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UNDOING THE DAMAGE

Geoengineering our way out of trouble

If you dig a ditch or recycle a can, you're managing the planet, at least on a micro-level. What would macro-scale planetary engineering look like?

By PATRICK HUYGHE

A fine mess we've gotten ourselves into: pollution, global warming, depletion of natural resources, a hole in the ozone layer. The list goes on. So the question arises: Can we humans keep doing what we are doing to our environment and still avert a global catastrophe?

Some think so. In the past decade a handful of scientists and engineers have offered some big, bold, and highly controversial schemes to avert impending global environmental problems. These grand (if not grandiose) projects, dubbed "geoengineering," range from ortho-tech to Star Trek, from massive reforestation efforts geared toward absorbing excess carbon dioxide to lofting a hundred or more 100-km-wide mirrors into orbit around the Earth to reduce the amount of sunlight reaching the surface, thereby offsetting the heating caused by CO_2 emissions.

Don't mistake these proposals for the fantasies of bored academics. Many of the ideas have been thoroughly worked out and appear feasible. But the enthusiasm for such projects varies wildly. Some wonder whether these schemes will be truly beneficial, whether our knowledge of planetary systems is comprehensive enough to guarantee there will be no unintended consequences. But the stakes of doing nothing are equally high. After all, we humans have been geoengineering our planet, albeit unconsciously, during the past 150 years; the industrial revolution has already transformed the atmosphere. Besides, geoengineering efforts that attempt to achieve global solutions by multiplying the effects of actions taken at the local level are already a reality. What is the paper recycling effort, after all, but an attempt to reduce deforestation and preserve a natural sink, or storage site, for CO_2 emissions? Clearly, geoengineering in one form or another is a necessity; the fate of the planet is now on the line.

Perhaps the best-known of the original large-scale geoengineering proposals is the so-called Geritol solution to global warming. Proposed at the end of the 1980s by the late John Martin, an oceanographer at the Moss Landing Laboratories in California, the idea involves dumping tons of iron into the waters of the Antarctic to stimulate plankton growth and thereby absorb the buildup of CO_2 and slow greenhouse warming. Last year an experiment to enrich a small patch of the Pacific demonstrated that iron fertilization could indeed stimulate the productivity of ocean plants. But an analysis of sediments from the waters of the Antarctic conducted in part by researchers at Lamont-Doherty has revealed that although such Antarctic blooms have occurred in the past, they absorbed much less carbon from the atmosphere than Martin had postulated.

Several years ago, Wallace Broecker, Lamont-Doherty geochemist and chief scientist at Biosphere 2, investigated what he thought was one of the "cheapest and least dangerous" of the geoengineering options: injecting massive amounts of sulfur dioxide into the stratosphere, using commercial flights of 747s. This scheme, originally proposed by the Soviet climatologist M.I. Budyko, essentially creates the human equivalent of one Mount Pinatubo eruption a year, which is enough to counter CO_2 warming, according to Broecker. But the plan, which he calls "insurance against a bad climate trip," would cost a small fortune (some $50 billion in 1984 dollars) and would probably damage the ozone layer.

Of course, no one suggests that such schemes be implemented any time soon--just that we should be aware of the options and perhaps explore them further, so that if the need arose, such dramatic efforts to save the Earth would be available to us. But the known high costs and, more important, the unknown potential side effects have kept these proposals strictly on paper. "All of these things might have unintended consequences," notes Tulane University mechanical engineer Robert Watts, who is editing the proceedings of a 1992 conference on the subject called *The Engineering Response to Global Climate Change*. "We really don't understand the climate well enough, so we don't want to start something where the cure might be worse than the disease."

Given what's at risk, most would agree that global-scale surprises are better avoided. "Do we have the capacity intellectually to understand complex systems at the level of the globe well enough to make intelligently thought-through conscious perturbations that result in only the consequences that we want, and nothing else?" asks Josh Tosteson, the curriculum coordinator at Biosphere 2. "My intuitive answer to that question is: No, we don't."

Perhaps the ultimate example of how conscious planetary engineering can go awry, Tosteson points out, is what happened with the original Biosphere 2 experiment. "The story of oxygen loss and the rise of CO_2 and the ways in which the Biospherians tried to combat those problems," he says, "is a sort of case study unto itself of how we don't have the intellectual resources at the limit to solve problems of this complexity. I think it illuminated just how difficult it is to do conscious management of a little mini-world." And if we can't manage a mini-world, what business do we have experimenting on the big one?

Though Biosphere 2 now provides scientists with a unique laboratory to gain insights into what steps humans might take to avert global environmental catastrophes, many scientists are aghast at the hubris of geoengineering proposals that try to compensate for whatever perturbations we are making to the climate system by some kind of equal and opposite reaction, especially when less risky options are still open. We could, for example, let the climate system change on its own and then adapt to it by building massive seawalls when sea levels rise. But such an expensive finger-in-the-dike solution eventually would prove overwhelming. "The fundamental trouble with most geoengineering proposals," notes Michael MacCracken, director of the Office of the U.S. Global Change Research Program in Washington, D.C., "is that the ones with the fewest side effects are those with the greatest up-front costs."

Clearly the best option at this point, MacCracken points out, is to focus our efforts on the source of a problem rather than its symptoms. He thinks the enormous sums of money involved in most geoengineering schemes would be better spent on developing alternative power sources. We could build solar-powered satellites that would beam energy back to Earth for a similar expense. That, at least, would avoid the uncertainties involved with many geoengineering schemes. But a far more cost-effective solution would be simply to continue reducing emissions and find savings in energy efficiency with the best application of technology.

The general consensus regarding radical geoengineering schemes is that it's too early to be talking about them--if it's not broken, don't fix it. But the future could well bring a change of mind. "Geoengineering may most likely become necessary if looming anthropogenic climate change becomes a disaster that can be avoided in time only by a temporary technical fix," notes author Martyn Fogg: "Natural climate change might also be mitigated in the more distant future, such as to prevent the next glaciation which, if unrestrained, would bury the wreckage of Northern civilization under several hundred meters of ice. It is also possible to imagine a situation in the remote future where geoengineering is permanently applied to extend the life of a biosphere no longer able to conduct satisfactory homeostasis due to a hotter, more evolved Sun."(1)

Aside from fears, controversy, and far-flung speculation, there is also a growing realization that in some ways geoengineering can and does work. In the 1960s, we realized that internal combustion engines were poisoning the atmosphere; engineers went to work on the problem, and cars now produce only a 10th of the pollution they did 30 years ago. Clearly that, too, is geoengineering. So is the Montreal Protocol. Nine years ago this international treaty restricted the use of ozone-harming chemicals containing chlorine and bromine and attempted to wean the world from its reliance on chlorofluorocarbons and other halocarbons. Recent measurements around the globe indicate that total concentrations of these ozone-destroying compounds have started to drop. With luck, scientists hope to see ozone healing beginning in the next decade.

But if this is geoengineering, some will argue, then something as ordinary as putting a dam on a river could be as well. And actually, it can. In a startling article that appeared in *Geophysical Research Letters* earlier late last year, Benjamin Fong Chao, a geophysicist at the Goddard Space Flight Center, calculated that the 10,000 dams built mostly around the mid-latitudes during the past 40 years have actually increased the Earth's spin, or orbital rotation.(2)

That something like a dam may not exist in isolation--that its construction may have a broad range of local, regional, and perhaps even global effects--is a notion that has helped fuel the formation of the Earth Engineering Center (EEC) at Columbia. Since September 1995, EEC founder Nickolas Themelis, a professor of chemical metallurgy in the School of Engineering and Applied Science, has attempted to direct Columbia's engineering research toward the goals of sustainable development and industrial ecology, trying to reconfigure industrial activities so as to minimize adverse environmental effects.

"The idea behind the Earth Engineering Center," explains Art Lerner-Lam, a seismologist at Lamont-Doherty associated with the EEC, "is to see if there is a systems engineering approach that can be used to investigate and solve the issues having to do with man's interaction with the environment." The EEC will work on technical problems that are encountered on small geographic scales but can still, taken together, exert a significant effect on the long-term state of the environment, such as global warming and ground water pollution. Lerner-Lam wants to avoid the sense of conceit that these problems are solvable, but he believes they can be understood by science and perhaps, one day, resolved through engineering. Human ingenuity has led to the fine mess we find ourselves in; it may also guide us out.

Related links...

- GeoEngineering Group, Los Alamos National Laboratory

- Global Climate Change Pathfinder, National Agricultural Library's guide to climatology resources

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1. Fogg, Martyn.*Terraforming: Engineering Planetary Environments* (Society of Automotive Engineers, Warrendale, Pa., 1995), p. 149.

2. Chao BF. Anthropogenic impact on global geodynamics due to reservoir water impoundment. *Geophysical Research Letters* 22.24 (December 15, 1995): 3529-2532.

PATRICK HUYGHE has written for *The New York Times Magazine*, *Discover*, *The Sciences*, *Audubon*, *Omni*, and *New York*, among other publications, and produced science and documentary video for WNET in New York and WGBH in Boston. His most recent book is *Columbus Was Last: From 200,000 B.C. to 1492, a Heretical History of Who Was First* (NY: Hyperion, 1992).

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