Current Geoengineering proposals for the polar regions

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The recently-published IPCC “Special Report on the Ocean and Cryosphere in a Changing Climate” states that surface air temperatures in the polar regions are rising at a rate higher than the global average and that polar areas continue to lose sea ice and snow cover. In the face of fossil fuel use that is likely to burn through carbon budgets, geoengineers have put forward large-scale proposals with the stated aim of restoring polar-ice or to slow the melting processes through interventions in the polar regions. Some of the proposals, and the concerns that have been raised about them, are outlined below.

Reflective materials as surface-cover

An organisation called Ice911 has proposed covering Arctic ice with a layer of floating reflective material to reflect more sunlight and to slow the melting of Arctic ice. The non-profit was founded in 2007 by Leslie Fields and is based in Menlo Park, California. The proposed cover material is a reflective silica glass and consists mostly of silicon dioxide. The silica glass has the shape of tiny glass spheres. Since 2010, Ice911 has conducted outdoor trials at five different test sites[i]. Different materials were tested for their suitability and reflectivity on frozen lakes in the US and Canada.

The project’s largest test site is the Arctic North Meadow Lake near Utqiaġvik, in Alaska. The surface of the shallow lake is used to test various reflective materials as well as the efficiency of different application techniques. The outdoor trials on North Meadow Lake started during winter 2015/2016. In the following two years the testing area on the lake covered 15,000 to 17,500 m².

According to Ice911 these works were carried out in partnership with Indigenous, local, regional and global communities. However, some community members say they have little or no knowledge of the trials, while raising questions about the ecological impacts of the project activities. The effects on photosynthesis, on animals’ feeding patterns, changes to the hydrologic cycle and weather patterns, and other unintended effects in delicate arctic ecosystems are among the concerns that have been raised.

Since 2018, Ice911 has been looking for funding and governmental permissions to conduct large-scale testing with reflective materials on arctic ice. These tests form part of Leslie Field’s proposal to cover 15.000 km² to 100.000 km² with silica glass in selected arctic regions, e.g. in Fram Strait or Beaufort Gyre. In May 2019 she announced the first tests on sea ice within a period of one to three years.

Perhaps most importantly, the current knowledge of the silica glass’ behaviour in the environment and on plant and animal life is insufficient. The impacts in the target regions or on regional cycles or global weather patterns are difficult to determine.

Sea walls and artificial islands for the stabilisation of outlet glaciers

Increased
melting of glaciers and ice sheets may also be caused
by warm ocean currents. In 2018, John C. Moore,
Michael Wolovick, and others from the US-American Princeton
University and the Finish University of Lapland proposed
three different potential megaprojects that they hypothesize could
delay global sea-level rise by stabilizing three fast-moving
outlet glaciers: Pine Island glacier and Thwaites glacier in
western Antarctica and Jakobshavn glacier in Greenland. The
three glaciers spread from the continent to the ocean and float
on top of the ocean water. Warmer ocean currents at a water depth of
300 to 500 metres melt the glaciers from below. To
avoid that the glaciers lose more ice than they gain or at least to
slow down the melt, the team outlined three different approaches:

(1)
The construction of a 100-metre high wall on the seabed, in order to
block warm water from melting the floating bottom of the glaciers;

(2)
The construction of several hundred metres high artificial islands in
front of the glaciers to hold back the glaciers and limit the amount
of glacial ice reaching the ocean;

(3)
Slowing the sliding of the glaciers by drying subglacial streams with
the help of huge pumping station or by freezing water at the glacier
bases.

In
western Greenland, warmer ocean currents reach the Jakobshavn glacier
at a water depth of 300 metres. To block the warm currents,
Moore and Wolovick's team suggested
a 100-metre high wall on the seabed across the 5 km wide
Ilulissat Fjord at the end of the **Jakobshavn**
glacier. In western Antarctica, the **Thwaites**
glacier encounters warmer ocean currents at a water depth of
500 meters. In this case the length of the wall necessary to
block the warm water is estimated
at 120 km and the wall would be located 600 metres under
the water surface. The amount of construction material needed to
build a similar wall in front of Pine Island glacier is estimated
at 6 km^3. The actual realisation of the walls would mean the
construction of one of the largest structures in the world under very
difficult conditions. In addition, there is no guarantee for success,
e.g. it cannot be fully ruled out that blocking warm water from one
glacier does not lead to increased
melting
in neighbouring glacial regions.

The
proposed projects would cause significant and poorly-understood
disruptions to water currents, sea life migration, water cycles and
potentially weather patterns. Negative effects on marine ecosystems
and fisheries have been raised as significant concerns
by the team members themselves.

Restoring

polar-ice: Various proposals

In March 2019, researchers from India proposed rebuilding polar ice by sprinkling desalinated sea water on the surface of the ice. The process involves a pumping unit, able to bring up cold ocean water, a desalination plant, and a spraying system. At sub-zero temperatures, the desalinated sea water is to be sprayed from a height of 50 to 60 metres above the ice, in order to turn into snow or ice. The researchers suggest placing sprinklers along the edges of the polar ice caps, e.g. 3 to 5 km away from the edges and spaced at 0,5 km intervals. While details related to possible ecological effects, costs or technical implementation are not available, the potential negative impacts on delicate ecosystems are significant.

In 2016, fourteen researchers at Arizona State University presented the results of a modelling study which also includes pumping water to the surface for restoring sea ice and thickening the polar caps. The proposed pumps are wind-powered and pump sea water to the ice surface, where the water freezes if allowed by the outside temperature. The study estimates that one pumping unit is able to cover an area of 0.1 km² with one meter of ice during one winter. The concept suggest covering 10% of the arctic regions with pumping units: This involves the installation of 10 million pumps at an estimated cost of US$500 billion.

Computer simulations were used to reach the conclusion that shooting very large amounts of artificial snow onto two glaciers in western Antarctica could thicken and stabilize the West Antarctic ice sheet and slow down global sea level rise. The study was conducted by researchers at the Potsdam Institute for Climate Impact Research (PIK) and published in July 2019. The two selected glaciers, Pine Island Glacier and Thwaites Glacier, occupy an area of more than 50,000 km². The approach would require 74 trillion tonnes of sea water over a period of ten years. PIK has further estimated that more than 12,000 wind turbines would be needed to lift, desalinate and spray this great quantity of cold water. The water would need to overcome an elevation of 640 meters from the sea level to the top of the ice sheet. According to the authors of the study, the realisation of the project “would mean the loss of a unique natural reserve” with ecological damages on a very large scale. The study notes that further unwanted effects or risks, e.g. a possible disrupting of ocean circulation patterns cannot be excluded.

In spring 2019, designers in Indonesia proposed covering arctic waters with icebergs produced by ice-making submarines. Each submarine would possess the capability to fill a hexagon-shaped well with sea water, to desalinate and freeze the water, and to release hexagon-shaped icebergs: 25 meters in diameter, 5 meters thick and with a volume of 2,027 m³.
A sizeable number of smaller icebergs could form a larger ice floe. The proposal did not detail costs, energy consumption or energy sources.

Outlook

The
modelling of such projects is much easier to accomplish in comparison to the actual realisation. Polar regions do not offer good conditions for large-scale building projects, e.g. in terms of maintaining a workforce, weather conditions and availability of building materials. Due to the complexity of marine cycles, there is no guarantee for success. Unwanted effects – such as increased melting in neighbouring glacial regions or disruption of ocean circulation patterns – cannot be ruled out. This also applies for possible – and highly likely – adverse effects on marine ecosystems. On these grounds, the above proposals raise more questions than they answer. The level of disruption caused by some of the proposals amounts to sacrificing ecosystems in order to continue the use of fossil fuels.

The
level of resources required by many of the proposals compares unfavourably to the cost of projects that would drastically reduce fossil fuel consumption while benefitting humanity, such as green housing or electrified rail transport. In spite of the substantial works and inputs required, the activities do not address the root problem of greenhouse gas emissions.

i. Ice911 test sites: North Meadow Lake (near Utqiaġvik, Alaska), Lake Miquelon (Alberta, Canada), Lake Elmo (Minnesota, USA), Serene Lake (California, USA), Truckee area (California, USA)

Resources for further information:

Ice911 experiment briefing.

The Interactive Geoengineering Map contains details and references for the above mentioned and further climate geoengineering projects.