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Forum: United Nations Environment Programme
Issue: The question of the application of geoengineering to combat climate change.
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Introduction:

Over the past few decades, climate change has severely impacted our planet, causing abnormal weather in many countries and the global temperature to rise. Climate change refers to long-term alterations to temperature and weather patterns. Some fluctuations can occur due to the sun or significant volcanic eruptions that can have a lasting impact on the atmosphere. But since the 1800s, human activities, primarily the combustion of fossil fuels like coal, oil, and gas, have been the primary cause of climate change. Fossil fuel combustion produces greenhouse gas emissions which trap the heat from the sun causing an increase in temperature. Carbon dioxide and methane are the primary greenhouse gases responsible for climate change. For instance, while burning fossil fuels to produce electricity and oil, these harmful greenhouse gases are emitted. Carbon dioxide can also emerge from deforestation as the gas trapped in the tree gets released into the atmosphere.

When sunlight enters the Earth's atmosphere, around 30% of the light is reflected back into space, and the rest, 70%, is absorbed and integrated by the climate's energy system. Greenhouse gases are crucial for keeping our planet warm for living things, however, they are too concentrated causing the global temperature to increase beyond the normal range. Although countries have started implementing clean energy in an attempt to reduce global warming using solar, wind, and nuclear energy, the carbon dioxide present in the atmosphere can have lasting effects for centuries. Therefore, geoengineering, which is the manipulation of the Earth's natural systems to combat climate change is worth trying to mitigate the effect of greenhouse gases.

Definition of Key Terms

Geoengineering

Large-scale intervention of the Earth's natural systems to counteract climate change.

Climate change

Long-term changes in the Earth's temperature and weather patterns are caused naturally or by human activity.

Greenhouse gases

Gases such as carbon dioxide, methane, and nitrogen oxide trap heat in the Earth's atmosphere.

Solar Radiation Management (SRM)

Attempts to cool the planet by reducing incoming solar radiation or reflecting it back into space.

Carbon Neutrality

Balance between emitting carbon and absorbing carbon from the atmosphere.

Drought

A period in a region where rainfall is low causing a lack of water.

Sulfate Aerosols

Sulfur dioxide aerosols (SO2) are tiny particles containing sulfur dioxide gas.

Key issues

Disruption of Weather Patterns:

Geoengineering methods, particularly Solar Radiation Management (SRM) techniques, hold the potential to profoundly alter global weather patterns. These interventions, such as stratospheric aerosol injection (SAI), aim to reflect sunlight away from the Earth's surface, affecting the Earth's energy balance. Altered weather patterns could lead to prolonged droughts in certain regions, severely impacting water resources and agriculture. This could result in crop failures, water scarcity, and food shortages, directly affecting millions of people. Conversely, other areas might experience intensified and unpredictable rainfall, leading to soil erosion, landslides, and devastating floods. Such events can cause significant damage to infrastructure, agriculture, and human settlements. The changing weather dynamics may also contribute to the intensification of extreme weather events such as hurricanes, heat waves, and monsoons. These events can lead to widespread destruction, casualties, and displacement of communities. Altered weather patterns also impact ocean currents, which influence marine ecosystems and fisheries. Disrupted currents can lead

to changes in fish migration patterns, impacting fisheries and the livelihoods of coastal communities. Moreover, the displacement of weather patterns can contribute to desertification, threatening biodiversity and ecosystems. This can further worsen food insecurity and environmental degradation. These disruptions can reduce resources for disaster response and recovery efforts, affecting economies and social stability. The unpredictability introduced into weather patterns can also lead to conflicts over resources, especially water, increasing existing tensions. Additionally, altered weather patterns can affect energy production and distribution, particularly in regions reliant on hydroelectric power. This can lead to energy shortages, impacting industries and households.

Ocean Acidification and Marine Life:

Geoengineering methods involving oceans, such as ocean fertilization, raise significant concerns about aggravating ocean acidification. The excess carbon dioxide absorbed by oceans reacts with seawater, lowering its pH and leading to profound consequences for marine ecosystems. Ocean acidification weakens the calcium carbonate structures of marine organisms, making them more susceptible to damage and erosion. This weakening disrupts the balance of marine ecosystems, endangering entire food webs and coral reefs that are vital for marine biodiversity and coastal protection. Acidification also impacts marine animals'' physiology, behavior, and reproductive capabilities, potentially leading to population declines and species extinctions. Moreover, altered pH levels affect phytoplankton, the foundation of marine food chains which could weaken phytoplankton and impact fish populations. Additionally, ocean acidification hampers the ocean's capacity to absorb carbon dioxide, increasing global warming and preventing the reverse of climate change. The economic consequences include reduced fishery yields, the collapse of marine-related industries, and challenges in adapting to rapidly changing marine environments. Coastal communities that rely heavily on marine resources face economic hardships due to reduced fishing yields. Finally, the loss of marine biodiversity also affects pharmaceutical research, as marine organisms are sources of potential medicines.

Impact on Agriculture:

Geoengineering-induced alterations in weather patterns can cause significant challenges to global agriculture, which plays a vital role in supporting life and economies worldwide. Changes in precipitation patterns, including irregular rainfall and prolonged droughts, stress crops, leading to reduced yields and quality. Unpredictable weather events, such as intense storms, hail, and frost, damage crops, disrupting

planting seasons and agricultural planning. Temperature shifts affect flowering times and pollination, leading to diminished fruit and seed production. Heat stress affects livestock, decreasing productivity and impacting animal health. Furthermore, these conditions create ideal environments for pests and diseases, escalating the need for pesticides and leading to crop losses. Disrupted agricultural production results in food shortages, spiking food prices, and market instability. Farmers face financial losses, especially smallholders, leading to increased poverty and food insecurity. Global supply chains are affected, causing economic challenges for agricultural exporters. These disruptions have broader social impacts, affecting rural economies and social stability. The environmental consequences include soil degradation due to erosion and loss of nutrients, impacting agricultural productivity in the long term. Moreover, altered weather patterns can lead to changes in crop suitability, forcing farmers to adapt or shift to different crops, which can be economically challenging. Climate change-related events, such as shifting rain patterns and rising temperatures, worsen the challenges faced by farmers. The agricultural sector also contributes significantly to greenhouse gas emissions, increasing climate change. Sustainable agricultural practices, including precision farming, water conservation, and agroforestry, are essential to mitigate the sector's environmental impact. Additionally, investments in agricultural research and development are crucial to developing climate-resilient crop varieties and innovative farming techniques. International cooperation is essential to address food security challenges, ensuring that vulnerable populations have access to nutritious and affordable food. Education and awareness programs are vital to promoting sustainable farming practices and environmental conservation.

Major Parties Involved:

United Kingdom

The United Kingdom has set a goal of net zero emissions by 2050 following its commitment to the Paris Agreement. British scientists have already started their investigation and are taking steps to familiarize themselves with Greenhouse Gas Removals (GGR) and other technology. The UK has been working with Research Councils who have launched an £8.6 million research on GGR in April 2017. Additionally, the UK launched a £31.5 million program funded by UK Research and Innovation’s (UKRI) Strategic Priorities Fund to support GGR Demonstrations. A study has also been published in September 2019 about the policy incentives for GGR deployment in the UK and other countries. Finally, a commitment of £100 million has been set by The Energy Innovation Program to help decarbonize industries and open routes to carbon capture, usage, and storage. However, despite commissioning research into the effects of solar radiation management (SRM), the UK government will not be deploying SRM anytime soon.

United States

The United States' involvement in geoengineering is evolving, with recent developments indicating a shift in its approach to climate change mitigation. The U.S. government, specifically the White House and associated agencies such as NASA, the National Oceanic and Atmospheric Administration (NOAA), and the Department of Energy, is currently in the process of developing a research plan to guide scientists in studying solar geoengineering. This marks the first coordinated federal effort of its kind in the U.S. The Federal Appropriations Act of 2022, signed by President Biden, directed the Office of Science and Technology Policy to establish a cross-agency group, in partnership with NASA, NOAA, and the Department of Energy, to coordinate research on climate interventions like solar geoengineering. While the specifics of US involvement are still developing, the establishment of this interagency group displays a significant step toward understanding the feasibility, benefits, and risks associated with solar geoengineering. Additionally, the U.S. government has allocated $22 million over the past three fiscal years for related research projects, primarily focusing on understanding the atmosphere and climate modeling which is essential for studying potential climate interventions.

China

China has been actively involved in geoengineering, employing various techniques as part of its strategic initiatives. China has focused on weather modification, particularly through cloud seeding technology. China aims to bring about 5.5 million square kilometers of its land under its weather modification program by 2025. They also claim that with the help of cloud seeding, it can improve agricultural productivity and disaster prevention; however, cloud seeding can potentially disrupt natural weather patterns in neighboring countries, impacting their agriculture and possibly even floods in countries that don’t have a good drainage system.

In 2015-2019, a geoengineering research project was led by John Moore in collaboration with Beijing Normal University, Zhejiang University, and the Chinese Academy of Sciences. Through this project, they modelled and analysed the impact on the climate of geoengineering and assessed its social impacts. To check if the findings of Moore and his team were applicable, the research team tried linking their models to economic, agricultural, and health outcomes. However, very few academics and policymakers are talking about the application of geoengineering and aren’t up to speed with the topic; therefore,

deployment in China isn't happening anytime soon as the government isn't taking this opportunity to reverse climate change too seriously. While China isn't looking at geoengineering at the moment, president Xi Jinping announced in the UN General Assembly that China is setting a goal to achieve carbon neutrality by 2060, meaning that it is crucial for them to start investigating into cutting carbon emissions.

NASA - Jet Propulsion Laboratory (JPL)

NASA's JPL is involved in geoengineering where they are mainly focused on improving their understanding with the concept of geoengineering and are formulating research questions to focus on. Questions like "How could you inject aerosols into the stratosphere?" are being investigated along with its feasibility and practicalness. JPL is also looking at how key climate processes are connected how satellites can be used to provide policymakers with better evidence and information about geoengineering. Finally, to conclude, NASA isn't diving straight into tests and experiments relating to geoengineering, however, they are in the researching process and hopes to obtain promising information.

Harvard University

Harvard University is deeply involved in researching geoengineering, especially in the realm of solar radiation management. Their Solar Geoengineering Research Program focuses on understanding various techniques to manage solar radiation, a key aspect of climate intervention. Currently, Harvard is conducting a small-scale stratospheric balloon experiment to collect important data about particle behavior in the upper atmosphere, a crucial step in understanding the practicality of geoengineering methods. Funding for this program comes from sources like the William and Flora Hewlett Foundation, the Alfred P. Sloan Foundation, and notable figures such as Bill Gates. This financial support allows Harvard to conduct experiments and studies related to geoengineering, gaining more and more knowledge about these climate interventions. Harvard has also established an independent advisory committee, critical in evaluating the ethical, environmental, and societal implications of their research activities. Finally, Harvard's research activities extend to simulations, exploring the feasibility and consequences of solar geoengineering methods. These simulations are vital for predicting potential outcomes and comprehending the intricate interactions between various environmental factors.

Timeline:

Year	**Event**
1932	The Soviet Union established the Institute of Rainmaking in Leningrad and cloud seeding experiments were conducted which was the first step in altering weather.
1946	In the US, researchers at the General Electric Research Laboratory in New York discovered that dry ice causes the formation of ice crystals.
1965	A landmark report issued by Former US President Lyndon B. Johnson's Science Advisory Committee that the utilization of fossil fuels has harmful effects on the planet.
1967	The US Air Force flies over 2,600 cloud-seeding planes over Vietnam, Laos, and Cambodia in an attempt to extend the monsoon season to hinder the movements of Vietnamese troops. The operation was called Operation Popeye.
1974	Mikhail Budyko, a Soviet climatologist, proposed that global warming could be prevented by burning sulfur in the stratosphere, which would create a reflecting haze "much like that which arises from volcanic eruptions."
December 1976	The United Nations General Assembly passed the Environmental Modification Convention, which bans weather warfare and other hostile forms of climate modification "having widespread, long-lasting or severe effects" after being driven into action by the United States cloud-seeding operations in Vietnam.
May 1990	The Intergovernmental Panel on Climate Change (IPCC) was established by two UN committees in 1998 with the purpose of evaluating the risk of human activity on climate change. The panel warns that unless global emissions are reduced by 60 percent in the next 110 years, temperatures worldwide could increase by up to 5.4 degrees Fahrenheit.

November 2006	Former top weapons designer at the Pentagon Lowell Wood proposes an idea of an "instant climatic gratification" scheme to combat global warming. His plan was to send over 1 million tons of sulfate aerosols into the Arctic Stratosphere to obstruct the sun's rays and build ice to cool the planet.
2012	The National Natural Science Foundation of China lists research on geoengineering as a priority and spends $100 million on weather modifications. This includes producing rain and preventing hailstorms.
March 2013	The National Academy of Science (NAS) and the CIA collaborated to fund a 21-month "technical evaluation" of various geoengineering techniques including solar radiation management and carbon dioxide removal schemes. The project costs upwards of $630,000.

Previous Attempts to Solve the Issue

Because geoengineering is a relatively new concept and hasn't been used before to solve the issue, there haven't been any previous attempts to solve climate change through geoengineering. However, there are other ways that have been attempted to solve climate change.

Cloud Seeding

Although cloud seeding isn't aimed at solving climate change, it has been conducted often in different countries to modify weather patterns. Cloud seeding has been used to mitigate drought in agricultural areas and increasing rainfall in warm countries such as the Middle East. By enhancing precipitation in these areas, it can increase farming and, therefore, increase supply of vital primary commodities to support human survival. Additionally, by increasing rainfall in these arid regions, it has increased freshwater supplies. Furthermore, cloud seeding has shown to be very effective in wildfires by increasing precipitation in wildfire prone areas and suppressing them if ignited. This has saved hundreds of lives and made living near forests possible. However, cloud seeding does have negative consequences. Cloud seeding uses silver iodine as one of the chemicals to produce rain. Silver iodine can cause Iodism which results in skin rashes, headaches, and running nose. Another con is that cloud seeding can only be

performed on rain clouds and will not work if performed on any other cloud. This makes scientist have to wait for the correct cloud formation to appear, disabling them from producing rain immediately when a decision is made. Finally, cloud seeding is an expensive practice. Planes need to be used to transport the chemicals to the clouds which many farmers or people living in drought-struck areas can't afford, therefore, it isn't accessible to everyone.

Carbon Capture and Storage

Carbon Capture and Storage (CCS) is another solution to reverse climate change, offering several advantages. One of its significant merits is that it has the ability to significantly reduce greenhouse gas emissions from industries and power plants, enabling industries to continue using fossil fuels while mitigating their environmental impact. By preventing carbon dioxide from entering the atmosphere, CCS helps in slowing down global warming, aligning with international climate goals. Moreover, CCS can play a vital role in transitioning towards renewable energy sources. For industries where immediate alternatives to fossil fuels are limited, CCS provides a bridge, allowing time for further technological advancements. It also helps preserve jobs in sectors heavily reliant on fossil fuels, maintaining economic stability during the transition. However, alongside these advantages, there are challenges and concerns associated with CCS implementation. Financially, the initial setup costs are high, making it a heavy investment for governments and industries. Additionally, the technology demands a vigorous infrastructure, including pipelines and storage facilities, which require planning and investment. Furthermore, there are environmental impacts about the long-term storage of CO2 underground. While geological formations are selected based on their stability, there is always a risk of leakage, which could reverse the intended benefits. This solution also would be hard for the public to accept as communities residing near the storage site may express fears about their safety.

Possible Solutions

Stratospheric Aerosol Injection (SAI)

Stratospheric Aerosol Injection (SAI) is a possible solution to reverse climate change. It works by aerosols or tiny reflective particles of sulfate that have the ability to reflect sunlight into space to cool the planet, and it is sprayed into the stratosphere. This ultimately cools down the planet since there isn't any source of sunlight. The stratosphere is a layer around Earth that covers from 7 miles to 31 miles above the

ground. This layer of Earth is the ideal location for the release of SAI since it is away from the human population; accessible by planes and other transportation methods; and doesn't have rain in between that would cause the particles to fall to the ground. SAI can benefit many fields and sectors. Stable global temperatures caused by SAI may contribute to sustainable water resources, mitigating droughts and ensuring a stable supply for agricultural and domestic use. Additionally, by stabilizing agriculture and preventing extreme weather-related damage, SAI might reduce financial losses incurred by farmers, citizens, and insurance companies, promoting economic stability. SAI could also reduce the impact of rising sea levels, protecting homes and infrastructure from floods. Finally, it's a fast and cost-effective solution since it can be launched using current technology and infrastructure, allowing scientists to carefully work on long-term solutions in the meantime. However, there are significant downsides caused by SAI. A loss of rainfall could occur in some areas, spoiling crops and decreasing access to fresh water. This could lead to a decrease in the supply of food resulting in starvation and deaths. Furthermore, sulfate could harm the ozone layer which is vital for protecting life on Earth as it absorbs harmful ultraviolet rays emitted from the sun. With damage to our ozone layer, the increase in UV radiation can lead to skin cancer.

Marine Cloud Brightening (MCB)

Marine Cloud Brightening (MCB) is another possible solution to cool the Earth. The process involves injecting sea salt into cloud updrafts. This will increase the reflectivity and potentially the lifespan of clouds so that they stay longer to reflect sunlight back into space. Since sea salt is abundant thanks to oceans, large amounts of it can be extracted from seas and sea salt won't be exhausted anytime in the near future. However, unlike SAI, MCB can't reduce the temperatures globally, instead, it can decrease the temperatures in some regions, especially oceans. Additionally, it would have to be done constantly to maintain the sea salt level in the clouds which could be costly. Not only does MCB have to be replenished, but it has negative environmental implications such as damage to vegetation could hinder agricultural practices, causing a decrease in the supply of food. Therefore, it could increase prices for food and prevent low-income citizens from purchasing food.

Cirrus Cloud Thinning (CCT)

Cirrus Cloud Thinning (CCT) is a possible solution that hasn't been tested in the real world yet, but, through simulations, it has shown promising results to cool the planet. Clouds have the ability to both heat and cool the planet. Heating occurs since clouds act like a blanket around Earth trapping heat and

contributing to the greenhouse effect, whereas cooling occurs since clouds reflect the sun's rays, similar to the concept of MCB. Cirrus clouds are a type of clouds that are wispy and are made up of ice crystals; when ice nuclei are injected into cirrus clouds, the thickness of the cloud is reduced, thus decreasing their ability to warm the planet. Furthermore, the idea behind cirrus cloud thinning is to disperse particles into the upper atmosphere to reduce the density of cirrus clouds, allowing more heat to escape into space.

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