TAG January 2011 Classroom Intervention
Resources for the Climate Change Unit
20th January 2011

Introduction to Climate Change

Climate change is an important topic that many people around the world are talking about. The United Nations has sponsored a series of climate change talks. One of the ones that people know best is the United Nations Climate Change Conference. The most recent talk was held in Cancun, Mexico in 2010.

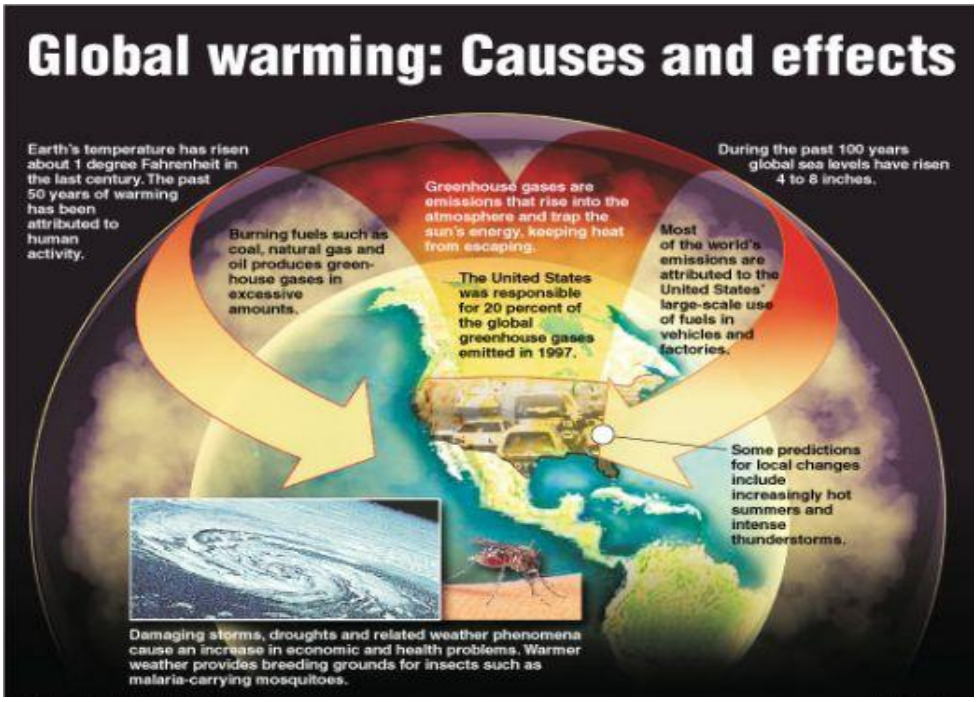
One kind of climate change that has been the focus of United Nations conferences is global warming. Over the last 100 years, the average global temperature has increased by about 0.75 degrees Celsius (1.3 degrees Fahrenheit). Global temperature could rise another 1.1 to 6.4 degrees Celsius (2.0 to 11.5 degrees Fahrenheit) over the next century. This might sound like a small change, but it can greatly affect the environment.

If the temperature of the Earth increases, we might have more extreme weather patterns such as hurricanes, droughts, and coastal floods. This is because global temperature indirectly affects the amount of precipitation the Earth receives.

So, why are these changes happening?
A lot of evidence suggests that humans are affecting the environment through their lifestyles. We burn a lot of fossil fuels, which add carbon dioxide and other greenhouse gases to the atmosphere. We also generate tons of garbage that we do not recycle. A lot of this trash goes into landfills and decays to produce methane, another greenhouse gas. Through deforestation, we also cut down a lot of trees and other vegetation. Deforestation also indirectly affects the amount of greenhouse gases. These greenhouse gases reflect heat to the Earth, and they eventually lead to increasing global temperatures.

What should we do?
We need to find ways to reduce greenhouse gases. Here are some important things to remember:

1. Human activities produce greenhouse gases such as carbon dioxide and methane.
2. Greenhouse gases cause the greenhouse effect that may result in global warming.
3. Global warming is causing extreme weather patterns such as drought and flooding along the sea coasts.



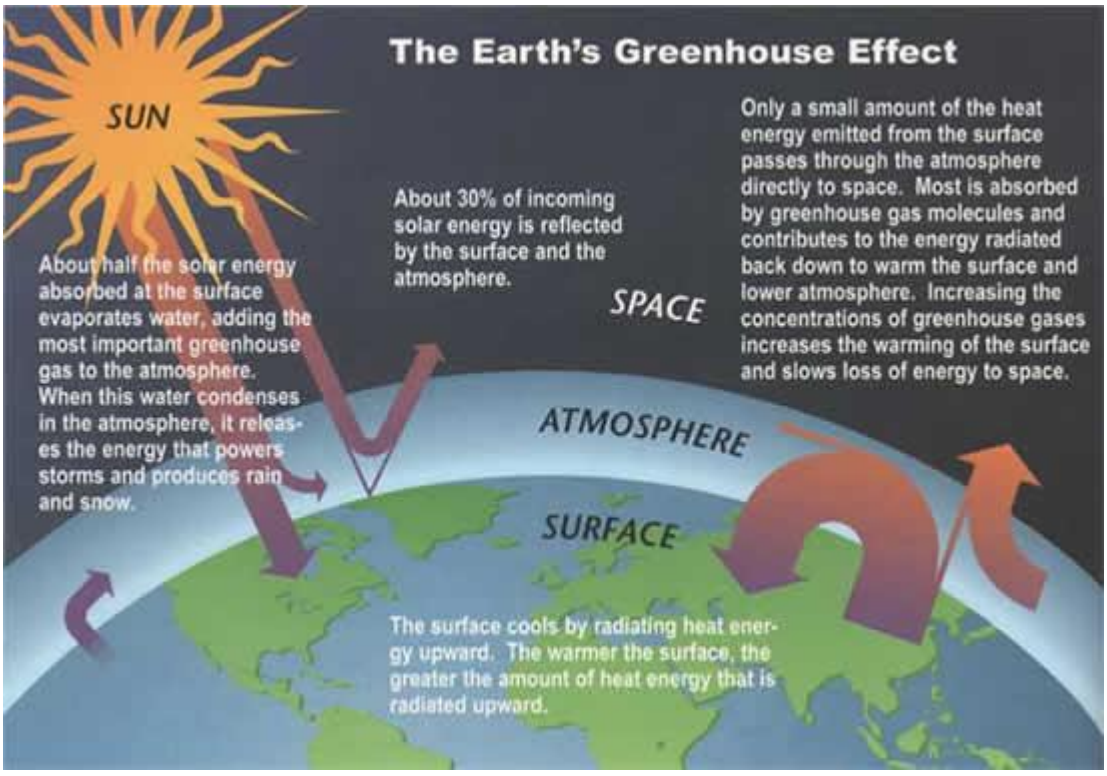
Greenhouse Effect

You might have heard about the greenhouse effect on television or in your science classes. That is because the greenhouse effect is important to how the world normally works. By trapping heat generated by the sun, the greenhouse effect prevents the earth from becoming too cold. A cold Earth would not support life, but when the greenhouse effect becomes too strong it can lead to global warming.

The surface of our Earth is surrounded by a layer of different gases called the atmosphere. Normally, the Earth is hit with a lot of energy from the sun. The Earth's surface absorbs some of this light energy and the rest bounces back to space. Some gases in our atmosphere, called greenhouse gases, trap the heat after it bounces off of the Earth's surface and reflect it back to the Earth, eventually making the Earth warmer. In this way, the atmosphere acts like a blanket that prevents the Earth from getting too cold for living things. This is how the greenhouse effect works.

So what is the problem? Why are so many people worried about global warming and the greenhouse effect if the greenhouse effect is a normal part of the world?

A major problem is that human activity has greatly increased the amount of carbon dioxide and methane in the atmosphere, and this has made the greenhouse effect stronger. The greenhouse effect has increased the heat reflected back to the Earth, and so the Earth has more absorbed heat energy which has led to higher average global temperatures.



Solar Energy

The sun is a star at the center of our solar system. Even though it is far away, solar energy from the sun is the major source of energy for the planet Earth. This energy keeps our planet warm enough for things to live and grow.

How does the sun produce so much energy?

Most of the sun is made of hydrogen gas. Through a process called **nuclear fusion**, some of the hydrogen in the sun is turned into helium. This releases a huge amount of energy! The energy from nuclear fusion in the sun is radiated into space as electromagnetic waves. **Solar energy** is electromagnetic radiation that carries the energy of the sun to the Earth.

Absorbed light energy

The ground and water that make up the earth's surface absorbs about 50% of the light energy the Earth receives. The energy absorbed by the Earth is called absorbed light energy. The more solar energy that the Earth receives, the more light energy it will absorb. The Earth does not absorb all of the solar energy that reaches it: Sea ice located around the world can act like a giant mirror. We have a lot of sea ice in the Arctic and the Antarctic! The sea ice, then, reduces the amount of Earth's absorbed light energy.

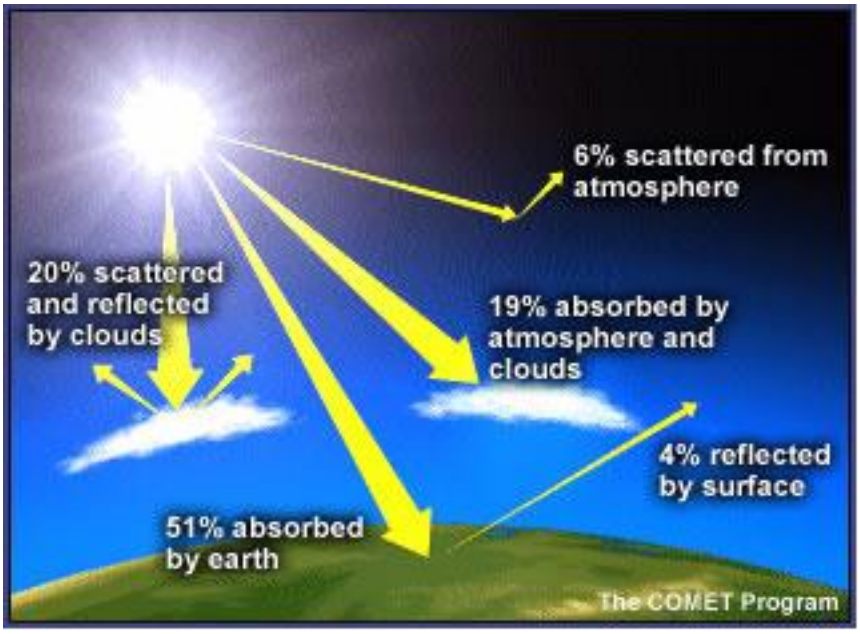
Absorbed Light Energy

When solar energy reaches the Earth's surface, the Earth absorbs it. Once it has been absorbed, we call it absorbed light energy.

Some absorbed light energy excites the molecules of the Earth's surface and becomes heat energy. We call this energy absorbed heat energy, and it raises the temperature of the Earth and atmosphere.

Some solar energy is reflected back into space by the atmosphere before ever reaching the Earth's surface. Other solar energy is reflected back into space by sea ice, which is a good reflector of heat. This means that sea ice reduces the amount of absorbed light energy.

The sun shines on the Earth all the time. An increase in absorbed light energy leads to more absorbed heat energy, which in turn increases the average global temperature. So why doesn't the Earth keep getting hotter? One reason is that the Earth doesn't absorb all of the solar energy. Only about 50% of the solar energy received by the Earth is actually absorbed.



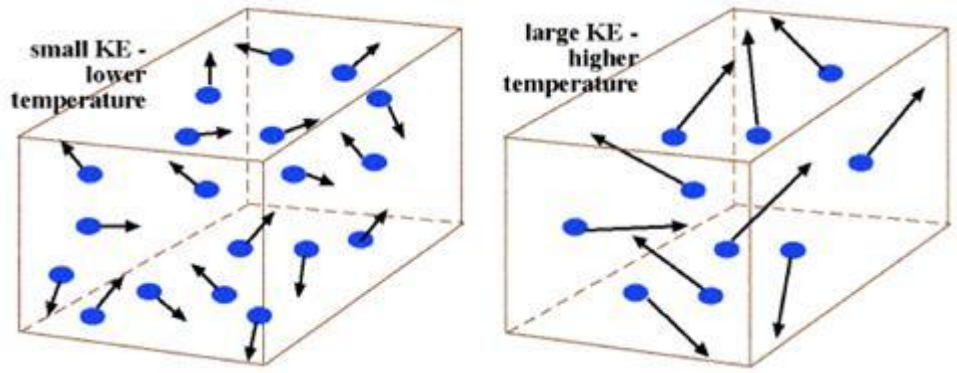
Absorbed Heat Energy

Everything in the universe is made of atoms and molecules. These particles are always moving around. Heat energy comes from the motion of these particles. The more they move, the more energy they have.

The energy of motion is called kinetic energy (KE). Why do we call this "heat" energy? Well, objects with more kinetic energy feel hot to us because when they touch us, some of the kinetic energy is transferred to us, making us feel hotter.

When solar energy hits a surface like the Earth, some of it is absorbed and is called absorbed light energy. Once absorbed, this energy can excite molecules in the earth's surface, causing them to move faster. As the molecules move around faster, they produce heat energy. This is why an increase in absorbed light energy produces more absorbed heat energy, in turn causing an increase in the average global temperature. This is also why solar energy, or sunlight, feels warm on our skin. Solar energy excites the molecules of our skin!

Greenhouse gases like carbon dioxide and methane indirectly affect absorbed heat energy through the greenhouse effect. The greenhouse gases trap heat radiation before it can escape into space, increasing the heat reflected to the Earth.

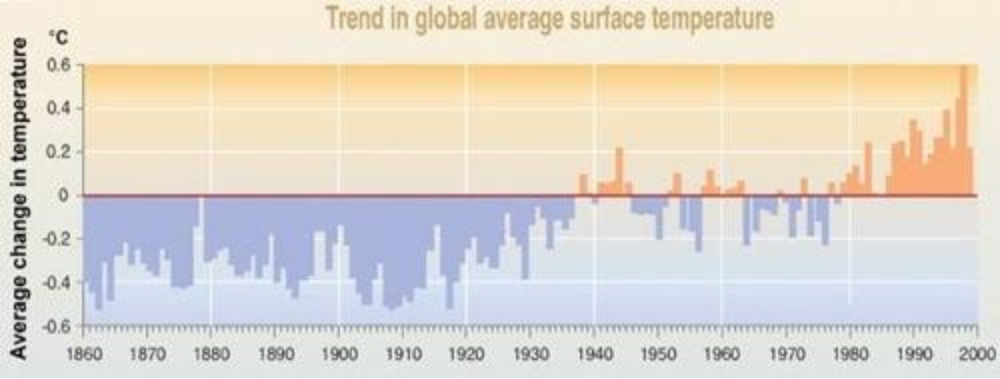


Global Temperature

Temperatures in our local region change based on day and season. Temperatures in places around the world might be very different from each other. It's often freezing in Antarctica and hot in the Sahara desert at the same time.

So why do people say that the Earth is getting warmer?

When we talk about global warming and climate change, we are not talking about the temperature of just one place. Instead, we are talking about the average global temperature of the whole world. Some places may be hotter or colder, but the global temperature tells us how hot or cold the whole Earth is on average.



As the temperature of the Earth increases, it can indirectly lead to more extreme weather patterns such as hurricanes, droughts and coastal flooding. Higher global temperatures also melt some of the sea ice. The decrease in sea ice from melting causes an increase in ocean levels and may indirectly cause coastal flooding. A decrease in the amount of sea ice can also indirectly cause higher global temperatures. This is because when there is less sea ice, less solar energy gets reflected and more of it can become absorbed light energy.

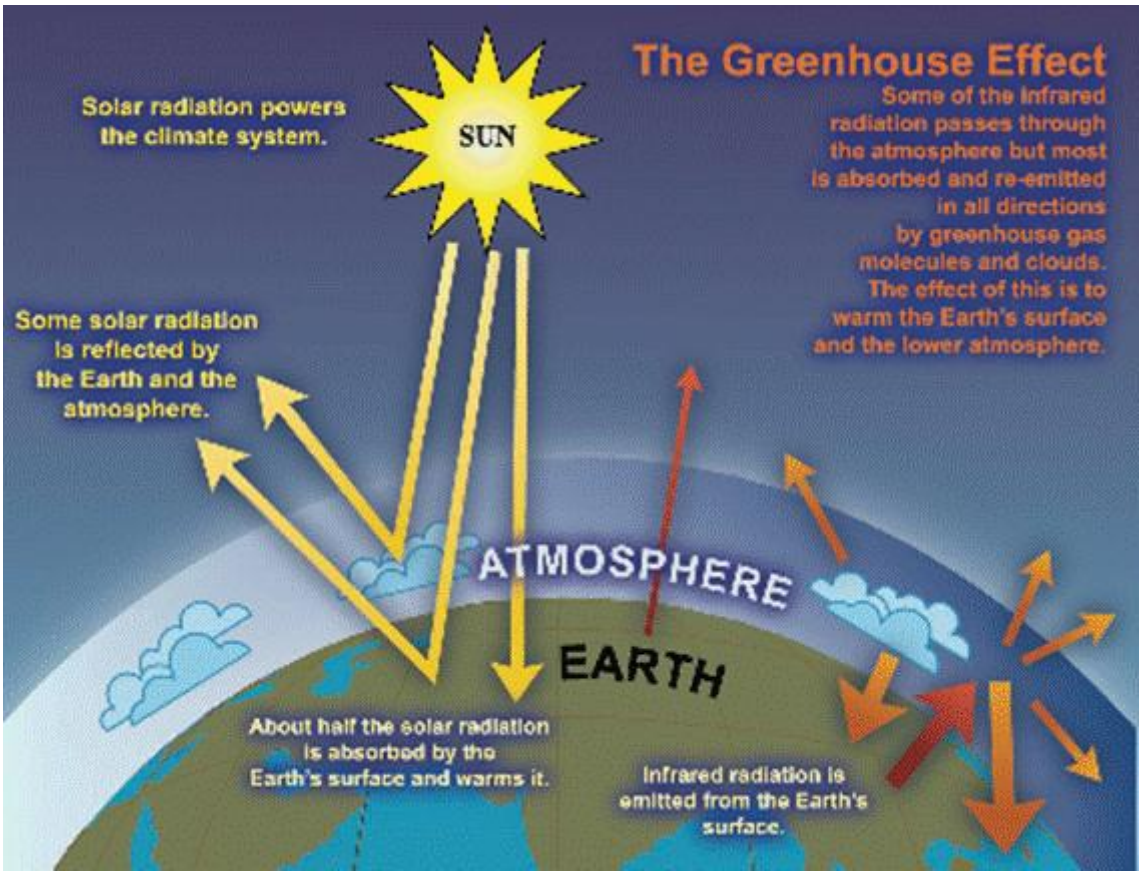
Heat reflected to the Earth

The Earth absorbs about half of the solar energy it receives. Once absorbed, this absorbed light energy is converted to absorbed heat energy. The absorbed heat energy makes the Earth warmer. Until recently, the average global temperature has mostly stayed the same.

The Earth receives energy from the sun constantly. Why doesn't the Earth keep getting hotter? Some of the absorbed heat energy is radiated back into space.

The remaining heat is reflected back to the Earth. This reflected heat causes increased absorbed heat energy and indirectly leads to higher global temperatures.

Normally, there is a balance between absorbed light energy and heat radiation. Absorbed light energy indirectly increases global temperature, but heat radiation indirectly lowers it. Some of the heat radiation is prevented by the greenhouse effect. The greenhouse gases like carbon dioxide and methane increase the heat reflected to the Earth.



Human activity

The Earth's population is steadily increasing, and the increase in population has increased our overall needs: we need more homes to live in, more electricity to power those homes, more vehicles to travel in, and more essential goods like food, clothing, tools, and toys. At the same time, we create much more garbage than we used to.

All of these activities add more greenhouse gases to our environment. When we build new homes, we often add to deforestation, which removes forests and other vegetation from the planet. When we create electricity or use vehicles, we burn fossil fuels. When we produce essential goods, we create more garbage.

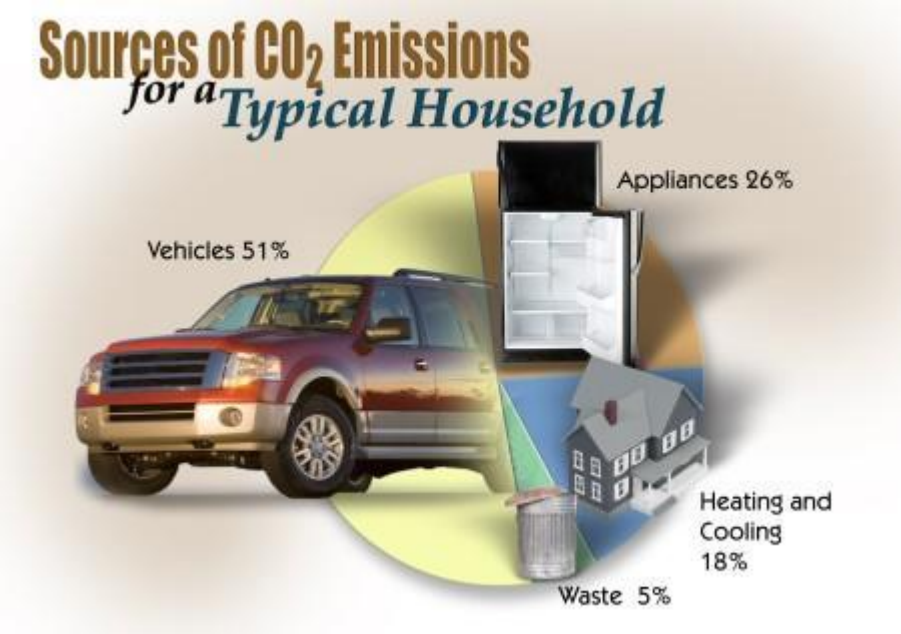
The increased amounts of greenhouse gases in the atmosphere contribute to the greenhouse effect and indirectly raise global temperatures. Since humans are causing this increase in greenhouse gases, scientists call it the human impact on global warming.

Vehicle Use

The vehicles we drive use about 378 million gallons of gasoline every day. Vehicles indirectly produce carbon dioxide when they burn gasoline. Gasoline is an example of a fossil fuel. When our cars burn fossil fuels, they release large levels of carbon dioxide into the atmosphere. Vegetation consumes some of the carbon dioxide during

photosynthesis, but the amount of vegetation we have today is not able to keep up with the amount of carbon dioxide we are currently producing.

Each gallon of gasoline you burn creates about 3 times as much carbon dioxide by weight. Carbon dioxide is a primary greenhouse gas responsible for the greenhouse effect. The increased greenhouse effect is ultimately responsible for the increase in average global temperatures.



Factories

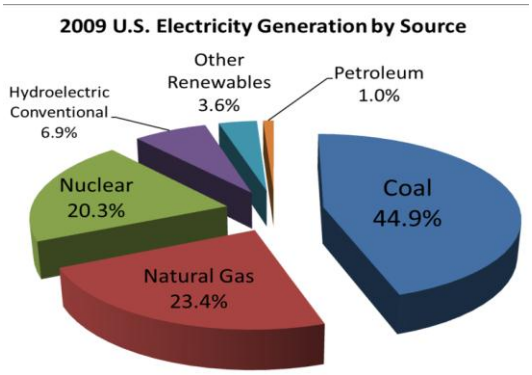
Most factories burn fossil fuels like coal, oil and natural gas. These burned fossil fuels increase the levels of carbon dioxide in the atmosphere. Carbon dioxide, being a greenhouse gas, is responsible for the increased greenhouse effect.

In the U.S., power plants and factories are the second largest producer of greenhouse gases. Only electricity generation produces more. We use our factories to produce many different things people use every day. For example, we have factories that make cement, steel, aluminum, cars and computers. In order to make these things, we use machines that need to burn fossil fuels as they work.

Remember, factories burn fossil fuels in order to produce the things we use every day. Because of this, the level of carbon dioxide in the air has increased from 290 parts per mission (ppm) to 320 ppm, an increase of just over 10 percent.

Electricity generation

Electricity generation is the process of creating electricity from other sources of energy. The first power plants ran on water power or coal. Today, we rely mainly on coal, petroleum, natural gas, and nuclear and hydroelectric power. We also create a small amount of electricity from renewable resources like solar energy, oceanic tidal waves, wind generators, and geothermal energy.



Most electricity is generated by burning fossil fuels like coal, natural gas, and petroleum to produce heat. The heat boils water, creating steam. The steam then passes through a turbine to generate electricity.

Like using vehicles and factories, generating electricity creates more burned fossil fuels, and this increases carbon dioxide levels in the atmosphere. A single coal plant generates about 1,322,719 megawatt-hours of electricity every year, which equates to roughly 1.2 million metric tons of carbon dioxide or 2.6 billion pounds of carbon dioxide.

Most scientists agree that emissions of pollutants and greenhouse gases from fossil fuel-based electricity generation account for a significant portion of world greenhouse gas emissions. In the United States, electricity generation accounts for nearly 40% of greenhouse gas emissions, the largest of any source.

Burned Fossil Fuels

Fossil fuels include things like coal, oil, and natural gas. These fuels contain lots of carbon. This is because they are made of organic matter that has been buried under pressure and heat for millions of years. About 90% of the energy used in the U.S. comes from burning fossil fuels.

Unfortunately, when we burn these fossil fuels to create energy, they add a lot of carbon dioxide and other gases into the atmosphere.

In the past 100 years, humans have used more fossil fuels. In the United States, most of our electricity is generated by power plants that burn coal and natural gas. All these power plants burn large amounts of fossil fuels each year to generate electricity for things like lights, heaters, televisions, and computers.

The more electricity we use, the more fossil fuel emissions, especially carbon dioxide, are added to the atmosphere. All this extra carbon dioxide increases the heat reflected to the earth. This makes the greenhouse effect stronger.

Carbon Dioxide

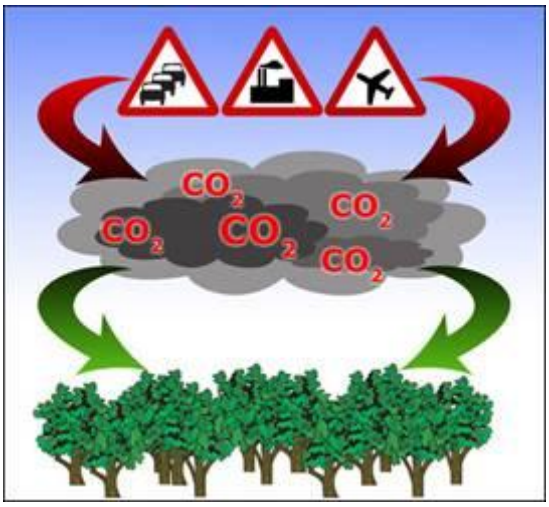
Carbon dioxide is a colorless gas found in the atmosphere. Carbon dioxide molecules have two atoms of oxygen and one atom of carbon. The chemical formula for carbon dioxide is CO2. In the diagram below the carbon is colored black and the two oxygen atoms are colored red.

Carbon dioxide is a greenhouse gas. This means that an increase in carbon dioxide in the atmosphere will increase the heat reflected to the earth. This makes the greenhouse effect stronger.

Carbon dioxide is added to the atmosphere in several ways. Most living things (like people, plants, and animals) produce carbon dioxide through respiration. In the process of respiration, food and nutrients are broken down to make energy. This process produces carbon dioxide.

Vegetation absorbs carbon dioxide during photosynthesis. Normally, vegetation absorbs the excess carbon dioxide produced by human and animal respiration. But now that human activity adds so much more carbon dioxide to the atmosphere, vegetation cannot absorb it fast enough. This unabsorbed carbon dioxide stays in the atmosphere, increasing the greenhouse effect.

Most of the human activity that produces greenhouse gases like carbon dioxide happens in the U.S. and other industrialized countries. Only about 20% of the world's population lives in these countries, but they produce about 65% of the world's carbon dioxide emissions. If we can find ways to reduce carbon dioxide emissions in these countries, then we can fight the greenhouse effect and keep our planet healthy.



Garbage and Landfills

The typical American throws away about five pounds of trash a day. This adds up to about 251 million tons of garbage a year, almost twice as much trash per person as most other major countries. Americans are making waste products faster than nature can break them down.

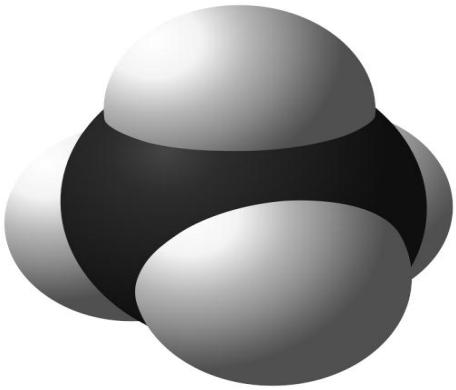
Garbage isn't just the old food, drink containers, and food boxes that we throw away in our homes. Regular household trash is only a part of the garbage people create. We use a lot of special equipment and materials in our jobs. For example, when we build or fix buildings, we throw away a lot of construction materials, and when we mine rocks from the ground, we use up and eventually throw away tools and equipment that help us get the job done.

What happens to all of this trash? Some gets recycled and some gets burned, but most of it gets buried in landfills. A landfill is a place where we bury large amounts of garbage underground. Landfills are dangerous for the environment. In landfills, garbage decays. When it decays, methane is released into the environment.

As more and more of our garbage piles up, it becomes harder to figure out where to put it all! Many of the landfills we are using now are filling up, so we will have to find new places to put our trash. We can help this problem by finding ways to reduce the amount of trash we generate. One way to reduce our trash is to recycle it instead. When people recycle, they take the useful pieces of their garbage, clean them, and use them to create new things. Recycling helps conserve natural resources, reduces landfills, saves energy and prevents pollution. According to eHow.com, a "How-To" website, "Over 70 percent of landfill waste could easily be recycled."

Methane

Methane is a colorless and odorless gas and is the primary component of natural gas. Methane molecules have four atoms of hydrogen and one atom of carbon. The chemical formula for methane is CH4. In the diagram below the carbon is colored black and the four hydrogen atoms are colored white.



Methane is more dangerous as a greenhouse gas than carbon dioxide. An increase in methane in the atmosphere will increase the heat reflected to the earth. This will indirectly increase the average global temperature by making the greenhouse effect stronger.

Methane is primarily produced by landfills when trash decays. If we create less trash, then there will be less of it to decay. If there is less trash decaying in landfills, there will be less methane. That's why it's important for us to try to make less garbage.

Vegetation

Vegetation includes all trees, plants, shrubs and grass that grow on the Earth. While every plant is different, they all use sunlight, carbon dioxide and water for their normal life processes.

Vegetation is important for the global climate. During the process of photosynthesis, plants absorb carbon dioxide from the air. So, the more vegetation there is, the less carbon dioxide there will be in the atmosphere. This is why deforestation is such a problem.

In addition to reducing carbon dioxide, vegetation also affects the atmosphere through the process of transpiration. In transpiration, extra water in vegetation is released onto its leaves. When this water evaporates, it becomes water vapor.

Deforestation

Deforestation is a process by which humans reduce the amount of vegetation in an area. The more deforestation there is, the less vegetation there is.

Humans are rapidly cutting down forests in order to create more farmland and expand cities. Because of this, there is less vegetation on our planet. This is dangerous for the planet because vegetation consumes carbon dioxide and prevents it from increasing the greenhouse effect.

Impact on Climate

Human activities in the last century have been adding excessive amounts of greenhouse gases to the atmosphere. This is making the greenhouse effect stronger. If greenhouse gases and the global warming that they cause are not reduced, they have the potential to cause catastrophic problems for the Earth and its inhabitants. Some of these problems include rising ocean levels, coastal flooding, and drought.

One of these problems, rising ocean levels, has already started to happen. In fact, the world's oceans have already risen 4-8 inches. As a result, people living in some South Pacific islands and off of the coast of India have had to move to higher ground. Areas that are low to the ground include a lot of the world's best farmland and some of the world's largest cities. If these areas flood, millions of people around the world might have to find new places to live.

Another problem caused by global warming has started to happen. Many dry areas, including the American West, Southern Africa, and Australia have been experiencing more severe droughts in recent years. As the Earth's temperature increases, it makes evaporation happen more quickly. Because of this, the amount of land on the Earth suffering from drought has doubled since 1970. This has occurred even as total global rainfall has increased by an estimated 10 percent.

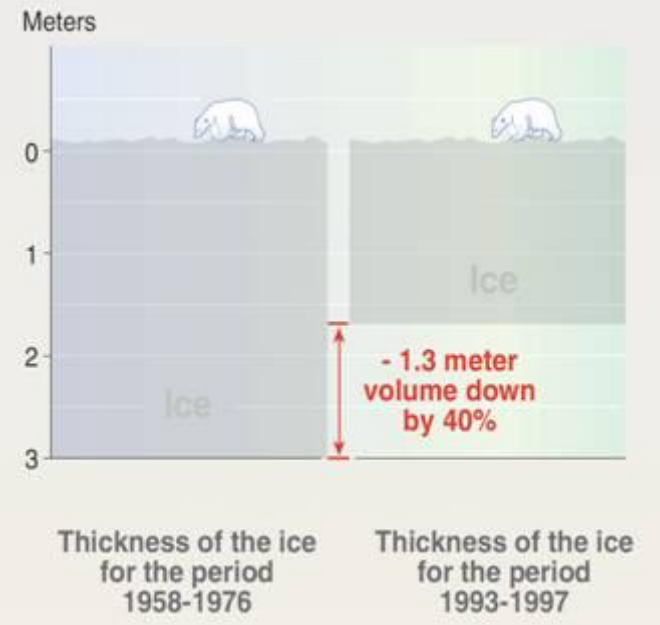
Sea Ice

Sea ice can take several forms. Some of it is seen as giant icebergs floating in the ocean. Near the polar regions of the Earth, there are large ice masses attached to the land. The polar ice caps are the size of whole continents! Sea ice is the main habitat for polar bears, ringed seals, and ice algae.

Sea ice reflects a lot of the light that hits it. This reduces the amount of absorbed light energy on the Earth. In other words, the ice acts like a giant mirror that bounces light energy from the sun back into space.

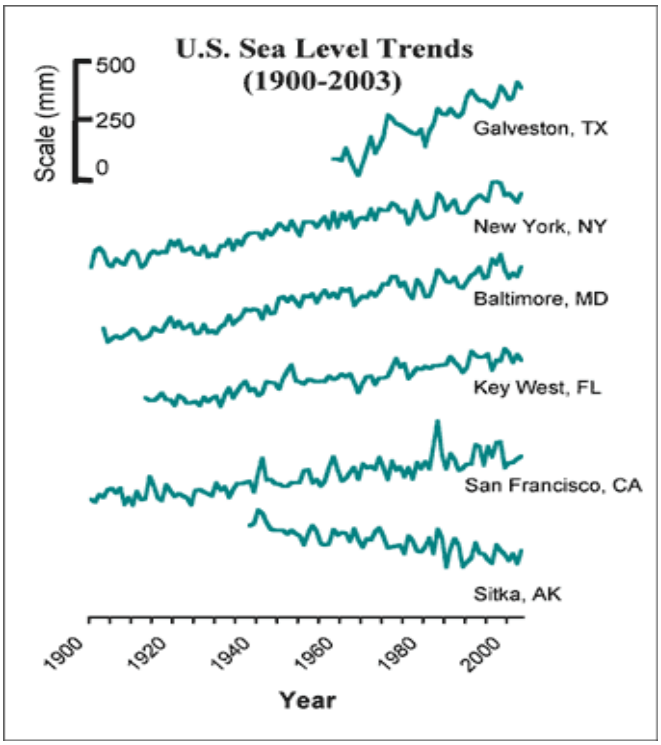
As the global temperature rises due to global warming, one side effect is that sea ice starts to melt. It's like putting an ice cube in a cup of hot water. As the sea ice melts, the Earth loses some of its reflectivity. With less sea ice, the Earth absorbs more light energy, which indirectly increases the global temperature. Melting sea ice also ends up causing higher ocean levels. This is bad news, because if the ocean levels rise too much, the coasts of the Earth's continents might get flooded.

Sea ice has been shrinking by about 5% per decade. By the later part of the 21st century, a lot of Arctic ice may be gone. This could mean that global temperatures could continue to go up.



Ocean Levels

Ocean level refers to the average height of the ocean. For the last 100 years, ocean levels have been rising at an average rate of about 1.8 millimeters per year. This rise is mostly due to the increase in the sea's temperature. The temperature of sea water is increasing because the Earth's temperature is going up. As the sea water gets warmer, sea ice and glaciers start melting. When they melt, they turn into water. This raises the ocean levels.



Scientists have found that with every 1°C rise in global temperature, enough sea ice is melted to raise the ocean levels by about 1 meter. According to their research, the Netherlands, Bangladesh, and the coral island Majuro in Oceania (which includes the Marshall, Kiribati, and Maldives islands) will be among the first areas of the world to suffer as the ocean levels continue to rise. If the ocean levels get too high, they will cause coastal floods that could devastate these and many other countries around the world. For instance, if the coasts of Vietnam or Egypt flood, the crops that these countries grow for food could drown.

Coastal flooding

Coastal flooding is sometimes caused by several natural events on the planet. Some of these events include sea storms, tsunamis, hurricanes, or cyclones. Coastal flooding can also be caused by higher ocean levels. When coastal flooding takes place, it can cause losses of both lives and property.

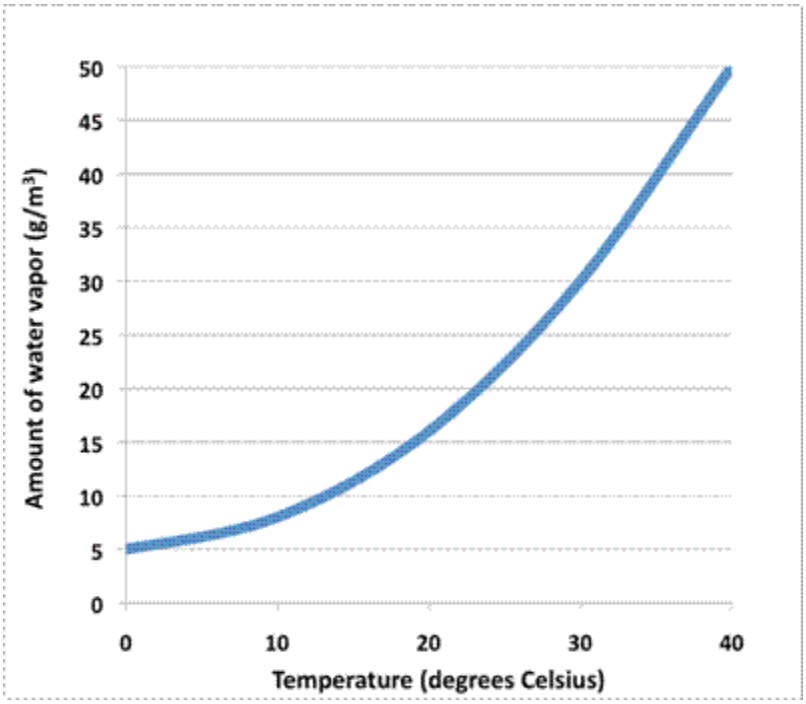
Scientists predict that rises in global temperature will melt some of the Earth's sea ice and land-based ice in the Polar Regions. According to recent projections, this could cause rises in ocean levels between 9 and 88 centimeters by the year 2100. This much of a rise would produce a lot of coastal flooding, which will have disastrous consequences for people living on low-lying islands. Scientists estimate that a rise in ocean level of 30 to 90 centimeters would increase the size of the 100-year floodplain in the United States by 10,000 to 20,000 square kilometers. If that much coastal flooding was to happen, ocean water would mix with many of our coastal freshwater, killing the freshwater fish that live in those areas.

Carrying Capacity

Saturation is the amount of moisture the air contains compared with the maximum amount it could possibly hold at a specific temperature. When air holds all the water vapor it can at a given temperature, the air is said to be saturated. The amount of water vapor that the air can hold before becoming saturated is called its carrying capacity.

When air is warmer, it can hold more water vapor before it becomes saturated. So when global temperatures increase, the carrying capacity of the atmosphere also increases. This means that the air becomes capable of

holding more water vapor. When carrying capacity grows, it takes longer for the air to fill up. Because of this, there is less condensation.

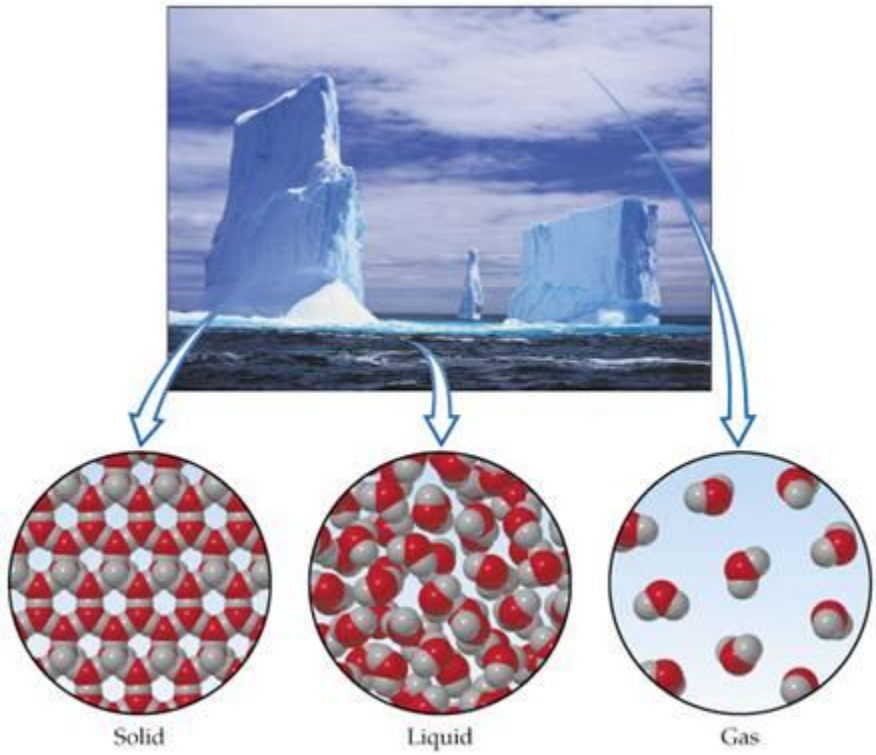


Water Vapor

Water vapor is water in the form of an invisible gas. It is not the same thing as steam because steam is not actually a gas. Instead, it is made up of tiny droplets of liquid water. Water is often called H2O. This is because each water molecule contains two atoms of hydrogen and one atom of oxygen. In the diagram below the oxygen atom is colored red and the hydrogen atoms are colored white.

The amount of water vapor in the air can vary by season and region. In a desert or polar region, the air is dry and it has almost no water vapor. In a tropical rainforest and other humid areas, as much as 5% of the air may be water vapor.

Water vapor is an important part of the Earth's weather. /When there is too much water vapor in the air, condensation happens. This is how clouds form. So, how is water vapor created? When water evaporates off of the Earth's surface, it turns into water vapor. A lot of water vapor comes from evaporating the Earth's precipitation. More water vapor comes from vegetation through the process of transpiration.



Condensation

You have probably seen water droplets form on the outside of a glass of ice water. As invisible water vapor in the air around the glass touches the glass, the cold temperature causes it to condense.

Condensation can only occur when the air is saturated with water vapor. Remember, when the air temperature rises, the air's carrying capacity increases. So, when the air temperature cools, the air's carrying capacity decreases. If saturated air is cooled even further, it can no longer hold all of its water vapor. When this happens, condensation takes place and the extra water vapor turns back into liquid water droplets.

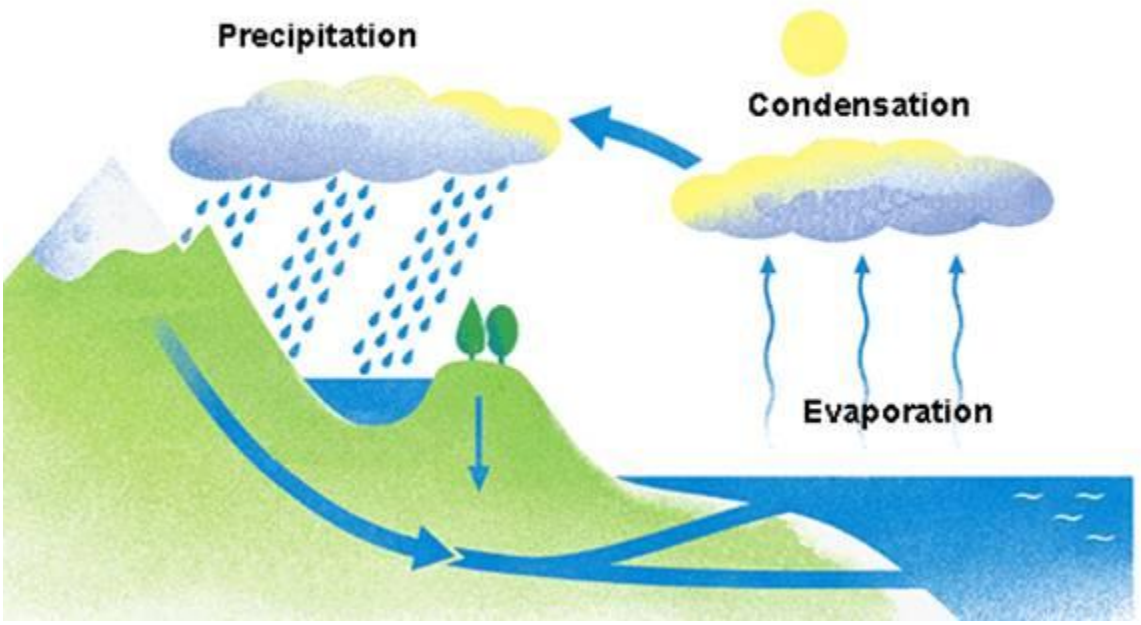
The thing to remember about this is that without water vapor, there can't be any condensation. In other words, the more water vapor there is, the more condensation there will be. Similarly, if there is more condensation in the atmosphere, there will be more rain and snow. Another word for rain and snow is "precipitation".

Precipitation

Precipitation is the water that falls to the Earth. When this water is in liquid form we call it rain. When it is solid we call it snow. About 90 percent of precipitation falls into the ocean. The rest falls on land, renewing the supply of fresh water.

Precipitation is important because plants and animals need fresh water to live. A healthy amount of precipitation will indirectly increase the amount of vegetation in a region. That is why the rainforests are filled with many plants, but very dry places like deserts are not. A severe lack of precipitation over a long period is called a drought. Droughts can kill almost all of the vegetation in an area.

Precipitation is an important part of the water cycle. The diagram below shows the whole water cycle. In the water cycle, precipitation is produced by the condensation of water vapor in clouds. A cloud produces precipitation when its water droplets become large enough to fall. Then, the rain water that falls into the lakes, rivers, and oceans evaporates in the heat of the sunlight to form water vapor. Finally, this water vapor condenses to form new clouds in the sky…and the whole cycle starts over.



Drought

One of the consequences of global warming and climate change is that weather patterns around the world may become more damaging.

For example, increases in global temperatures tend to indirectly increase droughts. A drought is a long period of lower than normal rainfall in a region. When there is a drought, vegetation does not get the water it needs to survive and begins to die off. Precipitation or rainfall helps reduce drought.

Occasional droughts are normal for the Earth's climate. However, droughts may become more common because of increased greenhouse effects. The table below shows how droughts have become more severe in recent years.