Geoengineering

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Provocative question: If solar geoengineering is inevitable, what unintended consequences might follow in its wake?

Geoengineering encompasses many proposed technologies for modifying the climate at continental or global scales. Although geoengineering remains controversial, people across the political spectrum are attracted to its varied possibilities. The political fight of the century, then, may be less about *whether* to open Pandora's box, and more about *which* form of geoengineering to deploy, at what scale. Geoengineering — specifically solar geoengineering — may be inevitable, for reasons discussed below.

Geoengineering proposals can be distinguished by the part of the Earth's energy balance they target. The climate is determined by a balance between "shortwave" radiation into the Earth from the sun and "longwave" radiation emitted back into space. Proposals for carbon dioxide removal would take greenhouse gases out of the atmosphere, allowing more longwave radiation to escape and cool the Earth. A more controversial category of proposals aims to reduce incoming shortwave radiation. The most prominent of these is solar geoengineering, where high-flying jets would spray particles in the upper atmosphere to partially blot out the sun.

The risks of solar geoengineering are many. Spraying sulfur aerosols into the stratosphere could bleach the blue from the sky, degrade the ozone layer, and disrupt global patterns of precipitation.[1] Any nation-state (or other actor) that launched a solar geoengineering program

might provoke conflict among nuclear armed states who disagreed on where to set the planetary thermostat. And yet, despite these risks, and despite the feasibility of less dangerous decarbonization paths, solar geoengineering is the most likely intervention to be deployed soon at scale. Why might this technology, whose proponents liken it to nuclear weapons and opioids,[2] appeal to policymakers? In a word, scale.

Carbon capture quickly runs into problems with either energy or land efficiency when deployed at an adequate scale. Existing technologies require at least six gigajoules of energy per megagram of CO_2 removed from the air; capturing enough to make a dent in global concentrations would require a significant percentage of global electricity generation.[3] Such energy costs could be avoided by sacrificing land instead. Bioenergy with carbon capture and storage (BECCS) is commonly prescribed in models used by the Intergovernmental Panel on Climate Change (IPCC). The concept is to grow a plantation of trees, which are then burned for electricity; the emitted carbon is captured in the flue and buried underground, leading to net negative emissions. Although the technology does not yet exist, IPCC scenarios propose dedicating as much as three Indias worth of land to BECCS in the latter half of this century to capture carbon at scale.[4] "Natural climate solutions" avoid many of the biodiversity and air quality costs of BECCS, and are the only mature method we have for carbon capture at scale, but also require extensive land to be dedicated to rewilded ecosystems. Because 35% of habitable land on Earth is used for animal agriculture, scaling either land-based option quickly will need to confront the meat industry.[5]

A safe path towards a stable climate could come through deep and fast emissions reductions coupled with rapid deployment of carbon dioxide removal. Because the biosphere has a limited capacity to remove carbon, the longer it takes to reduce emissions the more that

unproven technological means like BECCS or direct air capture will need to be scaled. Any such path is expensive and rife with potential political and economic conflict: fossil fuel companies, agricultural interests, and many industrial concerns will be euthanized, while new powers will rise through their control of various parts of new supply chains. While a muscular climate movement, forged through alliances among the working class, feminists, and environmentalists, could build enough power to overcome these interests, the specter of a red-green alliance provides an incentive for the powerful to line up behind a dangerous alternative.

Solar geoengineering could cool global mean temperature back to preindustrial levels for only a few billion dollars a year — cheap enough for most countries, or even a single wealthy "greenfinger," to deploy — neatly solving the scale problems of other forms of geoengineering. Solar geoengineering also cuts through the intra-capitalist class conflict that a green transition presents, buying time for market-driven emissions reductions and carbon capture to grow while protecting the interests of fossil capital.[6] Put bluntly, solar geoengineering smooths relationships among capitalists in service of a planetary class war. Rather than an emergency intervention, solar geoengineering proponents present the technology as means to temporarily prevent temperature overshoot as emissions are cut and carbon capture deployed. As the framing of solar geoengineering shifts towards promising a prudent, cost-effective policy with global humanitarian benefits (a "win-win"), it fits neatly within the politics of the existing US Democratic Party.

Outside the technocratic center, intellectual traditions of both the right and the left may foster support for solar geoengineering. On the neoliberal right, the Cato, Hoover, and American Enterprise Institutes have worked on geoengineering projects; they deny climate change with one side of their mouth while proclaiming an ultimate, cheap, technical solution with the other. Cap-

and-trade schemes can thus be understood as neoliberal tactics of delay until cheap aerosols become the last climate "solution" remaining.[7] On the left, a longstanding sense of humanity's capacity to master nature sometimes prevails. Contemporary writers like Holly Jean Buck have made a left case for solar geoengineering; the technology also had Soviet proponents, including a 1974 textbook by Mikhail Budyko which drew on the USSR's long history of weather modification projects.[8]

Solar geoengineering, then, may be inevitable as the final climate "fix." Yet the implications of the possibility are broader still. Some philosophers muse that the rise of solar geoengineering marks the end of the scientific revolution, and the beginning of a new technical age of engineering. The scientific revolution's habits of incremental experimentation seem quaint compared to the ambition of engineering impossibly complex systems like the atmosphere, an intervention that cannot be simulated beforehand on a computer or in a laboratory.[9] The chaos produced may be unpredictable, but perhaps could be mitigated by another planetary intervention that begets its own symptoms. With many different forces converging on solar geoengineering, we may be witnessing the dawn of a world where action precedes — and replaces — knowledge.

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