

Man-Made Global Climate Change



Essential Standard 2.6

Analyze patterns of global climate change over time.

Learning Objective 2.6.3

Analyze the impacts that human activities have on global climate change such as the burning of hydrocarbons, greenhouse effect, and deforestation.

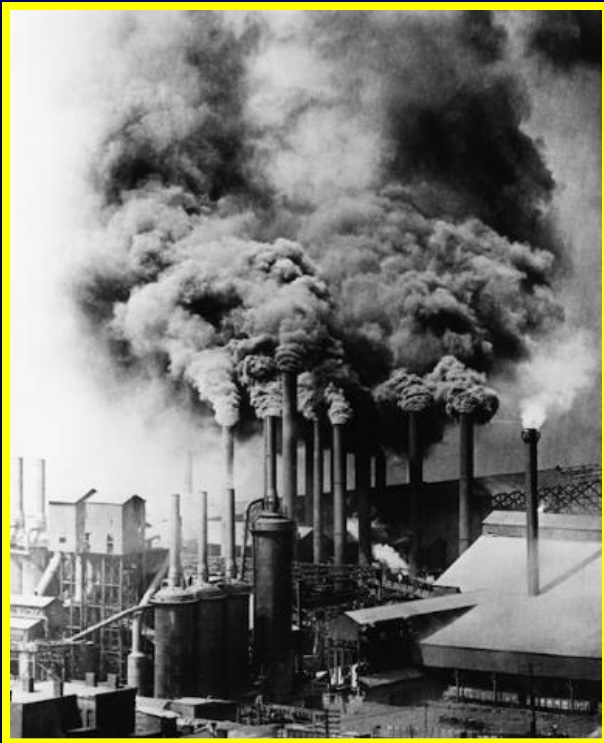
I Can Statements

At the end of this lesson, you should be able to say, with confidence:

- I can explain how carbon dioxide is cycled through various processes in the carbon cycle.
- I can explain how human activity led to an increase in carbon dioxide in the atmosphere and how scientists know it is from human activity.
- I can explain the relationship between increased carbon dioxide levels and an increase in the global average temperature.

Industrial Revolution

When the industrial revolution began in the mid-1800's, coal was mined and used as the main energy source, releasing large amounts of carbon dioxide into the atmosphere.



Industrial Revolution

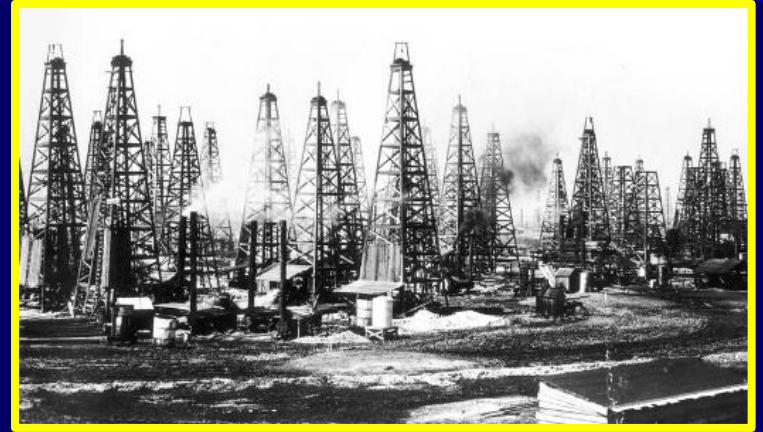
With better machinery and trains for transport, much of the forests were logged and used for timber.



In some places, forests were cleared through the slash and burn method to make room for agriculture.

Industrial Revolution

In the early 1900's, better techniques were used to drill for oil creating a large oil boom.



While coal was still the main source for electrical power, homes and businesses began switching over to oil and natural gas for heat.



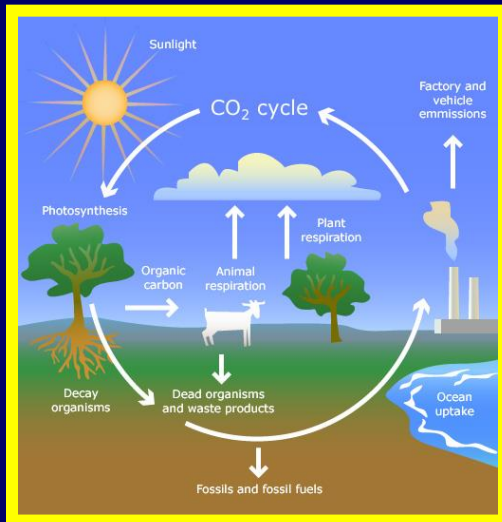
Ships, trains, and automobiles further increased the demand for oil.

Industrial Revolution

By the 1950's, people already knew that burning coal created health risks from smog.



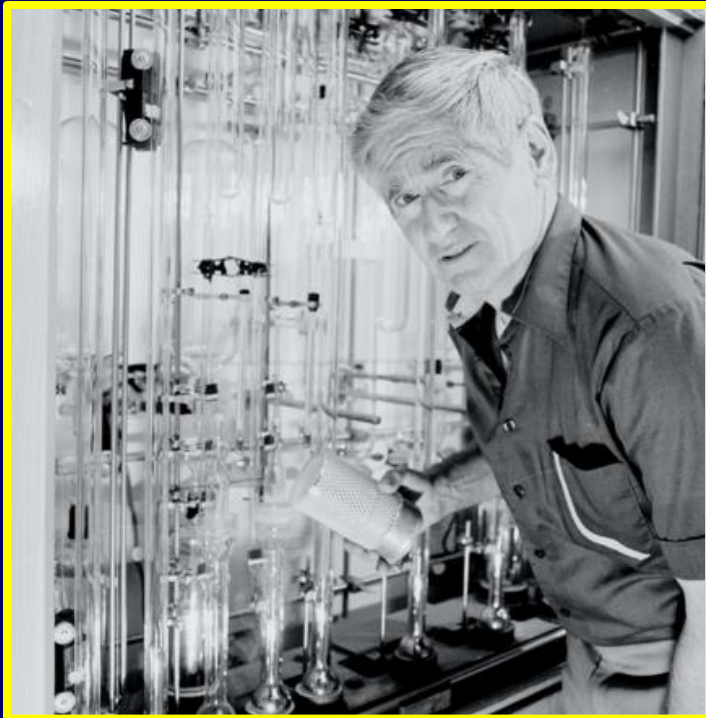
But at the time, people thought oil was the solution.



Nobody even thought about the impact the burning of fossil fuels and removal of forests would have on the environment.

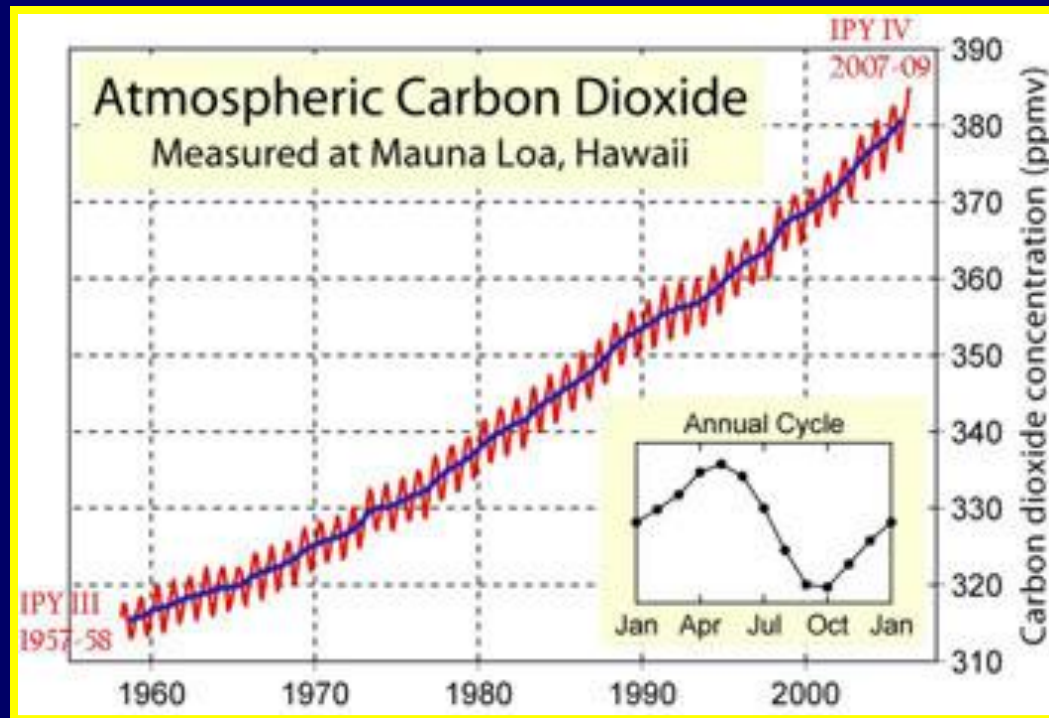
Measuring Atmospheric CO₂

In the mid-1950's, a geophysics professor, named Charles David Keeling, began recording atmospheric carbon dioxide levels in the atmosphere from on top of an Hawaiian volcanic island called Mauna Loa.



The Keeling Curve

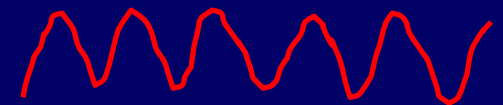
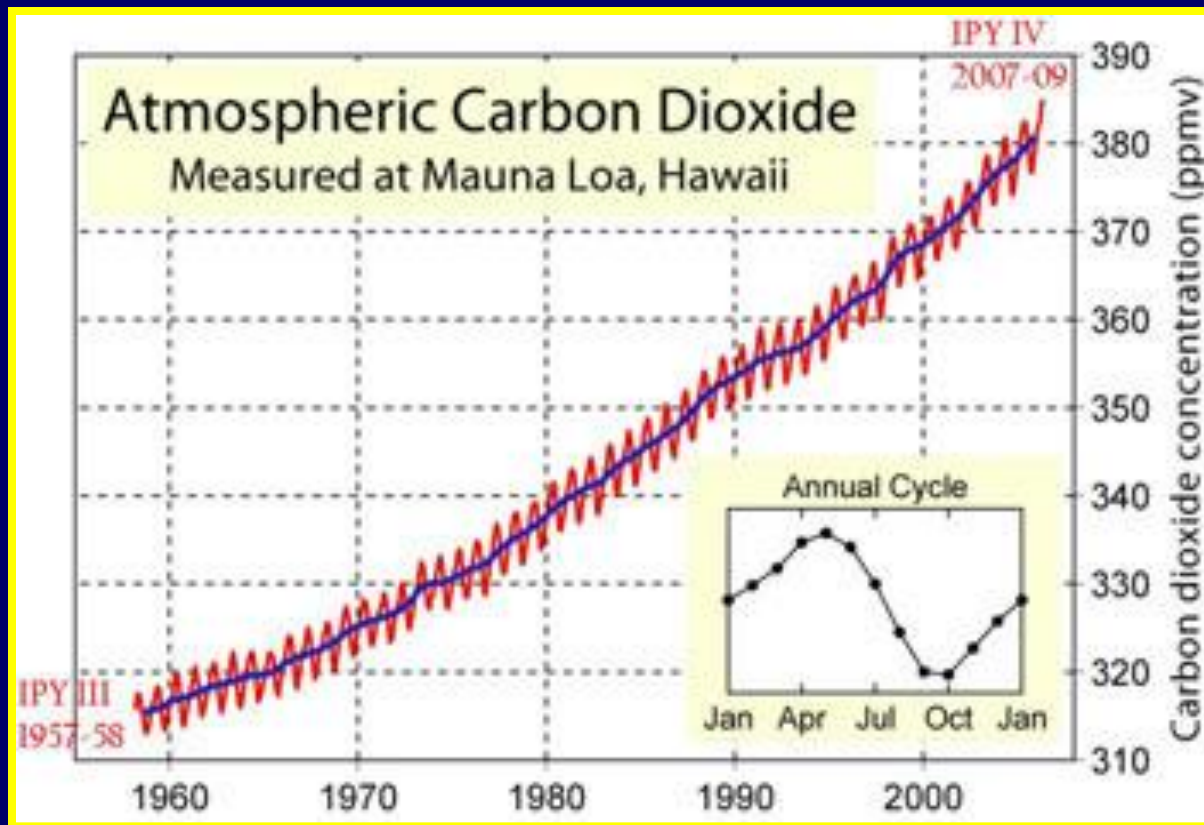
The first recorded measurements of atmospheric carbon dioxide, back in 1955, was 315 parts per million, ppm.



PPM = 1 carbon dioxide molecule
1,000,000 air molecules

Seasonal Changes

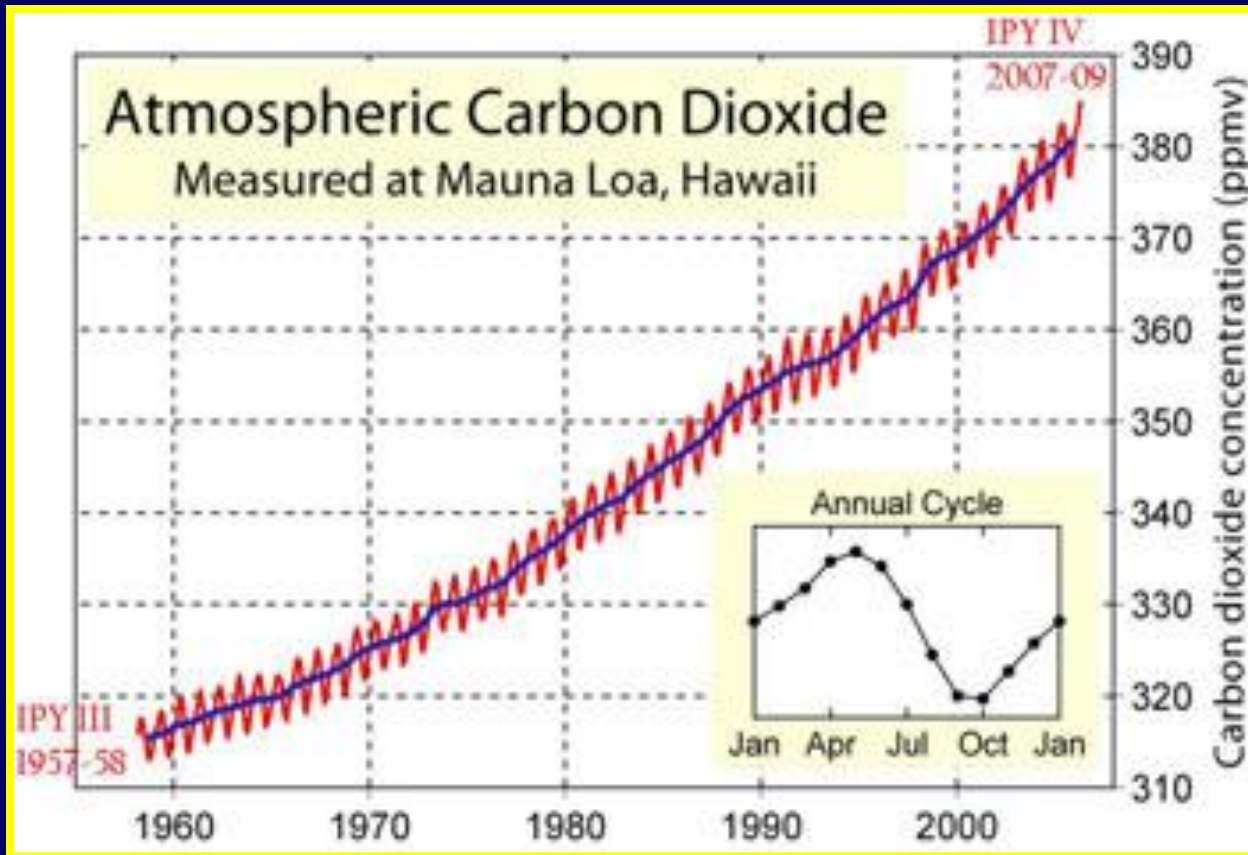
Within the first year or two, Keeling began to notice that the levels of carbon dioxide, in the atmosphere, rose and declined with the seasons.



Seasonal Changes

Overall Increase

Regardless of the up and down seasonal change, Keeling measured and recorded an overall increase in the levels of atmospheric carbon dioxide.



Overall trend

Ice Core Data

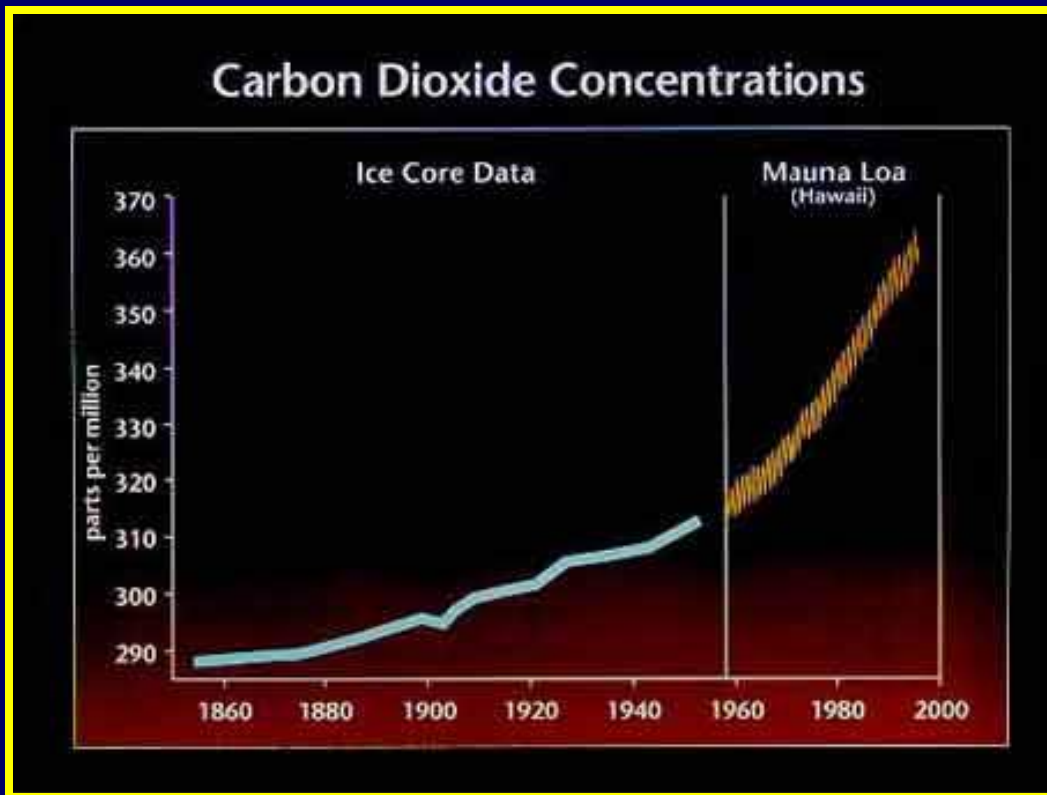
Ignited by Keeling's measurements, other scientists began finding ways to measure historic levels of atmospheric carbon dioxide.



One source of information about ancient climates was found in ice cores, where bubbles containing ancient air were trapped and frozen in time.

Industrial Revolution

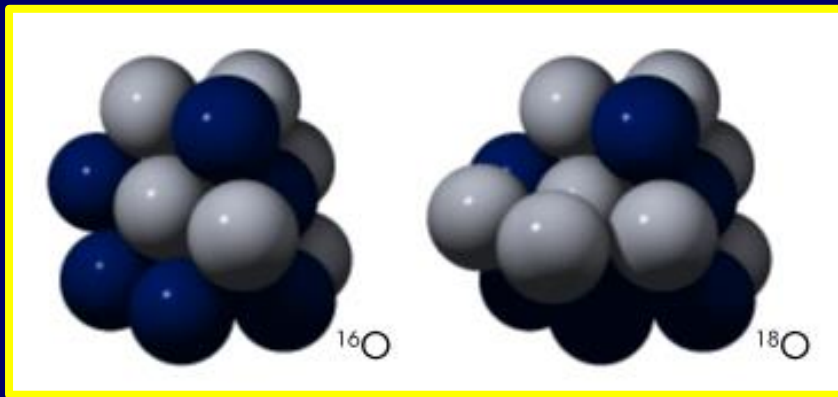
Ice core data showed increasing amounts of atmospheric carbon dioxide since the industrial revolution began in mid 1800's.



In 1850, the carbon dioxide levels were only 280 ppm.

Measuring Temperature

While humans have been measuring and recording the temperature of the atmosphere with thermometers for a few hundred years, scientists also found a way to measure ancient temperatures.

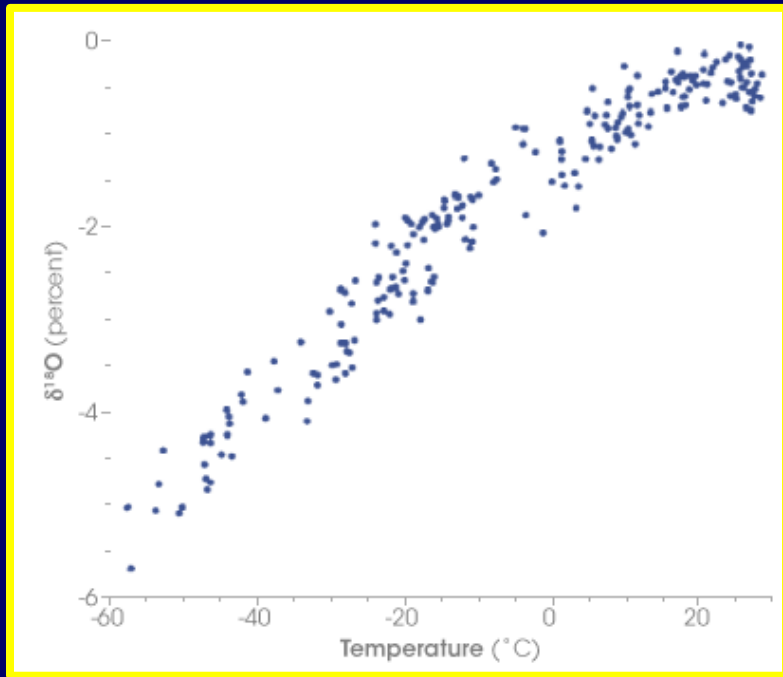


Oxygen atoms come in two varieties, called isotopes, which vary by mass.

Oxygen-16 has a lighter mass than oxygen-18, due to different numbers of neutrons in the nucleus of the atoms.

Measuring Temperature

Both oxygen-16 and oxygen-18 can and will chemically bond with hydrogen to form water molecules.



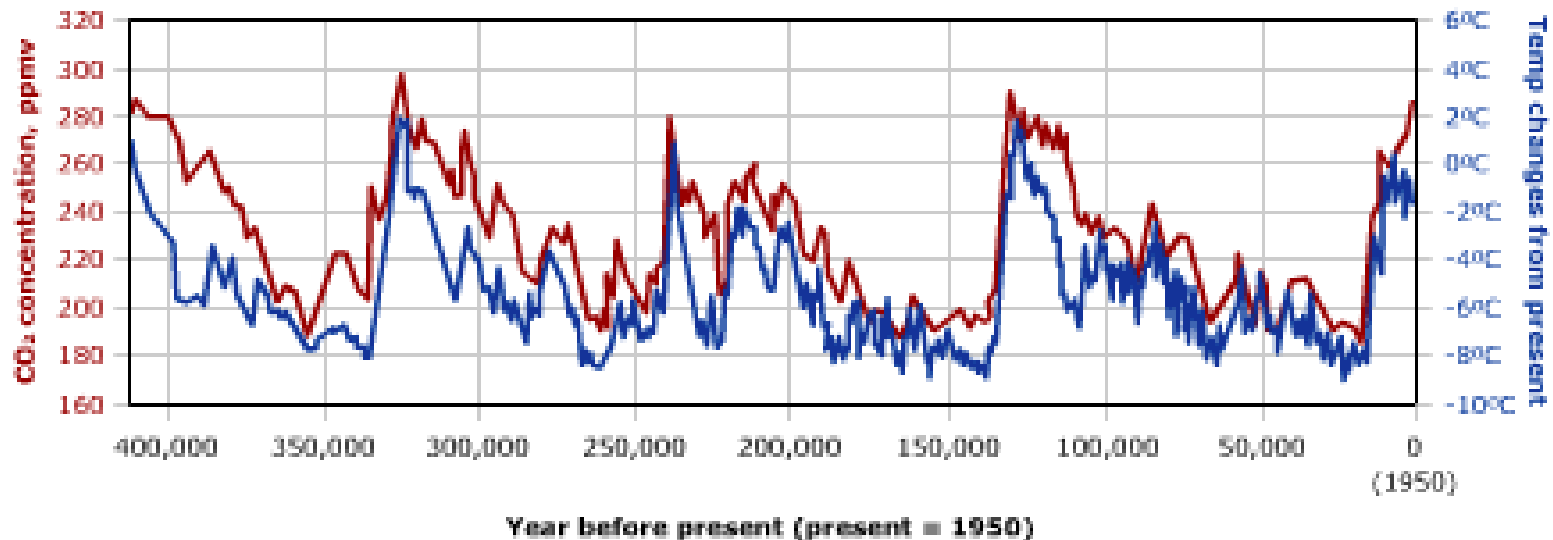
However, water vapor containing oxygen-18, will condense and precipitate out of the atmosphere more readily than the lighter oxygen-16.

At colder temperatures, water vapor in the air tends to contain very little oxygen-18.

Temperature and Carbon Dioxide

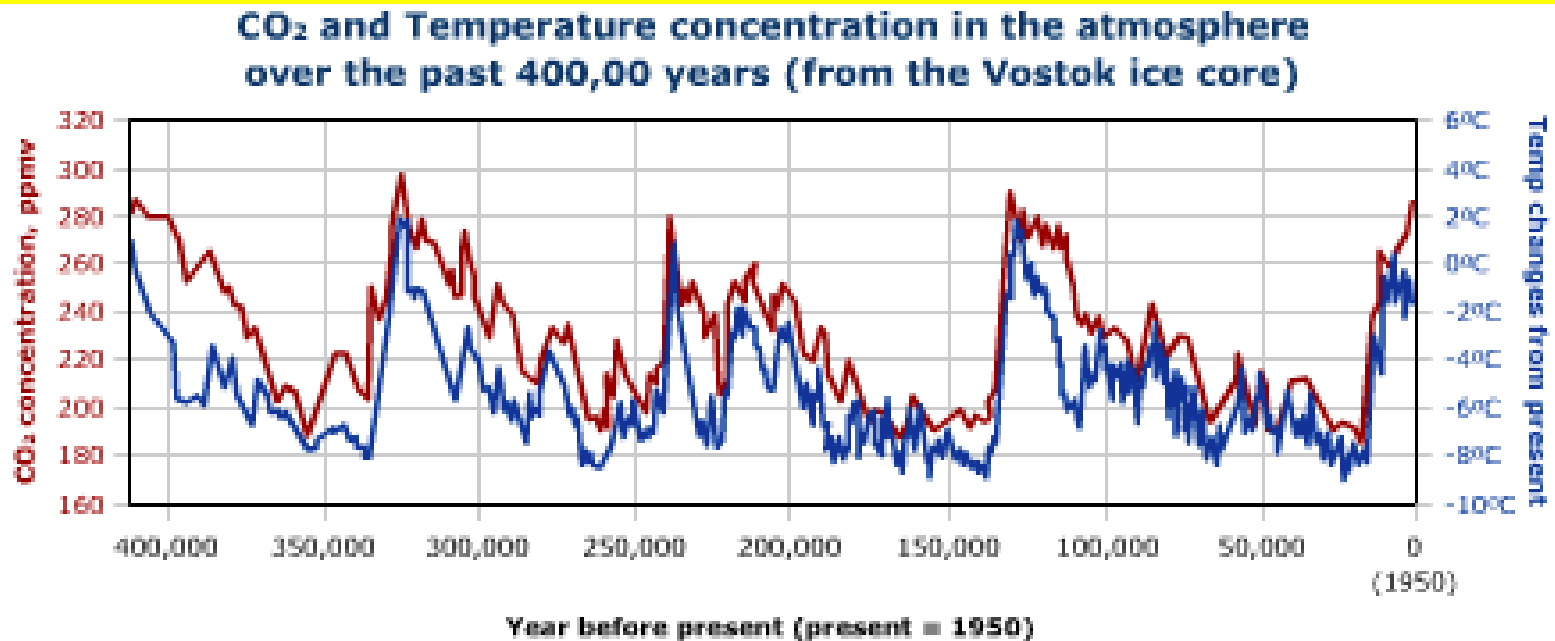
By examining ice core data, scientists have been able to not only measure the carbon dioxide levels but also estimate the temperature of the atmosphere for the past several 100,000s of years.

CO₂ and Temperature concentration in the atmosphere over the past 400,00 years (from the Vostok ice core)



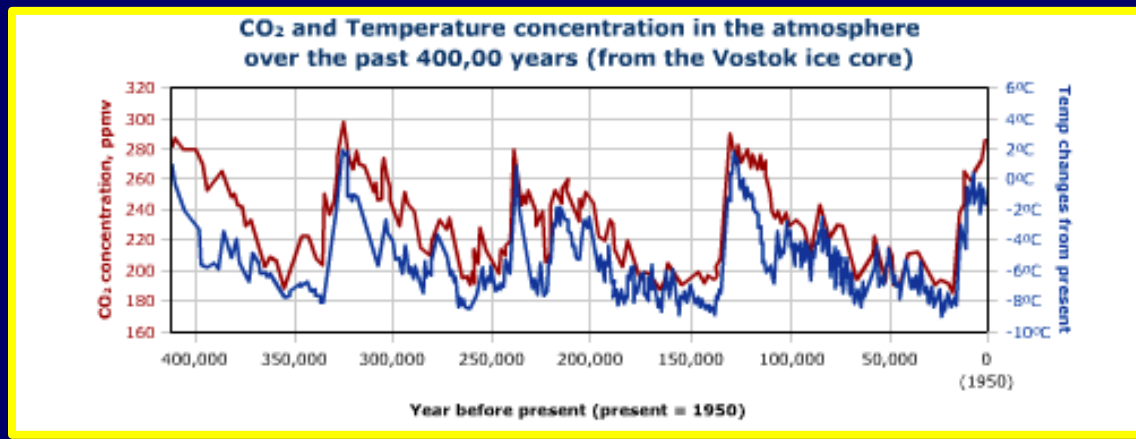
Temperature and Carbon Dioxide

While examining ancient temperatures and carbon dioxide levels, scientists found a correlation between rising carbon dioxide levels and rising temperatures.



Temperature and Carbon Dioxide

The rising temperatures and carbon dioxide levels also correlated with the periodic change in ice ages.

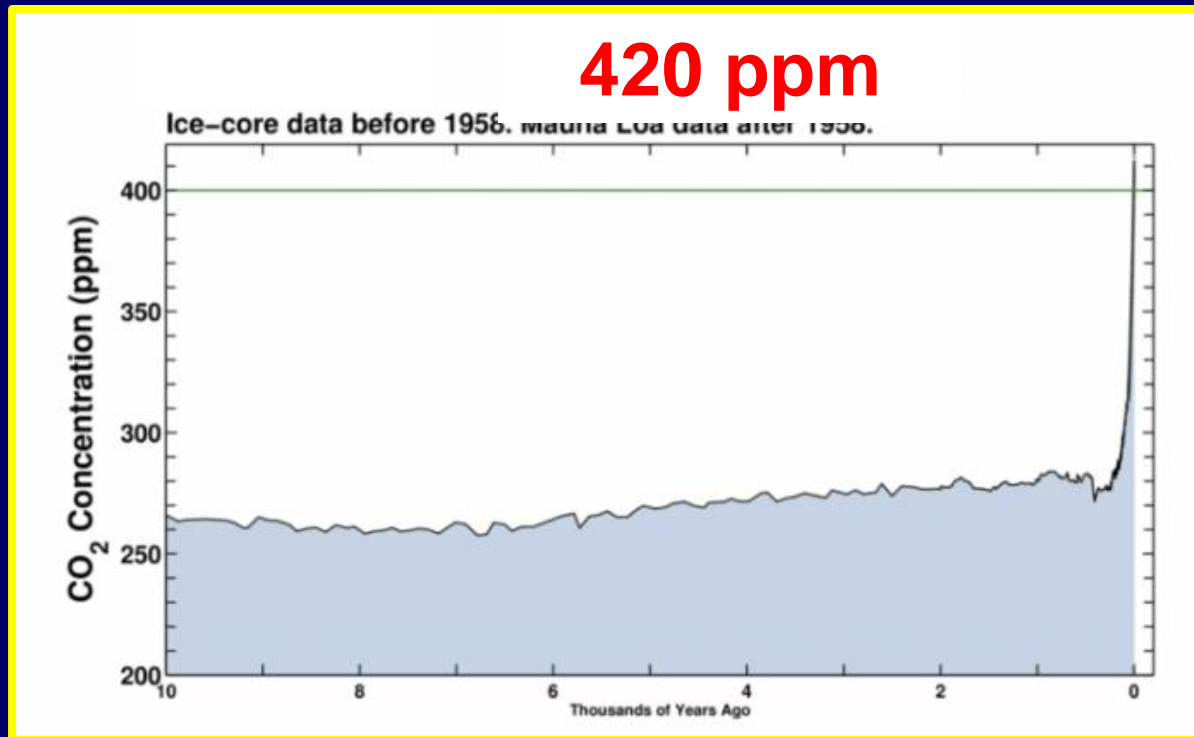


During high glaciation periods, more land and ocean was covered by ice.

So, there was less photosynthesis removing carbon dioxide from the atmosphere. As a result, the increased levels of carbon dioxide would cause warming trends that would melt the glaciers.

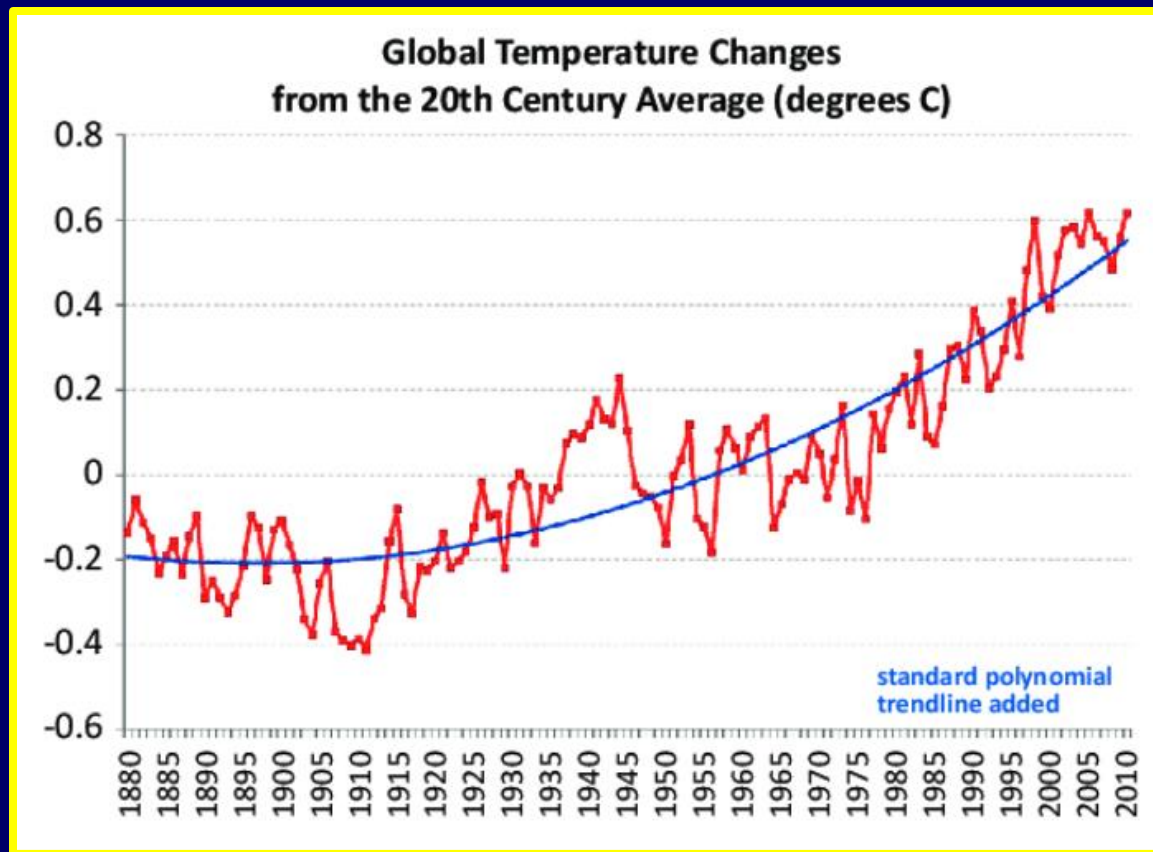
Temperature and Carbon Dioxide

While the data from ancient atmospheres show periodic increases in temperature and carbon dioxide are natural, the levels of carbon dioxide being recorded today are higher than they have ever been in recorded history.



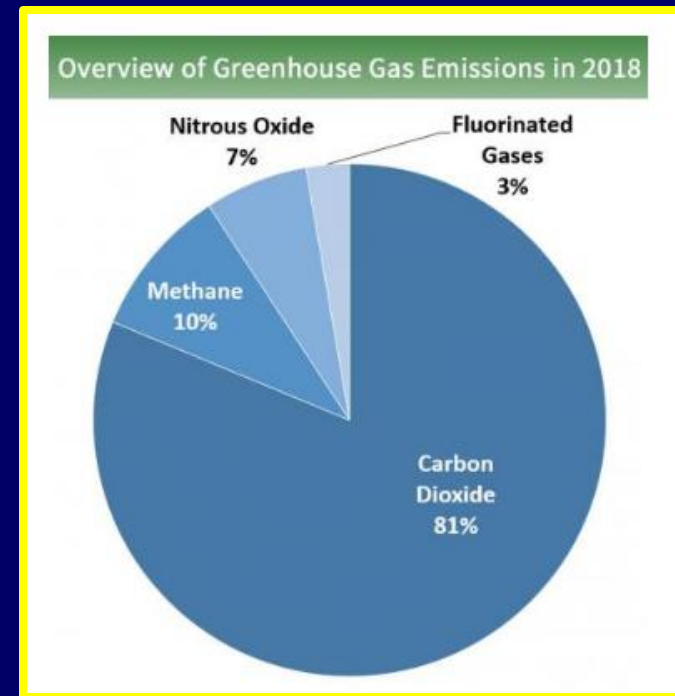
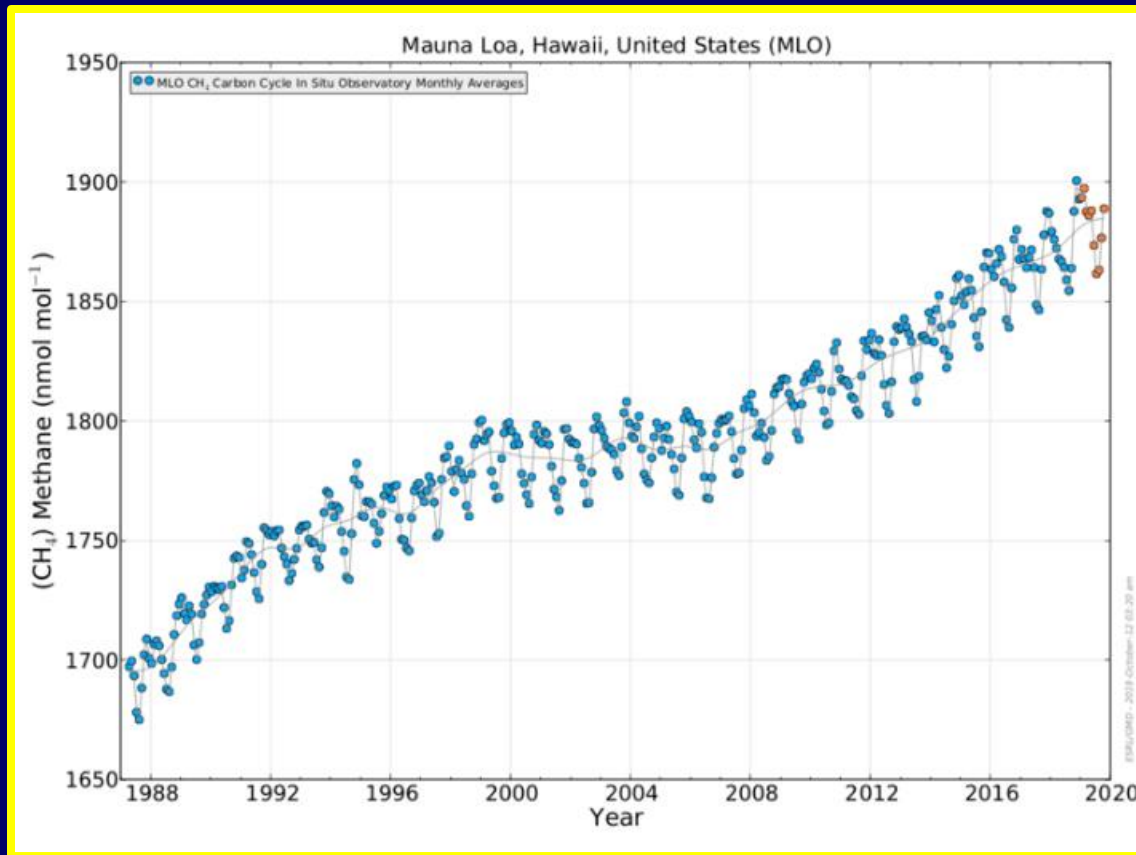
Temperature and Carbon Dioxide

There has also been an increase in the average global temperature with the rate of increase doubling within the last 50 years.



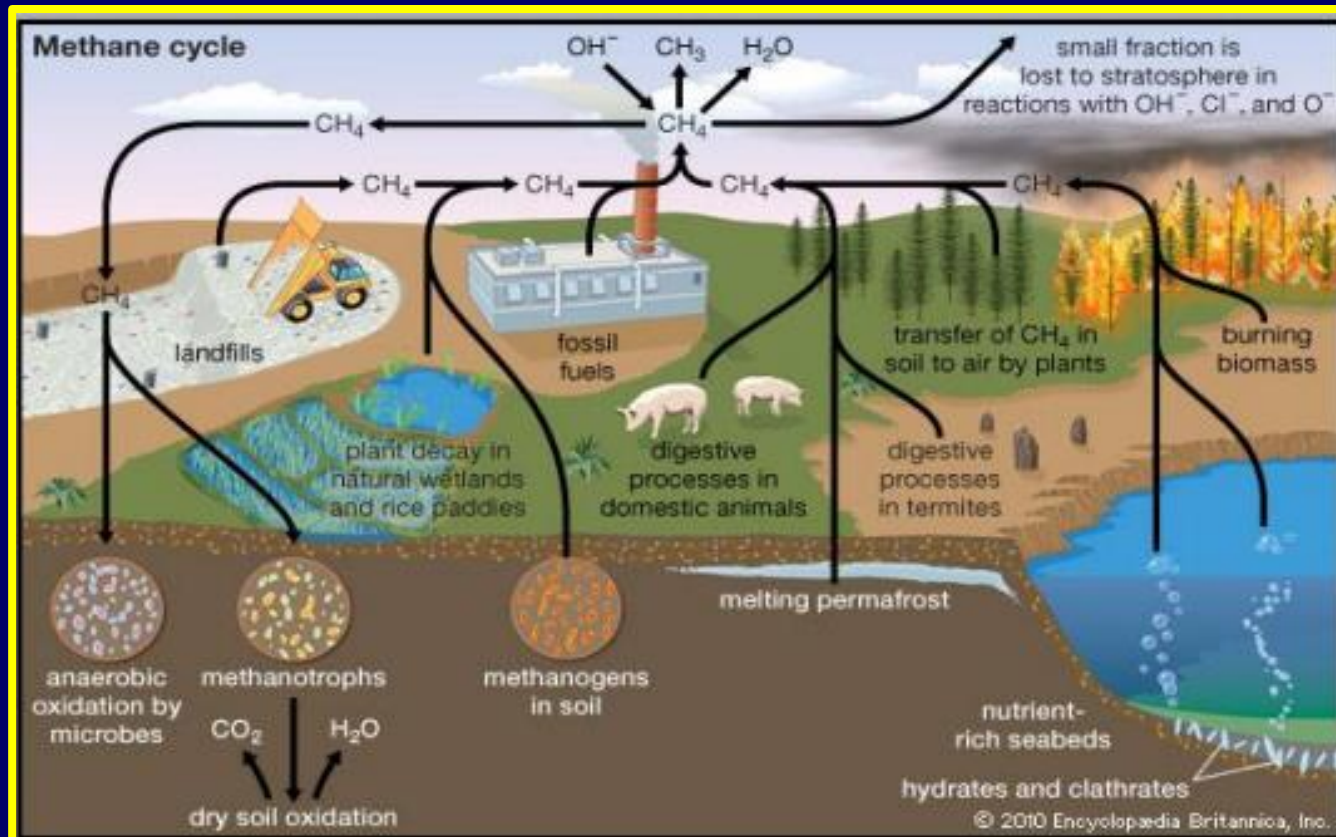
Methane

Besides carbon dioxide, methane, another greenhouse gas, has also been increasing in the atmosphere since the industrial revolution.



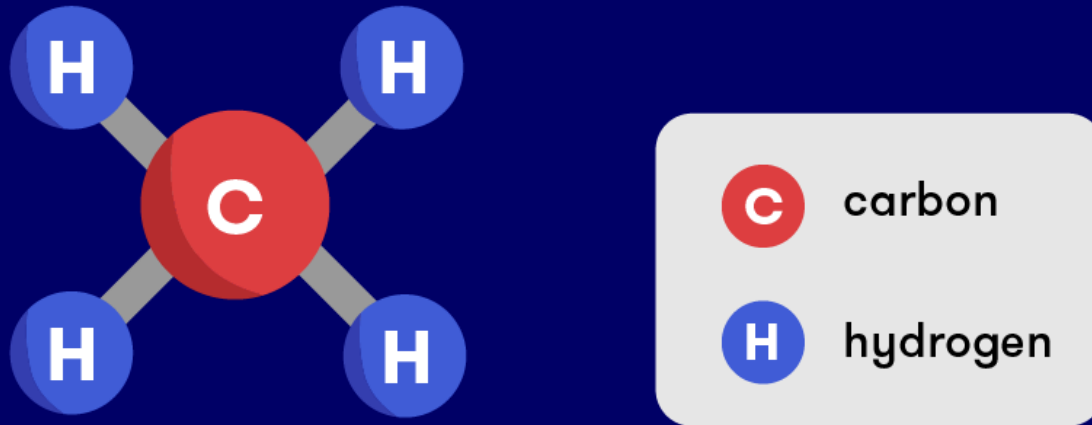
Methane Cycle

Methane is released into the atmosphere from plant decay in wetlands, organic decay in landfills, digestive process of livestock, and from the burning of fossil fuels.



Residency Time

Residency time refers to the amount of time a molecule will remain in the atmosphere before it is broken down.



Methane has a residency time of only 10 years before it reacts with water and is broken down in carbon dioxide gas.

This is why you don't hear as much about methane being a large concern.

Residency Time

Carbon dioxide's residency time is hundreds of years. In fact, after 100 years, only 50% of any carbon dioxide quantity is broken down.

1 gallon of gas = 6 lbs CO₂

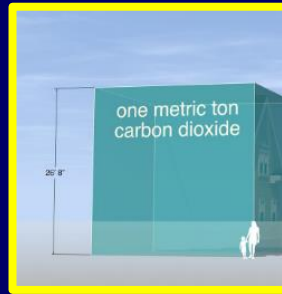
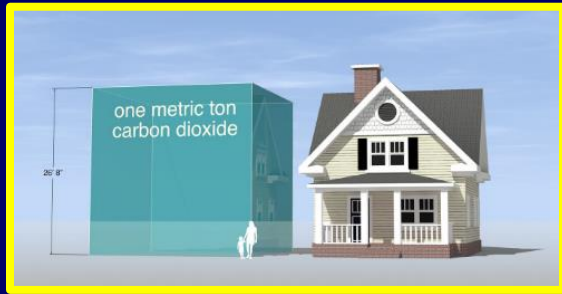
1 year = 15,000 miles

20 miles /gallon = 7.5 tons CO₂

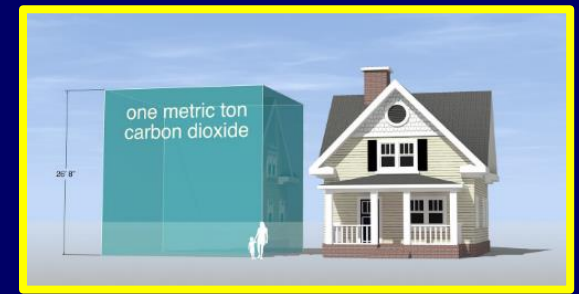
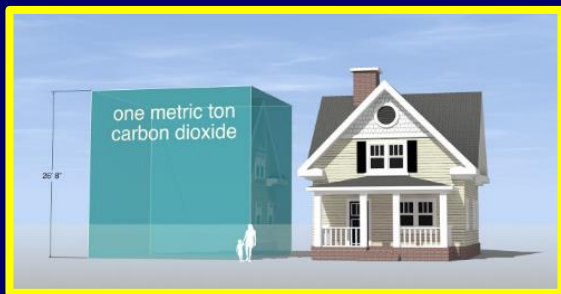
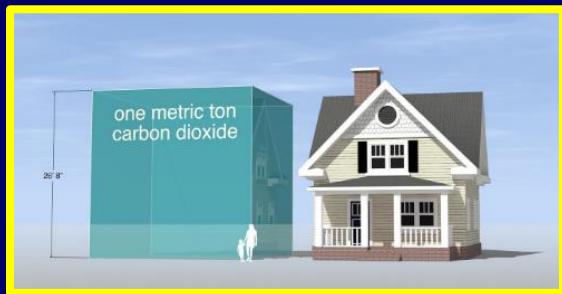
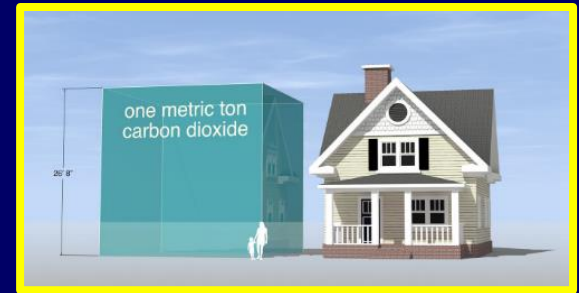
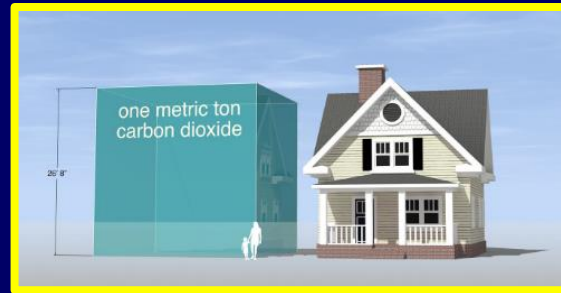
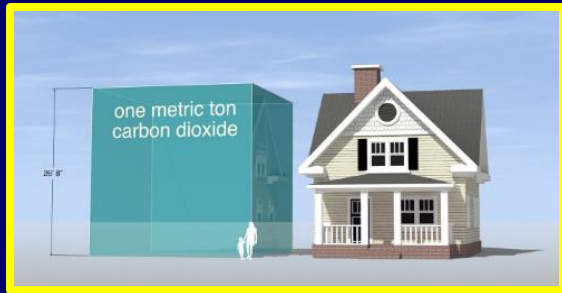
100 years = 3.75 tons still in atmosphere

7.5 tons of CO₂

The average car that gets 20 miles to the gallon releases 7.5 tons of carbon dioxide gas into the atmosphere each year.

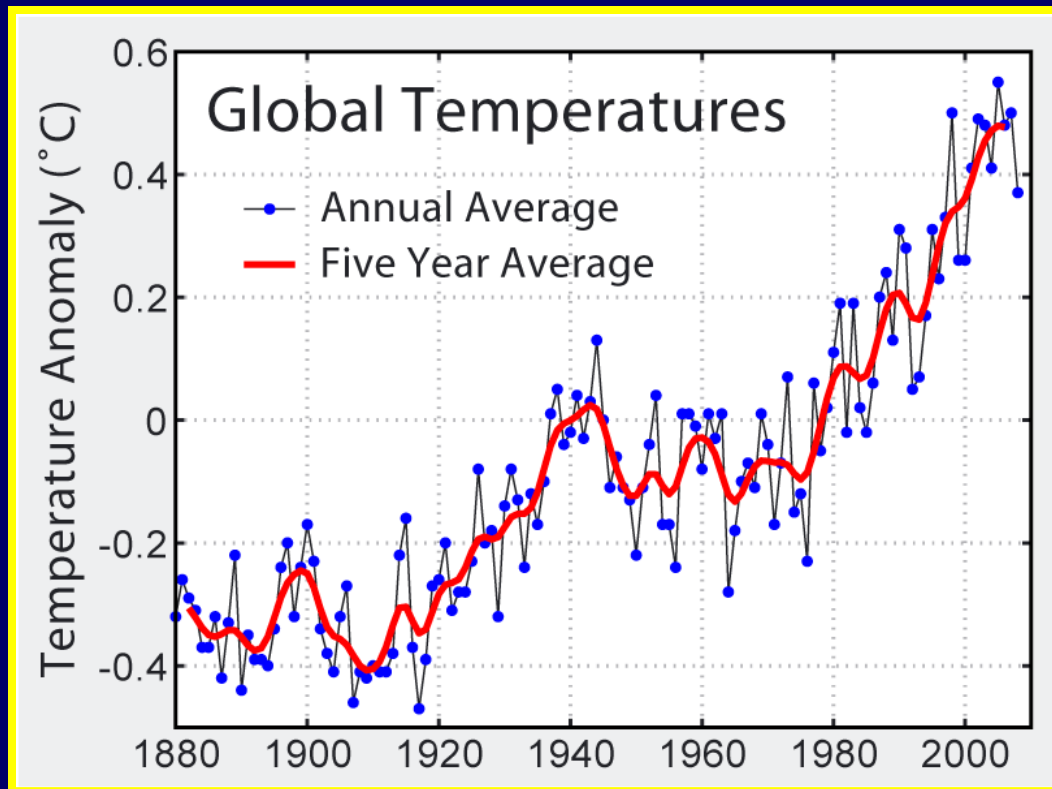


After 100 years, 3.75 tons of that is still left in the atmosphere.



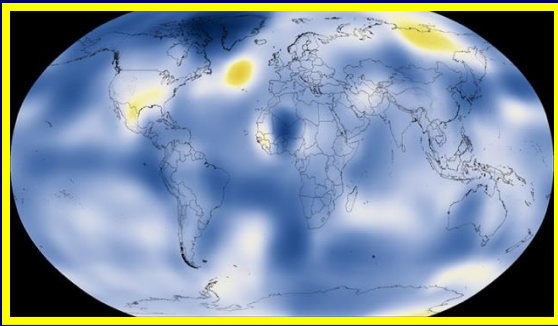
Global Climate Change

Since the early 1900's, there has been a 1° F increase in the average global temperature with the 10 warmest years all occurring since the year 2000.

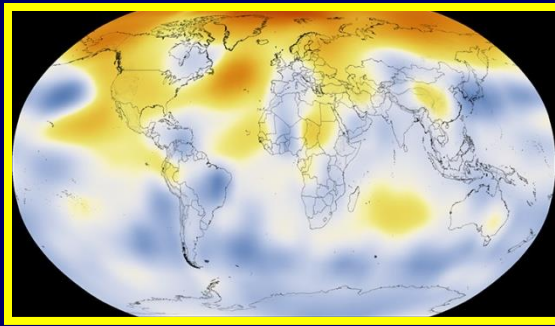


This is a change in the average global temperature.

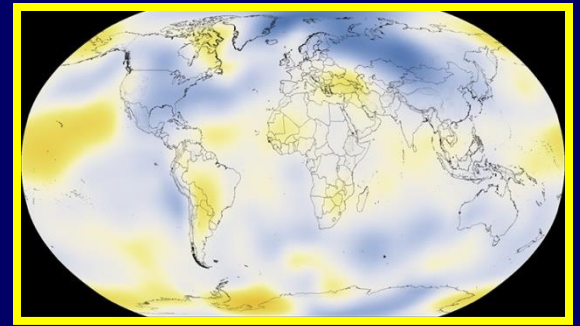
Some places have experienced cooling, other places have experienced warming.



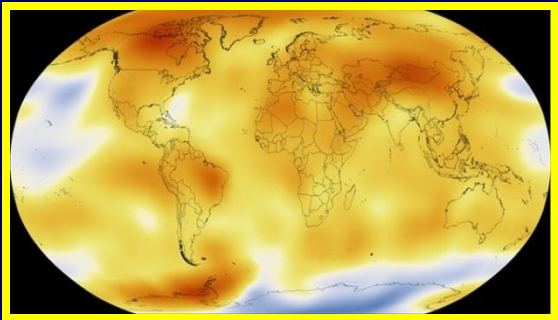
1910 31° F



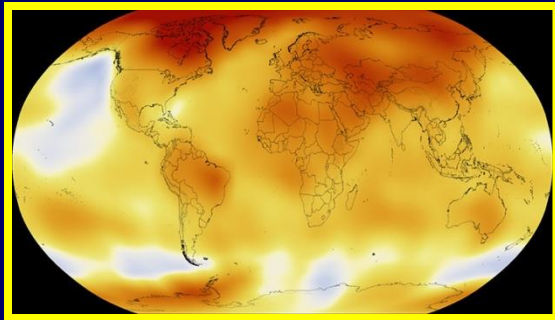
1940 32° F



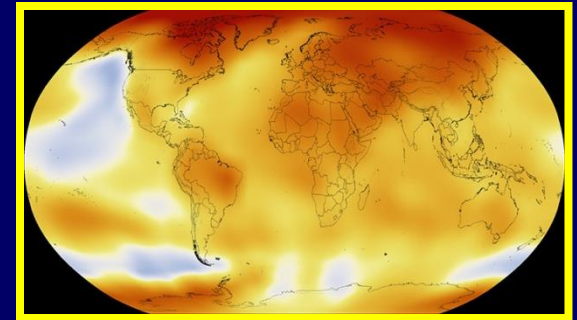
1970 32° F



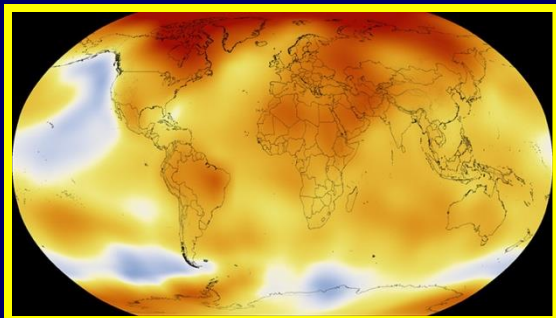
2000 32° F



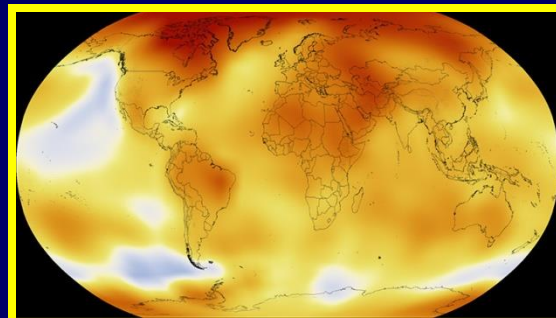
2010 33.2° F



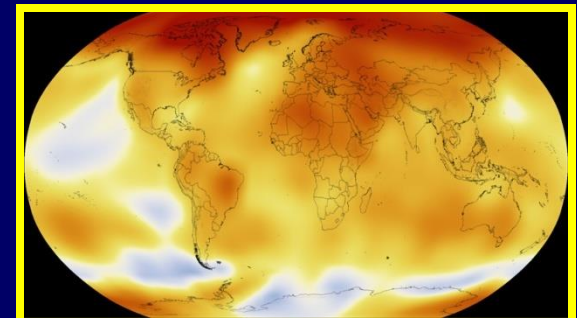
2011 33° F



2012 33° F



2013 33.1° F



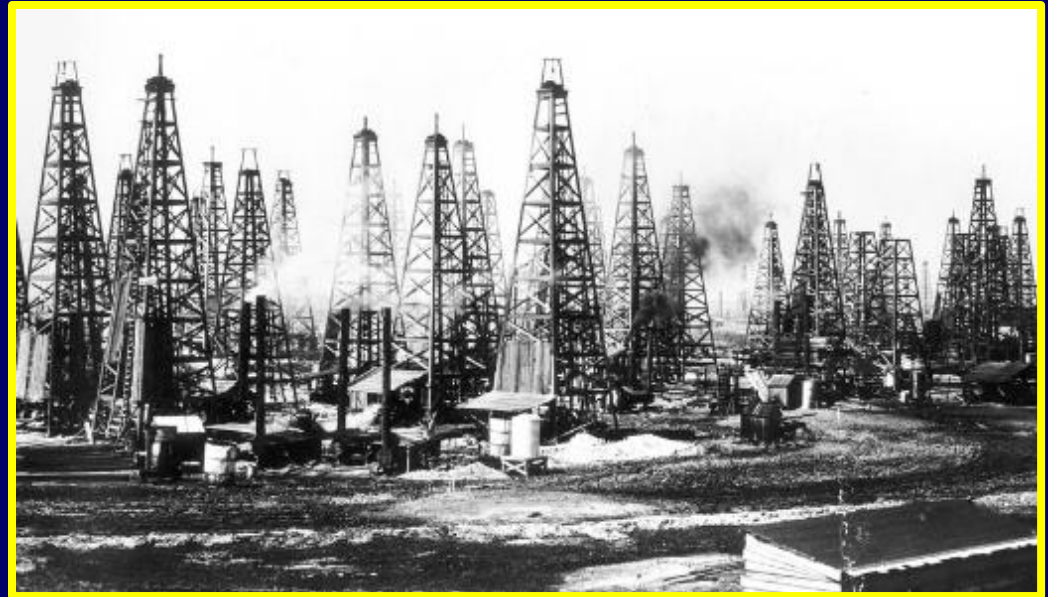
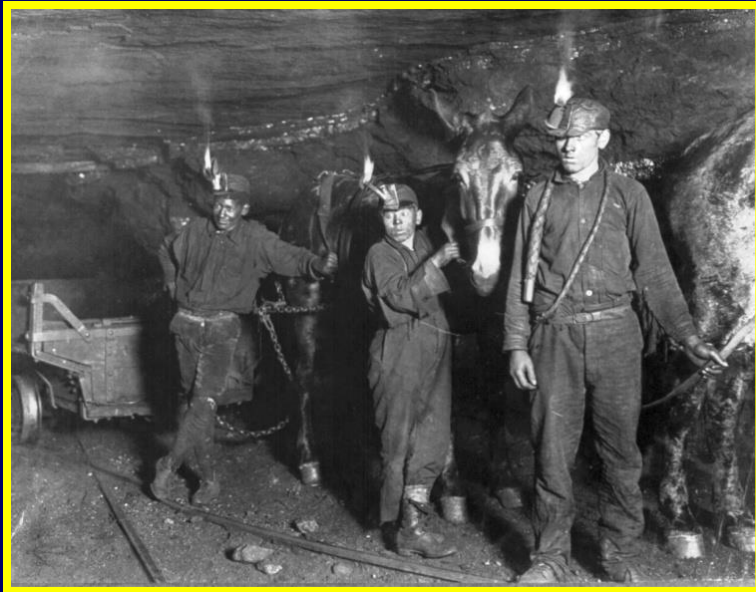
2014 33.2° F

Blue = Areas cooler than average

Red = Areas warmer than average

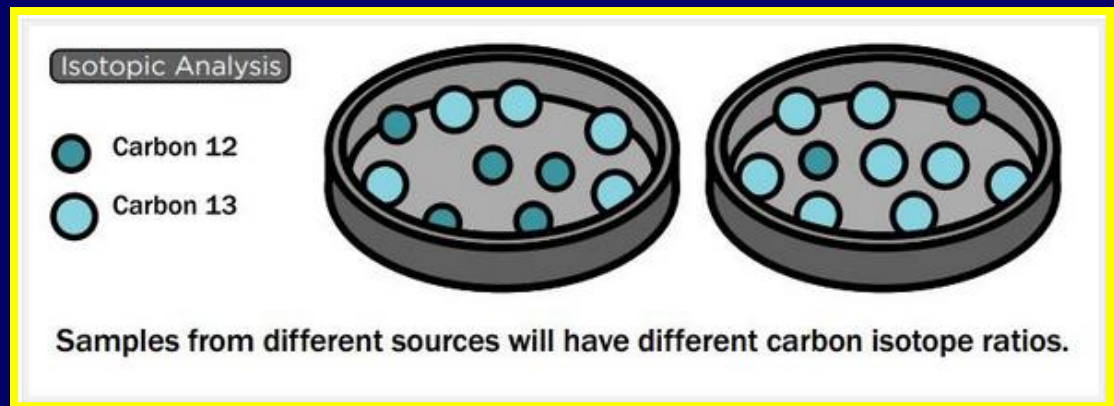
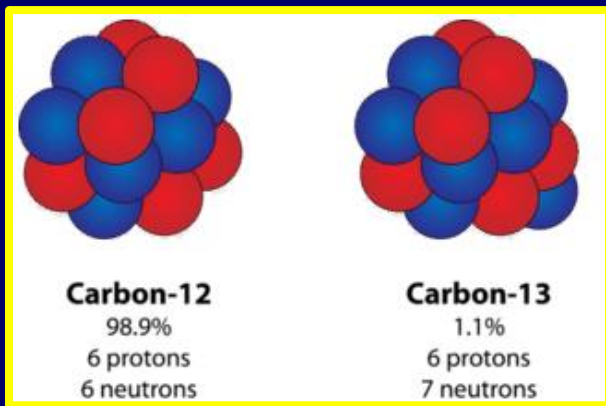
Human Activities or Natural?

The extraction of fossil fuels is a large money-making industry and very careful accounting methods let us know exactly how much fossil fuels have been extracted and combusted since the industrial revolution.



Human Activities or Natural?

Another method to determine whether the carbon dioxide in the atmosphere is from human activities or natural events is by examining the ratio of carbon isotopes, especially carbon-12 to carbon-13.



Different sources of carbon dioxide emissions will have different carbon isotope ratios, so scientists can determine the sources of CO₂ in the atmosphere.

Scientific Consensus

97% of climate scientists agree there is a global warming trend and that it is due to human activities.

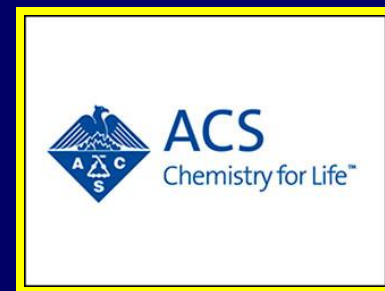


American Association for the Advancement of Science

"The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society." (2006)

American Chemical Society

"Comprehensive scientific assessments of our current and potential future climates clearly indicate that climate change is real, largely attributable to emissions from human activities, and potentially a very serious problem." (2004)



Controversy?

The fossil fuel industry is a large money-making industry that not only earns money for the people who own or work for the companies but also for people who buy stock in the company.



Controversy?

Oil is also some nation's main source of income.



Controversy?

All the people who have a financial interest in fossil fuels contribute to campaigns of politicians that agree to vote in favor of the fossil fuel industry.

The fossil fuel industry also creates and funds large organizations that's main purpose is to influence politicians and spread controversial, often inaccurate, information about global climate change.



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The End

