The Evolution of Climate Change

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Abstract

The continuing rise of global temperature over centuries has impacted both biotic and abiotic processes. The most significant increase in temperature occurred between 1975 and now, rising approximately 0.15-0.20˚C per decade. At this rate of increase, earthly processes cannot adapt and experience stress. When abiotic stress is too high, pieces of ice shelves break into the ocean, geological functions such as plate tectonic activity increase and the oceans chemical properties are altered.

These environmental changes also impact the stress of biological processes. When biological stress is too high, species fitness decreases, making biota unable to reproduce. If fitness decreases beyond reproductive abilities, species start to go extinct.

Climate change is more obvious individually when local weather conditions are more erratic. Terrestrial impacts are seen more quickly than oceanic impacts since the atmospheric temperature changes quicker than water. Irreversible consequences are certain if human production of carbon dioxide does not decrease.

Author Keywords

Data Science; Climate change; Environmental science; Ecological impact; Climate anomalies; Atmosphere; Ocean

ACM Classification Keywords

• Mathematics of computing~Time series analysis • Mathematics of computing~Multivariate statistics • Applied computing~Environmental sciences • General and reference~Measurement • General and reference~Validation • Computer systems organization~Real-time operating systems

Introduction

Over millennia, the Earth undergoes natural fluctuations of abiotic factors. Tectonic plates slowly shift under the ground, creating and destroying seas and oceans over hundreds of years. Climate and global temperatures rise and fall, moving through centuries of ice ages and periods of time where there is no ice on the earth. Animals must evolve to survive the natural changes of the Earth or go extinct. While these processes are natural, the existence and evolution of human technology has affected these processes.

To glimpse into past global climate, sediments are analyzed from different time periods. Other methods include tree ring analysis. Glaciers from an ice age can score rock and sediments and slow rates of growth for tree species. Both of these examples are proxy records, indirect records, and have helped build a climate timeline[23].

Almost all living creatures and most machines give off an amount of Carbon Dioxide (CO_2). While it is one of the most important greenhouse gasses[2], even seemingly helpful things have unhealthy levels. Too much oxygen or water could kill an organism. In the atmosphere, CO_2 acts as a blanket around the earth, trapping heat created by the earth or reflected off the earth from the sun. While this process is natural, the amount of CO_2 in the atmosphere currently is above any amount recorded previously, 405.0 parts per million in 2017[24].

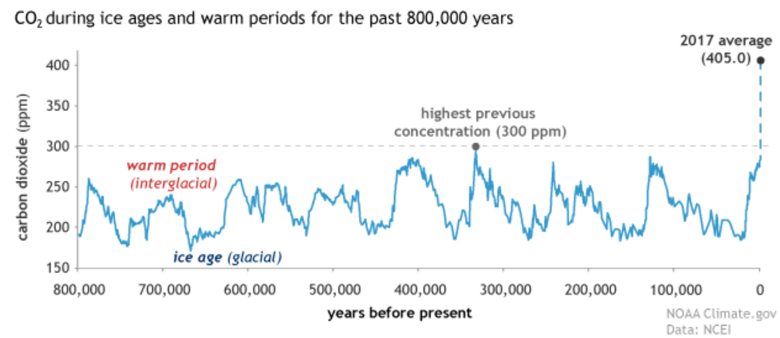

Figure 1: Graph depicting rise and fall of carbon dioxide concentrations in the atmosphere. Retrieved from https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

This exaggerated surge in atmospheric CO_2 can be traced back to the amplified use of CO_2 emitting machines beginning in the industrial revolution. This increase has impacts on both abiotic and biotic factors that could be detrimental to the current way life on earth.

Abiotic Effects

As more Carbon Dioxide (CO_2) is trapped in the atmosphere and oceans, weather events become more extreme in response. The existence of water in all three of its physical states on this planet is a critical aspect for life on Earth. With the inclusion of more CO_2 into the atmosphere, precipitation is affected[15]. The case of extremes is evident here, areas around the world that typically get a significant amount of rain are getting even more, while areas where drought is more common are getting even less rain. Also, more precipitation is in the form of rain than snow, and snow is melting faster[14]. More flash flooding occurring in early Spring has been a result of this.

Oceanic temperatures have also increased, nearly 1˚C in 100 years[25]. That change in temperature is not terribly significant in the atmosphere, but in the ocean is it more so. The amount of energy necessary to heat the entirety of the world's oceans by 1˚C is immense. There is also an issue with ocean acidification, the pH of the oceans decreasing as a result of the addition of oceanic CO_2. The more acidic a substance is, the more likely it is able to dissolve things such as shells and food sources.

Biotic Effects

The temperature and pH of the ocean are two factors that greatly affect the ocean's life. Microscopic organisms in the water column are ultra-sensitive to these changes. Numerous organisms in the ocean build shells and homes using calcium carbonate, which is a very strong substance. However, when there is the addition of CO_2 and the increase in temperature, this calcium carbonate cannot grow as thick and strong. Ocean organisms now grow thinner, weak shells that continue to dissolve as the organisms forms it. With this decreased fitness, some organisms are unable to reproduce and some even have gone extinct.

Corals are also greatly impacted by this for a similar reason. The hard structure of a coral is created by calcium carbonate, a home per say, but also a living organism. The small, feathery polyps often seen poking out of these corals is an organism called zooxanthellae, and the coral is home to thousands of these that give

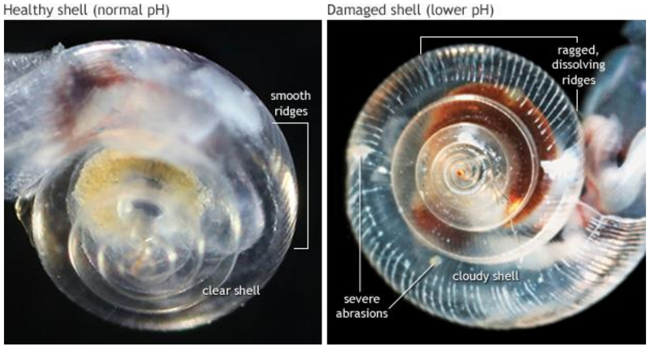

Figure 2: A depiction of the differences between a healthy microorganism shell and one under ocean acidification conditions. Retrieved from https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

the coral food to continue to grow. This is one of the largest symbiotic relationships in the ocean, but with the weaker 'home' organism as a result of ocean acidification, the zooxanthellae exit the coral, a process called bleaching. This process can essentially kill a coral reef ecosystem, the corals no longer build and give protection to smaller fish species, which in turn bring larger species of fish to feed on them so both find more suitable ecosystems.

Organisms on land also feel the pressure of these changes. As more of the glaciers in the north crumble, the population of polar bears crumbles in response. Most of a polar bear's life is spent on the ice, however, there is still some time on land in the summertime for foraging and mating. The bridges that connect these frozen and continental environments are quickly fading, trapping polar bears on frozen death beds. There is typically no food on a small chunk of ice and polar bears can only swim so far.

Options for Improvement

Predictions can be made on the future of climate change and how continued increases in temperature will affect the globe, yet no prediction can truly tell what will happen. Scenarios described in Chapman and Davis[3] conclude the following:

- Current population growth rate, economic development and technological change: +4˚C by 2100
- Decrease growth rate, balance of fossil fuel and greener energy sources: ~+2.5˚C by 2100
- Decrease growth rate, increase environmental awareness and greater green energy source use: <2˚C past current levels

One of the largest contributors to atmospheric CO_2 is big business. Large companies that produce massive amounts of products or services use more energy than any other area. Most of the time these energy sources are not green, but cheap. Only 100 companies total make up 71% of the carbon emissions[26]. Most of these include fossil fuel miners and distributors.

As technology advances, the options for cleaner sources of energy increases. Solar panels continue to improve to harness more energy and be more efficient. New type of panels are being created to be more flexible with different environments including roads. Other forms of energy could include wind turbines and hydrocarbons, or 'clean coal'[20].

Sources that may not have been harnessed include the oceans' currents. An ever flowing, powerful source of energy. Wind turbine energy is no match for the energy that could be harnessed from the ocean currents, streams and rivers. Another form of green energy is a daily task for most people, driving. The reason the car can move forward is partially from friction from the tires on the road. The amount of friction force and energy from that force could potentially be a great source of energy.

Data Science Inclusion

Predictions for future climate and weather all stem from data science usage. The amount of environmental data collected can be stored and compared to then use in a prediction model and adjusted for different paths as mentioned in Chapman and Davis[3].

Other clean energy technology with have data associated with them, and test and trials before production. Data science should be included in the development of these new products to help aid in further development and improvement.

Conclusion

Everyone has a contribution to atmospheric CO_2, however, large companies are the main culprit of climate change. To improve these levels, cultural standards on how energy is harnessed and used need to change to cleaner, greener sources. As the increase in CO_2 slows, it gives time for plants and animals to adapt and change habits to change with the planet, instead of being killed by it. Ecosystems threatened by collapse, such as coral reefs, will be able to bounce back and thrive once more. The abiotic and biotic stability of the planet will be able to balance again without the imbalance of additional CO_2.

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