Delivering solar geoengineering materials may be feasible and affordable

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A cost analysis of the technologies needed to transport materials into the stratosphere to reduce the amount of sunlight hitting Earth and therefore reduce the effects of global climate change has shown that they are both feasible and affordable.

Published today in *Environmental Research Letters*, the study has shown that the basic technology currently exists and could be assembled and implemented in a number of different forms for less than USD $5 billion a year.

Put into context, the cost of reducing carbon dioxide emissions is currently estimated to be between 0.2 and 2.5 per cent of GDP in the year 2030, which is equivalent to roughly USD $200 to $2000 billion.

Solar radiation management (SRM) looks to induce the effects similar to those observed after volcanic eruptions; however, the authors state that it is not a preferred strategy and that such a claim could only be made after the thorough investigation of the implications, risks and costs associated with these issues.

The authors caution that reducing incident sunlight does nothing at all to reduce greenhouse gas concentrations in the atmosphere, nor the resulting increase in the acid content of the oceans.

They note that other research has shown that the effects of solar radiation management are not uniform, and would cause different

temperature and precipitation changes in different countries.

Co-author of the study, Professor Jay Apt, said: "As economists are beginning to explore the role of several types of geoengineering, it is important that a cost analysis of SRM is carried out. The basic feasibility of SRM with current technology is still being disputed and some political scientists and policy makers are concerned about unilateral action."

In the study, the researchers, from Aurora Flight Sciences, Harvard University and Carnegie Mellon University, performed an engineering cost analysis on six systems capable of delivering 1 million metric tonnes of material to altitudes of 18 km: existing aircraft, a new airplane designed to perform at altitudes up to 30 km, a new hybrid airship, rockets, guns and suspended pipes carrying gas or slurry to inject the particles into the atmosphere.

Based on existing research into solar radiation management, the researchers performed their cost analyses for systems that could deliver around one million tonnes of aerosols each year at an altitude between 18 and 25 km and between a latitude range of 30°N and 30°S.

The study concluded that using aircraft is easily within the current capabilities of aerospace engineering, manufacturing and operations. The development of new, specialized aircraft appeared to be the cheapest option, with costs of around $1 to $2 billion a year; existing aircraft would be more expensive as they are not optimised for high altitudes and would need considerable and expensive modifications to do so.

Guns and rockets appeared to be capable of delivering materials at high altitudes but the costs associated with these are much higher than those of airplanes and airships due to their lack of reusability.

Although completely theoretical at this point in time, a large gas pipe, rising to 20 km in the sky and suspended by helium-filled floating platforms, would offer the lowest recurring cost-per-kilogram of particles delivered but the costs of research into the materials required, the development of the pipe and the testing to ensure safety, would be high; the whole system carries a large uncertainty.

Professor Apt continued: "We hope our study will help other scientists looking at more novel methods for dispersing particles and help them to explore methods with increased efficiency and reduced environmental risk."

The researchers make it clear that they have not sought to address the science of aerosols in the stratosphere, nor issues of risk, effectiveness or governance that will add to the costs of solar radiation management geoengineering.

More information: The published version of the paper 'Cost analysis of stratospheric albedo modification delivery systems' (Justin McClellan, David W Keith and Jay Apt 2012 *Environ. Res. Lett.* 7 034019: iopscience.iop.org/1748-9326/7/3/034019/article

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