

# Environmental Engineering-1

## Lecture 4- Environmental Pollution Issues

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# Acid Rain

Acid Rain forms with two main Acids  $SO_2$  and  $NO_2$



Acid Rain mostly affects Limestone and other different types of rocks and stones.

Acid rain can not kill humans but they can damage your skin if the rain is concentrated enough.



Ways of preventing acid rain is by having less factories, cars, and burning of any kind.

Acid Rain is polluted rain from factory smoke and smog in the atmosphere.



Acid Rain

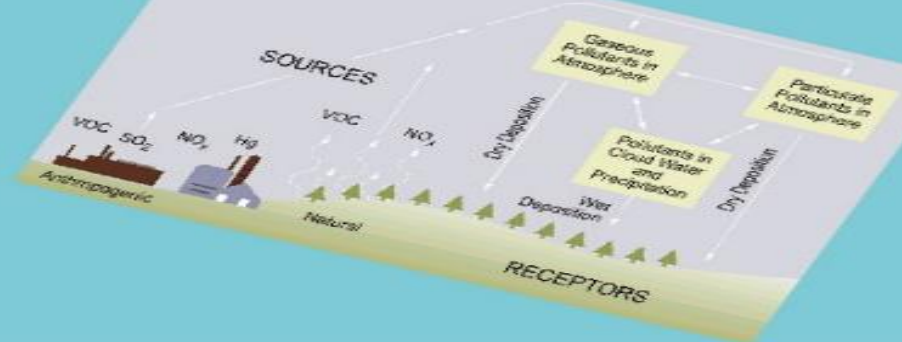
Acid Rain contains higher than normal amounts of nitric and sulfuric acids hurting

Acid Rain forms with two main Acids  $SO_2$  and  $NO_2$ .



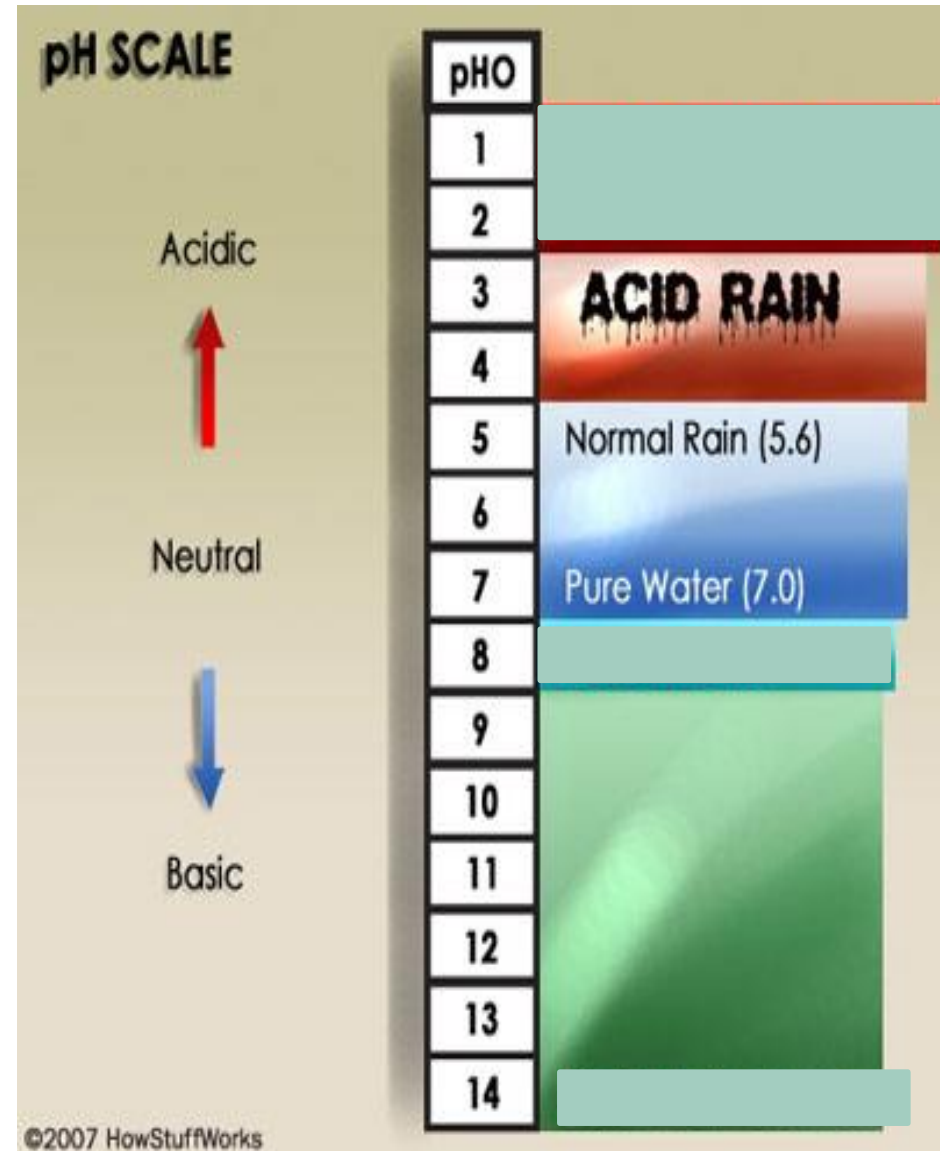
Putting lime substances, like quicklime, or Polarized Lime into any waters contaminated can help balance the pH levels.

Russia, Europe, America are the most affected by Sulfur Dioxide.

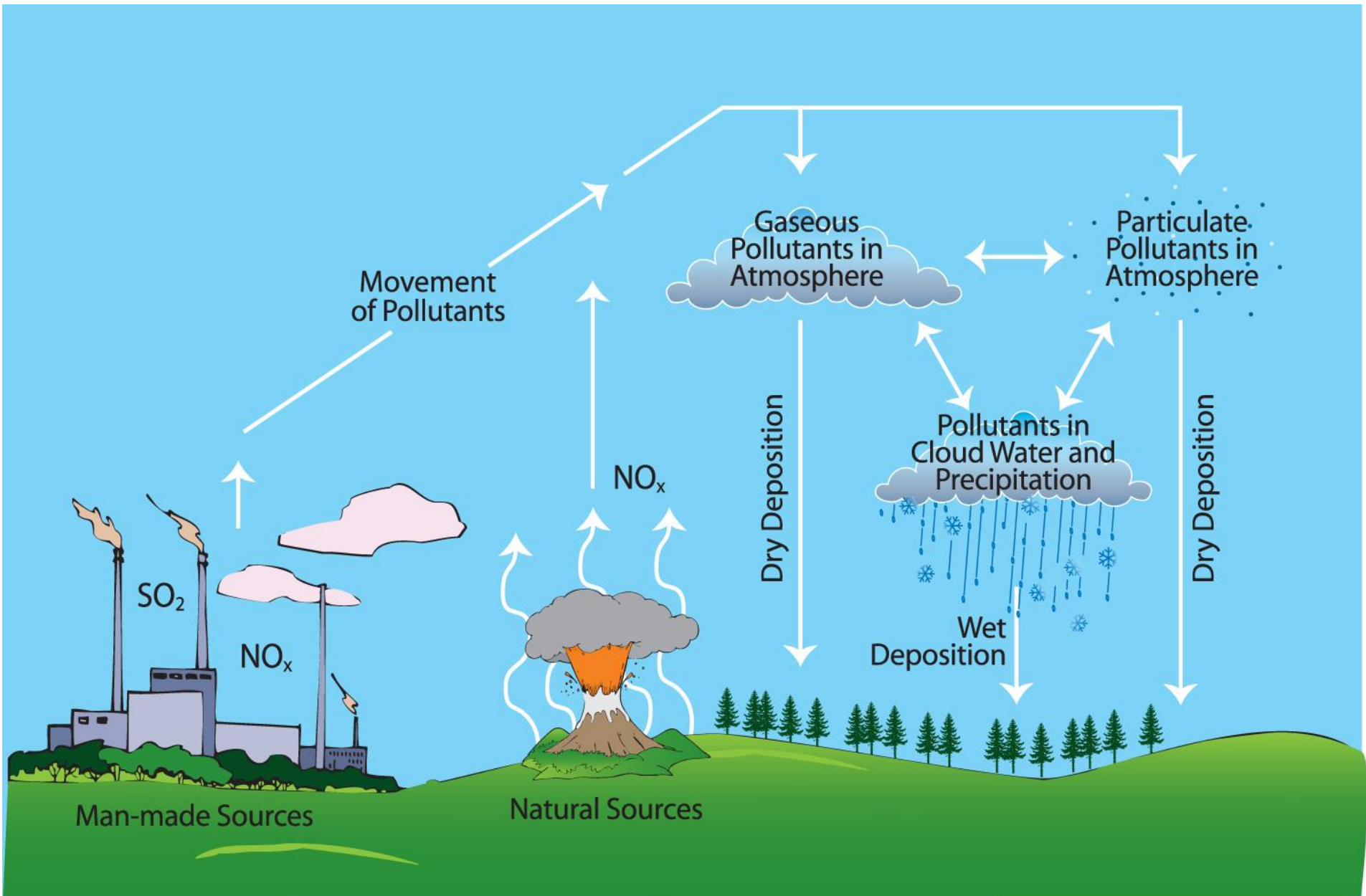


# Introduction

- pH of pure water is 7
- Rainwater is naturally acidic because its equilibrium with carbon dioxide
- So due to the presence of  $\text{H}_2\text{CO}_3$ , the pH of natural rain is about 5.7



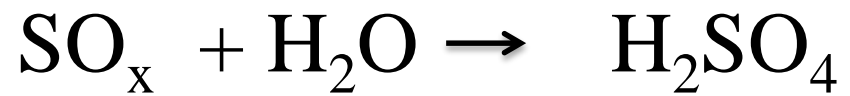
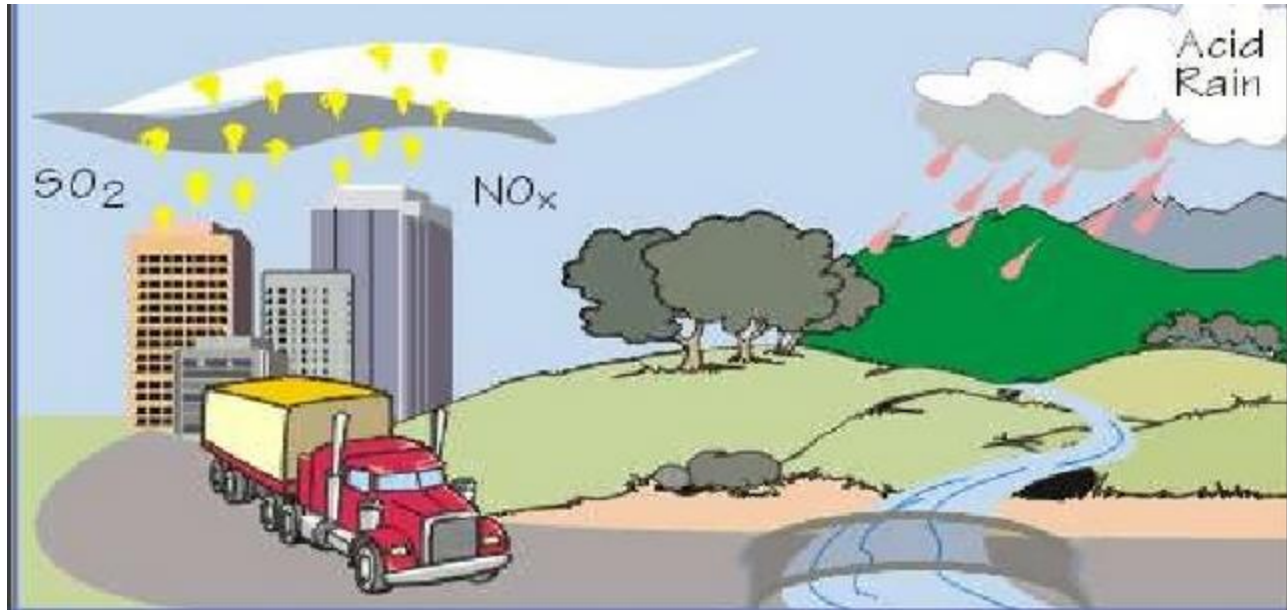
# Acid Rain



# Introduction

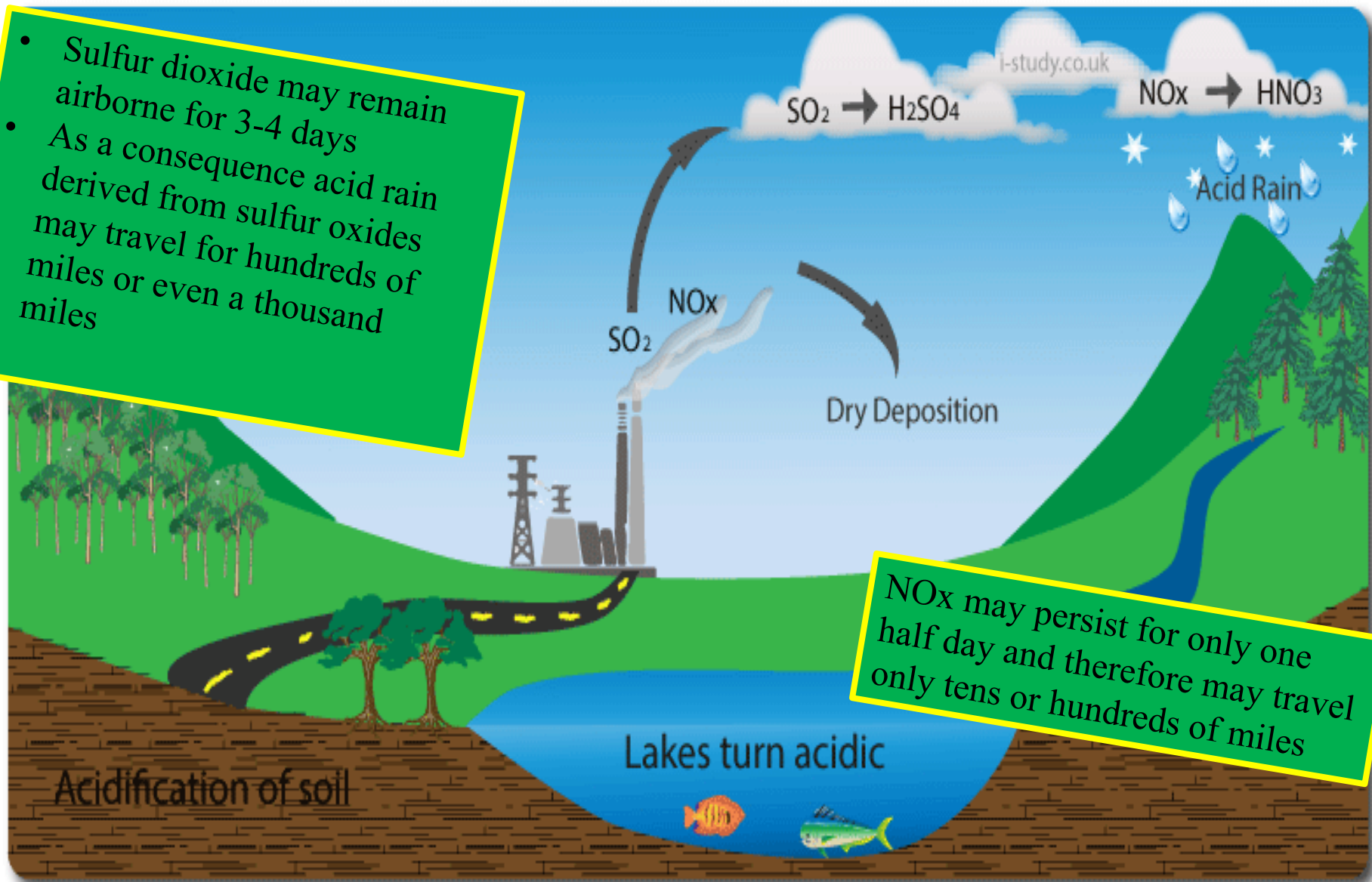
- It is defined as precipitation in which has  $\text{pH} < 5.6$
- Acid rain or acid snow is a direct result of the method that the environment clean itself.
- The tiny droplet of water that make up clouds continuously capture solid particles and gases in the atmosphere.
- When enough of the tiny cloud droplets clump together to form a larger water drop it may fall to the earth as “wet” acid precipitation including rain, snow , ice , sleet, or fog.

# Acid Rain Formation



# Acid Rain Transport

- Sulfur dioxide may remain airborne for 3-4 days
- As a consequence acid rain derived from sulfur oxides may travel for hundreds of miles or even a thousand miles



- $\text{NO}_x$  may persist for only one half day and therefore may travel only tens or hundreds of miles

# Acid Rain Transport

- The reactions of sulfur oxide to form sulfuric acid are quite slow
- Sulfur dioxide may remain airborne for 3-4 days
- As a consequence acid rain derived from sulfur oxides may travel for hundreds of miles or even a thousand miles
- Nitrogen oxides may persist for only one half day and therefore may travel only tens or hundreds of miles



# Acid Rain Transport

- Once airborne, the sulfur and nitrogen oxides eventually come down in one form or another.
- Where they come down depends on the height of the smokestack and the prevailing weather conditions.
- In general, prevailing winds in North America transport pollutants from west to east or northeast.

# Causes of Acid Rain

- The main precursors of acid rain are emissions of  $\text{SO}_x$  and  $\text{NO}_x$ , are primarily responsible for the harmful effects on environment.

## Sources of $\text{SO}_x$ :

### Anthropogenic (Man made):

- Fuel combustion in power plant
- Exhaust pipes in automobiles
- Industrial emissions(pulp and paper)
- Incineration of refusal waste
- Smelting of sulphur

# Causes of Acid Rain

## Natural:

- Volcanic eruptions
- Forest fires
- Out gassings from anaerobic wetlands(decay process)

## Sources of NO<sub>x</sub>:

### Anthropogenic:

- Fertilizers
- Fuel burning in automobiles

### Natural:

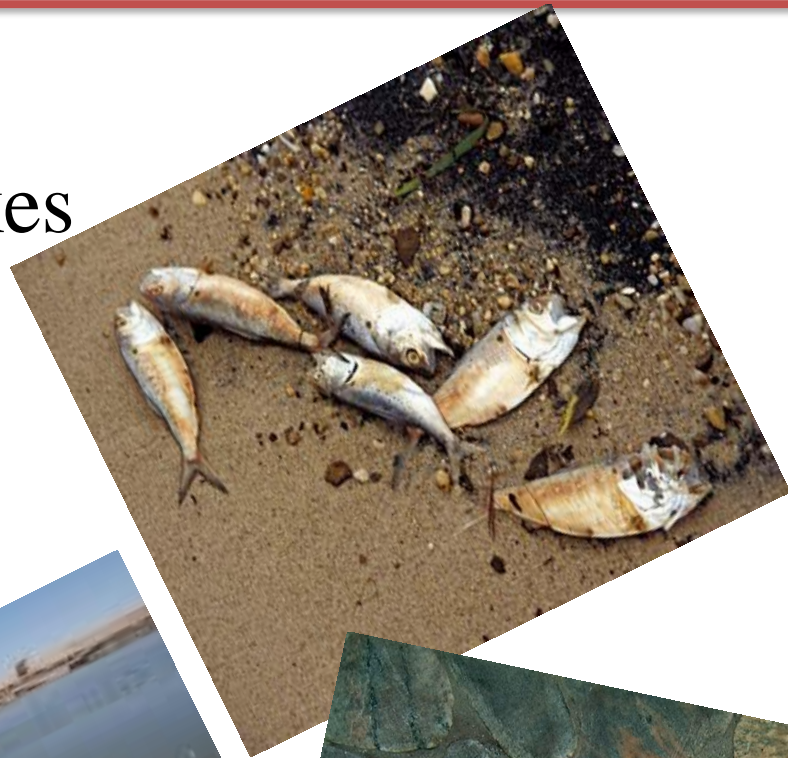
- Terrestrial , tidal, and nutrient- rich oceanic areas
- Decomposition of organic matter
- Sedimentation of rocks
- Lightning strokes

# Environmental Effects

# Environmental Effect

## Water and marine life:

- Extinction of fish in lakes



- Vegetation:



Necrosis



Epinasty



Abscission



Chlorosis

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## Human health:

- Respiratory problems
- Failure of Kidney (Norway)
- Irritation to eyes , etc.

## Building / Monuments:

- Sandstone, granite- discoloured
- Eroding of building surfaces

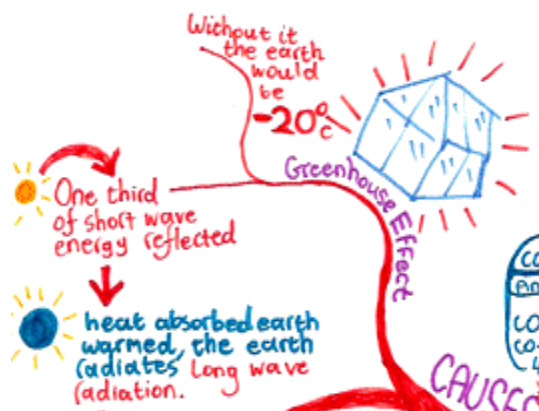
# Stone Cancer





## Reduced Fossil fuel Emissions:

- Fuel desulfurization (remove S from fuel)
- Fluidized bed technology (reduce  $\text{SO}_2$  during combustion)
- Flue gas desulfurization (remove sulphur gases using lime slurry in scrubbers)
- Scrubbers can be used to remove  $\text{NO}_x$  from industrial emissions
- Catalytic converter and lean burn engines (reduce  $\text{NO}_x$  in motor vehicles)



CO<sub>2</sub> recording starts 1958

**ICE CORES**

CO<sub>2</sub> trapped Antarctica & Greenland

CO<sub>2</sub> & Temperature co-varied for 400,000 years

3°C change in decades.

1997-1998 ARE THE HOTTEST YEARS ON RECORD

**WEATHER CHANGE**



40% storm increase

20cm increase in sea level

20th Century 0.6° increase

2000/2001 in the UK had 2 floods, these previously occurred in 50 year cycles

10 FOLD INCREASE IN PROPERTY LOSS IN 30 YEARS

5.8°C+ BY 21st CENTURY END



1997-98 EL Niño stronger ever

HEAT trapped

By greenhouse gases

Water vapour

CO<sub>2</sub>

Methane

Nitrous Oxide

**HUMAN ACTIVITY**



30% INCREASE IN CO<sub>2</sub> SINCE INDUSTRIAL REVOLUTION!

**WHO?**

NOT TAKEN SERIOUSLY TIL 1980'S

EQUIVALENT TO THE 160 BILLION TONS OF CO<sub>2</sub> THAT ENDS AN ICE AGE

BUT # THAT TOOK THOUSANDS OF YEARS!

NEXT ICE AGE NOT DUE FOR 5000 YEARS

**CAUSES**

**GLOBAL WARMING**

**GAIA THEORY**

Life balances greenhouse gases

United States

Europe

Asia

JAMES LOVELOCK

**THE RICH NATIONS SINCE 1700'S**

WHO? SHARE HOLDERS

WHO? MAIN ENEMIES

WHO? BIG OIL

EXAGGERATIONS OF FLOOD DROUGHT

Rising population

FRESH WATER AVAILABILITY

**SOLUTIONS**

IPCC STARTED IN 1988

CLIMATE CHANGE COSTS \$10 BILLION PER ANNUM (REAL COST \$100 BILLION)

60-80% CUT IN EMISSIONS NEEDED

ICE AGE - NEANDERTHAL

99% GEYSERS & HYDRO-ELECTRIC

UNAVOIDABLE EARLY FRESH IS CHEAPER

POTENTIALLY FASTER THAN NUCLEAR

IMMEDIATE RESULTS

OPPORTUNITIES

NEW TECHNOLOGY

WIND SOLAR EFFICIENCY NUCLEAR

10X CO<sub>2</sub> PER CAPITA OF CHINA

180 COUNTRIES

George W. Bush

13% REDUCTION IN EMISSIONS FOR 37 RICHEST

GEORGE W. BUSH PULLS OUT OF NEGOTIATIONS IN 2001

STILL HASN'T JOINED

## Global Warming

*“It is the natural or human induced increase in the average **Global Temperature** of the atmosphere near the earth surface or troposphere is known as “Global Warming”.*

## Mechanism:

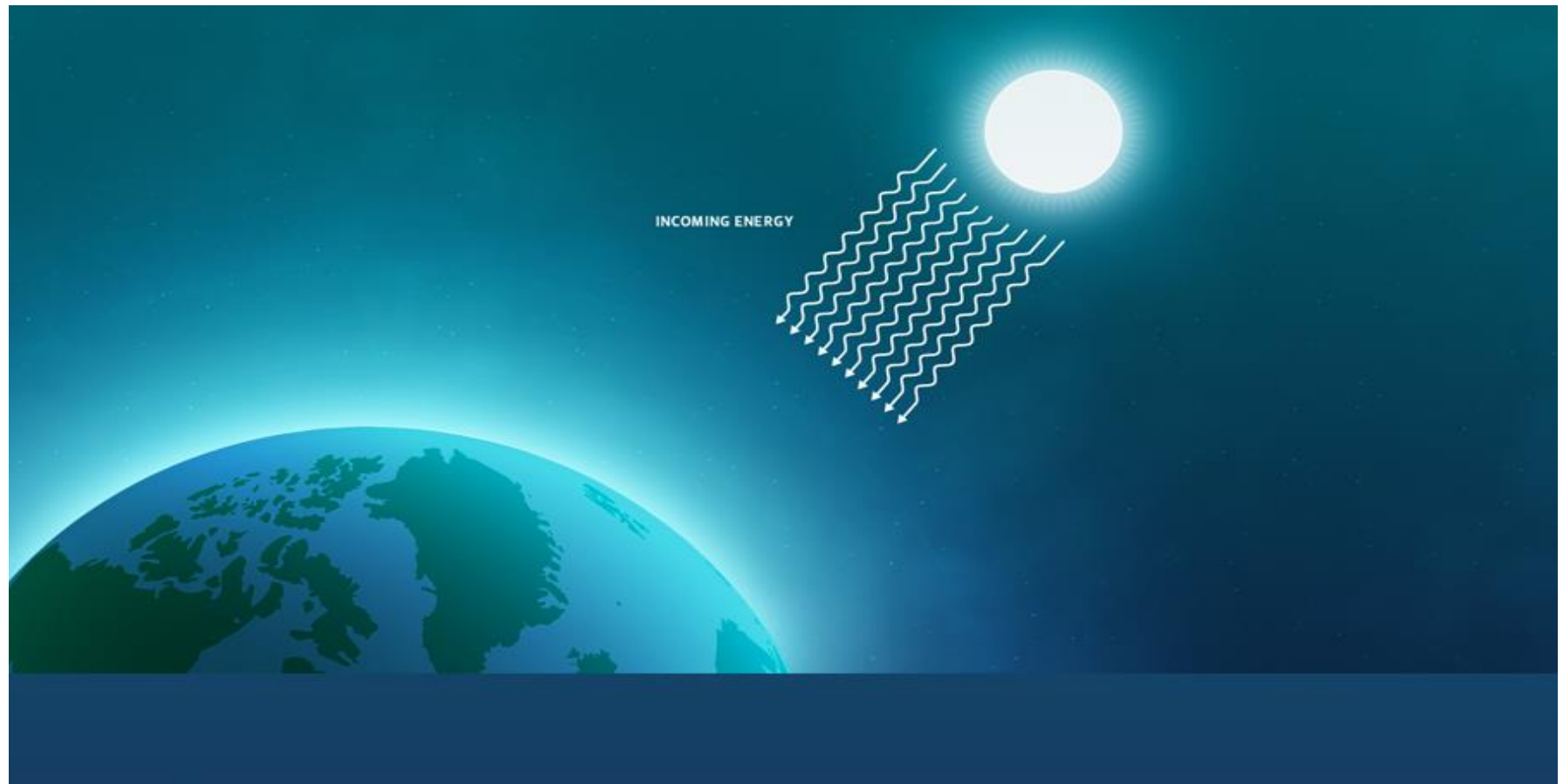
The incoming solar radiations are in the form of:

- ✓ UV Rays (0.1-0.4  $\mu$ ), 9 %
- ✓ Visible Light (0.4-0.7  $\mu$ ), 45 %
- ✓ Infrared Rays(0.7-4.0  $\mu$ ), 46 %

# The “GREEN HOUSE EFFECT”

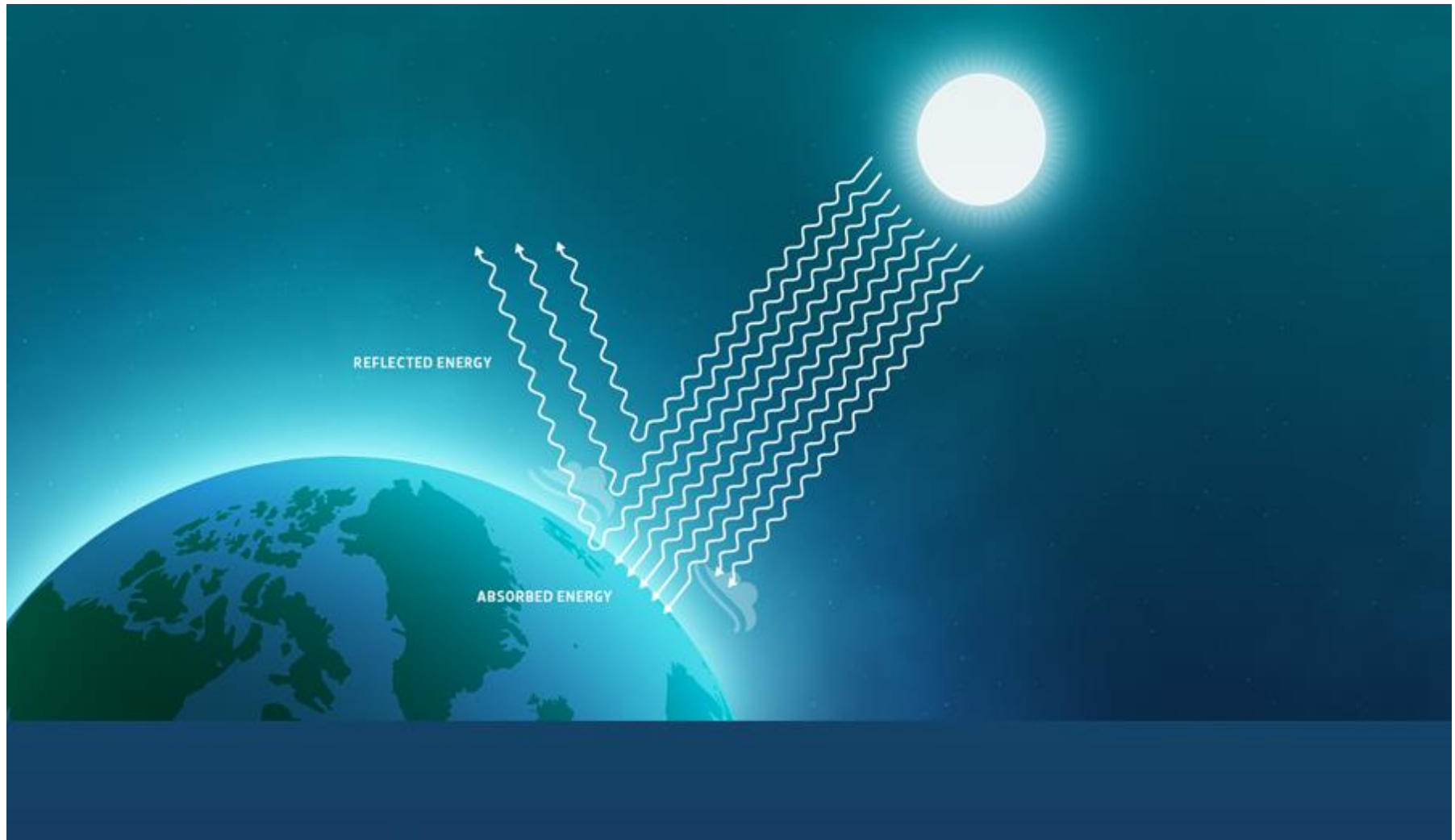
# The “GREEN HOUSE EFFECT”

## 1. Incoming Energy



# The “GREEN HOUSE EFFECT”

## 2. Absorption

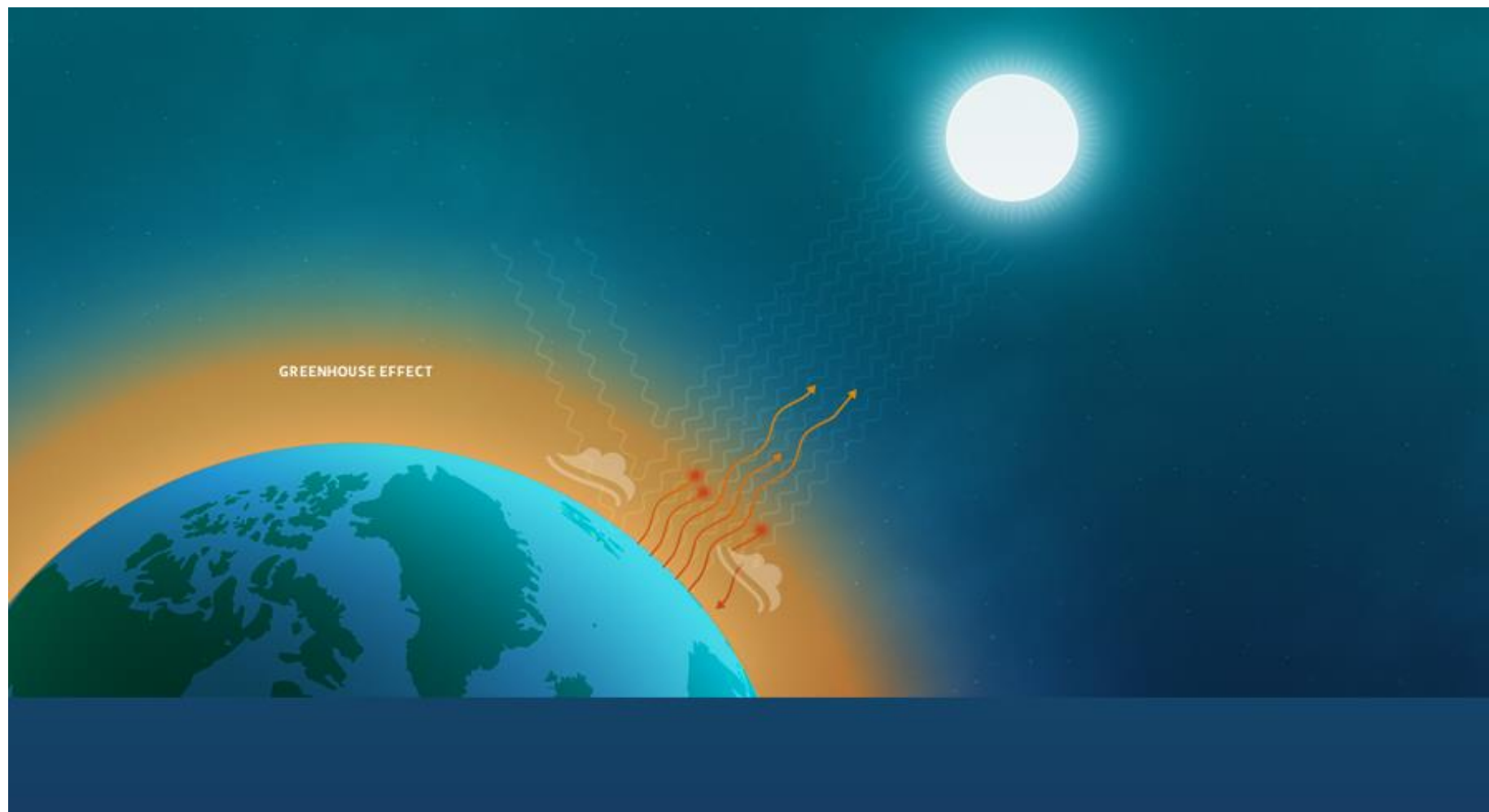


## 3. Emission





## 4. Role of Greenhouse Gases



## 5. Human Role



# Green House Gases(GHG)

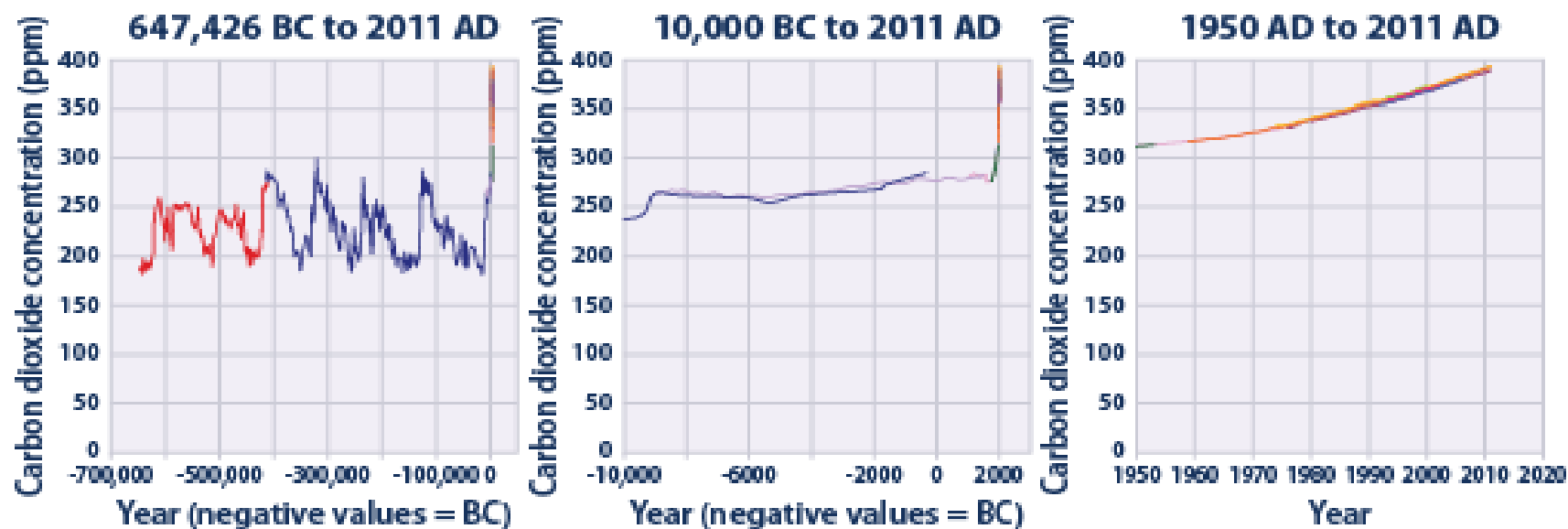
- Water vapors account for **97 %** of greenhouse process (Their concentration remains almost constant)
- Due to anthropogenic activities, concentration of
- GHGs is increasing, thus resulting in Global Warming.

✓ GHGs contribute **3 %**,

CO <sub>2</sub> ,	N <sub>2</sub> O,	CH <sub>4</sub> ,	CFCs
<b>76 %</b>	<b>6 %</b>	<b>13 %</b>	<b>5 %</b>

## 1. CO<sub>2</sub>:

Figure 1. Global Atmospheric Concentrations of Carbon Dioxide Over Time



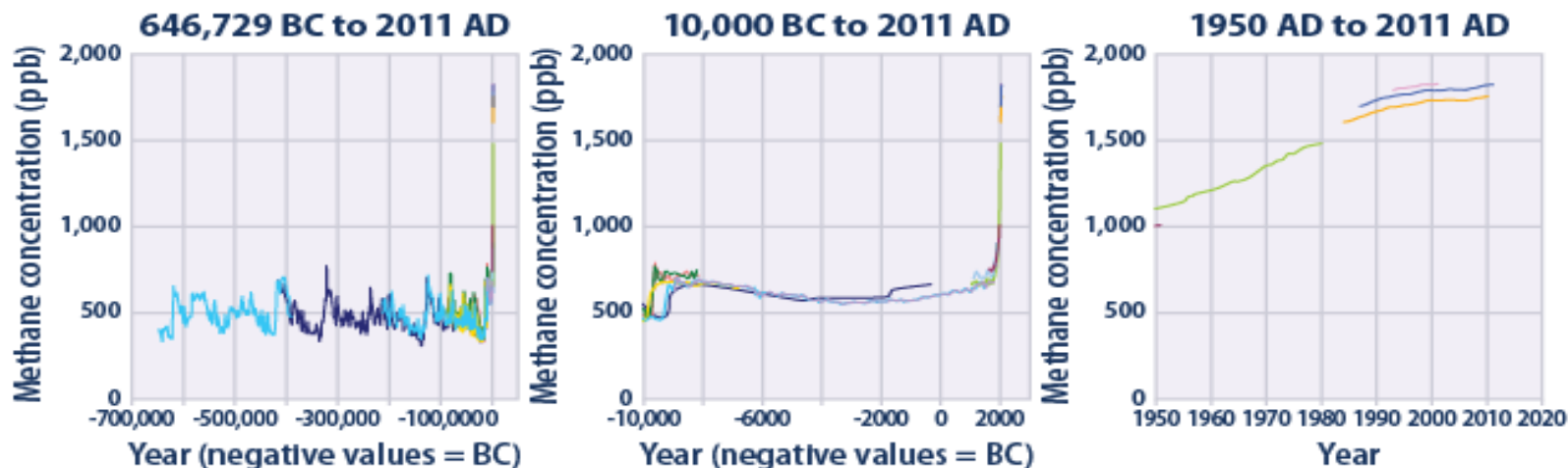
Present Concentration = 397 ppm

Increasing rate = 0.5 % per year

Expected level in 2050 = > 450 ppm

## 1. CH<sub>4</sub>

Global Atmospheric Concentrations of Methane Over Time



Data source: Compilation of 12 underlying datasets. See [www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html](http://www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html) for specific information.

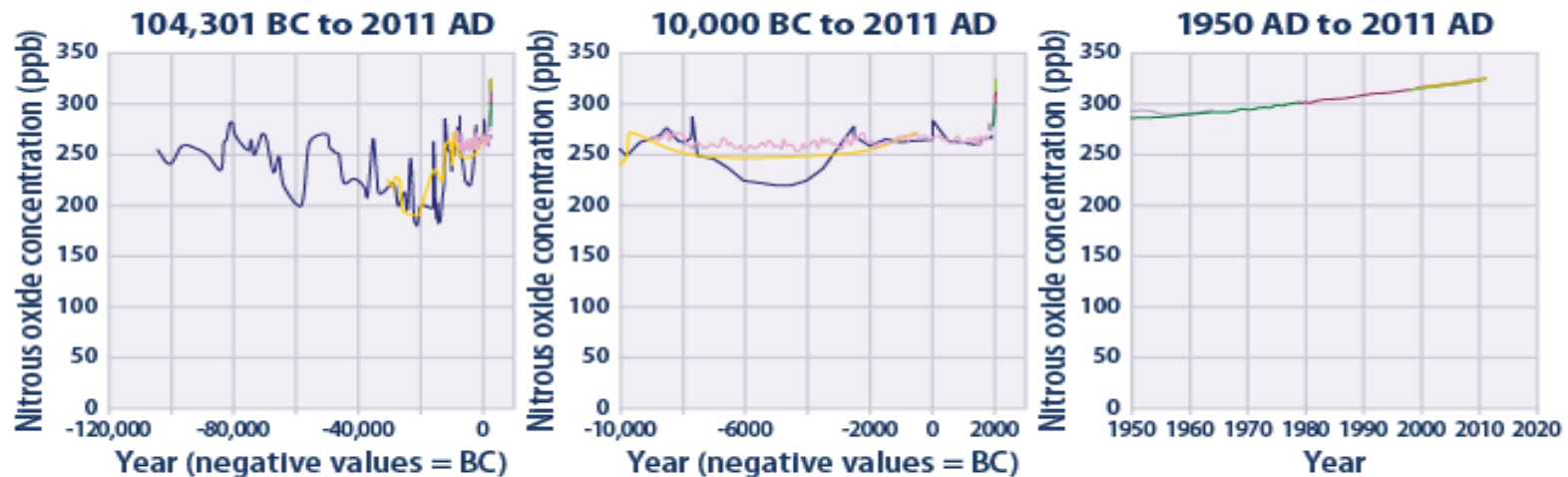
For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at [www.epa.gov/climatechange/indicators](http://www.epa.gov/climatechange/indicators).

Present Concentration = 1750 ppb

Increasing rate = 0.5 % per year

1. N<sub>2</sub>O

Global Atmospheric Concentrations of Nitrous Oxide Over Time



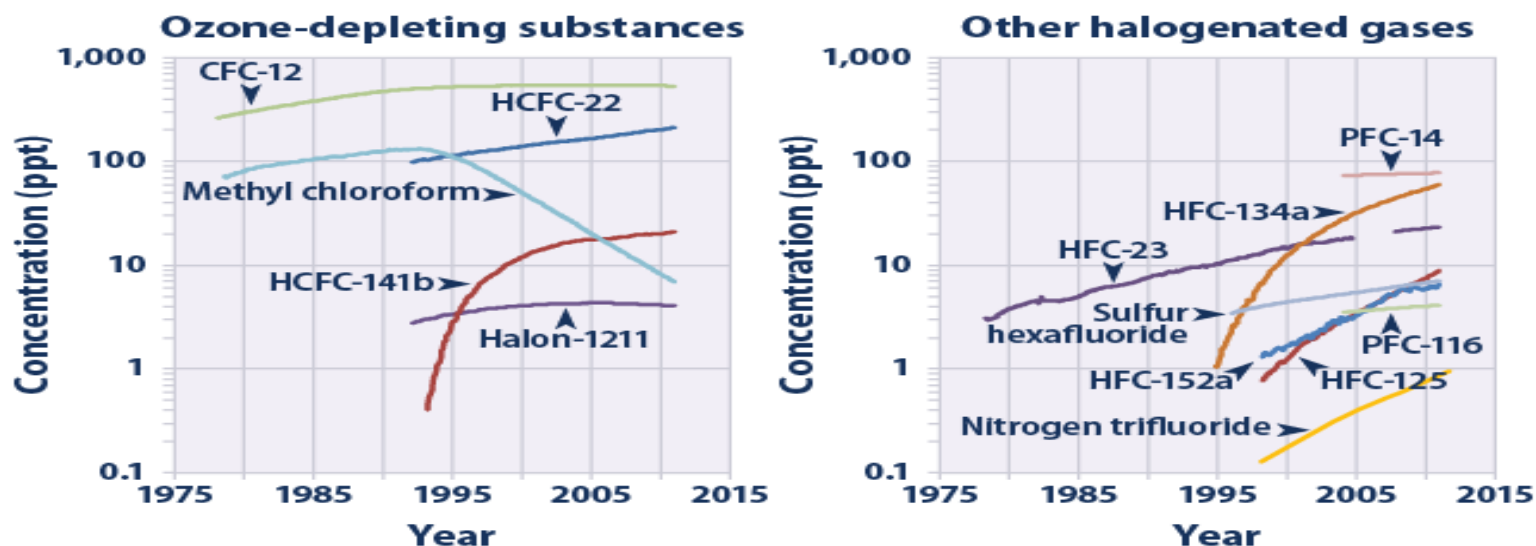
Data source: Compilation of nine underlying datasets. See [www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html](http://www.epa.gov/climatechange/science/indicators/ghg/ghg-concentrations.html) for specific information.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at [www.epa.gov/climatechange/indicators](http://www.epa.gov/climatechange/indicators).

Present Concentration = 322 ppb

# 1. CFCs:

Global Atmospheric Concentrations of Selected Halogenated Gases, 1978–2011



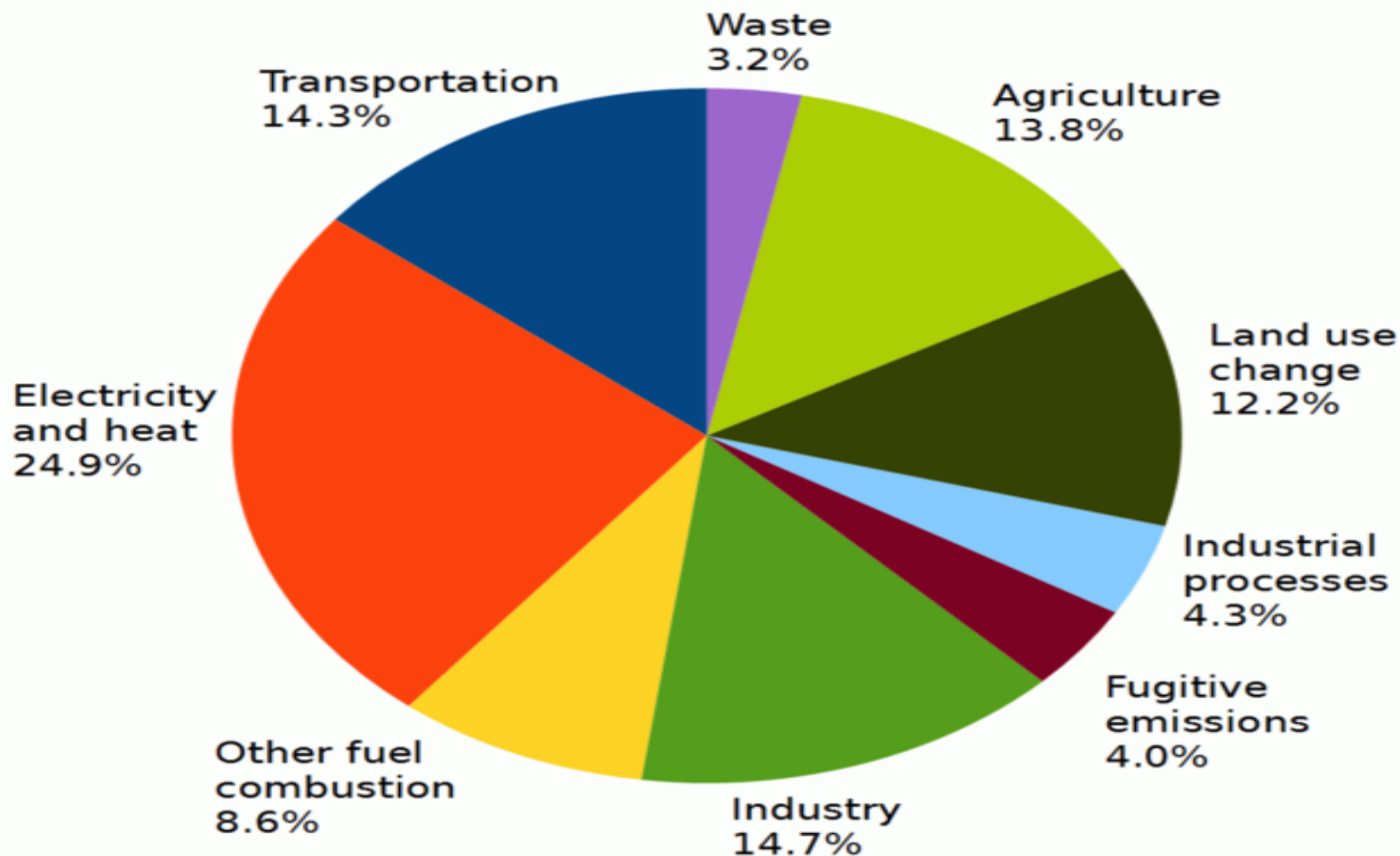
Data sources:

- AGAGE (Advanced Global Atmospheric Gases Experiment). 2011. ALE/GAGE/AGAGE data base. Accessed November 2011. <http://agage.eas.gatech.edu/data.htm>.
- Arnold, T., J. Mühle, P.K. Salameh, C.M. Harth, D.J. Ivy, and R.F. Weiss. 2012. Automated measurement of nitrogen trifluoride in ambient air. *Analytical Chemistry* 84(11):4798–4804.
- NOAA (National Oceanic and Atmospheric Administration). 2011. Halocarbons and other atmospheric trace species. Accessed October 2011. [www.esrl.noaa.gov/gmd/hats/](http://www.esrl.noaa.gov/gmd/hats/).
- Weiss, R.F., J. Mühle, P.K. Salameh, and C.M. Harth. 2008. Nitrogen trifluoride in the global atmosphere. *Geophys. Res. Lett.* 35:L20821.

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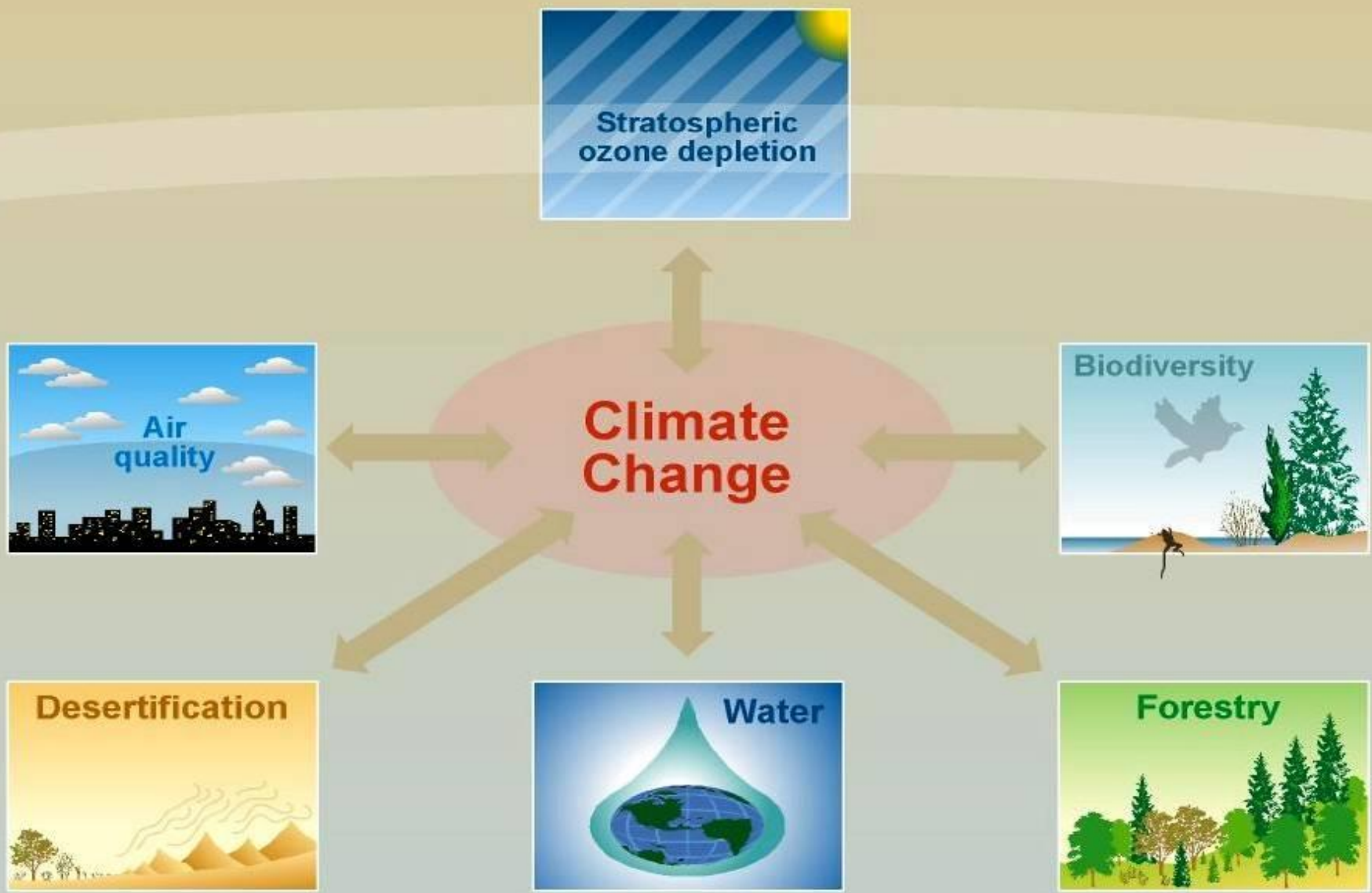
Present Concentration = 532 ppt

Annual world greenhouse gas emissions, in 2005, by sector





## Linkages between climate change and other environmental issues



# Consequences of Global Warming

Global temperature may rise (1.5 – 5.5 °C) by 2050.

## Climatic Change

- A warmer northern hemisphere
- Changes in precipitation patterns
- More droughts, more storms
- More incidents of Malaria
- Extinction of Animal and Plant species

# Consequences of Global Warming

## Impact on Crop Yield:

- ✓ Faster plant growth
- ✓ Plants prone to pest attack
- ✓ More fertilizers, pesticides needed.
- ✓ Global yield of key crops may decrease by 30-70 % by 2050

## Rise in Sea level

- ✓ 0.2-2.2 m rise by 2050 (Maldives, Bangkok may be flooded, Threats to ports)

## Impacts on Socio-economics:

- ✓ Displacement of people
- ✓ Changes of occupation
- ✓ Sufferings, Miseries

# Control Strategies

1. Reduce emissions of GHGs
2. Reduce use of fossil fuels
3. Encourage use of hydal power and solar energy
4. Control gas leaks
5. Employ less fertilizers
6. Stop using CFCs
7. Plant as many trees as possible



# Ozone Depletion

What is Ozone Depletion?

It is the reduction of concentration of ozone in the atmosphere

## Causes of Ozone Depletion

Chlorofluorocarbons (CFCs)

hydrochlorofluoro-carbons (HCFCs)

carbon tetrachloride

methyl chloroform

## Extent of Ozone Depletion

Ozone hole over the Antarctica

Ozone holes over the Arctic

Hole in the Ozone Layer?

To reduce the impact of global warming, we have to remove CFC and HCFC from old fridges or air-cons before disposal. Also replace old air-conditionings. Check regularly and fix gas leakages of fridges and aircons.

## Consequences

AFFECTING HUMAN HEALTH

It can cause skin cancer and eye cataracts

AFFECTING MARINE FOOD CHAIN

It decreases the population size of planktons and other tiny organisms. Also affects the population size of small fish, shrimps and

AFFECTING PLANT GROWTH AND CROP PRODUCTION

Trees grow more slowly and attain smaller sizes at maturity when exposed to large amounts of UV radiation

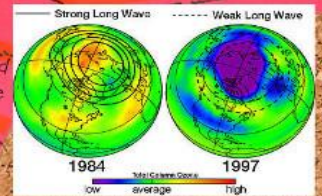
CAUSING DAMAGE TO MATERIALS

Plastic things will have much shorter lifespans with small increases of UV radiation.

AFFECTING GLOBAL CLIMATE

Increases the rate of global warming

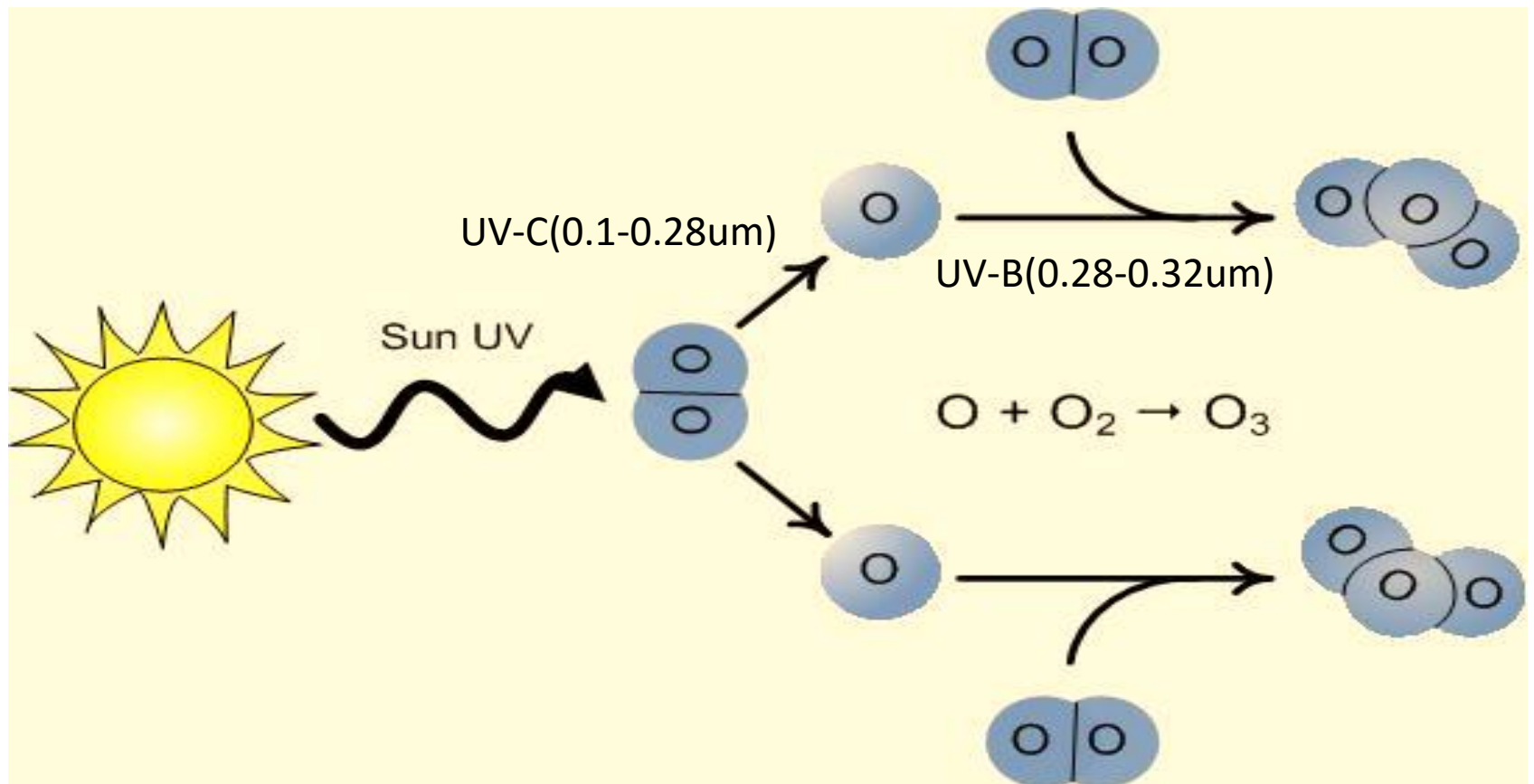
Buy products that are labelled "ozone-friendly" or "CFC-free". Also consider using fire extinguishers that do not contain ozone depleting substances.



## Ozone

- Ozone is a gas that is naturally present in our atmosphere.
- Each ozone molecule contains three atoms of oxygen and is denoted chemically as  $O_3$

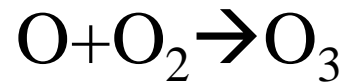
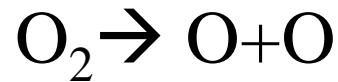
# Chemistry of Ozone





# Chemistry of Ozone

- In stratosphere



- UV-A(0.32-0.4um)  $\rightarrow$  Not affected by  $\text{O}_3$ , All reaches to earth
- **Ozone Hole**: refers to  $>50\%$  reduction in  $\text{O}_3$  conc. Over a particular area

- Significance of UV-B

- Damage cells, tissues, DNA
- Inhibit photosynthesis, kills phytoplankton
- Lower crop and sea food yield
- Sunburns, skin cancer

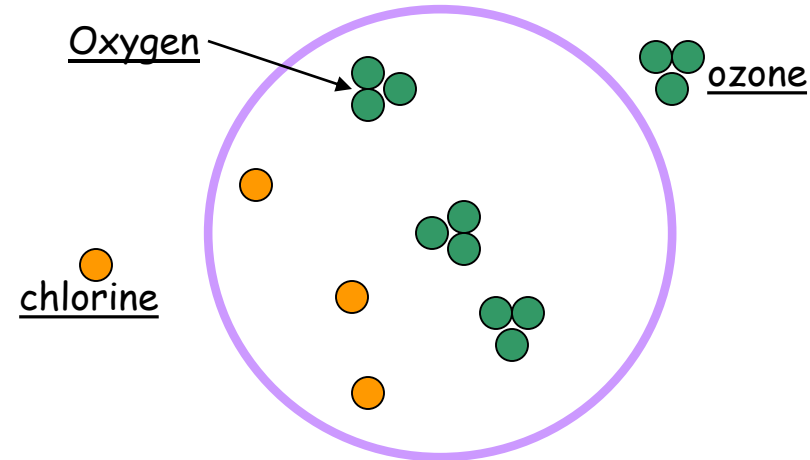
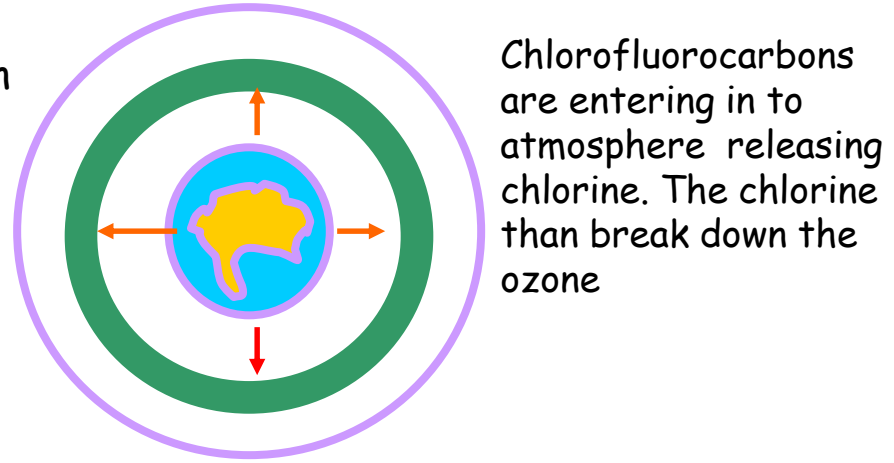
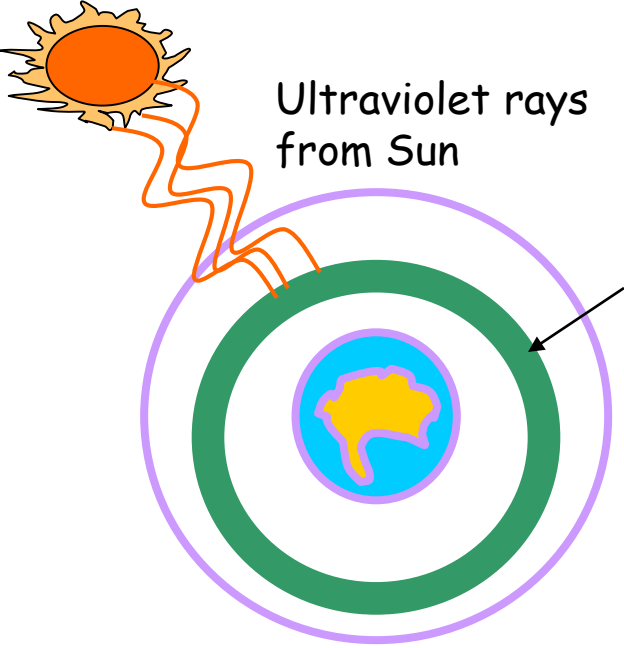
# Causes of Ozone Depletion

## Chlorofluoro-carbons (CFCs)

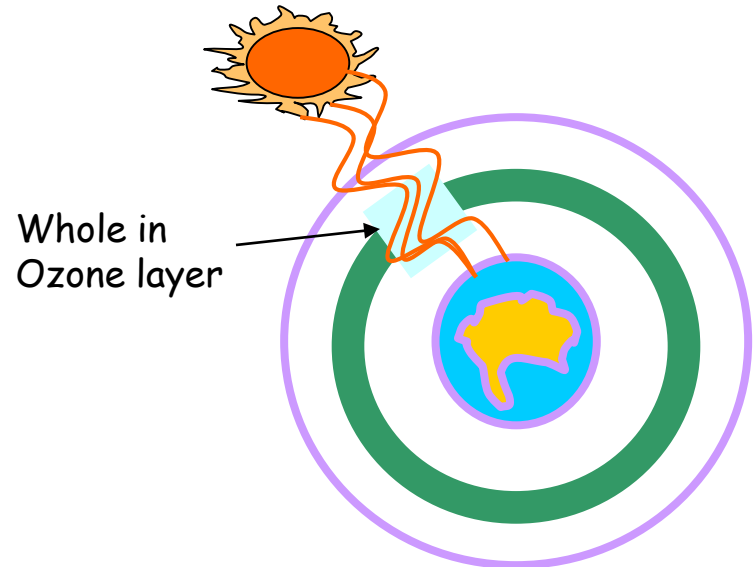
**Used as** : refrigerators, air conditioning, foam production, solvents, aerosols, insulation material

- CFC-11(CFCl<sub>3</sub>),CFC-12(CF<sub>2</sub>Cl<sub>2</sub>)
- $O_3 + Cl \rightarrow ClO + O_2$
- $ClO + O_3 \rightarrow Cl + 2O_2$

# Ozone layer depletion



The chlorine released from CFCs break down the ozone molecule.



More ultraviolet radiations are reaching in to earths surface as there is a whole in ozone layer.

## Nitric oxide (NO)

(50-70% ozone depletion)

- $\text{N}_2\text{O} + \text{O} \rightarrow 2\text{NO}$
- $\text{NO} + \text{O}_2 \rightarrow \text{NO}_2 + \text{O}$
- $\text{NO}_2 + \text{O} \rightarrow \text{NO} + \text{O}_2$

# Protection of O<sub>3</sub> Layer:

- ✓ Montreal Protocol (Sept, 1982)
- ✓ CFCs production to stop by 2000
- ✓ Available CFCs to be recycled
- ✓ Best alternatives of CFCs:
  - ✓ Butane (C<sub>2</sub>H<sub>10</sub>) + Propane (C<sub>3</sub>H<sub>8</sub>)