Union of Concerned Scientists

GLOBAL WARMING FACTS


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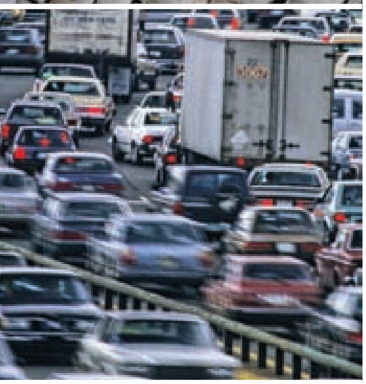
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Because most global warming emissions remain in the atmosphere for decades or centuries, the energy choices we make today greatly influence the climate our children and grandchildren inherit. We have the technology to increase energy efficiency, significantly reduce these emissions from our energy and land use, and secure a high quality of life for future generations. We must act now to avoid dangerous consequences.

Human Fingerprints

Earth's surface has undergone unprecedented warming over the last century, particularly over the last two decades. Astonishingly, every single year since 1992 is in the current list of the 20 warmest years on record. The natural patterns of climate have been altered. Like detectives, science sleuths seek the answer to "Whodunnit?"—are humans part of the cause? To answer this question, patterns observed by meteorologists and oceanographers are compared with patterns developed using sophisticated models of Earth's atmosphere and ocean. By matching the observed and modeled patterns, scientists can now positively identify the "human fingerprints" associated with the changes. The fingerprints that humans have left on Earth's climate are turning up in a diverse range of records and can be seen in the ocean, in the atmosphere, and at the surface.

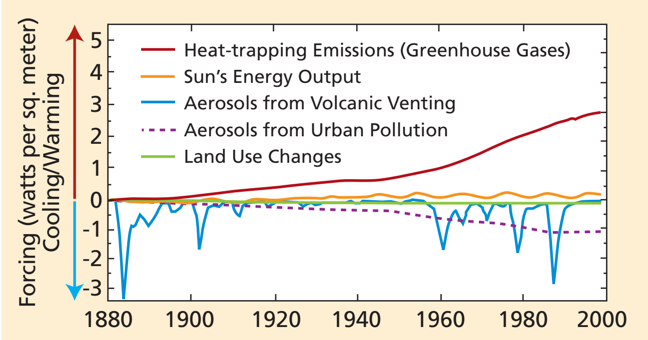
Background: Driving the Climate ("Forcing")

Climate is influenced by many factors, both natural and human. Things that increase temperature, such as increases in heat-trapping emissions from cars and power plants or an increase in the amount of radiation the sun emits, are examples of "positive" forcings or drivers. Volcanic events and some types of human-made pollution, both of which inject sunlight-reflecting aerosols into the atmosphere, lower temperature and are examples of "negative" forcings or drivers. Natural climate drivers include the sun's energy output, aerosols from volcanic activity, and changes in snow and ice cover. Human climate drivers include heat-trapping emissions from cars and power plants, aerosols from pollution, and soot particles.

Fingerprint 1: The Ocean Layers Warm

The world's oceans have absorbed about 20 times as much heat as the atmosphere over the past half-century, leading to higher temperatures not only in surface waters but also in water 1,500 feet below the surface. The measured increases in water temperature lie well outside the bounds of natural climate variation. *(See graphic on back.)*

Global Climate Drivers



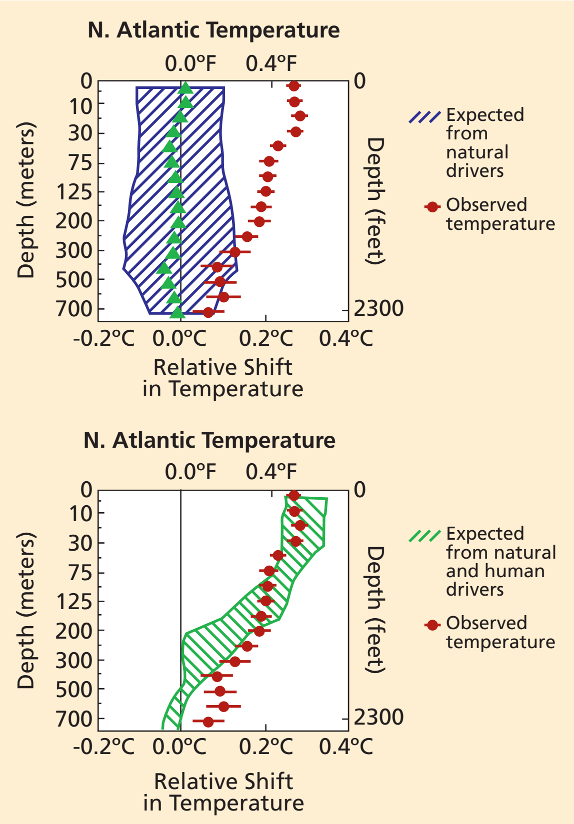
Heat-trapping emissions (greenhouse gases) far outweigh the effects of other drivers acting on Earth's climate.

Source: Hansen et al. 2005.

Fingerprint 2: The Atmosphere Shifts

Recent research shows that human activities have lifted the ceiling of Earth's lower atmosphere. Known as the troposphere (from the Greek *tropos*, which means "turning"), this lowest layer of the atmosphere contains Earth's weather. The stable layer above is called the stratosphere. The boundary that separates the two layers, the tropopause, is as high as nine miles above the equator and as low as five miles above the poles. In an astounding development, a 2003 study showed that this tropopause has shifted upward over the last two decades by more than 900 feet.

Climate Drivers Compared with Ocean Temperature



The observed temperature shift in the 40 years since 1960 in the North Atlantic Ocean (red dots) is compared with two different models (natural drivers, top, vs. natural plus human-induced drivers, bottom). This figure represents similar trends found in other ocean basins.
Source: Barnett et al. 2005.

In their search for clues, scientists compared two natural drivers of climate (solar changes and volcanic aerosols) and three human drivers of climate (heat-trapping emissions, aerosol pollution, and ozone depletion), altering these one at a time in their sophisticated models. Changes in the sun during the twentieth century have warmed both the troposphere and stratosphere. But human activities have increased heat-trapping emissions and decreased stratospheric ozone. This has led to the troposphere warming more because the increase in heat-trapping emissions is trapping more of Earth's outgoing heat. The stratosphere has cooled more because there is less ozone to absorb incoming sunlight to heat up the stratosphere. Both these effects combine to shift the boundary upward. Over the period 1979–1999, a study shows that human-induced changes in heat-trapping emissions and ozone account for more than 80 percent of the rise in tropopause height. This is yet another example of how science detectives are quantifying the impact of human activities on climate.

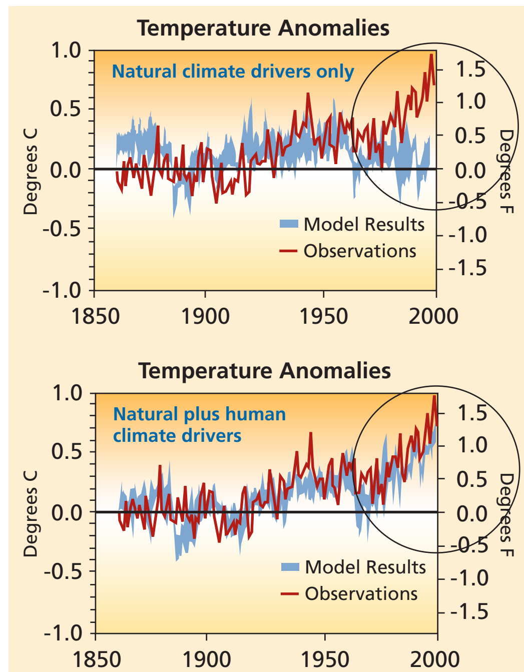
Fingerprint 3: The Surface Heats Up

Measurements show that global average temperature has risen by 1.4 degrees Fahrenheit in the last 100 years, with most of that happening in the last three decades. By comparing Earth's temperature over that last century with models comparing climate drivers, a study showed that, from 1950 to the present, most of the warming was caused by heat-trapping emissions from human activities. In fact, heat-trapping emissions are driving the climate about three times more strongly now than they were in 1950. The spatial pattern of where this warming is occurring around the globe indicates human-induced causes. Even accounting for the occasional short-lived cooling from volcanic events and moderate levels of cooling from aerosol pollution as well as minor fluctuations in the sun's output in the last 30 years, heat-trapping emissions far outweigh any other current climate driver. Once again, our scientific fingerprinting identifies human activities as the main driver of our warming climate.

Human Causes, Human Solutions

The identification of humans as the main driver of global warming helps us understand how and why our climate is changing, and it clearly defines the problem as one that is within our power to address. Because of past emissions, we cannot avoid some level of warming from the heat-trapping emissions already present in the atmosphere, some of which (such as carbon dioxide and nitrous oxide) last for 100 years or more. However, with aggressive emission reductions as well as flexibility in adapting to those changes we cannot avoid, we have a small window in which to avoid truly dangerous warming and provide future generations with a sustainable world. This will require immediate and sustained action to reduce our heat-trapping emissions through increased energy efficiency, expanding our use of renewable energy, and slowing deforestation (among other solutions).

Climate Drivers Compared with Global Surface Temperature



The model output (blue shading) that includes both natural and human-induced drivers (lower graph) gives a better match with the observed temperature response (red line). Source: IPCC TAR 2001.

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Citizens and Scientists for Environmental Solutions

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A fully referenced version is available from UCS at *www.ucsusa.org/fingerprintsclimate*

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