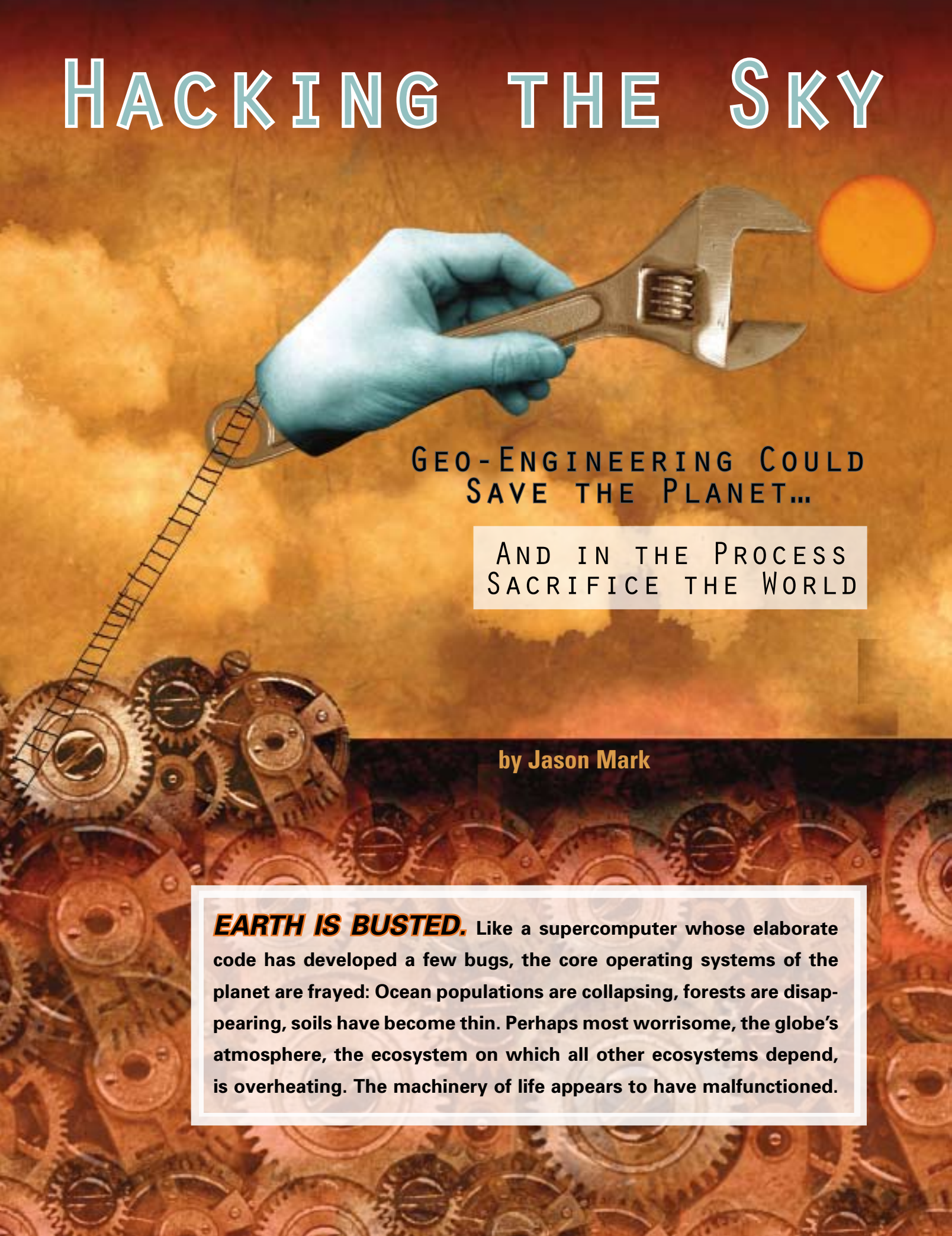
Hacking the Sky



Geo-Engineering Could Save the Planet...

And in the Process Sacrifice the World

by Jason Mark

EARTH IS BUSTED. **Like a supercomputer whose elaborate code has developed a few bugs, the core operating systems of the planet are frayed: Ocean populations are collapsing, forests are disappearing, soils have become thin. Perhaps most worrisome, the globe's atmosphere, the ecosystem on which all other ecosystems depend, is overheating. The machinery of life appears to have malfunctioned.**

Since the scale of the climate crisis became clear, the strategy for fixing this glitch has focused on remediation. To maintain the atmosphere's equilibrium, we need to reduce our emissions of greenhouse gases. Our chief goal should be to return the climate to something approximating the pre-industrial status quo.

But what if such a return isn't possible? What if the planet has gone permanently haywire? As the effects of climate change become obvious and global leaders remain unable to halt emissions, a growing number of scientists say we need to begin researching what's called "geo-engineering" — ways to artificially reduce global temperatures and/or manipulate plants or the oceans to absorb huge amounts of CO_2. Having unintentionally warmed the planet, we may have little choice but to intentionally cool it back down.

Even those most interested in geo-engineering say that the idea of deliberately deforming the planet in order to save it from ourselves is, as Stanford University's Ken Caldeira told NPR this summer, "scary." Yet if we shy away from manipulating the whole globe and continue on our present course, we could be left with a burnt Earth unlike anything ever seen. The scientists who are encouraging government-funded research into geo-engineering are driven by a powerful motive: fear. All too aware of the implications of unchecked CO_2 emissions — and worried that political systems aren't moving quickly enough to respond to changes in the planet's physical systems — these scientists say we may have no other option than to tinker with the sky.

That some of the world's foremost climatologists are contemplating this measure of last resort reveals how desperate our predicament is. We face the prospect of leaping into a new epoch of planetary history, one in which a single species will be responsible for all other life here. Or else finding some way of accommodating ourselves to the world as we have undone it.

This places us at a moral moment involving a dangerous gamble. Do we chance toying with the entire atmosphere? Can we afford not to?

Possible geo-engineering technologies range from the whimsy of science fiction to the purely hypothetical to the unsettlingly plausible. Some are so outlandish they defy gravity. A few have undergone small-scale experimentation. At least one has the advantage of a real-world analogue. All remain on the drawing board. None are free from concerns about unintended consequences.

Geo-engineering schemes fall into two categories: attempts to absorb the CO_2 in the atmosphere and efforts to manipulate the way Earth reflects sunlight, called the planet's "albedo." The first group is less controversial, because such techniques mimic natural processes. They are, however, slower, which reduces their effectiveness as a response to the kind of climate emergencies some scientists fear. Devices to re-jigger the planet's albedo can seem more worrisome, as they would create what critics have dubbed a "Frankenplanet." They are also more likely to work.

One idea for absorbing CO_2 involves seeding the oceans with iron to spur plankton blooms, which inhale large amounts of carbon and then die, pulling the gas to the bottom of the sea. Another brainstorm suggests that by creating "biochar" we can arrest the amount of carbon dioxide that naturally goes into the atmosphere during plant decay. Giant kilns would take agricultural waste and dead trees and, using a process called pyrolysis, burn them without using oxygen. The resulting CO_2-laden charcoal then would be buried. If that proves unfeasible, some scientists say we could genetically modify plants to absorb more of the heat-trapping gas. Or, in case that doesn't work, Professor Klaus Lackner at Columbia University proposes building "synthetic trees" that will capture CO_2 and turn it into a liquid form to store underground.

The second line of thought entails reducing the sunlight that strikes the planet. In a global version of pulling down the shades, this would cool temperatures and at least ameliorate the greenhouse effect. Roger Angel, a professor at the University of Arizona, imagines launching a trillion mirrors into a stable orbit between Earth and the sun, creating a kind of space-based umbrella. Or we could build a fleet of 1,500 computer-directed boats that will splash seawater into the clouds to make them whiter. John Latham of the National Center for Atmospheric Research predicts that increasing the reflective power of the clouds by three percent could offset humanity's contribution to global warming. Another method of cooling the planet involves spraying sulfur dioxide into the stratosphere as a way to deflect sunlight.

Until recently, such outlandish ideas weren't discussed in polite company, for fear that loose talk about geo-engineering would distract from the goal of doing everything possible to halt greenhouse gas emissions. Now, a significant number of influential ▶

Illustration by Michael Morgenstern

people are taking the idea seriously.

The US National Academy of Science held a one-day conference in June to discuss the idea. Last fall, the British Royal Academy of Sciences launched a study to examine geo-engineering options and their risks. NASA is looking at ways of managing how solar radiation hits the planet. Some environmentalists are also interested. In an essay published last year in *Orion*, Mike Tidwell, a veteran climate activist, wrote: "Human beings must quickly figure out some sort of mechanical or chemical means of reflecting a portion of the sun's light away from our planet. . . .Like it or not, we are where we are."

An indicator of the force of the idea — and the touchy politics surrounding the subject — came in April, when John Holdren, head of President Obama's Office of Science and Technology Policy, said in an interview with the Associated Press that he had mentioned geo-engineering in White House discussions. After the account came out, Holdren rushed to clarify his statements, saying that geo-engineering, though it warrants study, isn't an alternative to curbing emissions. Holdren's defensiveness is revealing. His carefully parsed statements show that few scientists are enthusiastic about the notion of engineering Earth. Even those who are curious about the possibilities are anxious over the prospect of actual deployment.

"It's not anything that anybody should look on with any sort of glee," Ken Caldeira, a fellow at the Carnegie Institution at Stanford, told me recently. "It's the kind of thing that you hope you don't need. But I don't see anything in our current policies that makes me think we will reduce emissions in time."

"When you are talking about global modification of the environment, that's scary, because it would be the most ambitious — and some would say arrogant and dangerous — experiment in human history," Samuel Thernstrom, a fellow at the American Enterprise Institute and a vocal proponent of increased geo-engineering research, says. "Geo-engineering is neither a perfect solution nor a permanent one. You'd have to be crazy to consider this a first, best option."

The mixed emotions surrounding geo-engineering hint at a dark mood. Among those who understand the climate science best, there is a creeping resignation that we won't make the hard choices necessary to halt catastrophic global warming. This is, it seems to me, a staggering admission just at a time when, to avert disaster, we need a buoyant sense of potential. If mitigation (reducing emissions) is the hope of the idealist, and adaptation (preparing for rising waters) is the consolation of the realist, then geo-engineering (call it circumvention) has become the refuge of the cynic. Geo-engineering assumes that although we may be able to alter how the planet works, we are incapable of changing the way we run the world.

Of course, idealism is often a privilege, and cynicism an unflinching wisdom. Which proves that geo-engineering — dystopian though it may be — is at least honest, the last chance of survival for a planet on the brink of collapse.

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But can it work? According to climatologists, the answer is … perhaps.

Many geo-engineering proposals are flawed. The mirrors-in-space scheme is wildly implausible. The physics of launching 20 million tons of material into space is untested, and the plan would cost about $400 trillion. The iron fertilization of the ocean had generated optimism until an experiment earlier this year dampened hopes. When the theory was tested in a 115-square-mile area of the Southern Ocean, tiny crustacean zooplankton ate up all the phytoplankton.

The idea of whipping up ocean spray to whiten the clouds seems possible. Climate models, however, suggest that the benefits would only be regional. A prototype of an artificial "tree" that uses plastic, resin-coated "leaves" to capture carbon has shown promise. But, as with any kind of carbon sequestration, it's unclear where all the carbon would be stored.

The geo-engineering proposal attracting the most attention is the one that involves injecting a sulfur dioxide (SO_2) aerosol into the atmosphere as a way of reflecting more sunlight back into space. Unlike the other geo-engineering proposals, the sulfur scheme has already undergone a successful experiment — by the planet itself.

In 1991, Mount Pinatubo, a long-smoldering volcano on the Philippine island of Luzon, blew its top off in an explosion 10 times stronger than the Mount St. Helens eruption. The volcano hurled a stream of ash 22 miles into air. An estimated 20 million tons of sulfur dioxide were let loose into the stratosphere, where they turned into droplets of sulfuric acid that scattered the sun's light. During the next year, global temperatures dropped by half a degree Celsius; the summer melt at the top of the Greenland ice sheet slowed.

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Computer models have demonstrated that humans could replicate the Pinatubo experience. Artificial stratospheric sulfur injection could cool the planet just enough to offset the greenhouse effect, giving us a buffer from the worst effects of global warming as we reduce emissions.

"A continuous injection of a few tens of kilograms per second would be enough to offset a doubling of CO_2," Caldeira says. "You could imagine deploying a system one percent this year and two percent next year and three percent next year. And if something bad happened, you could taper it off. From an environmental perspective, that is probably the lowest risk approach."

Caldeira and other scientists have imagined several ways to get sulfur to the top of the planet. One option is to use powerful artillery to launch the aerosol. Another method would employ giant, high-altitude blimps equipped with hoses to carry sulfur from the planet's surface to the sky. The sulfur strategy has key advantages. SO_2 is plentiful, a byproduct of the very coal combustion that is warming the planet. And the price is cheap. As little as $1 billion a year could decrease sunlight by one percent. That is far less than the cost of ratcheting down global CO_2 emissions.

The plausibility of the sulfur concept has provided realism to the geo-engineering discussion. Still, no one is arguing that we employ geo-engineering next year, or even in five years. For now, the consensus in the scientific community is that there should be an internationally coordinated research program. Even critics say more study is needed.

"There should be government funding for geo-engineering," says Alan Robock, a Rutgers University meteorologist who has a National Science Foundation grant to investigate geo-engineering. Last year, Robock published a paper in *The Bulletin of the Atomic Scientists* titled "20 Reasons Why Geoengineering May Be a Bad Idea." "Let's say there was a global warming emergency," he told me. "Policy makers would want to know, Would it work? Could we do it? Should we do it? And right now we don't know how to advise them. But if there is no Plan B, we should know that too."

"There are no reasons not to have a research program," Thernstrom said to me. "There is no advantage to ignorance on geo-engineering."

Research alone seems harmless enough. If caution warns against the consequences of jury-rigging the atmosphere, prudence argues that it's wise to have a backup plan in case of climate disaster. As Ken Caldeira put it, a coastal city would want to have dykes to protect itself against storm surges and sea level rise. But that doesn't mean city leaders wouldn't also have an evacuation plan in case the dykes failed. Geo-engineering is that evacuation plan.

Only in this case, the evacuation would be a retreat from the entire world, the planet as we have always known it. If we spray tons of sulfur into the air and, as scientists expect, it turns the sky a milky shade (while making sunsets a deep, blood red), we will alter not just Earth, but also ourselves, our understanding of how we fit within the natural environment. This is itself a dicey experiment. If we were to make the clouds glossy and the sky white, dot the horizon with dirigibles in a kind of *Blade*

Runner set piece, what would be the impact on the collective human psyche?

We may be technologically capable of hacking the sky, but politically and ethically unprepared to do so. After all, it's been more than 20 years since the public learned that there were "human fingerprints" on the global climate. And as the impasse over emissions reductions proves, we still haven't come to terms with the moral implications of that fact. Are we ready, then, to go a step further and put our hand on a lever controlling the weather?

The idea of dimming the sun carries a number of problems. First, take the ethical conundrum of unequal benefits. What if world leaders decided to deploy the sulfur option and, as one climate model has suggested, an engineered cooling led to a decrease in monsoon rains over Asia? In such a scenario, geo-engineering could benefit some 5 billion people, while putting another 2 billion people in danger of drought and famine.

The risk of unequal benefits connects to a second difficult question: Who would control such powerful technology? Few people would want the US (or Chinese) military to run the weather. Corporate control would have its own drawbacks. As Robock put it to me: "Would *you* trust the ExxonMobil geo-engineering unit?" Leaving management of a makeshift sky to the lowest bidder seems imprudent, to say the least.

Thernstrom says one of the virtues of geo-engineering is precisely this centralized control. While unilateral emissions reductions are pointless, unilateral geo-engineering could work. Any industrial power could likely do it on its own — which means you don't need collective action to cool the planet; you just need countries not to object.

But even if the major powers agreed to cool the globe, reaching consensus on how exactly wouldn't be simple. "How do we even decide what the temperature of the planet will be?" Robock wonders. "Whose hand will be on the thermostat? What if Russia and Canada decide they want it warmer and India wants it cooler? How do you decide those things?"

Imagine that the United Nations took control of the planetary thermostat. That would prevent any country from having a monopoly over geo-engineering or, worse, having several countries deploy geo-engineering at cross-purposes. But UN oversight would still involve geo-politics. It's been close to impossible to get the major polluters to agree to emissions reductions. Finding cooperation on something as powerful as geo-engineering would be at least as complicated.

That's a concern of James Lovelock, founder of the Gaia theory. Lovelock's new book, *The Vanishing Face of Gaia*, warns that climate change will wreck civilization. Still, he doesn't think that geo-engineering provides a way out. "If we can't predict what's happening now, how can we predict what's happening in 50 years with some kind of artificial mechanism?" he said to me in a conversation this summer. "It's just moonshine. I think that if we ever take on the task of trying to manage the planet completely — if we succeed with geo-engineering and we have to run the planet ourselves, doing what the system now does for free — that we will be on a course for extinction. Because we can never manage it. We haven't learned to live with ourselves yet."

As Lovelock points out, the political and ethical issues are compounded by an epistemological predicament: No one knows how the planet would react. Geo-engineering is unlike any experiment in history in that the subject is the entire globe. On a closed system floating in space, there is no laboratory to test ideas.

"I think geo-engineering is less an ethical question than a methodological question," Martin Bunzl,

a philosopher who works closely with Robock, said to me. "Could you answer the risk analysis with enough assurance to deploy at a large scale? The burden of proof is on the proponents to tell us we know enough about how the atmosphere works."

Take the sulfur aerosol proposal. Would stratospheric injection of SO_2 rip a hole in the ozone layer? Would it decrease the amount of energy that solar panels capture or, far more troublesome, affect how plants grow? What if it caused a massive drought in Africa? These are the known unknowns. More worrisome are the *unknown* unknowns — the consequences we can't even imagine.

"The difference with large-scale geo-engineering is that you can't actually proceed in the normal way that science proceeds: lab to field tests to increased levels of deployment," Bunzl says. "Because you don't have a model that models the whole world system well enough. You can only deploy the whole thing. Or you are trying to make an inference from a small-scale deployment? What will the consequences be at full strength?"

Geo-engineering takes a problem, simplifies its causes, and then exaggerates its solution. It's like a Rube Goldberg machine, employing eight or nine steps when one or two would do.

Without a laboratory, any test to see how the atmosphere would react is already a manipulation of the atmosphere. "The problem with sulfur insertion is that you can't get results until you get to a certain strength, and you can't do it without involving the whole atmosphere," Bunzl says. Or, put another way: The only way to investigate the results of tinkering with the sky is to tinker with the sky. The experiment is itself a fait accompli.

The epistemological checkmate means that the very term "geo-engineering" is flawed. Fixing the climate isn't like repairing a bridge or building a skyscraper. The planet is neither an engine nor, in the metaphor used at the beginning of this essay, a supercomputer. It's an enormous living system, intricate beyond the scale of human understanding, our impressive discoveries notwithstanding. A machine has certain parts that work in expected ways: Even when moving, an engine is static. That's why it's reliable. Earth is different: It is, by nature, ceaselessly dynamic. So we can't be certain about the outcome of a given input. Despite all our fancy computer modeling, we will never know for sure how the atmosphere will respond to manipulation.

More than an endeavor of science, geo-engineering would be an act of faith.

Beyond the political and scientific questions lies a much larger moral, even spiritual, problem: Do humans have the right to undertake such a monumental task?

The geo-engineering debate proves once again that while our technological society is adept at exploring the *how*, we are less practiced in pursuing *why* and *whether*. As geo-engineering proponents acknowledge, schemes like sulfur aerosol address only the symptoms, not the source, of global climate change. That fact betrays our society's bias for the techno-fix, the seemingly easy way out. *Seemingly* — because geo-engineering is the most complicated strategy we could pursue. It takes a problem, simplifies its cause, and then exaggerates its solution. It's like a Rube Goldberg machine, employing eight or nine steps when one or two would do. Instead of pursuing the elegant solutions — trading in our cars for buses, turning off the coal and turning on the wind — we are going to build a contraption to make the clouds shinier. Bill Becker, head of the Presidential Climate Action Project, summed up this thinking in an essay earlier this year: "Geo-engineering is rooted in the idea that although we're too stupid to do the simple things that would slow climate change, we're smart enough to do the improbable things."

Indeed, geo-engineering involves a surfeit of technological imagination and a poverty of political imagination, an imbalance that's ingrained in the notion that if we can do something we should do it. We prefer the overly complicated solutions because they flatter us, confirming our power and intelligence. This makes geo-engineering — the ambivalence of its promoters notwithstanding — human hubris compounded. It's like doubling down on self-regard.

Geo-engineering is a bet that we can save civilization by divorcing our species from the rest of the globe. The payoff is the idea that in "fixing" the planet, we can absolve ourselves of having ruined Earth. The risk is that if we turn the atmosphere into what Dale Jamieson, director of environmental studies at NYU, calls a "human artifact," we will lose ▶

our connection to much of what is best in life. In taking possession of the sky, we will become ungrounded.

The psychological ramifications of geo-engineering shouldn't be underestimated. It's exactly what Bill McKibben worried about 20 years ago in his seminal book on global warming, *The End of Nature*, when he warned of "the imposition of our artificial world in place of the broken natural one. … How can there be a mystique of the rain now that every drop … bears the permanent stamp of man? Having lost its separateness, it loses its special power. Instead of being a category like God — something beyond our control — it is now a category like the defense budget or the minimum wage, a problem we must work out. This in itself changes its meaning completely, and changes our reaction to it." Tinker with the heavens, and our relationship to the rest of the world suffers. We will sever our bonds to the other natural systems — rivers, forests, oceans — on which we depend. We will have made a decision that we can live without those things.

Once we take responsibility for managing the planet's curtains, our position in this place changes. We will be in charge in a way we never have been before, knowing that if for any reason we were to cease overseeing the sunlight, global temperatures would shoot upward again, spelling disaster. The new role will force upon us an existential anxiety. Because as soon as we are in control of the weather, we will always be fearful of letting our grip slip from the string that keeps the planet in a semblance of balance.

Such ownership of Earth would be a new step in human evolution. It would turn us into a bubble species, living inside a protective dome of our own making. If that comes to pass, we will cease to view the world as a comfort. It will have become, instead, a threat.

Maybe it's nothing. Perhaps these worries are overblown. After all, humans have been warping the planet since the Neolithic revolution. Having long ago changed the course of the world's most powerful rivers, having manipulated the genes of plants and animals, we are well beyond sentimentality for an unaltered Eden.

Bunzl pointed out that we have already made changes to the whole biosphere that are considered morally acceptable. A perfect example is the eradication of smallpox. Through concerted effort, the world's governments exterminated a virus that for millennia had played an important role in global ecology, serving as a check on human numbers. Hardly anyone would argue that this wasn't a good thing.

Other moral arguments could justify geo-engineering. The Doctrine of Double Effect, first formulated by Thomas Aquinas, says that it is permissible to engage in an act even with knowledge that the consequences may be deadly as long as the intention is pure. For example, a doctor may try a risky procedure to save a patient even if there is a chance the patient may die.

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We should at least be honest: There is scant difference between doing something unintentionally and knowing it's harmful, and intentionally, but riskily, trying to fix it. For 20 years, we have understood the consequences of pumping the atmosphere full of CO_2 and still we persist. We crossed a moral line long ago.

Our double bind is this: Either we keep our hands off the sky, and hope we act in time to prevent the destruction of Arctic ecosystems, the desertification of the Amazon, the abandonment of ancient cities. Or we try our luck at playing Zeus, knowing that it could make matters worse. No matter what, we risk losing Creation.

In contemplating geo-engineering, I keep returning to the words of the eco-theologian Thomas Berry. In the introduction to his book *The Dream of the Earth*, he wrote: "Our own well-being can be achieved only through the well-being of the entire world around us. The greater curvature of the universe and of planet Earth must govern the curvature of our being."

Yes, geo-engineering might be able to save the planet's body. But only at the cost of sacrificing its soul. ■

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