Q&A: Aerospace engineer discusses the design challenge of solar geoengineering

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Douglas MacMartin, a visiting scholar at the Stanford Woods Institute for the Environment, discusses how solar geoengineering could fit into the array of solutions for the climate future. Credit: Brett Sayles / Pexels

Solar geoengineering—artificially reflecting sunlight back into space—is a double-edged sword. It would cool the rapidly warming planet, but is it too risky to consider as a viable option? Douglas MacMartin, an aerospace engineer and visiting scholar at the Stanford Woods Institute for the Environment, thinks of solar geoengineering as a design problem. His research is dedicated to understanding how to most effectively optimize the cooling effects from climate engineering while minimizing the potential risks to humans and ecosystems. That way, if the time comes that we need to deploy it to avert the worst effects of climate change, we'll be ready.

MacMartin is an associate professor in the Sibley School of Mechanical and Aerospace Engineering at Cornell University. He has provided briefings on the subject of solar geoengineering to the UN Environment Program and testimony to the U.S. Congress, and was a member of the U.S. National Academies panel that made recommendations on both research and governance in March 2021. Here he discusses solar geoengineering and how it fits into the array of solutions for responding to a warming climate.

What does it mean to engineer the climate?

From a planetary perspective, we get energy from the sun and we radiate some energy back to space. Greenhouse gases in the atmosphere like carbon dioxide and methane—which we add to by burning fossil fuels—create a kind of blanket that makes it harder for that energy to escape. Reflecting roughly one percent of incoming sunlight back to space would be enough to cool the entire planet back to pre-industrial temperatures.

The way to do this that's best understood—and the way that I primarily focus on in my research—is to use specialized aircraft or balloons to introduce liquid or solid droplets called aerosols into the stratosphere roughly 12 miles (19 km) or more above Earth's surface. The particles then scatter and rebound sunlight back to space. We call this form of solar geoengineering "stratospheric aerosol injection."

What would you say to those who worry focusing on solar geoengineering will take attention away from the urgency of climate mitigation actions, such as reducing emissions?

There is a legitimate concern that conversations about solar geoengineering could lead some people to think, "Oh, we don't have to put as much pressure on mitigation." From my point of view, we would only realistically consider deploying this if climate change gets a lot worse.

So I definitely think about it as part of a portfolio of climate solutions. Just as if you're driving and you realize that you're going to hit the car in front of you, you take your foot off the gas. But you don't expect that to solve the problem by itself. Then you hit the brakes. Even so, you might still want to have your seatbelt and airbags. We never talk about that situation as, "Which one of these options do we pick?" We do everything. Fortunately, I don't think we're at a point yet where we have to deploy solar geoengineering. But I do think we're at a point where we should at least research these options.

What are some of the risks associated with deploying stratospheric aerosol injection?

Although we know that aerosols would cool the Earth's temperature, these materials would also likely weaken the ozone layer, which continues to repair itself following a successful campaign to eliminate many ozone-depleting chemicals. Sulfate aerosols would also fall back to Earth as acid rain once they complete their lifespan in the stratosphere. Additionally, if we were to suddenly stop deploying stratospheric aerosols after relying on it for significant cooling, the rapid rebound to warmer temperatures could cause extreme weather or ecological changes. It would be extremely challenging to reach a global consensus about whether or not to deploy, so there's a risk of geopolitical conflict.

What do you mean when you call solar geoengineering a 'design challenge?'

I'm using the term "engineering" to refer to a goal-oriented and mission-driven approach in contrast to a curiosity-driven approach. If you're considering deliberately modifying the climate, you need to think about a range of questions and factors. What happens if you inject at one latitude versus another? What happens if you inject different types of material? How do you systematically manage uncertainty?

How do you see solar geoengineering fitting into the web of climate solutions?

Beyond reducing our greenhouse gas emissions and removing carbon dioxide from the atmosphere, solar geoengineering is a third potential action—along with adaptation—that might reduce some of the climate impacts in the meantime. It won't help reverse some existing issues like ocean acidification, but it is likely to reduce important effects induced by global warming, including sea level rise, decreased soil moisture, and heat stress.

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