MuseLetter

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The first piece in this month's Museletter 'How to Build a Climate Bomb' is an essay on the perils of geoengineering. That is followed by a short essay I wrote to mark Earth Day.

How to Build a Climate Bomb

A major effort to limit climate change could actually make the problem much worse. If that sounds maddeningly paradoxical, then welcome to the bizarre science-fiction world of solar geoengineering.

There are two main pathways for deliberately altering Earth systems (i.e., geoengineering) in order to reduce the severity of global warming: carbon dioxide removal and radiation shielding. The former pathway is widely discussed, though little progress is being made. Methods of removing carbon from the atmosphere are either biological (regenerating soil and planting trees) or mechanical (building machines to suck carbon dioxide out of the air). Generally, biological methods show far more promise. But, regardless of method, the problem of scale is daunting: as a result of decades of rising greenhouse gas emissions, there's a hell of a lot of excess carbon that needs to be removed.

Hence the alternative pathway of radiation shielding or solar geoengineering. Why not cool the Earth by reducing the amount of sunlight warming it? By most calculations, this would be a cheaper and faster way out of the climate crisis than carbon removal. Again, there are diverging pathways. The two most frequently discussed are sending up high-altitude planes to disperse tiny reflective particles (this is known as stratospheric aerosol injection, or SAI), or building a space parasol to shield the planet from some of the sun's rays.

Many people regard these as last-ditch, risky projects. However, the failure of humanity so far to reduce carbon emissions, plus a flurry of alarming recent studies about rapidly warming oceans, climate feedbacks, and tipping points, are leading some scientists and activists who previously dismissed solar geoengineering to now have second thoughts.

The first SAI pilot projects could start soon. But to achieve global cooling of, say, 1 degree Celsius would require a fleet of planes hoisting and dispersing several million metric tons of particles high in the stratosphere. Forging international agreements for such a project and building the required infrastructure could take well over a decade. Constructing a space parasol would probably take even longer and be more expensive.

What could go wrong? Tinkering with the climate in one place could trigger droughts or mega-storms elsewhere. Only wealthy nations or corporations could undertake solar radiation geoengineering at the scale needed to achieve significant results; so, there is at least the theoretical possibility of the technology being used in a subtle or overt form of global extortion. (Nice climate you've got there. You want it to stay that way? Pay up.) Also, fossil fuel industries and governments dependent on fossil fuel revenues could use geoengineering as an excuse to keep polluting.

But there's one important risk that is discussed less frequently. If a global solar radiation management program were to start but then stop, then the warming that had been temporarily held in abeyance would show up quickly and with a vengeance. This is how a European Parliament briefing document from 2021 puts it:

> "Once started, solar geoengineering cannot be stopped. Assuming that carbon emissions continued, the artificial sunshade would mask increasing amounts of extra warming. If geoengineering ceased abruptly—due to sabotage, technical, or political reasons—temperatures would shoot up rapidly. This termination shock would be catastrophic for humans and ecosystems."

How Big of a Bomb Are We Talking About?

The word "catastrophic" in the text just quoted gives little indication of scale. A termination shock would be bad—but climate change is already bad. How awful might a geoengineering termination shock actually be? A couple of metaphors could prepare us to estimate the potential size of such a shock.

Think of climate change as a wildfire. An uncontrolled burn releases energy previously held in trees and grasses, adding it to the local environment in the form of heat. Similarly, by trapping solar radiation, greenhouse gases add energy in the form of heat to the global climate system (elsewhere, I have proposed calling the fossil-fueled industrial era "the Great Burning").

In contrast, a sudden release of pent-up warming would metaphorically more closely resemble a bomb, whose explosion releases energy far faster.

How much energy? Let's run the numbers. First, we should settle on a unit of measure. Energy can be expressed in Watt-hours or Joules, but for our purposes it might be more fitting to use a measure typically reserved for describing the energy released by nuclear weapons—the megaton (Mt), which refers to the explosive energy of a million tons of TNT.

The energy transfer that's causing climate change can be measured in megatons. A recent study found that the Earth's oceans, which absorb most of the heat trapped by greenhouse gases, capture "the heat of 5 to 6 Hiroshima atom bombs per second." The Hiroshima explosion was estimated at 15 kilotons of energy, so a little quick math tells us the oceans are absorbing at least one megaton of energy from global warming every 13 seconds or so.

The total firepower of all current nuclear weapons is estimated at 2500 Mt. A bit more arithmetic tells us that's about 9 hours' worth of global warming. So, the sudden release of just one year's worth global warming energy would be the equivalent of nearly a thousand times the energy yielded by exploding the world's entire nuclear arsenal.

That's a really, really big bomb.

I'm not saying that the effects of global warming would mirror the immediate effects of detonating the world's nuclear arsenal 1,000 times over. But there would surely be horrendous consequences from the Earth having to absorb all that energy so fast.

If we continue spewing greenhouse gas emissions, we will be capturing the same amount of energy from the sun and heating the planet just as much, but more slowly and over a longer time (that's the metaphorical wildfire). Adaptation to global warming at current rates will be extremely challenging for societies and ecosystems; in some cases, adaptation will probably fail, leading to casualties and collapse. The last thing we should be doing is speeding up the rate of change by building a climate bomb.

If we Start Geoengineering, How Likely Is an Unintended Termination?

Whether the risk of humanity's failure to maintain a solar geoengineering program, once it has started, is seen as substantial or trivial depends partly on whether you view modern industrial civilization as inherently sustainable.

Most governments and economists see industrial civilization as here to stay. We may have a few problems to contend with, say the techno-optimists, but these can be solved; ultimately, technological progress is unstoppable.

However, researchers in the fields of ecology and systems science claim that our current global industrial system will necessarily be self-limiting over time, due to resource depletion and pollution. We can improve the efficiency of industrial processes up to a point, but increasingly they are limited by supplies of natural resources and availability of waste sinks. For wealthy modern societies, whose resource flows and waste streams are gargantuan by any historical measure, those natural limits are set to bite soon, and bite hard.

Rockets, satellites, and high-altitude planes are all fixtures of the early 21st century. They depend on mining, manufacturing, and transport systems that didn't exist until the late 20th century, and that probably can't be maintained for more than another few decades. The future will be all about simplification—whether by design or default.

So, to me, the failure of humanity to maintain a solar radiation geoengineering project, once it has started, is not a remote risk; rather, it's the most likely thing that would happen.

Maybe I'm wrong about that. Perhaps there's only a ten percent risk of a geoengineering failure resulting in a sudden global warming rebound. But it's a risk that would entail global heating of a speed and magnitude that would be both unprecedented and terrifying.

What's really needed to reduce climate risk is a coordinated effort to greatly shrink humanity's overall energy usage and material consumption, along with massive investments in nature-based carbon removal. If world leaders continue to fail to mount that effort and make those investments, will they eventually turn to solar radiation geoengineering as an alternative solution, because it's cheaper and doesn't involve as much perceived sacrifice? We'd better hope not, because it would be an epically, apocalyptically horrible idea.

Finally, here's the good news. Solar geoengineering is still in the category of bad things that aren't happening, but might. This means that, with more public awareness, it could be prevented.

Earth Isn't Just Where We're From

This Earth Day, I find myself thinking about Star Trek. And not in a good way.

When I was a teenager and young adult I watched episodes of Gene Roddenberry's classic original TV series multiple times—on original broadcast, reruns, and video rentals. I thought it was a little cheesy, but entertaining and, at its best, thought-provoking. However, even though I still appreciate its implicit messages about diversity and inclusivity and perhaps even the "Prime Directive," I now also have some very different feelings about it.

Start Trek—along with a heap of other science fiction novels, movies, and comic books—promoted the idea that we humans are destined to colonize the rest of our solar system, then other star systems, the galaxy, and beyond. That was an understandable conclusion to draw, given two undeniable realities: the seemingly unstoppable force of European colonialism, and the more recent development of airplanes, rockets, satellites, and space exploration. It really didn't take much imagination to guess that the trajectory of events would eventually propel humanity to life among the galaxies.

However, that turns out to be a bad guess. As physicist Tom Murphy has pointed out, living for an extended period anywhere other than Earth is just about impossible. You can get an inkling of some of the dangers, costs, and momentary practical difficulties by watching the 2013 movie Gravity.

When, in 2021, William Shatner (star of the original series) made a real trip to space aboard Jeff Bezos's Blue Origin rocket, he expected to achieve an "ultimate catharsis." Instead, he was filled with an "overwhelming sadness" and a newfound appreciation for the beauty of Earth. He later wrote, "I love the mystery of the universe. I love all the questions that have come to us over thousands of years of exploration and hypotheses … but when I looked in the opposite direction, into space, there was no mystery, no majestic awe to behold … all I saw was death."

Nevertheless, Star Trek became a durable quasi-religion. Not only did it attract devoted followers ("Trekkies"), but it shaped the zeitgeist of two or three generations. And it has had real-world consequences, including the fact-defying (though well-funded) Mars-colonizing ambitions of Elon Musk. The World Economic Forum, in a new report, suggests that space holds a mouth-

watering $1.8 trillion worth of opportunity for economic growth—surely incentive enough for lots of new voyages to the final frontier.

But all religions have their dark sides, and Star Trek mania is no different in this regard.

Some opponents of environmentalism are Bible-thumpers who believe that God gave Earth to humans to use up, and that resource depletion and pollution won't be problems because Jesus will return soon and all the *good* people will be taken up into heaven. After that, who the hell cares what happens to the planet? To some of its acolytes, Star Trek offered a trendier and ostensibly more secular version of essentially the same line of thought: our destiny is among the stars, so don't get too worked up about the costs of progress.

Both those anti-ecological lines of thinking are not just wrong, but profoundly, existentially misleading.

Earth is it. It's not just where we're from, it's where we belong, and it's the only home we will ever know. If we don't take care of it, we will cease to exist.

And why shouldn't we want to care for our planet? Earth is miraculous and beautiful. It nourishes us physically, emotionally, and spiritually. If there is any religion that makes sense, it's the old-time religion of pantheistic Earth-worship.

This Earth Day, let's have a revival—a celebration of our true and only planetary home.