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Q&A: Experts discuss the geoengineering methods for reflecting sunlight to cool Earth

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As concerns about climate change intensify, researchers are exploring the potential for large-scale human intervention in the Earth's climate system, a strategy sometimes referred to as geoengineering. One approach to cooling the Earth involves sunlight reflection methods, or "SRM," such as adding aerosols to the stratosphere. While still in the realm of theoretical research, such approaches raise significant scientific, political and ethical considerations.

Two leading researchers focused on sunlight reflection methods are Douglas MacMartin, associate professor in the Sibley School of Mechanical and Aerospace Engineering and a faculty fellow at Cornell Atkinson Center for Sustainability, and Daniele Visioni, assistant professor of earth and atmospheric sciences in the College of Agriculture and Life Sciences.

Together, they are building a community of scholars across Cornell University and beyond to equip scientists, policymakers and society with a roadmap for responsible evaluation of sunlight reflection and other geoengineering methods.

Ben Furnas, executive director of the 2030 Project: A Cornell Climate Initiative, interviewed MacMartin and Visioni about their research and where SRM fits into the bigger picture of potential climate solutions.

Furnas: What is the basic idea behind sunlight reflection methods?

MacMartin: The climate is warming because greenhouse gases in the atmosphere, principally carbon dioxide, make it harder for heat to escape. Reflecting a tiny fraction of sunlight, less than 1%, would cool the planet substantially. There are a few plausible ways to do this, but the best understood is referred to as stratospheric aerosol injection.

Visioni: The idea stems from observing naturally occurring phenomena, such as large volcanic eruptions, which can inject aerosols—small droplets or particles—into the higher levels of the atmosphere where they last for a year or two, reflecting sunlight, which cools surface temperatures. These observations led scientists to wonder if such an effect could be artificially reproduced in light of the urgency to stop the increase in surface temperatures due to greenhouse gases, not as a substitute to cutting emissions but in addition to it.

Furnas: Why should sunlight reflection be considered alongside all the other options we have to address climate change?

Visioni: SRM is not a substitute for emissions reduction, nor an excuse to slow down the energy transition. We have to get to net-zero emissions of greenhouse gases, and we need to do that globally. However, even the most optimistic scenarios aren't likely to keep us below the 1.5°C-threshold in the Paris Agreement. Furthermore, when we've reduced emissions to zero we won't have solved climate change, we will have finally stopped making it worse.

We're already seeing serious impacts, especially for the most vulnerable populations, before we have even reached 1.5°. This begs the question: What are we doing to manage those short term risks, and will adaptation be enough to manage them in the future? In this framework, SRM should be considered part of a much more comprehensive strategy that centers emissions reduction and includes the exploration of carbon dioxide removal strategies.

MacMartin: We'd like to live in a world where we don't need to think about SRM because we've already solved climate change, but given where we are today that seems like a risky gamble. Right now, we don't really know enough to make informed decisions about SRM. If we want to be in a position to make wise decisions in the future, we need to do the research now.

Furnas: What are the risks of sunlight reflection?

Visioni: In terms of the physical climate response, it is important to acknowledge SRM would not be perfect, as it wouldn't cancel out precisely the warming effect of greenhouse gases, leaving some residual shifts in patterns of precipitation, for example. Modeling suggests these are generally small but more research is needed. Furthermore, there would be direct changes resulting from the addition of aerosols in the stratosphere, for instance, they would react chemically with ozone-producing mechanisms.

How well do we understand those interactions, and how important would they be in an overall assessment of risks? In future climate projections, there are always going to be uncertainties in our understanding. The question research needs to answer is if there are more uncertainties and more risks in letting our planet warm, or in directly intervening to prevent that warming from happening through SRM.

MacMartin: We also need to acknowledge that not all risks from SRM are related to physical risks. One of the biggest concerns many people have is that it could get used as an excuse to put less effort into cutting emissions; indeed, that risk is potentially present even with research.

There are political and societal risks as well, especially when thinking about unilateral actions from one actor, global governance, how to make decisions in a way that is just and equitable for everyone on the planet. This, for us, underlines the need to think of SRM research in a holistic way, not just focusing on the physical impact but also thinking about its ecological and political implications.

Furnas: What are other questions your research is trying to answer?

MacMartin: There are some key questions that need to be answered to ultimately inform policy: What do we think would happen if stratospheric aerosol injection were deployed? How does that answer depend on choices that can be made, such as at which latitude we choose to add aerosols to the stratosphere? And what are the risks, both from the physical climate side and from the human dimension?

We're working on all of these, either directly or through collaborations.

Visioni: The main tool we use is climate models, the same ones currently used for assessments by the Intergovernmental Panel on Climate Change, which we use to try to better understand the expected climate response, how that depends on design choices and uncertainties related to simulated SRM.

Combined with observations of natural proxies, we try to understand how good our models are in reproducing the physical mechanisms behind SRM, and what can be done in the context of model development to reduce some of those uncertainties. As these models are incredibly complex, we also focus on devising experiments capable of shedding light on single processes and quantifying their contribution to the overall uncertainties.

We also use these climate models, in collaboration with other groups around the world, to explore how large is the strategy and scenario space for SRM, that is, how many physically unique deployment scenarios—where, when and how much to inject—may exist based on physical constraints such as stratospheric circulation, and on potential desired targets for SRM such as how much to cool and what risks to manage.

MacMartin: To do this, we also collaborate with social scientists, climate modelers and ecologists and experts from around the world to make sure multiple interests and needs are reflected in the scenarios we devise, and that diverse impacts are assessed. We are particularly focused on ensuring that people in the developing world, who are typically the most climate-vulnerable, have access to climate model simulations to help them draw their own conclusions about the impacts in their countries.

Provided by Cornell University

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