Forcing Factors of Climate

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06/16/2019

Introduction

The Earth's climate is affected by many diverse and complex components. There are various external and internal forcing factors that create and shape the climate over different periods of time. External forcing factors develop outside of the earth and its atmosphere (Bloom, 2010, p.46), whereas internal forcing factors are those that act within the earth and its atmosphere (Bloom, 2010, p.54). Natural processes of the earth create the different climates experienced in various areas throughout the planet. However, the climate is also changing as a result of human activity. The combination of these varied events is what creates the climate as it is today.

Cosine Law

The cosine law refers to orbital variation and is an external forcing factor. It establishes that more energy is emitted at the equator than at the poles, and describes the differences in the climate that is experienced at each location (Bloom, 2010, p.47). The equator receives more of the sun's energy as it is directly perpendicular to it, whereas the poles procure less of the sun's energy as their angle of location is more parallel to the sun's rays, which causes the energy to be distributed over a larger surface area, resulting in less energy being absorbed by Earth (Bloom, 2010, p.47).

The cosine law relates to the climate on Earth as areas that are more perpendicular to the sun tend to have warmer climates as they are absorbing greater amounts of energy than locations that are parallel to the sun, which experience cooler climates (Bloom, 2010, p.47).

Albedo

Albedo is an internal forcing factor that pertains to the reflectance of solar energy by Earth, which modifies the climate (Bloom, 2010, p.54). Earth's albedo is about 29 percent, with snow-enveloped regions and deserts accounting for high albedo, and forest and crop fields with low albedos (Bloom, 2010, p.55). Due to the reduction of ice caps, glaciers, snow cover and other elements of ice, which is occurring due to rising temperatures, the Earth's overall albedo is decreasing (Bloom, 2010, p.55). This ultimately increases the amount of absorption of solar energy throughout the planet. Due to reduced albedo, ice and glaciers continue to melt, resulting in an increase in warming (NASA, 2019).

Axial Tilt

Axial tilt creates climate variation, which is experienced by numerous locations throughout the planet. It is an external forcing factor that influences the earth's climate as it shifts and alters the amount of solar energy experienced by areas across the planet (Bloom, 2010, p.49). The earth rotates around its axis daily and is currently at an angle of 23.4 degrees, which is known as the axial tilt (Bloom, 2010, p.49).

However, the earth teeters, which allows for it to move between 22.1 and 24.5

degrees every 41,000 years from its orbital plane around the sun (Bloom, 2010, p.49). In turn, this process enables the amount of solar energy that extends to the earth to differ over the span of thousands of years and creates seasonal differences (Bloom, 2010, p.49).

Greenhouse Gases

Greenhouse gases that affect the earth's climate include carbon dioxide, methane, and nitrous oxide, and are considered an internal forcing factor (Bloom, 2010, p.73). The greenhouse effect refers to how different greenhouse gases absorb certain wavelengths of energy, which traps heat in the lower atmosphere (Bloom, 2010, p.65). Greenhouse gases affect the temperature of the earth by absorbing particular wavelengths of energy, and altering which wavelengths leave the earth (Bloom, 2010, p.65).

As the concentration of these greenhouse gases in the Earth's atmosphere increase, they take in more emissions from the surface of the Earth, warm the globe, and emit shorter, higher-energy wavelengths to outer space (Bloom, 2010, p.73). Greenhouse gases directly impact the earth's climate as they are a significant contributor to the global increase in temperatures.

Ocean Currents

Much of the distribution and fluctuation in temperature experienced throughout the globe is caused by ocean currents, which are an internal forcing factor. Variation in solar energy at different points on the earth, ocean floor topography, coastal landforms, seawater density fluctuations, the earth's rotation, and atmospheric winds all contribute to the currents that circulate the globe (Bloom, 2010, p.67). As seawater cools, or its salinity intensifies, it becomes denser, which occurs due to the extraction of freshwater (Bloom, 2010, p.67).

The earth's rotation around its axis determines the prevailing atmospheric winds, which causes changes in ocean currents (Bloom, 2010, p.67). The Global Conveyor Belt of ocean currents occurs as warm surface currents near the North Atlantic become cooler and saltier as they travel past Greenland (Bloom, 2010, p.68). This leads to the increase in density of water, which then sinks in the Atlantic and creates a cold bottom current (Bloom, 2010, p.68). The current then goes on to flow past Antarctica and warms in the Indian or Pacific Ocean, bringing it back to the surface (Bloom, 2010, p.68). This ultimately affects the climate as the slowing and changes of the currents' temperatures will alter the climate with regards to temperature, precipitation, drought and storm severity on a massive scale.

Chemical Weathering

Chemical weathering refers to the process that minerals undergo as they break down or change substances due to the removal or addition of elements to the rock, becoming chemically altered (Earle, 2015). Surface conditions that result in chemical weathering are water, abundance of oxygen, and the presence of carbon dioxide (Earle, 2015). Climates that are warm and wet lead

to increased chemical weathering, while cold and dry environments experience a decreased effect (Earle, 2015). The main types of chemical weathering include hydrolysis, carbonation, and oxidation.

Hydrolysis relates to water, such as rainfall, and the process of rock becoming altered in composition and size due to this interaction (Earle, 2015). Water that seeps down into the ground, such as through soil, becomes more acidic due to carbon dioxide in the soil, which increasingly breaks down and alters the rock (Earle, 2015). Carbonation is the process of rocks interacting with carbonic acid that shapes as water is merged with carbon dioxide, which then degrades minerals of the rock (Plant and Soil Sciences eLibrary, 2019). Oxidation is how a substance reacts to oxygen, which can change the composition of the rock (Plant and Soil Sciences eLibrary, 2019). As the rock oxidizes, it becomes less immune to weathering (Plant and Soil Sciences eLibrary, 2019).

All minerals are affected differently by chemical weathering, with some that are severely affected and others that are not. This affects climate on Earth as it can lead to carbon sequestration, which results in cooling (Beerling, 2017).

Volcanism

Volcanism is an internal forcing factor that can affect vast amounts of area as it spews sulfur dioxide and fine particles into the atmosphere after an eruption, which reflect sunlight and can lower global temperatures (Bloom, 2010, p.55). For example, the eruption from Mount Pinatubo cooled the earth by 0.5 degrees Celsius for about two years due to the haze of aerosols that spread over the planet after the eruption, and reflected the sunlight, which lowered temperatures (Bloom, 2010, p.55).

Eruptions also release the greenhouse gas, carbon dioxide, which furthers the warming of the earth. However, volcanism's impact on the earth's climate is much less intense than that of the burning of fossil fuels (Bloom, 2010, p.55). Volcanoes can alter the climate through warming and cooling, but with the amount of fossil fuels being burned today through human activity, volcanoes contribute more to the cooling of Earth than the warming (Bloom, 2010, p.55).

Conclusion

All forcing factors are interconnected, influencing the weather and climate of the planet. Earth's temperature is defined by a balance of incoming and outgoing energy. Each of the forcing factors discussed, along with others, contribute to this process. As each of these forcing factors performs their role, the earth naturally responds, ultimately leading to a new equilibrium and a different climate (Colose, Hanania, Stenhouse & Donev, 2017). This process will continue throughout the life of the earth, and the relationships between these forcing factors will remain influencers of the earth's climate.

Both natural and human inflicted forcing factors will be ongoing determinants of the future climate. These factors are responsible for the outcome of many of the events experienced on Earth. It is important

to understand these natural and human based phenomena in order to prepare for the future and mitigate the effects of climate change. By learning more about these forcing factors, people can better support the earth, along with gaining insight into the natural processes to create a better future.

References

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