Geo-engineering: Plan C for climate change?

In the beginning … Re-engineering the Earth's climate may now be a possibility. But no-one knows what man-made technical fixes might bring. ***Jon Herbert*** looks at massive ambitions.

Global geo-engineering could be the ultimate Plan B. It won't work for ever and carries huge risks. But it might also be our last practical option to maintain a habitable climate.

Restructuring the world artificially on a monumental scale could also pose the ultimate question. How do you ask the seven billion people affected directly by totally novel, untried solutions to vote yes or no for something that will almost certainly affect their daily lives every day for ever?

The reality is that tinkering with the world's weather will inevitably be extremely complex. It would represent a brave, or foolhardy, attempt to rebalance disturbed natural energy systems with man-made technologies on a planetary scale. The aim would be to create benign outcomes to largely man-made problems. Unfortunately, there are no precedents.

If put into practice, geo-engineering will be an ultra-ambitious science designed to fundamentally alter the way in which the planet's skies and seas work. It is the environmental equivalent of pulling the communication cord. Once pulled, it stays pulled! There may be no going back.

This is no fairy tale alternative to the hard fight to reduce carbon emissions. If adopted as a stand-alone strategy for climate control, geo-engineering could well be for life. Switch off some of the innovative props we might quickly learn to rely upon, and the Earth could heat up again very swiftly. Re-corking the genie might prove impossible.

Global warning

The challenging concept of managing the world's weather is in its pre-infancy. To date, almost all geo-engineering is theoretical or laboratory based. Even test projects are controversial. But it is being discussed seriously around the world. Trying untried technologies on a global scale could be man's best and final shot at mechanically holding back global warming and climate change. But it comes with further stern warnings on the tin.

On the upside, the costs might be attractively low. On the downside, in the wrong hands climate could potentially become a weapon of war. In fact, rather like the curate's egg, the world's weather could become good in some parts but less good elsewhere.

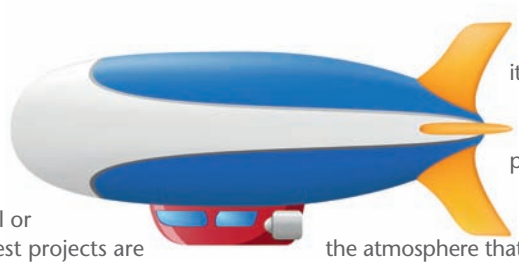
As a NASA scientist, James Lovelock suggested in the 1960s through his "Gaia" hypothesis that the biosphere evolves and adapts to create an environment that perpetuates its own survival.

However, there are limits and we are testing them to the extreme. Earth has been getting hotter since the planet first formed. Life has held that heating in check. Eventually, it will fail. Until then, biology has managed to maintain a Goldilocks climate — neither too hot nor too cold.

If man-made global warming forces up the temperature at a faster rate than the natural world can cope with, could humans re-engineer the planet strategically? And under Lovelock's definition, would that make us an integral part of the biosphere acting to ensure a viable environment for ourselves?

Deflecting solar radiation or containing carbon

Although there are numerous inventive ideas, geo-engineering intervention ideas fall into two broad categories. One would deflect away the sun's radiation before it can heat the Earth's surface. The other would prevent or remove greenhouse gas accumulations in the atmosphere that prevent surface heat escaping into space — the infamous greenhouse effect.



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Fantastic technologies they may appear to be. However, one solution taken very seriously is the creation of a protective layer of sulphate dust particles high in the upper atmosphere acting as tiny mirrors that reflect away solar radiation. Erupting volcanoes achieve this cooling effect naturally.

Another is to "whiten" existing clouds, or generate new clouds. Hoisting small sea water droplets into the atmosphere would increase cloud surface area and reflectivity to solar radiation. As polar ice-cap melting increases, the "cool roof" approach could see millions of building roof tops painted white to compensate and throw solar energy back into space.

A more controversial concept is to seed the seas with bulk iron filings. The aim would be to create conditions encouraging large plankton blooms that absorb dissolved atmospheric carbon dioxide. The downside is acidification that kills off marine life.

Thinking well outside the box has even led to the idea of creating thousands of vertical tubes made from old car tyres reaching down into the ocean. The theory is that wave action would then drive hot surface water down to lower depths.

The only limit seems to be human imagination. But would any of these schemes work? For many, the answer is that if politicians cannot limit global temperature rises in the century ahead — and progress so far has been pitiful — geo-engineering may be the essential Plan B.

Cunning plan

Actually, it would be Plan C. Mitigation and adaption to global warming would still be Plan A and Plan B. But here international co-operation is a problem.

Nations, business, industry, political leaders, statesmen and the world at large have failed to agree tough measures to hold back global warming — mitigation — in the last 20 years. Adaption is the idea of accepting inevitable change and learning to live with the new reality. Marks out of 10 are pretty dismal here, too.

Could geo-engineering be any better? Many think it is an outrageous idea that can never be put into effect, even if the theory is correct. But to others, geo-intervention is becoming a realistic possibility that cannot be ignored. And a few powerful people may be in a position to try to make it work.

Not only the UK Parliament but also the White House, US Congress and the United Nations are beginning to take its implementation seriously, as are many influential think-tanks and university research teams on either side of the Atlantic.

Moral hazard — cheapness

Cost is a potentially persuasive factor. According to recent calculations, geo-engineering is likely to be much cheaper than programmes to cut carbon emissions, or building the infrastructure needed to live sustainably on a planet of floods and droughts, rising sea levels, regular super-storms, greater heat and cold and, above all, much more uncertainty. This introduces the moral hazard argument that, despite the gravity of the problem, it is in mankind's nature to grab at any quick fix, particularly during an economic crisis. Geo-engineering must be a supplement. It is not a radical alternative to curbing greenhouse gases.

Low-cost is not the easy way out for one other crucial reason. Every action has an equal and opposite reaction, often affecting somebody else far away. "The massive complexities associated with geo-engineering and the potential for winners and losers means that some form of global governance is essential," explains Jim Haywood of the Met Office Hadley Centre in Exeter.

A regulatory framework may be needed to ban full-scale projects until their extended impact is understood comprehensively.

Met Office researchers modelled volcanic eruptions in both the northern and southern hemispheres. The results indicate that bulk sulphate injection to the north could cause severe droughts in many west African and Sahel countries as far east as Sudan. The same experiment in the south brought rains to the Sahel but drought to northeast Brazil.

The lesson is that you may be able to achieve better weather where you live but almost inevitably and unpredictably someone else will suffer unintended consequences. This accident waiting to happen raises global issues of accountability and world approval.

Weather warfare

More worrying is the prospect of climate hijacked by states, or well-intentioned, desperate or evil individuals. Cyber-war aside, could a third global conflict be fought with the weather?

There are increasing calls for some form of robust global veto, even though it might be hard to understand what exactly we are all voting for! With that hurdle overcome, the next challenge would be to turn geo-engineering into an applied technology, even though the world weather's sheer complexity still defeats the most powerful computers.

New questions then arise. How would implementation be organised? Would rich industrial nations with solutions to their own local climatic problems yield to economically

weaker nations? Given Earth's poor record in avoiding wars and military adventures, the prospects for good governance may not be too encouraging.

Spears into ploughshares

Nevertheless, being optimistic, geo-engineering might offer technologies that could become commonplace in the centuries to come. How would these work?

Volcanoes put a natural ceiling of sulphate particles over our heads with trillions of fine particles that reflect solar radiation back into space. Can we not do likewise? One plan considered in the US is to lift between one million and five million tonnes of sulphur dioxide (SO_2) to heights of 100,000 feet every year. The resulting sulphate particles, it is calculated, could create a cooling effect of 1–2°C. However, the impact has not yet been assessed.

One alternative suggestion would be to develop massive helium airships that might be able to do the job for $10 billion annually. Another solution may be for a fleet of 14 Boeing 747s working around the clock near the equator to complete the task for an estimated $8 billion.

There is one enormous drawback. What goes up has to come down. Sulphate particles would settle back to Earth within a couple of years. Once started, the process would have to be kept going ad infinitum, or at least until all fossil fuels have finally been burnt and their carbon captured and sequestrated. Otherwise, the ensuing rise in world temperatures, if underlying CO_2 levels were allowed to rise unchecked, would be swift and catastrophic.

Clouds got in my way

Cloud whitening is a real prospect. Playing with clouds is a tempting technology. High-level cold cirrus clouds tend to let sunlight in but block the exit of infra-red radiation created when sunlight heats the Earth's surface. Therefore, thinning or removing cirrus clouds could allow more heat to escape.

Alternatively, low warm cloud above approximately one third of the world's oceans tends to reflect sunlight back into space. Injecting them with sea water means that salt nuclei encourage more and smaller droplet formation. This "whitening" effect increases their reflectivity to the extent that it is calculated that global warming could be offset by some 3 watts/m^2. It has been estimated that this might stall temperature rises until atmospheric CO_2 levels reach double their present level. But again, once begun the strategy would have to continue.

The other unknown is the disruption that could be caused to world weather and storm patterns, marine eco-systems and plant and animal life. Prime target areas might be the coast off California and Peru. But coastal rainfall could be affected badly.

One practical proposal is to spray sea water droplets of circa one micron in size into the atmosphere from a fleet of some 1500 unmanned "rotor-ships", known as Fletter vessels, at a rate of 50m^3 per vessel per second over much of the world's oceans, according to Royal Society calculations.

Must go down to the seas again

One possibility considered recently by German researchers might be to employ 100 large ships to spread one billion tonnes of alkaline silicate dust obtained from the mineral olivine around the world's oceans to reverse acidification and allow the seas to hold more CO_2.

The downside is that this would also require a dedicated mining industry equivalent in size to the world coal sector. Marine biology would be affected significantly. It is estimated that sprinkling three billion tonnes of olivine, which is found commonly around the globe, would remove some 10% of man-made carbon emissions. But how much carbon-producing energy would be needed to mine and grind olivine down to the one micron size needed to prevent it sinking before it can dissolve?

Temptation

Coalitions of the willing may be essential. However, given the serious pros and cons — and for many people the unknown and unpalatable — reaching a workable consensus may be decades away, if it can ever be achieved.

Individual nation states may be able to approach the problem differently. China has listed geo-engineering amongst its earth-science research priorities. The Chinese air force has already shown that it is capable of artificially clearing cloudy skies above polluted Beijing to guarantee peerless blue on major national ceremonial days.

Happy endings

The obvious danger geo-engineering poses is the law of unintended consequences. Yet the greater threat may be to do nothing. Perhaps we should be optimistic. Everything may work out splendidly. If so, the long-range forecast for the 22nd century could be perfect weather wherever you live … and whenever you want it. But it might still be wise to carry an umbrella. ■

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