

**ANALYSIS** ([//FEATURE-TYPE/ANALYSIS](#))

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# The trouble with geoengineers “hacking the planet”

Raymond T. Pierrehumbert

Geoengineering seems to be the new darling idea making the rounds of the science and technology media. But what is geoengineering? Loosely speaking, the term refers to deliberate manipulation of the Earth’s ecosystem so as to achieve some desired climate effect—usually a cooling to offset the effects of human-caused global warming. Many researchers who have studied the subject are uncomfortable with the word “engineering” applied to meddling with a system we still understand rather poorly, so other terms—such as “Hacking the planet”—have come into play. In [National Research Council reports](#) (<https://nas-sites.org/americasclimatechoices/other-reports-on-climate-change/climate-intervention-reports/>) on the subject, of which I was a co-author, we settled on the term “Climate Intervention,” which carries less freight in assuming that the undertaking will necessarily achieve the desired end.

Climate intervention comes in two main flavors. One is albedo (i.e., reflectivity) modification, which involves putting something in the atmosphere to reflect more sunlight back out into space. The other is carbon dioxide removal and sequestration, which involves removing carbon dioxide from the atmosphere and stowing it somewhere where it will hopefully stay put for a few thousand years. The latter technique is relatively benign, though highly technologically challenging. It is albedo modification, which has some truly terrifying implications, which I will be concerned with here.

**Geoengineering in the news.** Albedo modification has been mooted as the [savior of the Great Barrier Reef](#) (<https://www.technologyreview.com/s/604211/scientists-consider-brighter-clouds-to-preserve-the-great-barrier-reef/>). The [Christian Science Monitor](#) (<http://www.csmonitor.com/Environment/2017/0315/New-CO2-record-Is-it-time-to-geoengineer-our-planet>) wonders if it’s time to re-engineer our climate. MIT’s [Technology Review](#) (<http://www.technologyreview.com/s/511016/a-cheap-and-easy-plan-to-stop-global-warming/>) basically thinks the answer is “yes,” having described it earlier as “cheap and easy.” [The Atlantic](#) (<https://www.theatlantic.com/science/archive/2015/11/its-time-to-start-talking-about-geoengineering/414283/>) seems quite smitten with [Economist writer Oliver Morton’s vision](#) (<http://press.princeton.edu/titles/10657.html>) of remaking the planet, which geoengineering booster Jane



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Long breathlessly called “[geopoetry](http://www.nature.com/nature/journal/v526/n7571/full/526038a.html) (<http://www.nature.com/nature/journal/v526/n7571/full/526038a.html>).” The idea received recent coverage (much of it favorable) by *New Scientist* (<https://www.newscientist.com/article/2126086-geoengineering-the-sky-is-scary-but-we-need-to-test-it-now/>), NBC, and in TED talks; I myself have recently participated in an [NPR panel discussion](http://www.kcrw.com/news-culture/shows/to-the-point/should-we-hack-the-climate-to-fight-global-warming) (<http://www.kcrw.com/news-culture/shows/to-the-point/should-we-hack-the-climate-to-fight-global-warming>) on the subject.

Too many science writers have been suckered in by one of two seductive narratives, which make for easy copy and a ready-made lead. One is the panic attack: After noting (with justifiable alarm) the woefully insufficient progress on reducing carbon dioxide emissions, the storyline goes that it’s time to get ready for albedo modification as a fallback measure, or in other words a bad idea whose time has come.

The other narrative is that of the courageous genius pioneer, daring to think the unthinkable. Propagators of this narrative are often dazzled as well by the sheer, gee-whiz, techno-optimistic audacity of being able to mess with the whole damn planet and call up climate on demand, rather like ordering up sushi from the latest foodie app on your iPhone. It’s not unusual for both narratives to appear in the same piece. One of the more egregious examples of this style of journalism is the fawning *New York Times Magazine* (<https://www.nytimes.com/2017/04/18/magazine/is-it-ok-to-engineer-the-environment-to-fight-climate-change.html>) piece on Harvard’s geoengineering impresario, David Keith.

**Harvard crosses the Rubicon.** But what has really catapulted the idea into the public eye is Harvard’s reckless plan for a privately-funded field trial testing some of the key elements needed for albedo modification. An article in *The Guardian* (<https://www.theguardian.com/environment/2017/mar/24/us-scientists-launch-worlds-biggest-solar-geoengineering-study>), while not quite right (<https://www.theguardian.com/environment/2017/mar/29/criticism-harvard-solar-geoengineering-research-distorted>) about the nature of the experiment, was nonetheless entirely right to sound the alarm.

Proceeding to field experimentation crosses a thin red line beyond which lies the slippery slope down to ever-larger field trials and ultimately deployment. The experiment is privately funded, and subject to no governance save what Harvard chooses to impose upon itself. Harvard researchers would argue that the experiment is subject to the usual environmental laws, such as the National Environmental Policy Act (which is going to have teeth under Trump, right?) but such laws are designed to protect against physical hazard only.

The experiment, called [SCoPEX](https://projects.iq.harvard.edu/keutschgroup/scopex) (<https://projects.iq.harvard.edu/keutschgroup/scopex>), involves a powered balloon which would spread about a kilogram of water or calcium carbonate (limestone) particles in the stratosphere, over a swathe of air about a kilometer long and 100 meters in diameter. It doesn’t pose a physical risk, but it does pose a considerable social and political risk in being the first step towards development of actual technology for deployment. There would be some limited scientific payback from such a small-scale experiment, but it is mostly a stunt to break the ice and get people used to the idea of field trials of albedo modification. (You know what they say about the camel’s nose in the tent.) The experiment would not address any of the really major issues

raised in the National Research Council climate intervention report, which indeed are hard to experiment with short of something that amounts to full-scale deployment.

In much of the news coverage running up to the experiment’s announcement, it was falsely claimed that our National Research Council report—and in its wake the [US Decadal Global Change Research Plan](http://www.globalchange.gov/browse/reports/national-global-change-research-plan-2012-2021-triennial-update) (<http://www.globalchange.gov/browse/reports/national-global-change-research-plan-2012-2021-triennial-update>)—broke new ground in endorsing such experimentation. The geoengineering boosters would no doubt like to spin the reports that way, but nothing could be further from the truth. Both reports essentially endorse research on basic climate processes that enter into consideration of albedo modification effects (for example, better monitoring of Earth’s radiation budget), computer simulations, and better monitoring of what researchers call “natural experiments” such as volcanic eruptions. They recognize that proceeding to outdoor experimentation represents a very serious step, that might someday be justified, but which requires some form of governance in the form of a serious deliberative process. Though, in the present US political context, can a “serious deliberative” discussion on any topic be carried out?

**Why is albedo hacking a bad idea?** To understand why albedo hacking is such a bad idea, we first have to understand the practically irreversible effects that carbon dioxide emissions have on climate. Carbon dioxide is removed only very gradually from the atmosphere, first through slow uptake by the oceans (where it causes ocean acidification) and ultimately by reaction with certain continental rocks over 100,000 years or more. If we emit a trillion tons of carbon in the form of carbon dioxide before we decarbonize the economy (we’ve already emitted more than half that) it will cause about 2 degrees Celsius of warming, and most of that warming will still be around in 10,000 years. Worse, a trillion tons doesn’t begin to exhaust the likely amounts of fossil fuels available, or the speed with which they could be tapped by an exponentially growing, energy-hungry, wasteful economy. This has such an enduring effect on the future that geologists are beginning to say that we are now living in a distinct geological era, called the Anthropocene. [Our Nature article](https://www.nature.com/nclimate/journal/v6/n4/full/nclimate2923.html) (<https://www.nature.com/nclimate/journal/v6/n4/full/nclimate2923.html>) on the way our energy choices determine the character of the Anthropocene for thousands of years to come gives an idea of the duration of today’s human imprint on future climate.

Albedo hacking by, say, injecting particles into the stratosphere tries to offset this persistent warming by a human action that needs to be continually renewed. If the particle injection were ever stopped, the particles would fall out in a year or so, and the world would suffer the full brunt of resurgent global warming in around a decade, a phenomenon called “termination shock.” In other words, once you start doing albedo modification, you need to keep doing it essentially forever. Let me reiterate: Any kind of geoengineering of the Earth’s reflectivity—such as seeding the stratosphere with crushed limestone, or spraying saltwater in the air—is not a one-time, one-off event, but something which would have to be repeated in perpetuity, on a regular basis. In other words, forever. This is a key concept that most mass media coverage of geoengineering seems to miss.

What is the morality of committing 10,000 years of future humanity to maintaining an activity year in and year out without fail? What is our track record as a species of maintaining any technological activity for more than a century or two? Oliver Morton, in his thoughtful (but

ultimately boosterish) [book](http://press.princeton.edu/titles/10657.html) (<http://press.princeton.edu/titles/10657.html>) puts forth the vision of albedo modification as just another stage in the cycle of technological dependencies that make the life of humanity better, rather like the Haber Process for making fertilizer has allowed agriculture to support a much larger population. It's an interesting point, but there remains the uncomfortable issue of whether a global-scale intervention like albedo modification is really in the same category. Or, more broadly, is our ever-expanding wave of technological dependency increasing the resilience of human society or just setting us up for a harder fall when it all becomes unsustainable?

Albedo modification is sometimes thought of as something you can do to hold warming in check while “buying time” to decarbonize the economy, but this is a fundamental misconception. Each additional kilogram of carbon dioxide emitted commits the Earth to a certain amount of warming that essentially never goes away (unless we learn how to suck carbon dioxide out of the atmosphere in massive amounts quickly—a [very debatable prospect](http://thebulletin.org/%E2%80%98we%E2%80%99d-have-finish-one-new-facility-every-working-day-next-70-years%E2%80%99%E2%80%94why-carbon-capture-no-panacea9949) (<http://thebulletin.org/%E2%80%98we%E2%80%99d-have-finish-one-new-facility-every-working-day-next-70-years%E2%80%99%E2%80%94why-carbon-capture-no-panacea9949>)). And so the need for continued geoengineering to counteract that additional warming never goes away—even after carbon dioxide emissions are eventually brought to zero.

Moreover, because carbon dioxide accumulates inexorably in the atmosphere so long as emissions continue, one cannot even achieve the more modest goal of slowing the rate of warming without inexorably increasing the amount of albedo modification deployed each year. It's like drinking water contaminated with a poison like mercury that accumulates in your body, but trying to cancel out the effects with ever greater dosages of antidote. So long as there is any poison left in the water, your bodily burden increases and each year you need to take a greater daily dose of antidote. Even if the poison is removed from the drinking water supply, you have to continue taking the antidote for the rest of your life, because of the poison accumulated in your body—unless you undergo some therapy which actively removes the poison from your body, which would be analogous to sucking carbon dioxide out of the air.

Some albedo modification proponents have said that there is no such thing as “millennial commitment” to the technology, because society is always free to make the decision to stop. However, that's like saying that a diabetic is always free to decide to stop taking medication—and die prematurely as a result.

It is far better to take preventive measures that reduce the risk of contracting the disease in the first place. Albedo modification proponents would probably reply that some people are going to make bad choices (or be stuck with bad genes) and get the disease anyway, in which case it is certainly better to have the treatment available as a fallback. The availability of albedo modification is then seen as something like diabetes treatment or seatbelts: something which can negate some of their benefits by encouraging riskier behavior, but which statistically averages out to have benefits nonetheless.

That only exposes the limitations of the medical analogy. With billions of individuals involved, most will survive and prosper even if some make bad choices or have bad luck, and the

consequences of an individual’s bad choices are borne by that individual only and only for his or her own lifetime. There is no Planet B to live on, and the consequences of the bad choices we make as a society today will inflict suffering on countless innocent generations to come.

There are many more problems with the climate and sociopolitical state entrained by deployment of albedo modification, but for me, it is the [millennial commitment problem](http://thebulletin.org/climate-crisis-how-long-do-we-have10363) (<http://thebulletin.org/climate-crisis-how-long-do-we-have10363>)—the essentially irretrievable addiction to geoengineering—that is the real showstopper.

Proponents of expanded albedo modification research say that to foreclose field experimentation would only give future generations “the gift of ignorance.” However, not all research is innocuous. The US decision to develop the hydrogen bomb led to an arms race that threatens the very survival of civilization, and I daresay that current generations are not especially grateful that past research gifted tyrants of our times with the knowledge of how to make Sarin nerve gas.

This is not to say that albedo modification is necessarily in the same category, but it does puncture the knee-jerk reaction that it never hurts to research a technology.

**The Trump effect.** But what of the Trump effect? Doesn’t Trump’s withdrawal of the United States from the Paris climate accord increase the urgency of preparing a Plan B? Indeed, in an [interview in \*The Atlantic\*](https://www.theatlantic.com/science/archive/2017/06/oppenheimer-interview/529083/) (<https://www.theatlantic.com/science/archive/2017/06/oppenheimer-interview/529083/>), Princeton’s Michael Oppenheimer claimed that Trump’s withdrawal eliminated our last chance to stay within the 2-degree Celsius warming target. Actually, the total US carbon emissions during four years of a Trump administration (if it lasts that long) amounts to 6.6 gigatons of carbon, which translates into a warming of .013 degrees Celsius; Trump’s actions affect only a small portion of this emission. The 2-degree target was always hard, but if the rest of the world holds firm and the United States eventually recovers from its present insanity, it will be no easier or harder to meet than it was before Trump. In fact, if anything, Trump’s actions seem to have [hardened the rest of the world’s resolve](http://thebulletin.org/eu-deepening-ties-climate-pact-members-after-us-withdraws10847) (<http://thebulletin.org/eu-deepening-ties-climate-pact-members-after-us-withdraws10847>).

To be sure, I can actually imagine a world in which a small and strictly limited amount of albedo modification could sensibly be deployed as a complement to strong and largely successful efforts to bring carbon dioxide emissions towards zero, accompanied by successful deployment of technologies for actively removing the gas from the atmosphere. But that would be a world with a truly exceptional level of international agreement, fact-based decision-making, and cooperation towards shared goals. A world where somebody like Donald Trump can become president of a superpower is not that world. Besides, it’s bad enough that Trump has his hands on the nuclear weapons launch codes. Do we really want to give someone like him the tools to monkey with the world’s climate as well?

**Harvard as Greenfinger?** Because the small “geoclique” who back field trials of albedo modification is so vocal and has such an easy time getting press coverage, one could easily get the false impression of an unstoppable juggernaut backed by a formidable research program. In reality, if one looks closely one just sees the same few names come up over and over again, rather

like the elephant cycling through the parade scene in *Aida* with a different outfit each time it appears on stage.

Few scientists have the stomach for this subject, geoengineering isn't attracting much new talent, and the modest burst of funding that came in the wake of the UK Royal Society report has mostly collapsed. What little funding remains is mostly directed, as it should be, on approaches involving governance, notably the [Carnegie Council Initiative](https://www.carnegiecouncil.org/programs/ccgg) (<https://www.carnegiecouncil.org/programs/ccgg>), which is an interesting endeavor. But I worry a bit that the effort has been infiltrated by the geoclique. So far as scientific research directed towards field experimentation goes, Harvard—with the help of Bill Gates and other private funds—is almost single-handedly keeping the field on life-support. But it is time to pull the plug on this ill-advised approach.

One of the albedo modification scenarios we considered in the National Research Council report is the “Greenfinger” scenario, in which a well-meaning, wealthy individual decides to save the world on his own, but with possibly disastrous unintended consequences. It is ironic that Harvard, my very own alma mater, appears to be setting itself up for that very role.

The following verse from T.S. Eliot's *Gerontion* could almost serve as an epitaph for a species whose technological prowess has outstripped its wisdom:

*After such knowledge, what forgiveness? Think now*

*History has many cunning passages, contrived corridors*

*And issues, deceives with whispering ambitions,*

*Guides us by vanities.*