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CLIMATE CHANGE, GLOBAL WARMING AND ITS IMPACTS ON OCEANS

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ABSTRACT

An abrupt climate change occurs throughout the world. The levels of greenhouse gas CO_2 are increasing in different parts of the world. The other greenhouse gases are water vapors, methane, ozone, nitrous oxide, fluorinated gases. The greenhouse effect is a process that keeps the earth warm enough for people, plants and animals to live on. Over the past decade the surface air temperatures have not risen very much whereas the temperatures of deep oceans have risen very much. Oceans store 97% of world's water. This water absorbed the 90% of energy of the atmosphere. The increase in the energy and temperatures of the earth is due to increase in the greenhouse gases. The human activity is changing the amount of greenhouse gases by three ways. The rain forests are cut down. The fossil fuels are being burned. The world's population has been increased. Global warming is affecting the world. The oceans and atmosphere interact both physically and chemically. They exchange energy, water, gases and particles. This exchange influences the earth's climate. It also changes the state of oceans. The salinity of the oceans has been changed, which accelerated the global rainfall and evaporation, which is responsible for climate change. The sea levels are expected to rise as the water expands due to rise in temperature. The sea levels also rise as a result of melting of polar caps. Rising sea levels impact many coastlines, and a large mass of humanity lives near the coasts or by major rivers. More CO_2 in the atmosphere more CO_2 in the oceans. This CO_2 is dissolved in water and reacts with it forming carbonic acid. The water becomes more acidic. This acidification of water significantly impacts upon the health of some fish and coral species. There are many millions of species in the oceans and each will have different sensitivities to acidification and respond in different ways. It is likely that acidified sea water will alter the makeup of marine ecosystem.

Key words: Global warming, Greenhouse gas, Fossil fuels.

INTRODUCTION

An abrupt climate change occurs when the climate system is forced to transition to a new state at a rate that is determined by the climate system itself, and which is more rapid than the rate of change of the external forcing[1]. The scientists found that over the past

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decade, while surface air temperatures have not risen very much, there has been a warming of the deep oceans that is unprecedented over the past 50 years. They also found acceleration in the overall warming of the Earth. More heat is being transferred to the deep ocean layers, due to changes in wind patterns associated with an ocean cycle called the Pacific Decadal Oscillation.

The global warming is due to the increase in the green house gases. Global warming is the rise in the average temperature of Earth's atmosphere and oceans since the late 19th century and its projected continuation. Since the early 20th century, Earth's mean surface temperature has increased by about 0.8°C (1.4°F), with about two-thirds of the increase occurring since 198[2]. Warming of the climate system is unequivocal, and scientists are more than 90% certain that it is primarily caused by increasing concentrations of greenhouse gases produced by human activities such as the burning of fossil fuels and deforestation[2-5]. These findings are recognized by the national science academies of all major industrialized nations[6].

Greenhouse effect

The greenhouse effect is a process that helps keep the Earth warm enough for people, plants and animals to live on. Think of the Earth like a giant greenhouse. Imagine the Earth's atmosphere like the glass of a greenhouse. Both the gases of our atmosphere and the glass of a greenhouse trap the sun's heat energy inside keeping the temperature balanced; not too hot or too cold. This is why some of the gases in our atmosphere are called "greenhouse gases".

The greenhouse gases in the atmosphere trap the infrared radiation and then raise the temperature of the lower atmosphere and the Earth's surface. The increased greenhouse gases increase the greenhouse effect and create global warming.

Earth's greenhouse effect is due to the presence of greenhouse gases in the atmosphere.

Water vapor increases most of the global warming, which is not directly influenced by human activity.

Greenhouse gases

The following are the greenhouse gases, whose concentrations are increased by human being.

CO_2: Its concentration is increased due to burning of fossils fuels such as coal, oil and gas. Deforestation also increases its concentration. CO_2 accounts for 75% of the warming effect from human created greenhouse gases.

Methane (CH_4): Methane accounts for about 14% of human created greenhouse gas emissions. Methane is produced from agriculture, fossil fuel extraction and the decay of organic waste. Methane doesn't persist in the atmosphere as long as CO_2.

Nitrous oxide (N_2O): Accounts for around 8% of the warming impact of current human greenhouse gas emissions. N_2O is produced due to nitrogen-fertilized soils and livestock waste and industrial processes. Warming effect of N_2O is more than CH_4.

Fluorinated gases: Accounts for around 1% of the warming impact of current human greenhouse gas emission. F-gases are even more potent per gram than nitrous oxide.

A clear change in salinity has been detected in the world's oceans, signaling shifts and acceleration in the global rainfall and evaporation cycle tied directly to climate change.

Scientists monitor salinity changes in the world's oceans to determine where rainfall has increased or decreased.

The ocean matters to climate: It stores 97 percent of the world's water; receives 80 percent of all surface rainfall, and it has absorbed 90 percent of the Earth's energy increase associated with past atmospheric warming. "Warming of the Earth's surface and lower atmosphere is expected to strengthen the water cycle largely driven by the ability of warmer air to hold and redistribute more moisture".

Coral reefs and mangrove forests contribute greatly to tropical coastal productivity and provide habitat for myriad fish and other species. These important ecosystems are under unprecedented pressure around the world due to declining water quality, overexploitation, and climate change.

Atmospheric levels of CO_2, the main greenhouse gas, measured from many locations around the world have been rising steadily for decades and the rate of increase is accelerating. This includes measurements taken for CSIRO Gas lab from the AIMS headquarters site at Cape Ferguson in North Queensland, where the level of atmospheric CO_2 has risen from 355 parts per million (ppm) in 1992 to 385 ppm in 2009, a steady increase of approximately 1.7 ppm per year and consistent with the 40% increase since the late 18th century (World Data Centre for Greenhouse Gases).

The amount of CO_2 in the atmosphere is known to be increasing and about 30% of the extra CO_2 dissolves into the ocean. As a consequence of this CO_2 absorption the chemistry of the oceans is changing and becoming more acidic.

A growing body of experimental evidence is showing that seawater acidified to mimic potential future scenarios significantly impacts upon the health of some fish and coral species. There are many millions of species in the ocean and each will have different sensitivities to acidification and respond in different ways. No single species lives in isolation and how the effects seen at an individual species level translate to an ecosystem response is not yet fully understood. It is likely that acidified seawater will alter the makeup of marine ecosystems.

The oceans and atmosphere interact constantly-both physically and chemically-exchanging energy, water, gases, and particles. This relationship influences the Earth's climate on regional and global scales. It also affects the state of the oceans.

Covering about 70 percent of the Earth's surface, the oceans store vast amounts of energy absorbed from the sun and move this energy around the globe through currents. The oceans are also a key component of the Earth's carbon cycle. Oceans store a large amount of carbon, either in dissolved form or within plants and animals (living or dead).

As greenhouse gases trap more energy from the sun, the oceans are absorbing more heat, resulting in an increase in sea surface temperatures and rising sea level. Although the oceans help reduce climate change by storing one-fifth to one-third of the carbon dioxide that human activities emit into the atmosphere, increasing levels of dissolved carbon are changing the chemistry of seawater and making it more acidic.

Changes in ocean temperatures and currents brought about by climate change will lead to alterations in climate patterns around the world. For example, warmer waters may promote the development of stronger storms in the tropics, which can cause property damage and loss of life. Other impacts come from increased ocean acidity, which reduces the availability of some types of minerals, thus making it harder for certain organisms, such as corals and shellfish, to build their skeletons and shells. These effects, in turn, could substantially alter the biodiversity and productivity of ocean ecosystems.

On the broadest scale, the rate at which energy is received from the sun and the rate at which it is lost to space determine the equilibrium temperature and climate of Earth. This energy is distributed around the globe by winds, ocean currents, and other mechanisms to affect the climates of different regions.

There is a great deal of concern over the potential impact of climate change on coral reef ecosystems. Both increasingly levels of acidity, which reduce the ability of coral to generate their main structural material, and higher sea temperatures, which can cause "bleaching" or expulsion of the symbiotic algae that enable corals to feed, are cited as the primary risks to reefs in a world of higher atmospheric carbon dioxide levels.

Ocean acidification is an effect of rising concentrations of CO_2 in the atmosphere, and is not a direct consequence of global warming. The oceans soak up much of the CO_2 produced by living organisms, either as dissolved gas, or in the skeletons of tiny marine creatures that fall to the bottom to become chalk or limestone. Oceans currently absorb about one ton of CO_2 per person per year. It is estimated that the oceans have absorbed around half of all CO_2 generated by human activities since 1800 (118 ± 19 pentagrams of carbon from 1800 to 1994)[7].

In water, CO_2 becomes a weak carbonic acid, and the increase in the greenhouse gas since the Industrial Revolution has already lowered the average pH (the laboratory measure of acidity) of seawater by 0.1 units, to 8.2. Predicted emissions could lower the pH by a further 0.5 by 2100, to a level probably not seen for hundreds of millennia and, critically, at a rate of change probably 100 times greater than at any time over this period[8,9].

There are concerns that increasing acidification could have a particularly detrimental effect on corals[10] (16% of the world's coral reefs have died from bleaching caused by warm water in 1998[11], which coincidentally was the warmest year ever recorded) and other marine organisms with calcium carbonate shells[12].

Coral reefs not only serve as home to multitudes of fish, coral and invertebrate species. Perhaps more importantly, they serve as the livelihood for millions of people worldwide. Reefs are vitally important as sources of food, cultural heritage, tourism income, protection from storms and pharmaceuticals. The health of coral reefs has been in serious decline the last few decades due to poor water quality, increasing disease, overfishing and coastal development. Even as aquarists have sought to bring the beauty of coral reefs into their homes, some unscrupulous fish and coral collectors have damaged reefs. Now, warming seas are stressing corals, causing more frequent and larger bleaching events, while ocean acidification has slowed the growth of corals. The ever-growing impact of climate change has the potential to deal a devastating blow to those reefs that remain. The future of our reefs is not lost, but to protect the reefs, immediate action is required to reduce the negative impacts of both climate change and local threats.

Corals are animals that live in a mutualistic symbiotic relationship with single-celled plants, algae known as zooxanthellae. A mutualistic relationship is one in which both partners benefit. In this case, the coral provides a safe, protected place for the zooxanthellae to live. In turn, through photosynthesis, the zooxanthellae use solar energy to convert carbon dioxide and water into oxygen and carbohydrates. The corals then use these carbohydrates as their major food source. The algae also give the corals their characteristicly brilliant colors.

As with all organisms, both corals and zooxanthellae have optimal temperature ranges in which their systems function efficiently. But high temperatures stress both corals and zooxanthellae, much like our bodies can become stressed on hot, humid days.

Zooxanthellae become more sensitive to the bright tropical sunlight, which causes their photosynthetic process to break down. When this happens, they become toxic to the corals. To protect themselves, the corals expel the zooxanthellae. This process is called "coral bleaching" because the corals turn a pale white color when the zooxanthellae are gone.

In addition to the stress of warming ocean temperatures, oceans are becoming more acidic, thus slowing coral growth and hindering the ability of corals to build their skeletons.

As the ocean takes up CO_2 from the atmosphere, water becomes more acidic and the concentration of carbonate ions in the water decreases. Corals require these carbonate ions to form their calcium carbonate skeletons. As ocean acidification continues, some coral reefs may no longer be able to grow fast enough to keep up with the natural forces that break them down.

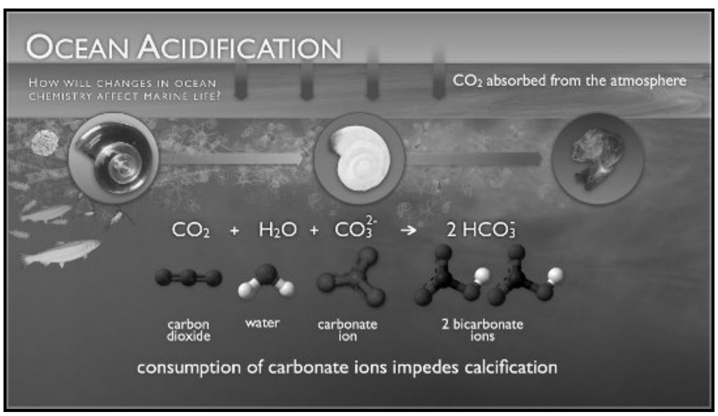

Fig. 1: Ocean acidification

The impacts of climate change are diverse and could be damaging to billions of people across the world, particularly those in developing countries who are the most vulnerable. Many of the effects of climate change will have negative economic consequences. The number of severe weather events, for example, is likely to increase and intensify as a result of climate change, which could result in billions of dollars in economic damage annually[13].

Intensified and more frequent weather events

The number of extreme weather events, such as heat waves, precipitation, floods, droughts, hurricanes, avalanches, and windstorms is expected both to increase and intensify because of climate change[14].

Recent events demonstrate the consequences of extreme weather. In 2003, an abnormal and extreme heat wave in Europe killed more than 35,000 people. In 2005, at least 1,300 people died as a result of Hurricane Katrina, which hit the U.S. Gulf Coast causing an estimated $ 135 billion in economic damage[15]. New evidence shows that the recent increase in hurricane intensity is due to climate change, and above figure depicts the rise in category 4 and 5 hurricanes around the world since 1975. A study published in 2005 in the journal Nature links hurricane intensity and duration to the recent ocean-warming trends associated with climate change. This study also found that over the past three decades, the destructive power of hurricanes in the Atlantic and Pacific has doubled[16].

Although no one particular heat wave, hurricane, or other extreme weather event can be attributed directly to climate change, it will likely cause these extreme weather events to intensify and occur more frequently over time.

Rising sea levels

Water expands when heated, and sea levels are expected to rise due to climate change. Rising sea levels will also result as the polar caps begin to melt.

Sea levels around the world are rising faster because of the melting of land-based ice and the thermal expansion of oceans. According to the Arctic Climate Impact Assessment (ACIA, an intergovernmental forum composed of the eight arctic nations)[17], in the past two decades the global sea level has risen by an average of 8 centimeters (3 inches), and projections show an additional rise of 10 to 90 centimeters (4 inches to 3 feet) during the twenty-first century[18]. This rise in sea level, coupled with heavier than usual precipitation, may increase the risk of flooding for tens of millions of people in coastal areas across the world[19].

Of particular concern is the Greenland Ice Sheet, which has been melting since 1979 more quickly than expected. Models indicate that over the longer term, climate change may eventually lead to its melting completely, which would raise the sea level by about 7 meters (23 feet)[20].

Rising sea levels is affecting many small islands. Earth's ice cover is melting in various places and at higher rates. Rising sea levels impact many coastlines and human beings living near the coasts and major rivers. Many cities in the world are not prepared for climate change effects such as rising sea levels.

The resulting changes in the chemistry of oceans disrupts the ability of animals to make shells and skeleton of calcium carbonate. The shells which are already formed dissolve.

There are dead zones (areas where there is too little oxygen in the sea to support life) which decline important coastal plants and forests as mangrove forests that play an important role in carbon absorption.

Disruption of the ecosystem

Climate change could magnify the cumulative impacts of other ecosystem stresses caused by human development, such as air and water pollution and habitat destruction. Natural systems, including glaciers, coral reefs, mangroves, boreal and tropical forests, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands, are particularly vulnerable and may be damaged irreversibly[19]. Considerable harm has already been done. For instance, according to the millennium ecosystem assessment, in the last several decades of the twentieth century, about 20 percent of the world's coral reefs were lost, and an additional 20 percent were degraded. This report also states that "by the end of the century, climate change and its impacts may be the dominant driver of biodiversity loss and changes in ecosystem services globally[21]. Changes in ocean water temperature and salinity as well as in CO_2 concentrations in ocean waters may compound other stresses placed on the world's fisheries, which would particularly hurt the poor. One billion people, mostly in developing countries, depend on fish for their primary source of protein[22].

Habitat destruction and species extinction

Habitat loss and ecosystem changes are expected to bring about a decline in the local diversity of native species by 2050, and the rate of extinction for these species may be hastened by climate change[21]. In the Arctic, warmer temperatures and melting sea ice caused by climate change will be particularly harmful to native species like polar bears and ice-dependent seals. It is unlikely that these species will survive the century if climate change persists[20].

Happening now

The surface of the world's oceans has become warmer overall since 1880. In this graph, the shaded band shows the likely temperature range, which depends on the number of measurements and the methods used at different times.

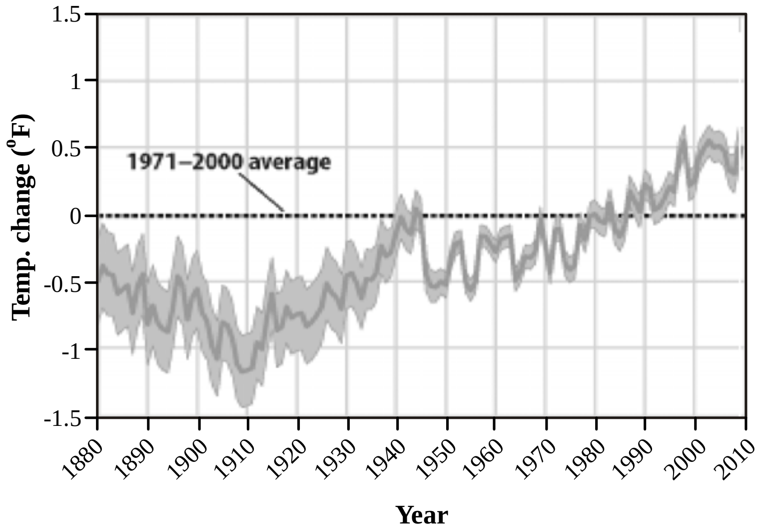

Fig. 2: Average ocean temperature worldwide

Overall, the world's oceans are warmer now than at any point in the last 50 years. The change is most obvious in the top layer of the ocean, which has grown much warmer since the late 1800s. This top layer is now getting warmer at a rate of 0.2°F per decade.

Oceans are expected to continue getting warmer-both in the top layer and in deeper waters. Even if people stop adding extra greenhouse gases to the atmosphere now, oceans will continue to get warmer for many years as they slowly absorb extra heat from the atmosphere.

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