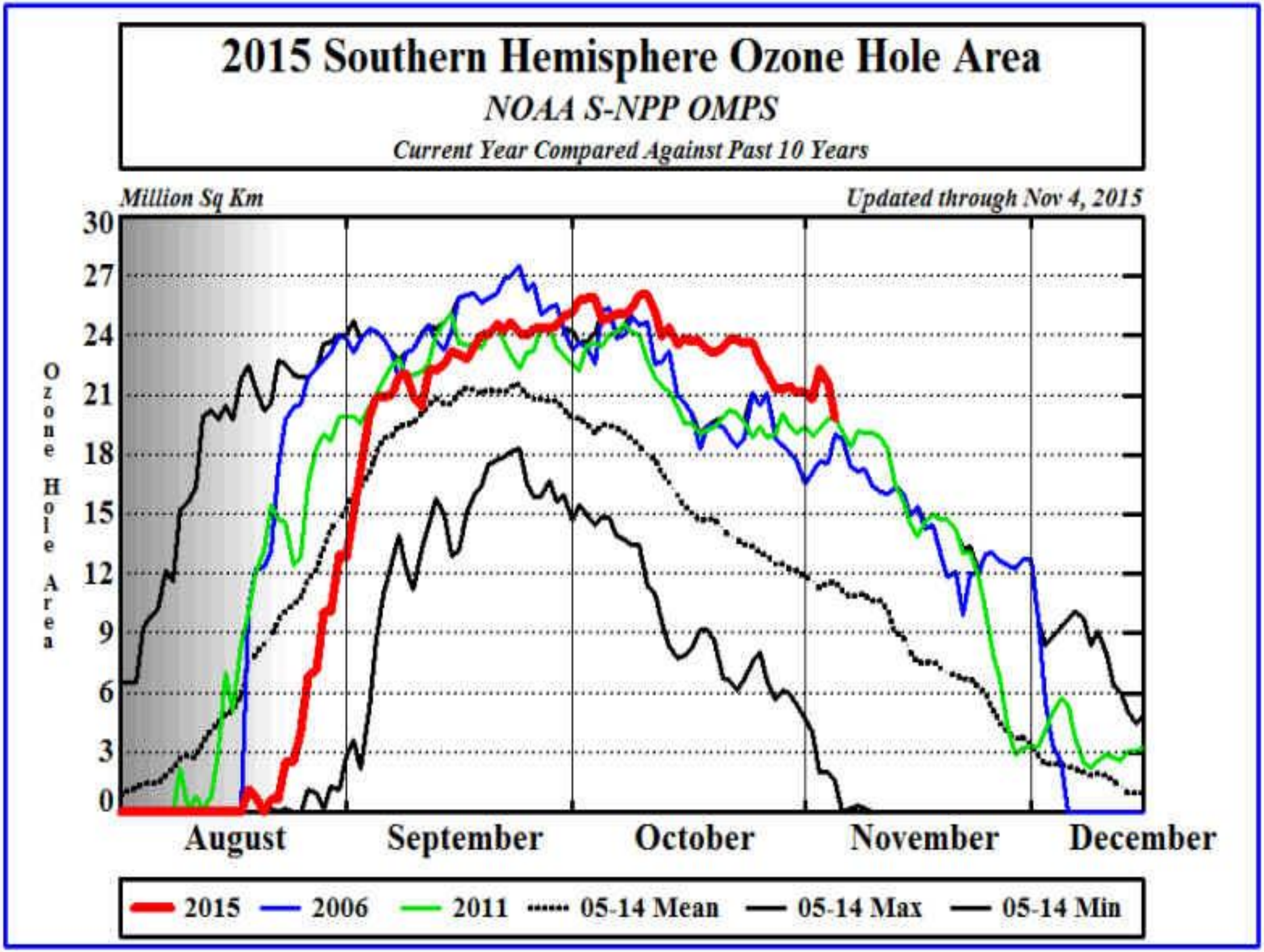


Stratospheric Ozone Depletion

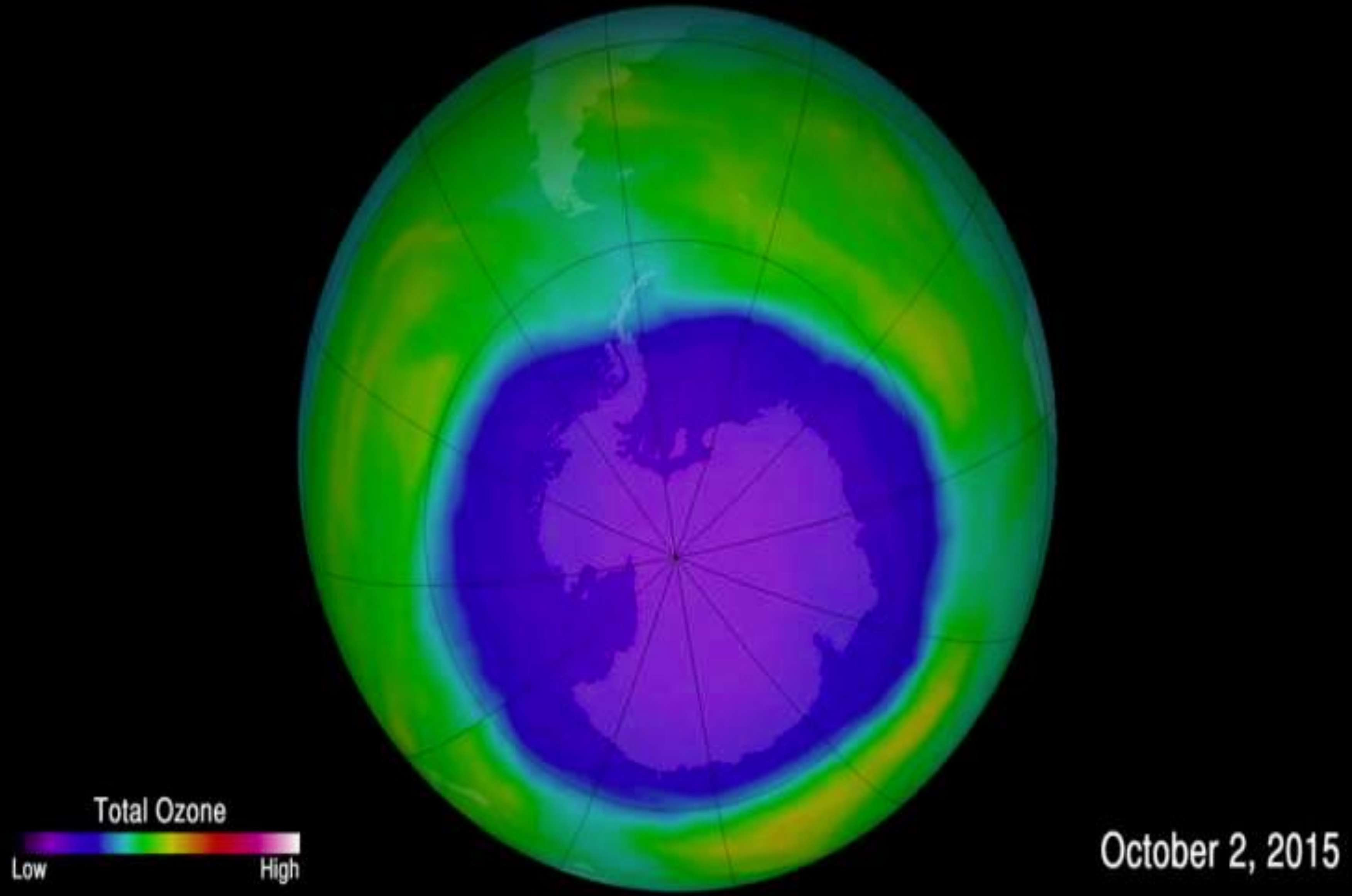
- 1987 Montreal Protocol committed 170 nations to limiting the production of ozone-depleting substances.
- As a result, the hole is stabilizing and should be gone by the end of the century.



(Ultraviolet rays)
UV-C
100~280nm
UV-B
280~315nm
UV-A
315~400nm
Outer space
Mesosphere
Ionosphere
(Altitude)
50 km
Stratosphere
Ozone layer
15 km
Troposphere
Ground surface



2015 Southern Hemisphere Ozone Hole Area
NOAA S-NPP OMPS
Current Year Compared Against Past 10 Years
Million Sq Km
Updated through Nov 4, 2015
Ozone Hole Area
30
27
24
21
18
15
12
9
6
3
0
August
September
October
November
December
2015
2006
2011
05-14 Mean
05-14 Max
05-14 Min


Total Ozone
Low
High
October 2, 2015

Risk Assessment

- Health risks are a measure of the chance that you will experience health problems.
- Risk management is the process the government uses to manage this health risk

The 4-Step Risk Assessment Process

Hazard Identification

What health problems are caused by the pollutant?

Exposure Assessment

How much of the pollutant do people inhale during a specific time period? How many people are exposed?

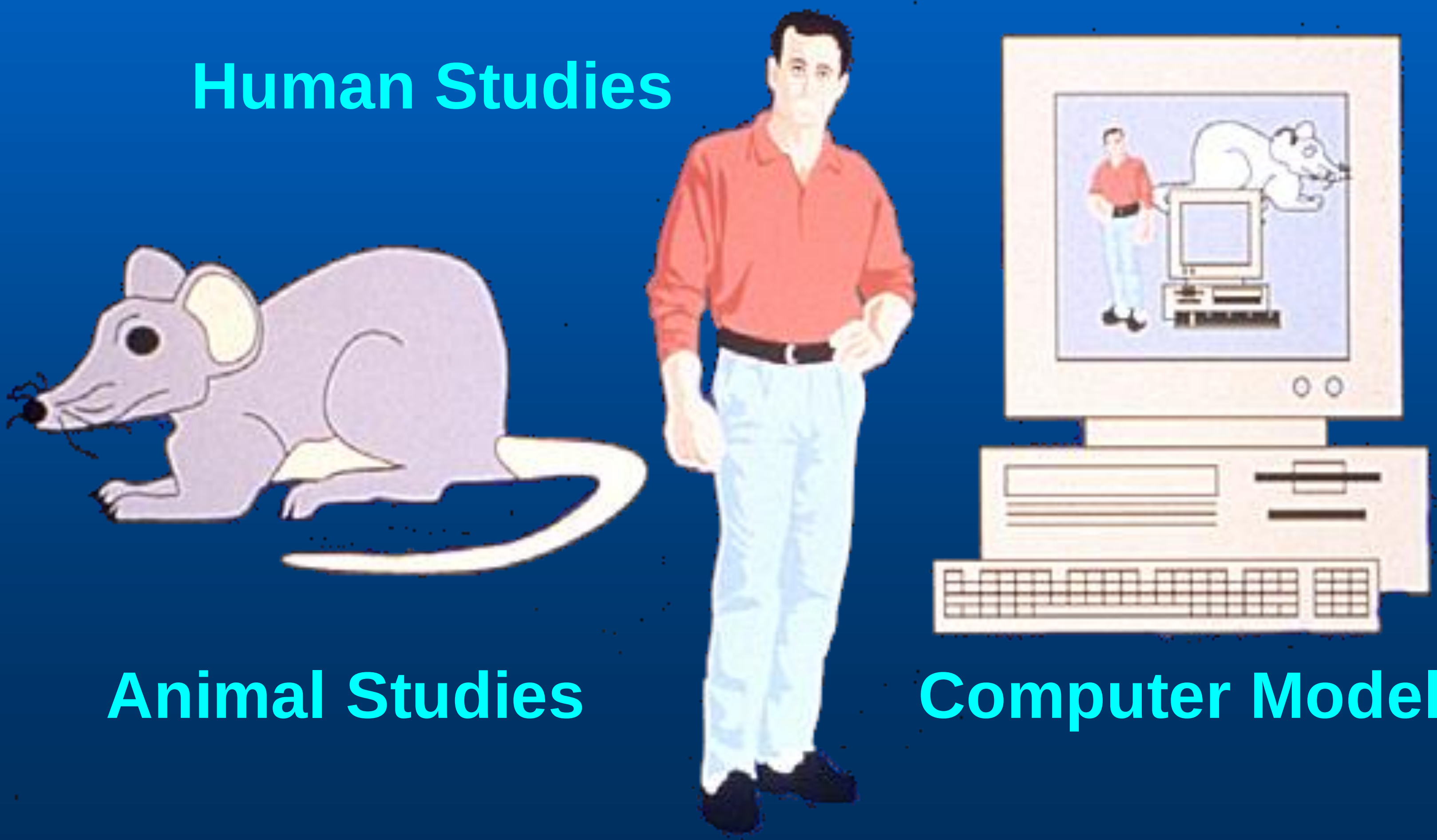
Dose-Response Assessment

What are the health problems at different exposures?

Risk Characterization

What is the extra risk of health problems in the exposed population?

Hazard Identification

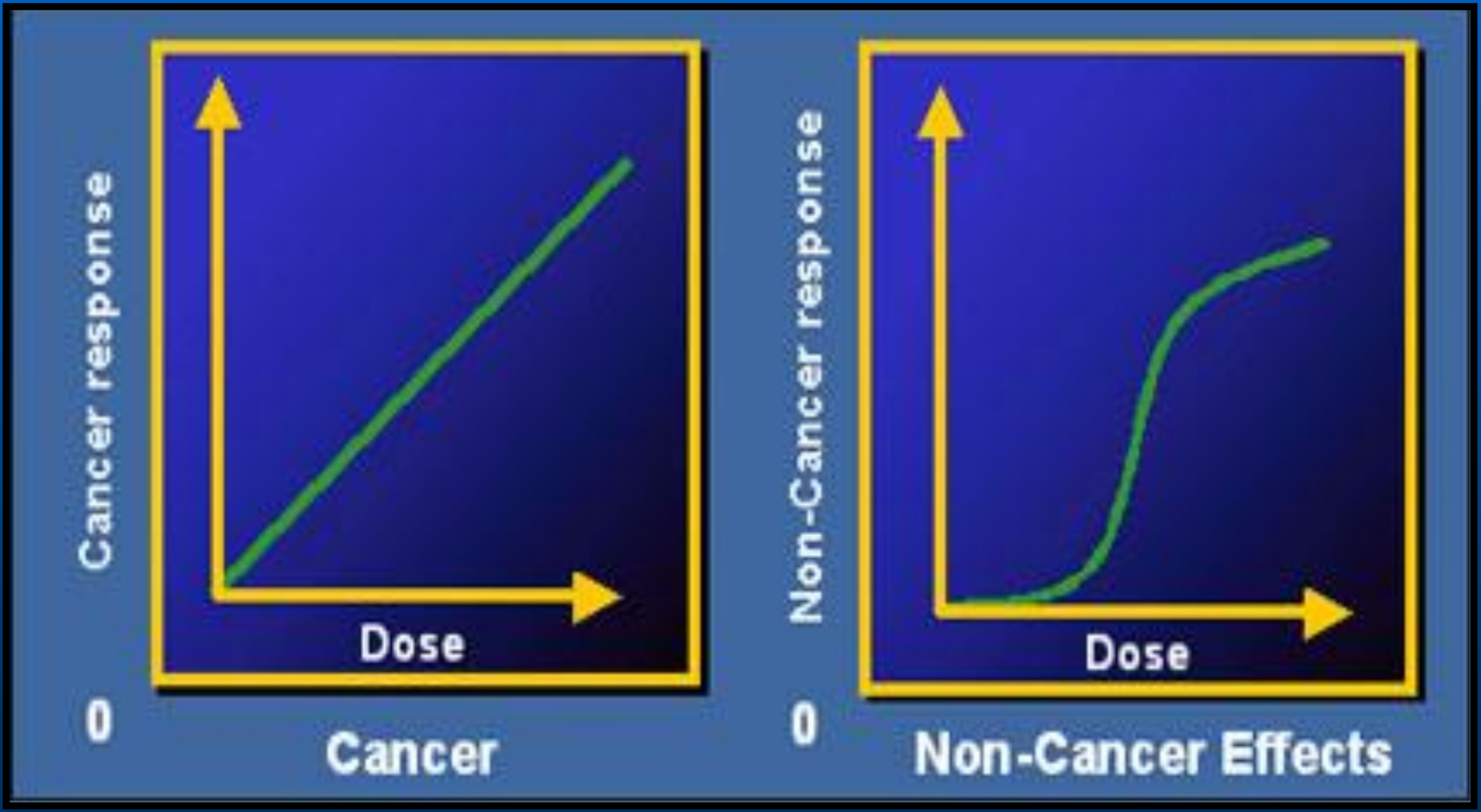


Exposure Assessment

- Exposure?

- Determine:
  - Sources
  - Amounts of toxins
  - Number of people
  - Pollution per person

Dose-Response Assessment



Risk Characterization: What is the extra risk to health?

Maximum Lifetime Exposure X Dose Relationship = Maximum Individual Lifetime Risk

Uncertainty of Risk Estimates

- Extrapolation Issues
- Inaccuracy
- Making Assumptions

Chapter Summary

- Hazardous Effects of Air Pollutants on the Human Body Systems
- Criteria Pollutants
- Toxic Air Pollutants
- Environmental Effects of Air Pollution
- Risk Assessment

Review Questions

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 3:
Transport and Dispersion of Air Pollution

Chapter Overview

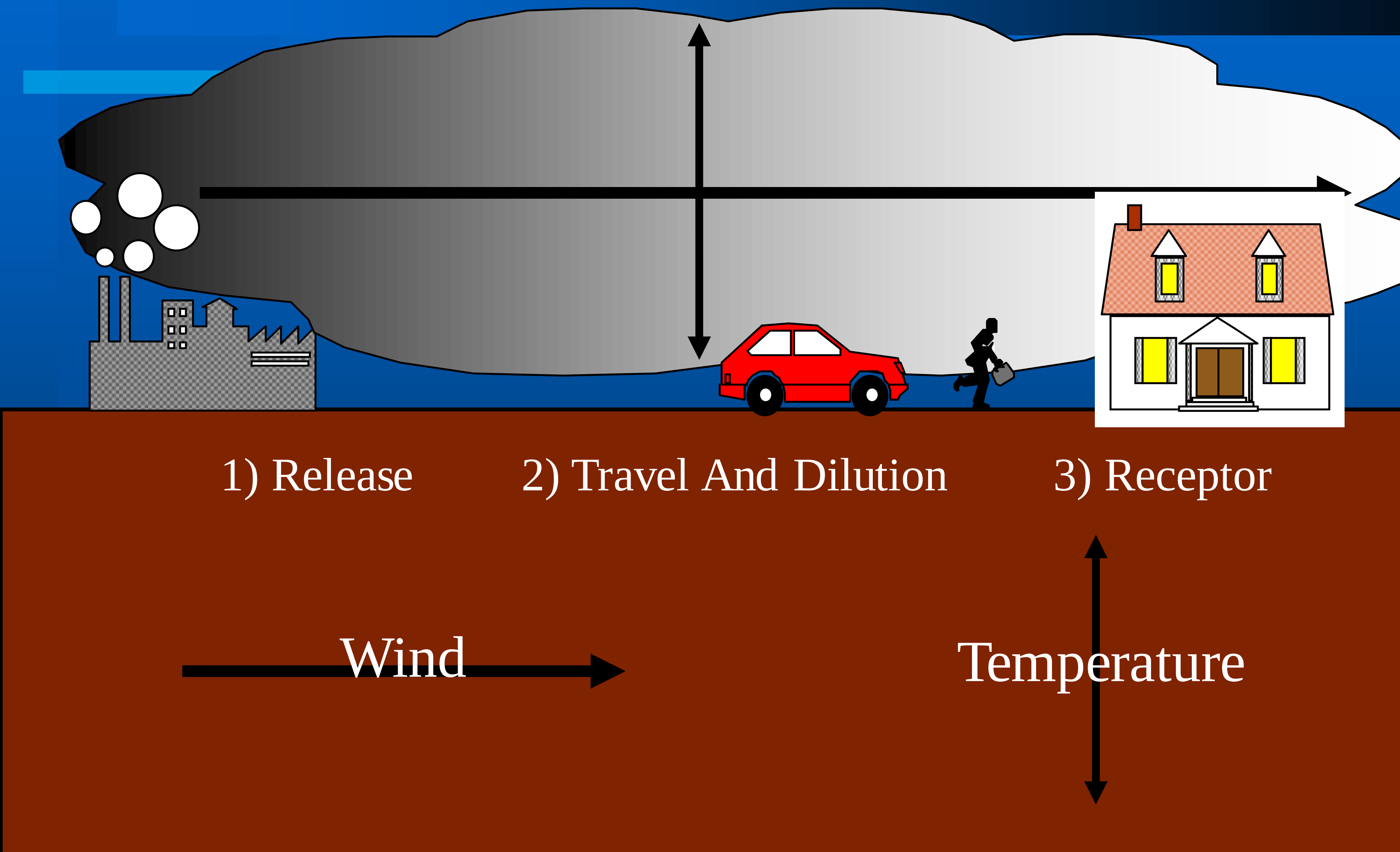
- Wind Speed and Direction
- Atmospheric Stability
- Topography
- New Sources

Essence of Air Pollution Meteorology

Diffusion = Expanding of Pollutant Cloud

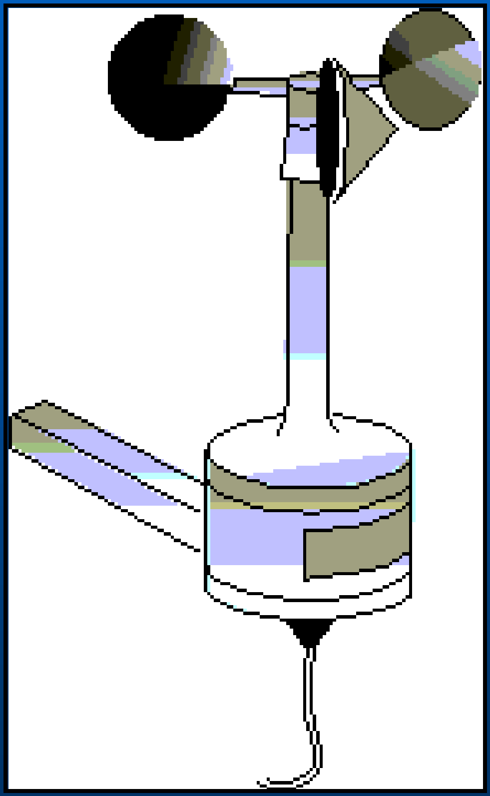
Transport = Moving of Pollutant Cloud

AIR POLLUTION CYCLE



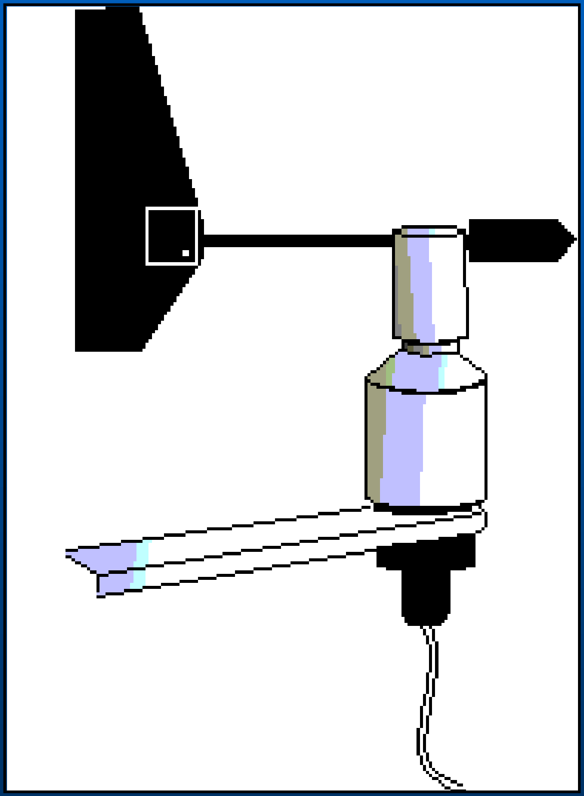
Wind Speed

- Horizontal Motion
- Effect on Pollutant Concentration
- Measurement



Wind Direction

- Importance
- Tools
- Gathering Data




10-2002

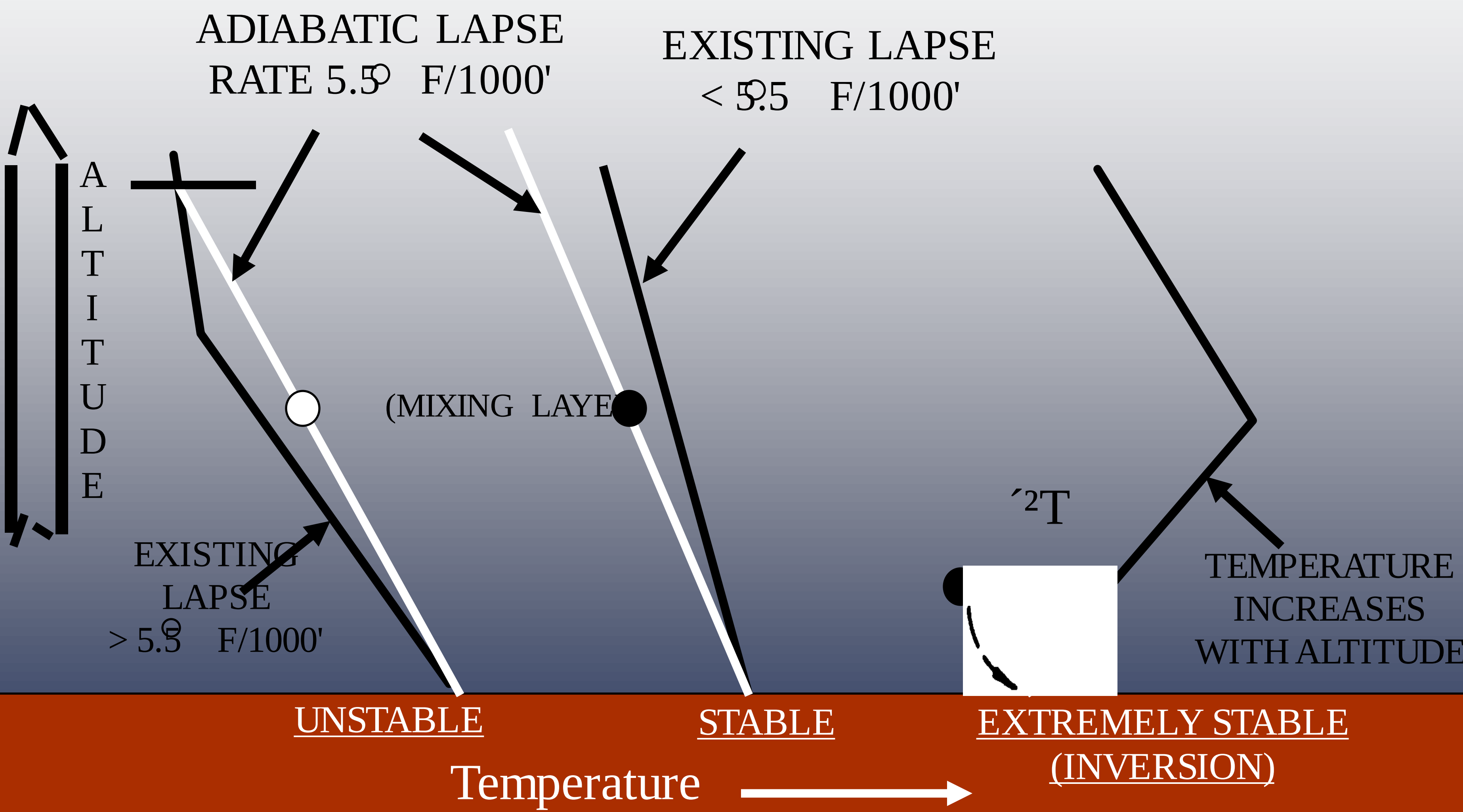
Atmospheric Stability

- Vertical Movement of Air
- Differential Heating
- Conduction vs. Convection
- Turbulence
  - Thermal
  - Mechanical

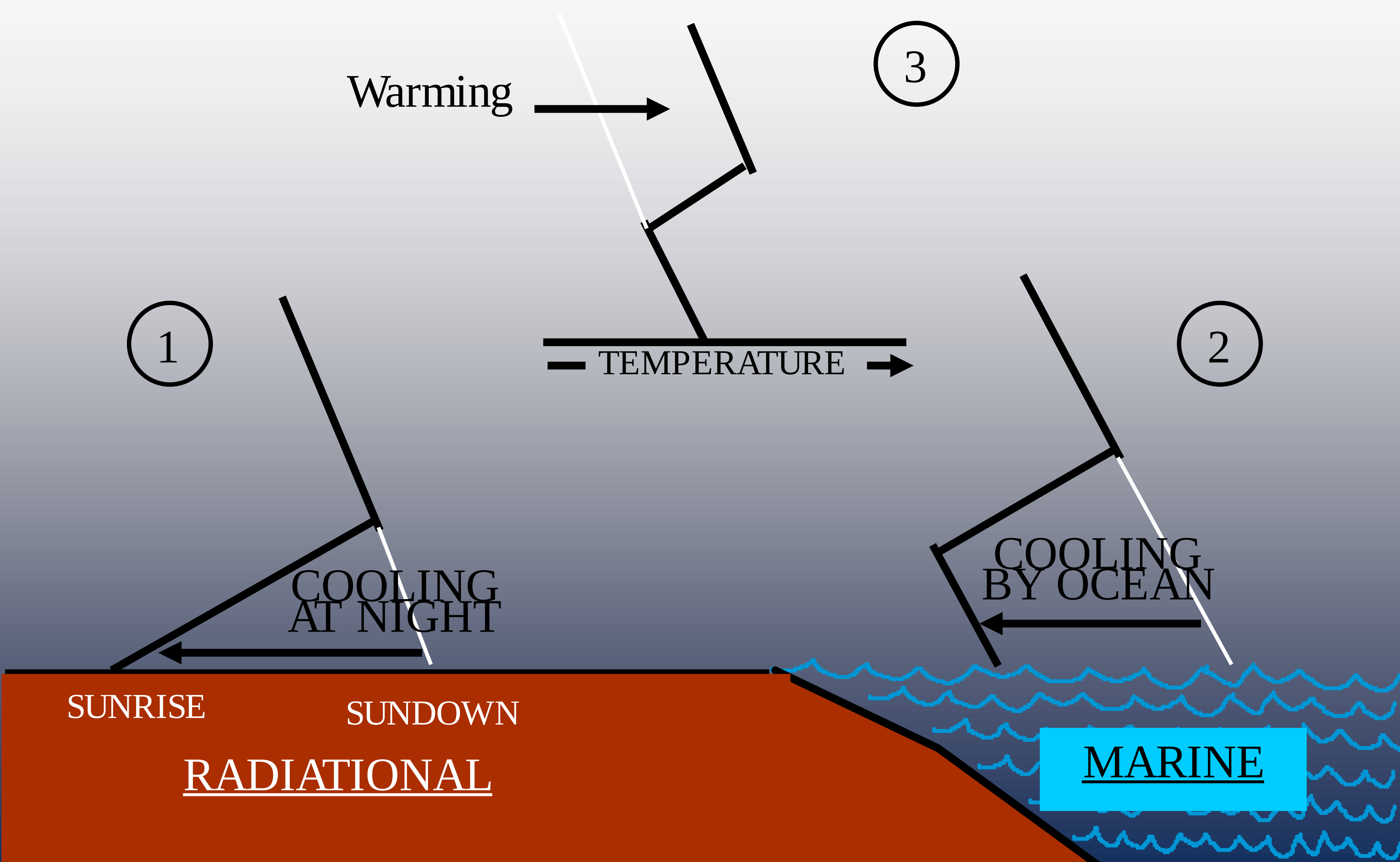
Atmospheric Stability (cont.)

- Adiabatic Lapse Rate
- Environmental Lapse Rate
- Plumes
- Plume Types

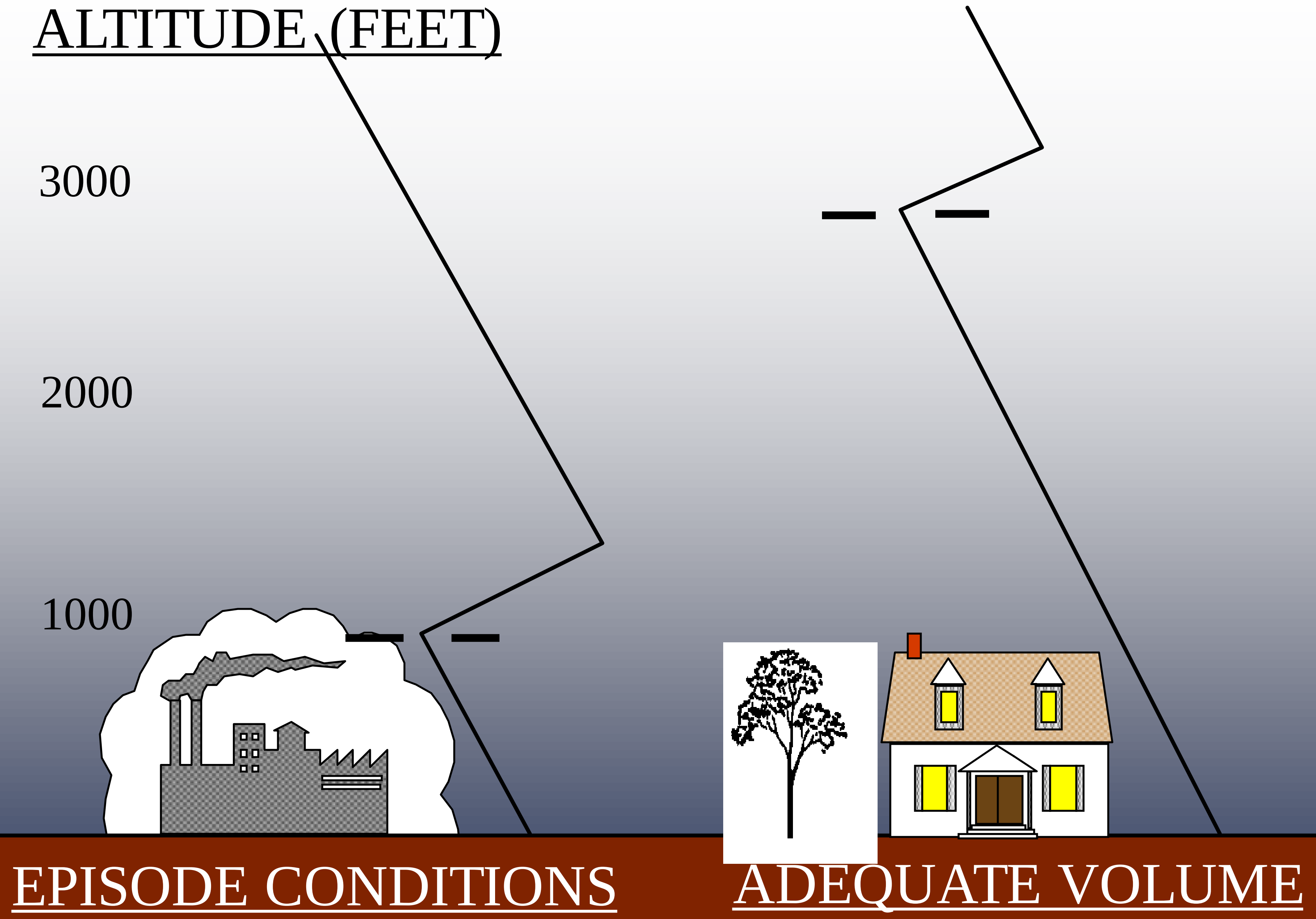
ATMOSPHERIC STABILITY



INVERSIONS

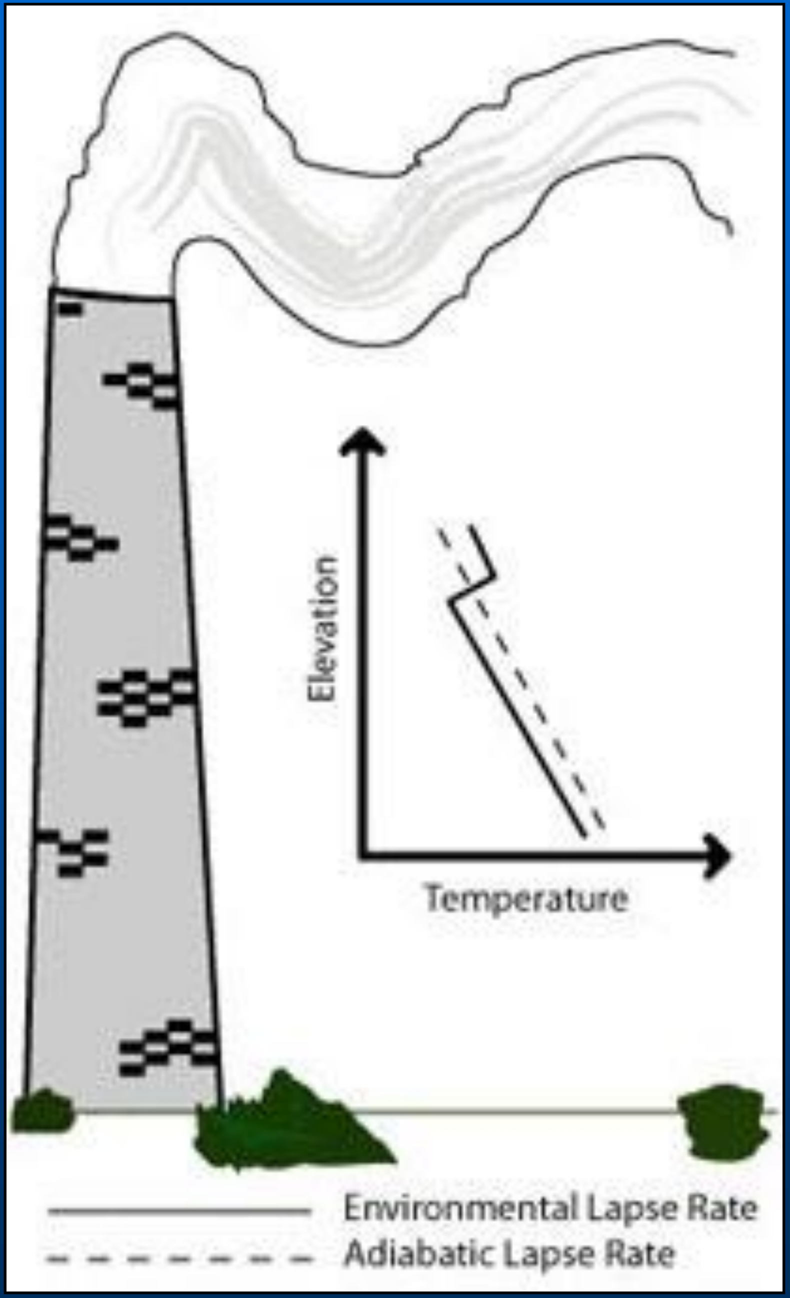


Warming
3
1
TEMPERATURE
2
COOLING
AT NIGHT
COOLING
BY OCEAN
SUNRISE
SUNDOWN
RADIATIONAL
MARINE


ALTITUDE (FEET)
3000
2000
1000
EPISODE CONDITIONS
ADEQUATE VOLUME

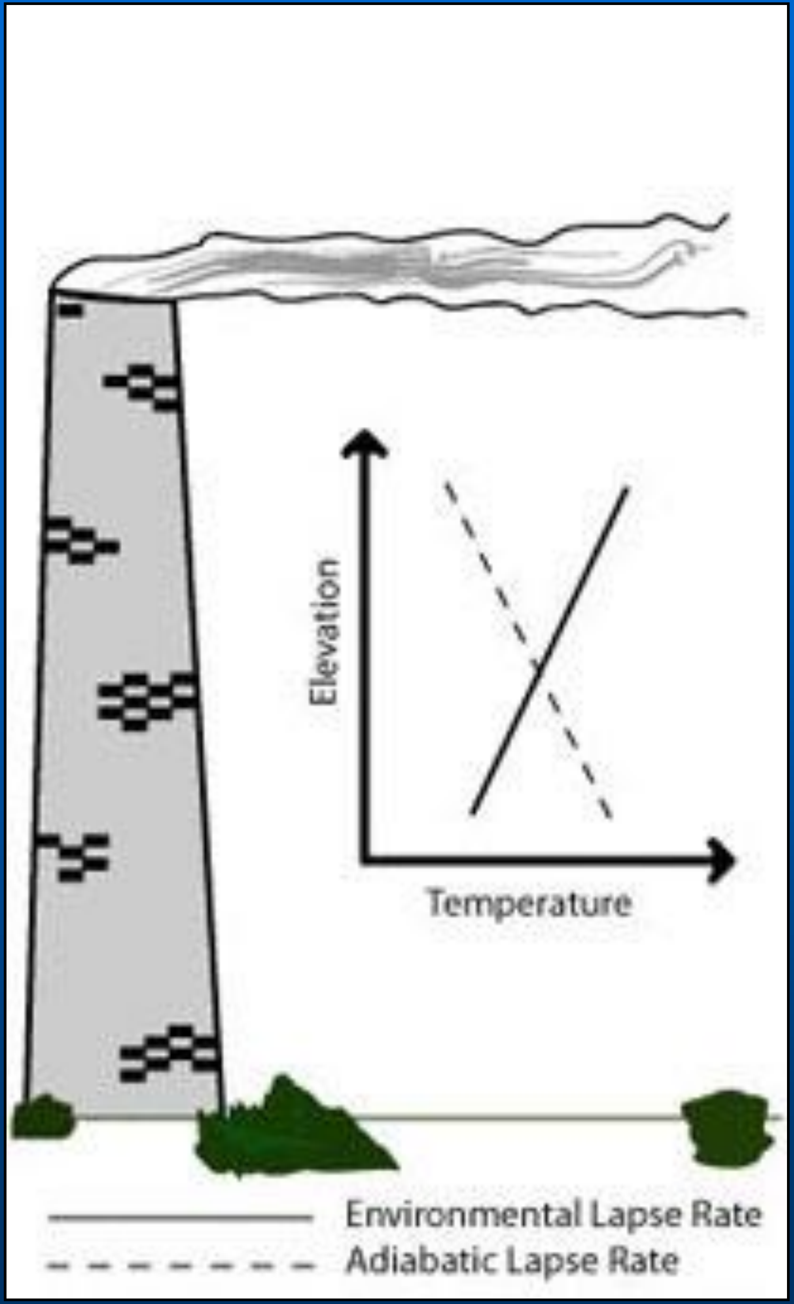
Looping Plumes

- Unstable Atmosphere
- Changing Temperature and Pressure
- Sunny Days with Wind



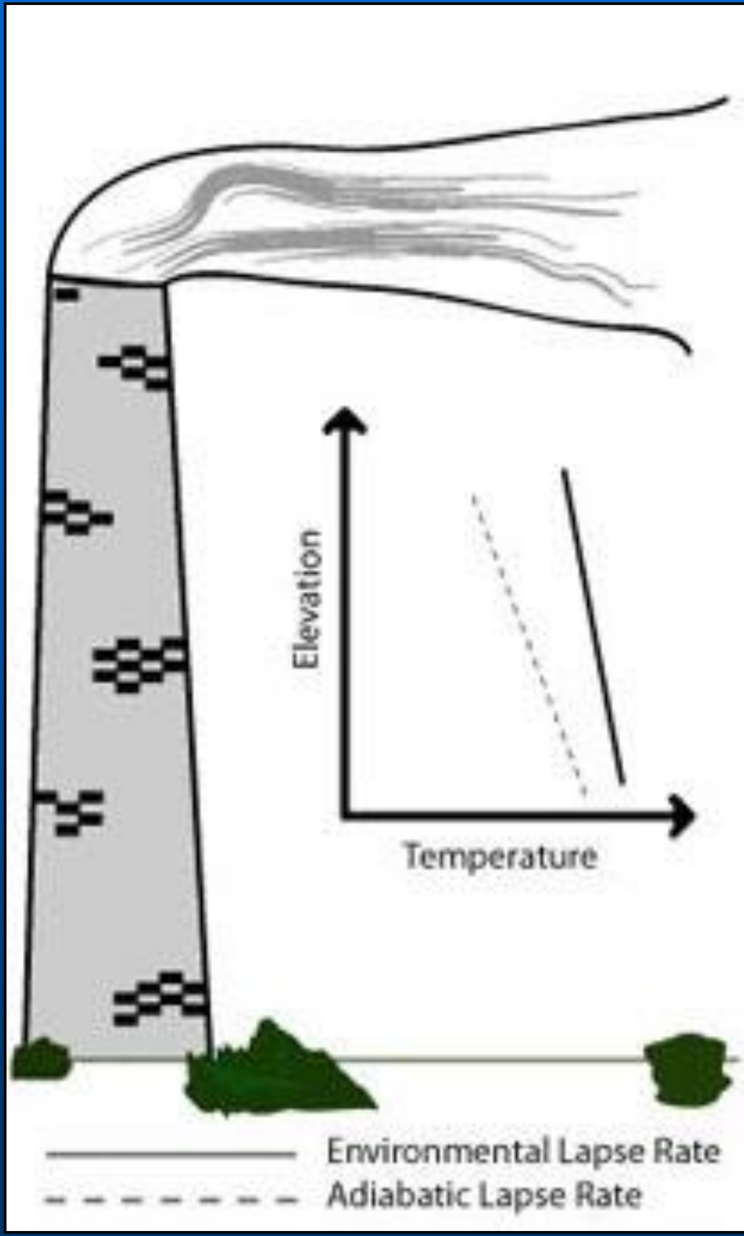
Fanning Plumes

- Stable Conditions
- Wind moving horizontally
- Early Morning



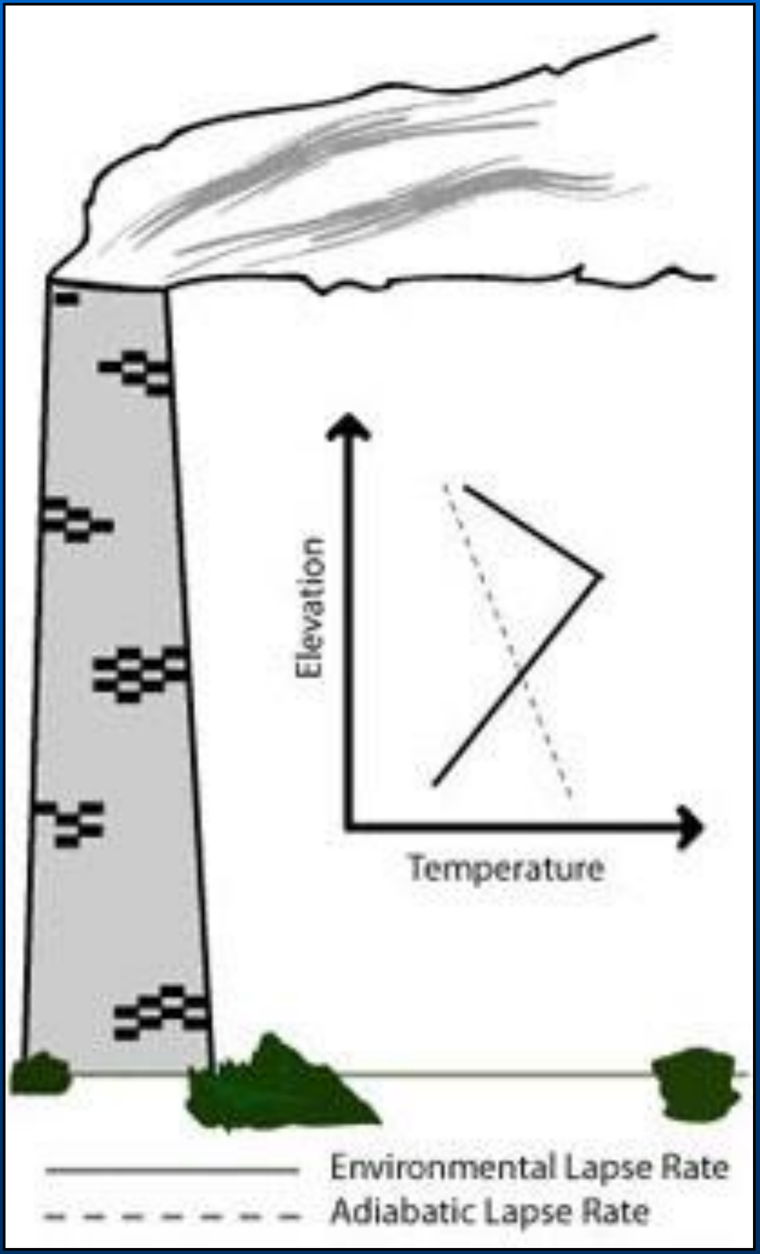
Coning Plumes

- Neutral or Slightly Unstable Conditions
- Large Billows
- Partly Cloudy Days



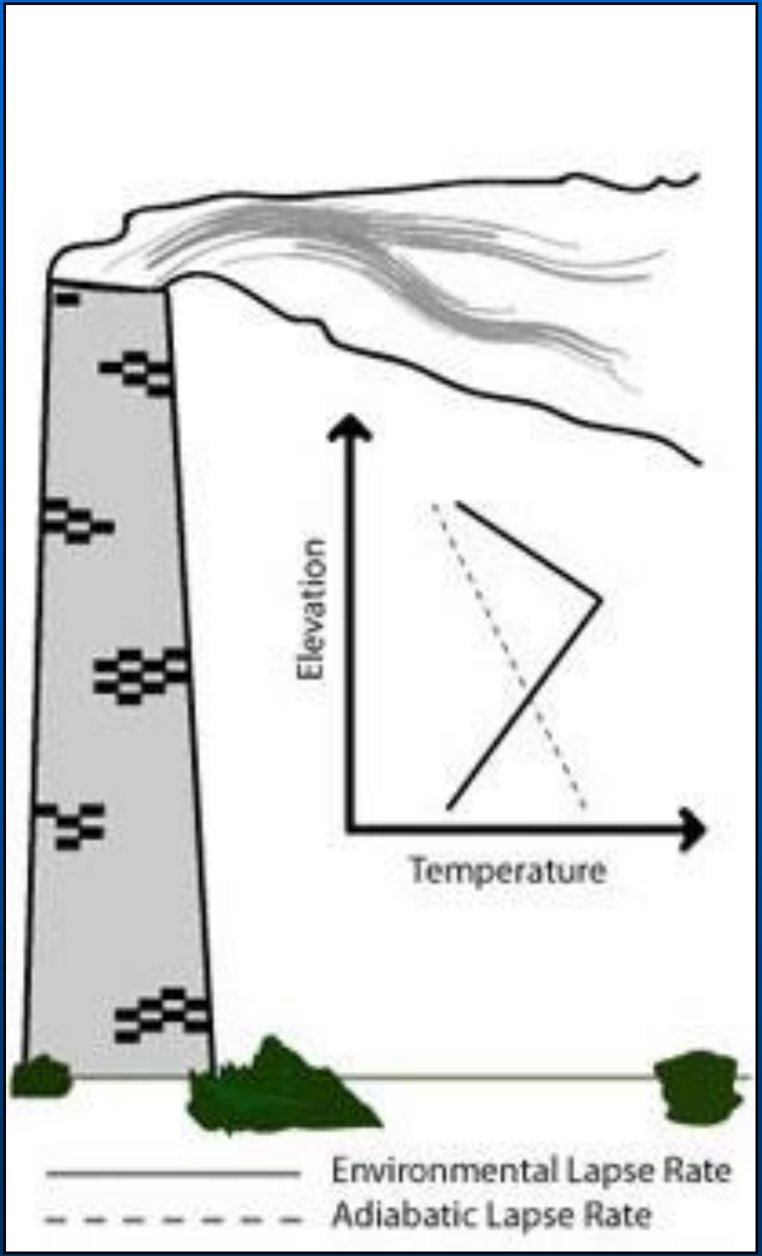
Lofting Plumes

- Stable Conditions
- Above the Inversion Layer
- Smokestack Height
- Effective Dispersion



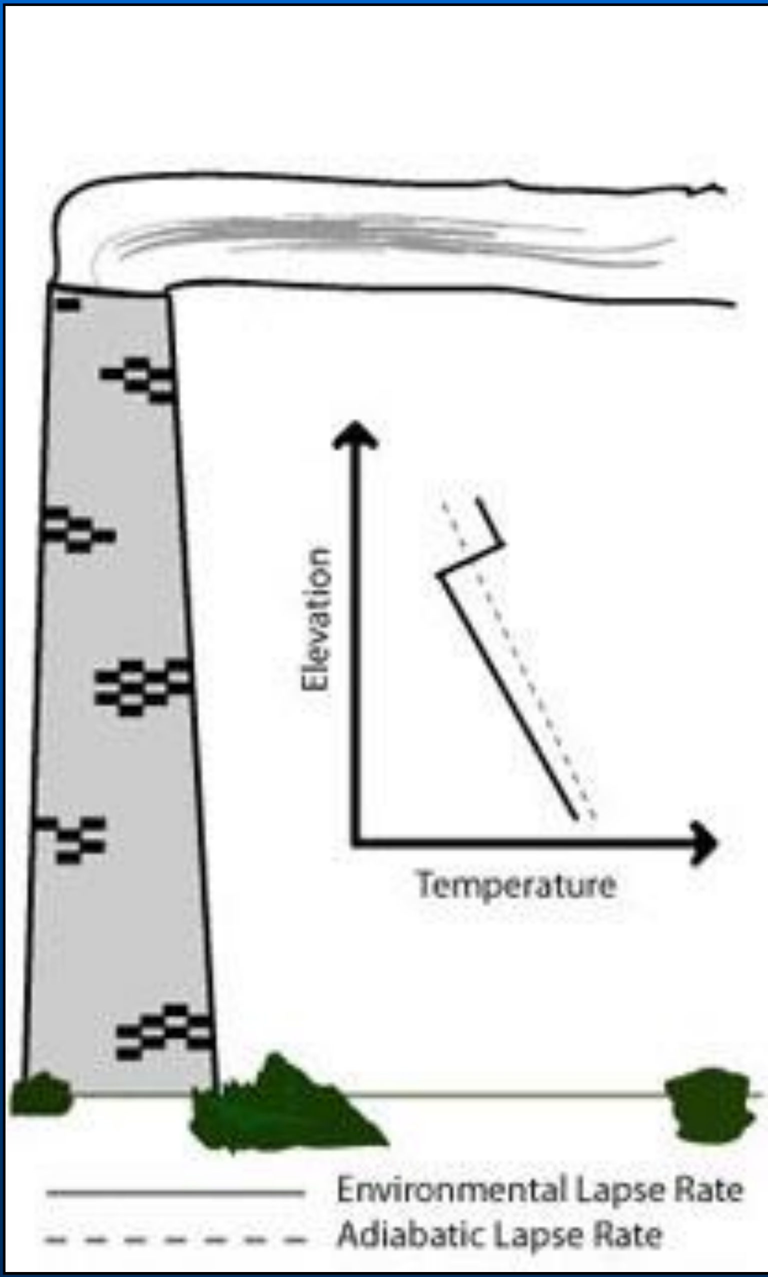
Fumigating Plumes

- Early Morning
- Below the Inversion Layer
- High Concentrations of Pollutants at the Surface



Trapping Plumes

- Clear and Sunny Days
- Inversion layer above and below
- Most Favorable Type

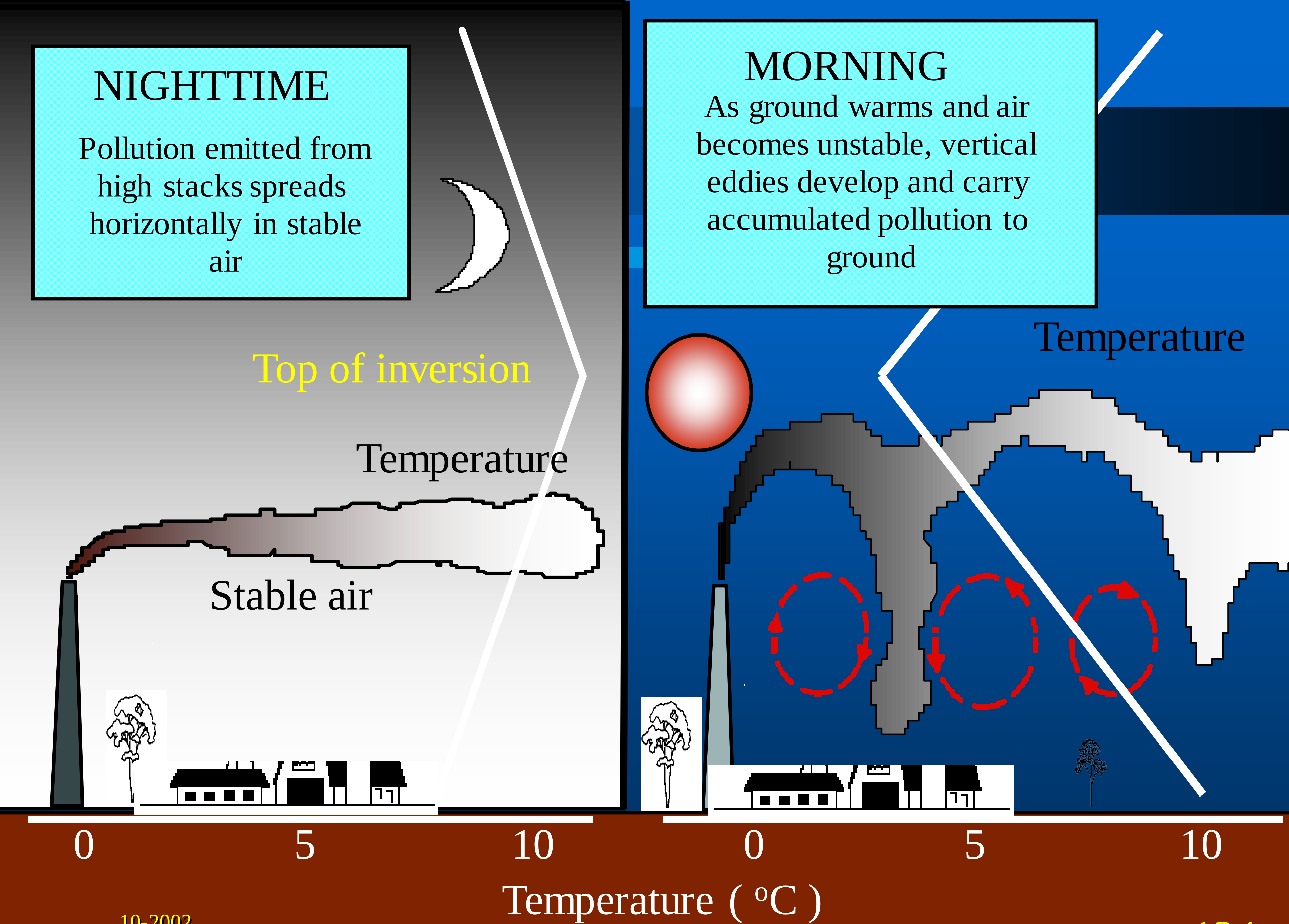



10-2002

10-2002


10-2002


10-2002

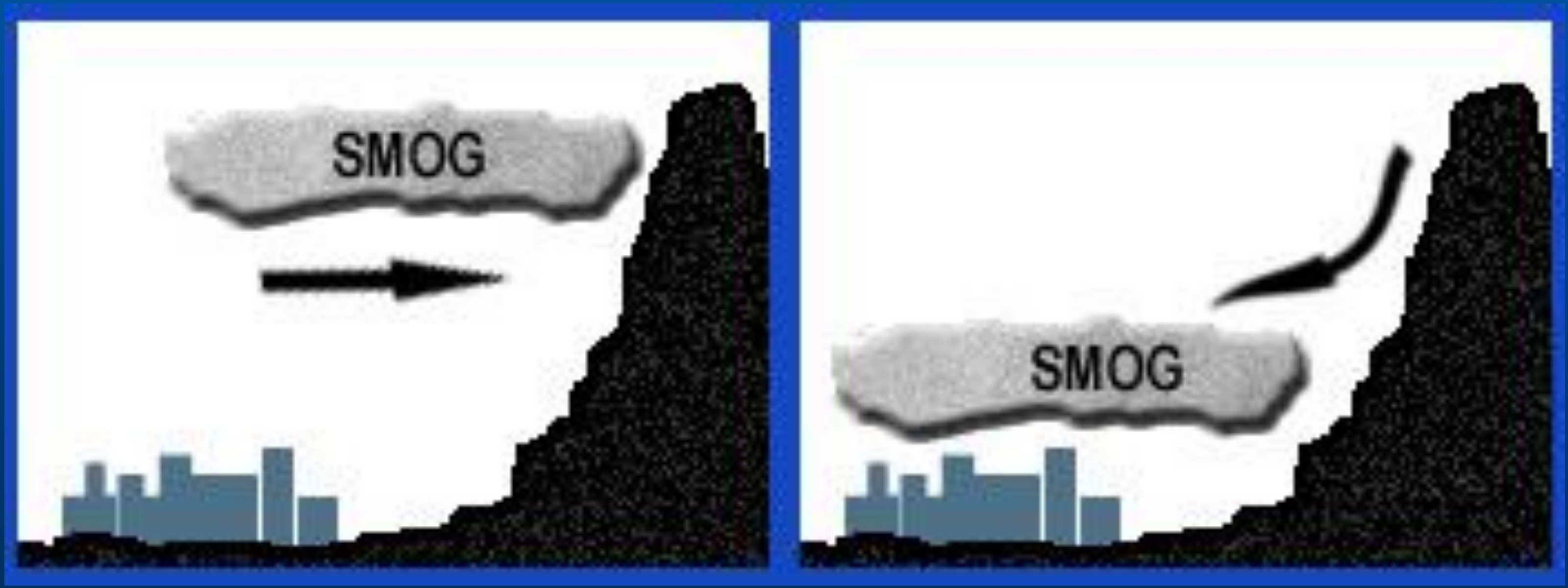

NIGHTTIME
Pollution emitted from high stacks spreads horizontally in stable air
Top of inversion
Temperature
Stable air
MORNING
As ground warms and air becomes unstable, vertical eddies develop and carry accumulated pollution to ground
Temperature
0
5
10
0
5
10
Temperature (°C)
10-2002

Topography

- Lakes and Oceans

Topography (cont.)

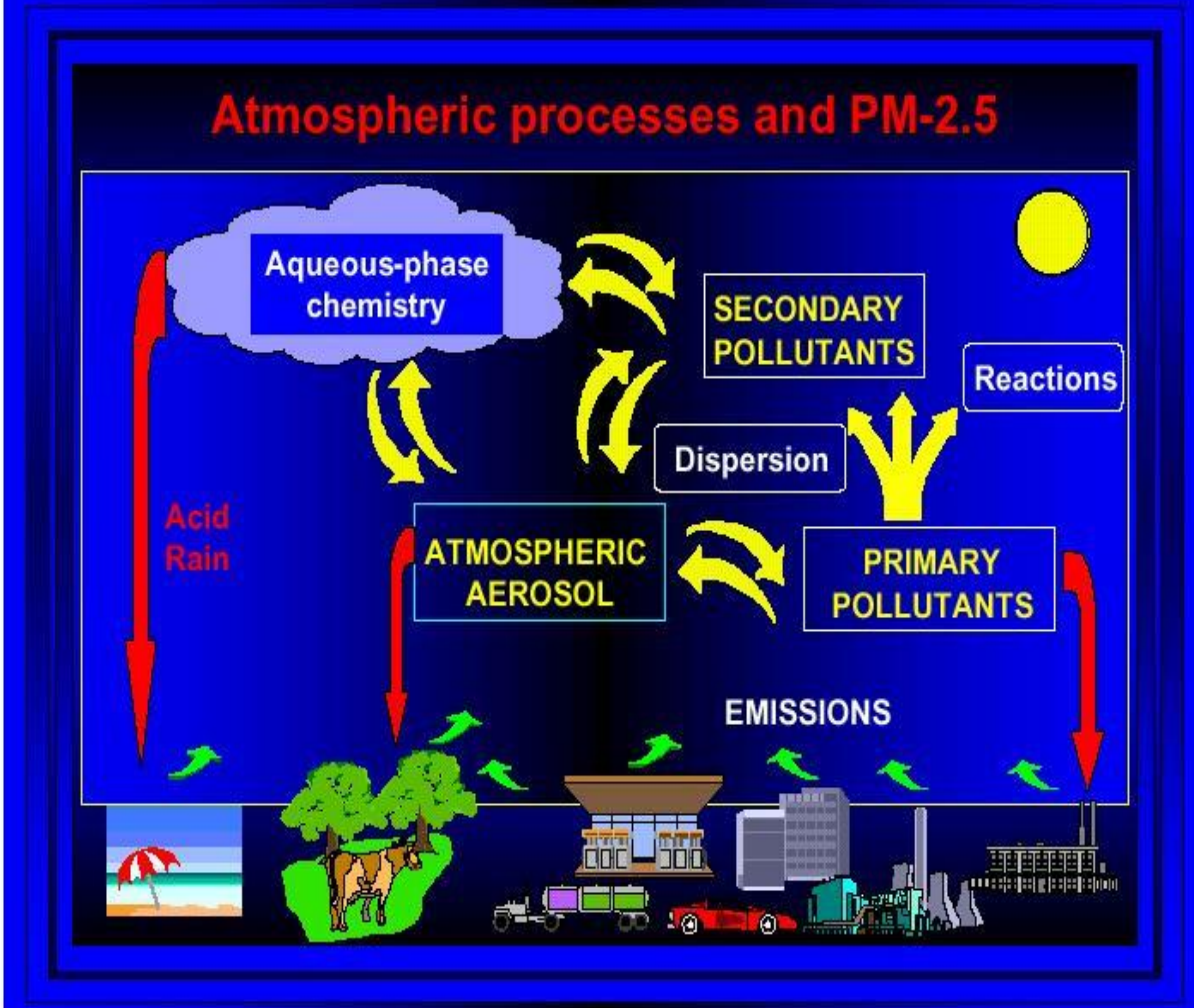
- Valleys
- Mountains



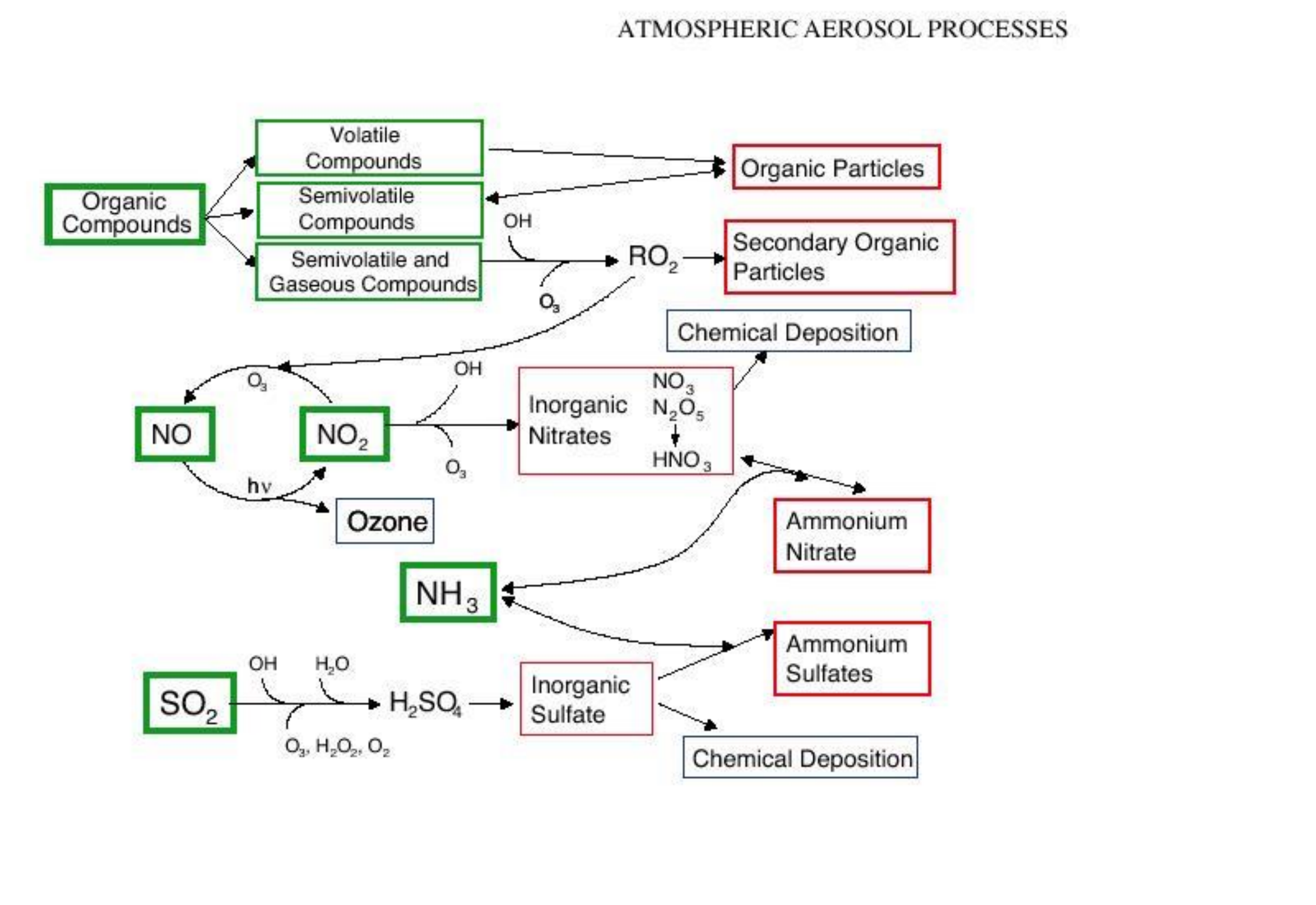
New Source Review (NSR)

- Prevention of Significant Deterioration (PSD) uses the appropriate dispersion model to evaluate whether the proposed source will exceed its part of the allowable air increment within the sites Air Quality Management Area.

- 40 CFR Part 51 Appendix W
  - modeling


Atmospheric processes and PM-2.5
Aqueous-phase chemistry
SECONDARY POLLUTANTS
Reactions
Dispersion
Acid Rain
ATMOSPHERIC AEROSOL
PRIMARY POLLUTANTS
EMISSIONS

ATMOSPHERIC AEROSOL PROCESSES



Modeling

- Dispersion Models – use mathematical formulations to characterize the atmospheric processes that disperse a pollutant by a source
- Photochemical Models – large-scale models that simulate the changes of pollutants concentrations using mathematical equations characterizing physical and chemical processes

Modeling continued

- Receptor Models – mathematical and/or statistical procedures for identifying and quantifying the sources of pollutants at a receptor location

- SCRAM – Support Center for Regulatory Atmospheric Modeling
- www.epa.gov/scram/air-quality-dispersion-modeling

Chapter Summary

- Wind Speed and Direction
- Atmospheric Stability
- Topography
- Dispersion Modeling

Review Questions

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 4:

Indoor Air Pollution

Chapter Overview

- Sources and Effects of Indoor Air Pollution
- Sick Building Syndrome
- Controls of Indoor Air Pollution
- EPA’s Approach and Progress

Sources of Indoor Air Pollution

Levels of Indoor Pollutants

May be 25 times the outdoor level.

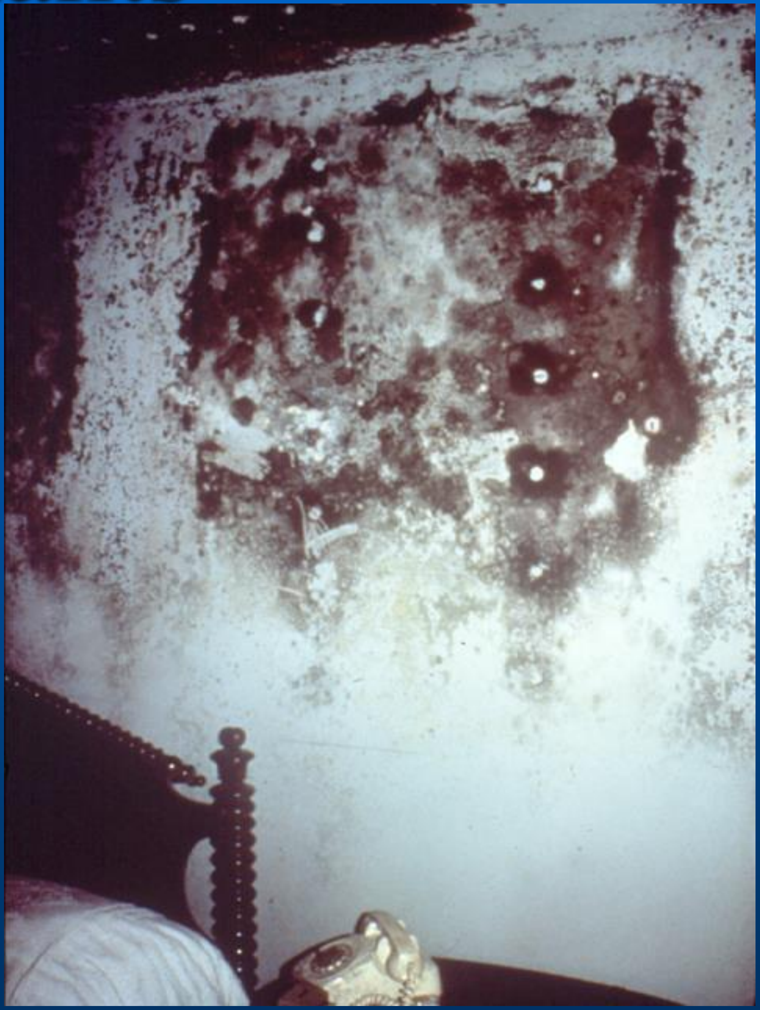
Many people spend 90% of their time indoors

Sources of Indoor Air Pollution

- Biological Contaminants
- Radon
- Environmental Tobacco Smoke
- Stoves, Heaters, Fireplaces and Chimneys
- Asbestos
- Pesticides
- Organic Chemicals
- Formaldehyde
- Lead
- Carbon Monoxide
- Nitrogen Oxide

Biological Contaminants

- Sources
  - Bacteria
  - Molds, mildew
  - Viruses
  - Animal dander
  - Dust mites, cockroaches
  - Pollen
  - House Dust
  - Pets
  - Poorly Maintained Air Conditioners



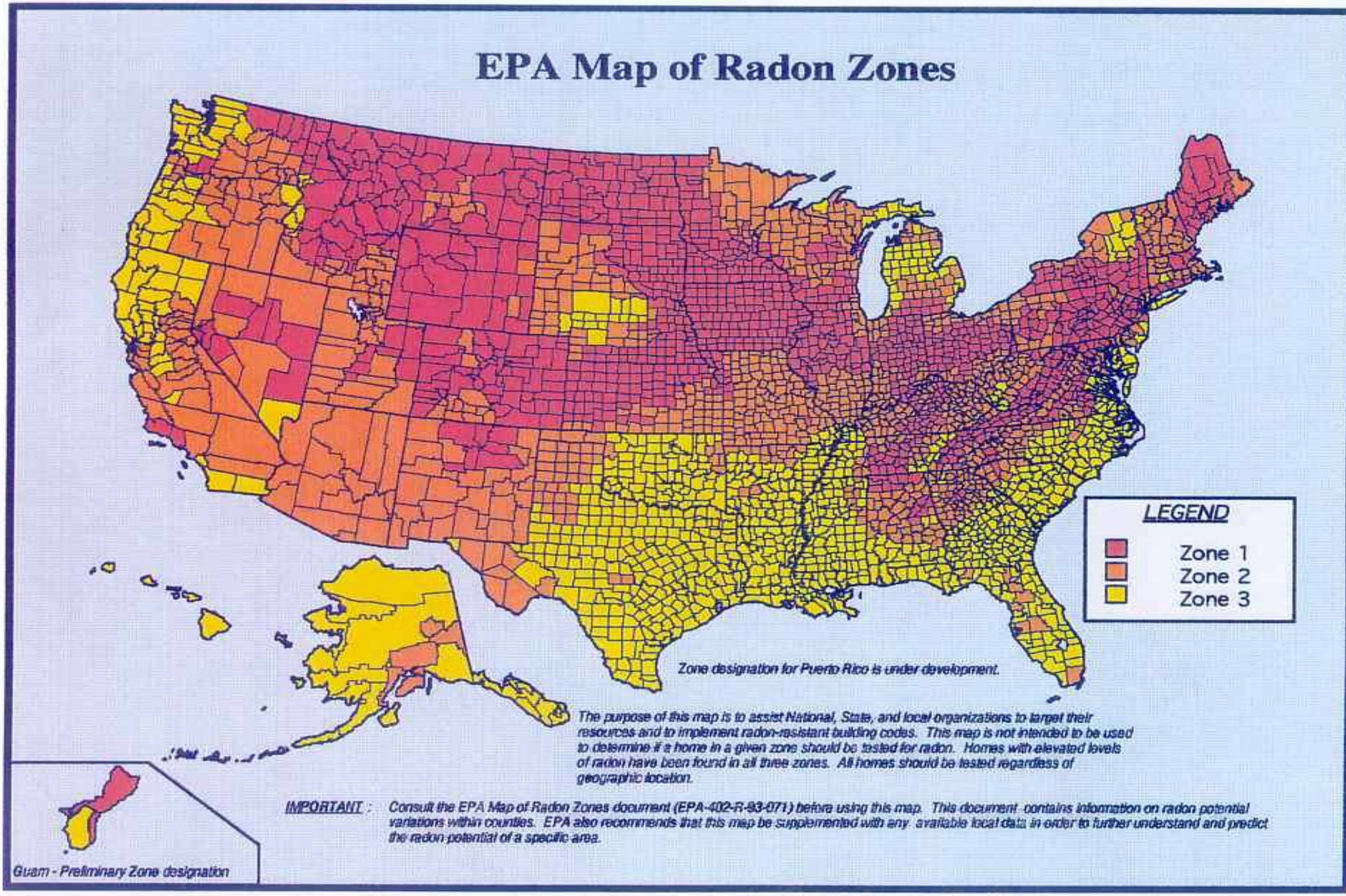
Biological Contaminants

- Health Effects
  - Asthma
  - Eye, nose and throat irritation
  - Shortness of breath
  - Dizziness, lethargy
  - Fever and humidifier fever
  - Digestive problems
  - Influenza and other infections
- Ways to Reduce Exposure
  - Clean, vent, use of filters

Radon

- Naturally forming radioactive gas produced when uranium decays.
- Found in soil and groundwater
- Health Effects – Lung Cancer

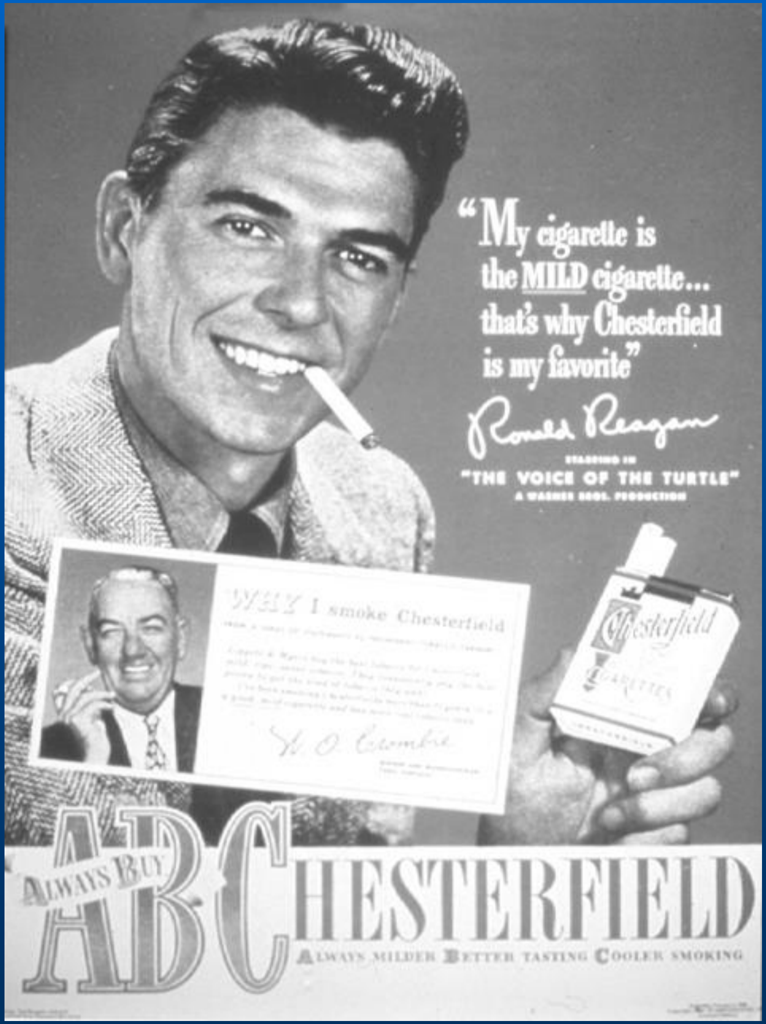
- Ways to Reduce Exposure
  - Vents and fans


EPA Map of Radon Zones
LEGEND
Zone 1
Zone 2
Zone 3
Zone designation for Puerto Rico is under development.
The purpose of this map is to assist National, State, and local organizations to target their resources and to implement radon-resistant building codes. This map is not intended to be used to determine if a home in a given zone should be tested for radon. Homes with elevated levels of radon have been found in all three zones. All homes should be tested regardless of geographic location.
IMPORTANT: Consult the EPA Map of Radon Zones document (EPA-402-R-93-071) before using this map. This document contains information on radon potential variations within counties. EPA also recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential of a specific area.
Guam - Preliminary Zone designation

Environmental Tobacco Smoke

- A complex mixture of over 4,000 compounds, more than 40 of which are known to cause cancer in humans or animals

- Estimated there are 40,000 deaths each year in nonsmokers.



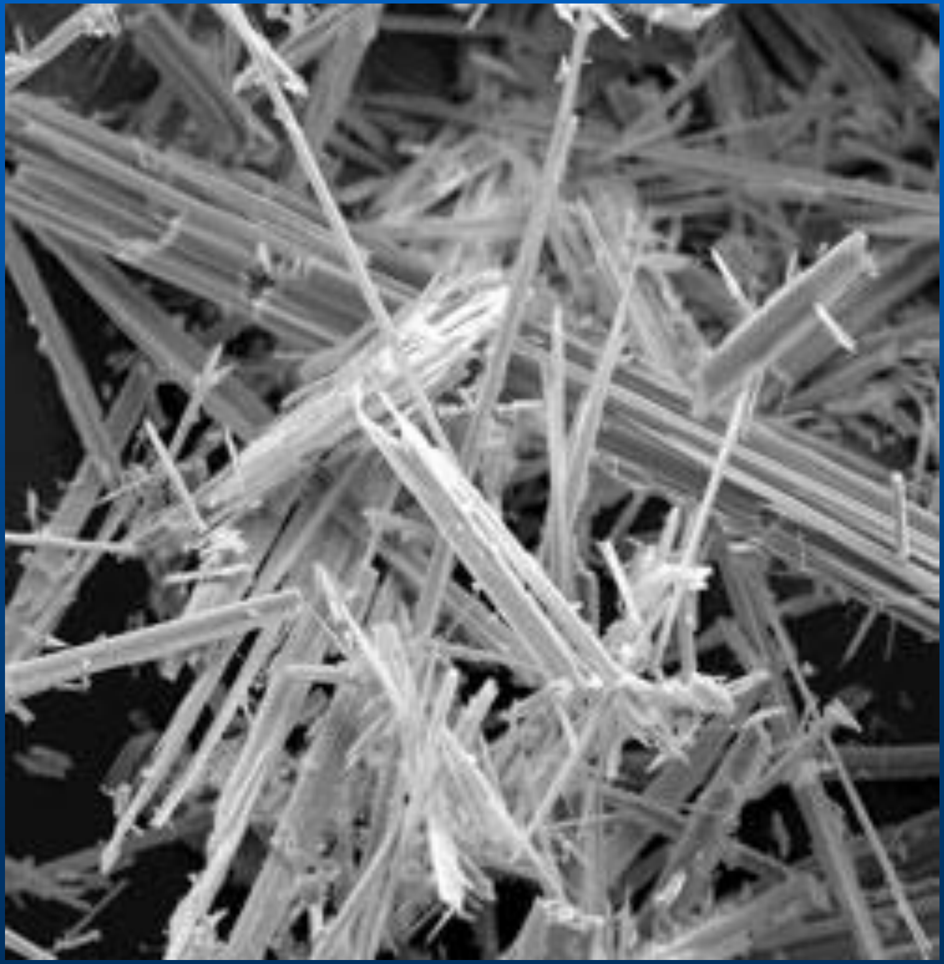
Stoves, Heaters, Fireplaces and Chimneys

- What is it?
- Health Effects
- Ways to Reduce Exposure

Asbestos

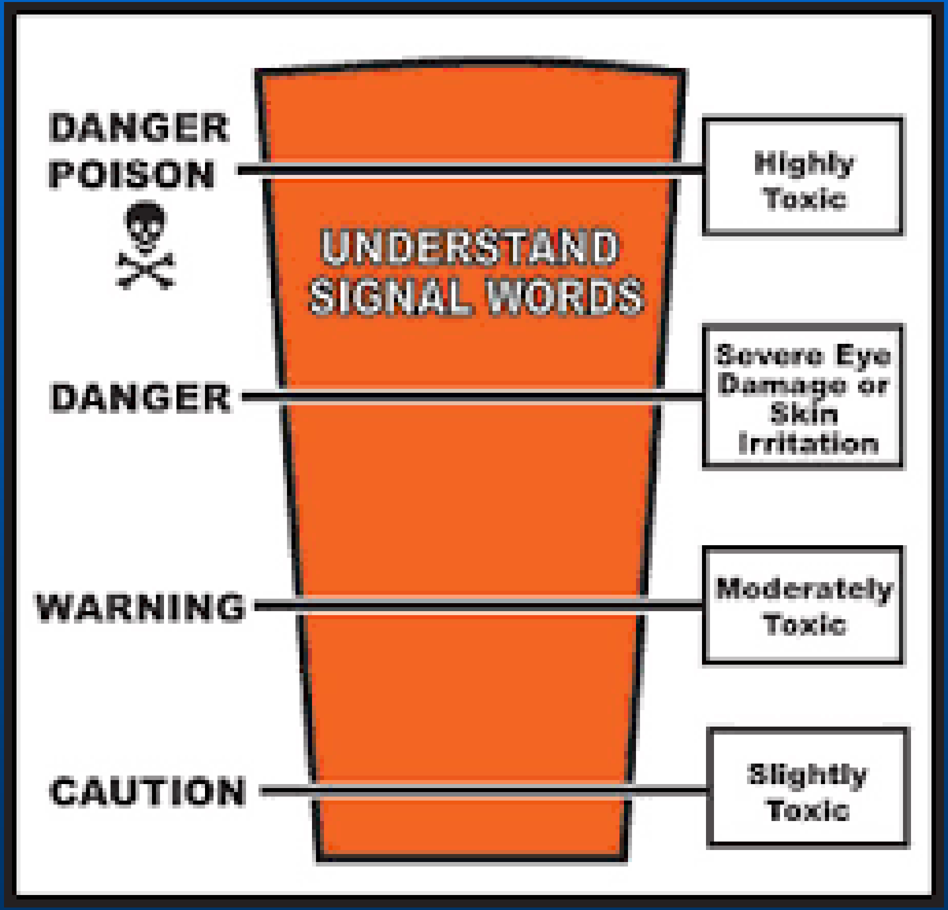
- A mineral fiber that has been commonly used in a variety of building construction materials, and brakes
- Can cause lung cancer, mesothelioma (a cancer of the chest and abdominal linings), and asbestos
- There is no danger unless fibers are released and inhaled into the lungs.

Asbestos



Pesticides

- Term includes insecticides and disinfectants
- 80 percent of most people's exposure to pesticides occurs indoors
- To reduce exposure, read the label and follow the directions



Organic Chemicals

- Paints, glues, solvents, cleaners, fuels
- Health effects are varied
- Reduce exposure by following the label instructions.

Formaldehyde

- A colorless, pungent-smelling gas that can cause watery eyes, a burning sensation in the eyes and throat, nausea, and difficulty in breathing.
- Sources include building materials, smoking, household products, and the use of unvented, fuel-burning appliances, like gas stoves or kerosene space heaters and pressed wood products.

Formaldehyde

- Possible health effects include increase in asthma attacks, has also been shown to cause cancer in animals.

- Ways to reduce exposure include ventilation

Lead

- See previous slides
- Affects the central nervous system
- Sources include old paint, soil, some types of old water pipes

Carbon Monoxide

- See previous slides
- To reduce exposure properly vent appliances

Nitrogen Oxides

- See previous slides
- To reduce exposure properly vent appliances

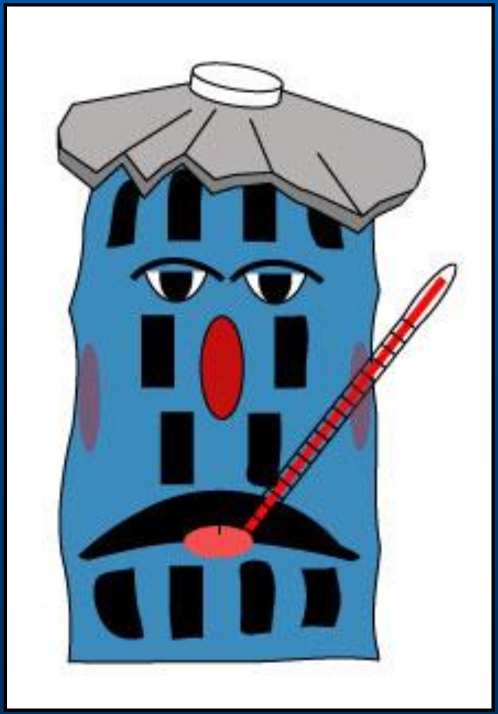
Sick Building Syndrome

- A variety of unrelated symptoms or health effects that are reported by at least twenty percent of a building's occupants.

- Estimates suggest that building-related illnesses result in direct medical costs of over $1 billion each year

Sick Building Syndrome

- Causes include poorly designed, maintained, or operated ventilation systems.



Controls of Indoor Air Pollution

- Source Control
- Ventilation
- Air Cleaners

EPA's Approach and Progress

- EPA Indoor Air Program
- Other Federal Agencies

Chapter Summary

- Sources and Effects of Indoor Air Pollution
- Sick Building Syndrome
- Controls of Indoor Air Pollution
- EPA’s Approach and Progress

Review Questions

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter5:

Control of Stationary Sources (Particulate Matter)

Chapter Summary

- Introduction to Stationary Sources
- Control Procedures
- Control Devices for Particulate Emissions

Introduction to Stationary Sources

- Process Operations Groupings
- Air Release Emissions Points

Process Operations Groupings

- Process Operations
- Atmospheric Releases
- Auxiliary Losses
- Waste Emissions

Air Release Emissions Points

Industrial Process Operation Air Emission Points and Categories	
Process Operation Reactors vents Distillation systems Vacuum systems Combustion stacks Blow molding Spray drying and booths Extrusion machines	Fugitive Sources Valves Pump seals Flanges/connectors Compressors Open ended lines Pressure relief devices Equipment cleaning/maintenance
Surface Area Sources Pond evaporation Cooling tower evaporation Wastewater treatment Land disposal	Handling, Storage, Loading Storage tank breathing losses Loading/unloading Line venting Packaging and container loading

Control Procedures

- Exhaust Stacks
- Plant Operations
- Control Technology

Exhaust Stacks

- Benefits
  - Reduce effects
  - Cheap
- Drawbacks
  - Transfer pollution to another location

Plant Operations

- Pre-Treating
- Cleaner Fuels
- Improved Plant Maintenance

Control Technology

- Exhaust Gas Characteristics
- Process or Site Characteristics
- Use of Control Devices

Combustion Considerations

3 T's of Combustion

- Residence *T*ime
- *T*emperature
- *T*urbulence (mixing)
- Increase 3T's = more NOx
- Decrease 3T's = more CO and uncontrolled pollutant

Exhaust Gas Characteristics

- Total Exhaust Flow Rate
- Exhaust Gas Temperature
- Required Control Efficiency
- Particle Size Distribution
- Particle Resistivity
- Composition of Emissions
- Corrosiveness of Exhaust Gas
- Moisture Content
- Stack Pressure
- Exhaust Gas Combustibility and Flammability

Process or Site Characteristics

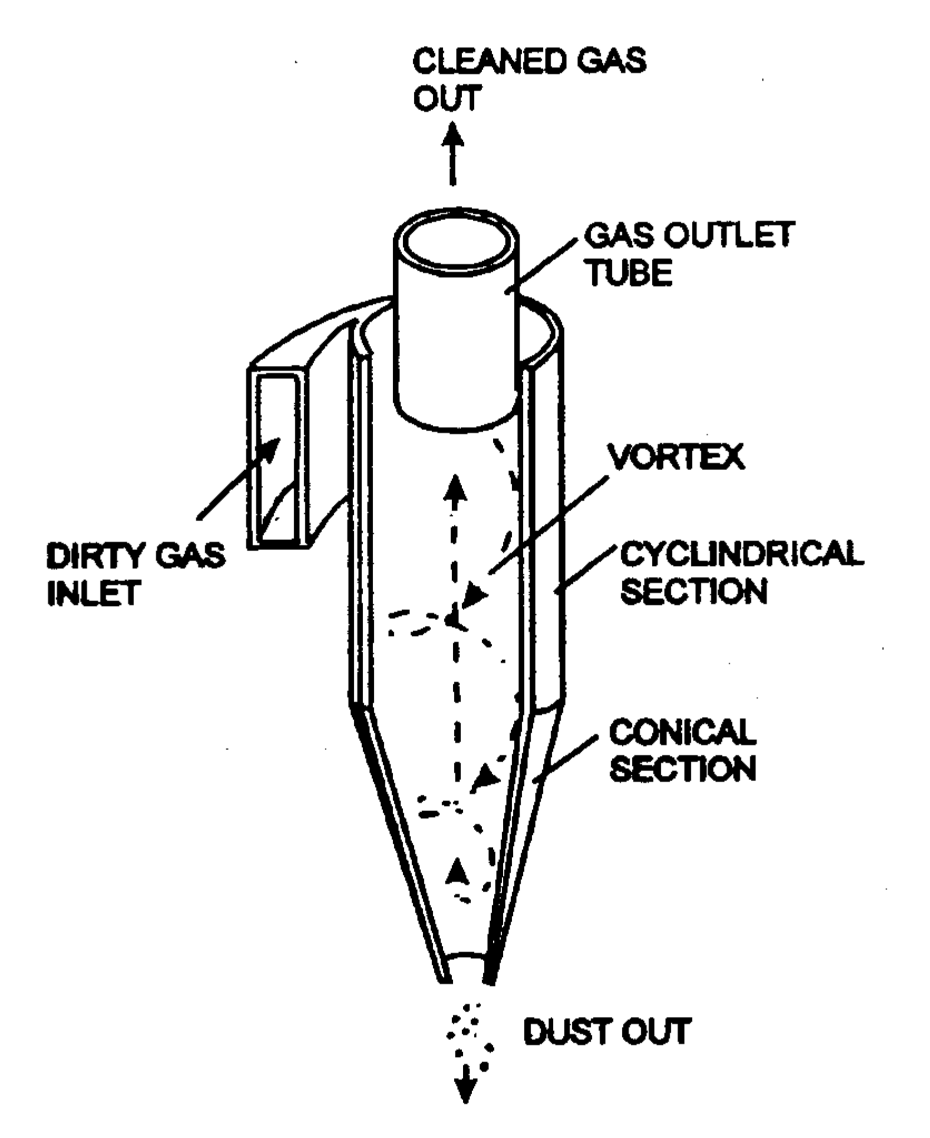
- Reuse/Recycling of Collected Emissions
- Availability of Space
- Availability of Additional Electric Power
- Availability of Water
- Availability of Wastewater Treatment Facilities
- Frequency of Startup and Shutdowns
- Environmental Conditions
- Anticipated Changes in Control Regulations
- Anticipated Changes in Raw Materials
- Plant Type – Stationary or Mobile

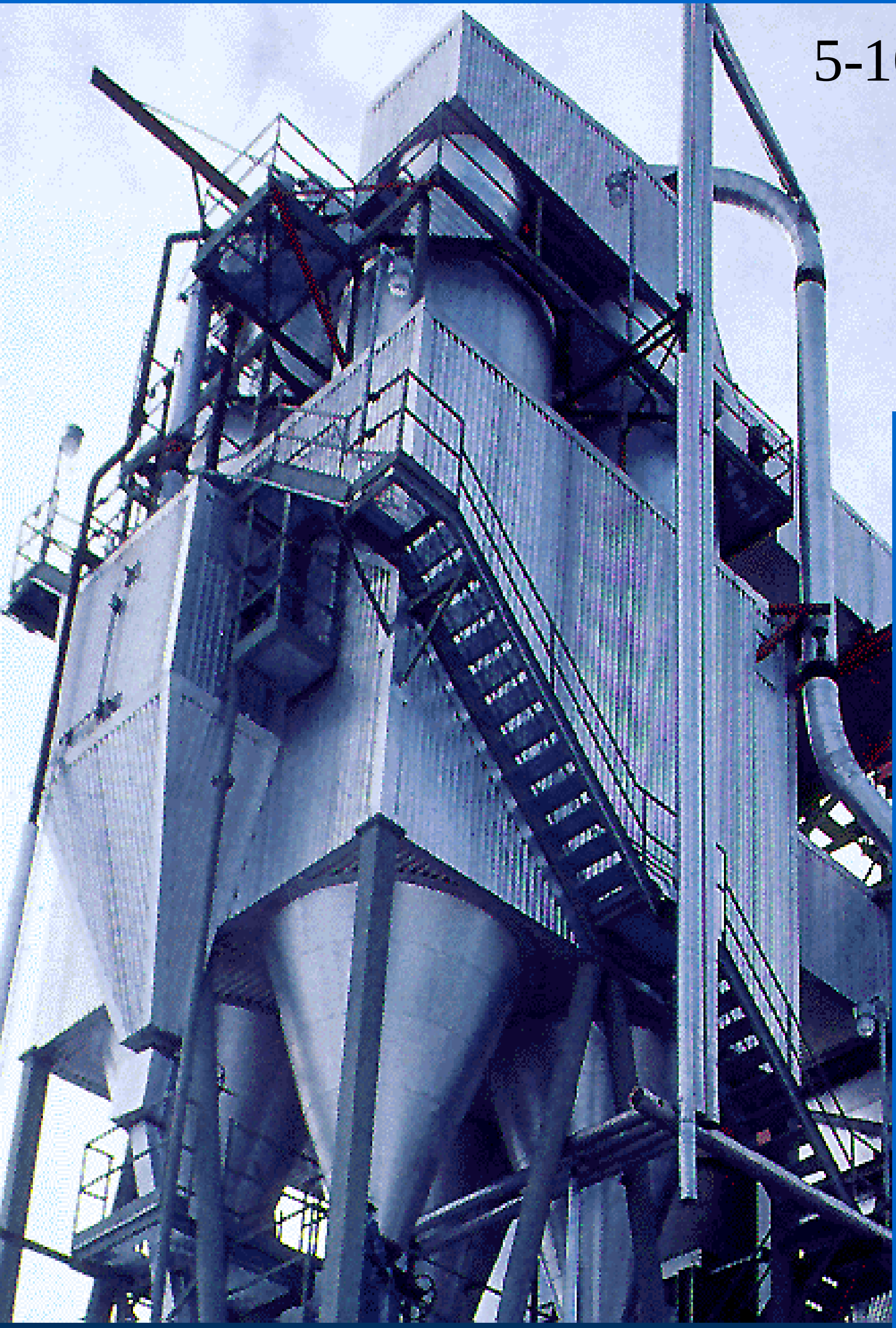
Let's Discuss PM Control

- Cyclones
- Baghouses
- ESPs
- Scrubbers
- Particulate Filters

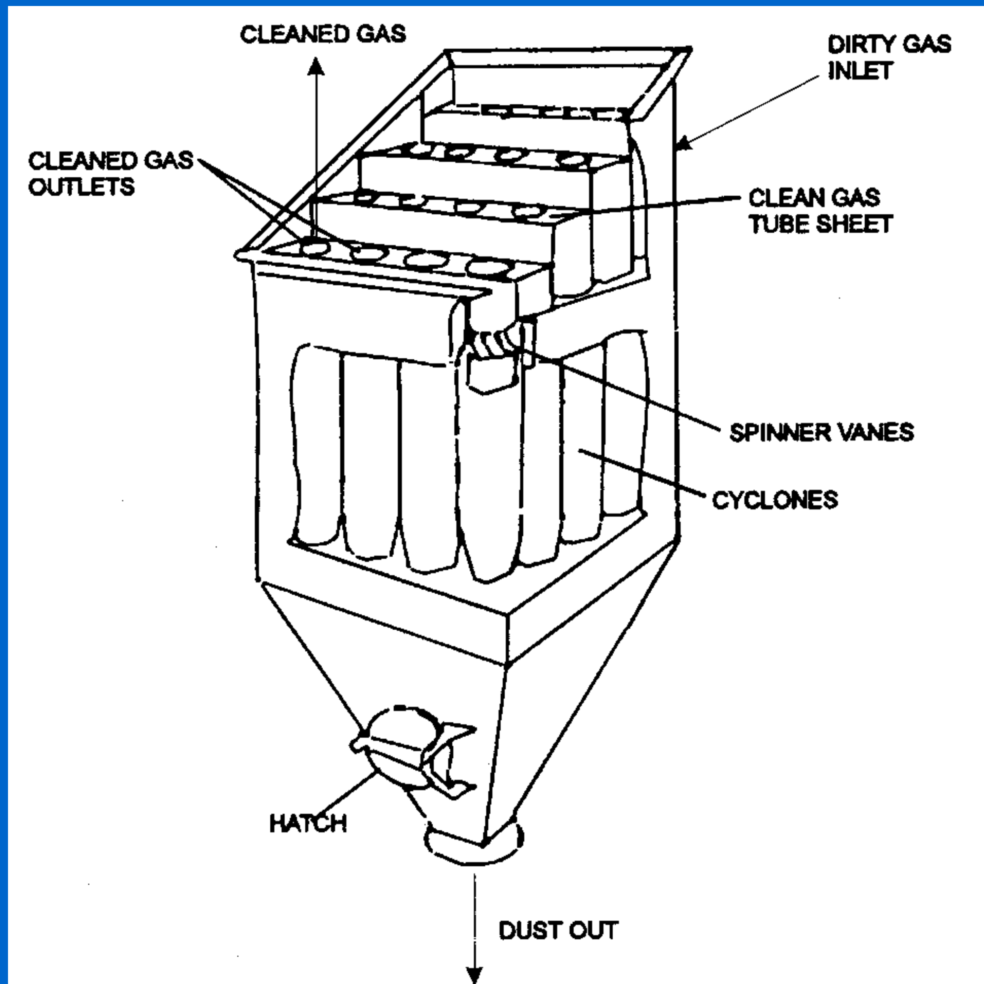
Cyclones

Greater 10 micro





Multi-Cyclone



Cyclones: Collection Efficiency

- Typical Efficiency
  - Single cyclone: 30-95% pm10
  - Single cyclone: 0-70 pm% 2.5
  - Multiple cyclone: 80-99%

- Determining Factors for Efficiency
  - Particle size and/or density
  - Inlet duct velocity
  - Cyclone body length and design

Cyclones: Advantages

- Low Capital Cost
- No Moving Parts
- Few Maintenance Requirements
- Low Operating Costs
- Relatively Low Pressure Drop
- Dry Collection and Disposal
- Relatively Small Space Requirements

Cyclones: Disadvantages

- Relatively Low PM Collection Efficiencies
- Unable to Handle Sticky or Tacky Materials
- High Efficiency Units May Experience High Pressure Drops

Let's Discuss Fabric Filters

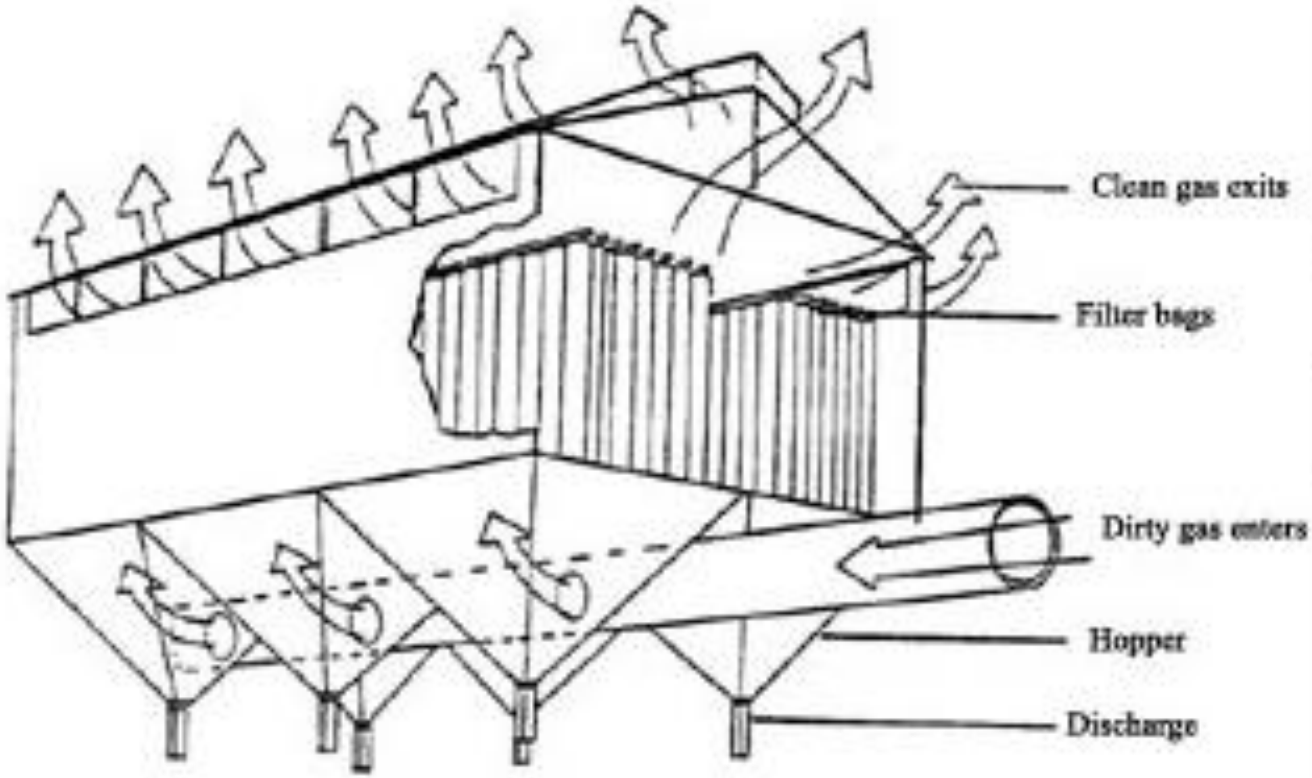

Air
Pollution
Control
Devices
Fabric
Filtration

Fabric Filters

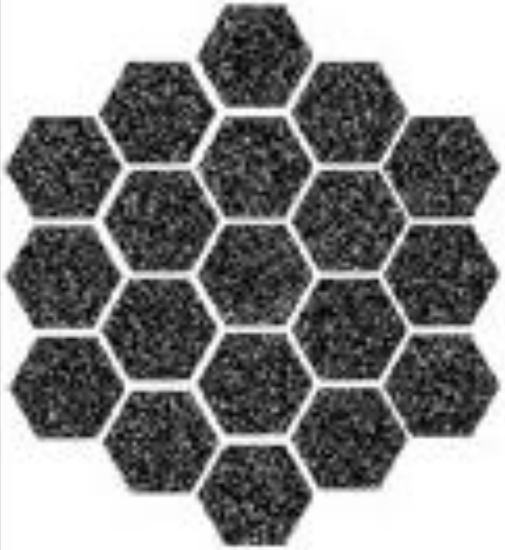
- Method of Operation
- Cleaning
- Collection Efficiency
- Benefits / Drawbacks

Fabric Filters: Method of Operation

- Mechanical Design



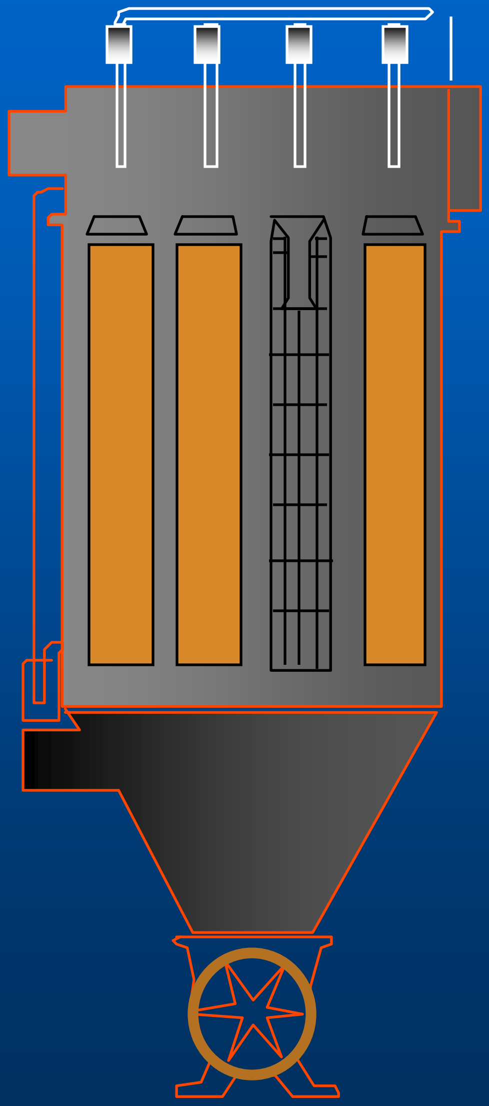
Baghouse



Cutaway of filter bag wall

Baghouse Design Considerations

- Pressure Drop
- Air-To-Cloth Ratio
- Collection Efficiency
- Fabric Type
- Cleaning
- Temperature Control
- Bag Spacing
- Compartment Design
- Space and Cost



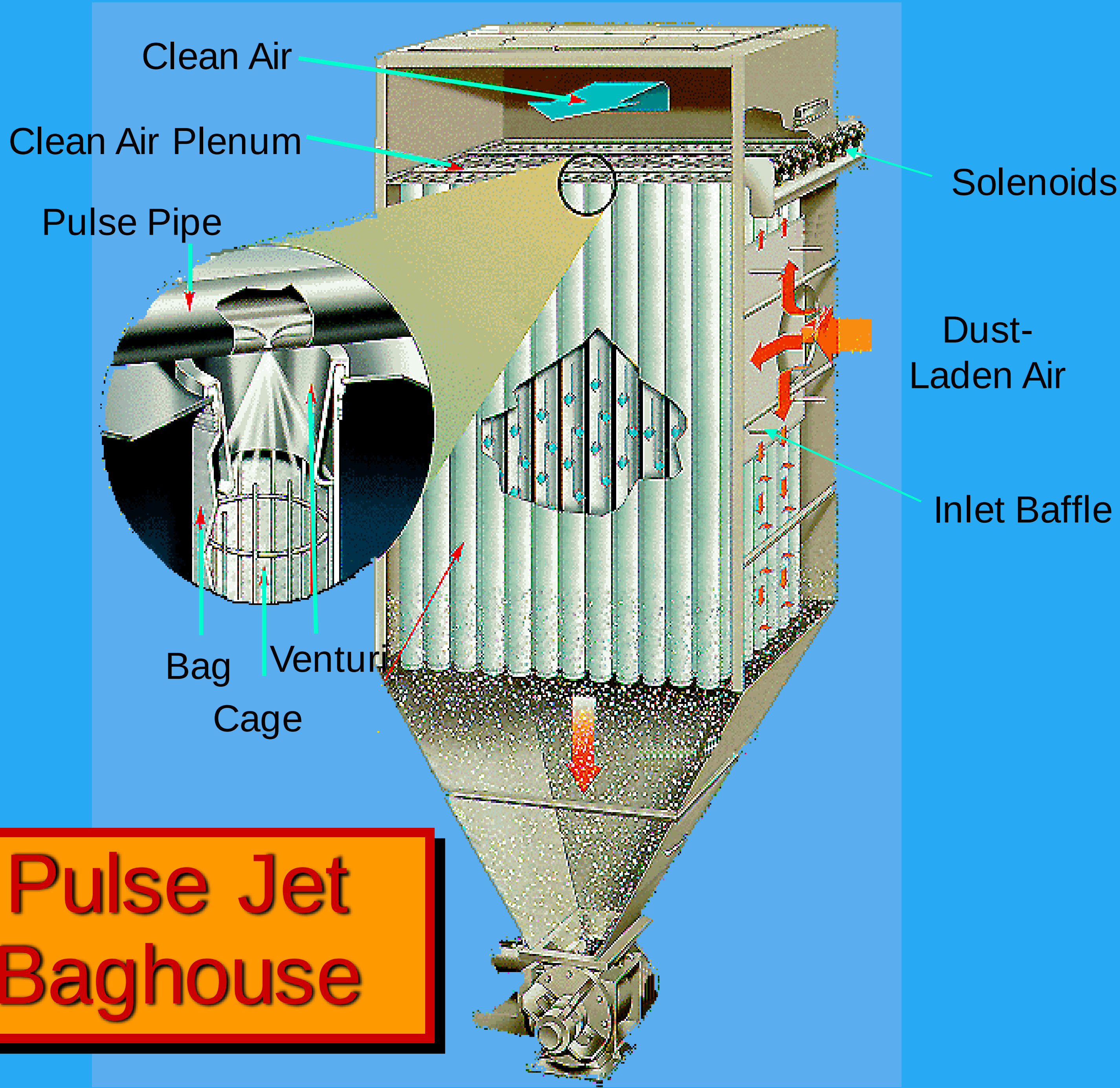

Mac2flo
MAC
GREEN
BEAN
Baghouse


Baghouse

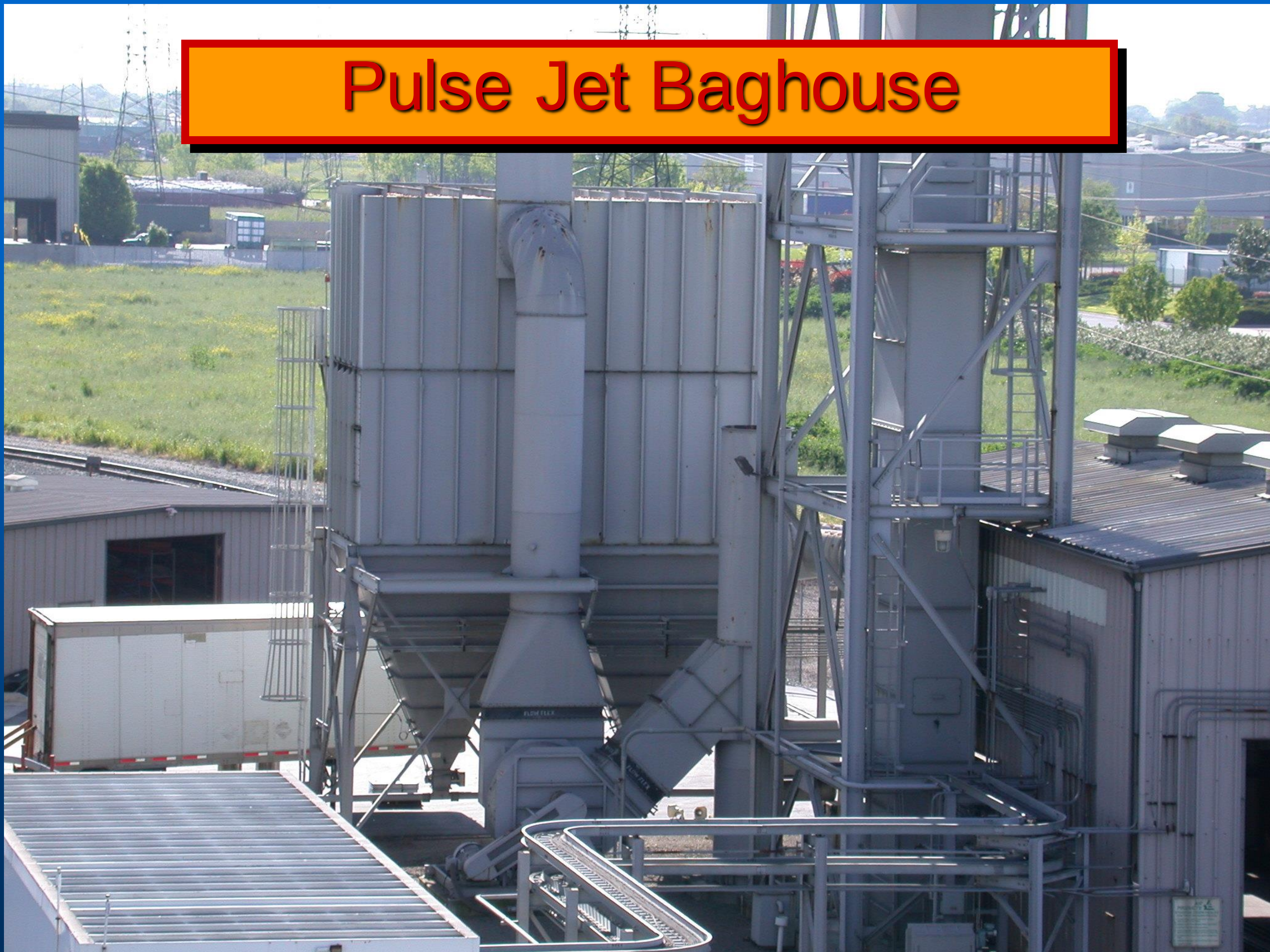
Fabric Filters: Cleaning

- Shaking
- Reverse-air
- Pulse-jet

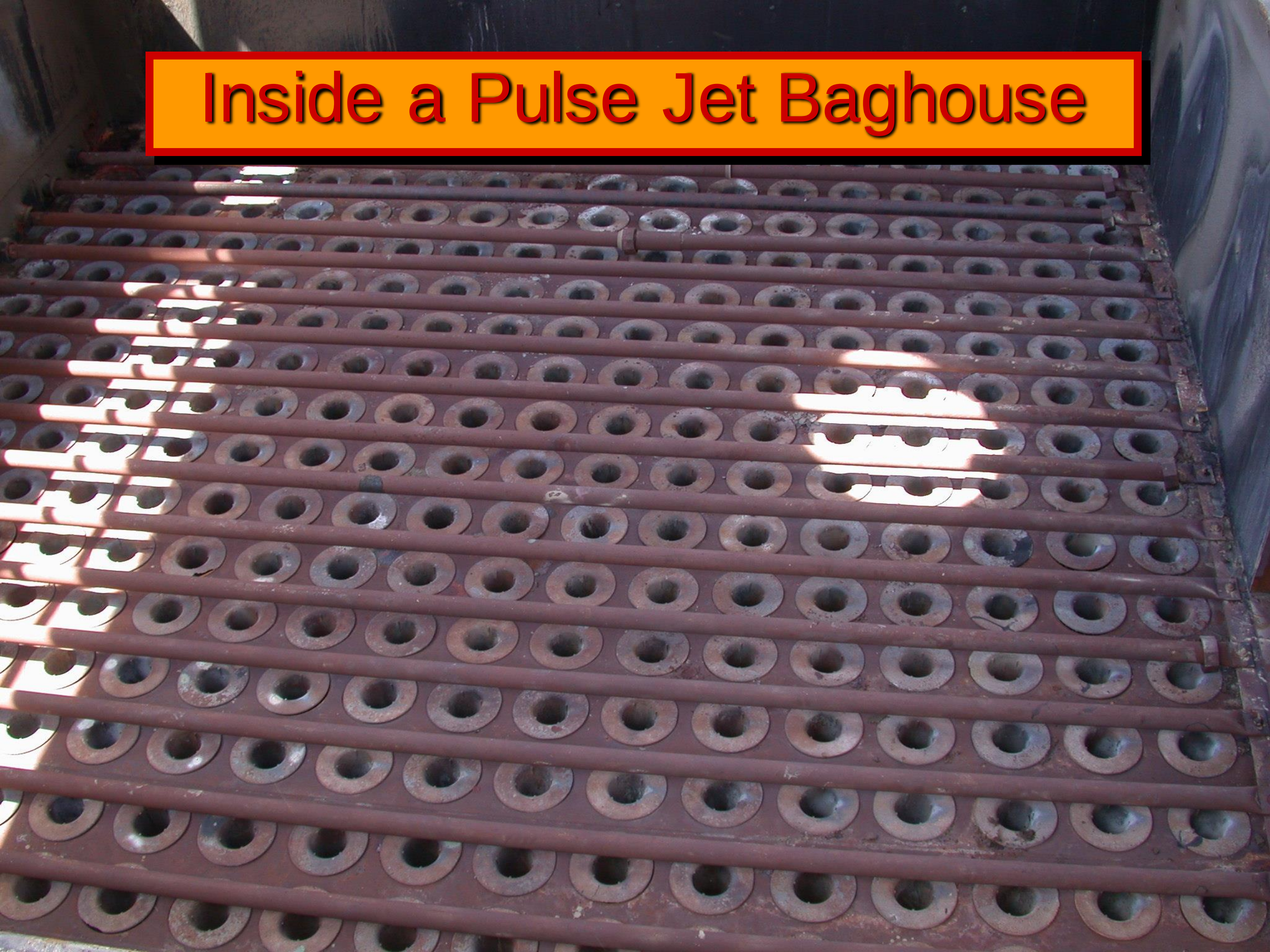
Pulse Jet Baghouse



Pulse Jet Baghouse

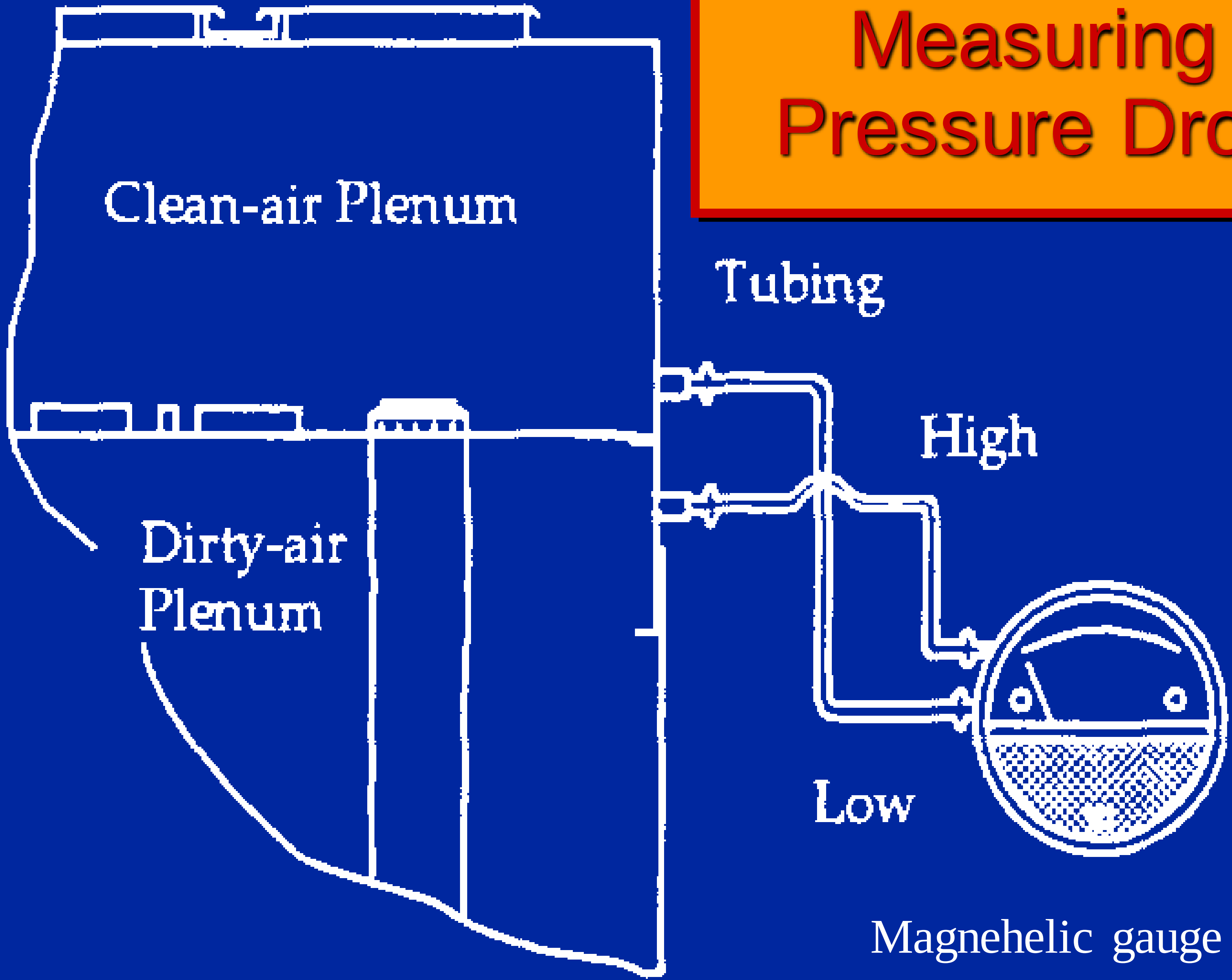


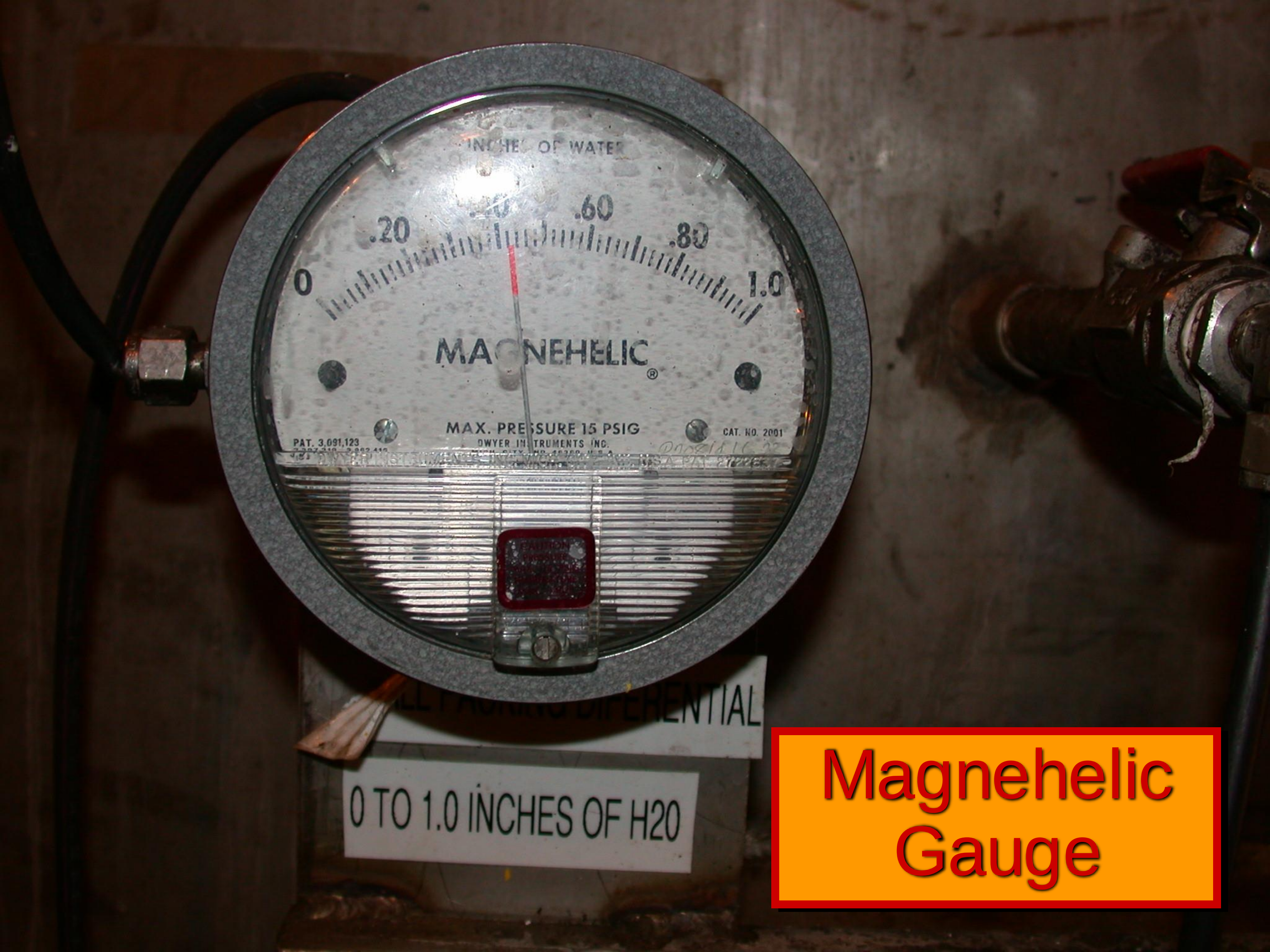
Inside a Pulse Jet Baghouse




Pulse Jet
Bag

Measuring Pressure Drop





Magnehelic Gauge

Pulse Jet Baghouse Advantages

- Have high collection efficiency for respirable dust
- Can have high air-to-cloth ratio (6 to 10 ft/min)
- Have increased efficiency and minimal residual dust buildup due to aggressive cleaning action
- Can clean continuously
- Can use strong woven bags

Pulse Jet Baghouse Disadvantages

- May not be used readily in high temperatures unless special fabrics are used
-
- Cannot be used if high moisture content or humidity levels are present in the exhaust gases

Fabric Filters: Collection Efficiency

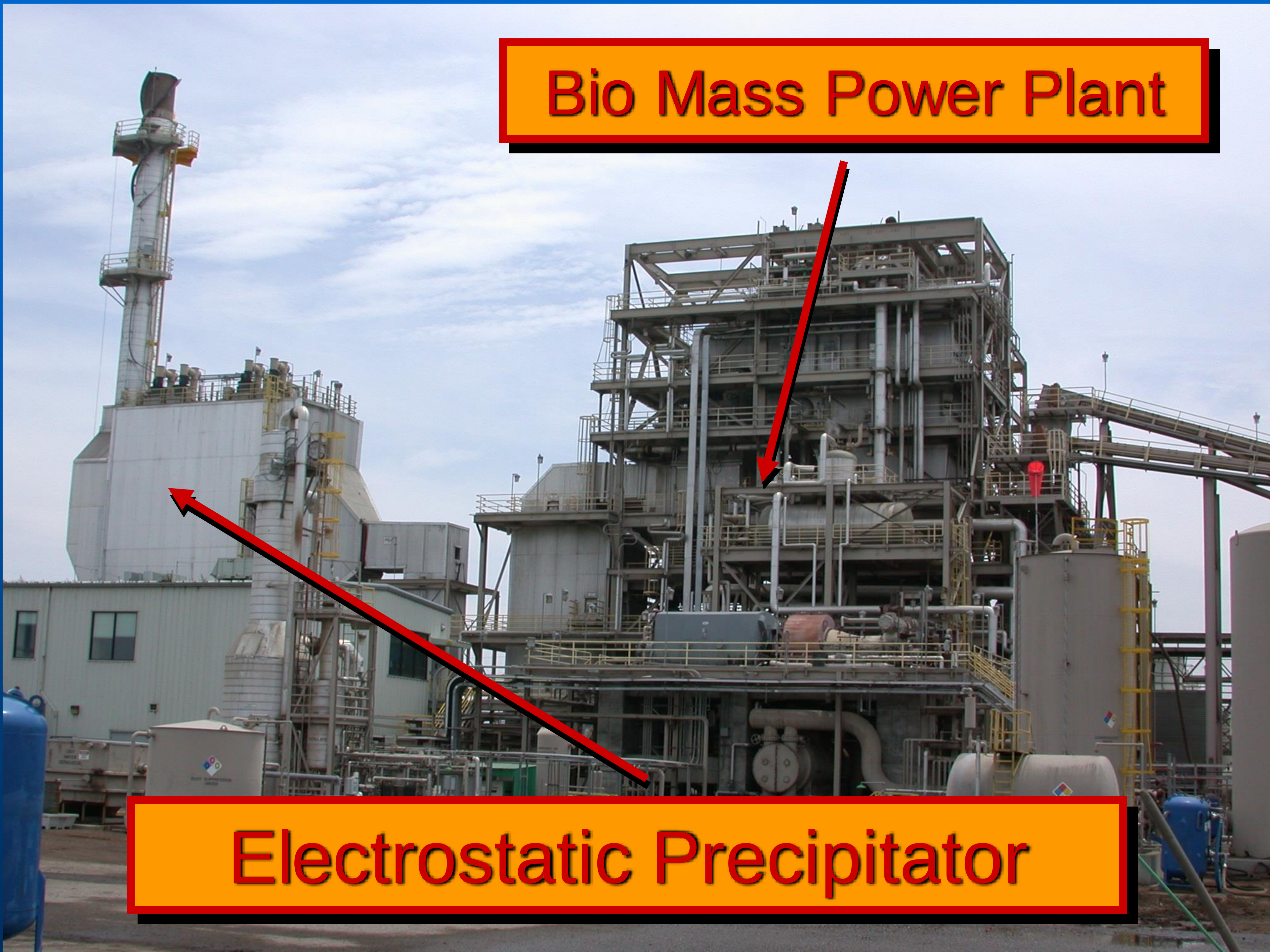
- Typical Efficiency
  - 95-99.9% (old equipment)
  - 99-99.9% (new equipment)

- Determining Factors for Efficiency
  - Gas Velocity
  - Particle characteristics
  - Fabric characteristics
  - Cleaning mechanism, intensity, frequency

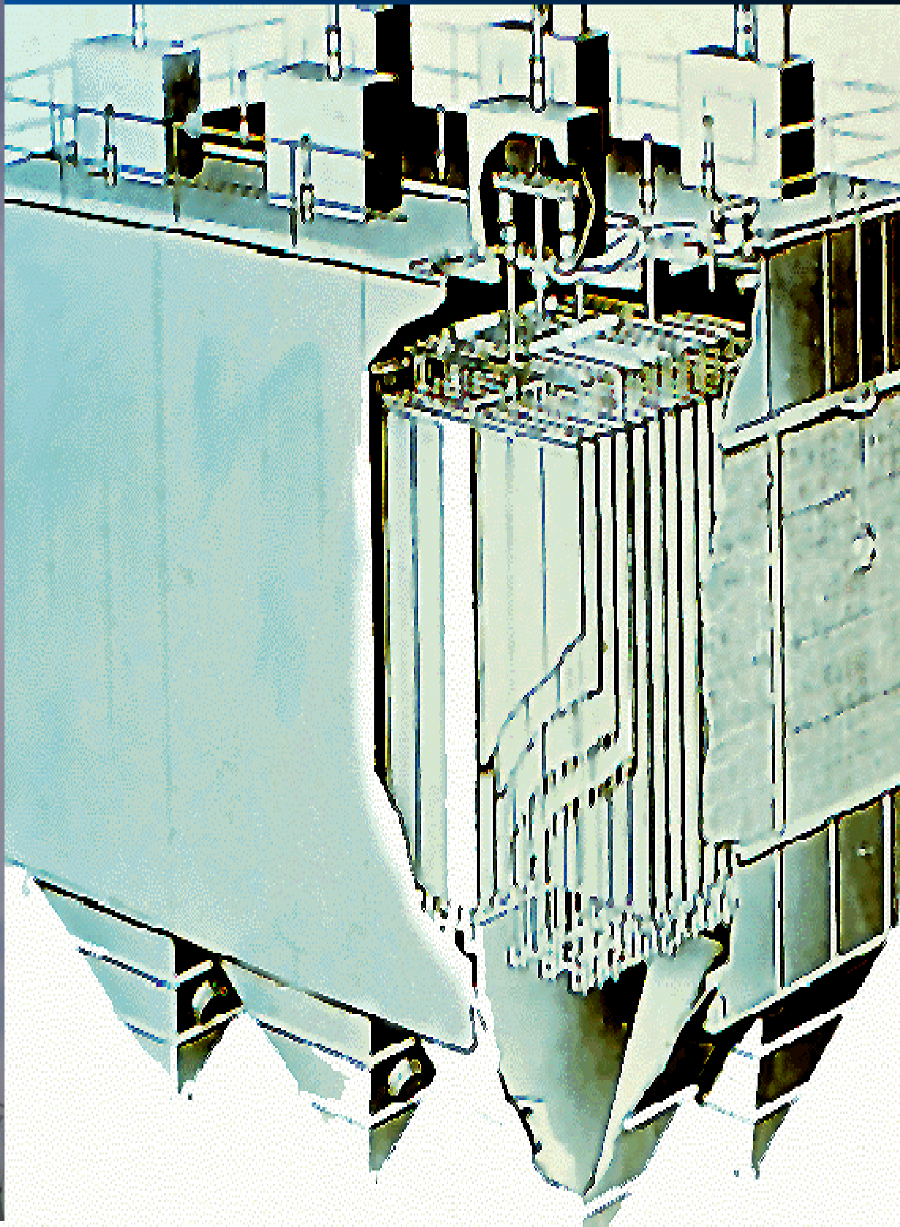
Fabric Filters: Benefits / Drawbacks

- Simplicity
- Sensitivity
- Installation
- Cleaning and Maintenance

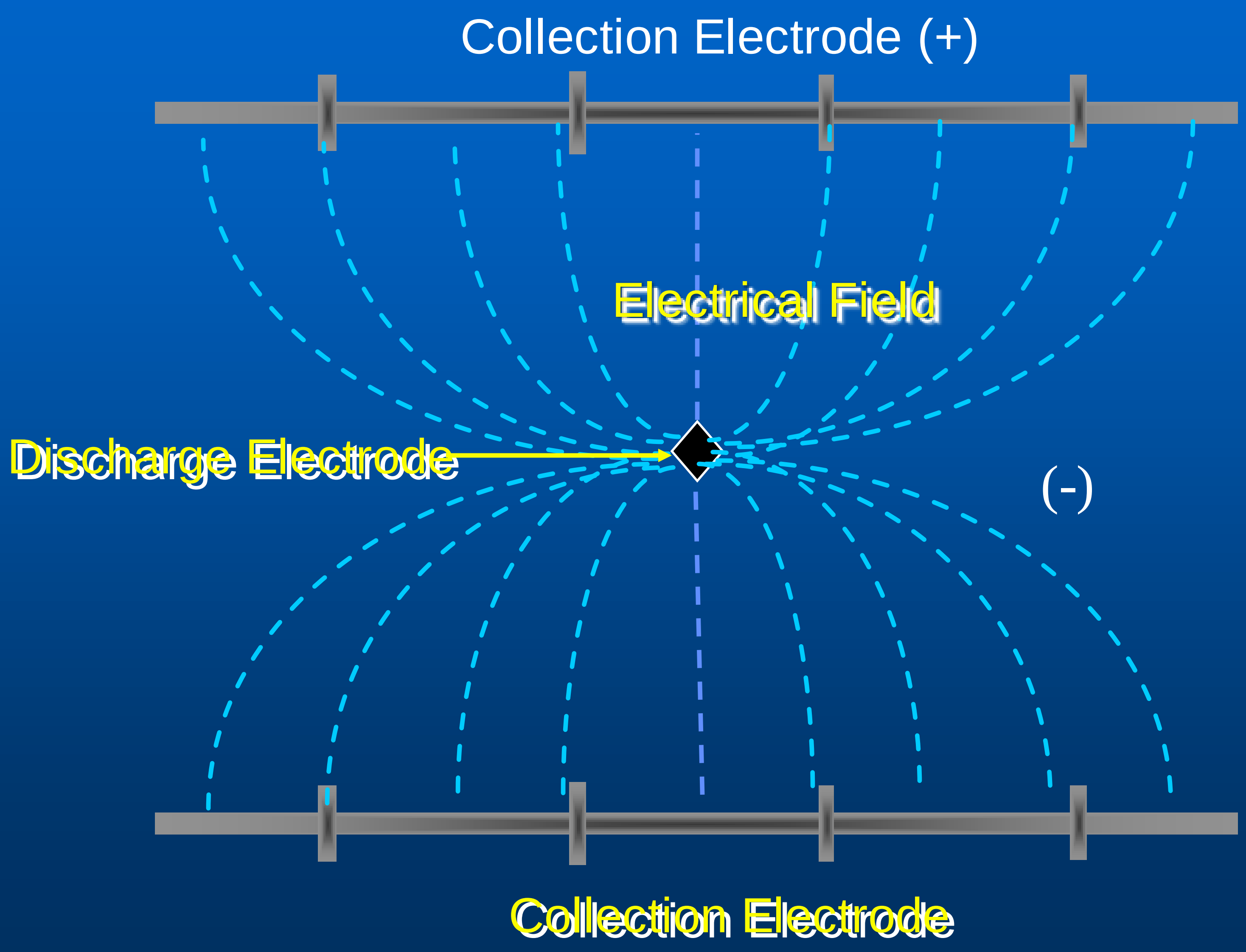
Let's Discuss Electrostatic Precipitators


Bio Mass Power Plant
Electrostatic Precipitator

Electrostatic Precipitator



Electrical Field Generation



Electrostatic Precipitator

- General Description
  - Two types
    - Dry type use mechanical action to clean plates
    - Wet type use water to prequench and to rinse plates

Magnetic Impulse Rappers

ESPs: Design Factors Affecting Performance

- Specific Collection Area
- Aspect Ratio
- Collection Plate Spacing
- Sectionalization
- Power Requirements/Spark Rate

Electrostatic Precipitators: Collection Efficiency

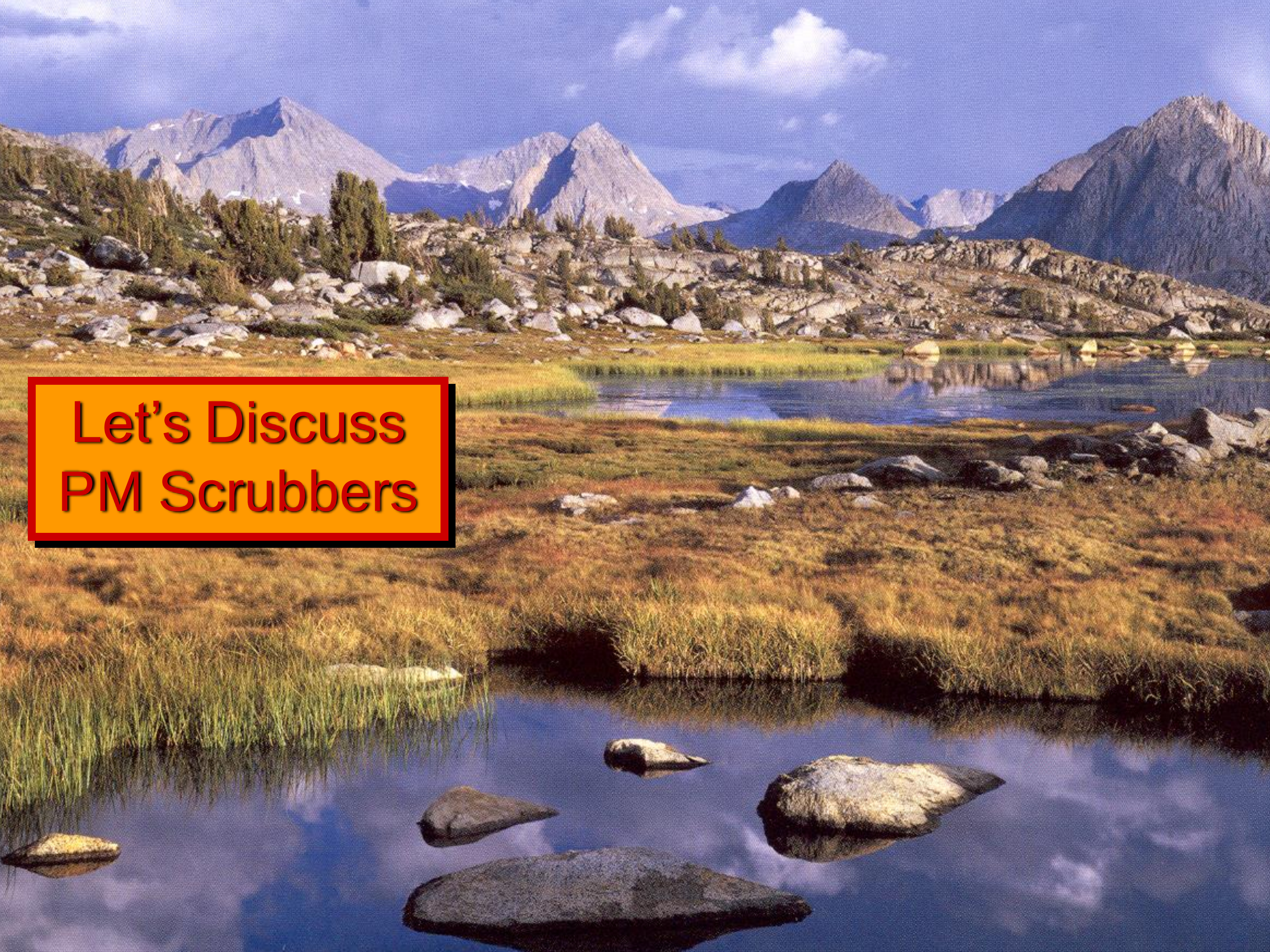
- Typical Efficiency
  - 99% <10microns

- Determining Factors for Efficiency
  - ESP size and retention time
  - Electric field strength
  - process factors

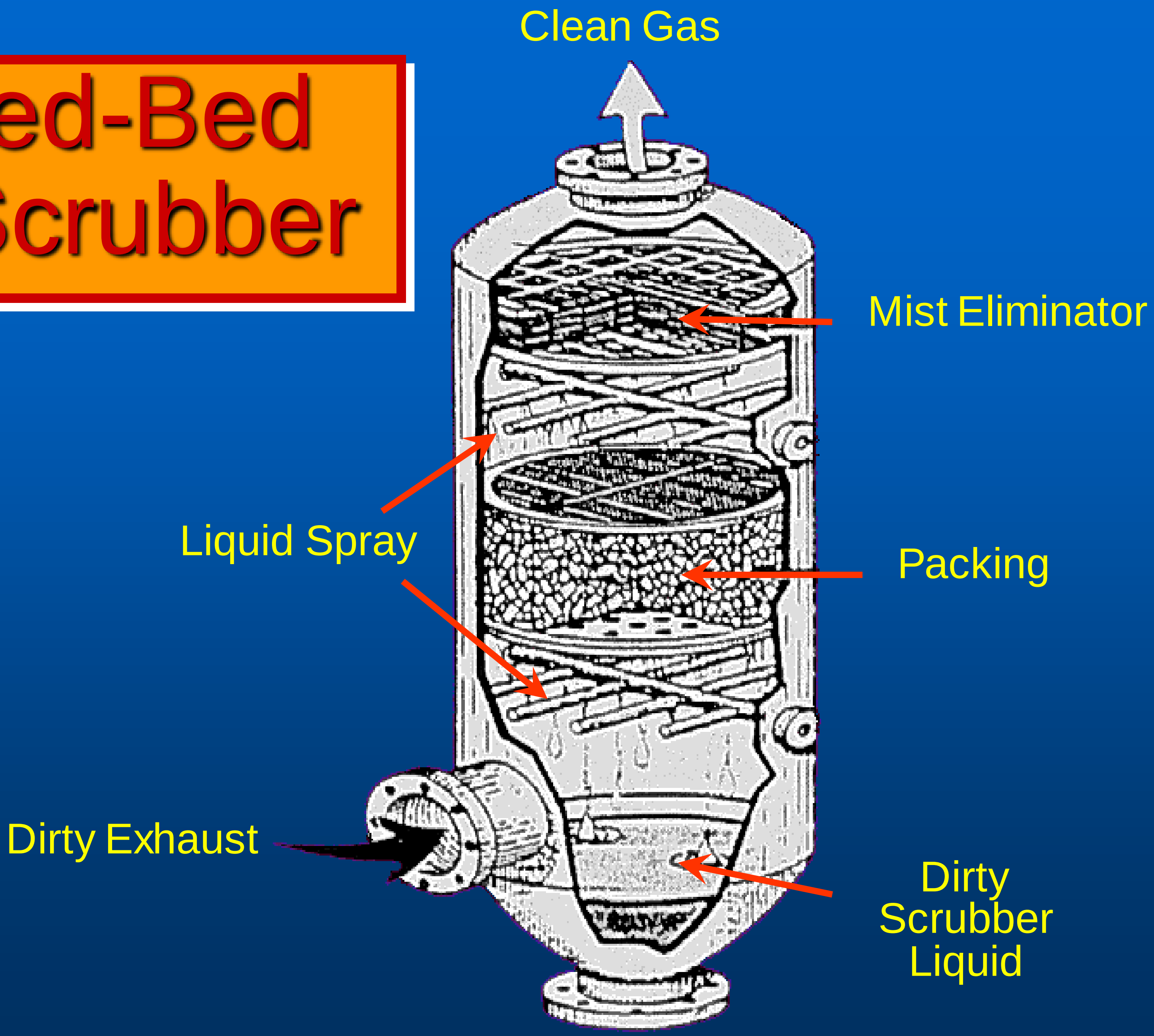
Electrostatic Precipitators: / Drawbacks

- Benefits
  - Removal efficiency
- Drawbacks
  - Cost
  - Installation
  - Operating Range
  - Treatment and Maintenance

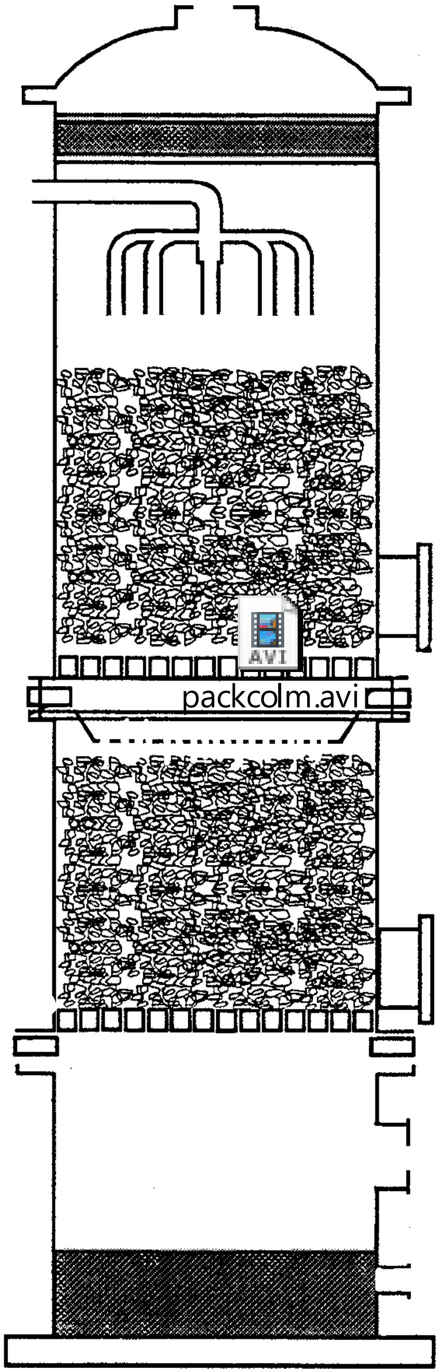
Let's Discuss PM Scrubbers



Packed-Bed Wet Scrubber

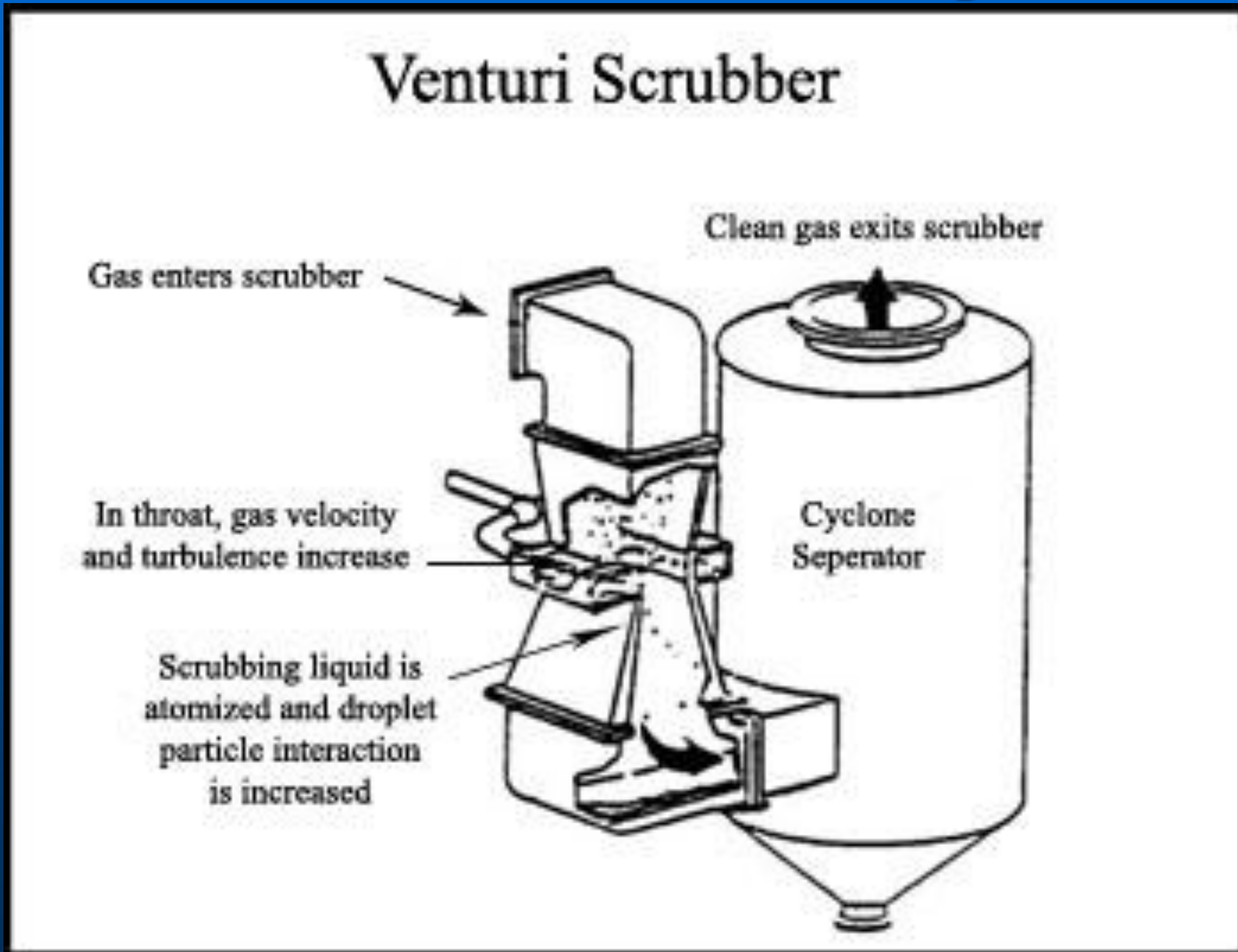



Air Pollution
Control Devices
Wet Scrubbers
for Particles


packcolm.avi


Packed-Bed Wet Scrubber

Venturi Scrubbers: Method of Operation




Venturi
Scrubber

Venturi Scrubbers: Collection Efficiency

- Typical Efficiency
  - 70 to 99 % removal
  - 0.5 to 5 microns
- Determining Factors for Efficiency
  - Pressure drop and energy consumption

Venturi Scrubbers: Advantages

- Capable of Handling Flammable and Explosive Dusts
- Can Handle Mists in Process Exhausts
- Low Maintenance
- Simple in Design and Easy to Install
- Variable Collection Efficiency
- Provides Cooling for Hot Gases
- Neutralizes Corrosive Gases and Dusts

Venturi Scrubbers: Disadvantages

- Water Pollution
- Wet Waste Product
- High Corrosion Potential
- Requires Protection Against Freezing
- Final Exhaust Must Be Reheated
- Collected PM May be Contaminated
- Disposal of Waste Sludge is Very Expensive

Let's Discuss Diesel Particulate Filters

Diesel Particulate Filter (DPF)

- High temperature regeneration (600-650 ºC)
- Catalytic regeneration (~375 ºC)
- Oxidize NO to NO_2 → adsorbs → reduces regeneration temperature
- Fuel-borne catalyst
- Ceramic coatings
- Engine adjustments necessary


OTTER VIEW
BERT
Diesel Particulate Filter (DPF)

Chapter Summary

- Introduction to Stationary Sources
- Control Procedures
- Control Devices for Particulate Emissions

Review Questions