Geoengineering Our Climate?

Ethics, Politics and Governance

Opinion Article 6
9 July, 2013
www.geoengineeringourclimate.com

Nitrogen Geoengineering

Oliver Morton

The Economist

olivermorton@economist.com

Geoengineering Our Climate? is a Working Paper and Opinion Article Series that explores the ethics, politics and governance of geoengineering – the intentional manipulation of the global climate to counteract climatic changes. Relying upon the efforts of over forty contributing authors from academia, policy, and civic environmentalism, our objective for this project is to create a comprehensive yet broadly accessible introduction to the complex societal dimensions associated with the emergence of geoengineering. Our Convening Partner organizations include high-profile institutes from across the global north and south: the Institute for Advanced Sustainability Studies (Germany); the Institute for Science, Innovation and Society, University of Oxford (UK); the Consortium on Science Policy and Outcomes at Arizona State University (US); the Council on Energy, Environment and Water (India), the Research Centre for Sustainable Development of the Chinese Academy of Social Sciences (China), and the Brazilian Research Group on International Relations and Climate Change (Brazil).

Please visit our website at www.geoengineeringourclimate.com to find out more about our project and partners.

Citation Information

Morton, Oliver. 2013. "Nitrogen Geoengineering." Opinion Article, Geoengineering Our Climate Working Paper and Opinion Article Series. Available at: http://wp.me/p2zsRk-8e

Discussions of climate geoengineering often treat it as an unprecedented venture. James Fleming's work on the history of weather modification shows clearly that this is not the case; people have been discussing manipulations of weather and climate, and developing technologies to that end, for a long time.[1] Acknowledging this provides perspective and context for discussing proposals that are current today.

The history of geoengineering, though, is not to be found entirely in the history of climate studies. If geoengineering is taken is taken to be the large-scale and purposeful technological manipulation of the earth system to a given end then the development and deployment of industrial nitrogen fixation provides an informative precedent.

The twentieth century's development of nitrogen geoengineering is the most dramatic example history provides of humans changing the way the earth system works. Those interested in bringing about a conceptually similar, if in some ways more modest, change through climate geoengineering would do well to familiarize themselves with this precedent's inception, its scale of action and its consequences, even while keeping in mind the limited value of analogues and precedents in such matters.

The technology required for the industrial takeover of the nitrogen cycle did not appear through an unguided process of innovation, nor was it deployed that way; the foresight involved is part of what makes it a geoengineering technology in a way that other agricultural innovations, and indeed agriculture itself, are not. Nitrogen fixation was developed purposefully in response to a threat, which, while not obvious in everyday life, had been identified by the scientific elite. Like climate change today, that threat was seen as being of global significance and to have no easily attainable political solution. That justified a concerted effort to develop a technological response. Though people working in the climate arena may not immediately recognize this response as geoengineering, some of those working on the nitrogen cycle have no problem seeing it as such.[2]

Fixing the Nitrogen Cycle

The nitrogen cycle, no less than the carbon cycle, is fundamental to the way the earth's biosphere works. The bacteria that "fix" nitrogen from its inert gaseous form into compounds that can be made use of by plants, and the animals that eat them, are a key part of this cycle. Though some inorganic processes fix nitrogen, bacteria in the soil and seas are the overwhelmingly dominant natural source of such compounds.

Crop yields can often be increased by the addition of extra nitrogen. Historically this was achieved at various times and places by treating the soil in ways that increase bacterial nitrogen fixation or by importing nitrogen in the form of manures. In nineteenth century Europe these techniques were supplemented with the use of nitrate minerals—resources that were also needed by the chemicals industry, notably for the production of explosives. In the 1870s strategic control of the richest South American nitrate deposits were a principal cause of the "War of the Pacific" (also called the Saltpetre War) between Chile, Peru and Bolivia.

[1] Fleming 2010

[2] Sutton et al. 2011

Some men of science became aware that the world's supply of nitrate was insufficient to cope with its remorselessly rising demand for food. Noting the ever-greater demand for wheat and the lack of new land on which to grow it, Sir William Crookes, a noted British chemist, used his 1898 presidential address to the British Association for the Advancement of Science to stress that it was "vital to the progress of civilized humanity" that chemists solve the problem by fixing nitrogen from the air into compounds that could be used as fertilizers and chemical feedstocks. If they failed there would be a planet-wide "catastrophe little short of starvation...and even the extinction of gunpowder!"[3] In 1908 Fritz Haber hit on a successful scheme; Carl Bosch made its use a practical industrial process, and Germany's need for explosives in the First World War saw the process put into large-scale use.[4] By the 1920s the Haber-Bosch process was available to industries throughout the world and chemistry textbooks were congratulating themselves on having solved the "nitrogen problem".

It has been estimated that the explosives made possible by the Haber Bosch contributed directly to 150 million deaths over the twentieth century.[5] In the second half of the century, though, it made an even greater contribution to life than it had to death. Nitrogen-based fertilizers were the single greatest contributor to near tripling of crop yields in the decades after 1950. Today fertilizers produced by the Haber-Bosch process account for almost half of the nitrogen in human food; without them the population would not have been able to grow close to its present seven billion. By the time the population stabilizes somewhere around 10 billion, most of the nitrogen in those peoples muscle fibers, nerve cells and DNA will be coming from factories.

Industry now far outdoes the world's terrestrial bacteria in the fixation of nitrogen. This makes human intervention in the nitrogen cycle considerably greater, in proportion to the natural flows, than is the climate-changing human intervention in the carbon cycle.

Lessons for Climate Geoengineering

In what ways can this historical analogue inform debates about climate geoengineering? First, it offers an existence proof. It is possible for humans to identify a global problem, create a technology that addresses that problem, and deploy it on a global scale.

It also shows that the scope of such an intervention can greatly outstrip its progenitors plans, and perhaps their imaginations. While Crookes did not put specific numbers on the amount of nitrogen he felt was needed, the scale of today's nitrogen industry and its effects surely far outstrips the consequences he expected. This suggests that those imagining possible futures for climate engineering should take care that they imagine applications of the technology well beyond the minimum that seems to be required—not as necessary endpoints to the programme, but as plausible ones.

There are other aspects of nitrogen geoengineering that climate geoengineers should be aware of. One is that it is deployed inefficiently. Most of the deliberately fixed nitro-

[3] Crookes 1898
[4] Smil 2004
[5] Erisman et al. 2008

gen does not get into crops; Vaclav Smil estimates that the overall efficiency of the global food system seen this way is less than 15%.[6] The wasted nitrogen is not just a loss; it often does harm. Over-fertilized soils produce nitrous oxide, which destroys stratospheric ozone and is also powerful greenhouse gas. Nitrate-bearing run-off waters from agricultural watersheds stimulate algal blooms and "dead zones" in coastal seas. While nitrogen fixation has made the world more habitable by humans—more precisely, habitable by more humans—than it could be in a state of nature, it has also done significant damage to biodiversity, human health and ecosystem services in the process.

The waste problems are made more complicated by the fact that humans fix nitrogen inadvertently as well as deliberately. The nitrates produced as by products of combustion in vehicles and industrial plant do a great deal of harm, most notably through particulate damage to human health. They also stimulate the growth of unfertilized ecosystems such as European forests and, indeed, organic farms. The effects of deliberately fixed nitrogen and inadvertently fixed nitrogen blend into each other in various ways.

There is a general lesson here; the side effects of geoengineering will often be intermingled with the effects of inadvertent pollution involving related substances. This does not make geoengineering indistinguishable from pollution. There is a qualitative, indeed categorical, difference between geoengineering to a specific end and heedlessly making a planet-sized mess. At the same time, nitrogen geoengineering shows that, when inspected closely, the dividing line between deliberate action and pollution can be disturbingly blurry.

Many other parallels (and distinctions) might suggest themselves. I will close on two. One is that geoengineering is surprisingly easy to overlook. To its proponents and opponents, climate geoengineering currently seems a fundamental and historic transition. After the fact it might look much less vexatious. The billions benefiting from nitrogen geoengineering hardly know it is going on. The same might well be true of, say, an aerosol layer in the stratosphere that reduced incoming solar radiation by a watt per square meter. Many people would know it was there and some would oppose it (it is worth remembering that the organic farming movement began in large part as a response to nitrogen fixation). But it might well be only a minor concern to most.

The second closing point is to draw out a difference. While there was a well-articulated need for nitrogen fixation that drove the development of the technology, its deployment was often decentralized. This was not always the case. In China, and other smaller economies, the rearrangement of the nitrogen cycle was planned at a national level. The deployment of fixed nitrogen was fundamental to the political goals of the "green revolution" and was coordinated accordingly. In this nitrogen geoengineering was quite distinct from agriculture-as-usual. But the dynamic of the technology's spread was shaped by the fact that local and regional benefits could be achieved independently of the global picture, and their benefits captured immediately and privately.

[6] Smil 2011

Some climate geoengineering approaches might spread in a similar way: crop albedo changes, perhaps, or cloud brightening aimed at steadying monsoons. But such a piecemeal dynamic is not likely to shape climate geoengineering techniques with primarily global impacts, such as stratospheric particle injections. This all-or-nothing attribute of climate geoengineering may well make it harder to achieve that nitrogen geoengineering was. But it might also offer the possibility of a better-designed intervention—its benefits optimized, its burdens shared equitably.

References

Crookes, W. 1898. "British Association for the Advancement of Science, Bristol 1898, Inaugural Address of the President" *The Chemical News* 73 (2024): 125-136.

Erisman, J.W., M.A. Sutton, J. Galloway, Z. Klimont and W. Winiwarter. 2008. "How a Century of Ammonia Synthesis Changed the World" *Nature Geoscience* 1: 636-639.

Fleming, J.R. 2010. *Fixing the Sky: The Checkered History of Weather and Climate Control*. New York: Columbia University Press.

Smil, V. 2004. *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production.* Cambridge: MIT Press.

Smil, V. 2011. "Nitrogen Cycle and World Food Production." *World Agriculture* 2: 9-10.

Sutton, M.A., O. Oenema, J.W. Erisman, A. Leip, H. Van Grinsven, and W. Winivarter. 2011. "Too Much of a Good Thing." *Nature* 472: 159-161.