A Review of The Royal Society report on Geoengineering

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If your knowledge of the Royal Society report (2009) on Geo-engineering is based only on media comment, you might be forgiven for thinking that Global Warming could readily be addressed by engineered solutions. Maybe we do not have to give up our long-haul holidays after all!

That is not the message that I took away, though I admit to surprise that initial cost estimates for some of these proposed projects were rather smaller than I might have guessed. The media headlines were based on predictions that some geo-engineered solutions might have less economic impact than foregoing the use of the carbon.

If you read the report, you will find that it is not quite that simple. The only certain way to return the climate to a safe state is the removal of the greenhouse gasses that are driving change – and to do it fairly promptly. Once we reach a "tipping point", even the removal of CO_2 may not save us. The Earth's long term climate appears to be more stable in its "greenhouse" rather than its "ice-house" mode. When the polar ice starts to go, less of the Sun's heat is reflected back to space and more is absorbed. Other positive feedback mechanisms also come into play in the short-term, and it would then take a fair reduction below current carbon dioxide levels to restore current temperatures any time soon. This consideration is one of the motivations for the Royal Society report: it is looking increasingly unlikely that there will be any agreement to cut CO_2 emissions sufficiently far and sufficiently quickly to avoid the tipping point. We may need to follow a much riskier path if we wish to avoid catastrophic climate change – perhaps as an option of last resort.

The geo-engineering options all carry a good deal of risk. The cost estimates are subject to considerable uncertainties. Novel and large scale engineering projects frequently exceed initial cost estimates by substantial factors. (One reason is that the people promoting such ventures are rarely taking the financial risks.) I suspect, however, that this is the least of the problems. Most importantly, geo-engineering may not work. We have never tried experiments on this scale before (apart from dumping geologically significant amounts of carbon in the atmosphere and oceans). It may have unexpected side-effects, and the people taking most of the risks may not be those seeing the benefits. How will we decide who will get the short-end of the stick? How will we allocate the costs? Who will be responsible if things go badly wrong? Who will have their hands on the levers controlling the climate? I suspect the politics will be far more difficult than the engineering.

Having entered these caveats, all the options appear technically feasible, at least in principle, and all involve interesting science. There are two fundamentally different approaches: those that aim to get the CO_2 *out* of the atmosphere, and back *into* the ground, and those that attempt to compensate for the enhanced retention of heat in the atmosphere by diverting some of the incoming solar radiation. CO_2 removal is clearly more desirable, since we already have some understanding of the way the climate behaves with lower levels of carbon dioxide, and the politics will be easier to sell. The trouble is the thermodynamics: extracting a low-concentration gas from the air will always be harder than putting it there in the first place. One way or another you will pay a substantial cost. Even growing trees – highly desirable from many points of view – involves the use of land that is also needed to provide food for a World population that is still

rapidly growing. Industrial process, based in desserts, powered by solar energy, and pumping CO_2 back into old oil wells may avoid most of the land-use difficulties – but they will still cost a very great deal of money. They also take a good deal of time to give a significant effect – and we may not have that time.

It was, of course, the "active" geo-engineering proposals that attracted all the media attention: putting sun-shades in space, seeding the air with sulphur, or creating clouds by spraying sea water high into the troposphere from fleets of robot planes and ships. Some of these options come with a surprising reasonable price. £9 billion is actually within the limits of affordability of a very rich individual. Unfortunately, these options also come with the highest uncertainties (the cost estimates are almost certainly highly optimistic) and the biggest political and safety difficulties. Neither do they deal with the direct effects of CO_2, for example, the acidification of the oceans, which is itself a very serious issue. (See the Royal Society report on *Ocean Acidification Due to Increasing Atmospheric Carbon Dioxide*. 2005).

Some people have argued that we should not even be talking about the possibility of engineering our way out of Global Warming, just in case it diverts attention from the need to reduce carbon dioxide emissions. Paradoxically, however, the visible activity of a large-scale engineering geo-engineering project, constantly in front of the World's attention, may do more to convince people of the real need to reduce fossil fuel consumption than any amount of exhortation. Most people find it easy to see that stopping CO_2 going into the air must be easier and cheaper than getting it out again.

In summary, there are no easy decisions: the most affordable options are either unsafe or ineffective, while the safe and effective options are much more expensive. Perhaps long-haul holidays *will* sooner or later become as socially unacceptable.