Article

How can geoengineering research be regulated?

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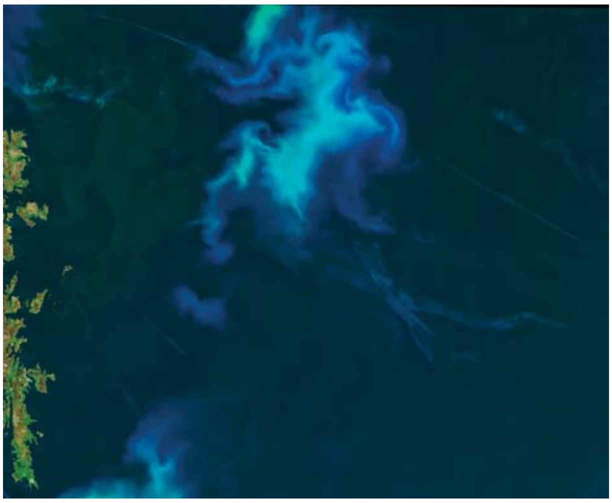
The term climate engineering (or geoengineering) refers to a broad range of concepts, some with a history of practical research, others still largely theoretical. These concepts range from artificially enhanced mineral weathering and large-scale ocean fertilisation to modifying the chemistry of the upper atmosphere or making croplands or seas more reflective. Assessments of their likely effectiveness in mitigating climate change and their potential for adverse effects have highlighted substantial uncertainties and unknowns (*1*, *2*). In 2009, the Royal Society concluded that although "geoengineering of the Earth's climate is very likely to be technically possible… the technology to do so is barely formed, and there are major uncertainties regarding its effectiveness, costs, and environmental impacts" (*3*). Seven years on, that assessment remains just as valid.

In response to the limited knowledge and understanding of what might happen in a geoengineered world, some call for an expansion and acceleration of research (*4*), including stepping beyond modelling studies to the design and conduct of field experiments or even proof of concept engineering trials. By definition, such experiments would need to be carried out at scales sufficient to generate measurable effects that could be distinguished from background variability, and the area (or volume) of impact could neither be precisely defined nor contained. This raises the questions of whether and, if so, how such proposed research could be properly assessed, regulated, controlled and monitored. How could research at scale be distinguished from actual deployment of a geoengineering technique? And who would bear responsibility for the review and authorisation of such research and would ultimately be liable for any damages or other impacts caused?

Unless studied with theoretical models or in contained laboratory experiments, geoengineering experiments will not respect geographical boundaries. In fact, it is the potential for transboundary impacts, which may be uncontrollable and possibly irreversible, that has led to strong international concerns regarding proposals for field research into geoengineering concepts. For the same reasons, any mechanisms put in place to provide independent oversight and control of such research must also be international in nature, incorporating elements of cautious and consistent assessment and consultation. This may sound like an impossible task in a world in which collective action to tackle climate change itself has been so painfully (and dangerously) slow, but recent efforts to regulate ocean fertilisation studies provide a relevant precedent in international environmental law.

Ocean fertilisation was first proposed as early as the 1960s as a way of boosting fisheries production to feed a growing population. About 15 offshore field experiments have been carried out in the last couple of decades, driven by various hypotheses. These experiments have tended to confirm that adding iron as a nutrient to offshore waters, in which algal populations are lower than expected given the supply of nitrogen and phosphorus, commonly boosts their growth. What happens to the plankton community from there, however, appears far less predictable, not least because the final outcome depends heavily on the starting conditions and on the weather and oceanography as the experiment progresses (*5*).

Despite these limitations, promotion of iron fertilisation as a method of stimulating the drawdown of carbon dioxide from the atmosphere became more prominent at the turn of the millennium. From the start, many marine scientists warned about harmful consequences for marine ecosystems (*6*). It was in 2007, however, that the proposed actions of a handful of commercially driven companies focused the attention of international regulatory bodies with responsibility for protecting the marine environment. In particular, a high-profile announcement by the company Planktos of its intent to conduct a large-scale iron fertilisation experiment in the South Pacific Ocean (near the Galapagos Islands) and to create and sell carbon credits as a result, led rapidly to the issuance of a statement of concern by the Scientific Groups that advise the Parties to the London Convention and Protocol (LC-LP). These concerns were endorsed at a political level in the same year. By October 2008, the LC-LP Parties had passed a formal resolution to rule that ocean fertilisation activities other than for legitimate scientific research were not allowed (*7*).



Natural phytoplankton bloom in the North Atlantic. *Ocean fertilisation aims to create artificial blooms to draw carbon dioxide out of the atmosphere. NASA Earth Observatory image by Joshua Stevens, using Landsat data from the U.S. Geological Survey.*

This was something of a departure for the London Convention, a legal instrument established in the 1970s to deal primarily with the dumping of wastes at sea, but was a development that nonetheless recognised the parallel concerns for marine ecosystems that would arise from deliberate attempts to fertilise the oceans. Early in 2009, work began within the LC-LP Scientific Groups to define an assessment framework for ocean fertilisation, defined as "any activity [other than conventional aquaculture] undertaken by humans with the principal intention of stimulating primary productivity in the oceans". The framework was completed by October 2010. Final adoption of the approach through legally-binding measures followed three years later, and although it is still to enter into legal force globally, all parties to the London Convention and Protocol (more than 90 countries worldwide) have continued to observe the spirit of the original resolution. One uncontrolled iron fertilisation activity, carried out by a private company off the west coast of Canada in 2012 and with no prior independent assessment, remains subject to legal proceedings under Canadian law.

The Ocean Fertilization Assessment Framework (OFAF) (*8*) sets out how proposals should be assessed by national or regional authorities, including an initial assessment to reject those that are not legitimate scientific research, i.e. those for which the scientific purpose or objectives are weak, there are no commitments to transparency, publication and peer review, or there are concerns that economic interests might drive or bias outcomes. Thereafter, the OFAF is technical in nature, and aims to establish and assess the scale of risks to the marine environment. This approach to regulation does not, therefore, prohibit research, but does place reasonable limits on when, where and how it might be carried out and for what purpose.

Although the focus has so far been on ocean fertilisation because of the perceived immediacy of the threat, amendments to the legal text of the London Protocol are designed to address concerns arising from other marine geoengineering activities that might develop as practical realities in the future. Such activities include alkalinity management, enhanced upwelling, and reflectance management using microbubbles or foams. Although each proposed activity may require some unique elements of assessment and control, the general principles of (i) governance before research, (ii) allowing only activities determined to be legitimate scientific research, and (iii) setting standards and expectations for peer review and prior consultation apply to all. The legal framework is, in effect, ready to be adapted for the future (*9*).

The LC-LP approach cannot, of course, directly address geoengineering activities proposed beyond the marine environment, i.e. on land or in the atmosphere above land or sea. Atmospheric geoengineering encompasses an equally diverse array of concepts, ranging from the modification of clouds in the lower atmosphere to the release of sulphates, alumina, titanium dioxide and even dust into the upper atmosphere in attempts to reduce incoming solar radiation. Such interventions would arguably be even more difficult to contain and control than those in the sea. Scientists have raised serious concerns about uneven distribution of impacts on temperature and weather patterns and disruption of rainfall, among others (*10*).

When ocean fertilisation emerged as a threat to marine environments, existing legal structures under the UN Law of the Sea and the LC-LP provided an obvious route toward regulation and offered some degree of international consistency for the assessment of research and its impacts. In the case of atmospheric modification, an appropriate regulatory umbrella is harder to identify. Nevertheless, the fact that, under the LC-LP, the regulation of ocean fertilisation developed from a simple statement of concern to a permanent legal measure applicable at a global scale within just six years shows what can be achieved through effective co-operation between countries, even when complexity and uncertainties are high. If a suitable equivalent institution can be identified, there is no fundamental reason why an effective governance regime for research could not also be developed for atmospheric concepts.

Greenpeace has long maintained the view that any moves to deploy geoengineering as a strategy to try to counteract climate change would neither be sensible nor sustainable. In its most recent assessment of the possible impacts of geoengineering on natural systems, the Convention on Biological Diversity concluded that "changes in ocean productivity through large-scale fertilisation would necessarily involve major changes to marine ecosystems, with associated risks to biodiversity" (*11*). Moreover, as IOC-UNESCO has stressed, "we have insufficient knowledge, let alone technique...to reverse any large scale, long term changes to ecosystems" (*5*).

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From the outset, talk of geoengineering as a possible emergency escape route—or, even more worrying, a cheaper and simpler option to tackle climate change impacts—has also proven to be a distraction from the urgent work of cutting emissions of greenhouse gases as quickly and deeply as possible. Even in a post-Paris Agreement world, with a tightened ambition on temperature targets (*12*), geoengineering must not be seen as an alternative to cutting emissions or to preparing for adaptation to change already upon us.

Nevertheless, it seems inevitable that calls for more geoengineering research will become increasingly loud. We can decide to leave the design and conduct of that research to the scientists and talk of governance only as and when things move towards deployment, as, for example, implied under the so-called Oxford Principles, (*13*). Alternatively, we can take a more proactive approach to the development of effective governance for all forms of geoengineering research, taking a lead from the example of the LC-LP in relation to ocean fertilisation. Given the nature and scale of the interventions proposed, the backdrop of uncertainty and unknowns and the propensity for unintended consequences, the latter seems to be by far the more defensible option.

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