

The Causes and Effects of Global Warming and Climate Change

Global Warming and Climate Change

Climate is the long-term statistical expression of short-term weather. Climate can be defined as "expected weather". When changes in the expected weather occur, we call these climate changes. During the most recent history, scientists have been able to construct evidence of climate change from the information on temperature, rainfall and other weather variables collected from measuring stations all over the world. The oldest time series of climate data is a temperature record from central England beginning in the 17th century. Most instrumental records however, date back only to the 19th century. Despite this relatively short period of data collection, by careful mathematical analysis, scientists have been able to demonstrate that the Earth's surface has warmed on average by about 0.6°C during the 20th century. Such warming is believed to be related largely to mankind's pollution of the atmosphere by greenhouse gases.

In the polar region however, regional warming has been considerably greater than the average. In some parts of Antarctica and northern Russia, temperatures have increased by about 2°C in only 50 years. Many scientists think that such rapid warming in these ice-covered parts of the world is a consequence of the ice-albedo feedback effect. Ice, being white, reflects a lot of sunlight and keeps the surface colder for longer. Highly reflective surfaces like ice have high albedo. As an enhanced greenhouse effect, warms the surface of the Earth, some of the ice at high latitudes melts, exposing either bare ground or ocean, both of which have lower albedo (or reflectivities) than ice. With a lower albedo, the exposed surfaces reflect less sunlight, with more sunlight being absorbed. This causes a further rise in surface temperature and in turn a further melting of ice.

Global Warming has become familiar recently as environmental issues have hit the headlines. Within the past decade, there has been a considerable rise in public awareness and interest in climate change and in the possible impact of human activities on global climate. Such interest is particularly acute amongst environmental scientists, but is also prevalent amongst politicians, economists and some industrialists and has resulted in continuing attention in the media.

The focus of attention has been upon the present and continuing effects upon climate of both domestic and industrial fuel use and of other processes both agro-environmental and industrial that leads to the release of greenhouse gases into the atmosphere. A recorded rise in temperature this century is mainly attributable to human activities.

Records show global temperatures increasing. According to the data collected from selected terrestrial stations and marine sea-surface temperature (SST) records round the world there have been seven warmest years since 1980. The recorded rise in temperatures has been linked to an estimated 30 per cent rise of carbon dioxide concentrations in the lower atmosphere over the last 200 years.

Since the 19th century, there have been temperature data available from weather stations throughout the world. But it is difficult to compile an accurate picture of changes in world temperature over the last century due to various problems and errors. Overall, there has been a worldwide warming of about 0.5°C since the end of the 19th century. During this time, there have been two periods of rapid temperature increase, one between 1910 and 1930 and the other between 1970 and the present. The 1990 was the warmest decade and 1998 the warmest year. On average, between 1950 and 1993, night-time daily minimum air temperature over land increased by about 0.2°C per decade. Warmest episodes of the El Nino Southern Oscillation (ENSO) phenomena have been more frequent, persistent and intense since the mid 1970s, compared with the previous 100 years.

The Elements of Global Warming and Climate Change

(i) Carbon dioxide (CO₂)

Carbon dioxide is a greenhouse gas. The amount of it in the atmosphere has risen by about 30 per cent due to human activities since the beginning of the Industrial Revolution. The present concentration of 360 parts per million (ppm) means that 360 of every million molecules of gas in the atmosphere are carbon dioxide. Between 1950 and 1980, carbon dioxide emission increased by an estimated 586 percent in the developing countries, 337 percent in the former Soviet Union and Eastern Europe, and 91 percent in North America (Pain,

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1989). Why is carbon dioxide increasing? Increased industrialization of the planet-wide economy is the predominant cause. Burning fossil fuels (oil, gas, coal etc.) is one way that carbon dioxide is released into atmosphere, while another source is the burning of timber and vegetation. Trees and plants remove carbon dioxide from the atmosphere in the course of the photosynthesis process.

Fossil fuels

Since the industrial revolution, there has been an increase in the concentration of carbon dioxide in the atmosphere, particularly since the 1940s. It has been inferred that, it is human disruption of the natural biological and chemical interchange of carbon that is responsible for the increase. Since prehistoric times, people have burnt wood and other plant remains to produce heat and light. As wood became scarce in Europe in the 18th century, the use of coal became increasingly important. The demand for energy increased sharply during the industrial revolution to fuel the new industries and to provide for the domestic needs of a rapidly expanding urban population. This demand was largely met by the increased use of fossil fuels, primarily coal.

Industrial revolution gathered pace in the early part of the 19th century was restricted geographically. But it has grown at an unprecedented rate after the second world war. As a consequence, coal consumption has increased rapidly. Worldwide industrial development is one factor driving increased carbon dioxide production, but at the same time the world's population has increased from 3 billion in 1960 to over 5 billion in 1990, producing an ever-increasing demand for energy. The per capita carbon dioxide output is much higher in the industrialised developed nations in Europe, North America and the Pacific. The USA is the largest emitter of carbon dioxide, accounting for 24 per cent of global emissions. Many countries have a great capacity to increase carbon dioxide emissions in the future as their economies develop and their per capita usage of energy increases.

Land use changes

The burning of fossil fuels is not the only way in which carbon dioxide can be released into atmospheric. Large amounts are also produced as a consequence of land use changes. In fact, it is only since about 1960 that emissions from fossil fuel combustion have become more important. Up until then, the rise in the atmospheric concentration of carbon dioxide can be largely ascribed to deforestation and agricultural changes. Land use changes can release carbon dioxide into atmosphere by causing the oxidation of carbon compounds in the vegetation or the soil. The burning of forests for the purpose of land clearance releases carbon dioxide rapidly into the atmosphere by combustion, whereas decomposition of felled trees releases carbon dioxide more slowly. Emissions of carbon dioxide due to land use changes are greatest for developing tropical countries with large forest reserves. However, the estimated emission of carbon dioxide due to land use changes is only about 20 per cent of the total.

Deforestation

Most of the deforestation at present takes place in the tropical forests of South America, Southeast Asia, and Africa. The latest published figures from satellite surveillance indicates that 150,000 square km of tropical rainforest in the Amazon Basin fell to deforestation in the decade 1978-1988. This deforestation takes place as a result of a complex mix of economic, political, and historical factors within the developing countries of the tropics.

There is another aspect of human activity that may be affecting the fixing of carbon in the biomass. Life depends on the availability of the inorganic nutrients nitrogen and phosphorus. We have altered the natural abundance of these nutrients with intensive applications of fertilisers. In the middle to late 1980s roughly 70×10^9 kg of nitrogen were applied to fields mostly some parts of middle latitudes of the Northern Hemisphere.

(ii) Methane

Methane is produced as a by-product of a number of anaerobic (oxygen-deficient) chemical reactions in the land portion of the biosphere. The main sources of methane are emissions from natural wetlands, rice fields, and animal digestive processes. Additional sources include: methane emissions released as a result of drilling for natural gas and oil, burning of vegetation, the prolific eating habits

of termites, and the anaerobic decay of organic material in landfills.

A methane molecule is much more effective in absorbing infrared radiation and has 11 times more global warming potential than a carbon dioxide molecule (IPCC, 1992). Thus methane is an important greenhouse gas, even though its amount in the atmosphere is small. The atmospheric concentration of methane has increased by 1060 parts per billion (151%) since 1750 and continue to increase in the 20th century.

(iii) Chloro Fluoro Carbons (CFCs)

CFCs were developed for industrial purposes such as refrigerants, spray-can propellants, and solvents. They are also among the most potent greenhouse gases capable of destroying stratospheric ozone. In the early 1990s, levels of CFCs in the atmosphere were growing at rates of 4-10 percent. Other halocarbons, such as Halon-1211 and halon 1301, were growing at a rate of as much as 15 percent. CFCs do not react readily with other chemicals. The non-reactive characteristic of CFCs is their chief liability once they enter the atmosphere. They are destroyed by ultraviolet solar radiation in the stratosphere at a very slow rate, which gives them a long lifetime.

(iv) Nitrous oxide

The third highest concentration among the greenhouse gases is nitrous oxide. Nitrous oxide is produced naturally from a variety of chemical reactions in land biota and in the oceans. Human activities such as combustion and the use of fertilisers have increased the amount of this substance in the atmosphere. Its pre-industrial concentration was about 0.27 parts per million volume, and that grew to 0.314 parts per million volume by 1998 (IPCC 2001).

(v) Sunspots variations

The leading hypothesis in climate science is that most of the warming during the 20th century was due to man-made gases, enhancing the natural greenhouse effect that reduces heat loss into space. There is also renewed attention to natural changes in climate due to the Sun. There is a link between Sunspots and climate that has been a popular idea for 200 years, but recently measurements by spacecraft cast doubt on it. They showed that the Sun is brighter when there are many Sunspots, at the climax of each sunspot cycle of roughly 11 years, but the variations seemed too small to have a major effect on climate.

During the past ten years astronomers and solar-terrestrial physicists have reappraised the role of the Sun. Some American Scientists have argued

that previous changes in Sun's brightness were greater than those seen during the short period of satellite measurements. In Europe, there has been more emphasis on other ways in which the Sun may affect the climate, either by invisible X-rays and ultraviolet radiation which peak where there are many Sunspots, or by the solar wind, which blows non-stop from the Sun and became more vigorous during the 20th century.

Mike Lockwood studied the results from the ESA-NASA solar spacecraft Ulysses and deduced that the magnetic field carried by the solar wind has doubled in strength since 1990. And the climate record from weather satellites, showing changes in the Earth's cloud cover, suggest that cloud formation is affected by cosmic rays arriving from the Galaxy. When the Sun is most active, there are fewer cosmic rays and fewer clouds. There are correlations between sunspot cycles and climatic effects. It is known that thunderstorms and lightning activity increase worldwide during peak periods of sunspot activity.

The Effects of Global Warming and Climate Change

The effects of global warming and climate change already visible. Examples include: the shrinking Arctic ice cap; accelerating sea level rise; receding glaciers worldwide; thawing permafrost; earlier breaking-up of river and lake ice; increasing intensity and duration of tropical storms; lengthening of mid-to high-latitude growing seasons; and affecting agriculture and agro-based industries, plants and animals and their behaviours and human health.

(i) Shrinking Arctic sea ice

There are important geographical and political distinctions between the Arctic and Antarctic. The arctic is a partially-frozen ocean surrounded by a diversity of landscapes influenced by seasonal snow cover and permafrost, including ice, sparsely-vegetated barren lands, tundra, wetlands and forests. The Arctic Ice Cap consists of glaciers, ice sheets, icebergs and sea ice. Sea ice covers approximately 7.5 to 15 million square kilometres of the Arctic Ocean, with an average thickness of about three metres. During the summer, 10 to 15 percent of the Arctic Ocean is not covered by ice. Greenland Ice Sheet is the largest Arctic glacial mass. It constitutes 10 percent of the world's total freshwater reserves. Melting of sea ice will not increase sea levels, but if all the Green ice were to melt, the sea level in the world's oceans would rise by 7 metres.

(ii) Sea level rise

In the past 100 years, global sea level rose between 1 and 2 millimeters a year. Since 1992, the rate has increased to about 3 millimeters a year, primarily through thermal expansion of warming oceans and freshwater flowing into the oceans from melting ice. Melting ice is responsible for a significant portion of the observed sea level rise, with the Greenland and Antarctic ice sheets the largest contributors. The Greenland Ice Sheet is melting faster than new ice is being formed. Antarctica is a continent surrounded by ocean. It is the coldest, windiest and driest continent on the earth. Almost entire continent is covered by an ice sheet with an average height above sea level of approximately 2,500 metres. Antarctic ice sheet has an average depth of around 2000 metres. The largest depth that has been measured is approximately 4,700 metres. The amount of ice in Antarctica constitutes about 91 percent of the world's total. If all Antarctic ice were to melt, sea level would rise by more than 60 metres.

Initial estimates of global warming and the rise in sea level suggested a rise of between 10-30 cm by 2030, and 33-75 cm by 2070, compared with present sea level. The most recent estimates, however, have revised these figures downwards and suggested a global sea level rise of 2-4 cm per decade due to thermal expansion of ocean water alone.

(iii) Receding glaciers

In China, highland glaciers are shrinking each year by an amount equivalent to all the water in the Yellow River. The Chinese Academy of Science says that 7 percent of the country's glaciers are vanishing annually. By 2050, as many as 64 percent of the country's glaciers will have disappeared. An estimated 300 million people live in China's north west and depend on water from glaciers for their survival.

(iv) Increasing tropical storms

Scientists know that warm sea surface temperatures provide the energy source for tropical storms, but many other factors influence whether hurricanes form and which way they go. Scientists projected current climate conditions for 2080 using nine different global climate models. Comparing the results, they found that global warming would increase hurricane intensity by 8 to 16 percent, with rainfall increasing by 12 to 26 percent within 60 miles of the storm centre. Meanwhile, sea level

rise due to global warming will push shorelines inland by 400 feet or more in low-lying areas, making storm surges even more damaging.

(v) Effects on agriculture and agro-based industries

Although crop yields may increase in some areas due to climate change; the negative effects are likely to dominate as warming increases. Africa is especially vulnerable, and there may be a significant increase in hunger. Poor communities are most directly dependent for their livelihoods on a stable and hospitable climate. They often rely on rain-fed subsistence agriculture, and are deeply dependent on climatic phenomena, such as the Asian monsoons. The cereal production in developing nations would decline by around 10 percent as a result of climate change.

A comprehensive regional study of the impacts of global warming in California shows that higher temperatures and summer water shortages would seriously harm California's \$30 billion agricultural industry. Alpine meadows in the Rocky Mountains to disappear, sugar maple trees to vanish in the Northeast, and greater risk from storm surges in the Southeast. Rising temperatures will also exacerbate water shortages in the west. As glaciers melt in the world's great mountain ranges, water supplies to rivers will be affected. In Europe, eight out of nine glaciated regions show significant retreat. Between 1850 and 1980, glaciers in the European Alps lost approximately one-third of their area and one-half of their mass.

This is also bad news for everyone who enjoys the fruit of their vines. The quality of California wine grapes would be degraded by excessive temperatures during ripening. An increase in temperature will move the northern boundaries for crops further north, altering the range of crops available to farmers. A 1°C increase in temperature may move the northern agricultural boundary 150-200 km further north. (Graves et al, 1996).

(vi) Effects on plants and animals and their behaviour

Antarctica has no native terrestrial vertebrates, but large populations of marine birds and seals go there to breed. A large proportion of the world's seals are found in the ocean surrounding Antarctica. In the summer season, both toothed whales and baleen whales are present in the Antarctic marine environment. Around 45 species of nesting birds are found south of the Antarctic Convergence, all of which are connected to the marine ecosystem. Penguins constitute 85 percent of the biomass of

Antarctic sea birds. In the Antarctic, three large sections of ice shelves in the Antarctic Peninsula have collapsed over the past 11 years.

The Arctic is warming twice as fast as the global average. NASA satellite images show a 20 percent decline in summer arctic sea ice since 1979, while Antarctica glaciers are melting faster than expected accelerating sea level rise. Since 1980, between 20 and 30 percent of sea ice in the European Arctic has been lost. Some climate models project that there may be an almost complete loss of summer sea-ice in the Arctic before the end of the century. If this happens, polar bears are unlikely to survive as a species. The Arctic Climate Impact Assessment found that in Alaska, western Canada and eastern Russia average winter temperatures have increased as much as 4° to 7°F in the past 50 years. Hunting has become more difficult and dangerous due to less reliable sea-ice conditions.

Coral reef is thought to host the most species-rich communities of the marine environment. They are comparable to tropical rainforest in that damage to their ecosystems may affect thousands of species adversely. Two thirds of all marine fish species are associated with tropical reefs where many human societies are depended on coral reefs for food, sport, protection of shorelines from storm damage, and tourism. All the nucleus of the coral reefs that have photosynthetic plant cells living symbiotically in their tissues. This plant-animal partnership is responsible for an efficient recycling of nutrients. Geologically, reefs are made up of calcium carbonate produced by corals and other organisms, most notably coralline algae that has accumulated layer upon layer over thousands of generations. Reef communities are dependent on this reef structure for substrate and shelter and also on the reef's primary production, to which the corals and algae make substantial contribution.

In the tropical waters, no reef occurs where the waters are too deep, too muddy, too diluted by fresh water, or too hot. No corals reefs occur where temperatures exceed 30°C for extended periods. It is also noted that many coral reef are already near their upper thermal limit, at least for some months of the year. Thus, the small increases of 2°-3°C that are predicted for the surface waters of tropical oceans have profound implications for the structure, function, and distribution of reef ecosystems.

At least three major effects of temperature increase on coral reef may be identified. The first is physiological. Corals may expel their symbiotic algae in response to heat stress so that they appear bleached. Without those cells, corals cannot grow, and unless the algae become reestablished, the corals die within a few months. Warming of tropical eastern Pacific waters contributed to wide-spread coral bleaching and death in 1982-83, and surface water temperatures above 30°C are thought to have been responsible for the wider spread bleaching of corals in the Caribbean Sea in 1987 (Roberts, 1987).

Second, mechanical damage to reefs could increase. If corals die and reef growth stops, the reef will become more vulnerable to erosion. Further more, warming of tropical oceans may increase the frequency of hurricanes. Mechanical damage due to storms is a major source of coral mortality. Hurricanes can strip all living corals from long stretches of reef. Third, thermal expansion of ocean water, among other factors, causes elevation of sea level. The rate of sea level rise may affect the extent, structure and functioning of coral reef communities. Elkhorn, staghorn and fused-staghorn coral, which live in the Caribbean and off the southeast coast of Florida, have declined up to 98 percent in the past 30 years, largely due to global warming.

New research shows that carbon dioxide is a direct threat to corals because ocean water becomes more acidic (lower pH) as it absorbs some of the CO₂ emitted by power plants, automobiles and other sources. With corals already suffering from rising temperatures, the additional stress of falling pH could push them over the edge. The oceans have absorbed approximately half of the CO₂ produced in the past 2000 years, producing carbonic acid and lowering the pH of surface seawater. This could affect the process of calcification by which animals such as corals and molluscs make their shells from calcium carbonate.

Animal and plant species have begun dying off or changing sooner than predicted because of global warming. These fast-moving adaptations come as a surprise even to biologists and ecologists because they are occurring so rapidly. At least 70 species of frogs, mostly mountain-dwellers that had nowhere to go to escape the creeping heat, have gone extinct because of climate change, the analysis says. It also reports that between 100 and 200 other cold-dependent animal species, such as penguins and polar bears are in deep trouble.

For millennia, the Inuit have lived in the Arctic coastal areas of Alaska, Canada, Russia and Greenland. Like many indigenous peoples, the Inuit are the product of the physical environment in which they live. The culture, economy and identity of the Inuit as an indigenous people depend upon the ice and snow. Climate change now threatens the Inuit's human rights to culture, life, personal security, health, housing and food.

(vii) Health effects

Hotter temperatures caused by global warming will accelerate formation of the lung-damaging pollution commonly known as smog, significantly reducing the number healthy air days enjoyed by residents in more than a dozen cities in the USA. The residents of the inner city are particularly vulnerable to the effects of global warming and climate change. The most threat is from heat waves. Exposure to excessive heat caused over 8,000 deaths in the United States between 1979 and 1999. Extreme heat waves caused more than 20,000 deaths in Europe and more than 1500 deaths in India during 2003. Higher temperatures also elevate the level of ozone smog in urban areas, which contributes to excess mortality and triggers more asthma attacks.

Conclusion

The scientific findings released over the last few years show the humankind's impact on earth's climate. Given this growing body of evidence, we must act now to reduce pollution from vehicles and power plants. By deploying already available technologies, it is possible to prevent a doubling of carbon dioxide in the atmosphere during the next 50 years and avoid the most dangerous threats from global warming. Any delay would be dangerous, because an additional warming of merely one degree Celsius could be enough to trigger the eventual disintegration of ice sheets in Greenland and parts of Antarctica.

The international community needs to work together immediately, not only to stabilise the level of heat-trapping greenhouse gases, but also to develop alternative technologies in order to move away from our dependence on fossil fuels. Delaying action will only make it "more disruptive and more expensive" to deal with global warming. Substantial reductions in emissions can come from improvements in fuel efficiency of cars and trucks, policies that require energy efficiency and the use of renewable energy, and long-term investments in new technologies like hydrogen fuels and bio fuels.

Carbon dioxide is the main greenhouse gas, and slowdown of its emissions must have priority. It will be a growing issue in international relations for decades. 'Kyoto' gives too little or no weight to gases such as methane, the trace gas HFC-134a, ozone and the precursor gases that form ozone. The slowdown in the growth rate of the GHGs contribution to global warming from the peak in the 1980s is due mainly to the phase out of CFCs as dictated by the Montreal Protocol. This success could be diminished by increases of other trace gases not controlled by the Montreal Protocol. Therefore, it is well worth extending the Montreal Protocol machinery to phase out many of these trace gases.

More than half of all humanity has probably always lived within coastal areas of the world, and that proportion is increasing rapidly. Human activities have already caused extensive alteration of natural coastal ecosystems, which can ill afford further damage. Therefore, natural and international efforts to protect coastal areas should be given the highest priority, and long-term plans should include provisions for dealing with climate change. Climate change cause profound changes in the ecology of marine systems, but also climate change will add stress to systems that are already experiencing increasing and often severe disruption from other human activities, including pollution, habitat destruction, and over harvesting of the seas.

Finally, how strongly does the Sun vary and to what extent does it influence the Earth's Climate? It is important to find answer to this question in order to put the Solar contribution within the global warming debate and particular to determine its weight relative to that of the man-made greenhouse gases. At present, the question of the Sun's contribution to global warming can only be partly answered.

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