FOOD & WATER WATCH

Is the Solution to Climate Change More Pollution?

Real alternatives to the use of fossil fuels have moved firmly into the category of boring, off-the-shelf products like solar, wind, and storage. But without bold political action, renewables will merely supplement fossil energy.[1] Meanwhile, in an effort to avoid the political confrontation to end fossil fuels, some insist on keeping science fiction solutions to climate change "on the table." One common fantasy solution to global warming is "solar radiation management," which aims to turn down the amount of light from the sun.

Prominent among these proposals is stratospheric aerosol injection (SAI), a plan to inject fine particles or aerosols (most commonly sulfur dioxide, or SO_2) into the upper atmosphere to reflect sunlight before it reaches Earth.[2] While it is possible to change the average global temperature by adding more pollution to the Earth's atmosphere, doing so would merely add another layer of climate change and environmental damage on top of existing ones. This overly simplistic understanding of climate change also ignores the dangers of rising ocean acidification, a problem that sun dimming proposals would do nothing to abate.

While SAI was first considered in the early 1970s by Soviet scientist[3] Mikhail Budyko, the idea gained notoriety with the release of the book *SuperFreakonomics*. This best-seller cast doubt on the link between carbon dioxide (CO_2) and global temperatures, emphasized the positives of CO_2, and suggested that the sensible solution to climate change involves pumping SO_2 into the stratosphere.[4]

Similar proposals continue to attract adherents, eager for a quick-fix solution that does not involve ending the use of fossil fuels.[5] In June 2023, the White House released a study of solar radiation modification; while it recommended no specific policies, the study suggested that more research could help inform future policy debates, and that the technology "offers the possibility of cooling the planet significantly on a timescale of a few years." European leaders have also begun to discuss how to best study the issue.[6]

Atmospheric Science Is Very Complex; Aerosols Are Not a "Thermostat" for the Earth

Proponents of SAI like to argue that it is a simple process with predictable results. However, increasing concentrations of aerosols in the stratosphere would impact hydrological and atmospheric systems in hard-to-predict ways.[7] These uncertainties are likely to strongly impact the effects of aerosol deployment.[8] Pouring funding into solar management research is unlikely to resolve these uncertainties.[9]

Proponents of SAI point to a 1991 volcanic eruption in the Philippines that released 20 million tons of SO_2, cooling the Earth by 0.6 degrees Celsius (about 1 degree Fahrenheit) over 15 months.[10] Almost all models of stratospheric aerosol emission rely on this singular eruption for data and

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problematically assume that the impacts would hold across different seasons or weather patterns.[11] This eruption showed that adding SO_2 to the atmosphere has a cooling effect, but aerosols remain in the atmosphere only temporarily; keeping temperatures down would require continued releases of additional SO_2, so long as atmospheric greenhouse gases remain high. Using volcanic data cannot fully capture the long-term complex impacts from sustained aerosol deployment.[12]

If the underlying sources of greenhouse gases are not addressed, reliance on and side effects of aerosol deployment would grow indefinitely.[13] This could create the political conditions for continued CO_2 emissions and very high levels of atmospheric CO_2. Disruption of the aerosol layer (or failure of the technology used to maintain the system) could result in significant warming in a very short time frame.[14] For example, space weather events (such as a solar flare) could knock out this infrastructure.[15] This could be particularly dangerous, as rapid changes in temperature can undermine the ability of ecosystems to adapt.[16]

Globally Adjusting the Temperature Would Create Chaos Regionally

Adjusting the average temperature through such radical means does not necessarily mitigate the real-world effects of climate change — and could even make them worse. Lowering the average global temperature would still result in regional temperature changes, with an uneven distribution of consequences and a high degree of continued climate chaos.[17] For example, an SAI scenario could reduce global temperatures while still resulting in record hot years and a decade of increasing temperatures for 55 percent of the Earth's population. This is because SAI does not fully reverse the increase in temperature variability caused by greenhouse gas-driven climate change.[18]

Because lower latitudes receive more sunlight, dimming to limit global temperature would reduce temperatures in the tropics by too much and the poles too little.[19] This uneven distribution of cooling has the potential to create significant side effects for the Global South, including increased drought and disease.[20] For example, changes resulting from aerosol injection could increase malaria transmission in Sub-Saharan Africa and Southern Asia, exposing up to 1 billion people to malaria.[21]

Additionally, changing the amount of solar radiation that reaches Earth would dramatically alter rainfall patterns, in turn altering plant habitat and impacting agriculture.[22] Globally, a reduction in solar radiation would slow the hydrological cycle by decreasing evaporation and therefore precipitation.[23] Regionally, most models predict that SAI would cause substantial drying in India, the Amazon Rainforest, and parts of Africa.[24] Multiple studies highlight that under global aerosol deployment, South Asia would experience significant reductions in monsoon precipitation, rainfalls that currently support crop productivity and water supplies for billons.[25]

These Proposals Use Toxic, Polluting Chemicals

The most commonly studied aerosol for SAI is sulfur dioxide, a regulated pollutant that is linked to health problems, ozone depletion, and acid rain.[26] Other proposed aerosols range from calcium carbonate to diamond dust, but there is far less research on the potential climate and health effects of these particles.[27] While the specific impacts vary among aerosol types, inhalation of this fine particulate matter can impact respiratory and heart health.[28] Dramatically increasing the release of these pollutants would likely have significant, unpredictable effects on human health and the environment.

Although highly uncertain, by one estimate, constraining global warming to 1.5 degrees Celsius (2.7 degrees Fahrenheit), the target set under the Paris Agreement on climate change, would require roughly a 40 percent increase in SO_2 pollution, directly into the stratosphere.[29] Here, SO_2 oxidizes into sulfate particles.[30] A portion drifts to the ground level and creates air pollution, with potentially fatal impacts on human respiratory and cardiovascular health when inhaled.[31] However, sulfates primarily leave the upper atmosphere as acid rain, raising the potential for soil acidification and ecosystem damage, particularly in North America, Europe, and Oceania.[32] The changes to pH levels in lakes, rivers, and streams would also impact the availability of water for human consumption.[33]

Certain types of aerosols cause significant ozone layer depletion.[34] For example, injecting large quantities of SO_2 into the stratosphere would significantly delay the projected recovery of the ozone hole.[35] The ozone layer protects humans from harmful, cancer-causing ultraviolet B (UV-B) radiation. Shortwave UV-B radiation is harmful to plants, resulting in an increase in CO_2 emissions in addition to potential crop damage.[36] Finally, sulfate aerosols change the chemistry of the stratosphere and impact the cycle of carbon, nitrogen, and sulfur.[37] Changes to the nitrogen cycle would in turn have unpredictable impacts on the ozone layer, which impacts skin cancer risk.[38] These changes also affect water quality and availability by altering the chemical composition as well at the extent and distribution of algae blooms.[39]

Ocean Impacts

Only around half of emitted CO_2 remains in the atmosphere; the land absorbs around 20 percent and the remaining 30 percent dissolves in the ocean.[40] Rising ocean CO_2 levels lower the pH of the ocean, a phenomenon known as ocean acidification.[41] Specifically, this causes the pH of seawater to decrease while simultaneously decreasing the availability of carbonate ions (CO_3^{2-}), which are necessary for the production of minerals such as calcium carbonate, used by shellfish and corals to build their shells and skeletons.[42] This change threatens numerous ocean species, some of which play a critical role in ocean food chains.[43]

Potentially more important is the impact that ocean acidification will have on the vast diversity of invisible microorganisms that function as a “life-support system” for all life on Earth.[44] Ecosystem function is necessary for all human life, most critically in the realm of nutrient cycling, which enables, among other functions, the continued existence of fertile soil for crop production on land.[45] Ocean organisms play a critical role in the regulation of atmospheric oxygen, nitrogen, and CO_2.[46] Ocean acidification is already interfering with the global nitrogen cycle and resulting in increased emissions of nitrous oxide (N_2O), a potent greenhouse gas.[47]

The geological record suggests that neglecting the ocean is playing with fire; ocean acidification has been a key element of multiple mass extinction events in the Earth’s history.[48] Recent research highlights the role of ocean acidification in the end-Permian mass extinction event, the most severe loss of biodiversity in the planet’s history.[49] The current rate of species loss is faster than during any previous historical period, even events that wiped out up to 95 percent of all life on Earth.[50] Continued CO_2 emissions are on pace to cause significantly more ocean acidification by the end of the century than the pH change associated with past mass extinctions.[51]

None of these technological magic bullets will address ocean acidification; only ending CO_2 emissions will stop the acceleration of ocean acidification and allow the ocean to recover.[52] In fact, side effects of these sci-fi proposals may cause additional damage to the ocean. Changes in solar radiation would impact the circulation and temperature of the ocean, with unpredictable ecosystem impacts.[53] A reduction in sunlight would have a correspondingly negative impact on phytoplankton, which are not only a key carbon sink but also a crucial primary source of energy for ocean food chains.[54]

Conclusion

SAI primarily serves as a distraction from the very real project of ending fossil fuel use. Even ignoring the climate consequences, the ongoing pollution from unconstrained burning of fossil fuels has an immense human health toll.[55] Beyond prolonging fossil fuel use, the consequences of injecting large volumes of aerosols into the atmosphere would be catastrophic. Instead of science fiction proposals, we must end the production and use of fossil fuels, end factory farming, and transition to 100 percent renewable energy. This would not only halt rising global temperatures; it would also avert a potentially existential collapse of ocean and land species.

Endnotes

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