

Chapter 1

Introduction

1.1 Introduction to Global Warming

Global warming involves a temperature change on planet Earth. The temperature is climbing gradually so that the average person does not feel it. However, there are indirect lines of evidence that the average person can see and feel. Increasing unusual weather patterns reported by the news media nearly every day indicate climate change. More floods in parts of the world and more intense droughts in others indicate climate change. Fires raging in some areas and unusual snowfalls in others indicate climate change. A season of intense tornados and more intense hurricanes indicates more energy in the atmosphere and that is climate change. As the Earth's global temperature increases, rates of evaporation also increase placing more water in the atmosphere. More evaporation dries out the land, soils, forests and takes more water from the ocean. All are signs of a changing climate. A warming Earth is climate change and it is affecting everyday life throughout the globe. Thus 'global warming' is used to refer to Earth's gradually increasing temperature.

1.2 Greenhouse Effect

The greenhouse effect is due to a set of chemicals present in Earth's atmosphere known as greenhouse gases that trap heat close to the planet's surface. As the Sun's rays travel through the atmosphere they are in the form of ultraviolet (UV) rays and visible light that warms the Earth's surface. The warm surface then emits heat that travels from the surface back toward space as infrared (IR) waves and some of it makes its way back to outer space. The rest of it is trapped by greenhouse gases such as water vapor, carbon dioxide, methane, ozone, chlorofluorocarbons, and a

few other chemicals and is re-radiated by these chemicals back to the Earth's surface. This keeps the lower part of the atmosphere warm enough for humans to survive. If the greenhouse gases increase in the atmosphere, more of this heat is trapped and the Earth warms; if the greenhouse gases diminish in the atmosphere, less of this heat is trapped and the Earth cools. One of these greenhouse gases, carbon dioxide, is so important in trapping and re-radiating this heat energy that it is known as the Earth's thermostat. Geologists tell us that throughout Earth's history (about 4.5 billion years) there is a direct correlation between carbon dioxide and Earth's temperature. Today's climate scientists tell us that models show the temperature increase with the addition of carbon dioxide; and the models do not show the temperature increase without the increase in carbon dioxide. There are other lines of evidence that point to carbon dioxide as the major cause of the most recent global increase in temperature.

The Earth is hurtling through space in its orbit around the Sun while spinning like a top on its axis of rotation. It would be a frozen lifeless place like our moon or the other planets in our Solar System if not for the thin layer of atmosphere that traps solar energy and insulates the Earth's surface. The way the atmosphere traps solar energy is called the greenhouse effect because it is similar to a greenhouse or an enclosed car heating up in the Sun. In the case of the car, sunlight comes in through a largely transparent window or windshield and is absorbed by whatever it hits, heating up the interior. Some of that heat is trapped inside, because glass lets heat in but doesn't let it out and the inside temperature of the car increases rapidly in the bright sunlight.

In the Earth's atmosphere, sunlight is absorbed by the Earth's surface or rooftops or rocks, and that energy is radiated as heat, infrared energy, back toward space. The Earth's atmosphere absorbs 531 W/m^2 from the Sun plus surface infrared plus thermals plus latent heat, then radiates 333 W/m^2 back to the surface and 199 W/m^2 back to space. Most of the heat that the atmosphere absorbs doesn't make it to space because it gets reradiated back to the Earth's surface by certain gases in the atmosphere, mainly water vapor, carbon dioxide, chlorofluorocarbons, ozone, methane, and a few other gases.

The greenhouse gases consist of more than one atom that are bound together in a way that allows them to vibrate in wavelengths that enable them to capture the infrared radiation on its way back out of the atmosphere. Normally this is a good thing, because without the heat trapped in the atmosphere by these greenhouse gases, planet Earth would be frozen and the temperature would be an uncomfortable -15°C . There would be no life on Earth today as we now know it. Life has evolved under CO_2 levels of approximately 280 ppm.

If extra carbon dioxide that is not part of the natural carbon cycle is added to the atmosphere, then extra heat is trapped that would otherwise escape to space, and the atmosphere gets warmer.

Global warming is an increase in the Earth's overall average temperature, since records have been kept, caused by adding extra carbon dioxide and other greenhouse gases to the atmosphere that absorb and trap heat. The illustration below (Fig. 1.1) shows the result of this trapped heat during the period 1880–2009 as compared to the average global temperature for the period 1961–1990 (stated as a change or an anomaly from the 0 line, either plus or minus in degrees centigrade or Celsius).

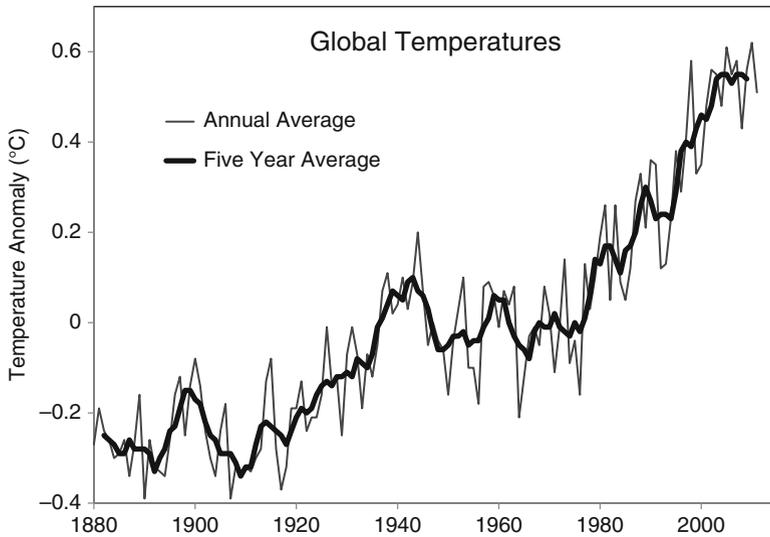


Fig. 1.1 Average global temperature during the period 1880–2009, compiled from various data sources by NASA. The 0-line is the average global temperature for the period 1961–1990. The *smooth curve* is a 5-year average (NASA/GISS, Public Domain)

1.3 Climate Sensitivity

We know that Earth is a sustainer of life because it provides us with an environment that has allowed living organisms, including humans, to evolve and thrive on its surface, in its oceans, and in its air. The atmosphere is the main reason life thrives on the planet, at least for humans. It is the air we breathe. It provides water we drink from precipitation. It provides warmth from sunlight captured by molecules that keep the planet warm enough to grow our food and for us to live. It provides us with something called the “greenhouse effect” that allows us to live on what would be just the third rock from the Sun without it.

How sensitive is Earth’s climate to change? If it is not very sensitive, maybe there is little reason to worry about climate change and global warming. If it is very sensitive, maybe there is every reason to worry. Of course, the sensitivity of the system is also related to feedbacks, such as glacial ice and clouds.

One way to measure the sensitivity of something is to measure how it changes when it is subjected to a known force or a known change in conditions. Put another way, if the climate system is forced to change, how much will it change? So one way to measure sensitivity of Earth’s climate is to measure something that will or is changing it, then measure how much it has changed.

If we could measure the greenhouse gases over an interval of time and determine if they are increasing or decreasing, one part of the climate system would be known and we could measure the temperature over the same interval and that would tell us whether the Earth was being forced to cool or to warm.

If we double CO_2 from its pre-industrial level of 280–560 parts per million (ppm), the temperature caused by the doubling of CO_2 will be between 2 and 4.5°C as determined by the Intergovernmental Panel on Climate Change (IPCC) in 2007 and by a number of independent analyses since. The higher number (4.5°C) is an approximation and is due to the influence of feedbacks on Earth's temperature. The IPCC concluded that the 2°C was conservative, that it was unlikely to be less than 2, and that the most likely value would be an increase of 3°C .

There is a cause for concern with the analysis used above. The increase in carbon dioxide in Earth's atmosphere has not increased in a straight line. Neither has the temperature increased in a straight line. Both rates of increase in the atmosphere have accelerated over time so that the current annual increase in carbon dioxide is around 2 ppm (2 ppm/year). If we double the current amount of carbon dioxide in the atmosphere ($394 \times 2 = 788$) humankind will experience a world that perhaps it has never experienced before. It is dangerous to make predictions, but the situation is not likely to be good.

1.4 Average Global Temperature from 1880 to 2009

The illustration above (Fig. 1.1) is a graph of Earth's global temperature in degrees Celsius from 1880 to 2009. The trend is generally in an upward direction but the light dots indicate the annual variability. The dark line is a 5 year average that smoothes out the annual averages.

1.5 Carbon Dioxide

Carbon dioxide (or CO_2) is the familiar gas that bubbles out of carbonated beverages, and in its solid form, is "dry ice." Carbon dioxide is also a waste product of animal metabolism. Much of the carbon dioxide in the atmosphere is from the burning of fossil fuels. In the carbon cycle, plants take in carbon dioxide and solar energy and they produce oxygen in Earth's atmosphere that we need to live. For most of human civilization, the amount of CO_2 in the atmosphere has been stable at about 280 parts per million (ppm), meaning that out of every million molecules in the air, 280 of them are carbon dioxide. Carbon dioxide is a small fraction of the atmosphere (0.040%), but it's the right amount to absorb just enough heat so that the Earth has the overall average temperature that we and everything else living on the planet have gotten used to. Human civilization has existed in an environment that has had around 280 ppm of carbon dioxide in the atmosphere for thousands of years and it has recently reached over 400 ppm in the Arctic (Fig. 1.2).

The Industrial Revolution began around 1750 when we learned to generate great amounts of electricity and heat needed to build modern civilization by burning coal, oil, and natural gas as fuels for sources of energy. Fossil fuels are the remains of plants and

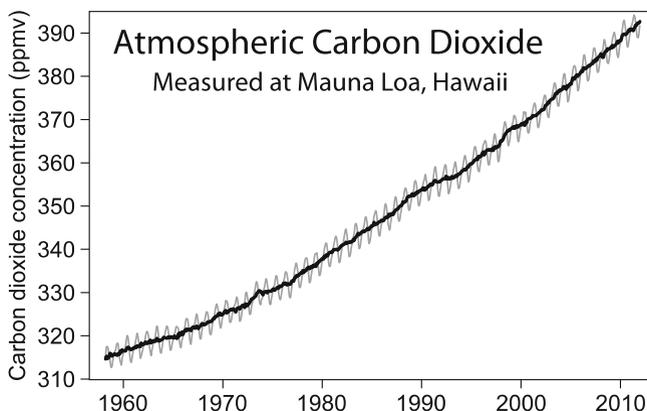


Fig. 1.2 Carbon dioxide concentrations in the atmosphere measured at NOAA's Mauna Loa, Hawaii observatory from 1958 to the present (NOAA, Public Domain)

animals that died and accumulated millions of years ago sinking to the bottom of stagnant water that lacked oxygen necessary to feed the bacteria needed to decompose them. As a result, they became buried under layer upon layer of sediment and compressed into coal or oil. Today we mine coal and drill for oil and then burn them in power plants and cars and airplanes. Fossil fuels are mostly made of carbon, and burning them in oxygen converts them into carbon dioxide that goes up the smoke stack or out the tailpipe and into the atmosphere. This is the extra carbon dioxide beyond the amount we used to have when the carbon cycle was in balance. It is this additional carbon dioxide that is currently causing the Earth to warm. Carbon dioxide doesn't just go away, most of it builds up in the atmosphere and traps more heat and makes the planet warmer. Carbon dioxide stays in the atmosphere for thousands of years. The amount of carbon dioxide in the atmosphere in June of 2012 was 400 ppm and it is increasing at a rate of 2 ppm/year as more and more humans burn more and more fossil fuels. It's astonishing that we can have such a large effect on the whole planet's atmosphere. But it's not so astonishing when you realize that 7 billion humans dump about 30 billion tons of carbon into the atmosphere every year and this amount is rising each year. In 2010, a record 30.6 gigatonnes (Gt) of carbon dioxide poured into Earth's atmosphere, mainly from burning fossil fuel; a rise of 1.6 Gt from 2009, according to estimates from the International Energy Agency (IEA) regarded by many as the gold standard for emissions data.

1.6 Global Warming, Climate, and Weather

Global warming is not about the daily weather, and there's no clear connection between global warming and any single hurricane or snow storm or drought. Adding energy to the whole Earth climate system leads to such things as more frequent severe weather events that on average are stronger and more damaging. One

definition of climate by the World Meteorological Organization (WMO) is “weather over a 30-year period or longer.” There’s a great deal of day-to-day and even year-to-year variability in the weather, and the 0.8°C (or 1.1°F) increase in the average global temperature over decades shown in Fig. 1.1 is a trend that an individual can’t detect or feel. However, scientific research brings to bear lots of measurements, data analysis, computer modeling, debate, and discussion among thousands of experts who spend their careers studying these trends in great detail. That’s what makes them experts, and why they should be listened to with an open mind.

Global warming is about an overall increase in the amount of energy in the whole Earth climate system caused by an increase in heat-trapping greenhouse gases. The experts are only talking about a few degrees of average temperature increase, which doesn’t sound like much, but consider this example. A person’s average temperature is 98.6°F. If that person’s temperature goes up 1–99.6°F it means a person has a fever and this is reason for concern. Something is causing the fever, either a virus or bacterium and most individuals would want to know its cause and what can be done about it, especially if it lingers. Also, imagine a glass of water and ice cubes in a refrigerator whose temperature is set right at the freezing point of water, 0°C or 32°F. The mixture of ice and water will remain pretty much as it is, but if the temperature is raised by even 1°, the ice cubes will start to melt, and at 2° they will melt faster. Everything was in balance at the old temperature, but at the slightly warmer temperature you eventually end up with all water and no ice, much like what is happening right now to Earth’s Arctic sea ice (Fig. 1.2) and mountain glaciers.

1.6.1 Arctic Sea Ice Extent 1979–2005

The Polar Regions of Earth appear to be the most sensitive places on the planet to climate change and global warming. In the illustration below (Fig. 1.3), it can be seen that the north polar region of Earth has lost more than 20% of the Polar Ice Cap since 1979. This loss of Arctic ice is causing unusual weather patterns in the North Atlantic area and possibly influencing oceanic circulation patterns.

1.6.2 Impacts of Global Warming

What happens when the planet gets warmer? More extreme weather, disappearing Arctic ice cap, and receding glaciers throughout most of the world have consequences, such as drowned coastal areas, decline of the polar bears and other Arctic animals, and disappearing, glacier-fed, fresh water supplies for over a billion people. The current rate of sea level rise is 3.2 mm per year (Fig. 1.4), which is cause for concern in low-lying or hurricane-prone coastal areas like Bangladesh, or certain disappearing Pacific islands, or the U.S. Gulf Coast. This will become a national security and military concern when there are millions (perhaps over a billion) of “climate refugees” displaced by rising sea level. They will do what they must to

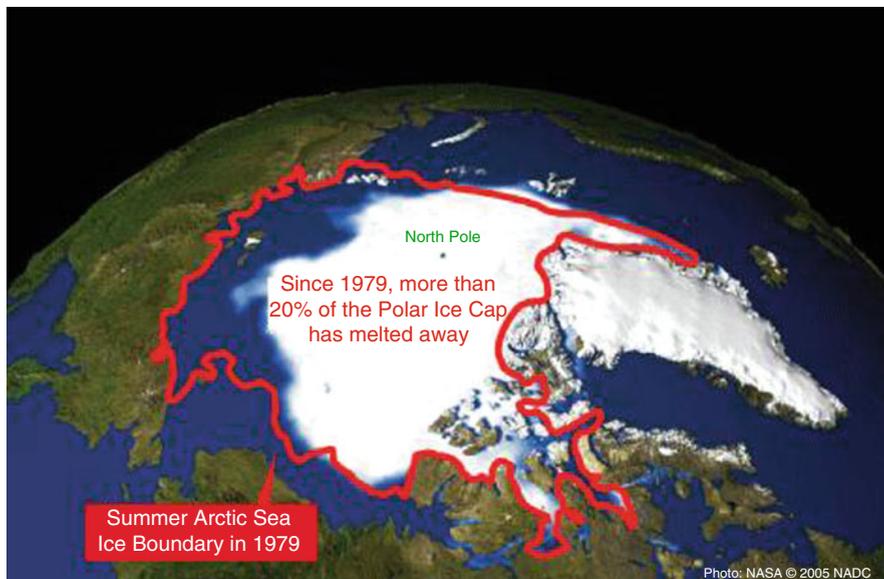


Fig. 1.3 Arctic sea ice is melting away. Actually, ice not only melts but also sublimates passing from the solid state into the atmosphere. The reduction of Arctic sea ice does not raise sea level, just as the reduction of an ice cube in your glass of iced tea doesn't raise the tea level in the glass. Arctic sea ice is frozen ocean water. Since 1979, more than 20% of the polar sea ice cap has disappeared (Source: NASA and the National Snow and Ice Data Center, Public Domain)

survive, as we all would, and they will go inland to China, Australia, the U.S., and elsewhere where they probably won't be welcomed with open arms and invitations to tea. Other consequences of global warming include extended droughts and encroaching deserts, increasing wildfires and insect infestations, and changing rainfall and agricultural patterns. We are seeing some of this already with destructive beetle infestations in the Rocky Mountains and elsewhere in the U.S. and Canada.

The oceans and marine life are doubly affected by global warming; first by an increase in temperature, which intensifies storms such as hurricanes and melts sea ice, and second by increased acidity caused by dissolved CO_2 . And these aren't even the worst-case scenarios.

1.7 Timescales, Positive Feedbacks, and Tipping Points

These three factors, timescales, positive feedbacks, and tipping points make confronting global warming both more difficult and more urgent. Natural processes that permanently remove CO_2 from the atmosphere take place on a timescale of decades or longer, so we are already committed to a certain amount of additional

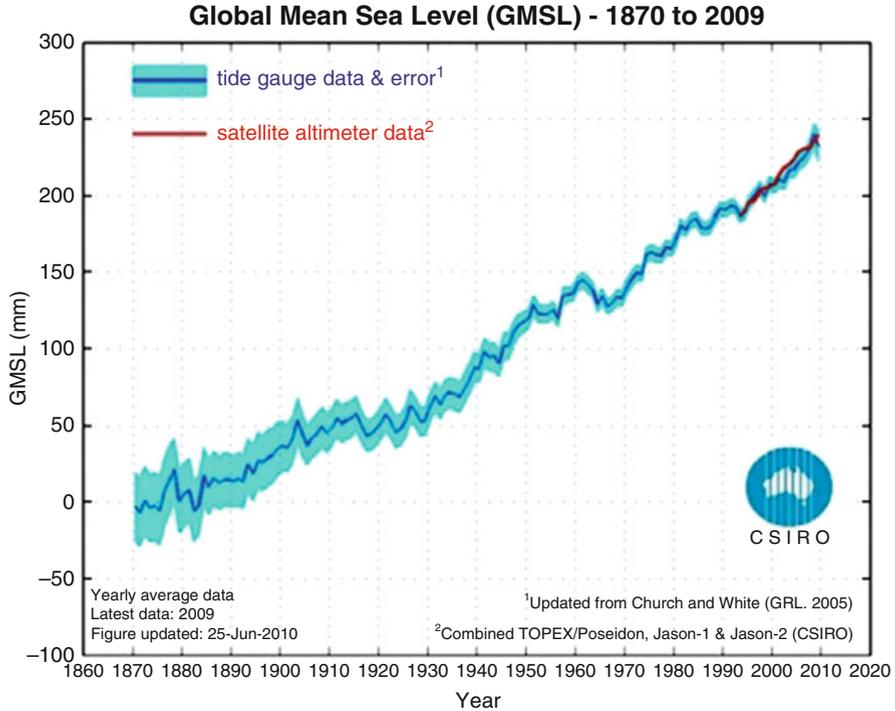


Fig. 1.4 The trend of sea level since 1870 (1870–2009). The *light blue* region is the range of uncertainty in the measurements. Satellite measurements are represented by the *red line* and tide gauge measurements are represented by the *dark blue line*. Sea level has increased about 24 cm (9.4 in.) since 1870. Since 1993, sea level has increased by about 6 cm (2.4 in.) at a fairly constant rate of 3.2 mm per year (Source: CSIRO, the Australian National Scientific Research Organization)

warming even if humans totally stopped burning fossil fuels today. When a system such as Earth’s climate system is perturbed from a stable state, “positive feedback” processes can cause the system to move even farther from its previous state, while “negative feedback” processes tend to restore a perturbed system to its previous state. There are several positive feedbacks in the Earth’s climate system that could lead to a “tipping point,” which is a threshold condition that leads to an irreversible change because once it’s done it’s done, like pulling the trigger on a loaded weapon with the safety off. There’s no way to stop the bullet from its ultimate impact.

One example of a positive feedback in the climate system concerns the decreasing Arctic ice cap shown in Fig. 1.3. Ice is a reflective surface with an albedo of 0.5–0.7, meaning that 50–70% of Sunlight is reflected back toward space and contributes less to global warming. Ocean water is one of the least reflective surfaces with an average albedo of only 0.08 (only 8% reflected, 92% absorbed), so most of the solar energy hitting the ocean participates in global warming. As the size of the Arctic ice cap decreases from melting, a less reflective surface (the ocean) replaces a more reflective

surface (the ice), so more solar energy is absorbed and the rate of global warming increases, leading to faster ice cap melting, leading to faster warming.

A second positive feedback in the climate system concerns the thawing of permafrost in northern latitudes. Vast stretches of permafrost contain huge quantities of CO₂ and methane frozen into the soil, which is released into the atmosphere as the permafrost melts, which traps more heat and increases the rate of global warming, which melts more and deeper permafrost, which further increases the rate of global warming, etc. These and other positive feedbacks could lead to a tipping point, where dramatic changes in the Earth System happen quickly and are permanent and irreversible.

1.8 Energy and Climate Policy

Climate science is enormously complex due to the numerous variables yet sufficient progress has been made over the last few decades so that we know the broad outlines of what is needed to avoid the worst consequences of global warming. We need to make major changes in the way we obtain and use energy, and we need to do it soon, or the world will change in ways we won't like and our children and grandchildren will like even less.

Having a specific goal can sometimes motivate progress, and some climate scientists think that we should stabilize the atmospheric CO₂ concentration at no more than 350 ppm. The pre-industrial CO₂ level was 280 ppm, and we're currently at 400 ppm (in June 2012) and increasing at a rate of 2 ppm per year; so we're already above the desired level and rapidly heading in the wrong direction. The target of 350 ppm originated with a paper by NASA climate scientist Dr. James Hansen that reported on an analysis of past climate conditions and their associated CO₂ concentrations. A commonly cited target for policy considerations is to limit global warming to 2°C (3.6°F) from pre-industrial conditions, which gives us a chance to avoid positive feedbacks such as widespread melting of permafrost that could lead to a tipping point. The 2°C limit roughly corresponds to an 80% reduction in CO₂ emissions by the year 2050 if substantial reductions begin immediately. Meeting such targets requires transformational energy policy that establishes clear requirements and a mechanism to meet them, and puts a price on the emission of carbon to drive reductions. Currently there is zero cost for contributing to global warming, so there's no incentive to stop. Nevertheless, taxpayers will continue to pay for the effects of global warming and as time passes the severity of the problem increases and the costs go up.

1.8.1 Energy Choices

Energy choices made today will determine the climate in coming decades. Historically it has been difficult for humans to confront a major problem until some catastrophe occurs. This does not bode well for addressing global warming because

we must act far in advance of any catastrophe due to the long timescale for removal of CO_2 from the atmosphere. The solutions are clear; we need to use energy more efficiently, as about half is now wasted by inefficient cars, appliances, buildings, electrical grid, etc., and we need to transition to clean and renewable (non-fossil fuel) sources of energy such as wind, solar, tides, etc. We already know how to do these things. The technologies already exist.

However, the forces opposing change in energy use are formidable, well funded, and very good at deceiving a poorly-informed public about a complex and long-term issue. Coal was cheap for powering the Industrial Revolution and electrifying civilization, but now we know there are long-term global consequences for Earth's future climate. We now know how to make electricity in smarter ways than using fire to boil water to turn a generator. Petroleum is a major contributor to global warming, plus having volatile pricing, environmental damage such as the Gulf oil disaster, leaking pipelines, or tar sands mining; and the loss of life, political destabilization, and enormous expense to taxpayers of protecting oil supplies. Even relatively "clean" natural gas (methane) is not really very clean unless much more is done to prevent leakage of this potent greenhouse gas into the atmosphere at the wellhead and in the pipeline.

Confronting global warming will require a combination of strong legislation crafted by informed and courageous legislators, personal actions to reduce one's own energy use and to support renewable energy, and educating the public about the reality of global warming and what's at stake. One thing that an individual can do is to emphasize the importance of strong clean energy and climate legislation when making political and voting decisions.

For most of us, this issue of global warming is beyond politics; it's about the future of our planet, our offspring and our species. Who to believe about global warming? Consider this simple analogy: if one wants to know how to fix the plumbing, call a plumber, not a climate scientist. If one wants to know if global warming is real and whether or not we should do something about it, ask a climate scientist; not the Coal Lobby, the American Petroleum Institute, some politician, or your local weather TV or radio personality.

1.9 Forcings and Feedbacks

Climate forcing is a change in direction that is caused by an external or internal force operating on Earth's climate system, such as a warming or cooling. If the Sun's energy output changes, it forces a change in Earth's climate. The Sun is the most obvious forcing agent for Earth's climate change but there are others.

Feedbacks supplement forcings. An obvious example of a feedback is glacial ice. If the Earth is cooling and glacial ice on Earth expands, more energy is reflected back to space and the planet cools. If the planet is warming and glacial ice retreats, more energy is absorbed by Earth and less energy is reflected back to space; the Earth warms.

Feedbacks may be positive or negative. A positive feedback enhances a forcing; a negative feedback works against a forcing. The glacial ice feedbacks mentioned above are both positive feedbacks. An example of a negative feedback is if the Earth is warming and thick white cloud cover forces more sunlight to be reflected. It would eventually cause the Earth to slow the warming or cause the Earth to cool.

Being able to determine the evolution of global climate from the end of the Last Glacial Maximum (LGM) approximately 20–18 thousand years ago to the early Holocene 11,700 years ago presents to scientists an unrivaled opportunity for understanding the response of Earth's climate system to external and internal forcings. During this interval of global warming, the decay of ice sheets caused global mean sea level to rise by approximately 80 m; terrestrial and marine ecosystems experienced large disturbances and range shifts; perturbations to the carbon cycle resulted in a net release of the greenhouse gases CO_2 and CH_4 to the atmosphere; and changes in atmosphere and ocean circulation affected the global distribution and fluxes of water and heat.

We will see and study the causes and effects of this evolution of global climate as we proceed in this text.

1.9.1 Earth's Albedo

Albedo is the same as reflectivity and is defined as a substance's ability to reflect light. Glacial ice has a high albedo, ocean water a low albedo. Things with a high albedo, like glacial ice, reflect energy while those with a low albedo absorb energy. A dark landscape like volcanic material absorbs energy while desert sand reflects energy in the form of the Sun's rays that strike them.

1.9.2 Irradiance

Irradiance is the power of electromagnetic radiation (in this case radiation from the Sun) per unit area (radiative flux) incident on a surface. It is expressed in Watts per square meter (W/m^2). Irradiance due to solar radiation is also called insolation.

1.10 Energy Budget

An energy budget for Earth's climate system can be thought of as the amount of energy into the system equals the amount of energy out of the system. If the climate system is in equilibrium, these two are equal (energy out equals energy

in). However, the Earth has an atmosphere that absorbs energy in the form of infrared radiation. Energy coming into the atmosphere is in the form of short-wave radiation and energy going out is in the form of longwave radiation. The Earth's atmosphere is transparent to ultraviolet radiation but the gases in the atmosphere (mainly water vapor and carbon dioxide) trap much of the infrared radiation given off by the Earth's surface. This entrapment of energy by atmospheric gases (called greenhouse gases) is what causes the Earth to be able to support life at an average global temperature around 15°C (59°F). Without the atmosphere, Earth's temperature would be about -15°C (5°F), too cold to be comfortable for humans.

1.11 Affected Weather

Climate scientists have been warning since about the mid-1980s that the Earth would warm to the point that it would begin to affect the weather. A warmer atmosphere causes more water to evaporate from the ocean, lakes, streams, and soils. The extra water in the atmosphere will lead to more severe storm activity, including hurricanes and tornadoes, heavier rainfall and flooding in some areas, and dryer deserts in others. We are seeing this today in some weird weather that is becoming the new normal in many areas of the globe.

There are many people who deny that human activity is disrupting our climate but they are a small minority in the general public and nearly non-existent in the climate science community. In 2009, a large number of emails between climate scientists were stolen and released on the Internet, many of them altered or selectively edited. This illegal act has been dubbed "Climategate" and because of its influence in the "debate" about climate change and global warming, warrants further discussion in later chapters.

1.12 Hockey Stick Controversy

The "hockey stick" is a diagram attributed to Michael Mann and colleagues drawn for a paper in 1998 from a variety of sources including proxies from dendrochronology that showed a sharp increase in temperatures during the final years portrayed on the graph (see Fig. 1.5 below). The graph and the research on which it was based were groundbreaking. No one had previously compiled these data and put them together so convincingly.

The Mann, Bradley, and Hughes (MBH) 1988 paper was the first quantitative hemispheric-scale reconstruction going back in time to 1400. It was a landmark paper. In a 1999 paper, the authors extended the reconstruction back to 1000 and it was the later graphic that was prominently featured in the IPCC 2001 AR3 (TAR) Report (see Fig. 1.5).

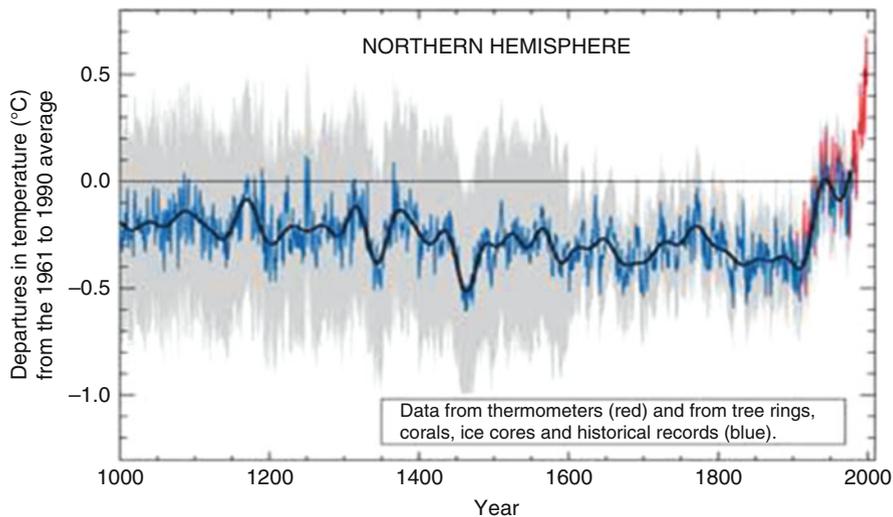


Fig. 1.5 The plot of temperature for the past 1,000 years (the “hockey stick” graph) (Originally published in GRL in 1998 by Michael E. Mann, Raymond S. Bradley, and Malcom K. Hughes and relied upon and republished by the IPCC in their Third Assessment Report (AR3) in 2001)

Much criticism of the graph ensued and it became a favorite of the denialist group, but most subsequent scientific papers supported the basic message of the hockey stick; that the Earth is warming and a great deal of the warming has occurred in the last half of the twentieth century. More than 12 subsequent scientific papers, using various statistical methods and combinations of proxy records, produced reconstructions broadly similar to the original MBH hockey-stick graph, with variations in how flat the pre-twentieth century “shaft” appears. Almost all of them supported the IPCC conclusion that the warmest decade in 1,000 years was probably that at the end of the twentieth century.

The first decade of the twentieth century was even warmer than the last decade of the twentieth century and scientists have seen a leveling off of the rise in temperature in the past several months of the year 2011, which ironically has been attributed to coal-fired power plants in China and India that emit sulphur aerosols that have slowed the warming trend. Of course, this is a temporary situation and not a good environmental one, because the coal-fired power plants are using high-sulphur coal and emitting sulphur into the atmosphere which in turn is causing acid rainfall and adding to ocean acidification.

Actually, the appearance of “climategate” in web searches and the occasional article one hears about or comes across, is a relic or an anachronistic episode still being held on to by skeptics and deniers. In March of 2010, the British House of Commons Science and Technology committee released results of their investigation into the scandal that revealed nothing in the emails conflicted with the scientific consensus that “global warming is happening and that it is induced by human activity.”

Additional Readings

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