Scientists offer better ways to engineer Earth's climate to prevent global warming

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There may be better ways to engineer the planet's climate to prevent dangerous global warming than mimicking volcanoes, a University of Calgary climate scientist says in two new studies.

"Releasing engineered nano-sized disks, or sulphuric acid in a condensable vapour above the Earth, are two novel approaches. These approaches offer advantages over simply putting sulphur dioxide gas into the atmosphere," says David Keith, a director in the Institute for Sustainable Energy, Environment and Economy and a Schulich School of Engineering professor.

Keith, a global leader in investigating this topic, says that geoengineering, or engineering the climate on a global scale, is an imperfect science.

"It cannot offset the risks that come from increased carbon dioxide in the atmosphere. If we don't halt man-made CO_2 emissions, no amount of climate engineering can eliminate the problems - massive emissions reductions are still necessary."

Nevertheless, Keith believes that research on geoengineering technologies,their effectiveness and environmental impacts needs to be expanded.

"I think the stakes are simply too high at this point to think that ignorance is a good policy."

Keith suggests two novel geoengineering approaches-'levitating' engineered nano-particles, and the airborne release of sulphuric acid-in two newly published studies. One study was authored by Keith alone, and the other with scientists in Canada, the U.S. and Switzerland.

Scientists investigating geoengineering have so far looked mainly at injecting sulphur dioxide into the upper atmosphere. This approach imitates the way volcanoes create sulphuric acid aerosols, or sulphates, that will reflect solar radiation back into space - thereby cooling the planet's surface.

Keith says that sulphates are blunt instruments for climate engineering. It's very difficult to achieve the optimum distribution and size of the aerosols in the atmosphere to reflect the most solar radiation and get the maximum cooling benefit.

One advantage of using sulphates is that scientists have some understanding of their effects in the atmosphere because of emissions from volcanoes such as Mt. Pinatubo, he adds.

"A downside of both these new ideas is they would do something that nature has never seen before. It's easier to think of new ideas than to understand their effectiveness and environmental risks," says Keith.

In his study-published in the *Proceedings of the National Academy of Sciences*, a top-ranked international science journal-Keith describes a new class of engineered nano-particles that might be used to offset global warming more efficiently, and with fewer negative side effects, than using sulphates.

According to Keith, the distribution of engineered nano-particles above the Earth could be more controlled and less likely to harm the planet's protective ozone layer.

Sulphates also have unwanted side-effects, ranging from reducing the electricity output from certain solar power systems, to speeding up the chemical process that breaks down the ozone layer.

Engineered nano-particles could be designed as thin disks and built with electric or magnetic materials that would enable them to be levitated or oriented in the atmosphere to reflect the most solar radiation.

It may also be possible to control the position of particles above the Earth. In theory, the particles might be engineered to drift toward Earth's poles, to reduce solar radiation in polar regions and counter the melting of ice that speeds up polar warming-known as the ice-albedo feedback.

"Such an ability might be relevant in the event that warming triggers rapid deglaciation," Keith's study says.

"Engineered nano-particles would first need to be tested in laboratories, with only short-lived particles initially deployed in the atmosphere so any effects could be easily reversible," says Keith.

Research would also be needed to determine whether such nano-particles could be effectively distributed, given the complex interplay of forces in the atmosphere, and how much cooling might be achieved at the planet's surface.

It is also unknown whether the amount of particles needed-about 1 trillion kilograms per year or 10 million tonnes over 10 years-could be manufactured and deployed at a reasonable cost.

However, Keith notes another study, which looked at the cost of putting natural sulphates into the stratosphere.

"You could manipulate the Earth's climate at large scale for a cost that's of the order of $1 billion a year. It sounds like a lot of money, but compared to the costs of managing other environmental problems or climate change, that is peanuts."

"This is not an argument to do it, only an indication that risk, not cost, will be the deciding issue," he adds.

In a separate new study published in the journal *Geophysical Research Letters*, Keith and international scientists describe another geoengineering approach that may also offer advantages over injecting sulphur dioxide gas.

Releasing sulphuric acid, or another condensable vapour, from an aircraft would give better control of particle size. The study says this would reflect more solar radiation back into space, while using fewer particles overall and reducing unwanted heating in the lower stratosphere.

The study included computer modeling that showed that the sulphuric acid would quickly condense in a plume, forming smaller particles that would last longer in the stratosphere and be more effective in reflecting solar radiation than the large sulphates formed from sulphur dioxide gas.

Keith stresses that whether geoengineering technology is ever used, it shouldn't be seen as a reason not to reduce man-made greenhouse gas emissions now accumulating in the atmosphere.

"Seat belts reduce the risk of being injured in accidents. But having a seat belt doesn't mean you should drive drunk at 100 miles an hour," he says.

Provided by University of Calgary