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## Guns and sunshades to rescue climate

By Molly Bentley

**Any cook who has tasted a dish after tossing in too much salt or hot pepper knows the panic of trying to undo the damage.**

You raid the spice rack to mask the glut of cayenne, but oops - now it is swimming in oregano. It is hard to restore the balance once you overdo it.

We have experienced this with the Earth's atmosphere for some time now; concentrations of greenhouse gases continue to grow even as we adopt international protocols and clean technologies in an attempt to bring them down.

It is apparent our energy-saving tricks are not enough to prevent perhaps catastrophic climate change. But there may be a "plan B"; and while scientists hope it will not be needed, they are considering it anyway.

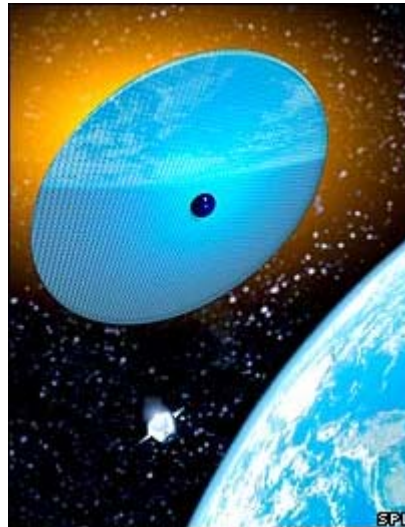
It would be plucked from an array of bold and contentious proposals which go under the heading "geoengineering".

### Feasible or far-out?

"Humans are changing the Earth, and it's a big effect we're having," says Mike MacCracken, chief scientist for climate change projects at the Climate Institute in Washington DC.

"To really stop climate change in its tracks, you have to go to virtually zero emissions in the next two decades.

"So the question is, is there a silver bullet that can help us to limit the amount of climate change?"



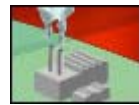
Could giant shades in space curb climate change on Earth?

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Some such "silver bullets" aim to scrub carbon dioxide (CO<sub>2</sub>) out of the atmosphere, some to cool Earth directly by veiling it; others are yet more radical.

While most are confined to computer models or scribbling on the backs of envelopes, a few have been tried cautiously.

Scientists have sprinkled iron in patches of the Southern Ocean to increase absorption of carbon dioxide from the atmosphere, and are testing the feasibility of sequestering carbon in saltwater aquifers or rock.

But what distinguishes geoengineering from localised tinkering is the scope; this would be manipulation on a global scale.

### Earth in the shade

Consider the notion of shading the planet with mirrors. The US National Academy of Sciences found that 55,000 orbiting mirrors would reflect enough sunlight to counter about half the doubling of carbon dioxide.

But each mirror must be 100 sq km; any larger and you would need a manufacturing plant on the Moon, says Dr MacCracken. The price tag of space-based fixes makes them prohibitive - for now.

By contrast, the "human-volcano" approach is on *terra firma* and less costly. Inspired by studies of the Mt Pinatubo eruption of 1991 and the cooling effect of its sulphur plume, one proposal suggests that naval guns shoot sulphur pellets into the air to increase Earth's albedo, or reflectivity.

We know that blocking sunlight can counter global warming, but can we get the balance right?

"I don't think we can get it right," says Ken Caldeira from the Carnegie Institution Department of Global Ecology at Stanford University in California.

"One of the problems of putting sulphate particles in the stratosphere is that it would destroy the ozone layer;



“ Humans are changing the Earth, and it's a big effect we're having ”

Mike MacCracken

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Ships could fire sulphur aerosols to mimic the effect of volcanoes

so you might solve the global warming problem, but then we'd all die of that."

And this from a man whose work supports the idea of dimming the Sun.

A few years ago, Dr Caldeira set out to disprove an idea put forward by Livermore physicists Lowell Wood and Edward Teller to cool the Earth with a sheet of superfine reflective mesh - similar in concept to orbiting mirrors.

In a computer model, Dr Caldeira and colleague Bala Govindasamy simulated the effects of diminished solar radiation.

"We were originally trying to show that this is a bad idea, that there would be residual regional and global climate effects," explains Dr Caldeira.

"Much to our chagrin, it worked really well."

### Acts of hostility

The simulation showed that blocking even a small percent of sunlight balanced out the doubling of atmospheric CO<sub>2</sub>. But in their published paper, the scientists caution against the environmental risks of geoengineering.

A broad simulation cannot account for all feedbacks lurking in the system, and Dr Caldeira does not recommend building an Earth parasol based on the results; current computer models are not up to the task of predicting the consequences of large-scale plans such as Earth shades.

Perhaps the most radical of all geoengineering concepts involves nothing less than moving the Earth itself, cooling the planet by shifting its orbit further from the Sun.

Dr Caldeira did the numbers. He found it would require the energy of five thousand, million, million hydrogen bombs to move Earth's orbit 1.5 million km out, which would compensate for doubling CO<sub>2</sub> in the atmosphere.

If geoengineering seems like a "what if?" diversion for the science fiction crowd, scientists take it seriously, even if they are set against it.



“ The knowledge that we maybe could engineer our way out of climate problems inevitably lessens the political will to reduce emissions ”

"I should say right up front, I am not at all in favour of geoengineering," says Richard Somerville, a climate researcher at Scripps Institution of Oceanography in California.

"I think it's inherently unethical. I don't see how you decide on the basis of all humanity how to change the planet. But I think it's irresponsible, in a way, not to study it."

Aside from its feasibility, says Dr Somerville, geoengineering raises many issues that scientists have only begun to list.

There are ethical questions of whether we commit children to a planet that requires constant tinkering, and of who ultimately decides to release a supertanker full of iron into the oceans.

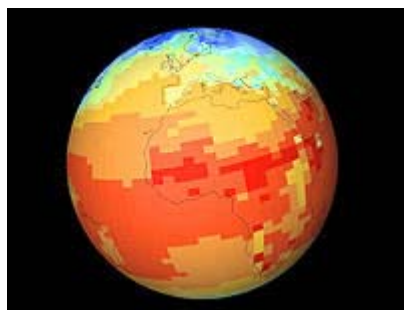
There may be legal questions as well, says Dr MacCracken. Prompted by US cloud-seeding attempts in Vietnam, a 1976 international convention outlaws the hostile use of environmental modification techniques.

"That would normally be in the case of war, but 'hostile' is not a word that's easily defined," says Dr MacCracken.

Perhaps some countries would consider re-calibrating the Earth's reflectivity - let alone its orbit - as a hostile act.

### **Diversionsary tactic?**

While humans have a long history of wanting to control weather and climate - cloud seeding is an example - this incarnation of geoengineering is such a hot potato that scientists cannot even agree whether it should be discussed publicly.



Climate models cannot predict impacts of geoengineering

"The knowledge that we maybe could engineer our way out of climate problems inevitably lessens the political will to begin reducing carbon dioxide emissions," observes David Keith from the University of Calgary in Canada.

Meanwhile, we might reconsider our investment priorities, says Dr MacCracken. For the enormous sum it would take to launch an orbiting mirror, we could develop energy alternatives.

"If I'm going to put satellites in orbit, why not put energy generating satellites that capture solar energy and beam it down to Earth?" he asks.

"Rather than blasting sulphur into the stratosphere, why not

invest in other kinds of energy systems, such as wind energy or ocean energy, that don't cause these kinds of problems? There's a lot to do well before you get to geoengineering."

Ken Caldeira agrees that geoengineering is, for the moment, a tempting but illusory quick fix to an intricate system; a much less problematic solution, he says, would be to change our lifestyles by reducing energy consumption and CO2 emissions.

"I think the Earth's system is so complicated that our interfering with it is very likely to screw things up and very unlikely to improve things," he says. "And this is the only planet we have."

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