No quick or easy technological fix for climate change, researchers say

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Global warming, some have argued, can be reversed with a large-scale "geoengineering" fix, such as having a giant blimp spray liquefied sulfur dioxide in the stratosphere or building tens of millions of chemical filter systems in the atmosphere to filter out carbon dioxide.

But Richard Turco, a professor in the UCLA Department of Atmospheric and Oceanic Sciences and a member and founding director of UCLA's Institute of the Environment, sees no evidence that such technological alterations of the climate system would be as quick or easy as their proponents claim and says many of them wouldn't work at all.

Turco will present his new research on geoengineering — conducted with colleague Fangqun Yu, a research professor at the State University of New York–Albany's atmospheric sciences research center — today and Thursday at the American Geophysical Union's annual meeting in San Francisco.

"We're talking about tinkering with the climate system that affects everybody on Earth," said Turco, an atmospheric chemist with expertise in the microphysics of fine particles suspended in the atmosphere. "Some of the ideas are extreme. There would certainly be winners and losers, but no one would know who until it's too late.

"If people are going to pursue geoengineering, they have to realize that it won't be quick, cheap or easy; indeed, suggestions that it might be are utter nonsense, and possibly irresponsible. Many of these ideas would require massive infrastructure and manpower commitments. For example, one concept to deliver reflective particles to the upper atmosphere on aircraft would require numerous airports, fleets of planes and a weather forecasting network dedicated only to this project. Its operation might be comparable to the world's entire commercial flight industry. And even after that massive investment, the climatic response would be highly uncertain."

Given the difficulties of reducing greenhouse gas emissions, the idea of a simple large-scale technological solution to climate change can seem very appealing.

"Global warming due to carbon dioxide emissions appears to be happening even faster than we expected," Turco said. "Carbon dioxide emissions are continuing to grow despite all of the warnings about climate change, despite all of the data showing such change is occurring and despite all of the efforts to control carbon emissions. The emissions are rising, in part, because China and India are using increasingly more energy and because fossil fuels still represent the cheapest source of energy.

"If we continue down this path, the climate is likely to change dramatically — major ice sheets could melt, sea levels could rise, it may evolve into a climate catastrophe. So it is tempting to seek an alternative response to climate change in case we can't get emissions under control. The result is that more and more geoengineering proposals are surfacing. Some of the people developing such proposals know what they're talking about; many don't."

Turco and Yu have been studying a particular geoengineering approach that involves the injection of nanoparticles, or their precursor gases — such as sulfur dioxide or hydrogen sulfide — into the stratosphere from aircraft or large balloons.

While our climate system normally involves a balance between incoming sunlight and outgoing heat radiation, excess atmospheric greenhouse gases trap additional heat and cause the Earth's temperature to rise, Turco noted. "One way to control the potential warming is to reduce the emissions of greenhouse gases," he said. "We haven't been able to get a handle on that. Another idea, instead of reducing emissions, is to somehow compensate for them."

The idea of injecting sulfur dioxide or other toxic gases into the stratosphere in gaseous or liquefied form would mean that planes or balloons would have to fly as high as 13 miles — higher than any commercial aircraft can reach. And the amounts involved range to many millions of tons.

"Some of these proposals are preposterous, mind-boggling," Turco said. "What happens, for example, when you spray liquefied sulfur dioxide into the stratosphere? Nobody knows."

In a study published earlier this year, Turco analyzed what happens when a stream of very small particles is injected into the atmosphere. He showed that when the particles are first emitted, they are highly concentrated, collide frequently and coagulate to much larger sizes than expected.

"To create the desired climate outcomes, you would need to insert roughly 10 million tons of optimally-sized particles into the stratosphere," he said. "You would have to disperse these particles very quickly over the entire stratosphere or they would coagulate into much larger sizes. At such enhanced sizes, the particles do not have the same effect; they're much less effective in forcing climate compensation. In the end, you would have to fly thousands of high-altitude jets every day to get enough particles into the atmosphere to achieve your goal. And this activity would have to be sustained for hundreds of years."

The basic idea behind stratospheric particle injections is that the Earth's temperature depends on the reflectivity of the atmosphere. About one-third of the energy from the sun hitting the Earth is reflected back into space. That fraction is called the "albedo." If the albedo increases, the average global temperature decreases because less energy is available to warm the planet. So if we can increase the albedo sufficiently, we can compensate for global warming.

"The size distribution of the particles is critical," Turco said. "If the particles are too large, that will actually create a warming effect, a greenhouse warming. Small particles are not useful because they don't reflect much radiation; you need something in between, and we have shown that is hard to achieve reliably."

Turco and Yu have simulated, for the first time, the actual injection processes that might be used, focusing on the early evolution of the injection plumes created from aircraft or balloon platforms. They used an advanced computer model developed by Yu to calculate the detailed microphysical processes that ensue when reactive, particle-forming vapors are emitted into the atmosphere. They also accounted for the photochemical reactions of the injected vapors, as well as the mixing and dilution of the injection plume.

"We found that schemes to emit precursor gases in large quantities would be extremely difficult to design and implement within the constraints of a narrow tolerance for error, and in addition, the outcomes would be very sensitive to variables over which we would have little control, such as the stability and mixing conditions that occur locally," Turco said.

"Advocates of geoengineering have tried to make climate engineering sound so simple," he added. "It's not simple at all. We now know that the properties and effects of a geoengineered particle layer in the stratosphere would be far more unpredictable, for example, than the physics of global warming associated with carbon dioxide emissions. Embarking on such a project could be foolhardy."

How can global warming be combated?

"We must reduce carbon emissions," Turco said. "We need to invest big-time in alternative energy sources with minimal carbon footprints."

Source: University of California - Los Angeles

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