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This sunset in Chile photographed in 1991 is tinged red by ash from the Mount Pinatubo eruption

**Any attempts to engineer the climate are likely to result in "different" climate change, rather than its elimination, new results suggest.**

Prof Ken Caldeira, of Stanford University, presented research at a major conference on the climate risks and impacts of geoengineering.

These techniques have been hailed by some as a quick fix for climate change.

But the impacts of geoengineering on oceans, the water cycle and land environments are hotly debated.

They have been discussed at a meeting this week of 12,000 scientists in Vienna.

Researchers are familiar with the global cooling effects of volcanic eruptions, seen both historically and even back into the deep past of the rock record.

With this in mind, some here at the **European Geosciences Union General Assembly** have been discussing the possible worldwide consequences of pumping sulphate aerosols into the stratosphere to attempt to reflect sunlight back into space and cool the planet.

## Planetary sunshade

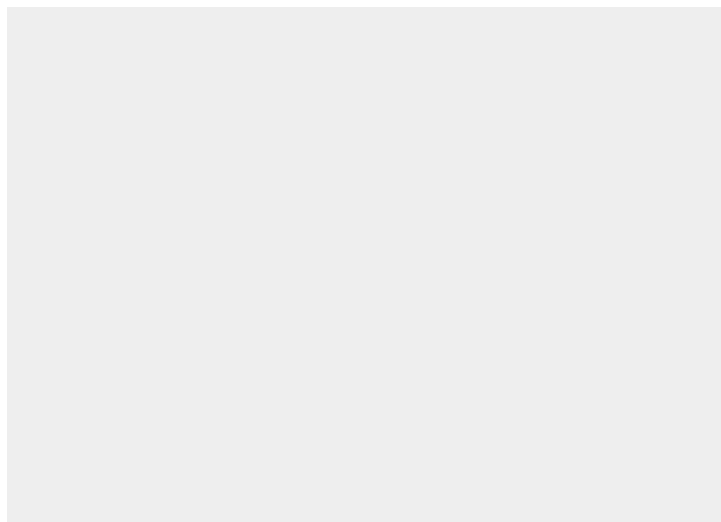
Two hundred years ago this month, the huge volcano Mount Tambora erupted in Indonesia, throwing tonnes of gas and ash into the stratosphere.

Maybe as much as 100 million tonnes of sulphur dioxide aerosols spread as a blanket around the globe, acting like a planetary sunshade.

Global temperatures plummeted, and across America and Europe 1816 became known as the year without a summer.

Such global cooling processes, but managed in a geoengineering solution, have been touted by some as a possible mechanism to extricate the planet from its path towards a warmer future.

Solar radiation management would use stratospheric sulphate aerosols to dim the Sun. Using a variety of climate models, Ken Caldeira, from the Carnegie Institution for Science in Stanford, California, has investigated the likely consequences of such geoengineering on agriculture across the globe.



Mount Pinatubo pumped 20 million tonnes of sulphur dioxide high into the sky above the Philippines

His research shows that while dimming could rapidly decrease global temperatures, high CO<sub>2</sub> levels would be expected to persist, and it is the balance between temperature, CO<sub>2</sub>, and sunlight that affects plant growth and agriculture.

Exploring the regional effects, he finds that a stratospherically dimmed world would show increased plant productivity in the tropics, but lessened plant growth across the northerly latitudes of America, Europe and Asia.

It is easy to see how there might be geopolitical shifts associated with changes in regional food production across the globe.

"It's probably the poor tropics that stand to benefit and the rich north that stands to lose," said Prof Caldeira.

But what if geoengineered sulphate aerosols were, nonetheless, deployed and then a large volcanic eruption like Pinatubo in the Philippines took place? Three such eruptions occurred in the last century so the scenario seems likely.

## Bad timing

Hannele Korhonen, of the Finnish Meteorological Institute, suggests that the climate impacts could be quite unexpected.

Her results indicate increased temperatures in the Southern Ocean and in northerly latitudes, as well as the mid-Pacific, but cooling in African and Asian mid-latitudes.

Regional weather patterns would still change, as they did after Tambora in 1816, with similar widely felt disruption.

"Deploying solar radiation management methods would lead to a completely new climate state with enhanced greenhouse effect and reduced solar radiation," said Korhonen, adding: "There are great uncertainties, related especially to the regional climate impacts of solar radiation management."

Commenting on the results, Helene Muri, of the University of Oslo, said: "These modelling experiments have highlighted the new risks associated with solar radiation management. The safest option is, of course, to reduce greenhouse gas emissions and aim for a more sustainable way of living and managing the planet."

It is not at all obvious what the other consequences of global geoengineering approaches might be. For example, Patrick Applegate from Pennsylvania State University, reported that solar radiation management may yet fail to prevent sea-level rise from melting ice sheets, which respond on much longer time scales than the temperature effects of solar shielding.

Aside from being ineffective in stemming sea-level rise, solar radiation management - according to results from Jerry Tjiputra at Bergen University - would lead to increased ocean acidification in the North Atlantic.

These results also suggest that climate engineering could not offer a long-term solution, with the world eventually being in the same place, by 2200, as it would reach without any geoengineering interventions.

Asked whether he believed solar radiation management would be deployed, Prof Caldeira responded: "A lot has to do with how bad climate change will end up being. Humans are quite adaptable as a species.

"On the other hand, projections for summers in the tropics suggest almost every summer will be hotter than the hottest summer yet on record, associated with crop failures. There is the possibility that there would be widespread crop failures in the tropics in the summer.

"The only thing a politician can do to start the planet cooling is solar geoengineering. If a catastrophic outcome does occur, the pressure to deploy a scheme could be overwhelming.

"Research into this is an act of desperation on the part of scientists. People see the greenhouse gas concentrations increase and are looking for other ways to reduce environmental risk."

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