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Preventing the Deluge: Climate Change, the Four Spheres, Interactions, and Causalities

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Abstract

Climate change means water change, and the impacts of climate change cause not only global sea levels to rise, but also elicit dangerous levels of coastal and mainland flooding. This study relates the effects of climate-change-induced sea level risings to several harmful, and sometimes preventable, factors causing floods. One topic discussed here will be the ocean's current (more specifically, "The Atlantic Meridional Overturning Current") as it continues to warm with increasing temperatures. In addition to discussing the effects of the AMOC, it also relates the increasing causes that are contributing to flooding, plus the proliferation of melt from ice sheets, ice caps, and glaciers, which inevitably contributes to the devastating effects of flooding on coastal communities, destroying habitats and contributing to the extinction of both aquatic and land animals, and even impacting human infrastructure and livelihoods. This examination additionally presents the serious implications that climate change and flooding have had on the planet's freshwater resources and reserves, which are being further destroyed by the added influx of salt water, causing water to then be treated with aquifers, an energy-intensive and highly expensive process. Lastly, this paper provides several suggested possibilities for curbing some of the harmful effects humans have already had on contributing to climate change, as well as the environmental factors that have further caused dangerous levels of flooding.

Keywords

Climate Change, Flooding, Toxic Algae, Water Cycles, Precipitation, Runoff, Currents, Glaciers, Weather

1. Introduction

As the US Geological Survey so eloquently put it in its water science page for secondary school children, "water exists in the air as water vapor, in rivers, lakes, icecaps, glaciers… in the ground as soil moisture, in aquifers, and even in you and your dog" [1]. That is certainly a truism and any changes to the planet's water supply, therefore, influences everything, plus has the ability to create a contagion effect. Climate change is perhaps the most pressing environmental issue facing the planet today, especially since the Earth's lakes, rivers, streams, and oceans, plus the water cycle itself, are all intertwined and thus heavily impacted [2]. Showing how the Earth's water supplies are affected not only explains how interconnected everything is, but also leads to better methods for prevention. With up to 71% of the Earth's surface being covered by water, and considering that the planet's oceans contain about 96.5% of the planet's water supplies in the first place, that is not surprising [3]. By monitoring any changes within, and around, the Earth's water areas, scientists are better predicting future patterns for possible flooding, as well as trying to prevent any upcoming catastrophes. As the surplus of water caused by climate change becomes more prolific, researchers are now proving that anthropogenic climate change has clear effects pertaining to the very water distribution on our planet, even creating flooding. Moreover, the frequency and intensity of flooding is being affected by the very changes within the planet's precipitation patterns themselves, and this produces several other effects worthy of investigating further.

2. Hydrosphere and Climate Change

Climate change affects Earth's hydrosphere, and while most natural disasters on the planet are in fact water-related, flood conditions worsen even more as climate change becomes increasingly more extreme [4]. The Earth's water cycles influence when, where, and how much precipitation falls, so they ultimately have potential to lead to even more severe and extreme weather conditions over time, causing increases in global temperatures by making water evaporate into larger amounts, which in turn creates greater levels of atmospheric water vapor leading to more frequent, heavy, and intensive rains that cause flooding [5].

Scientists predict that such changes will continue to further the prevalence of heavy flooding events, since more water will fall at certain locations on the planet than the land vegetation and soil are able to absorb, and worse still, the excess water runoff tends to then drain into waterways, picking up manmade land contaminants like fertilizer, and then traveling on to other, sometimes even larger, bodies of water, causing pollution and further limiting the water supplies of humans, animals, and the surrounding ecosystems [6]. Moreover, whenever floods occur, they always have potential to either completely destroy or contaminate some of the planet's water resources altogether, thus increasing the risk of life-threatening illnesses, diseases, and even death to both humans and animals.

2.1. The Hydrosphere, Climate Change, and the Biosphere

On the planet, extremely populated areas tend to live near or in water vulnerability areas, and thus do not have enough water resources to already meet daily needs for all populations [7]. Increasing temperatures can lead to toxic pathogens in water resources, posing a huge threat. Dehydrating diarrhea, typhoid, and other water sanitation-related diseases can cause illness, and even death, to humans. Moreover, increased competition over water resources in certain areas of the world can also cause conflicts and wars. Whenever food security is threatened by flooding conditions and/or the lack of clean water resources, refugee dynamics and political instability can be greatly affected. Water insecurities after flooding also tend to play a primary role in how people and animals both migrate and adapt [8]. Moreover, increasing and rising sea levels caused by coastal flooding can create a multitude of other problems for humans, especially since freshwater resources run the danger of becoming increasingly salty, further compromising the ability for farmers to till the land [9].

Since water is highly influenced by climate, and the Earth's rising temperatures have great impact on how water both moves and circulates, higher temperatures and more extreme, less predictable, weather conditions in the Earth's atmosphere affect the availability and distribution of rainfall, snowmelt, river flows and groundwater, further deteriorating the planet's water quality that humans and animals rely on to survive [10]. As temperatures rise in the planet's troposphere, more water evaporates from both the oceans and land areas, where it is then held in the lowest section of the atmosphere.

Warmer air is able to hold more water vapor, creating even greater precipitation and heavier rain than just ice and snow, and the consequence becomes an increased frequency of heavy rainfall and flooding to certain areas of the planet, especially coastal regions. Worse still, as the atmosphere heats up, causing warmer waters and heavier rainfalls leading to flooding in certain places on the planet, the effects of climate change become even more exacerbated, thus contributing to repeated, dangerous cycles of patterned flooding [11].

It goes without saying that any changes to temperature profoundly affect atmospheric water vapor concentrations, clouds, precipitation patterns, runoff, and stream flow patterns, and such extremes can easily lead to serious levels of flooding of the lithosphere. Such conditions will eventually morph the planet's water cycles and patterns, making it potentially impossible for some humans and animals to find safe, non-toxic drinking water [12].

Underserved and vulnerable communities, who already suffer from scarce water resources to begin with, are often the worst affected when flooding happens. With climate change wreaking havoc on the planet's weather patterns, creating extreme conditions leading to dwindling water resources for humans and animals, there also becomes an even greater potential for future water contamination for these at-risk communities, so there are several reasons why humans should be greatly concerned about how climate change relates to flooding [13]. Humans should do every measure possible to prevent it in the first place.

Earth's increasingly warming atmosphere also results in even more precipitation falling as rain rather than snow. Some regions within the lithosphere depend on the gradual melting of the snowpack to supply surface water throughout the warmer months of the year. Diminishing ice and snow packs result in lower flows and greater water stress during the summer in several lithospheric regions, leading to water scarcity at the planet's surface and resulting in an even greater reliance, and overuse, of limited groundwater reserves by both humans and animals [14].

2.2. The Hydrosphere, Lithosphere, and Climate Change

As sea levels, streams, rivers, and lake waters rise from extreme flooding on nearby land, a sedimentation runoff can be caused, smothering coral reef areas. This is why scientists estimate that climate change has been the single-most cause of coral reef destruction due to rising water levels from flooding [15]. It should also be noted that in addition to increased water levels from flooding, coral reef destruction is further exacerbated by higher ocean temperatures, constant acidification due to increased carbon dioxide levels, changes in precipitation, and altered currents.

Further wreaking havoc on this already tenuous situation, however, is that after flooding, fertilizers used by nearby farms can wash into neighboring lakes as well as the ocean, promoting the rapid growth of toxic algae. The resulting toxic algae blooms can potentially clog waterways and coastal areas. The algae blooms can also potentially block the sunlight necessary for aquatic life to live and flourish, further diminishing the crucial levels of oxygen within the water. Moreover, the toxins from algae blooms have potential to completely kill any underwater life, and can even make both people and animals who feed off them sick, and these toxins are especially dangerous since they have the ability to survive purification processes, making tap water unfit to drink even after it is treated [16]. Toxic blooms can even impact infrastructures and the industries relying on clean water to run businesses, and firms can even be forced to shut down during toxic blooming occurrences [17]. Worse still, as the climate continues to warm, toxic blooms, just like all the other implications of climate change, become more frequent and severe, causing even further issues and for longer periods of time.

2.3. Toxins and Flooding

Changes in atmospheric precipitation levels can create increased water runoff of either freshwater, sediment, or land-based toxins. In the case of toxic blooms, while they can prolifically happen as a result of the dangerous runoff of nitrogen-rich fertilizer materials from agriculture, scientists have also now linked an increase to the emissions caused by greenhouse gas as a further contributor to the problem as well. As air and water temperatures increase, the environment becomes more amenable to dangerous levels of blooms, and this is further worsened by extreme rainfall that leads to dangerous levels of flooding. Plus, this also increases carbon dioxide levels, and whenever this happens, methane and carbon dioxide get released back into the atmosphere, further intensifying climate change by creating a sort of toxic feedback cycle [18].

As the oceans warm, freshwater glaciers around the planet begin to melt at an unsustainable rate which results in rising sea levels that can lead to coastal area flooding [19]. Whenever freshwater from melted glaciers runs into the ocean, causing dangerously rising sea levels, saltwater then becomes a contaminate to underground aquifers. Although environmentalists and scientists have developed desalination processes to remove some of the additional salt from saltwater, it is extremely costly, energy-intensive, and is only feasible for places with continual droughts or with extremely limited freshwater resources [20].

3. Oceanography

What is clear is that the planet's oceans are the biggest solar energy repository on the planet, and as coastal levels rise in certain regions from flooding, this creates problems for both the lithosphere and atmosphere. The oceans must remain at better regulated temperatures in order to stabilize the entire Earth's climate system, since they both store and release heat over long durations of time. Plus, the oceans are normally able to do so without ever really increasing in temperature. However, as greater amounts of greenhouse gasses enter the atmosphere from careless humans, the heat radiating from the Earth's surface then becomes trapped in the planet's oceans. As a result, it is then unable to escape into the atmosphere, causing excess heat to then become stored in the upper ocean as it continues to heat up. Finally, with larger amounts of water from flooding being dumped into the oceans, it is then absorbed at even greater amounts of heat than are being released, causing yet another issue, since the heat content continues to increase instead of decreasing. Such contagion effects as these further contribute to increased flooding in certain areas of the planet [21].

3.1. Warmer Air and Rising Oceans

It has been estimated that more than 90% of the warming changes that have occurred over the last century have happened within the Earth's rising ocean waters, some of that due to increased flooding. However, running directly counter to this extreme, there will be other areas on the planet that will simultaneously experience even drier air and droughts due to the increasing water's rises in temperatures. Moreover, warmer air caused by the water's higher temperatures can then cause an increased level of evaporation to take place, which could make soil conditions in the lithosphere drier, and worse still, heat energy within the oceans has great potential to warm the entire planet for much longer periods of time than its initial absorption [22].

Frighteningly, such a contagion effect can also melt entire ice shelves, causing even more water to evaporate, and it can even directly reheat the Earth's atmosphere, causing more severe flooding conditions for certain areas of the planet. Furthermore, in the Northern Hemisphere of the planet, for example, where snow typically accumulates, warmer temperatures mean less snowfall, which then equates to less water being available within crucial local reservoirs after the winter period ends, and this can negatively impact agriculture, since without enough water for irrigation, crops simply cannot grow [23].

3.2. The Atlantic Meridional Overturning Current

There is a massive circulating seawater current that scientists call the "Atlantic Meridional Overturning Current" and this conveyor type belt plays a huge part in regulating the entire global climate system. Any significant alterations to its circulation will heavily affect flooding conditions in certain parts of the world. The Atlantic Meridional Overturning Current is something that actually regulates the ocean's currents. Simply put, whenever the current's motion slows down, it will then have great effect, especially since large amounts of colder water will then begin to sink deeper into the northernmost part of the Atlantic Ocean, potentially causing the entire Atlantic Ocean to drive larger currents into the other surrounding oceans. Such a reaction would have potential to then cause further and greater coastal flooding [24]. For example, if the entire Northern Hemisphere cooled down, the monsoon areas would then start to dry up and show drought conditions [25]. North Atlantic storms would, as a direct result, become even greater in intensity, causing massive flooding. Plus, this type of slowdown would cause significantly less ocean mixing and would thus produce less potential for spawning aquatic life, which would inevitably lead to more extinctions [26] [27].

4. Possible Solutions for the Future

Finally, scientists believe that the rising oceans that are the harbingers of coastal flooding in the first place, plus the increased amounts of freshwater caused by increasing levels of melting ice, are all due to climate change, and are, therefore, further slowing the Atlantic Meridional Overturning Current. Moreover, evidence of this can be cited in how the Atlantic Meridional Overturning Current functions in relation to the densities of cold and salty water. After all, if cold water sinks in the North Atlantic and then travels south, while warmer tropical waters at the ocean's surface flows north and into the Gulf Stream, this conclusion would make perfect sense. However, if northern waters begin to heat up even more than they have, or if saltwater becomes even more diluted from larger amounts of freshly melted ice, then the ocean's water could stop becoming dense enough to cause this necessary sinking motion. As a result, this might even stop the water from moving north at a faster pace, slowing it all down, and even having the potential to make it stop altogether. If emissions and global temperatures continue to rise, this slowing or stopping completely of the Atlantic Meridional Overturning Current could result in numerous and cascading effects for the planet's temperatures, rainfall patterns, weather, and yes, most certainly flooding. However, there are still many things that humans can do to lessen the impact of climate change to prevent flooding catastrophes like the one I just outlined.

5. Summary

As one solution, industries dependent on fossil fuels could all change to better, cleaner, and renewable energy sources, but one thing is clear, humans need to act, and most of that action should be focused on paying attention to the regulation of the planet's waterways, oceans, and land enclosed water bodies. Humans must start adapting to, and focusing on, the actual effects of climate change and how this relates to flooding. Learning how to use water more efficiently by seeking out new and better methods, like transitioning to solar-powered water systems or finding better ways to reduce greenhouse gas, would be a start.

If all humans would elicit these simple measures, like growing their own fruits and vegetables, buying locally grown produce instead of transporting it from long distances by truck, adding to carbon dioxide into the atmosphere, or by walking or riding bikes instead of using cars, then flooding, which has been vastly exacerbated by such practices, could be better regulated. Outside of these changes, working to affect laws surrounding the ongoing destruction caused by climate change is simply a necessity for the good of the planet.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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