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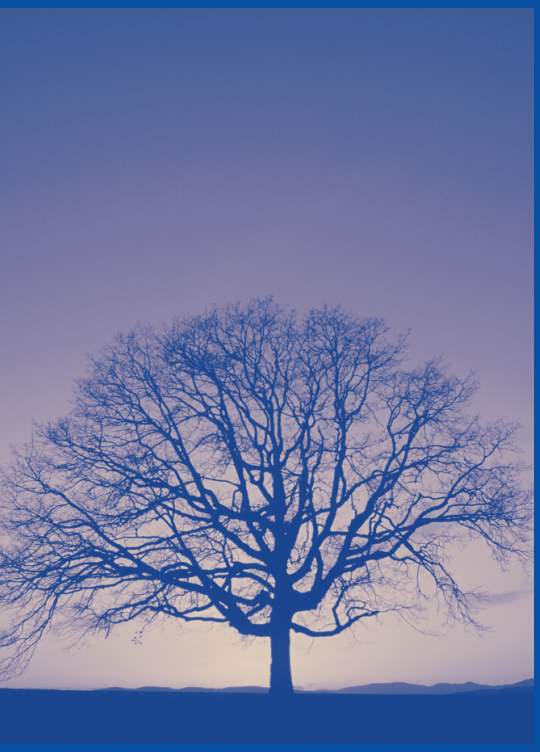
Global Warming and Our Changing Climate

Answers to Frequently Asked Questions

Human activities are adding greenhouse gases — pollutants that trap in Earth's heat — to the atmosphere at a faster rate than at any time over the past several thousand years.

A warming trend has been recorded since the late 19th century, with the most rapid warming occurring over the past two decades. If emissions of greenhouse gases continue unabated, scientists say we may change global temperature and our planet's climate at an unprecedented rate for our society.

This brochure addresses the most frequently asked questions about the science of global warming and our changing climate. Answers are based on the assessments of the Intergovernmental Panel on Climate Change and on the most recent peer-reviewed scientific literature.

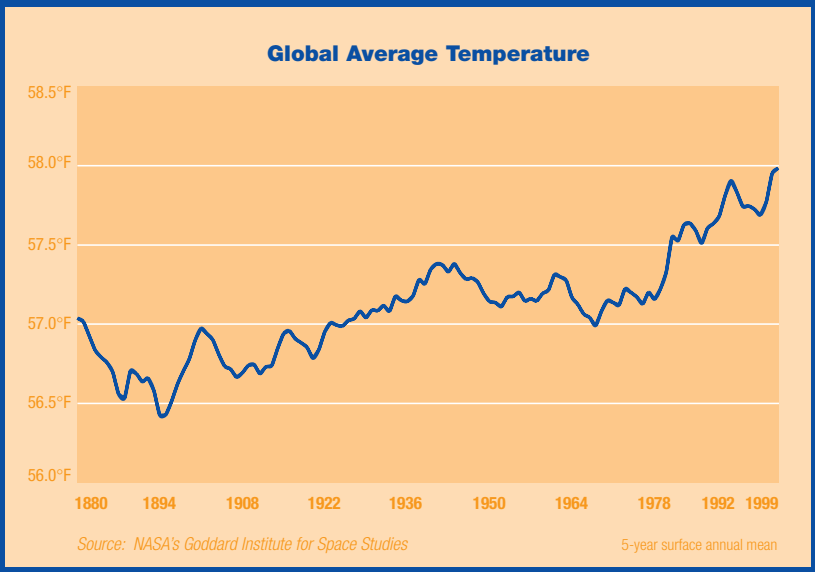


Is our planet warming?

The global temperature record shows an average warming of about 1°F over the past century (see graph). This warming has been recorded in both the northern and southern hemispheres, and over the oceans, with some areas substantially warmer and others actually cooler. The ten warmest years have occurred since 1983, with seven of them since 1990. Recent evidence shows the 20th century was the warmest in the last 1,000 years. The 1990s were the warmest decade and 1998 was the single warmest year of the past millennium.

How do we take Earth's temperature?

Earth's temperature is taken through a network of thermometers on ships, buoys and land-based weather stations. The data are compiled by organizations like the World Meteorological Organization, NASA and the U.S. National Oceanic and Atmospheric Administration. This global temperature record dates back to about 1860. During this period, measuring techniques have changed, some weather stations relocated and others became surrounded by cities. Scientists have taken special care to address these problems to ensure the global temperature record is reliable and consistent. To know what temperatures were like before 1860, scientists must rely on limited records or reconstruct Earth's temperature history by examining tree rings, pollen records and air locked away in ancient ice.



What's the Intergovernmental Panel on Climate Change (IPCC)?

The IPCC was formed jointly in 1988 by the United Nations Environment Program and World Meteorological Organization. The IPCC brings together the world's top scientists in all relevant fields, synthesizes peer-reviewed scientific literature on global warming studies, and produces authoritative assessments of the current state of knowledge of climate change. The IPCC's Second Assessment (1996) serves as the key reference for this brochure. The IPCC's Third Assessment is scheduled for publication in 2001.

Fundamentals of the Greenhouse Effect, Global Warming, and Our Changing Climate

Q. What is the greenhouse effect?

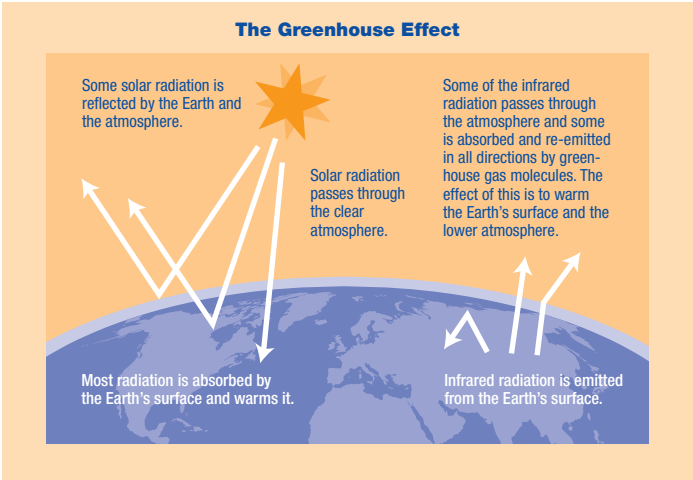
A. Earth's greenhouse effect is a natural phenomenon that helps regulate the temperature of our planet. Simply put, the sun heats the Earth and some of this heat, rather than escaping back to space, is trapped in the atmosphere by clouds and greenhouse gases, such as water vapor and carbon dioxide. If all of these greenhouse gases were to suddenly disappear, our planet would be 60°F colder and uninhabitable.

Q. Are human activities responsible for the warming?

A. Separating out the impact of human activity from natural climate variation is extremely difficult. Nonetheless, the IPCC concluded there is a "discernible human influence" on climate. This means the observed global warming is unlikely to be the result of natural variability alone and that human activities are at least partially responsible.

Q. What are the most important greenhouse gases? Where are they coming from?

A. Many greenhouse gases occur naturally, but human activities are adding gases to the natural mix at an unprecedented rate. Water vapor is the most abundant greenhouse gas; it occurs naturally and makes up about two thirds of the natural greenhouse effect. Fuel burning and other human activities, however, are adding large amounts of greenhouse gases to the atmosphere — the most important ones being carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). Since preindustrial times atmospheric concentrations of CO_2, CH_4 and N_2O have climbed by over 30%, 145% and 15%, respectively. Scientists have confirmed this is primarily due to human activity. Burning coal, oil and gas, and cutting down forests are largely responsible.



Q. What will happen to Earth's climate if emissions of these greenhouse gases continue to rise?

A. Because human emissions of CO_2 and other greenhouse gases continue to climb, and because they remain in the atmosphere for decades to centuries (depending on the gas), we're committing ourselves to a warmer climate in the future. The IPCC projects an average global temperature increase of 2–6°F by 2100, and greater warming thereafter. Temperatures in some parts of the globe (e.g., the polar regions) are expected to rise even faster. Even the low end of the IPCC's projected range represents a rate of climate change unprecedented in the past 10,000 years.

Q. What are the potential impacts of global warming and a changing climate?

A. Our health, agriculture, water resources, forests, wildlife and coastal areas are vulnerable to global warming and the climatic changes it will bring. The IPCC concluded that "climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life." A few degrees of warming increases the chances of more frequent and severe heat waves, which can cause more heat-related death and illness. Greater heat can also mean worsened air pollution, as well as damaged crops and depleted water resources. Warming is likely to allow tropical diseases, such as malaria, to spread northward in some areas of the world. It will also intensify the Earth's hydrological cycle. This means that both evaporation and precipitation will increase. Some areas will receive more rain, while other areas will be drier. At the same time, extreme events like floods and droughts are likely to become more frequent. Warming will cause glaciers to melt and oceans to expand. The IPCC projects that sea level will rise one half foot to three feet over the next century. This threatens low-lying coastal areas. Scientists are also concerned that warming could lead to more intense storms.

Looking at global warming in more detail...

Q. How serious is global warming of a few degrees? Couldn't warming be beneficial?

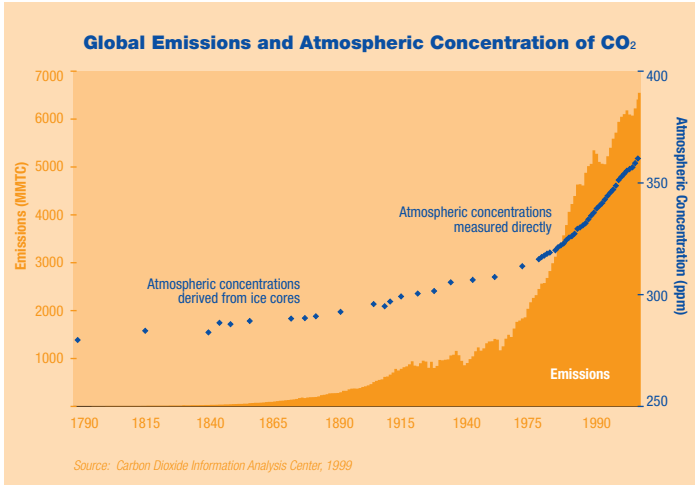
A. A warming of 1°F over the past century and a further 2–6°F over the 21st century, as projected by the IPCC, may appear minor compared to short-term weather changes from night to day and winter to summer. But in global climate terms, a warming at this rate would be much larger and faster than any of the climatic changes over the past 10,000 years. Global temperatures during the last ice age (about 20,000 years ago) were 'only' 9°F cooler than today, but that was enough to allow massive ice sheets to reach as far south as the Great Lakes and New York City. The warming that humans are causing will change Earth's climate in the opposite direction, but tens or possibly a hundred times faster than natural rates of climate change. Warming of a few degrees would lead to more frequent droughts and heat waves, cause greater rainfall, and possibly change the strength of storms. It is possible that some areas would benefit from global warming even as other areas were harmed. Certain farming areas, for example, could enjoy a longer growing season, while others suffer from more frequent droughts. Local effects, however, are the most difficult to predict, making it difficult to know who will benefit and who will not, and for how long these conditions will persist, as the warming continues and the climate keeps changing.

Q. How can we talk about climate change over the next 100 years when we can't be sure of tomorrow's weather?

A. Weather and climate are different. The methods used to forecast changes in weather and climate differ as well. Because the weather changes from day to day, current weather forecasts are reliable for roughly ten days. Climate, on the other hand, can be thought of as average weather, including weather's variability over much longer time horizons (e.g., from year to year). Natural changes in our planet's climate happen over the course of years, centuries and many millennia. Long-term climate forecasts are possible because scientists understand many of the factors that influence climate over such long periods, such as changes in the sun's energy and the level of greenhouse gases in the atmosphere. Climate scientists do not claim to know how to predict day-to-day fluctuations (weather) over the 21st century. Rather, they are predicting how they think average temperature and precipitation (climate) will change due to human activities.

Q. How do we know CO_2 in the atmosphere is increasing? And that humans are responsible?

A. Careful measurements have confirmed that CO_2 is increasing in the atmosphere and that human activities are the primary cause. CO_2 measurements have been taken directly from the atmosphere over the past few decades. CO_2 trends for earlier times have been derived from measurements of CO_2 trapped in air bubbles in glacial or polar ice. The 30% increase in atmospheric CO_2 observed since pre-industrial times (shown in the graph above) cannot be explained by natural causes. CO_2 concentrations have varied naturally throughout Earth's history. However, CO_2 concentrations are now higher than any seen in at least the past 450,000 years.



Q. Aren't other factors responsible for global warming?

A. Natural and human factors affect the average temperature of our planet. Natural variability in the Earth's climate system can cause small changes over decades to centuries. Gradual changes in Earth's orbit around the sun (which in turn change how sunlight hits our planet) are thought to be the key pacemaker for the comings and goings of past ice ages over many millennia. The sun's energy can also vary slightly over time. Large volcanic eruptions can cool the planet for a few years by spewing out particles that block some sunlight. Even some of our own pollutants, like the sulfur dioxide released from power plants and heavy industry that contributes to acid rain, have a similar cooling effect. Depletion of the ozone layer — caused by our release of chlorofluorocarbons — has led to cooling of the upper atmosphere. Scientists think these temporary cooling effects have been masking some of the long-term warming being caused by human emissions of greenhouse gases. Over the 21st century, the ongoing buildup of greenhouse gases in the atmosphere is likely to be the most dominant influence on our planet's climate.

Q. How will global warming affect the polar ice caps?

A. Polar ice caps are some of the largest surface features on our planet and any changes to them, however small, could have far-reaching effects. Melting due to global warming is expected to reduce the size and extent of the polar ice caps, even after taking into account the potential for more snow and ice accumulation atop the ice sheets due to increased precipitation. Melting of polar ice and land-based glaciers is expected to contribute to the one half foot to three-feet sea level rise projected by the IPCC for the 21st century. Shrinking ice caps may also cause changes in ocean circulation and even storm tracks. To be sure, not all of the melting currently occurring is due to global warming, and the melting of floating sea ice does not affect sea level. Further warming will likely accelerate the shrinkage of ice caps and glaciers, however. Of particular concern is the stability of the West Antarctic Ice Sheet. A sudden collapse would raise sea levels 16–20 feet but the IPCC considers the likelihood of such a collapse before the year 2100 low.

I've heard these things about global warming...

Q. I've heard satellite data contradict other evidence of global warming.

A. Until recently, conflicting studies suggested that temperatures measured by satellites revealed a slight cooling trend, whereas the surface temperature record showed a warming trend. This confounded the global warming issue. Satellites began measurements in 1979 and the surface temperature record, which reveals global warming of about 1°F, dates back to about 1860. Satellites take temperatures through vertical slices of the atmosphere, not at the surface. Satellite measurements are also known to be influenced by ozone layer depletion, which has caused *cooling* of the upper atmosphere. For these and other reasons, satellite and surface data are not expected to be a perfect match. Nevertheless, the discrepancy between the two data sets was too large to be ignored. Then scientists discovered they neglected some measurement and calibration problems with the satellites, including the fact that satellites were falling from their orbits, which produced an artificial cooling trend. Correcting the satellite data for these problems revealed a small warming trend. These corrections — though not the last word on the satellite vs. surface discrepancy — bring the satellite record into better agreement with surface measurements. Any remaining discrepancies do not invalidate the fact that surface temperatures are rising.

Q. I've heard more CO_2 in the air could be beneficial for plants and crops.

A. The impacts of climate change on crops and vegetation depend on complex interactions among increased CO_2, rising temperatures, and water and nutrient availability. Elevated levels of CO_2 can essentially fertilize plants and crops. However, plant growth is also affected by other factors in addition to CO_2 — factors that will be influenced by climate change. Modest temperature increases, for example, can enhance growth, but if temperatures increase too much, growth actually declines. Rising temperatures also increase the process by which plants *release* CO_2. Higher temperatures can increase the rate of evaporation, drying out soils. Insufficient water decreases plant growth. Plants also cannot respond to more CO_2 unless sufficient nutrients are available. Furthermore, the growth-enhancing effects of CO_2 may diminish over time. Real-world crop yields would also be subject to the hazards of droughts and floods under a changing climate.

Q. I've heard CO_2 emissions from human activities are small compared to what's released by nature.

A. The Earth has a natural CO_2 cycle that moves massive amounts of CO_2 into and out of the atmosphere. The oceans and land vegetation release and absorb over 200 billion metric tons of carbon into and out of the atmosphere each year. When the cycle is balanced, atmospheric levels of CO_2 remain relatively stable. Human activities are now adding about 7 billion metric tons of carbon into the atmosphere every year, which is only about 3–4% of the amount exchanged naturally. But that's enough to knock the system out of balance, surpassing nature's ability to take our CO_2 emissions out of the atmosphere. The oceans and land vegetation are absorbing about half of our emissions; the other half remains airborne for 100 years or longer. This is what is causing the rapid buildup of CO_2, a buildup that dwarfs natural fluctuations.

Here are some other questions you may have...

Q. How do scientists predict future climate?

A. Basic physics tells us that greenhouse gases trap Earth's heat and cause warming. But Earth's climate is very complex, involving interactions among the air, land and oceans. That's why scientists use computer models to project the effects of global warming. Though the models are far from exact, they do a reasonable job of simulating our current climate and reproducing known changes from past climates. Scientists are confident about the models' abilities to simulate large-scale effects of global warming, such as global temperature increase and average sea level rise. The models are less reliable when it comes to simulating changes in other weather variables such as changes in rainfall. Also, current models are still ill-equipped to predict with any confidence what will happen in local areas.

Q. Can you say the recent extreme weather is a manifestation of climate change?

A. Given our knowledge of global warming and our changing climate, we can expect more extreme weather, including more frequent hot days and droughts, less frequent cold days, and more precipitation (including more snowfall in cold areas). But attributing any particular extreme weather event to global warming remains beyond the current limits of scientific capability.

Q. Does El Niño have anything to do with global warming and climate change?

A. El Niño is a natural phenomenon that has been occurring throughout the centuries, though not always with the same regularity; it now occurs about every two to seven years. El Niño is the strong warming of the equatorial Pacific ocean. Its effects are felt worldwide, which demonstrates the interconnected nature of the Earth's climate. Recent El Niño events have been very strong and have contributed to the record-setting temperatures of the 1990s — evidence that El Niño events can warm parts of the Earth. But now scientists are examining how human-induced global warming could affect El Niño. Scientists are concerned that the accumulation of greenhouse gases in our atmosphere may inject enough heat into the Pacific Ocean to make El Niño events more frequent and fierce.

Q. Does ozone layer depletion have anything to do with global warming and climate change?

A. The human health and environmental concerns about ozone layer depletion are different from the risks we face from global warming. Nevertheless, the two phenomena are related in certain ways. Some pollutants contribute to both problems and both alter the global atmosphere.

Ozone layer depletion allows more harmful ultraviolet (UV) radiation to reach our planet's surface. While increased UV radiation is not the cause of global warming, it can lead to skin cancers, cataracts and a suppressed immune system in humans, as well as reduced yields for crops. Ozone layer depletion is mainly caused by chlorofluorocarbons or CFCs. CFCs are therefore no longer produced in industrialized countries, and will eventually be eliminated worldwide. But like CO_2, CFCs are also a strong greenhouse gas. CFCs can remain in the atmosphere for as long as a century, meaning that their contribution to both ozone layer depletion and climate change will persist for a long time.

For more information and to learn what you can do...

www.epa.gov/globalwarming

Here are some other websites we recommend

Intergovernmental Panel on Climate Change:
www.ipcc.ch

U.S. Global Change Research Program:
www.usgcrp.gov

NASA's Goddard Institute for Space Studies:
www.giss.nasa.gov

NOAA's National Climatic Data Center:
www.ncdc.noaa.gov

You, your business and global warming...

Q. How might global warming affect my health and well-being?

A. Exactly how global warming will impact individual locations, let alone individuals, is uncertain. But because global temperatures, rainfall, sea levels and the frequency of extreme weather are expected to increase, you could be affected in many ways.

A lot of attention is paid to estimating the cost of reducing greenhouse gas emissions. But what is often overlooked is that global warming and climatic changes can themselves impose economic — as well as health and environmental — costs on people and businesses.

Your health and comfort could be affected if your region experiences more frequent heat waves and worse air pollution. These health concerns are especially serious if you are or care for the very young, very old, or if you have heart and respiratory problems. In the wintertime you may feel milder temperatures. You may pay higher energy bills for air conditioning in summer, and lower bills for heating in winter. If you live in the country's interior, particularly in dry areas, water shortages may be more frequent, leading to more restrictions on your water usage. If you live along the coast, your home may be threatened by sea level rise and an increase in storm intensity. The cost of food may change as farmers and the food industry adapt to new climate patterns. And the outdoor activities that you and your family enjoy could be affected by increased beach erosion, decreased snow fall and retreating glaciers, and loss of forests and wildlife, where species are unable to adapt to the changing climate.

Q. How might global warming affect my business?

A. As a business owner, your costs, competition, and planning decisions may be affected. Your health care costs could increase if the public health sector is burdened by increases in heat and climate-related mortality and illness. Like homeowners, your business's energy costs will reflect the need for greater cooling in the summer and less heating in the winter. Your property insurance premiums could go up due to more droughts and floods and possibly more intense storms. If your business is located along the coast, sea level rise may also affect property insurance, not to mention how rising seas may directly impact your business. If your business depends on waterways for transportation, those shipping costs could increase in some areas due to reduced river flow and lower lake levels, though in northern areas shipping could be eased by a longer ice-free season. If you're in the agricultural or food industry, changing climatic and growing season conditions will require adaptations. Your competitors in this sector may experience either more or less favorable climatic changes than you. The same is true if you're in a forestry-related business. Some of global warming's impacts may be most severe in other nations less capable of adapting. This may create social and economic disruptions that ripple across the globe to affect your business. For all of these reasons, long-term business planning will increasingly have to consider the changing nature of our planet's climate.