

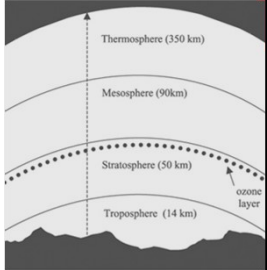

Climate Change



[Climate Change](#)

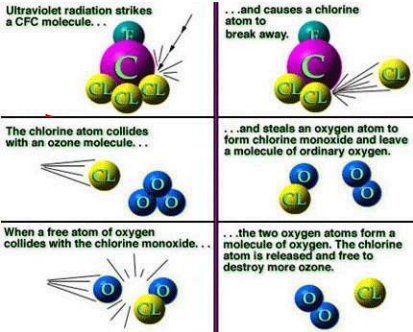
STRATOSPHERIC OZONE DEPLETION 9.1

- Protects the Earth's life and health
- **Ozone** is the chemical compound O_3
 - Ozone Layer absorbs most UV radiation coming from the sun
- **Chemicals Can Destroy Ozone**
 - CFCs – chlorofluorocarbons
 - CFCs used as propellants in spray cans and coolants in fridges/air conditioners
 - It takes 10 -20 years for CFCs to reach the stratosphere from the Earth's surface
- **Natural causes like melting of ice crystals in atmosphere at the beginning of Antarctic spring.**

OZONE-DEPLETING SUBSTANCES (ODS)

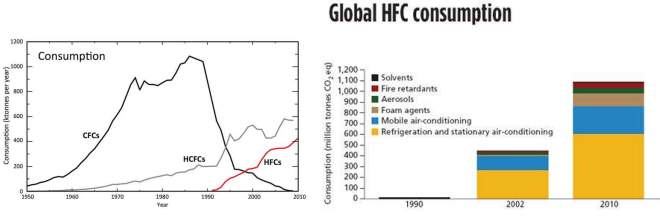
- CFCs are broken apart in the stratosphere
 - High energy of the UV radiation breaks it down
 - The single chlorine from CFC can react with O_3 and changes it, depleting the O_3
- Chlorine (halogen)
 - One chlorine atom can break down 100,000 ozone molecules
- Bromine (halogen)



[Ozone depletion](#)

REDUCING OZONE DEPLETION 9.2

- Ozone depletion can be mitigated by replacing ozone-depleting chemicals.
- Using Hydrofluorocarbons (HFCs) are a good replacement.
 - However, they are strong greenhouse gases.

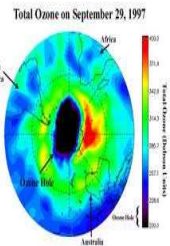
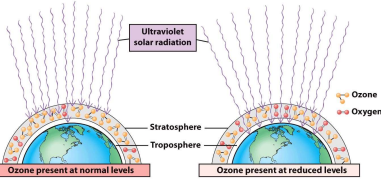


OZONE LAYER

- First noticed in 1970 from satellite photos over the South Pole
- What Causes it?
 - During the cold polar winters, dry stratospheric air over the pole is isolated.
 - Air becomes so cold that it condenses and forms clouds

(Polar Stratospheric clouds: high-altitude clouds made of water and nitric acid at - 80° C)

- Chlorine from CFCs builds up on the surface of the clouds
- When the pole begins to warm the chlorine goes back to depleting ozone.





VIDEO ON OZONE DEPLETION

OZONE LAYER

Negative affects of ozone depletion:

- Skin Cancer in humans
- Cataracts in humans
- Increase in UV radiation can damage organisms DNA
- Phytoplankton can be killed by UV

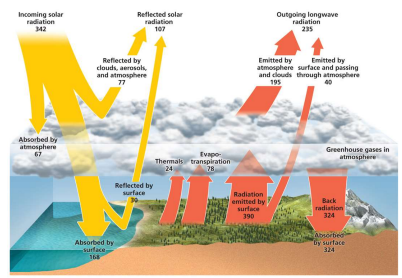


The **Montreal Protocol on Substances that Deplete the Ozone Layer** is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion.

- Many nations banned the use of CFCs in 1992 (US stopped production by 2000)
- CFCs still a problem....Why?
- CFCs molecules remain in the stratosphere for 60 – 120 years

What is climate change?

- **Global climate change** = describes trends and variations in Earth's climate
 - Temperature, precipitation, storm frequency
- **Global warming** = an increase in Earth's average temperature
 - Earth's climate has varied naturally through time
 - The rapid climatic changes taking place now are due to human activity: fossil fuels, combustion, and deforestation

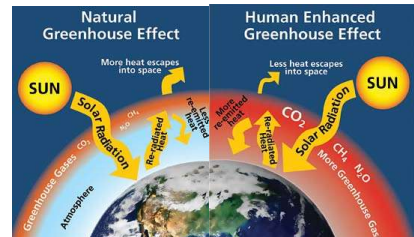



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GREENHOUSE EFFECT

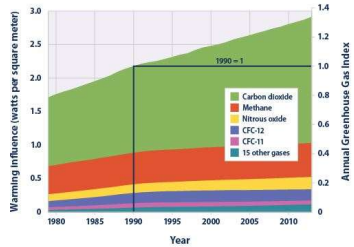
9.3

- Creates Earth's temperature necessary for life.
- **The earth is like a greenhouse**
 - The atmosphere acts like the glass – which lets the sun's rays pass through.
 - The earth absorbs this as heat energy and keeps it in, only letting a little heat out
 - The gases in the atmosphere absorb the radiation keeping it from escaping out to space
 - This absorption of radiation by gases is called the greenhouse effect

GREENHOUSE GASES

- **Main Greenhouse Gases**
 - **Water Vapor, CO₂, Methane, NO_x and CFCs, all absorb radiation**
 - Water vapor and CO₂ are the primary greenhouse gases
- **Water vapor** is the most abundant, but doesn't contribute much to global climate change due to it not staying long in the atmosphere.



GREENHOUSE GASES

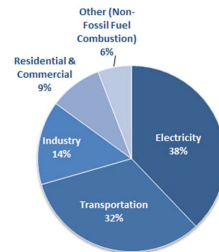
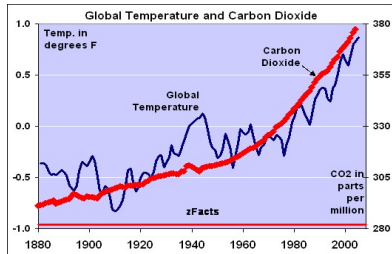
- China & USA create the most
- Carbon dioxide has a global warming potential (GWP) of 1, which is the lowest of other greenhouse gases.
- CFCs have the highest GWP, 2nd highest are the nitrous oxides, then methane.
- Direct correlation between CO₂ levels and global warming



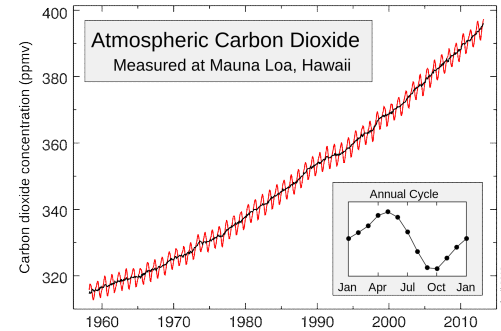
Greenhouse Gas	GWP	Lifetime (y)
Carbon Dioxide (CO ₂)	1	variable
Methane (CH ₄)	21	12.2
Nitrous Oxide (NO ₂)	206	120
Hydrofluorocarbons (HFC)	140-11700	1.5-264
Perfluorocarbons (PFC)	6500-9200	3200-50000
Sulfur Hexafluoride (SF ₆)	23000	3200
Chlorofluorocarbons (CFC)	12000-16000	

GREENHOUSE GASES

- Carbon dioxide
 - Direct correlation between CO₂ levels and global warming
- China & USA create the most



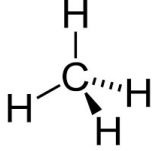
- Since 1958 (in Hawaii) CO₂ levels have been measured – reflective of the entire earth (the gases have traveled across the entire Pacific Ocean)
 - Levels are higher in the winter: fewer leaves on the trees (dying grasses and leaves release carbon)
 - General increase because of burning fossil fuels(not just in winter)



GREENHOUSE GASES

METHANE

- Methane (CH₄) is the second most prevalent greenhouse gas emitted in the United States from human activities.
- 11% of all U.S. greenhouse gas
- Over 60% of total methane emissions come from human activities.
 - Industry emissions, leakage from natural gas systems, raising livestock, landfills, coal mining, permafrost melting
- 40% is emitted by natural sources such
 - Wetlands, oceans, volcanoes, forest fires

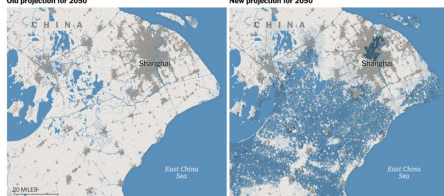


U.S. Methane Emissions, By Source

Source	Percentage
Natural Gas and Petroleum Systems	29%
Enteric Fermentation	25%
Landfills	18%
Coal Mining	10%
Manure Management	9%
Other	9%

INCREASES IN GREENHOUSE GASES

- **Environmental problems:**
 - Rising sea levels resulting from melting ice sheets and ocean water expansion.
 - Disease vectors spreading from the tropics toward the poles.
- These issues can cause changes in population dynamics and population movements in response.



A Superstorm in 2100

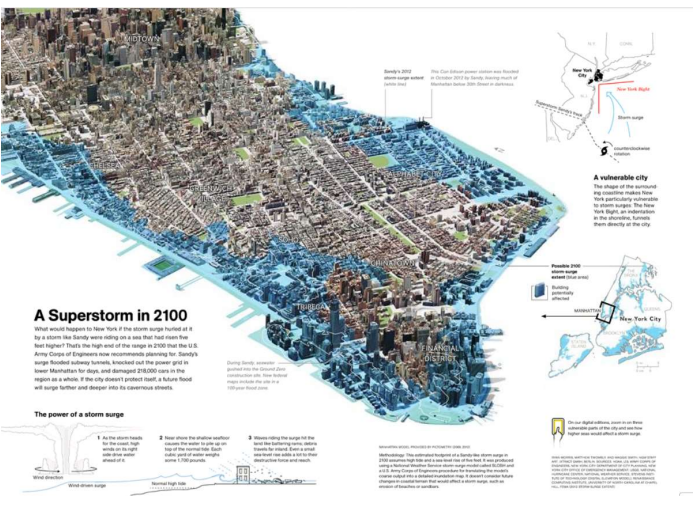
What would happen to New York if the storm surge flooded it? By a storm, the Sandy were rising on a sea that had risen five feet higher? That's the high end of the surge in 2100 that the U.S. Army Corps of Engineers now recommends planning for. Sandy's surge flooded subway tunnels, knocked out the power grid in lower Manhattan for days, and damaged 230,000 cars in the region as a whole. If the city doesn't protect itself, a future flood will surge higher and deeper into its vulnerable streets.

The power of a storm surge

- As the storm tracks to the coast, the wind pushes the water up the beach. The higher the wind, the higher the water will rise.
- When the storm reaches the coast, the wind pushes the water up the beach. The higher the wind, the higher the water will rise.
- When the surge hits the shore, the water can rise several feet above the normal level. The surge can be as high as 10 feet.

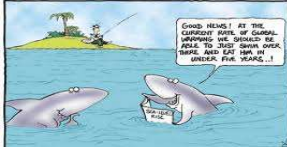


A vulnerable city

The surge of the storm will knock out the power grid in lower Manhattan for days, and damaged 230,000 cars in the region as a whole. If the city doesn't protect itself, a future flood will surge higher and deeper into its vulnerable streets.



WHAT HAPPENS IF THE EARTH WARMS?

- **Melting Ice and Rising Sea Levels**
 - Coastal areas flooded
 - Nearly 3 billion people live within 100 km of a coast
 - Excess sea water can change freshwater aquifers near coasts
- **Changing Weather Patterns**
 - Warming the oceans could change currents that influence weather today
- **Human Health Problems**
 - Deaths due to heat waves
 - Longer growing seasons, more pollen, more asthma
 - Warmer weather allow mosquitoes and other disease carrying organisms to live longer
- **Agriculture**
 - Heat leads to droughts, severe impact to crops
 - May change where plants and animals live

[All ice Melted Clip](#)

[Chasing Ice Clip](#)

1997 Kyoto Protocol

The Kyoto Protocol to the United Nations Framework Convention on Climate Change is an international treaty that sets binding obligations on industrialized countries to reduce emissions of greenhouse gases.

US is largest emitter of CO₂

Participation in the Kyoto Protocol: green indicates states parties, yellow indicates states with ratification pending, and red indicates those that signed but declined ratification of the treaty.

Annual CO₂ Emissions (expressed in metric tons of carbon)

Country	Annual emissions (in million metric tons)
U.S.	573
China	433
Russia	211
India	177
Japan	143
Germany	75
Canada	52
U.K.	52
S. Korea	22
Iran	12

Top 10 Countries

Annual Emissions by Country (in million metric tons)

- 200 and greater
- 100-199
- 50-99
- 10-49
- less than 10
- no data
- *2000 data

Source: J. Marland, T.A. Boden, and R.J. Andres. Carbon Dioxide Information Analysis Center, International Geosphere-Biosphere Programme, U.S. Department of Energy, Oak Ridge, Tennessee.

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INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- An international panel of scientists and government officials established in 1988
- Has presented a series of reports on the synthesis of scientific information concerning climate change
- Evidence that climate conditions have changed since industrialization has increased
- The IPCC report concludes that average surface temperatures on earth have been rising since 1906, with most of the increase occurring in the last few decades

[Climate change talks](#)

Aerosols

- **Aerosols** = microscopic droplets and particles that have either a warming or cooling effect
- Soot, or black carbon aerosols, cause warming by absorbing solar energy
- Some tropospheric aerosols cool the atmosphere by reflecting the Sun's rays
- Sources of aerosols
 - Volcanic eruptions, fossil fuel combustion, ocean, wetlands, biomass
- Reduce sunlight reaching the earth and cool the Earth

Sources of Stratospheric Aerosols

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Increased Planetary Albedo

Stratosphere

Main Stratospheric Aerosol Layer

Insolation

Tropopause

Aerosol Nucleation and Growth

Slow Ascent

Troposphere

Ash · SO₂

Deep Convection

Rainout of Ash

Surface cooling

Human Activity

Biomass Burning

Ocean and Wet Lands

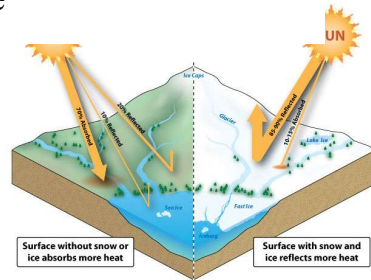
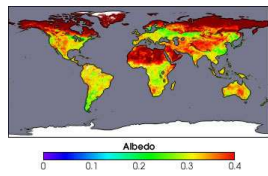
Biomass

Aerosols

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Albedo Effect

- Ability of a surface to reflect light
- Ice, especially with snow on top of it, has a high **albedo**
- Most sunlight hitting the surface bounces back towards space



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Ocean Warming

9.6

- Increases in ocean water temperature is due to an increase in greenhouse gases in the atmosphere.
- Ocean warming affects marine species.
 - Loss of habitat
 - Metabolic and reproductive changes
- Lead to coral bleaching.
 - Warmer waters kills off algae within coral
 - This causes the coral to bleach white.
 - More genetically tolerant coral will survive, while more sensitive coral die off.

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Coral Bleaching

9.6

Causes of decline of Coral reefs around the world

1. **Coral bleaching** = occurs when *zooxanthellae* leave the coral
 - Coral lose their color and die, leaving white patches
 - From climate change, pollution, or unknown natural causes
2. Nutrient pollution causes algal growth, which covers coral
3. Divers damage reefs by using cyanide to capture fish
4. Acidification of oceans deprives corals of necessary carbonate ions for their structural parts



Artificial Coral Reefs

Ocean Acidification

9.7

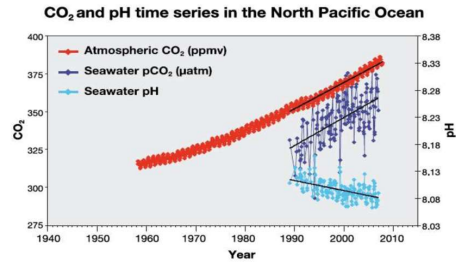
- Oceans becoming more acidic (lowering the pH) as a result of increased carbon dioxide moving from the atmosphere into the ocean.
 - Carbon dioxide reacting with water forms carbonic acids. $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$
 - Carbonic acid dissociates into bicarbonate ions and hydrogen ions. $\text{H}_2\text{CO}_3 \rightarrow \text{HCO}_3^- + \text{H}^+$
 - Hydrogen ions then combine with carbonate ions to form additional bicarbonate ions. $\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{HCO}_3^-$

Ocean Acidification

9.7

- **Anthropogenic activities that contribute to ocean acidification include:**
 - Burning fossil fuel
 - Vehicle emissions
 - Deforestation

- Damage coral and other organism with shells.
- Acidification destroys calcium carbonate which make up shells in marine animals.



The debate over climate change is over

- Most Americans accept that fossil fuel consumption is changing the planet
- *An Inconvenient Truth* helped turn the tide
 - 84% of people surveyed thought that humans contribute to global warming
 - Many corporations offer support for greenhouse gas reductions



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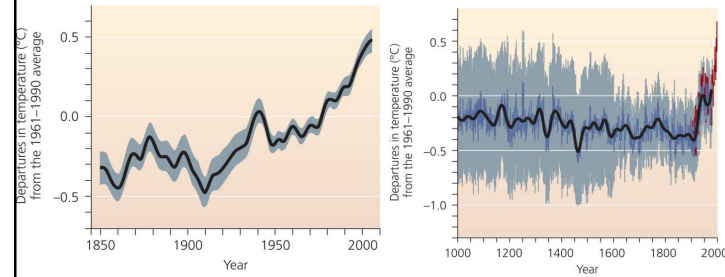
[Inconvenient Truth Video](#)

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CLIMATE CHANGE EVIDENCE



Temperature increases will continue



(a) Global temperature measured since 1850

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(b) Northern Hemisphere temperature over the past 1,000 years

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