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Scientists Rank Global Cooling Hacks

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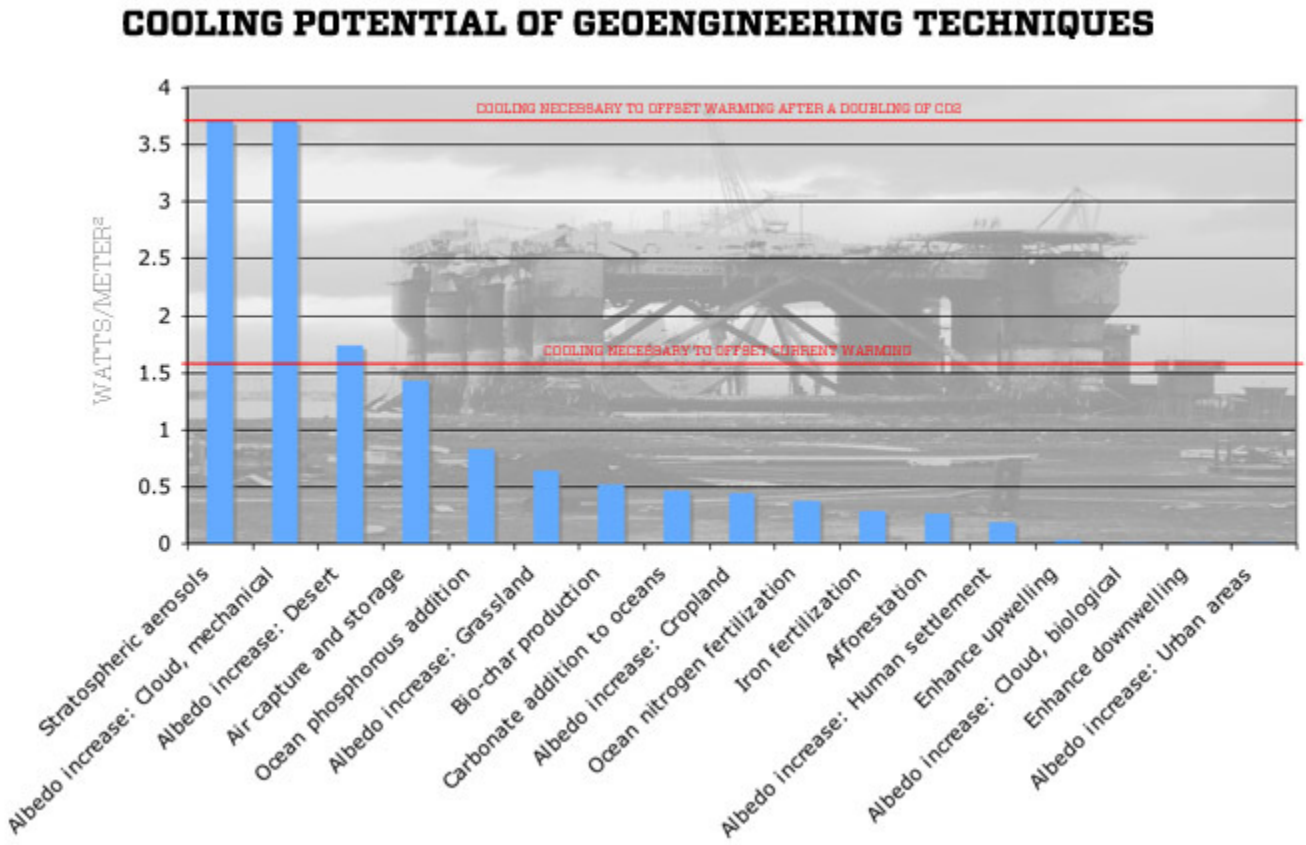


Not all climate hacks are created equal.

The dozens of ways that scientists, as well as crackpots, have proposed to geoengineer the world's climate won't all be equally effective. In fact, some of them, particularly the ones that rely on sucking up carbon dioxide instead of blocking out solar radiation, will hardly have any impact at all, a new study in the journal *Atmospheric Chemistry and Physics* found.

"By 2050, only stratospheric aerosol injections or sunshades in space have the potential to cool the climate back toward its pre-industrial state," earth scientists Tim Lenton and Naomi Vaughan of East Anglia University in England write.

Many global cooling approaches have been floated. The broad range of the proposals — from injecting the upper atmosphere with sun-blocking particles to creating plankton blooms by feeding them extra iron to burying carbon-filled "biochar" in soil — has made comparing them very difficult. The new study provides the first useful comparisons of a wide variety of geoengineering ideas.

The study did not calculate the costs or environmental impacts of any of the techniques, but for most of the climate hacks, they could be large. For those reasons, the authors of the paper recommend reducing the amount of our emissions, not just banking on geoengineering to bail us out.

"Climate geoengineering is best considered as a potential complement to the mitigation of CO2 emissions, rather than as an alternative to it," they write.

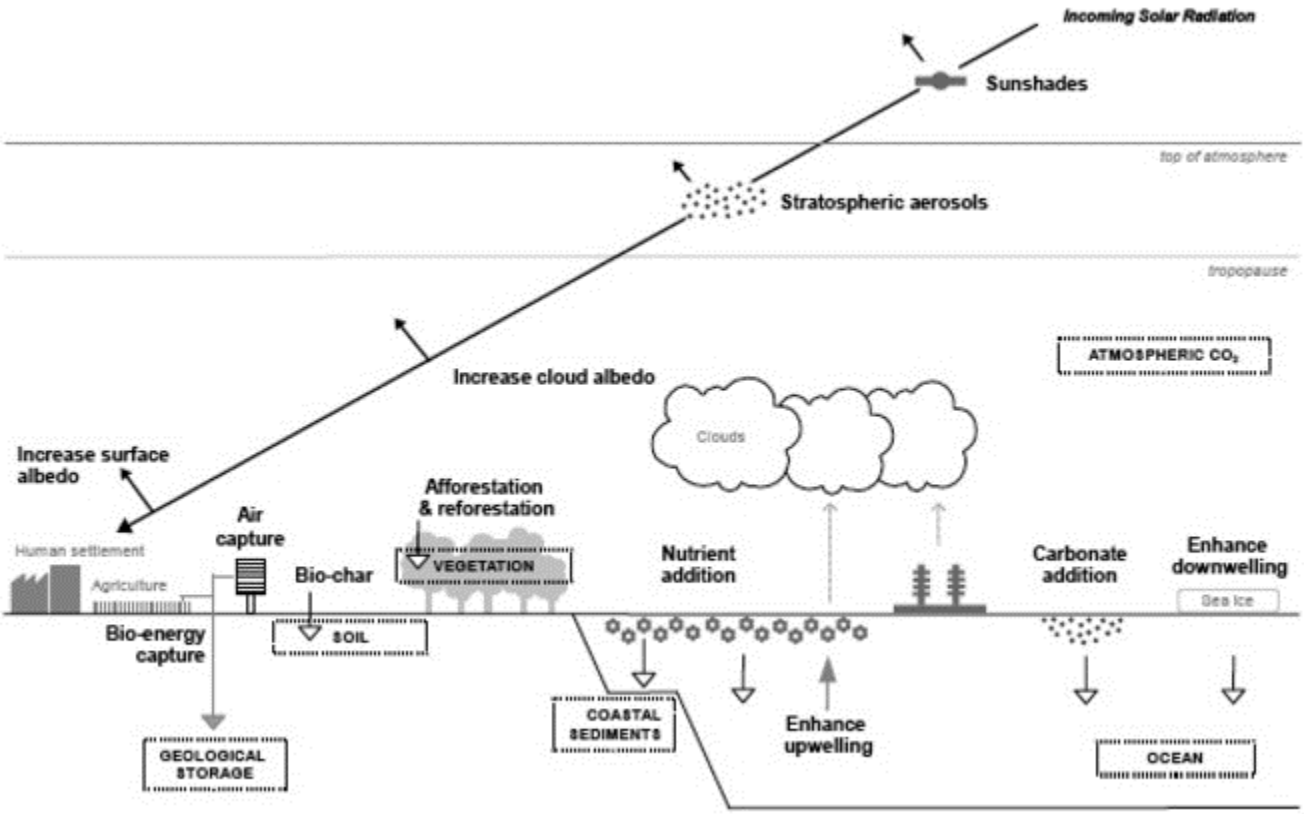
The study of climate change tries to compute the change in the energy balance between energy coming from the sun — shortwave radiation — versus the longwave radiation emitted by the Earth. When there's more carbon dioxide, less longwave radiation escapes and the world heats up. Scientists calculate that humans' carbon dioxide emissions from 1800 to 2005 are causing 1.6 watts of extra energy per square meter of surface area to stay in Earth's atmosphere. If CO2 levels double again, that number goes to 3.71 watts.

So, logically enough, the scientists decided to evaluate geoengineering schemes with the same watts-per-square-meter metric. How much cooling or climate balancing could each scheme provide? Though "not intended to be definitive" the researchers claim their numbers are at least as good as previous analyses of individual techniques.

The clear winners, cost aside, are strategies that would block out some solar radiation. Perhaps the most currently workable version of this technique is injecting millions of tons of sulfur dioxide into the atmosphere. Of course, the injections would have to continue until the greenhouse gases in the atmosphere were brought back down and the environmental costs could be high. Another high-impact technique would increase the albedo — or reflectivity — of the tops of clouds.

The results are presented in the table below. Short descriptions of each technique follow. For more detailed information on each technique, check out the full text of the paper (.pdf), which is available online.

Technique	Cooling potential (w/m2)
Stratospheric aerosols	3.71
Albedo increase: Cloud, mechanical	3.71
Albedo increase: Desert	1.74
Air capture and storage	1.43
Ocean phosphorous addition	0.83
Albedo increase: Grassland	0.64
Bio-char production	0.52
Carbonate addition to oceans	0.46
Albedo increase: Cropland	0.44
Ocean nitrogen fertilization	0.38
Iron fertilization	0.29
Afforestation	0.27
Albedo increase: Human settlement	0.19
Enhance upwelling	0.028
Albedo increase: Cloud, biological	0.016
Enhance downwelling	0.016
Albedo increase: Urban areas	0.01



1. **Stratospheric aerosols** Inject enough sulfur dioxide into the stratosphere to reflect the small percentage of sunlight necessary to offset increased warming caused by carbon dioxide. This scheme is akin to the cooling induced by large volcanic explosions.
2. **Albedo increase: cloud, mechanical** Manufacture sea salt spray to change the way clouds form over the ocean to increase their reflectivity.
3. **Albedo increase: desert** Cover the earth's non-sandy deserts with a material composed of a white polyethylene top and an aluminum bottom. That would increase the albedo of those surfaces, cooling the earth.
4. **Air capture and storage** Use chemical processes to pull carbon dioxide out of the air and sequester it in geological reservoirs.
5. **Ocean phosphorous addition** Add phosphorous intentionally to the oceans, fertilizing the water, and creating more carbon-munching life there. Eventually, those creatures or the creatures that eat them die and drift into the deep ocean, taking that carbon with them.
6. **Albedo increase: grassland** Breed or genetically engineer shinier plants to increase the reflectivity of the world's savannahs and shrublands.
7. **Bio-char production** Create charcoal from biomass, effectively sequestering the carbon in the plant matter, and bury it.
8. **Carbonate addition to oceans** Add carbonate to the oceans, increasing their carbon intake and fighting ocean acidification.
9. **Albedo increase: cropland** Breed or genetically engineer shinier crops to increase the reflectivity of the world's farmed land.
10. **Ocean nitrogen fertilization** Add nitrogen intentionally to the oceans, fertilizing the water, and creating more carbon-munching life there. Eventually, those creatures or the creatures that eat them die and drift into the deep ocean, taking that carbon with them.
11. **Iron fertilization** Add iron intentionally to the oceans, fertilizing the water, and creating more carbon-munching life there. Eventually, those creatures or the creatures that eat them die and drift into the deep ocean, taking that carbon with them.
12. **Afforestation/reforestation** Plant massive amounts of trees across the Earth and count on them to sequester more carbon dioxide naturally.
13. **Albedo increase: human settlement** Make the areas where humans live considerably more reflective by, say, painting roofs white.
14. **Enhance upwelling** Bring nutrient-rich water up from the deeps to foster carbon-using life at the surface of the ocean.

15. **Albedo increase: cloud, biological** Add dimethyl sulfide to a patch of ocean to create more microorganisms that act as formation sites for water droplets and eventually lead to clouds.
16. **Enhance downwelling** Cool down huge amounts of water with large pumps to form and thicken sea ice that would in turn cool the sea water. That water would descend to the depths, taking a bit of extra carbon with it.
17. **Albedo increase: urban areas** Make cities considerably more reflective by, say, painting roofs white.