GLOBAL WARMING

credit: Scott Kominers, HSR

a gathering storm or a green scare?

By Megan Bartlett

Poised rigidly for decades, the Greenland glacier Kangerdlugssuaq suddenly triples the speed of its slow-motion avalanche, casting colossal chunks of ice into the surrounding ocean at one of the fastest rates of any glacier in the world (1). Across the Atlantic Ocean, at a quiet intersection in Manhattan, a troop of zealous Greenpeace members eagerly chain themselves to the pumps at a previously unremarkable gas station (2). A hemisphere away, Russia ratifies the iconic Kyoto Protocol, further polarizing the already heated debate over the importance of global warming in government policy.

> *"The most bitterly fought global warming debate is about who causes it"*

New articles and reports appear constantly: glaciers are melting more quickly, atmospheric temperatures are increasing, and ocean levels are rising (3). Ordinary houseplants are blooming earlier, while violent hurricanes and typhoons are ravaging coastal cities (4). Scientists and politicians clamor to contradict each other, their arguments swooping from one end of the doom spectrum to the other, ranging from global warming as our ultimate destruction to a radical environmentalist scare tactic.

Varying widely in source and time scale, the scientific data about global warming is confusing to compile and interpret. It is easily distorted by clever statistics, and even legitimate data consists mostly of obscure bases from which to extrapolate the economic, political, and social implications of climate change. Considering the disorganized nature of even the most basic facts of global warming, it's hardly surprising how confused and clouded the issue has become to scientists, politicians, and individuals attempting to get an unbiased understanding of it, or even to come to a consensus about how important it is, if it even exists at all.

What is climate change?

Climate is the average weather of an area or the globe, including seasonal variations. Climate change is nothing new: because exact weather patterns never recur in detail, climate change takes place every year (5). Also, by its very definition, climate includes a wide range of values for precipitation and temperature depending on the location, year, or time of year, further blurring the lines between ordinary and potentially destructive climate change.

Global warming is the most vilified form of climate change, characterized by a continual increase in global temperature caused by human and nature-derived changes in atmospheric composition (6). The atmosphere is primarily nitrogen and oxygen, with small concentrations of additional gases like carbon dioxide and water vapor. When sunlight radiates to the earth, most of the gases in the atmosphere simply allow the light to pass through. Some of the light is absorbed by the ground and water, and some is reflected back into the atmosphere to pass into space. However, a certain class of gasses, known as the greenhouse gasses because they function like the heat-trapping glass panes of a greenhouse, allow light to pass through to warm the earth and retain that heat (7). These gases, including carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (CFCs), absorb the heat from the Earth's surface without emitting it into space, instead storing it to offset the extremely low temperatures found in their layer of the upper atmosphere. This imbalance between heat retained and heat emitted causes an increase in the atmospheric temperature, which warms the pool of heat-storing gasses and makes them radiate more heat into space, restoring balance by recalibrating the climate to a higher temperature.

Heat retention by greenhouse gasses, called the "greenhouse effect," produces this global warming. However, it is not entirely harmful: the average global temperature today would be 61°F (34°C) colder without its effects (4). The distinction lies between the natural greenhouse effect, which is caused by greenhouse gasses present long before human beings, and the enhanced greenhouse effect brought about by human activity.

It's getting hot in here... maybe

The last two decades have been the warmest on record; the four warmest years since 1860 occurred during the 1990s. The global temperature has increased between 0.5-1.0°F (0.3-0.6°C) since the nineteenth century (especially in the Northern Hemisphere), sea level has risen between 4 and 8 inches, and precipitation across the world has increased by 1% (8, 9). Snow cover, a significant reflector of solar energy that would otherwise contribute to warming, has decreased by 3-5% every year for the past 24 years, and sea ice, which shields the cool polar air from the relatively warm ocean, has decreased in area by 7.7% per decade and thickness by 1.3 meters (about 4 feet) over the past 30 years (1). Analysis of air trapped in shallow ice cores and the growth recorded in tree rings and deep-sea coral suggest that current temperatures exceed those of the past 600 years, while data from deep ice cores extends this time period to the last millennium (Figure 1) (4). The rate and duration of warming observed in the 20th century is unprecedented in the climate change of the past 1,000 years (9).

These data, while dramatic, are not universally accepted by scientists or politicians. The most ardent critics of global warming claim that it either does not exist or that it is a natural phenomenon independent of human influence, citing changes in international energy policies as a waste of resources and profit. For example, some critics claim that in contrast to surface temperature measurements, data from weather satellites shows no significant warming trend in atmospheric temperature (10). However, these measurements span only 25 years of climate history and ignore the different trends that can appear in atmospheric and surface temperatures. The calibration of these satellites has even been called into question, suggesting that what appears to be a cooling trend may actually be a slight warming (4).

Critics of global warming have also cited natural cooling and warming trends as the source of our current climate change, claiming that the warming pattern we have now is simply a planetary response to the "Little Ice Age," a cooling period lasting from 1480-1850 (10). Possibly, but it hasn't been proved that this cooling took place outside of the Northern Hemisphere, reducing the likelihood of a global reaction to it. Also, the current

warming trends deviate so greatly from those observed in the past millennium that natural climate trends do not fully account for them (9). The bane of global warming is the great deal of variance in data, depending on how it is measured (satellite versus ground measurements, for example) or modeled, with different computer models using different factors to influence climate change. Some scientists have offered increased solar output, changes in heat energy transfer by ocean and air currents, and inaccurate cloud cover modeling in computer simulations as possible explanations for global warming, and the absorption of carbon dioxide by vegetation and increased ocean evaporation as possible natural inhibitors of warming, eliminating the need for changes in human activity (11).With a global system to take into account, the influence of these factors and how they should be included in climate change models is frustratingly obscure, crippling most of the political attempts to tackle it.

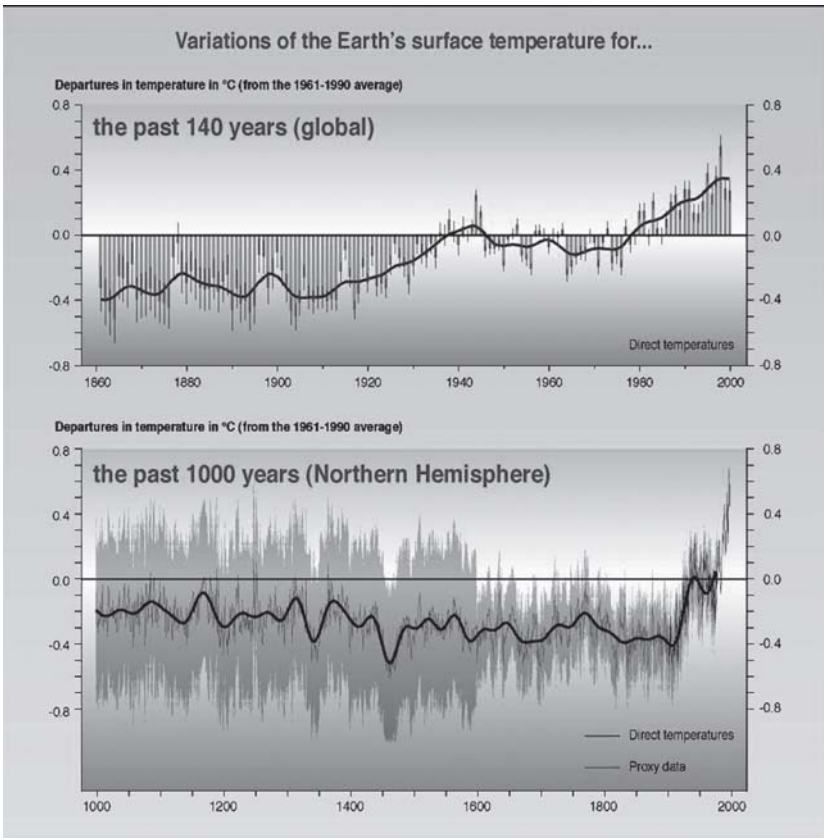

Figure 1. One millennium of temperature measurements from ice cores shows small historical fluctuations, with a steep rise, an entirely different pattern, starting in the early 1900s with the industrial era.

Who's to blame?

The most bitterly fought global warming debate is about who causes it – natural processes beyond our control, our own energy policies, or a combination of the two? The concentration of CO_2, the most important greenhouse gas, in the atmosphere has increased 30% over the past 200 years, since the start of the Industrial Revolution. However, 95% of those emissions – 220 billion tons a year – come from natural ecological processes, like forest fires and animal respiration, which occur without human activity. Of the CO_2 that does come from humans, 80% is due to the burning of fossil fuels, and 20% comes from changes in land use, including deforestation. As for the other greenhouse gases, human activity has increased concentration of methane, the second most important greenhouse gas, by 145%, and that of nitrous oxide by 15% (4).

But if human activity is such a small contribution to atmospheric CO_2, how could it cause global warming? The natural production of CO_2 is balanced by the sinks that absorb it, including plants and sea water. However, the human contribution is slightly greater than the amount that those sinks can absorb, leading to the gradual build-up observed today (7).

Also, how do we know the CO_2 build-up is due to humans? First, measurements taken since the 1950s show that CO_2 levels – and global temperature – have increased at a rate consistent with projected human emissions (9). Second, ice cores containing bubbles of centuries-old air have CO_2 levels at 25% of those observed during the industrial era. Finally, the atmospheric CO_2 today has low levels of radioisotopes compared to naturally produced CO_2, pointing to the burning of fossil fuels, which have lost most of their radioisotopes over the eons it took them to form (4).

What's next?

The Intergovernmental Panel on Climate Change, the most respected source for climate change data, incorporates what is currently known and suspected about global warming and creates the following scenario. Global temperature will rise by 2-6°F by 2100, about a third of the change that occurred during the ice age. CO_2 concentration is expected to double. The heat index, drought in arid areas, precipitation in wet areas, number of warm days, the surface warming of land, storm wind intensity, and weather intensity are predicted to surge upward as well (7). Ice sheet area, snow cover, Greenland glaciers, and ice caps will continue to shrink, while the Antarctic ice sheet might actually gain mass from precipitation (1). Sea level rise might range from 0.11 to 0.77 m, pushed higher by melting glaciers and ice caps and expansion caused by warmer ocean water (13).

The social and economic impacts of these climate changes are considerably

credit: "Climate Change 2001: The Scientific Basis," Intergovernmental Panel on Climate Change (2001)

less clear. However, what the IPCC does expect is bleak: increased temperature and rain could widen the range of tropical diseases like malaria and dengue fever, while intensifying winds carry more of the pollen, fungi, and dust that cause asthma and allergies (12, 13). Stronger storms may worsen red tide, forest fires, and flooding, allowing pest species like mosquitoes, rats, and kudzu vine to push out native organisms in damaged environments. Waves of human, livestock, and crop diseases could surge, while shifts in agricultural areas might destroy the main source of income in developing countries and create migrating bands of environmental refugees. As desertification in already dry lands intensifies, freshwater run-offs could dry up, and increases in sea level could potentially displace the 50-70% of the world population that lives in coastal areas – all within the next 50 years (7, 12, 13). Already fractured by pollution and deforestation, ecosystems cannot cope with the extremely rapid warming rate (4). Shattered by natural disasters, the near collapse of agriculture, and the potential uprooting of billions, governments are powerless to contain the damage. 2050 is too late to try to stop it.

Future directions

In response to these apocalyptic scenarios, 160 countries united in 1994 to sign the United Nations Framework Convention on climate change, declaring global warming a real threat requiring effective action, especially the stabilization of human-generated CO_2 greenhouse gasses. Although an optimistic step forward on paper, the Climate Convention had accomplished little until it drafted its most famous legislation – the Kyoto Protocol. Unprecedented in international treaties, the agreement called for the reduction of greenhouse gas emissions to at least 5% below 1990 levels between 2008-2012 and the development of CO_2 sinks (such as replanted forests), sustainable agriculture, renewable energy sources, and increased energy efficiency by the 37 developed countries that account for over half of all greenhouse gas production (14). Despite U.S. withdrawal, the treaty passed and came into effect, mostly due to support from the European Union, Japan, Canada, and Russia. However, in this growing international awareness of global warming, where is Washington?

The U.S. is the world's biggest producer of CO_2, accounting for 25% of the world's CO_2 – about 6 tons per person, versus 3 tons for the average Briton and 0.25 for the average Indian (7). To ameliorate this enormous CO_2 output, the Kyoto Protocol called for a 33% reduction – an amount considered by President Bush to be potentially crippling for the U.S. economy. As an alternative to the Kyoto Protocol, the Bush administration proposed a 4.5% reduction in greenhouse gas emission over the next 10 years, with emphasis on market-supported strategies and economic stimulation (15). However, the administration has been accused of gutting recent EPA reports about rising global temperature changes and possible human involvement in response to a study, funded in part by the American Petroleum Institute, which questions those trends (16). Environmental groups have accused President Bush of sacrificing science and public interest for business, and risking severe future crises for the sake of short-term economic profit, while conservatives claim global warming is an exaggerated natural phenomenon that will correct itself. Public opinion tends to fall between either extreme, with about 79% of the public favoring and 17% opposing a reduction in greenhouse gas emission and 67% believing that requiring major industries to reduce gas emissions would effectively target global warming without hurting the economy (17).

However intriguing or convincing these numbers might be, they do little to address the problem of global warming. Data taken from myriad facets of our climate, ranging from centuries to millennia, have revealed a warming surge that cannot be satisfactorily explained by our natural history, but points forcefully to human disruption in an ancient natural balance. The possible collapse of our world order has been scientifically projected, published, and forecasted to fall in this generation. With these catastrophes in mind, we must decide how to progress with the knowledge that we have. H

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