Air Pollution
Climate change

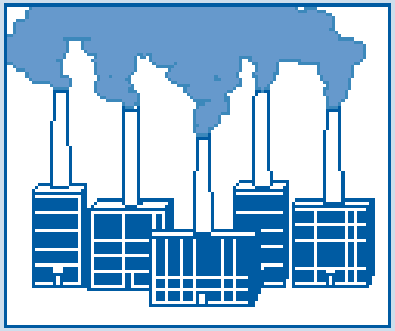
CE 107

Air Pollution

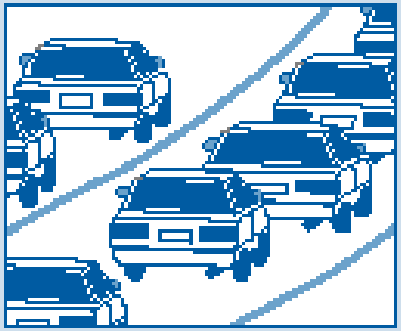
Stationary and Mobile sources of Air Pollution

- Two Sources of Air Pollution
  1. **Stationary Sources:** have a relatively fixed location
     - Point Sources: controllable sites
     - Fugitive Sources: burning, dirt road, construction sites, farmlands
     - Area Sources: Communities, agriculture
  2. **Mobile Sources:** move from place to place while emitting pollutants
     - Ex) Airplanes

Sources of Air Toxics

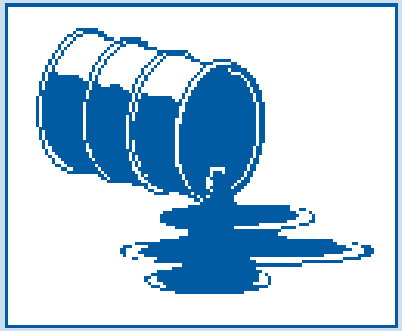


Routine Emissions From Stationary Sources

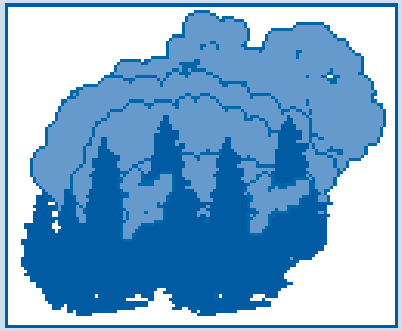


Mobile Sources

Each year, millions of tons of toxic pollutants are released into the air from both natural and manmade sources.

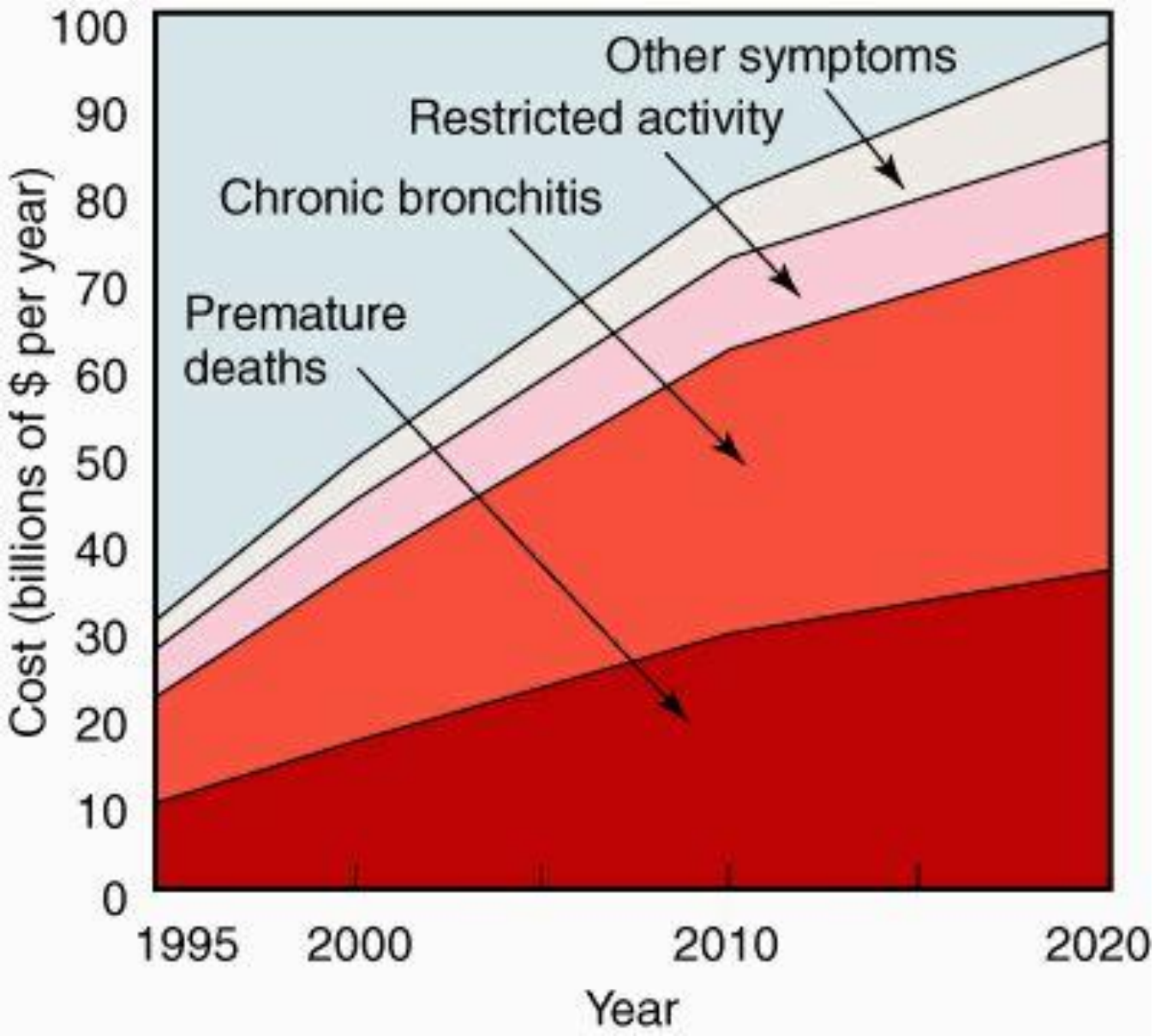


Accidental Releases

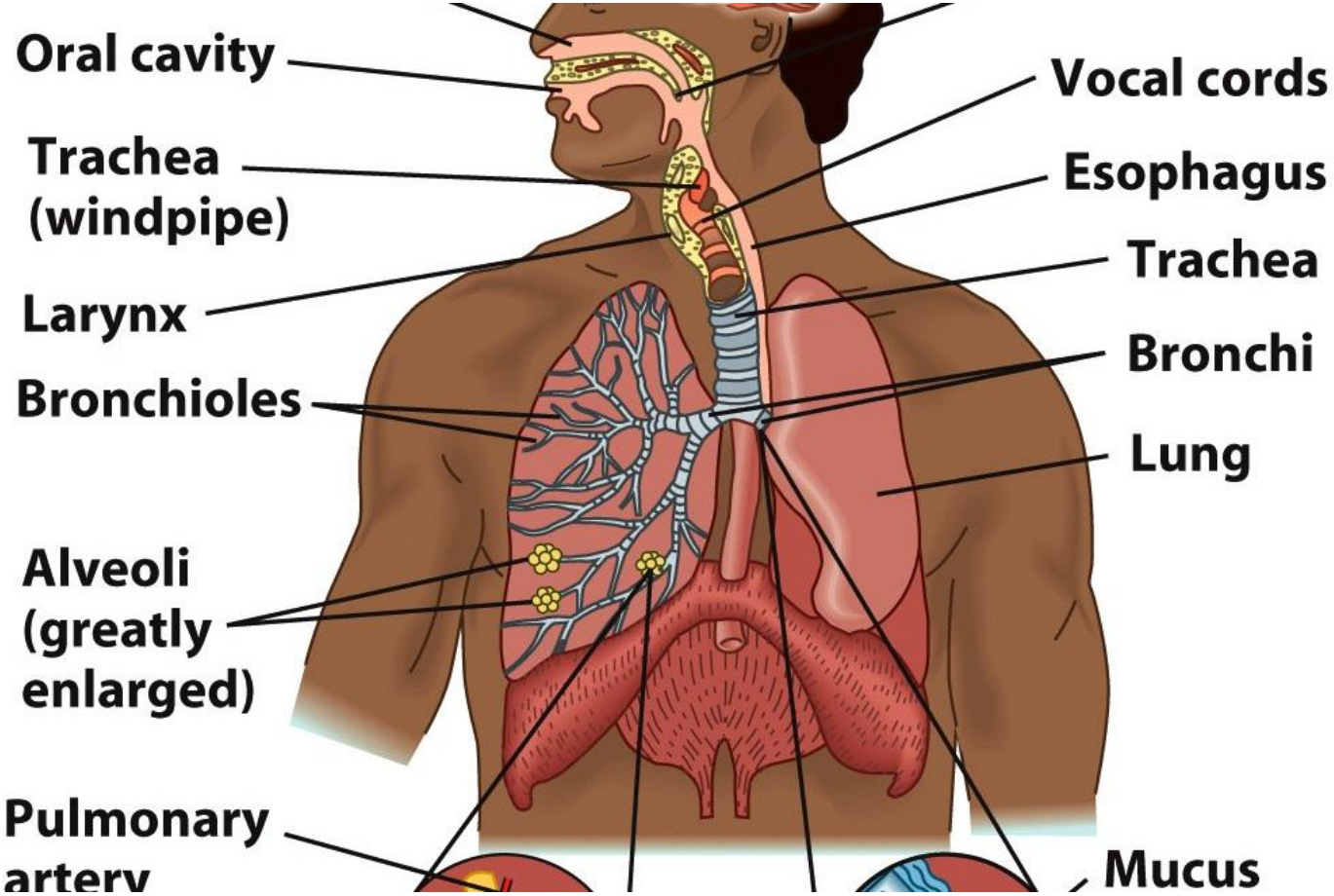


Forest Fires

Health cost due to air pollution in US



Idealized diagram showing some parts of the human body (brain, cardiovascular system and pulmonary system)



Major Air Pollutants

- Sulfur Dioxide (acid rain)
- Nitrogen Oxide
- Carbon Monoxide
- Ozone and Other Photochemical Oxidants
- Volatile Organic Compounds
- Particulate Matter
- Hydrogen Sulfide
- Hydrogen Fluoride
- Hazardous Gases
- Lead

Specific Impacts of Air Pollution

- Greenhouse effect
- Ozone depletion
- acidification
- smog formation
- human health
- ecosystem health

Criteria Air Pollutants

- Nitrogen Dioxide: NO2
  - brownish gas irritates the respiratory system originates from combustion (N2 in air is oxidized); NOx sum of NO, NO2, other oxides of N
- Ozone: ground level O3
  - primary constituent of urban smog
  - reaction of VOC + NOx in presence of heat +sun light
- Carbon monoxide: CO
  - reduces bloods ability to carry O2
  - product of incomplete combustion

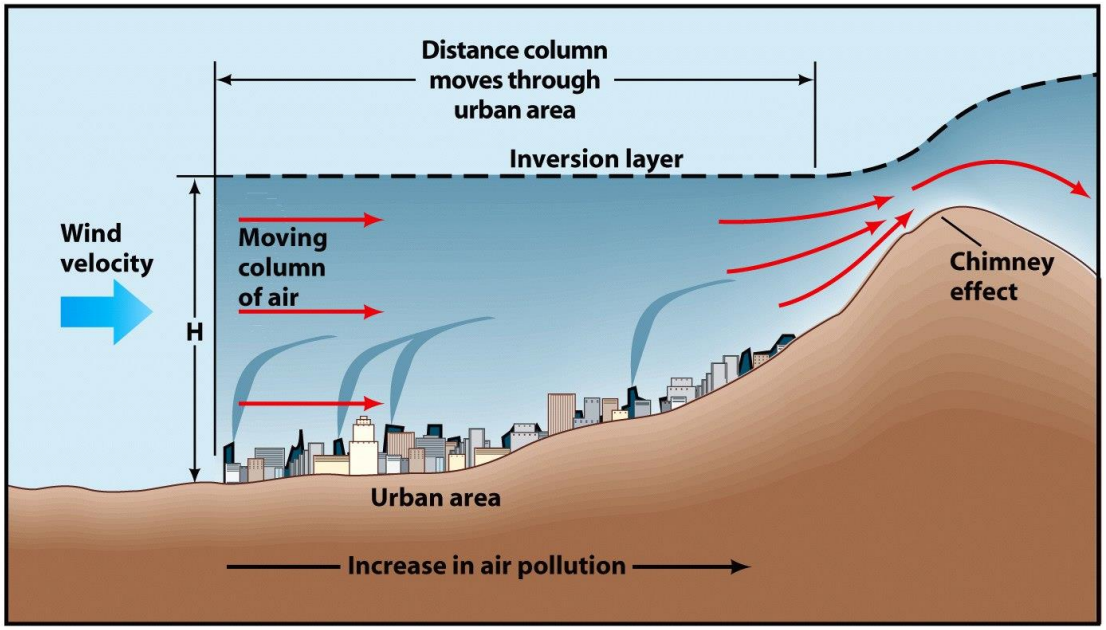
Criteria Air Pollutants

- Lead: Pb
  - cause learning disabilities in children , toxic to liver, kidney, blood forming organs
  - tetraethyl lead – anti knock agent in gasoline
    - leaded gasoline has been phased out
- Particulate Matter: PM10 (PM 2.5)
  - respiratory disorders
- Sulfur Dioxide: SO2
  - formed when fuel (coal, oil) containing S is burned and metal smelting
  - precursor to acid rain along with NOx

Urban Air Pollution

- Potential for Air Pollution Determined by:
  - Rate of emission
  - Downwind distance
  - Average wind speed
  - Elevation

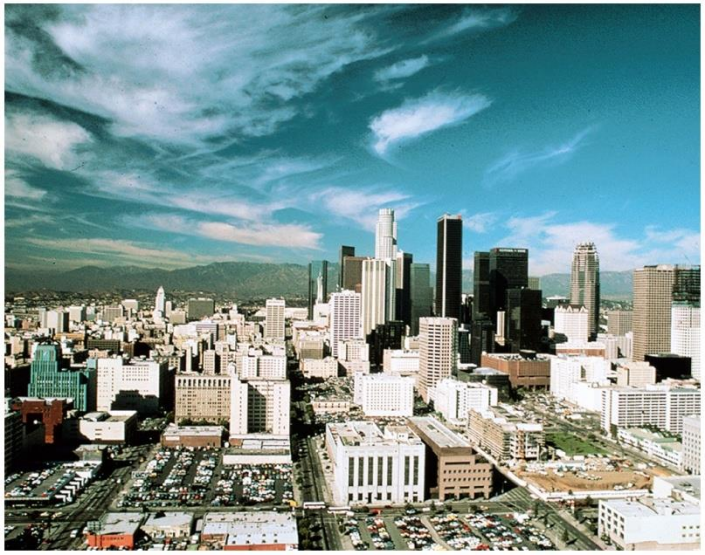
The Higher the wind Velocity the thicker the mixing layer (H), the lower the air pollution



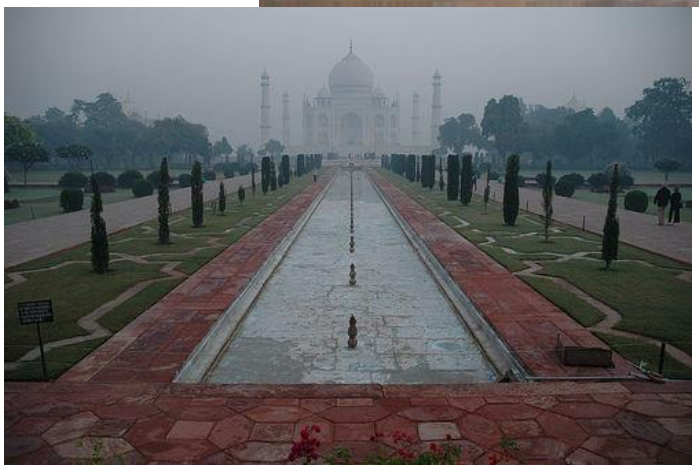
- The greater the emission rate and the longer the downwind length of the city, the greater the air pollution
- The chimney effect allows polluted air to move over a mountain and down into an adjacent valley

Smog

- Smog
  - A mixture between smoke and fog that produces unhealthy urban air
- Two Types
  - Photochemical Smog
  - Sulfurous Smog

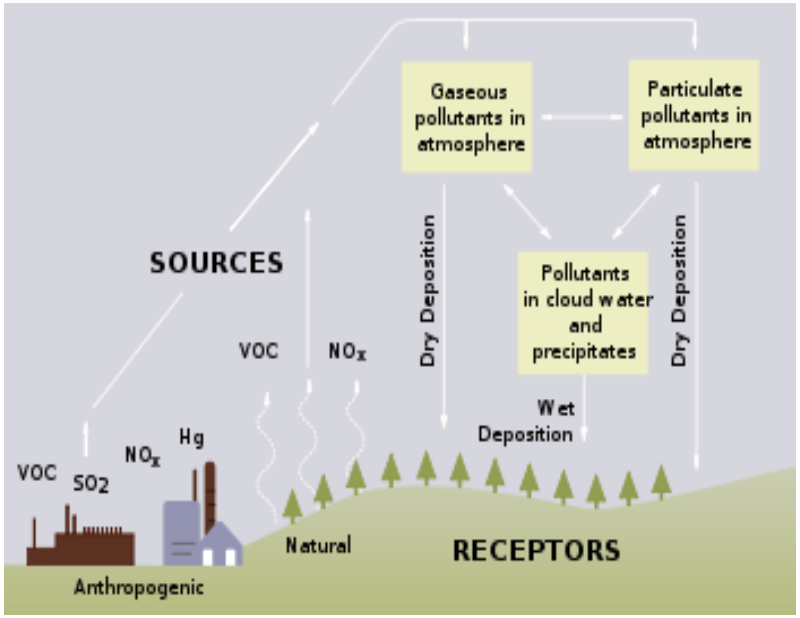


Air Pollution threatens Tajmahal



Acid Rain

- **Acid rain** is a rain or any other form of precipitation that is unusually acidic, meaning that it possesses elevated levels of hydrogen ions (low pH).
- Acid rain is caused by emissions of carbon dioxide, sulfur dioxide and nitrogen oxides which react with the water molecules in the atmosphere to produce acids
- The chemicals in acid rain can cause paint to peel, corrosion of steel structures such as bridges, and erosion of stone statues.



Pollution Control

- Particulates: control of stationary sources
- Automobiles: Use of catalytic converters, CNG (controls CO, HC), dilution in automobile exhaust reduces NOx
- Sulfur Dioxide
  - Coal Gasification: converts coal to gas to remove sulfur
  - Scrubbing: gas desulfurization

Table 1: Ambient national air quality standards ($\mu g/m^3$) in Bangladesh (2005) and comparison with neighboring countries including WHO and US

Pollutant	Averaging time	Bangladesh standard	India standard	Pakistan standard	Nepal standard	Thailand standard	US standard	WHO guideline
Carbon Monoxide (CO) (mg/m^3)	8 hour	10 (9 ppm)	2	5	10	10	10	10
	1 hour	40 (35 ppm)	4	10	100	35	40	30
Lead (Pb) ($\mu g/m^3$)	Annual	0.5	-	-	-	-	0.15	0.5
Oxides of Nitrogen (NO_x) ($\mu g/m^3$)	Annual	100 (0.053 ppm)	40	40	40	30	100	-
Suspended Particulate Matter (SPM)	8 hour	200	-	-	-	-	-	-
Coarse	Annual	50	60	120	-	-	-	20
Particulates (PM_{10}) ($\mu g/m^3$)	24 hour	150	100	150	120	120	150	50
Fine Particulates ($PM_{2.5}$) ($\mu g/m^3$)	Annual	15	40	15	-	25	15	10
	24 hour	65	60	35	-	50	35	25
Ozone (O_3) ($\mu g/m^3$)	1 hour	235 (0.12ppm)	100	-	-	70	235	-
	8 hour	157 (0.08ppm)	180	130	-	100	157	100
Sulfur dioxide (SO_2) ($\mu g/m^3$)	Annual	80 (0.03ppm)	50	80	50	40	78	-
	24 hour	365 (0.14ppm)	80	120	70	120	365	20

AQI table

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

Table 9. Currently Approved AQI Scheme for Bangladesh			
AQI Value	Level of Health Concern (স্বাস্থ্যগত উদ্বেগের অবস্থান)		Colours
	English	ঊাংলা	
0 - 100	GOOD	ঋাল	GREEN
101-150	MODERATE	মধ্যম	YELLOW
151 – 200	UNHEALTHY	অস্বাস্থ্যকর	ORANGE
201 – 300	VERY UNHEALTHY	খুব অস্বাস্থ্যকর	RED
301 – 500	EXTREMELY UNHEALTHY	অত্যন্ত অস্বাস্থ্যকর	PURPLE

Table 10. Suggested AQI Scheme for Bangladesh			
AQI Value	Level of Health Concern (স্বাস্থ্যগত উদ্বেগের অবস্থান)		Colours
	English	ঊাংলা	
0 - 50	GOOD	ঋাল	GREEN
51-100	MODERATE	মধ্যম	YELLOW GREEN
101-150	CAUTION		YELLOW
151 – 200	UNHEALTHY	অস্বাস্থ্যকর	ORANGE
201 – 300	VERY UNHEALTHY	খুব অস্বাস্থ্যকর	RED
301 – 500	EXTREMELY UNHEALTHY	অত্যন্ত অস্বাস্থ্যকর	PURPLE

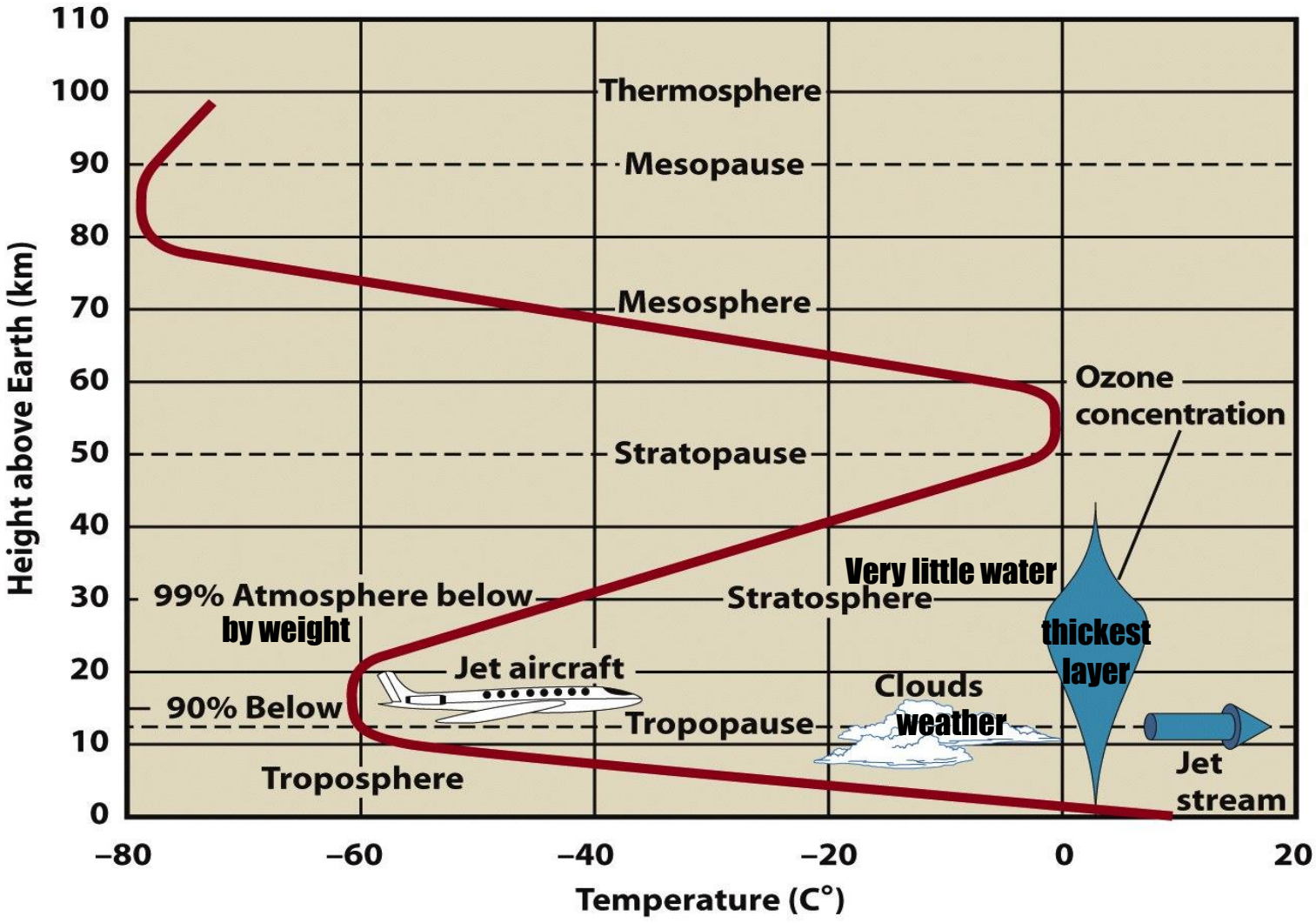
*www.case-moef.gov.**bd**/.../Review%20of%20an%20**Air**%20**Quality**%20I...*

Climate change and Global warming

The Atmosphere

- The thin layer of gases that envelops the Earth
- Chemical reactions
- Atmospheric circulation produces weather and climates

The Atmosphere



Processes that Remove Chemicals from Atmosphere

- Sedimentation:
  - Particles that are heavier than air settle out as a result of gravity.
  - Ex: Coal /volcanic particles will settle out over time
- Rain out:
  - Precipitation will physically and chemically flush materials from the atmosphere.
  - Ex: $CO_2 + H_2O \rightarrow H_2CO_3$ carbon dioxide is removed
- Oxidation:
  - Where oxygen is chemically combined with other substances.
  - Ex: atmospheric sulfur dioxide oxidizes to form sulfur trioxide which produces sulfuric acid
- Photodissociation:
  - Solar radiation can break down bonds in this chemical process. For example ozone may break down due to this process from O_3 to O_2.

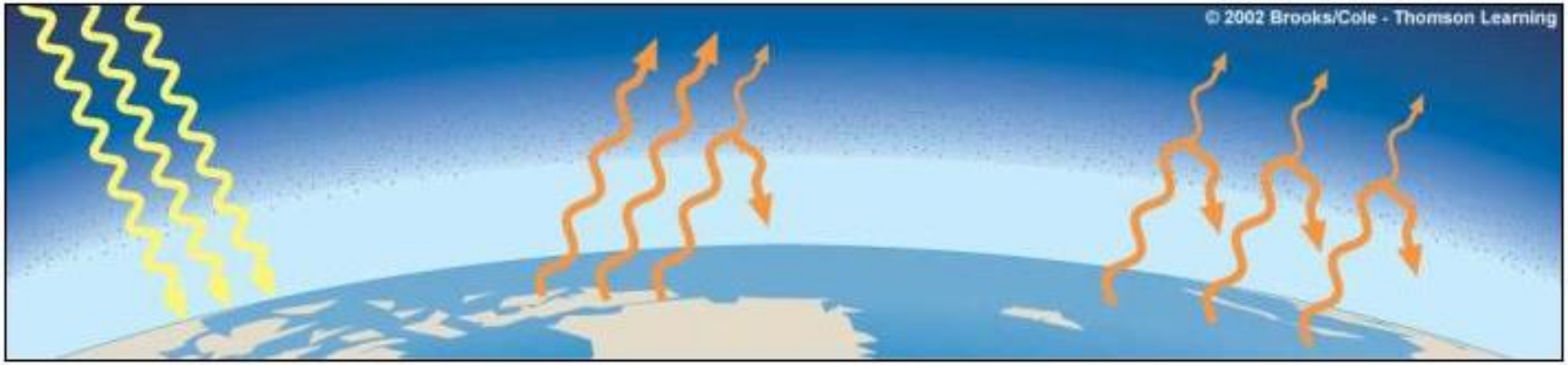
Weather vs Climate

- Weather:
  - Weather is what conditions of the atmosphere are over a short period of time, (hours, days, weeks)
- Climate:
  - climate is how the atmosphere "behaves" over relatively long periods of time (seasons, decades)
  - that “behavior” includes the representative or characteristic atmospheric conditions for a region on Earth
- Microclimate
  - The climate of a very small local area

The Greenhouse Effect

- Greenhouse Effect
  - The process of trapping heat in the atmosphere
    - NATURAL!
    - Without it the world would be too cold to support life!
  - Water vapor (85% of greenhouse warming), waste particles (12%) and several other gases warm the Earth's atmosphere because they absorb and emit radiation
- Greenhouse Gasses
  - Gasses that have a greenhouse effect
  - Water vapor
  - Anthropogenic sources: carbon dioxide, methane, nitrous oxide, CFCs

The Natural Greenhouse Effect

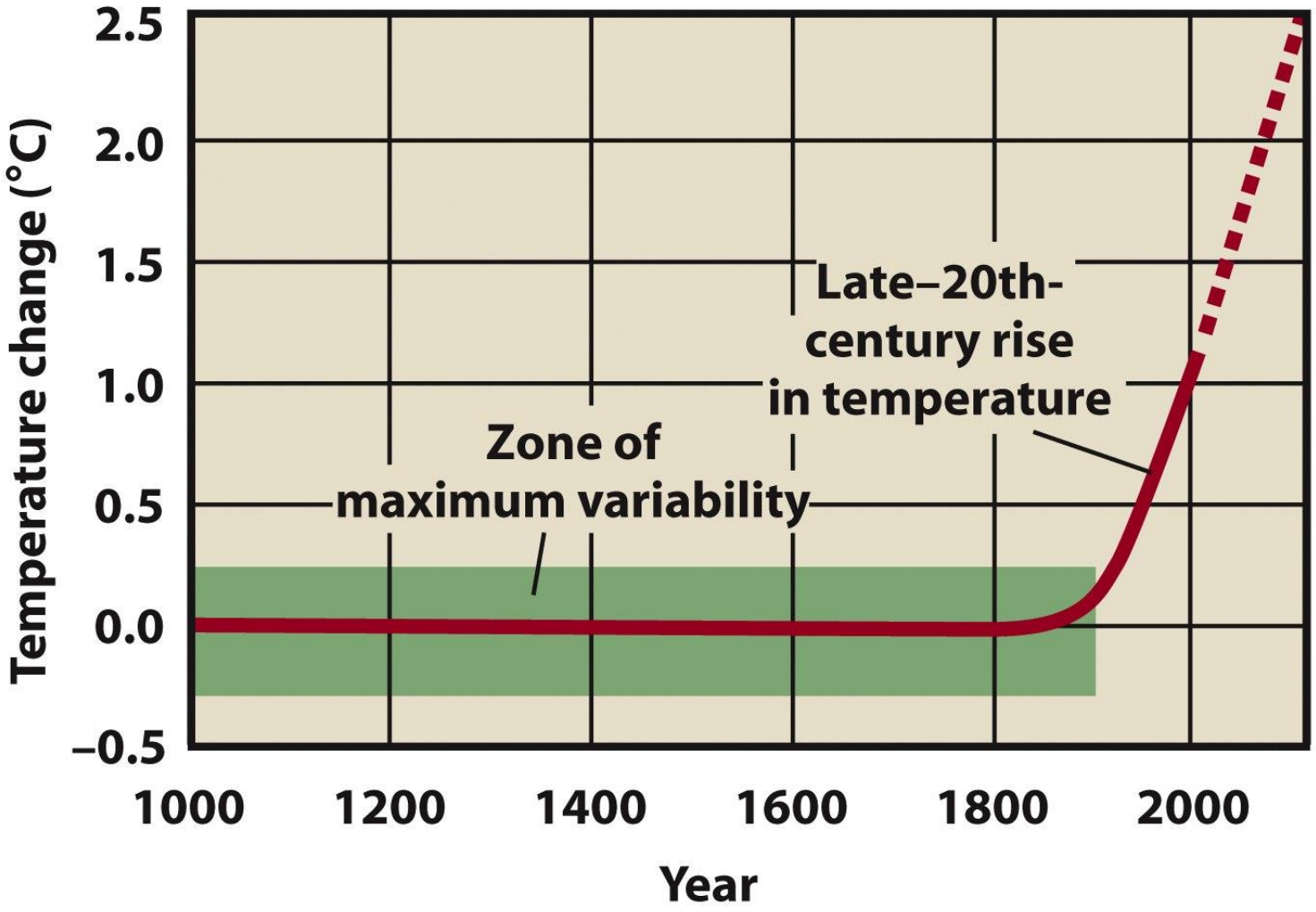


(a) Rays of sunlight penetrate the lower atmosphere and warm the earth's surface.

(b) The earth's surface absorbs much of the incoming solar radiation and degrades it to longer-wavelength infrared radiation (heat), which rises into the lower atmosphere. Some of this heat escapes into space and some is absorbed by molecules of greenhouse gases and emitted as infrared radiation, which warms the lower atmosphere.

(c) As concentrations of greenhouse gases rise, their molecules absorb and emit more infrared radiation, which adds more heat to the lower atmosphere.

20th Century Rise

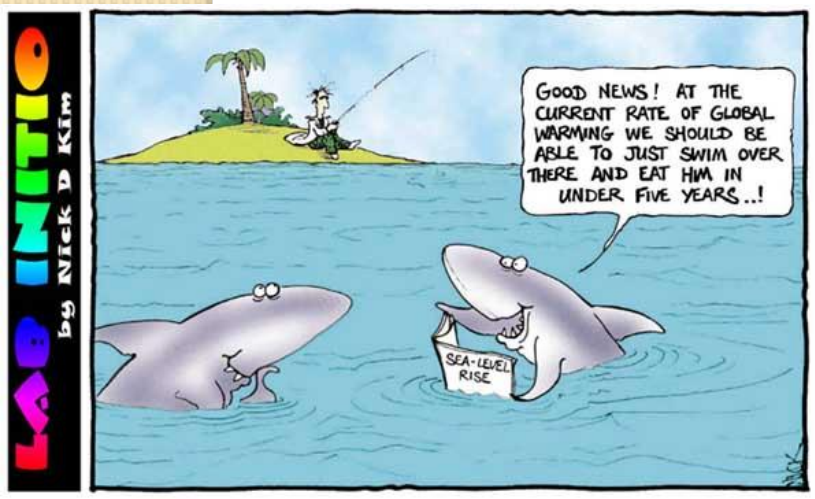


Climate Change and Human Activities

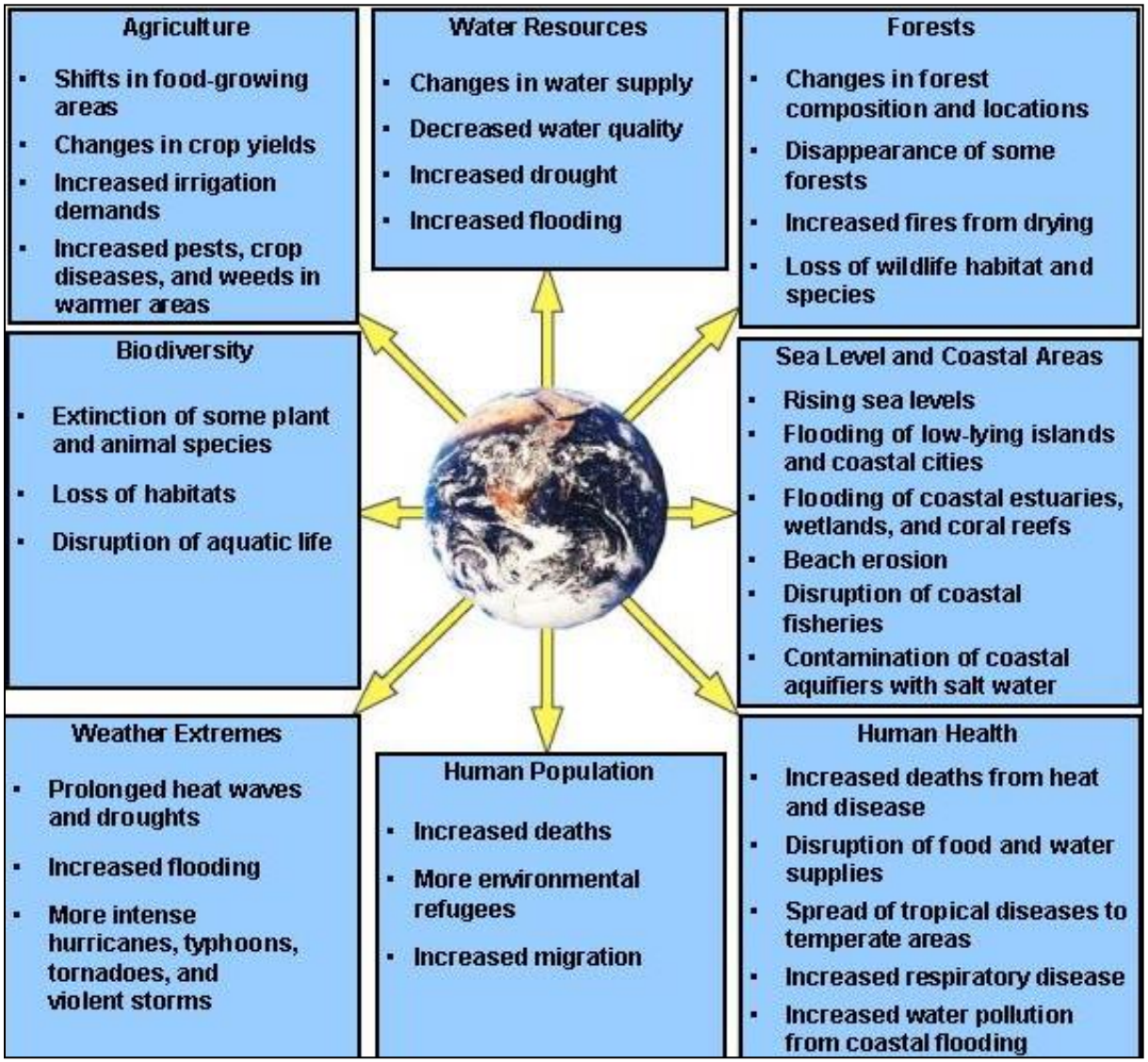
- Increased use/burning of fossil fuels
  - Adds ~ 5.5 gigatons per year to the atmosphere. The carbon combines with oxygen to produce CO_2
- Deforestation
  - Adds ~ 1.6 gigatons per year to the atmosphere. Burning of the trees releases carbon stored in the wood that combines with oxygen to produce CO_2
  - Not to mention the fact that the trees are no longer taking IN CO_2!

Effects of Global Warming

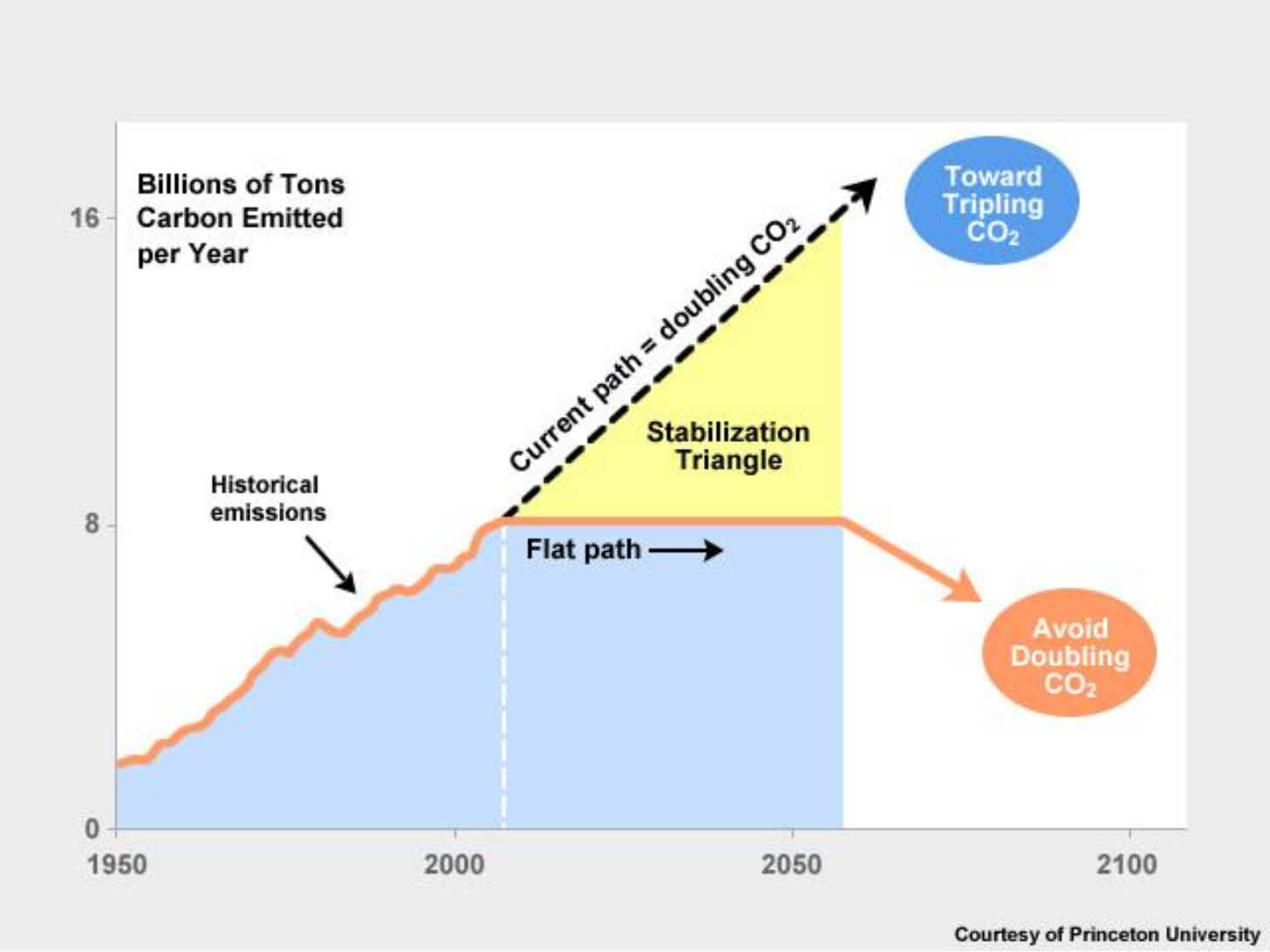
- Changes in climatic patterns
- Melting icecaps & glaciers
- Rise in sea level
- Coral reef bleaching
- Changes in biosphere



Some Possible effects of a Warmer World



What Next? What can we Do?



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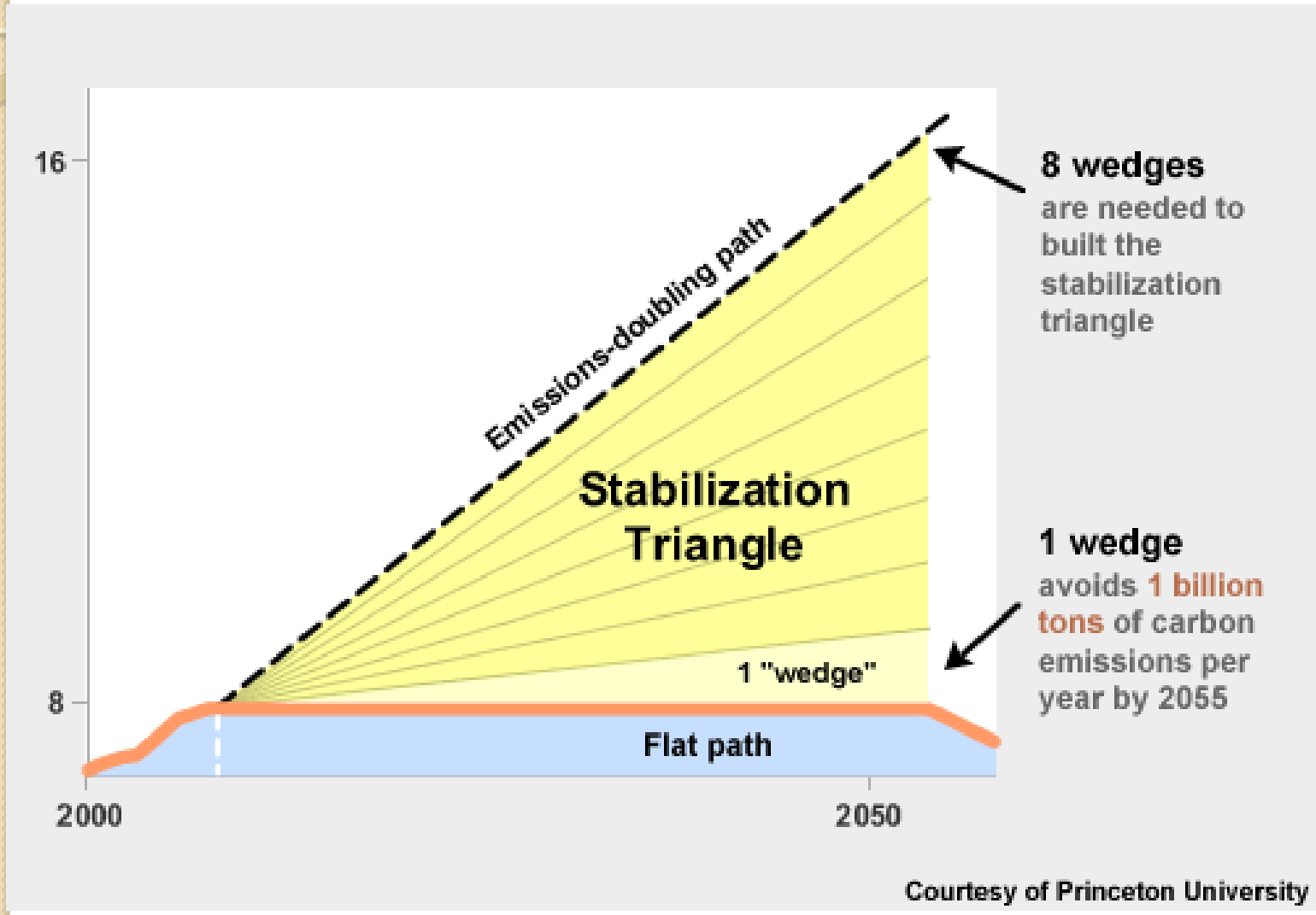

What Next? What can we Do?

- Produce more fuel-efficient vehicles
- Reduce vehicle use
- Improve energy-efficiency in buildings
- Develop carbon capture and storage processes
- Triple nuclear power
- Increase solar power
- Decrease deforestation/plant forests
- Improve soil carbon management strategies

Solutions: Dealing with the Threat of Climate Change

- Options
- Do nothing
- Do more research
- Act now to reduce risks
- Precautionary Principle