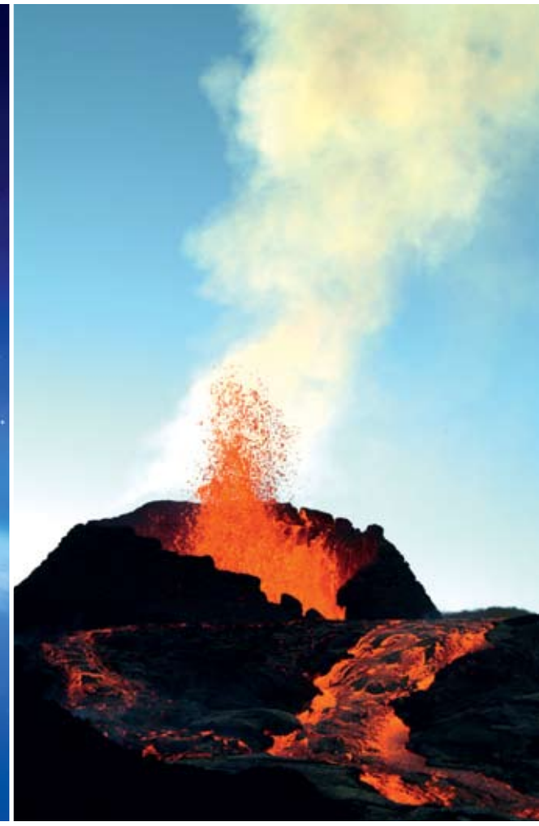
Grand plans



Giant sunshades, cloud ships and mechanical trees sound fantastical, but scientists are coming to believe they could help fight climate change, **Emma Young** discovers.

The Copenhagen Conference may be over, but negotiations over emissions go on. Almost all scientists agree slashing emissions and moving towards green energy is the only way to safeguard our future, but many fear we're not doing this fast enough to avert dangerous climate change. So are we doomed?

Not exactly. There is in fact a 'Plan B', a plan that until recently was taboo – engineering the planet to cool it.

Ideas for so-called 'geoengineering' sound like they're straight from science fiction and, until recently, scientists have been wary even of discussing them. Not so much because they seem outlandish, but for fear that politicians may seize on them as an 'easy' way out. But slow progress in talks to reduce global outputs of carbon dioxide means this attitude is now changing.

In September 2009, the UK's Royal Society published a report concluding that, unless future efforts to reduce emissions are much more successful than they've been so far, geoengineering will be necessary to cool the planet. "With the release of the Royal Society report – the first by a national science academy – it's now easier to talk about geoengineering," says Philip Boyd of New Zealand's National Institute of Water and Atmospheric Research.

Then in November, the US House Science and Technology Committee held the first congressional hearing on the topic. This is an indication of how geoengineering has moved into mainstream scientific and political thinking, says Ken Caldeira, a US professor of climate modelling at Stanford University who advocates research into various proposals and who gave evidence to the hearing.

So what are the ideas? Geoengineering concepts fall into two categories: deflecting incoming sunlight and removing carbon dioxide from the air. The main advantage of the sunlight techniques is that, in theory, they could work fairly quickly to lower temperatures on Earth. "If we are talking about sunlight reflection, the most feasible and effective method is likely to be to imitate volcanoes, and put small particles into the stratosphere," Caldeira says.

Imitating volcanoes

In 1991, Mt Pinatubo in the Philippines erupted, blasting about 10 million tonnes of sulphur dioxide into the atmosphere. These particles reflected incoming sunlight, reducing global temperatures by 0.5˚C the following year. Paul Crutzen, a Nobel-prize winning chemist at the Max Planck Institute for Chemistry in Germany, suggests injecting sulphates into the stratosphere to mimic this effect. He estimates that pumping between 0.5 and five million tonnes of sulphates to about 16 km above Earth, near the equator, could counteract the warming that would be caused by a doubling in the current amount of carbon dioxide in the atmosphere. A recent study by a different team concluded that existing US military planes could do the job for several billion dollars a year, which is considered relatively cheap, compared with the cost of severe climate change. However, there could be serious side effects, such as damage to the ozone layer and acid rain.

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Cloud-seeding yachts

It sounds a little like a plan hatched by British comedy trio The Goodies: yachts that would continuously sail the oceans, pumping droplets of seawater into low-level clouds to thicken them, thereby increasing the amount of sunlight they reflect back into space. The power for the spraying would be generated from turbines dragged behind the vessel. However, the scheme belongs to John Latham at the US National Centre for Atmospheric Research and Stephen Salter from the University of Edinburgh in the UK.

The pair estimates the technique could reflect up to two per cent of sunlight, and a test vessel could be ready in about five years, says Salter, at a cost of about US$30 million. "Once the bugs are sorted, mass production can be done in lots of places so that a 'hold the fort' fleet of 50 units could be built in a year," he says. He estimates this would cost about US$150 million.

Latham and Salter also like the idea of sulphate injections. "If that idea and ours were both found to be practicable, there may be considerable benefit in deploying both in concert," says Latham.

However, the Royal Society report warns the impact of cloud ships on regional weather patterns and ocean currents are "of great concern but not well understood". Much more research is needed before this technique is seriously considered, it says.

Reflective buildings

Painting roofs white and covering deserts in reflective foil have been proposed by a number of scientists. But the Royal Society report concluded that these ideas are "ineffective, expensive, and in some cases likely to have serious impacts on local and regional weather patterns". »

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Space sunshades

» A space-based 'sunshade' made up of trillions of spacecraft – each 60 cm in diameter – orbiting a million miles above Earth, is the brainchild of US astronomer Roger Angel from the University of Arizona. The spacecraft would form a cylindrical cloud with a diameter about half that of Earth, and about 10 times longer. This enormous cloud would deflect sunlight, reducing the amount reaching us by about 1.8 per cent – which would be enough to counteract the heating created by twice the amount of carbon dioxide currently in our atmosphere, Angel estimates.

Development and deployment would take about 25 years and cost a few trillion dollars. But the cloud could have complex effects on Earth. While it would cool the tropics, the poles would continue to warm, melting Arctic sea ice and raising sea levels.

Then there are other costs – like the energy costs of producing the launchers – to take into account. "It's easy to come up with a pie-in-the-sky techno fix," says New Zealand's Boyd, "but when you do the cost-benefit analyses, the benefits aren't necessarily that clear."

However, the extracted carbon dioxide would have to be stored somewhere, presenting a problem. Research on different ways to safely sequester CO_2 underground is still going on. (See *G*19, p15, for more about carbon sequestration.)

Ocean fertilisation

This idea, first put forward back in 1989, involves fertilising the ocean with iron particles to create enormous blooms of microscopic phytoplankton. These tiny plants float near the surface of the water, removing carbon from the air and taking it with them to the seabed when they die – so, at first sight, the idea looks quite elegant.

However, as well as sucking up carbon dioxide, the extra phytoplankton would also be mopping up a host of nutrients normally used elsewhere in the ocean, perhaps affecting fish stocks and other marine life in regions far from the phytoplankton blooms. And it's far from clear exactly how much of the carbon would actually be trapped long-term.

A bigger problem with all of the sunlight techniques is that they don't combat other serious environmental impacts of higher levels of carbon dioxide, such as increased acidification of the oceans. Partly for this reason, the Royal Society thinks that the most promising geoengineering ideas are those that remove CO_2 from the air. These are also likely to have less serious side effects.

Mechanical trees

Planting enough real trees to mop up the excess carbon dioxide already in the atmosphere would leave no fertile land left for anything else, says Klaus Lackner of the US Lenfest Center for Sustainable Energy at Columbia University's Earth Institute.

So Lackner and his colleagues are developing 30-metre tall imitation trees, with 'leaves' that are several thousand times more effective than their natural counterparts. The artificial trees could be 'planted' anywhere – like on motorways or even out at sea. Each would cost about US$20,000 and could mop up as much as 10 tonnes of carbon dioxide a day. The UK's Institution of Mechanical Engineers recently estimated that 100,000 of the trees could absorb all the UK's carbon dioxide emissions from vehicles.

Stopgaps

Much more research into these ideas is urgently needed, say Boyd and others, to get a better understanding of how they would work and what their effects would be. Some scientists think they might never be used. "The choice to geoengineer turns on how bad the climate problem turns out to be," says David Keith from the University of Calgary in Canada, who was a member of the Royal Society's geoengineering working group. "For example, people need to think through how much they want to stop climate change in the Arctic. There is no scientific answer."

But Latham, for one, thinks it is probably inevitable that we'll see geoengineering in some form, as a stopgap to prevent climate catastrophe. If further research does show that his, or another, technique could work to stabilise Earth's temperatures and the amount of sea ice at the poles, then "this could provide us with some decades of breathing space within which to develop a clean energy system," he says. G

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