SYSTEMS OF THE EARTH

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Introduction

When looking at the systems of the Earth, we find that they are a complex web that ties together vastly different systems. It is a critical thought to keep in mind when we examine how the climate system of the planet works, and how climate change and ocean degradation brought about by human impacts have changed that system. We also need to consider our current and future actions if we want to maintain the Earth in a condition suitable for Human civilization. To that effect, in this paper, we look at the underlying processes behind the greenhouse cycle of the planet, and how we have interfered with our actions.

Greenhouse cycles

The sun is the energy source that fuels the Earth's greenhouse cycle. The energy entering the Earth's atmosphere is considered short wave radiation. That energy is then absorbed by the ground and oceans, with some reflected into space according to their albedo rating. Albedo is the ability of a surface to reflect incoming light; darker materials such as vegetation and the oceans reflect very little energy and, as such, have a low rating. Elements like snow and ice reflect more of the incoming energy and have a high albedo rating. The effect on climate starts with the amount of energy either absorbed or reflected by the Earth. Large amounts of ice, snow, and cloud cover will reflect the energy of the sun and cool the planet by limiting the amount of incoming energy that can be absorbed.

In contrast, large areas of land with vegetation and areas of open ocean absorb that energy and cycle it into the greenhouse effect. The energy that is absorbed is then re-radiated into the atmosphere as long wave or heat radiation. This energy interacts with the atmosphere in a couple of different ways. Some is lost to space, while the rest is captured by greenhouse gasses in the atmosphere and then re-radiated again, increasing the amount of heat retained. This energy is often captured and released multiple times, increasing the amount of heat energy contained in the atmosphere and oceans.

Studies have shown that water vapor and CO2 are the primary greenhouse gasses in our atmosphere. Studies have also shown that CO2 is the dominant factor that controls climate change. CO2 is a long-lived gas in the atmosphere, while water vapor and clouds are a more active part of the climate system that is continuously cycling between water and vapor states in various weather systems. When looking at the percentages for how each gas affects the planet, we see that water vapor and clouds account for around 75% of the greenhouse effect, with CO2 at 20% and other GHGs at about 5%. Because water vapor is considered a fast responder and CO2 with the remaining GHGs are classified as forcers, we then see that the 25% total of gasses in the atmosphere drives the entire greenhouse effect. We can also then infer that without the gases such as CO2, the Earth would be rapidly cooling into another glacial state. (Lacis, 2010)

CLIMATE CHANGE

Over geologic time scales, volcanic activity tends to be the primary source of CO2 in the atmosphere. While drawdown from weathering of rocks acts as the principal carbon sink of the planet. Since both processes operated independently of each other, there can be significant fluctuations in how much CO2 is in the atmosphere. This can lead to conditions of extreme glaciation to periods of hothouse conditions. As a matter of fact, for a million years, the Earth has gone from glaciation to more moderate conditions repeatedly. The critical point to consider when looking at conditions today is that very rarely would CO_2 levels in the atmosphere rise about 300 parts per million. In contrast, today, we have increasing levels over 415 ppm. We also need to keep in mind that CO_2 can stay in the atmosphere for hundreds and even thousands of years.

Another point we need to consider is the exponential increase in emissions from industry and power plants. Our dependence on oil and gas has led us to a tipping point when we are looking at the future of the planet. Every year we produce billions of tons of CO_2 and other GHGs that our world has to deal with. With the industrialized nations wanting to keep their lifestyles, and the developing countries driving to reach the same levels, we have a nearly logarithmic increase every year of emissions that our supporting industries put out. When we consider the vast amount of pollution we emit every year, we need to also look at how the planet deals with it.

A significant factor we need to consider is that a large amount of the increase of CO_2 in the atmosphere is due to the destruction of vast areas of forest for agriculture and animal use. The biosphere is considered a massive sink for much of the GHGs we emit every year, but we have been consistently overwhelming that capacity. Another important sink is the oceans, which take in about one-third of all CO_2 emissions during the year, and we will talk about later in this paper.

One more consideration we need to include is the fact that another GHG, methane, is considerably more potent than CO_2 as a heat forcer. With more methane released from natural gas usage, we have to add that into our calculations when considering climate change. When considering methane, we also need to acknowledge that a large percentage of methane released comes from the global livestock industry. Over forty percent of livestock emissions are in the form of methane, with the rest a mixture of CO_2 and nitrous oxides (potent GHGs). In total, GHG emissions from various livestock contribute around 15% of the total amount released into the atmosphere every year. While this is not a huge amount compared to the emissions other industries release, it is still a significant factor we need to keep in mind. (Wolf, 2017)

OCEAN DEGRADATION

Effects on oceans from climate change due to land use come in a variety of ways, deforestation, and land-use changes contribute to higher CO_2 and Methane levels in the atmosphere, which then affects oceans. Another pathway of change is the land-use runoff of those same pollutants.

Current estimations state that we currently have more land devoted to agriculture and livestock than in all previous centuries combined. Add to that the fact that we are using vast amounts of synthetic fertilizers, nitrogen oxides and CO_2 from coal, oil, and natural gas, and untreated animal wastes that are producing large quantities of methane, and you will see that we are overloading the ocean's capacity to absorb all of our waste products. The presence of all these material acts as a super fertilizer to marine plant life, especially phytoplankton. This frequently causes massive blooms that then die off and fall to the seafloor. During this process, large amounts of O2 are removed, creating dead zones where no sea life survives. (Dbyas, 2005)

These dead zones have increased every year, and while most are seasonal, there is an increasing amount that has become year-round phenomena. Fed by both atmospheric CO2 and nitrogen, as well as by the excess fertilizers and wastes washed into the ocean, these zones can vary significantly in size. They are sometimes as small as section of coastal bays, to vast areas of the open ocean. Common in the more temperate waters of the globe, they tend to be found in areas like the east coast of the US, and waters off China and Japan. A vivid example of this is the dead zone in the Gulf of Mexico, which is fed by the polluted waters out of the Mississippi and the oil industries in the US south. (Dybas, 2005)

As we examine the extent of ocean degradation, we also have to look at the absorption of CO2 by the ocean waters and the effects that it has on sea life and its future ability to sequester GHGs from the atmosphere.

The rate of increase and current levels of CO2 emissions is at least a full magnitude faster that our planet has experienced in millions of years. (Doney, 2009) The increasing amounts of CO2 are mitigated by the fact that the oceans take up nearly a third of all the carbon that we are releasing into the atmosphere. Without that uptake, CO2 levels would be vastly higher than the levels we are recording today. There is a consequence, however, to the massive amount of CO2 that is absorbed. It is causing significant pH reductions, increasing the acidity levels of the waters, and changing core chemical balances that are essential to the food web of the seas. (Doney, 2009)

One of the key indicators of ocean acidification is corals. They are considered an essential group of hypercalcifiers, with the ability to produce calcium carbonate in massive amounts, but with the caveat that they are susceptible to the environmental conditions around them. (Doney, 2009)

> Analyses of cores from massive coral colonies of the Great Barrier Reef show that calcification rates declined 21% between 1988 and 2003, although this decrease exceeds that expected from lowered saturation state alone and probably reflects the composite effects of a suite of changing environmental conditions. Under increasing ocean acidification, not only will coral community calcification decrease, but also dissolution rates will increase, particularly for those reefs that are already near the limit for reef growth. (Doney, 2009 p. 175)

The impact on corals is not an isolated factor. In the oceans, there is a vastly complicated web of life that exists, and corals play a significant factor in it. They are home to numerous species of fish and plant life and are an essential source of nutrients for the fish that we harvest commercially. There is also concern that as we overload the ocean's ability to handle CO_2 and nutrient intake, there will reach a point where the exchange process between the water and atmosphere will rebound, and more of the GHGs will remain in the atmosphere to contribute to climate change.

<u>CONCLUSION</u>

As we look at the effects that climate change and ocean degradation have on the planet, we need to consider our place in it. The changes we have made and the continuing effects of the changes that we will be dealing with are a crucial challenge in how we face the need to ensure a sustainable life for ourselves. One pressing need that we have to implement as soon as possible is the switch to a greener method of power generation. Even methods such as natural gas produce more GHGs than we can comfortably afford. We must switch over to technologies such as solar and wind, to drastically cut emissions of CO_2. We should also reduce the amount of artificial fertilizer for crops, and untreated animal wastes in the livestock industry. Without these changes, we are faced with rising sea levels as ice sheets melt and oceans warm. Increased amount and severity of storms, as well as droughts in different areas of the planet. The oceans, considered a breadbasket, by many around the world, will continue to see reduced fish populations and even large-scale die-offs in large areas.

References

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