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A Framework for Geoengineering to Combat Climate Change

United Nations Environment Assembly

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Introduction

Climate change has been a globally discussed problem, and remains one of the greatest threats on the Earth. Millions of scientist keep themselves busy with this ongoing issue, and at the beginning of the 20th century some found a solution. Or, say they do, since not every nation benefits from the result. It also comes along with a lot of risks, and various of those risks could be lethal.

The so called geoengineering is the answer they are talking about. It has two parts: Solar radiation Modification (SRM) and Carbon Dioxide Removal (CDR). SRM, or solar engineering, refers to deliberate, large-scale actions intended to decrease global average surface temperatures by increasing the reflection of sunlight away from the Earth and back to space. Or in other words, enabling sunlight to heat the earth, which is supposed to mitigate the global warming. Some of the benefits would include; reduce of reverse sea level rise, reduce or reverse sea ice melting and , increase plant productivity. The other form is CDR, which is a climate engineering approach that focuses on removing carbon dioxide from the atmosphere. This is done by; directing air capture, capturing and storing carbon dioxide and enhancing weathering. The goal of this approach is to offset the carbon dioxide emissions that are currently being produced by the burning of fossil fuels, reduce the amount of carbon dioxide that is stored in the atmosphere and oceans, and reverse the impacts of high concentrations of carbon dioxide in our biosphere such as ocean acidification.

In this research report, another explanation of SRM and CDR will be discussed, the benefits and risks coming along with these pursuits and the origin of geoengineering. With this a timeline, the major parties (nations or organizations) involved in the matter and some possible solutions to solve the issue will be given.

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Definition of key terms

CB

Cloud brightening, is an approach in a suite of options to combat climate change. CB is a method of Solar Radiation Management.

CBC

Coastal Blue Carbon, is the term coined for carbon dioxide (CO2) stored in the world's coastal and marine ecosystems such as mangroves, saltmarshes, and seagrasses. It's called "Blue" Carbon because of its proximity to the ocean: it is stored mostly in the soil and silt up to 6 meters under the seabed.

CDR

Carbon Dioxide Removal, a geoengineering or climate engineering approach that focuses on removing carbon dioxide from the atmosphere. Also 'climate engineering'.

Geoengineering

The large-scale manipulation of a specific process central to controlling Earth's climate for the purpose of obtaining a specific benefit.

LEDC's

Less Economic Developed Country.

MEDC's

More Economic Developed Country.

SDG13

Sustainable Development Goal 13, focused on taking urgent action to combat climate change and its impacts.

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SRM

Solar Radiation Modification refers to deliberate, large-scale actions intended to decrease global average surface temperatures by increasing the reflection of sunlight away from the Earth.

General Overview

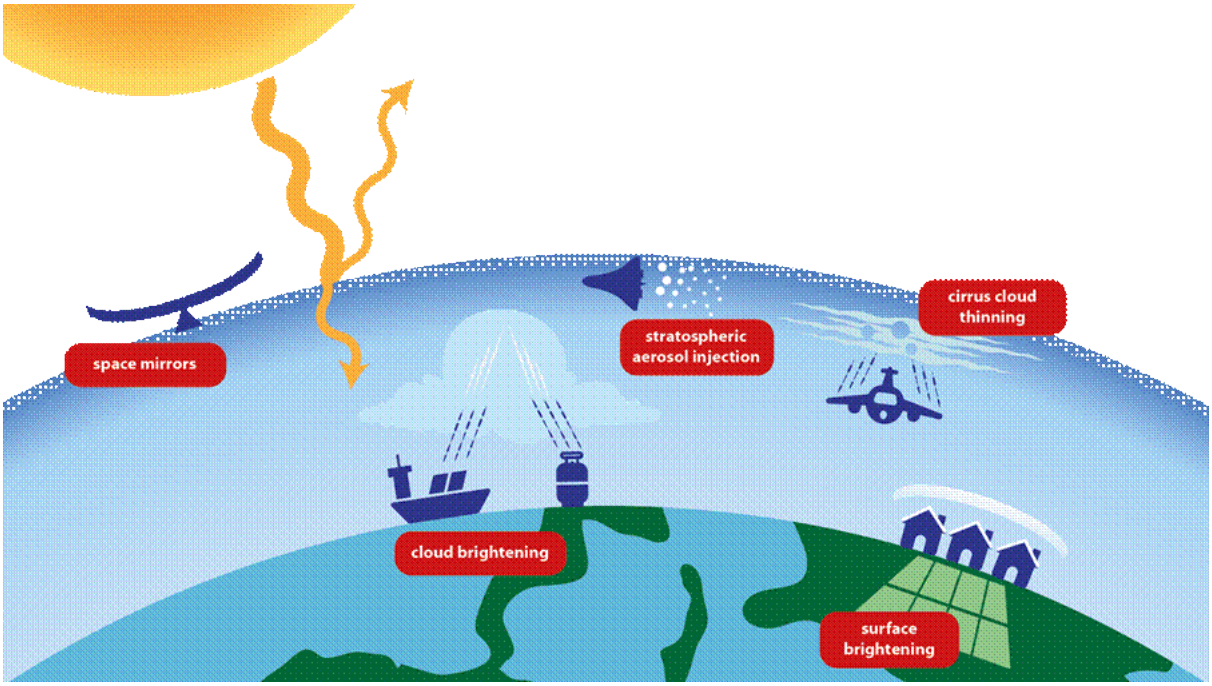
Geoengineering is a category of emerging technology that can manipulate the environment to manage or mitigate the effects of climate change. It generally involves either pulling planet-warming emissions out of the atmosphere or addressing the effects of having so much greenhouse gas in the atmosphere. Geoengineering, also known as climate engineering, consists of two major parts. Carbon Dioxide Removal, or CDR, and Solar Radiation Modification, SRM. Not all nations agree with these methods, as they can have negative consequences for some of them. The last UNEA conference was based on this unsettlement, where about fifteen resolutions were passed on the matter. The UN created 17 sustainable development goals, which are certain plans that the UN wishes to succeed before the year 30. This matter fits best with SDG13, based on climate change.

Origin of geoengineering

The whole story began with an idea from a group of scientist after the second world war, primarily to alter the weather systems in order to obtain more favourable climate conditions on a regional scale. One of the earliest techniques is cloud seeding, a weather-modification process that attempts to bring rain to parched farmland by dispersing particles of silver iodide or solid carbon dioxide into rain-bearing clouds. Cloud seeding has also been used in attempts to weaken tropical storms. By the 21st century, however, cloud seeding as a true form of geoengineering, as well as weather modification in general, had become a matter of debate, since the scale upon which cloud seeding operates is small (and not at the planetary scale) and that it does not seek to reverse the effects of human-driven climate change. In addition, the U.S. military suggested that nuclear weapons might be used as tools to alter regional climates and make certain areas of the world more favourable for human habitation. This proposal, however, was not tested.

SRM

Solar Radiation Modification is due its many consequences and risks a very controversial topic in politics. Not all nations benefit from these effects, while others suffer from the extreme drought, or worse, not able to see a blue sky anymore. Some of these methods include:



For example, SAI. The effectiveness of Stratospheric Aerosol Injection, has been extensively explored using numerous climate modelling studies. A general conclusion is that global cooling is in principle achievable. Uncertainties in required amounts and deployment strategies are still considerable. Significant uncertainties in climate model results exist due to the lack of sufficient complexity in many current climate models. Interhemispheric uneven injections, and single point injections of SAI, can lead to large and uneven climate impacts. Also, SAI masks the warming from increasing greenhouse gas concentrations. In the case of sudden termination, any masked warming would re-emerge within a few years.

Another example of the methods of SRM, is cloud brightening. The scientific foundation supporting cloud brightening is significantly less robust compared to that for SAI, due to substantial uncertainties in the understanding of aerosol-cloud-radiation interactions and mixed assessment of efficacy and impacts from observational analogues and modelling studies. It remains uncertain where and when clouds could be brightened, and, if so, by how much. Significant technological and methodological challenges remain before CB could be operationally deployed. The short lifetime of injected particles could, in principle, allow deployment of CB for limited periods and regions.

CDR

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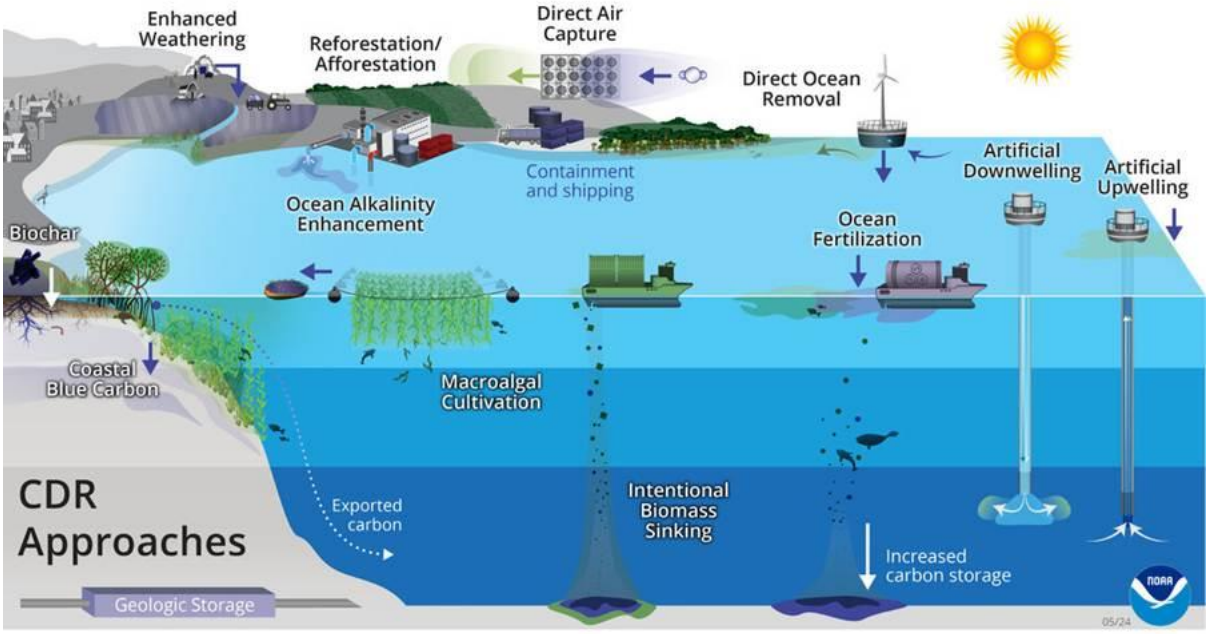
Carbon Dioxide Removal is another method of geoengineering, but a little more specific. It lives after its name, taking carbon dioxide out of the atmosphere. This consists of many approaches:



Land-based approaches involve changes to agriculture, forests, and other land-use activities, as well as direct air capture (DAC) of CO2. DAC describes a number of processes that remove CO2 from the air with a liquid or solid adsorbent and then store the carbon in under- ground reservoirs. Other land-based CDR approaches include accelerated weathering of natural carbonate and silicate rocks, methods for increasing soil carbon uptake (e.g., agricultural sequestration), and storage in above- ground biomass (e.g., reforestation/afforestation). Biomass/crop residues can be converted into a more stable form of carbon, known as biochar, which can be stored long-term in soils or underground.

Marine CDR approaches can amplify the ocean's natural carbon cycles that pull carbon from the atmosphere and transport it into the deep ocean. Ocean alkalinity enhancement, which increases the ocean's drawdown of CO2 by lowering surface water acidity, has the potential added benefit of mitigating ocean acidification. Other methods include macroalgal cultivation (aquaculture) and sinking, ocean fertilization (nutrient addition), and artificial upwelling/downwelling to encourage phytoplankton growth and export. Alternatively, engineered approaches can strip CO2 from seawater in a process known as direct ocean removal (DOR).

Activities that enhance coastal blue carbon (CBC) typically focus on restoration and/or conservation of naturally occurring ecosystems, but may also provide local to regional carbon removal. When these methods are carefully carried out alongside appropriate monitoring, reporting, and verification (MRV),

they can be considered CDR. A coastal blue carbon project may be considered a land- or ocean-based approach depending on the methodology (e.g. mangroves vs seagrass projects).

Benefits and risks of SRM and CDR

As said before, for not every country are these methods beneficial, and they have a lot of risks attached to them. While solar geoengineering may cool the planet, the consequences could be devastating if we suddenly stopped. According to a 2018 study published in Ecology & Evolution, sudden termination of solar geoengineering could result in a scenario of rapid global warming that would occur ten times faster than if we had never used the technology. Such a rapid rise in temperature could wreck ecosystems and lead to a massive extinction crisis. This is one of the riskiest consequences that we are threatened with, since this means we're unable terminate SRM. The study also suggests solar geoengineering could reduce global rainfall by up to 10 percent in certain parts of the globe, which would naturally affect the local ecosystem. In particular, tropical ecosystems and evergreen forests rely on rainfall for growth. Rainfall changes due to solar geoengineering could affect vegetation, which affects the wildlife that feeds on that vegetation. And lastly, our knowledge isn't broad enough to fully comprehend. It's hard to quantify the risks of solar geoengineering because we know so little about how solar geoengineering would look in reality, or how it will intersect with different greenhouse scenarios in the future. These limitations on our knowledge currently make it hard for scientists to take a stance on solar geoengineering. A 2018 Nature study concludes: "Based on present knowledge, climate geoengineering techniques cannot be relied on to significantly contribute to meeting the Paris Agreement temperature goals."

The scientists in the PNAS study describe SAI — a type of solar geoengineering — as a "scheme that is likely to have a large impact on Earth's surface temperature." Ultimately they agree it could induce one major benefit: lowering Earth's global temperature. That's essentially the point of solar geoengineering — reducing temperatures and offsetting the costs of global warming. A 2019 Nature study suggests the right "dose" of solar geoengineering could cut massively cut the planet-warming induced carbon dioxide emissions. "Previous work had assumed that solar geoengineering would inevitably lead to winners and losers... our work challenges this assumption," the Nature team argued in a statement. By reducing global temperatures, solar geoengineering could mitigate the impacts of natural disasters. The same Nature study finds that solar geoengineering could offset the increased risk of tropical cyclones from carbon dioxide emissions. Cooling temperatures could even help reduce income inequality, according to a 2020 study published in Nature Communications.

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Major parties involved

UNEA-6

UNEA-6 has been organized around six thematic areas that were considered by members in developing the draft resolutions to compel more effective, inclusive and sustainable multilateral action. The member states developed and negotiated 22 resolutions along five clusters. The delegates strongly opposed the resolution based on solar engineering, seeing not all these nations have the necessary complex technology.

Vanuatu

Vanuatu, a country in the continent of Oceania, present at the UN science summit at the 79th edition of the General Assembly, firmly rejects the notion that the Pacific Island countries could serve as testing grounds for such risky technologies: “We in the Pacific are not your guinea pigs. (...) We will not allow ourselves to be subjected to another reckless experiment in planetary engineering.” This sentiment resembles earlier concerns with the promotion of solar geoengineering projects on the African continent, and puts those advocating for further research, especially those claiming to benefit climate-vulnerable countries or “the global poor” on increasingly shaky ground. Their stance could not be clearer: a ban or non-use agreement on planetary-scale solar geoengineering technologies is both essential and urgent.

The Continents of Africa and Asia

Severe drought around these continents are some of the risks that occur with solar engineering. Other disadvantages such as; no more clear blue skies or rapid warming if stopped quickly, are also threatening these continents. The MEDC’s seem to have more of a voice in the matter, and ignoring the needs of LEDC’s simply because they are labeled so. We should not forget that our actions have consequences and that nations such as Namibia and Vanuatu suffer under the results of reckless tests of geoengineering, especially with SRM. The extreme drought around the continents are causing issues and in multiple conferences, for example the 79th edition of the General Assembly, these countries have called upon a direct termination of the plans.

The United States

A two-man start-up from the United States, calling itself Make Sunsets, is behind all kinds of tests and appears to be seeking to profit from the climate crisis through such experiments. Inspired by science fiction and academic solar geoengineering research, such as the Harvard SCoPEx project, Make Sunsets - did not hold or apply for any permits from Mexican authorities to conduct a new business activity, let alone solar geoengineering experiments. In fact, the tests took place before the company was incorporated. Nonetheless, the company is already announcing further experiments in the same region.

The Harvard SCoPEx project (Stratospheric Controlled Perturbation Experiment) was established by the American David Keith, a Professor of Geophysical Science and founding faculty director of the Climate Systems Engineering initiative at the University of Chicago, and as said before, previously led the development of Harvard's Solar Geoengineering Research Program. He got the idea from one of his students who brought up geoengineering, and created a review on the subject which he published shortly after.

China

During the last three years, China has assembled one of the largest federally funded geoengineering research programs in the world, marking another area where it's forging ahead of other nations on climate matters. The approximately $3 million program, funded by the Ministry of Science and Technology, incorporates around 15 faculty members and 40 students across three institutions. The researchers are assessing the impact of employing technological means of altering the climate, and exploring related policy and governance issues. The effort explicitly does not include technology development, or outdoor experiments, in contrast with emerging U.S. research programs at Harvard and the University of Washington.

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Timeline of events

1965	The first official mention of geoengineering as a method to combat climate change
2013 sept. 20th	David Keith published his review on Climate Engineering
2022 dec. 16th	Ocean geoengineering scheme aces its first field test
2024 feb. 26th	The start of the 6th edition of the United Nations environmental Assembly
2024 sept. 10th	The start of the 79th edition of the General Assembly

Possible solutions

To clarify, it's difficult to name solutions for geoengineering, seeing this is seen as a solution. SRM and CDR are created to mitigate climate change and to combat the extreme threats and consequences of it. It depends on the view of each nation whether climate engineering is the true solution, or if it's the issue that has been attacking the Earth. In this report, the solutions are told looking from the view of a nation that opposes geoengineering, since naming solutions from the other one is needless. We should also clarify that a clear fixing does not exist. We could mitigate, but never terminate the issue.

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UN declaration/treaty

Even though there have been many conferences where the issues has been discussed, this problem remains threatening various nations, such as the continents of Africa and Asia, with their risky consequences named earlier in this report. This could be an example of not every voice being heard, but also an illustration of vagueness or ignorance. It could be solved by establishing a clear UN declaration based on geoengineering, to mitigate the worsening of the issue by vague laws. Creating a strong treaty, listening to all voices, forces the world to listen too.

More research on the topic

On the other hand, a lot of scientists are not fully familiar with the topic. They could use the better research done on the matter and discussions about how to perhaps solve the issue. Hereby we not only gain knowledge on the issue, we also spread awareness of the problem and create a bigger community of scientists and researchers working on the matter. This could immensely help them to at least reduce the risky effects of geoengineering and creating a real solution to the issue. The more research done, the more safe these activities would be. And the more we learn about the topic, the better we can mitigate the real problem, such as the negative effects of geoengineering and the unheard voices.

Monitoring, detection and verification systems

To keep track of all the activities around climate engineering, it’s necessary to monitor all the actions of geoengineering. Detecting and terminating all these methods and tests before they are performed, could reduce the chance of it occurring once again. Organizing special teams and establishing systems, could aid to monitor these activities. The idea is to use satellites, ground-based sensors, and atmospheric sampling to track signs of SRM or other interventions. By measuring aerosol concentrations, cloud changes, or unusual atmospheric chemistry, the system can quickly identify deliberate climate manipulation and distinguish it from natural events like volcanic eruptions.

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