Reducing global warming: Could reflecting sunlight back into space work?

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Imagine a scenario in the next 15 to 20 years where unprecedented heatwaves, droughts, floods and forest fires occur around the world along with extensive melting of Greenland and Antarctic ice sheets leading the sea to rise, submerging many islands and coastal cities, and many coastal areas being hit by strong storms, hurricanes and cyclones. This is potentially not impossible.

Paris Agreement has a goal of stabilising global warming between 1.5-2 Deg C by the end of the century. But the earth has already warmed by nearly 1.1 Deg C and we see the adverse impacts already felt around the world. The voluntary commitments made in the Nationally Determined Contributions (NDC) by all the countries to the United Nations (UN) before the Paris Agreement, if implemented may still lead to a warming in the range of 2.7-3 Deg C. This level of warming could lead to more unprecedented extreme climatic events threatening humanity and nature.

In such a scenario, the leaders and countries may want an urgent solution, to reduce warming and the related adverse impacts. Some scientists believe “geoengineering” is the solution in such an emergency situation. Geoengineering is the deliberate large-scale alteration of the earth’s environment to mitigate climate change. It is one of the quickest ways to reduce the warming of a region or globally.

One of the most important geoengineering options is Solar Radiation Management (SRM). SRM aims at reflecting inbound sunlight back into space, reducing the amount of heat absorbed by the earth and lowering global temperatures. Its techniques involve:

i) Stratospheric (20 to 50 kms) aerosols injection — the spraying of small, reflective particles into the upper atmosphere to reflect some sunlight before it reaches the earth.
ii) Albedo enhancement aimed at increasing the reflectiveness of clouds or the land surface so that more of the sun's heat is reflected back to space.
iii) Space mirrors blocking a small proportion of sunlight before it reaches the earth.

A real-life example is the Mount Pinatubo volcano in the Philippines that erupted in 1991. An estimated 20 million tonnes of sulfur dioxide and ash particles were released into the stratosphere. Such volcanic eruptions can impact global climate, reducing the amount of solar radiation reaching the earth's surface, lowering temperatures for many years.

Similar to volcanic eruptions, the most effective solution appears to be injecting highly reflective sulphate aerosol particles into the stratosphere. Alternatively, the placement of mirrors in space or enhancement of the reflectivity of marine clouds by injecting sea-salt aerosols into them could be considered.

Solar geoengineering can cool the planet rapidly within 1-2 years and is estimated to cost much less than the conventional climate mitigation techniques through renewable energy, energy efficiency, etc. Many scientific bodies such as the American Meteorological Society, American Geophysical Union and the Royal Society of UK have advocated research into solar geoengineering which could contribute to a comprehensive risk management strategy to slow climate change.

The most studied among the solar geoengineering options is the proposal to inject aerosol particles such as sulfates or calcium carbonate into the stratosphere and deflect about 1-2% of the incoming solar radiation. Modelling studies have consistently confirmed that solar geoengineering can diminish regional and seasonal climate change from anthropogenic CO_2 emissions.

Though SRM is cheap and can rapidly cool down the climate system, it has many undesirable side effects such as weakening the global water cycle, potentially leading to drought in some areas. If SRM fails or is halted, the planet could be subjected to extremely rapid warming with the rate of warming many times that of the current warming. Thus, human and natural systems could be subjected to severe stress following an abrupt termination or failure of SRM.

Reputed scientific bodies such as the Royal Society of UK and the US National Research Council have published reports that recommend research into a portfolio of geoengineering schemes. China started its regional geoengineering program in 2015 and Japanese researchers have assessed the attitudes in the Asia-Pacific region to geoengineering. In India, climate modelling studies have investigated the impacts of solar geoengineering on the hydrological cycle, cyclones in the Bay of Bengal, monsoon and agriculture.

Oxford University has a Geoengineering Programme. Harvard University launched the Solar Geoengineering Research Program which is planning field experiments to test the effects of injected particles (sulfates and calcium carbonates) in the stratosphere at a height of 20 km. However, recently a field experiment in Sweden using a high-altitude balloon, which mimics the cooling effect of volcanic eruptions, was stopped due to opposition from activists and citizens.

According to an assessment by the Overseas Development Initiative, a UK-based think tank, "potential downsides of SRM include changes in regional weather patterns that could lead to droughts in Africa and Asia, damage to the ozone layer, continued ocean acidification, impacts on natural ecosystems and agricultural crops, impacts on tropospheric chemistry, diminished radiation for solar power, and the risk of human error."

There is also a fear that research into geoengineering could lead to the problem of countries stopping the work on emission reduction as there is an engineering solution to the climate problem. There is also the fear that once a research program on geoengineering is initiated, we might ultimately end up implementing geoengineering.

Geoengineering actions such as placing mirrors in the sky may seem like science fiction, and they may not be a panacea for all the adverse effects of climate change. However, it is not clear whether the risks of solar geoengineering are greater than the risks of warming above 1.5 -2 Deg C. The environmental, economic, social, ethical, political, and legal risks of using these technologies are also poorly understood. Scientific research must, however, continue and developing countries including India should be actively engaged in solar geoengineering research, evaluation and discussion.

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