



Geo-engineering

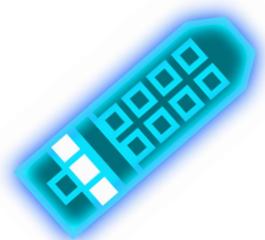
Science background: Cloud Control

What's the issue?

Can we use engineering to cool the planet instead of changing our behaviour?

Global temperatures are climbing, and the weather's gone weird. Time is running out to reverse climate change by altering our lifestyles.

Geo-engineering offers a different way to fight global warming. By using new technologies, we may be able to manipulate the climate on a huge scale and cool the Earth. But how much money should we spend on these untested solutions? And are they so risky that we'd be better off learning to adapt to a hotter planet?



Key terms

Weather describes conditions such as temperature, rainfall and cloud cover at a particular moment, or over a few days, in a specific place.

Climate is the average of weather patterns over many years.

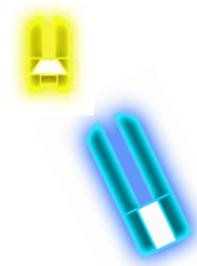
Geo-engineering is the large-scale use of technologies designed to manipulate the climate, either by reducing the amount of heat we receive from the Sun, or removing carbon dioxide (CO₂) from the air to reduce the greenhouse effect.

Greenhouse gases trap heat in the atmosphere. Some are naturally occurring and others man-made, but the levels of greenhouse gases such as CO₂ have increased through human activity, causing warming.

Cloud brightening is a developing type of geo-engineering that may one day help slow climate change and tackle global warming. Scientists aim to add salt particles to sea clouds, for example via remote-controlled boats. The salt particles would make more droplets of water form in the clouds, so that they appear whiter and brighter. These whiter clouds would reflect back more light and heat from the Sun, **which should help cool the Earth.**



Brighten clouds over the ocean to keep the Earth's temperature from rising.



What's all the fuss about?

The climate is a complicated system. We really don't know what the impacts of cloud brightening would be, either locally or globally.

Brightening clouds over the ocean may work well to control the Earth's temperature (and buy us some time), but it won't fix the problem of ever-increasing amounts of greenhouse gases being pumped into the air. Will we be lulled into a false sense of security if the urgency of climate change is delayed?

Geo-engineering technologies might take the spotlight away from the need to stop burning of fossil fuels. Should we be *trying* to alter our climate so that we can continue adding greenhouse gases into the atmosphere?

Cloud brightening has never actually been tested on a large scale, so we may find ourselves relying on risky technology without really understanding the serious side effects it could have. What if the unintended consequences of geo-engineering are as bad as climate change?

But we certainly have to do something about climate change. Up to 250 million people across Africa could face water shortages by 2020. If temperatures rise by between 1.5 and 2.5 °C, 20–30% of all plant and animal species will be at increased risk of extinction. Crop yields could decrease by up to 30% in central and south Asia. Glaciers and snow cover are expected to decline, reducing water availability in countries supplied by meltwater.¹

Should money be spent on developing geo-engineering technologies rather than finding a permanent solution to the planet's problems?

Key facts

- Atmospheric carbon dioxide concentration was 280 parts per million (ppm), 0.028%, before the Industrial Revolution; in 1958 it was 320 ppm. In 2010 it was around 390 ppm and still rising.²
- Over half of the greenhouse gas emission caused by human activity is CO₂ from the burning of fossil fuels. The rest is mostly methane (e.g. from livestock farming), and CO₂ from cement production, deforestation and decay of biomass.³
- Indeed, since 2005 burning fossil fuels has released 26 billion tonnes of CO₂ into the atmosphere every year. That's over 100 times more than the CO₂ released by all the volcanoes on the planet.⁴
- The Earth's temperature has gone up 0.7 °C in the last century, and could rise by between 2 and 6 °C by the end of this century, even if we reduce our greenhouse gas emissions. That may not sound like a lot, but if you've ever fallen through melting ice on a pond, you'll know what difference a few degrees can make!³



The Earth as seen from a weather satellite. Brightening clouds over the oceans would make the planet whiter overall, which should reflect more sunlight and lower the Earth's average temperature.

What are the different types of geo-engineering?

Carbon capture involves removing carbon dioxide from the air.

For example:

- Planting more trees to absorb CO₂
- Fertilising the sea to promote algal growth to absorb CO₂
- Removing CO₂ directly from the air using chemicals

Solar radiation management (SRM) is designed to reduce the amount of heat we receive from the Sun. Using SRM technology would mean the Earth should remain cooler, even though CO₂ levels rise.

For example:

- Painting cities white to reflect sunlight
- Putting mirrors in deserts or in space
- Brightening clouds to reflect more of the Sun's energy

Do we only need to add salt to the clouds once to brighten clouds?

To keep the clouds bright the salt would need to be continually added. The effect of adding salt to brighten the clouds should be seen quickly, but it would disappear in about ten days if we stop adding salt.

Has cloud brightening been tested?

Not yet. But we know how it works because cloud brightening already occurs in the exhaust fumes from ships, which create tracks in the clouds that are brighter than surrounding clouds. This is because particles in the fumes are the right size for water droplets to form around them. Salt particles could be used for intentionally brightening clouds because they are the right size and relatively harmless.

How effective will cloud brightening be?

No-one can tell until there are trials exploring the local and global effects. Research suggests it may be able to hold off the heating effects of climate change for about 50 years. After that we would still have to combat greenhouse gases.

What effects could it have on the rest of the world?

Unfortunately, we don't know yet. However, salt spray is already found in marine clouds, so cloud brightening can sometimes happen naturally. The technology doesn't involve adding any other chemicals to these clouds. The increase of water droplets held in the air may decrease rainfall in some areas, or increase it in other areas, when these clouds reach land. Cooling the sea more than the land could also lead to stronger winds in places.



Ships like this concept Flettner vessel could spray sea-water mist into the air to brighten clouds. Thousands of these remote-controlled ships would be deployed to brighten the clouds over large portions of the Earth's oceans.

Can we predict any major downsides?

The 'termination problem' is what will happen at the end of an SRM programme such as cloud brightening. If nothing is done about the amount of CO₂ in the air when an SRM programme ends then the Earth will heat up rapidly and potentially catastrophically.

How is this different from weather modification?

Cloud brightening is not designed to make it rain, or stop it from raining, in a specific place. Ideally there would be no change in weather patterns, just brighter clouds that reflect more sunlight away from the Earth's surface. However, until there are large-scale trials it will be hard to say what changes might happen to weather patterns.

You could discuss...

- Is combating climate change up to you and me, or the responsibility of governments and scientists?
- Why do you (or don't you) care if the climate changes?
- What animal or plant species are you prepared to lose?
- Is engineering the climate better than changing our habits or using different energy supplies?
- How much money should we spend on testing geo-engineering technologies?
- Who should decide what the global temperature should be?
- Do you think there will be any positive impacts of a changing climate?

Links to the Science Museum

The *Atmosphere* gallery explores the science of our changing climate. The ice core reveals how we know what the climate was like hundreds of years ago.

www.sciencemuseum.org.uk/ClimateChanging/AtmosphereGallery.aspx

Find out where we currently get our energy from in *Energy – fuelling the future*, and explore what our energy future might look like.

www.sciencemuseum.org.uk/visitmuseum/galleries/energy_fuelling_the_future.aspx

We also have a selection of climate science resources, including everything you need to run a collapsed timetable day for KS3 and KS4.

www.sciencemuseum.org.uk/educators/classroom_and_homework_resources/ks4/climate_science.aspx

The *Antenna* website is a dynamic collection of science news and opinions.

<http://antenna.sciencemuseum.org.uk>

Further information

The Royal Society's comprehensive review of geo-engineering possibilities:

<http://royalsociety.org/policy/publications/2009/geoengineering-climate>

A collection of *Guardian* articles on geo-engineering, including images of cloud-brightening ships:

www.guardian.co.uk/environment/geoengineering

The UK government's page on the history of climate change and its policies:

www.direct.gov.uk/en/Environmentandgreenerliving/Thewiderenvironment/Climatechange/DG_072901

The National Environment Research Council's report on geo-engineering:

www.nerc.ac.uk/about/consult/geoengineering.asp

Sources

- 1 Richard Black, 'Humans blamed for climate change', BBC News (2 February 2007), <http://news.bbc.co.uk/1/hi/6321351.stm>
- 2 'Trends in atmospheric carbon dioxide', National Oceanic and Atmospheric Administration, www.esrl.noaa.gov/gmd/ccgg/trends
- 3 'Global greenhouse gas data', US Environmental Protection Agency, www.epa.gov/climatechange/emissions/globalghg.html
- 4 Holly Riebeek, 'Global Warming', NASA Earth Observatory (2010), <http://earthobservatory.nasa.gov/Features/GlobalWarming/printall.php>



Contemporary science discussion for the classroom
sciencemuseum.org.uk/educators

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