Climate Change: A Runaway Train?

By Stephen L. Baird

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Photo courtesy of the National Oceanic & Atmospheric Administration (NOAA), NOAA Central Library.

Sea ice regulates exchanges of heat, moisture, and salinity in the polar ocean and provides key habitat for wildlife. A loss of sea ice leaves coasts more vulnerable to storm surges and erosion.

Our rich diversity of life on Earth is the outcome of over three billion years of evolutionary history. It has been shaped by forces such as continental drift, ice ages, fire, weather, and the interaction of all the different species that inhabit the earth. Now, it is increasingly being altered by the dominant species of the planet, humans. From the dawn of agriculture over 10,000 years ago, through the industrial revolution of the past three centuries, the human species has reshaped Earth's landscapes on an ever-larger and lasting scale. Despite growing awareness and increasing investments in environmental protection, pressure on the world's natural resources and ecosystems continues to increase rapidly. The impacts of human activities envelop every aspect of the natural world. No ecosystem on Earth is free from pervasive human influence (World, 2006). Global warming, pollution, and the unabated use of the Earth's natural resources have given rise to questions of our planet's continued ability to sustain us. Global atmospheric changes, such as ozone depletion and climate change, only add to the stress. Global warming poses an extraordinary challenge. The world's leading scientists tell us that a gradual warming of our climate is under way and will continue. This long-term warming trend poses serious risk to the world's economy

and to the environment. It poses even greater risks for poorer countries that are far less able to cope with a changing climate and for low-lying countries where a rise in sea level will cause significant damage. Meeting the challenges of global warming will require sustained effort over decades—on the part of governments, that must establish regulations and modify them as we learn more about climate change and as technological solutions begin to manifest themselves; on the part of industry, which must innovate, manufacture, and operate under a new paradigm where climate change will drive many decisions; and on the part of the citizens of the world, who must not only be educated on the effects of climate change but who must also switch to a more Earth-friendly path in purchases and lifestyles. While the earth has always undergone changes in its climate and environment, the potential importance of human contributions affecting changes on a global scale has emerged comparatively recently. Global public opinion, like American public opinion, has been most recently influenced by the unprecedented drought in Brazil, the melting Arctic ice, the recent hurricane season, and a torrent of scientific findings.

The Science of Climate Change

Global warming is shorthand for "climate change," and the term is correct if you realize that it's referring to the average temperature of the earth over the years; not the temperatures at particular times and places. Climate change is a much better term to use than global warming because much more than warming is involved, although the changes begin with the average temperature of the earth increasing. Studying past climates can help put the twentieth century warming into a broader context, lead to better understanding of the climate system, and improve projections of future climate temperatures.

Because widespread, reliable instrumental records are available only for the last 150 years or so, scientists must estimate climatic conditions in the more distant past by analyzing proxy evidence from sources such as tree rings, corals, ocean and lake sediments, cave deposits, ice cores, boreholes, glaciers, and documentary evidence. Starting in the late 1990s, scientists began combining proxy evidence from many different locations around the world in an effort to construct an estimate of surface temperature changes that have occurred over broad geographic regions during the last few hundred to few thousand years. Controversy arose because many people interpreted this result as definitive evidence of anthropogenic causes of recent climate change, while others criticized the methodologies and data that were used. In response to a request from Congress, a committee was assembled by the National Research Council to describe and assess the state of scientific efforts to reconstruct the surface temperature records for the earth over approximately the last 2000 years and the implications of these efforts for our understanding of global climate change. After considering all of the available evidence, the committee reached the following conclusions:

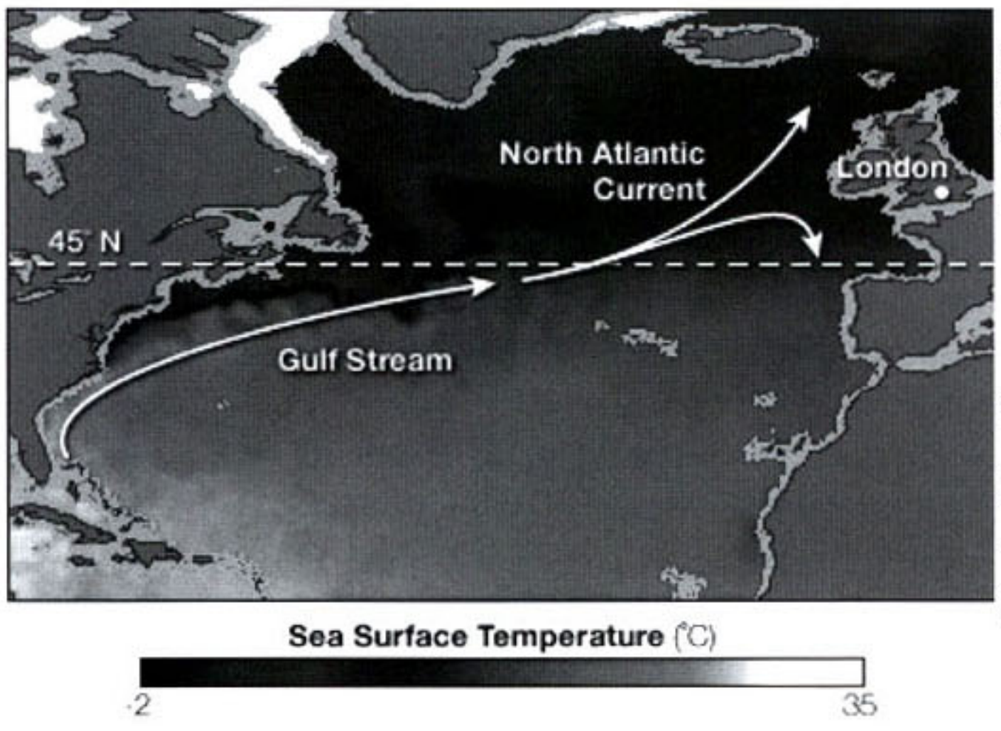
- The instrumentally measured warming of about 0.6°C during the twentieth century is also reflected in borehole temperature measurements, the retreat of glaciers, and other observational evidence, and can be simulated with computer climate models.
- Large-scale surface temperature reconstructions yield a generally consistent picture of temperature trends during the preceding millennium.
- It can be said with a high level of confidence that the global mean surface temperature was higher during the last few decades of the twentieth century than during any other comparable period during the preceding four centuries.

Large-scale surface temperature reconstructions are proving to be important tools in developing a more complete understanding of global climate change (Surface, 2006). Copies of *Surface Temperature Reconstructions for the Last 2,000 Years* are available from the National Academies Press, 500 Fifth Street, NW, Washington, DC, 20001; (800) 624-6242; www.nap.edu.

Feedback Loops

The three warmest years on record have all occurred since 1998; 19 of the warmest 20 since 1980, and the earth has probably never warmed as fast as in the past 30 years—a period when natural influences on global temperatures, such as solar cycles and volcanoes, should have cooled the earth down. Climate-change scientists (Climatologists) reporting for the United Nations *Intergovernmental Panel on Climate Change* (IPCC) say that we are seeing global warming caused by human activities and that there are growing fears of feedbacks that will accelerate this warming.

In a feedback loop, a change occurs and then amplifies the original problem; in this situation the rising temperature on the earth changes the environment in ways that can create even more heat. Scientists consider feedback loops the single biggest threat to civilization from global warming. Past a certain point—the tipping point, they say—there may be no stopping the changes (Blakemore, 2006). Scientists working in the Arctic are reporting that feedback loops are already under way. As the frozen sea surface of the Arctic

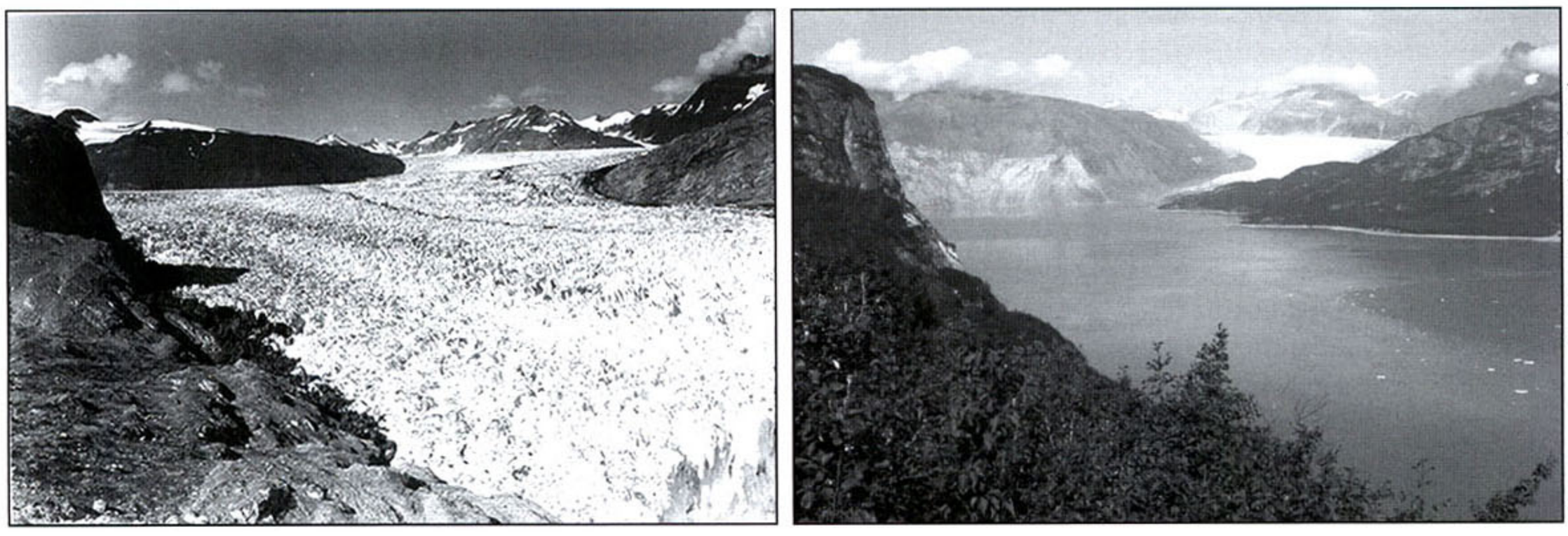


Map by Robert Simmon, courtesy of NASA.

Figure 2. This image shows values of sea surface temperature from Satellite observations. The reason Europe's climate is more moderate than climates in other Northerly locations lies in the ocean.

Ocean melts, there is less white surface area to reflect the sun's heat back into space, leaving the dark, open water to absorb that heat, which then melts the floating sea ice even faster. More than a third of summer sea ice has disappeared over the past 30 years. (Figure 1.) One study published last year in the journal *Science* found that of 244 glaciers in the Antarctic, 87 percent have retreated at unprecedented and accelerating rates. According to NASA scientists, the melting of Arctic sea ice is occurring more rapidly than predicted. The volume of ice melting will lead to changes in the salinity of the ocean and alterations to the ocean's conveyor-belt system (currents) that brings warmer water to the North Atlantic and moderates the climate of Northern Europe (Lash, 2006). (Figure 2.)

In the ground next to the Arctic Ocean, scientists say warming has also awakened another enormous danger—billions of tons of carbon locked up for eons by what was once frozen ground. As global warming thaws and dries out the vast tundra, old, decayed vegetation releases carbon dioxide, the same greenhouse gas that comes from car and plane exhausts and power-plant chimneys—and the tundra releasing carbon dioxide warms the atmosphere even more. The permafrost issue has caused a quiet buzz among climate scientists and geologists. Specialists in Arctic climate are developing research plans to study the permafrost effect, which is not well understood or easily observed. Climate scientists studying the release of carbon dioxide into the atmosphere in the Arctic say that it's a slow-motion time bomb that's speeding up and could become self-generating (Blakemore, 2006). (Figure 3.) The Arctic offers one of the most striking examples of the effects envisioned with climate change. Climate change is expected to be more extreme in the Polar Regions than anywhere else. The warming trend is having a significant and negative effect on polar bears that rely on the sea ice as a platform from which to hunt seals—and the seals that rely on the sea ice to give birth to their pups. Villages on the shoreline are also in jeopardy because the protective sea ice that once acted as a buffer against storms isn't as massive or long-lasting—the weather has been too warm for too long—making the shoreline vulnerable to erosion at an average of 10 feet a year (Bowen, 2006). With shifts in the seasons and scarcer, thinner ice, all of the inhabitants of the Arctic face an uncertain future. (Figure 4.)



Photos courtesy of NSIDC/WDC for Glaciology, Boulder, compiler.2002, updated 2006. Online glacier photograph database.

Figure 3. The photo of Muir Glacier on the left was taken by William O. Field on 13 August 1941, and the photo on the right was taken by Bruce F. Molina on 31 August 2004. These photos tell a captivating visual story of the changes glaciers are experiencing due to climate change.

Photo courtesy of U.S. Fish & Wildlife Service Digital Library.

Figure 4. Polar Bears are dependent on the sea ice for hunting; they wait on ice floes for seals to come to the surface.

The Threat

The effects of a changing climate will not be felt equally across our planet. Regional climate changes will likely be very different from changes in the global average. Differences from region to region could be in both the magnitude and rate of climate change. Furthermore, not all things, whether they are natural ecosystems or human settlements, are equally sensitive to changes in climate. Nations, and regions within nations, vary greatly in their ability to cope and adapt to a changing climate. Some nations will likely experience more adverse effects than others, while some nations may benefit more than others. Poorer nations generally will be more vulnerable to the consequences of global warming. These nations tend to be more dependent on climate-sensitive sectors, such as subsistence agriculture, and the lack of resources to buffer themselves against the changes that global warming may bring. Rising global temperatures are expected to raise sea level and change precipitation and other local climate conditions. Changing regional climate could alter forests, crop yields, and water supplies. It could also affect human health, animals, and many of our natural ecosystems.

While scientists continue to improve their predictions, nature has already been showing some signs of the changes that may be in store. Little doubt remains that these changes have the power to degrade habitats, disconnect food chains, and drive plants and animals from their current homes. Melting glaciers and precipitation are already causing some rivers to overflow, while evaporation is emptying others. Diseases are spreading. Some crops are growing faster, while others see yields slashed by disease and drought. Strong hurricanes are becoming more frequent and destructive, and natural ecosystems such as coral reefs are being disrupted by warmer waters, jeopardizing the survival of reef fish on which millions of coastal residents depend (Pearce, 2006).

Is There a Solution?

Climate change is a global problem requiring action from the entire international community. Countries from around the world are working together to share technologies, experience, resources, and talent to lower net greenhouse gas emissions and reduce the threat of global climate change. At the Earth Summit in 1992, the world agreed to prevent "dangerous" climate change. The first step was the 1997 Kyoto Protocol. Since the Kyoto Protocol entered into force in February 2005, much of the international community has turned its attention to a successor agreement that builds on, or replaces, the Kyoto Protocol by incorporating new features that attract the interest of the United States, Australia, and key developing nations. The world cannot tackle this critical issue without the involvement of the United States, Australia, Brazil, China, India, and Indonesia. The biggest challenge, apart from U.S. involvement, lies with the major developing countries. With urgent development problems of their own—hundreds of millions without electricity, adequate incomes, or transportation—countries such as Brazil, China, India, and Indonesia are understandably reluctant to treat climate change as a priority (World, 2006).

Organizations such as the *World Resources Institute*, *The Nature Conservancy*, the *Intergovernmental Panel on Climate Change*, the *United Nations Environment Programme*, and the *United States Environmental Protection Agency*, to name just a few, are committed to implementing projects that reduce, avoid, or sequester greenhouse-gas emissions. International efforts are helping to establish guidelines for land use, land use change, and forestry practices that reduce greenhouse-gas emissions and increase carbon sinks. As countries continue to grow and develop, international cooperation will become increasingly important as the global community searches for ways to meet the climate-change challenge efficiently and effectively. The key to successful cooperation is finding activities that will help all countries achieve their economic, environmental, and developmental goals in a climate-friendly manner.

Americans increasingly are coming to believe global warming is a problem. Gallup polling data shows that the number of Americans who say they worry about the environment "a great deal" or "a fair amount" increased from 62 to 77 percent between 2004 and 2006. (The 2006 poll was done in March, before the attention-getting release of former Vice President Al Gore's global-warming film, *An Inconvenient Truth*.) All over America, a post-Katrina future is taking shape under the banner of "sustainability." Architects are creating sustainable skyscrapers—like the current champion in Manhattan, the futuristic headquarters for the Hearst Corporation, lit to its innermost core by the sun; and the soon-to-be-built Bank of America Tower, also in Manhattan, that takes "sustainability" to a point just short of growing its own food. Every drop of rain that falls on its roof will be captured for use; scraps from the cafeteria will be fermented in the building to produce methane as a supplementary fuel for a generator intended to produce more than half of the building's electricity; and the waste heat from the generator will both warm the offices and power a refrigeration plant to cool the building (Adler, 2006). Last year more private-sector leaders began to address climate issues. Companies like JP Morgan, Goldman Sachs, and Wal-Mart took strong positions on climate change. The CEO of Wal-Mart, H. Lee Scott's goal is to reduce the company's "carbon footprint" (carbon footprint is a measure of the impact human activities have on the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide) by twenty percent in seven years. If the whole country could do that, it would essentially meet the goals set by the Kyoto Protocol on global warming, which the United States refuses to sign, to the dismay of its European allies. If Wal-Mart meets its [20%] goal, it's going to demonstrate irrefutably that reducing your "carbon footprint" is not only possible but financially efficient (Adler, 2006). To calculate your carbon footprint and to find out how you can reduce it, go to www.carbonfootprint.com/ or www.safeclimate.net/calculator/ on the Internet (supported by the World Resources Institute).

The most effective way to ensure that the private sector facilitates sustainable growth is to give it the tools with which to "green" and prosper in the marketplace. By introducing simultaneously profitable and sustainable business practices into the marketplace, goods and services that generate social and environmental benefits can be developed. The 2005 Annual Report "Ideas into Action," published by the World Resources Institute, comprehensively covers pertinent subject matter dealing with climate and energy and can be obtained by accessing www.wri.org/pubs/pubs_description.cfm?pid=4231.

Summary

More energy will be needed to fuel global socio-economic growth and sustainable development, in particular, to bring economic opportunities to billions of people in developing countries, many of whose choices in life are severely constrained by poverty and limited access to modern energy sources. The amount of additional energy needed will depend on the efficiencies with which the energy is delivered and put to use. The increasing demand for energy poses serious environmental and health challenges; however, the most challenging by far is that of global warming.

A second problem complicating the picture is the unpredictability of human behavior. At what rate will the human population—and its carbon footprint—grow? As formerly undeveloped countries expand their industry, often using cheaper (and more polluting) fossil-fuel technology, their contributions to greenhouse gases will rise and add to the problem—but by how much? To what extent will new, cleaner technologies (such as cars powered by hydrogen fuel cells) be developed and adopted by countries around the world? These kinds of uncertainties make the tough problem of predicting climate change all the more difficult. Even moderate increases in atmospheric temperature could alter precipitation levels, making some areas wetter and others drier, and affecting agriculture worldwide. Warmer temperatures could increase the frequency and strength of storm systems, leading to more powerful and destructive hurricanes and subsequent flooding.

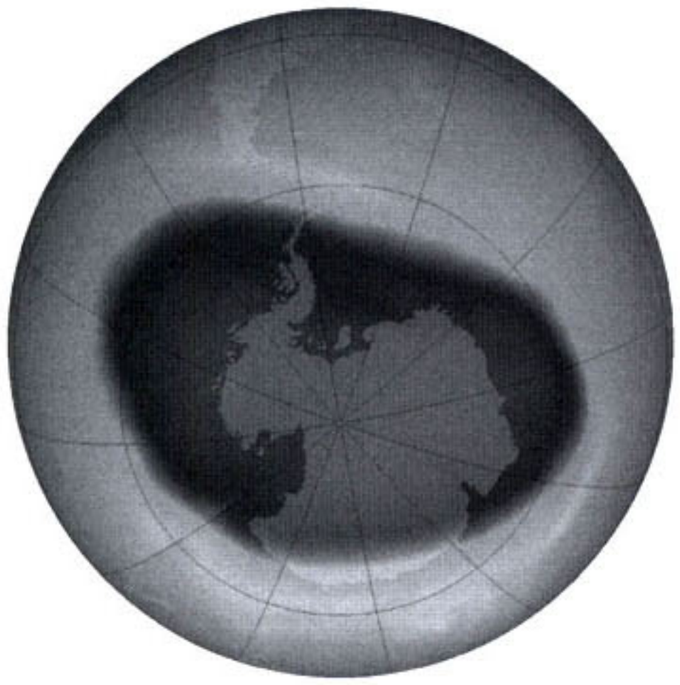


Figure 5. This image from September 29, 2006 shows the ozone concentration in the stratosphere above the South Pole observed by the Ozone Monitoring Instrument on NASA's Aura satellite. A purple veil of extremely low levels of ozone stretches across most of Antarctica, which is roughly centered on the image. Photo courtesy of NASA.

Figure 6. Warmer ocean temperatures have caused some species of coral to expel their algae in a phenomenon known as coral bleaching. Disruptions to ecosystems are a major concern of climate change that threatens the biodiversity of many species. Photo courtesy of NOAA.

Slight changes in temperature may lead to higher ozone levels near the earth's surface, which could significantly increase smog problems in large cities—bad for all humans, but serious for many elderly, ill, or otherwise physically vulnerable people. (Figure 5.)

Unaddressed, climate change will have significant impacts across the United States and around the world. Sea-level rise will add to stresses coastal communities are already facing, including erosion, storms, and pressures from development. Relatively modest changes in precipitation could have large impacts on already limited water supplies. Terrestrial, freshwater, and coastal ecosystems are particularly sensitive to climate change, threatening biodiversity and ecosystem goods and services such as fisheries and recreation. Even human health may be threatened as heat waves, extreme weather, and vector-borne diseases become more prevalent. Even if we are able to reduce emissions of greenhouse gases, some further warming is unavoidable. We must plan and take action now to adapt to the changes we will face as our climate changes. (Figure 6.)

Activity

Is human activity bringing about alarming global warming scenarios and related catastrophes? Or is such thinking a myth brought about by flawed or incomplete science? Finding the answers to these questions has turned global warming into a highly politicized and contentious issue. Today, most scientists agree that earth's temperature has risen over the past century and that carbon dioxide is one of the primary greenhouse gases that contribute to global warming. Disagreement persists, however, over whether or not global climate change is a normal environmental variation, and over how big of a problem global warming could become for the planet.

A comprehensive lesson plan has been developed for PBS (Public Broadcasting System) and is available online at: www.pbs.org/now/printable/classroom_globalwarming_print.html.

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