Planning for plan B

Controlling the climate with technology was once the stuff of science fiction. But with tests already underway, there's an urgent need for global governance of geoengineering. **Mason Inman** reports.

When Victor Smetacek and his colleagues cruised to the Southern Ocean in January 2009, they hoped to launch straight into pouring ten tons of iron sulphate into the waters below. Instead they spent days on board cranking out a risk assessment of their experiment, making the case that their plans were legal.

This kind of experiment had been done a dozen times before with little fanfare. The scientists were mainly interested in understanding iron's role in ocean ecosystems. But because their results would also be crucial for testing the feasibility of a particular plan to cool the climate, fierce opposition met the experiment by Smetacek — an oceanographer from the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany — and his Indian collaborators. Infusing the ocean with iron could stimulate the growth of plankton blooms, which theoretically would draw carbon down into the deep sea, keeping it out of the atmosphere for hundreds or even thousands of years.

By early 2009 such 'geoengineering' schemes had become the subject of serious scientific discussion. With emissions still rising, scientists had started to warn that deliberate climate control might be a necessary last-ditch attempt to curb warming and its deleterious impacts. "There's a sense that the world is getting out of control," says Michael Oppenheimer, a geoscientist and climate policy expert at Princeton University in New Jersey. "That's what's led some scientists to refocus on geoengineering."

Early research shows that various schemes such as pumping sulphate aerosols into the sky or spraying saltwater above the oceans could, in theory at least, cool the planet — some perhaps by a few degrees or more. But research also suggests that there could be unintended — and ugly — consequences, such as widespread drought and substantial ozone depletion[1,2]. Added to those concerns are the ethics of intentionally interfering with the climate, creating a legislative nightmare. "Geoengineering is the most serious governance concern that we're going to be facing in the next couple of decades," argues Maria Ivanova, director of Yale University's Global Environmental Governance Project. "It's really about planetary survival."

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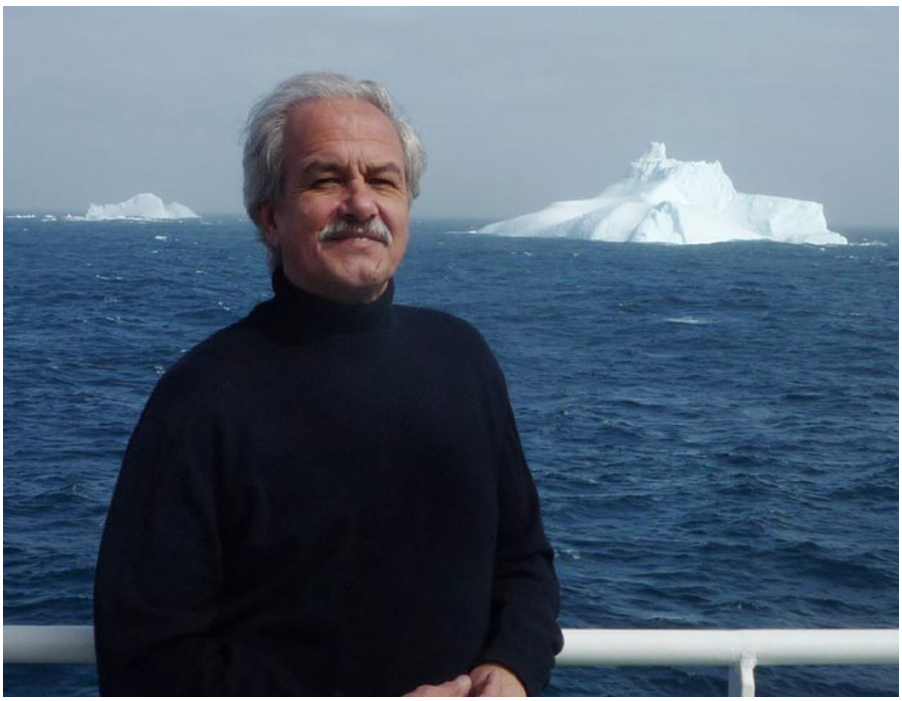
Yet there have been no laws in place specifically aimed at regulating geoengineering, precisely because there has been no need. The science community's growing interest in more research into potential approaches, however, has led to fears that experiments could easily get ahead of efforts to regulate them. Such was the concern of those opposed to Smetacek's plans.

Back in 2008 the project, named Lohafex, had been given the green light from the London Convention, which governs dumping in the open ocean. The Convention opened a loophole specifically to allow ocean-fertilization experiments. But as Smetacek and colleagues set sail, the UN Convention on Biological Diversity, the German Ministry of Environment and a Canadian watchdog organization called ETC Group tried to stop the experiment. "There was no accepted legal authority, so there was a task team at our institute trying to solve this whole thing," says Smetacek, who found the experience "really nerve-wracking".

FULL STEAM AHEAD

Besides its impact on research, the legislative situation — hazy and full of



TOM BRESNIKSKI / AWI

Victor Smetacek and colleagues faced fierce opposition to their experiment on ocean ecosystems in January, owing to its possible implications for climate control.

holes — means that any nation or company, or even an individual with the will and financial means to do so, could start to interfere with the climate.

In fact, companies are already moving ahead on developing and testing various approaches. Two such companies, Climos and Planktos, both founded in the past five years, hope to fertilize the oceans using the same method being tested by Smetacek and to sell emissions offsets for the sunk carbon. "When Planktos and Climos entered the picture, the dread of unregulated commercial scale-up was enflamed," says Ken Caldeira, a climate scientist at the Carnegie Institution for Science in Stanford, California, who was not involved in the research.

Caldeira is not against private-sector involvement in geoengineering, however, and has lent his scientific expertise to another company, Intellectual Ventures, based in Bellevue, Washington. Intellectual Ventures has filed for several patents for climate-altering technologies. One, called StratoShield, would use a long hose suspended from balloons to send sulphate aerosols into the stratosphere. Intellectual Ventures says on its website that "we do not expect or intend that our climate technology inventions will make money" and that it's doing the work for the public good. Caldeira says he would donate any profits from the technology he has advised on to charity.

But the possibility of profit from carbon credits has led to fears that the cash incentive could push geoengineering ahead too fast, or in the wrong directions. Already, evidence exists that the profit motive can lure unscrupulous companies into the market. In November, the US Securities and Exchange Commission charged a Pennsylvania-based company, the Mantria Corporation, with operating what regulators called "a $30 million dollar Ponzi scheme", saying it used exaggerated claims and aggressive marketing to con people into investing in biochar sequestration.

PROCEED WITH CAUTION

The thought of mavericks tinkering with the climate, whether for money or for the greater good, could lead some to conclude "that maybe we ought to have a global taboo against doing this", says Granger Morgan, an engineer and director of Carnegie Mellon's Climate Decision Making Center in Pittsburgh, Pennsylvania. But there are legitimate reasons for allowing geoengineering research to go ahead. As no climate-altering technique has yet been tested at a large scale, there

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Early research has shown that pumping sulphate aerosols into the stratosphere could cool the planet, but could also lead to some seriously unpleasant side effects.

are a lot of uncertainties. "We know how to do this right now," Morgan says. "What we don't know is the cost or the unintentional consequences."

To try to get a better handle on the possibilities, many experts are calling for more research. Among supporters of the idea, a common argument is that geoengineering could be a back-up plan in case the world doesn't manage to cut greenhouse gases enough or the climate turns out to be more sensitive than we thought. There could be a planetary emergency where the climate crosses a tipping point — say, with the potent greenhouse gas methane pouring from thawing Arctic permafrost — and heats up much faster. "If those long-tail possibilities turn out to be reality, we may wake up one day with a billion people at risk and actually need to do something," says Morgan. In a case like that, he argues, geoengineering could look much more appealing.

Another popular argument for research is that it's necessary to avoid a big mistake. Suppose, says Morgan, "a major state finds that because of climate change it can't feed its people and starts doing [geoengineering], or decides it's a lot cheaper than mitigation". Then the world could face tough decisions about whether to condone geoengineering or try to stop it. "If we haven't done the research," Morgan says, "the international community has to fall back on a moral argument, as opposed to a science-based argument."

But while testing schemes such as ocean fertilization on a small scale is one thing, far more contentious are 'quick and dirty' plans to alter the global climate. Such proposed schemes include 'cloud ships' that would spray seawater into the air to thicken ocean clouds, and — most popular of all — various methods of pumping sulphate aerosols into the upper atmosphere, where they would reflect sunlight and cool the planet quickly, just like huge volcanic eruptions do.

Studies of past volcanic eruptions — such as the 1991 eruption of Mount Pinatubo in the Philippines — suggest that sulphate aerosols could be used to cool the climate by a few degrees or more, but that they could also eat away at the ozone layer or slash rainfall worldwide[3,4]. More worrying still are the unknowns. "Compared with mitigation, it's much harder to predict the outcome," Oppenheimer says. "If you reduce emissions, you're moving back along the limb you walked out on, but with geoengineering, you're not."

LEGAL LABYRINTH

Regulating geoengineering research will thus be tricky, but necessary. "If you don't legitimize this, you better not attempt it, because you're likely to be attacked," says John Steinbruner, director of the Center for International and Security Studies at the University of Maryland in College Park, who thinks that maverick attempts at regulating the climate could lead to violence.

Many see the UN Framework Convention on Climate Change — the same body that oversees the Kyoto Protocol and its successor that's now under negotiation — as the logical authority to control these activities[5]. But others say that because geoengineering techniques are so varied, trying to create a global treaty to cover them would be a disaster. "It would take a very long time to negotiate it," says Steve Rayner, director of the University of Oxford's Institute for Science, Innovation and Society. "That would mean that in the meantime either things go ahead unregulated, which would be a bad idea, or that you go ahead with a moratorium until you get the regime in place, which

would also be a bad idea." And the field is not quite ripe for a meaningful review by the Intergovernmental Panel on Climate Change (IPCC), argues Michael MacCracken of the Climate Institute, a think tank based in Washington DC. "The IPCC mainly prepares reports based on reviews of the literature, [so] it would have a difficult time addressing this challenge early in the process."

But regulation could begin without the advent of a new global treaty. As Smetacek and colleagues found out, existing treaties can also be interpreted to cover some approaches. One geoengineering proposal involving mirrors orbiting in space to deflect sunlight would probably be regulated under the 1967 Outer Space Treaty. Sulphate aerosols could be covered under the Montreal Protocol, which bans key ozone-destroying chemicals, since the aerosols could eat away at the ozone layer. But the aerosol approach could also fall under the UN Convention on Long-Range Transboundary Air Pollution, originally put in place to stop power plants' sulphate emissions — a common cause of acid rain — which were crossing borders in Europe and North America.

And if a country felt it was being targeted by hostile geoengineering, this could bring the 1978 Environmental Modification Convention, now largely dormant, off the bench and into play. "It does have the provision that if some nation says they think another country is ruining their weather, it can trigger a [UN] Security Council meeting," says science historian James Fleming of Colby College in Waterville, Maine.

But since none of these environmental treaties was originally designed with geoengineering in mind, bending them to this new purpose could lead to a "governance trap", warns Jason Blackstock, a physicist and international relations expert at the International Institute for Applied Systems Analysis in Laxenburg, Austria. Then the world could get locked into a certain approach to governing geoengineering, even if it's far from ideal. For sulphate aerosol geoengineering, for example, "the Montreal Protocol, in principle, could be applicable — but is it the right [instrument] for that?" he asks. "Its function and role is to ban substances, not to evaluate risks and benefits of field tests."

RESPONSIBLE RESEARCH

As a first step to guide further research, the London Convention has pulled together a science advisory board. "The objective was to try to come up with a sensible set of regulations," says board member Richard Lampitt, an oceanographer at the UK's National Oceanography Centre in Southampton. And a wider discussion about how to move forward on geoengineering — involving scientists, policymakers, watchdog organizations, ethicists, legal experts and security experts — is gathering steam. In addition to a review of geoengineering options conducted this year by the UK's Royal Society[6], several groups in the US — including NASA, the Council on Foreign Relations and the National Academy of Sciences — have organized meetings to weigh various approaches.

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A meeting planned for March, the Asilomar Conference on Climate Intervention Technologies, will aim for a set of guidelines for geoengineering field trials, says MacCracken, who's helping to organize it. It's modelled after a 1975 conference, also in Asilomar, California, which hashed out guidelines on genetic engineering, a new and controversial field at the time. The Asilomar meeting argued for self-policing, which at the time was widely hailed as successful in taking research forward responsibly. But genetic engineering was much easier to regulate than geoengineering, since "there were no national interest issues involved", Blackstock says. "With climate, national interests are already entrenched in the discussion."

Beyond self-governance by the sector, governments will probably be involved — and in the United States and United Kingdom they're already starting to take a closer look. The science and technology committees in the UK House of Commons and the US House of Representatives both held hearings on geoengineering in 2009 and will have additional hearings in early 2010, with a joint report between the two committees planned for the spring.

"If you had talked [in government] about geoengineering as a practical solution to climate change, even three years ago, you'd have been laughed off the planet," says Phil Willis, chair of the UK House of Commons Science and Technology Committee. But now, because of "real concern that mitigation is simply not going to be effective enough to halt catastrophic effects of climate change", he says, these committees are trying to raise awareness and are looking at the best vehicles to deliver regulation.

With clear regulation in place, scientists like Smetacek would probably face an easier time in conducting their fieldwork. Luckily for Smetacek and colleagues, they got approval from the German ministries to go ahead with their experiment. They sailed out to the open ocean, away from the island of South Georgia, and chose a spot where a vast, spiralling eddy would hold their iron sulphate in one spot, as if in a giant test tube. Cruising in a spiral covering 150 square kilometres, they poured in the iron compound. But their fertilization experiment sparked a bloom of plankton known as flagellates, which seem to have been eaten by predators, and so it ultimately failed to draw any additional carbon down from the surface waters.

Rather than being a step toward geoengineering, it poured cold water on the whole idea of ocean fertilization for sequestering CO_2, says Smetacek. The approach might sequester one billion tons of carbon a year at most, he says — roughly one-tenth of people's emissions. "It's not going to have much of an impact," Smetacek says. "In that way, we were lucky, because we showed it didn't work, so everyone shut up." Indeed, says Morgan, "Doing some serious research and discovering there are a bunch of problems that nobody had anticipated might in fact make folks pause."

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References

1. Lenton, T. M. & Vaughan, N. E. *Atmos. Chem. Phys. Discuss.* **9,** 2559–2608 (2009).
2. Bala, G. *et al. Proc. Natl Acad. Sci. USA* **105,** 7664–7669 (2008).
3. Trenberth, K. E. & Dai, A. *Geophys. Res. Lett.* **34,** L15702 (2007).
4. Tilmes, S. *et al. J. Geophys. Res.* **114,** D12305 (2009).
5. Lin, A. C. *Issues Legal Scholar.* **8,** 3 (2009).
6. Shepherd, J. *et al. Geoengineering the Climate: Science, Governance and Uncertainty* (Royal Society, London, 2009); http://royalsociety.org/Geoengineering-the-climate/

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