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POLAR GEOENGINEERING: A RISKY EXPERIMENT THAT WILL NOT FIX CLIMATE CHANGE

Helen Millman [1*], ***Sammie Buzzard*** [2], ***Sian F. Henley*** [3], ***Heïdi Sevestre*** [4] ***and Martin Siegert*** [5]

[1] *Geography Department, University of Exeter, Exeter, United Kingdom*
[2] *Geography and Environmental Sciences, Northumbria University, Newcastle upon Tyne, United Kingdom*
[3] *School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom*
[4] *Arctic Monitoring and Assessment Programme Secretariat, Tromsø, Norway*
[5] *University of Exeter, Penryn Campus, Penryn, United Kingdom*

YOUNG REVIEWERS:

MOMO

AGE: 13

Earth's climate is warming because we burn fossil fuels for electricity, transport, heating, and food production, and this releases greenhouse gases. The polar regions (the Arctic and Antarctic) are warming faster than anywhere else, and ice melting there will affect the whole planet. To stop the melting, we must reduce fossil fuel use. However, some people believe reducing fossil fuel use is too difficult or expensive and suggest developing technologies to control the climate. These ideas are called geoengineering. But geoengineering is risky, expensive, slow to develop, and may not work. It also requires global cooperation and could harm fragile polar ecosystems. The best solution is to cut greenhouse gas emissions. We already have the technology to do so, it is proven to work, and it will benefit everyone,

including the polar regions, if we act now. Cutting emissions is the safest and most effective way to protect our planet.

"TREATING" A SICK PLANET

Have you ever been to the hospital for a bad cut or broken bone? The doctor might give you medicine to stop the pain, but that only treats the symptom. To really help you heal, the doctor must treat the cause, by stitching the cut or putting a cast on the broken bone.

Right now, climate change is making our planet sick. So, what should we do? Should we only ease the symptoms? Or should we treat the real cause of the problem by cutting greenhouse gas emissions? This article explores the idea of only treating the symptoms of climate change using a method called **geoengineering**—and why this approach might be risky or even dangerous for the planet and its inhabitants.

GEOENGINEERING

Using machines to try to reduce the consequences of climate change.

WARMING IS WORSE AT THE POLES

Earth's climate is warming because we burn fossil fuels, which release greenhouse gases like carbon dioxide. The Arctic (north pole) and Antarctic (south pole) are warming faster than the rest of the world. This process is known as **polar amplification** (to learn more about polar amplification, you can read this Frontiers for Young Minds article). Polar amplification is dangerous because, even though the poles might feel far away, what happens there affects the whole Earth.

POLAR AMPLIFICATION

Snow and ice reflect the sun's rays, but when they melt, dark land or ocean absorbs heat. This process means the poles warm up faster than other parts of the world.

As the poles warm, the ice that covers them is melting. Melting ice raises sea levels, which threaten coastal areas where millions of people live. Melting ice adds cold, freshwater to the salty ocean, which can also change the way ocean currents work. Polar ice is important for keeping the planet cool, for keeping sea levels stable, and for providing a home for unique wildlife such as penguins in the Antarctic and polar bears in the Arctic. Polar ice is also important for the people who live in the Arctic and need the ice to travel and hunt for food. The warming at the poles is so serious that some people are thinking about using geoengineering in these regions.

WHAT IS GEOENGINEERING?

Geoengineering means using technological methods across large areas of Earth, to try to control the climate. Some of these technologies can help fight climate change by removing carbon dioxide from the air, but other geoengineering ideas involve huge changes to parts of Earth's natural systems. While some of the geoengineering ideas we describe below might sound clever, most are

unproven, expensive, hard to build, and could cause more problems than they solve, especially in fragile places like the poles.

The following sections describe some of the geoengineering ideas people are talking about.

"Sunscreen" for the Earth

One way that people think they could stop climate change is by stopping some sunlight from reaching the Earth. They think this could be done by spraying tiny particles high into the atmosphere to block sunlight, like a giant sunscreen for the planet (Figure 1A) [1]. This could reduce global warming in some places for a short time, but once the particles wear off, the Earth could heat up even faster than before. The particles could cause global weather patterns to change, which might help some countries, but could also cause big problems in others, like making droughts and other extreme weather worse (Figure 1B). In other words, this method of geoengineering will not be fair for everyone. Also, this idea involves deliberately adding pollution to the atmosphere, which would form acidic rain and increase acidity in our oceans, altering fragile marine ecosystems.

Growing More Ocean Algae

Tiny algae in the ocean called phytoplankton make most of the food for marine animals and take carbon dioxide out of the atmosphere like plants do, through the process of photosynthesis. To grow, phytoplankton need iron, which is found naturally in small amounts in the oceans. Some people think that if we add more iron into the ocean, phytoplankton could grow better and thus take up more of our carbon dioxide [2]. This method is called ocean fertilization, and it would involve dumping lots of iron from ships into the ocean around Antarctica (Figure 1A). The main problem with this idea is that the algae cannot store the carbon long enough to help fight climate change. Another problem is that adding iron to the Southern Ocean could harm marine life all over the world, even as far away as tropical islands (Figure 1B)!

Hoovering Up Meltwater

One of the most bizarre ideas is to drill lots of holes through the Greenland and Antarctic **ice sheets** and use giant pumps to suck up meltwater from underneath the ice sheets and spray it back onto the top of the ice, so it can refreeze (Figure 2A) [3]. People think that this would make the ice sheets bigger and less slippery, so that the ice might stop sliding into the sea and raising sea levels. However, ice sheets are thousands of meters thick, and it takes a lot of effort to drill all the way through them. The ice is always moving, and the holes would close after a few days or weeks. This method would cost a fortune, need massive amounts of energy (causing more greenhouse gas emissions), and will most likely not stop the ice from melting.

ICE SHEET

A country-sized pile of ice made by snow that has built up and compressed over millions of years. Greenland and Antarctica have ice sheets, and sea level rises when they melt.

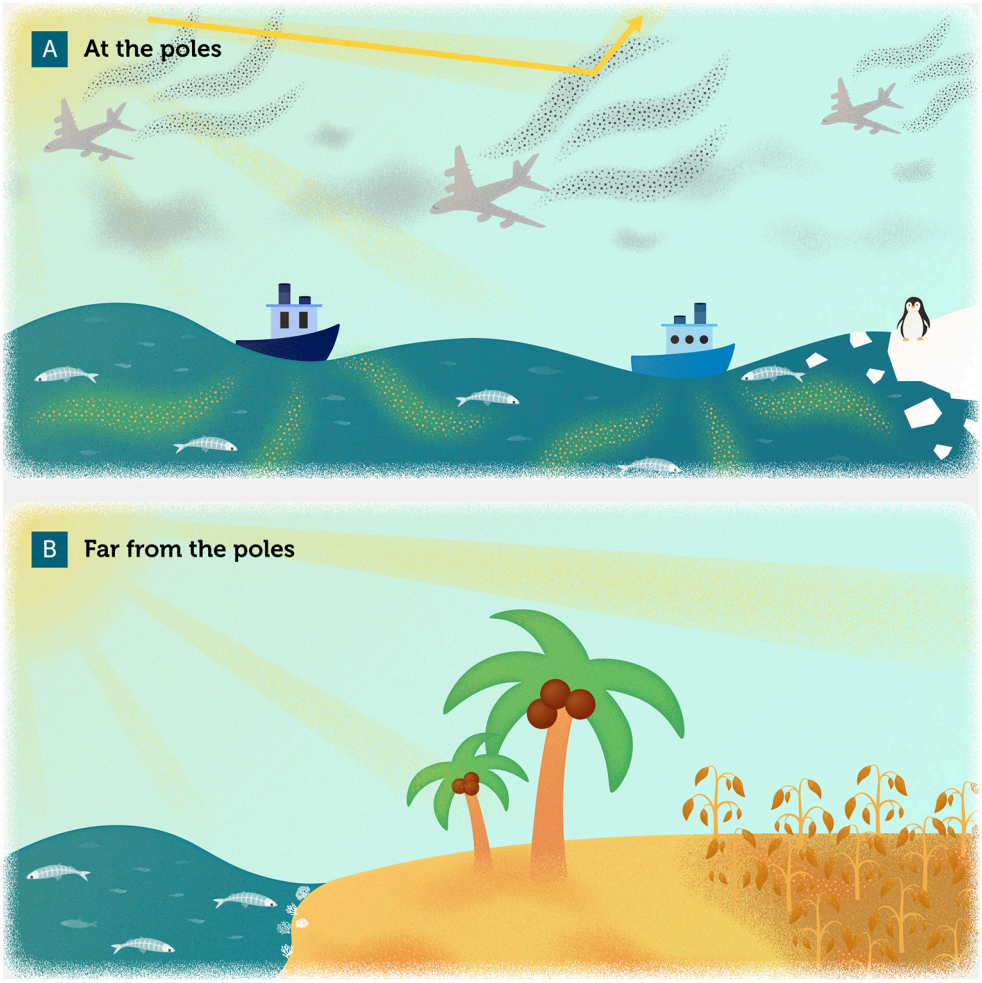

Figure 1

Figure 1

(A) In one type of geoengineering, airplanes would spray particles into the atmosphere. Particles would reflect the sun's rays to create "sunscreen" for the Earth. In another type, large amounts of iron (yellow-brown particles) would be dumped into the ocean to help grow more algae (green clouds around yellowish particles). The idea is that the algae would take up carbon dioxide from the ocean. **(B)** Both methods would be dangerous for wildlife all over the world. Global "sunscreen" could stop crops from growing in some regions, and iron dumped into the Antarctic Ocean could harm fish living on far-away tropical reefs.

Sea Curtains

Another geoengineering idea is to put up giant underwater sea curtains in the Antarctic Ocean and around Greenland [3]. These curtains would act like huge walls to stop warm water from reaching the ice sheet and melting it (Figure 2B). One of the big problems with this idea is that building and taking care of sea curtains across hundreds of miles in harsh polar environments would be incredibly difficult. The curtains would be so big that we do not even have ships large enough to carry the anchors needed to hold the curtains in place. Even if we did, Antarctica is one of the toughest places on Earth to work, and some areas where the curtains would need to go cannot even be reached by ships. On top of all this, the curtains could harm the ocean environment, cause problems for sea creatures, and probably will not even work to keep warm water from reaching the ice. It is a risky idea that would be very expensive and is not practical.

Re-growing Sea Ice

Sea ice is a layer of frozen seawater that floats on the surface of the ocean in the Arctic and Antarctic. Two geoengineering techniques

SEA ICE

In very cold places, the surface of the sea freezes. This ice floats on the top of the sea and is important for polar wildlife.

Figure 2

(A) Running pumps to suck water up from the bottom of an extremely thick ice sheet to prevent it from sliding would be difficult and need lots of energy. Ice is constantly flowing, so holes would need to be regularly redrilled. **(B)** Sea curtains would be impossible to maintain in the harsh polar regions. They could break and pollute the environment, and they would cause problems for wildlife. To hold them in place, the curtains would need anchors so big that we do not have ships big enough to transport them.

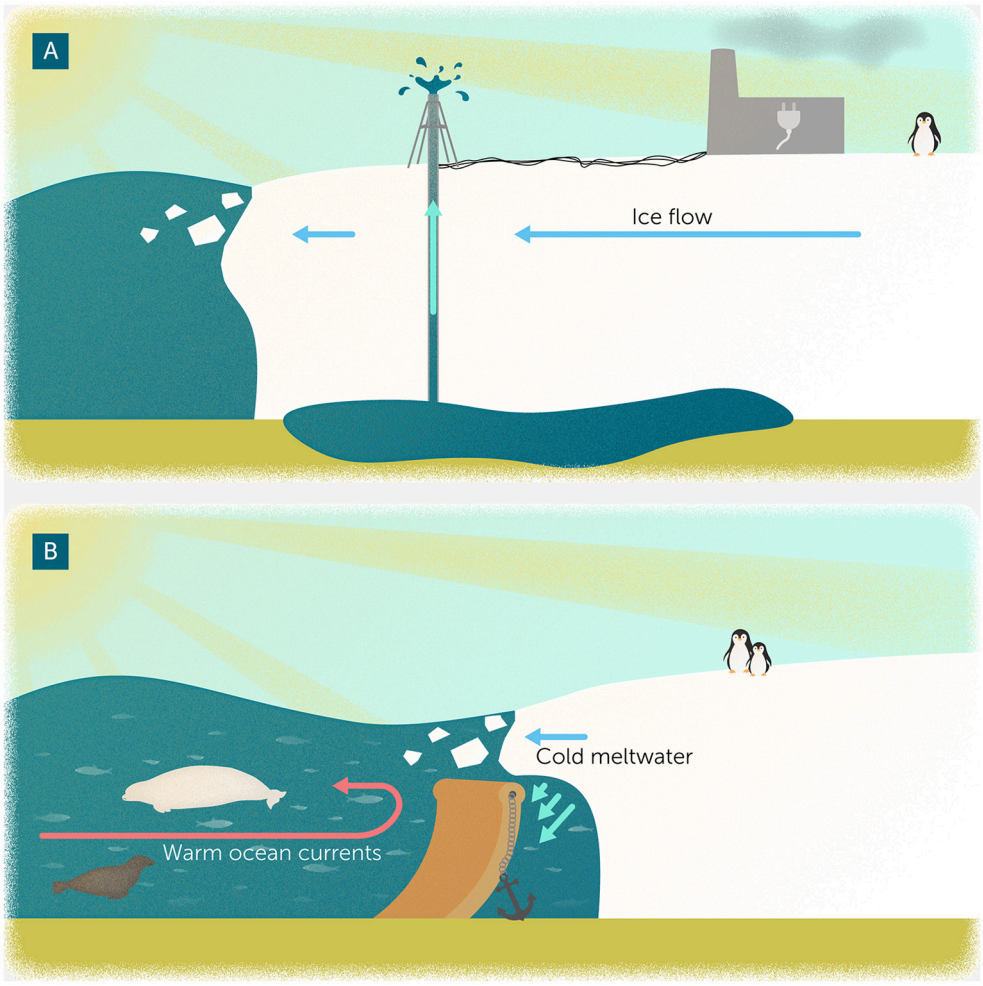

Figure 2

have been suggested to re-grow Arctic sea ice, which could help to keep the Earth cool. The first method involves spreading small glass beads on the sea ice to reflect sunlight (Figure 3A) [4]. However, these beads are toxic to wildlife and disrupt the food chain, causing more harm than good. One project that was planning to do this has already shut down because they realized that the beads are dangerous to animals.

The second method involves making the Arctic sea ice thicker by installing lots of pumps to spray water onto the top of the ice (Figure 3B) [5]. This is a bad idea because we would need over 1 million pumps to really make a difference, and it would take over 1,000 years to set them all up! This is far too late to help stop climate change, which needs to be done now. Even if the pumps *were* all set up, they would need to be looked after, and this would be very difficult and expensive. Sea ice is always moving, and the pumps could fall into the sea when the ice melts, causing even more damage to the environment.

Figure 3

Some geoengineering methods aim to regrow sea ice or stop it from melting. **(A)** One idea proposes using small glass beads to reflect sunlight and prevent the ice from melting. However, these beads are toxic to wildlife. **(B)** To regrow sea ice, we would need over a million pumps powered by wind turbines to pump up sea water and spray it onto the remaining ice. It would take over 1,000 years to set up all these pumps, which is too long to prevent the harmful effects of global warming.

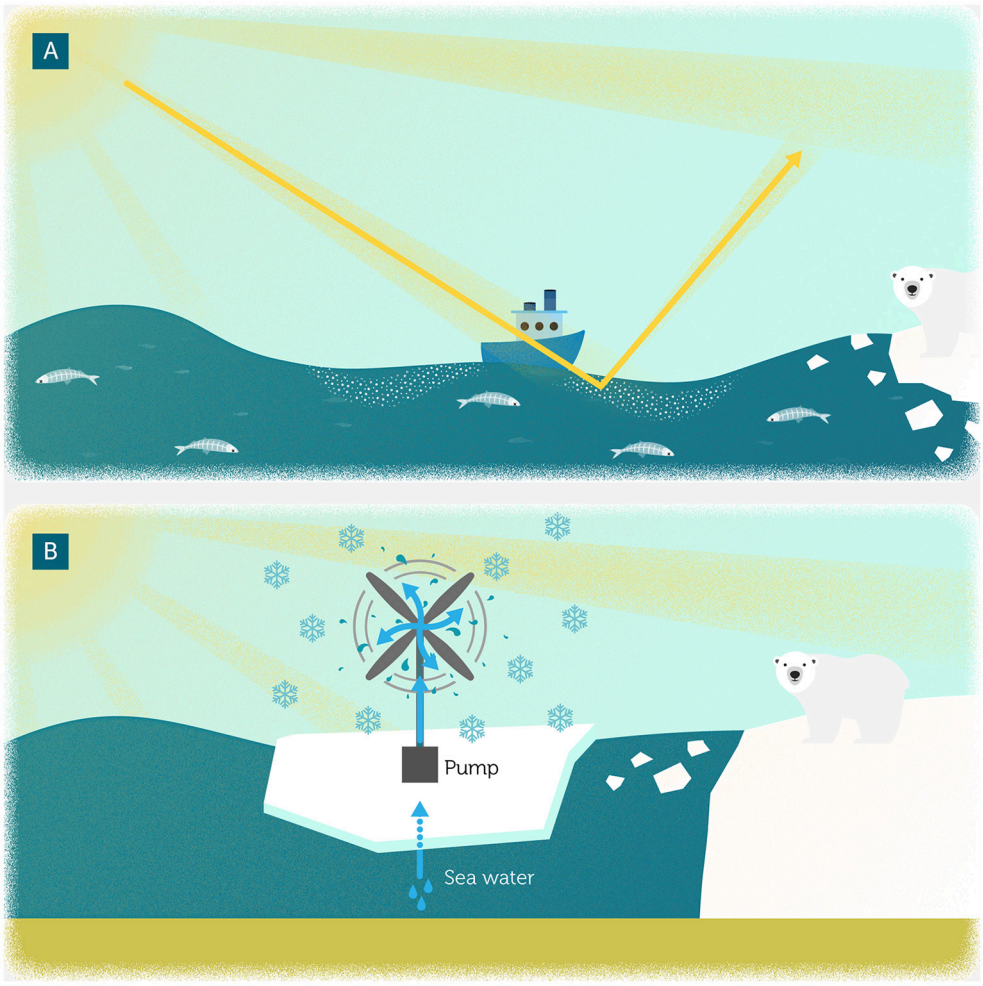

Figure 3

REDUCING FOSSIL FUELS IS THE BEST SOLUTION

Geoengineering ideas like these may sound exciting and futuristic, but they are expensive, risky, and very unlikely to solve the problem of climate change. What is worse, they could harm the fragile ecosystems in the polar regions and cause problems all over the world.

Some experts worry that geoengineering might lead people to think that we can fight climate change by treating only the symptoms. This might make governments, companies, or individuals less motivated to cut greenhouse gas emissions, which would be a huge mistake. The world needs rapid, deep reduction of greenhouse gas emissions—not distractions or delays. Trying to "play climate doctor" with risky, expensive polar geoengineering experiments might end up doing more harm than good.

The good news is that we already know what works: burning less fossil fuel. By switching to clean energy sources like wind, solar, and hydroelectric power, we can reduce greenhouse gas emissions and

stop global warming. This will help protect the polar regions and their inhabitants, the wildlife that depends on them, the rest of the planet, and all its people.

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YOUNG REVIEWERS

MOMO, AGE: 13
Momo loves to travel the world and see new places. Even so, she is a self-proclaimed couch potato when she is at home. The two extremes can coexist in one person! Her favorite couchmate is her fuzzy and affectionate dog, Lita.

AUTHORS

HELEN MILLMAN
I am a polar scientist with a special interest in ice sheets and how they cause sea-level rise as they melt. I use calculations done by supercomputers and pictures of the polar regions taken by satellites in space to study how the polar regions are changing as the climate gets warmer, and what that might mean for us. Sometimes I also get to go to Antarctica and the Arctic to collect information, like ice cores, that help us to better understand the changes that are happening there. *h.m.millman@exeter.ac.uk

SAMMIE BUZZARD

I am a polar scientist who uses maths to understand how the Arctic and Antarctic are changing. I look at how water moves on top of big floating ice shelves using computer simulations and information from satellites in space. My work helps people understand how sea levels could rise and how that might affect our planet.

SIAN F. HENLEY

I am an ocean scientist focusing on polar oceans in the Arctic and Antarctic. I use lots of different methods from ships and research stations to understand how the oceans are changing and what this means for ecosystems and the incredible biodiversity of these icy regions. I also like teaching in my university and in schools, museums, and science centers. Another important part of my job is to go to conferences of the United Nations and talk to politicians and other people to tell them how important the polar regions are for us all and why we must protect them.

HEÏDI SEVESTRE

I am a glaciologist (a scientist who studies glaciers) and climate advocate known for my dynamic science outreach in the field, media, and documentaries. I work with the Arctic Council's AMAP program secretariat and lead scientific expeditions to polar and high mountain regions.

MARTIN SIEGERT

I am a glaciologist and I specialize in measuring what is underneath the Antarctic ice sheet. Using methods that can peer through the ice, the work I am involved in has unveiled a hidden continent of mountains, valleys, lakes, and rivers—all beneath the 2–4 km thick ice.