GEOENGINEERING MONITOR

Geoengineering Technology Briefing
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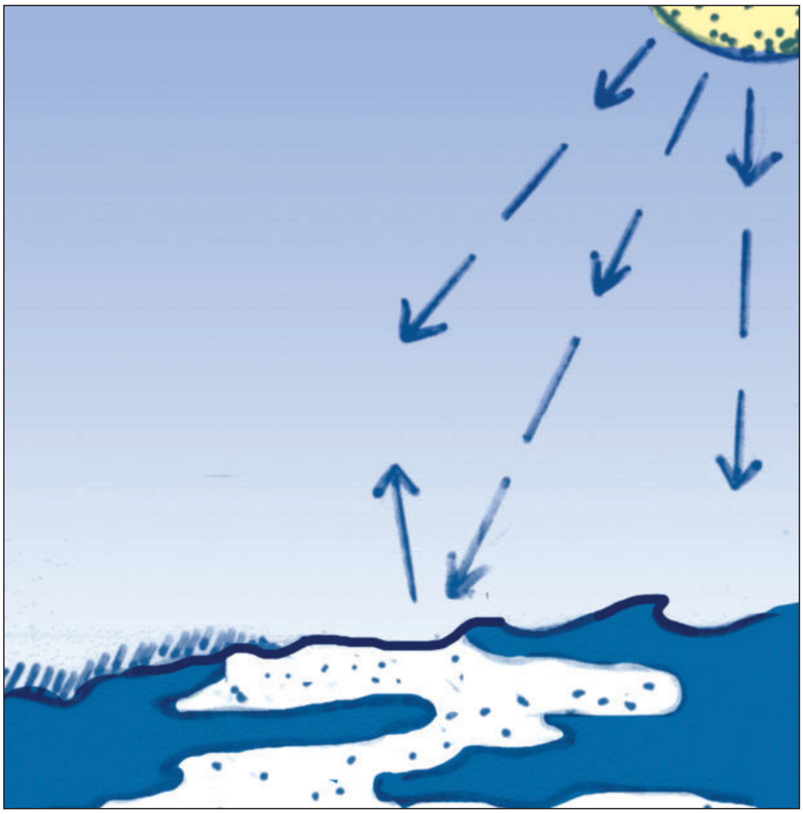
Enhanced Microbubbles / Sea Foam

Description and purpose of the technology

Microbubbles injected into water bodies or sea foam sprayed onto the surface of the ocean are theoretical solar geoengineering proposals which aim to reflect more sunlight back into space by altering the albedo (reflectivity) of water surfaces. The brighter a water surface is, the higher its albedo is, and the lower the absorption and transformation of the sun's energy into heat is.

Whitecaps on wave crests in windy weather or white foam as waves break on a shore are brighter and thus more reflective compared to a calm and thus darker water surface. This solar geoengineering proposal aims to extend the lifetime of bubbles from minutes to days or by dispersing artificial foam.

Proposals to produce long-lasting bubbles combine two different approaches:



Microbubble technology proposes to reflect sunlight into space by adding bubble-forming chemicals to seawater.

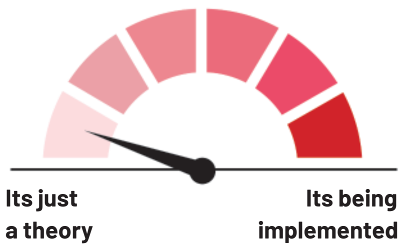
(1) ships should be equipped with technology to produce large quantities of microbubbles, e.g. by using nozzle technology or mechanical shakers;

(2) the microbubbles will be stabilized by the addition of chemicals, so-called surfactants, such as amphiphilic nanoparticles or phospholipids.

The production of artificial foam requires the application of foaming agents onto the ocean or other large bodies of water: chemical foaming agents, such as gelling agents with cellulose ethers, could create a layer of microbubbles on the water surface.[1]

Point of Intervention:

Reality Check:



If applied on a large scale, microbubble techniques could have negative effects on ocean food chains, and reduce oxygen levels: A long-lasting surface layer of bubbles or foam diminishes the photosynthetically active radiation, thereby reducing the photosynthetic activity and growth of phytoplankton, the base of the marine food web. The surface layer may also inhibit gas exchange and therefore reduce the oxygenation of the seawater. These impacts would negatively affect marine biodiversity and productivity. Furthermore, surfactants may be toxic to marine life.

Actors involved

Russell Seitz, a geoengineering physicist at Harvard, proposed to "cool the planet" by pumping great quantities of microbubbles into the oceans to alter the albedo of the ocean surface and to lower water temperatures. Shortly after publishing the results of his computer simulations in 2010, Seitz tried to commercialize his solar geoengineering proposal through the formation of a company, Microbubbles LLC. The company focused on the development of long-lasting microbubbles through the use of mechanical and chemical solutions such as compressed air and added surfactants, but scarcely discussed the environmental implications of the proposed technology.[2]

Researchers at the University of Leeds in the UK modelled the solar geoengineering potential of brightening ship wakes and published the results in 2016, proposing the addition of chemical surfactants to extend the lifetime of microbubbles created by ship wakes from minutes to days.[3]

In the past decade, scientists at the University College London in the UK proposed increasing the ocean surface albedo by enhancing the ocean whitecap formation with reflective foam. The climate effects of a large-scale application were modelled and different foams were tested on laboratory-scale, aiming to increase the lifetime of the foam on sea water.[4]

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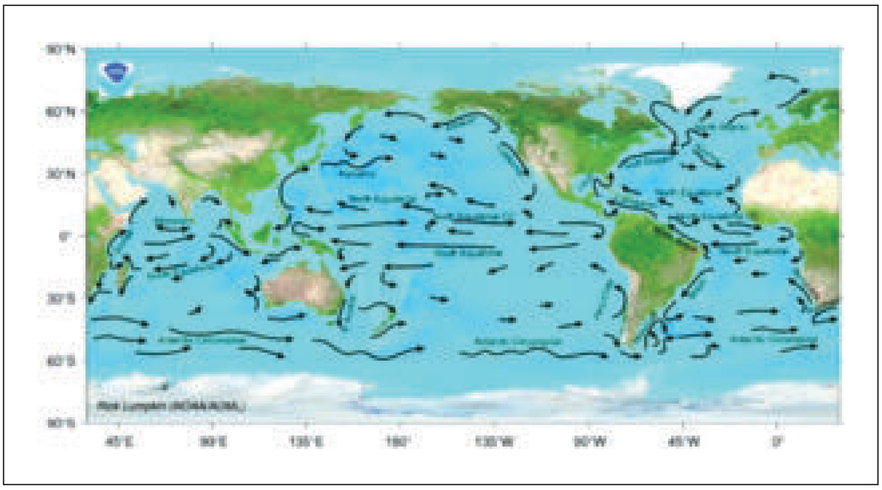
The project G4Foam modelled the climate impacts of altering the ocean albedo by adding stable, nondispersive foam, in order to establish a layer of reflective microbubbles. The study, published in 2017, was conducted by researchers from the Rutgers University in New Jersey, in cooperation with the US Pacific Northwest National Laboratory.[5]

Impacts of the technology

Deploying microbubbles or artificial sea foam at the scale required to impact the climate could disrupt the entire basis of ocean and freshwater life, which is dependent on access to light, from phytoplankton to marine mammals. This would have devastating impacts on the livelihoods of coastal communities and all artisanal fisheries and algae cultivators in the first place, and to many more communities and people dependent on freshwater and marine resources for their subsistence. The effects of bubble clouds on oceanic life, both in terms of temperature and sunlight changes, are unknown.



Ocean currents are complex, and the impacts of geoengineering are poorly understood   Illustration from NOAA

Chemicals could be added to a ship's wake to make it last longer   Photo by Kevin Harber via Flickr

The use of surfactants would also reduce gas exchange and the oxygenation of the upper ocean layers, where most fish and other species live.[6]

A cooler ocean will also absorb CO_2 more efficiently, enhancing ocean acidification. Bubble clouds would change oceanic circulation and cause unexpected or unusual evaporation, which would in turn affect atmospheric heating, circulation and precipitation patterns. This would also raise questions about the possibility of regional climate control, with potential unilateral deployment and even using the technology as a weapon.[7]

The potential impacts of microbubbles on human society was highlighted by research conducted by the Integrated Assessment of Geoengineering Proposals. Through modelling exercises, it found that geoengineering with ocean microbubbles could affect 2 billion people through regional weather changes and extreme events such as floods and droughts.[8]

Microbubble proposals involve the addition of large volumes of chemical "surfactants" to the surfaces of oceans or other bodies of water. Although the researchers do point out that the surfactants would need to be ecologically benign, these chemicals may have unknown and undesirable impacts on ecosystems.

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For example, they can affect microbiological or photochemical processes[9], and they can also be highly toxic. The BP oil disaster in the Gulf of Mexico in 2011 is an example: the oil dispersant BP used was a mixture of two surfactants, which they claimed were safe, and the US Environmental Protection Agency didn't require any safety testing prior to use. A record 1.8 million gallons were used to disperse the oil, and toxic components of the dispersants could potentially have killed more sea life than the oil would have destroyed by itself.[10] This illustrates what "technofixes" of this kind could mean in practice, especially if put in the hands of irresponsible companies, or unscrupulous government agencies.

Another issue unique to the ship wake approach is that there are far more shipping movements in the Northern Hemisphere than the Southern, resulting in a very uneven distribution of microbubbles. This imbalance would need to be addressed, perhaps through even more ships burning diesel in the southern oceans?[11]

Reality check

Research into this technique has so far been limited to modelling and laboratory experiments.

Further reading

Geongineeringmonitor.org, ***Using ship wakes to fight climate change? Time to anchor climate research to common sense.*** www.geoengineeringmonitor.org/2016/03/using-ship-wakes-to-fight-climate-change-time-to-anchor-climate-research-to-common-sense/

The Guardian, ***Reflecting sunlight into space has terrifying consequences, say scientists***. https://www.theguardian.com/environment/2014/nov/26/geoengineering-could-offer-solution-last-resort-climate-change?CMP=fb_gu

ETC Group and Heinrich Böll Foundation, "***Geoengineering Map***" https://map.geoengineeringmonitor.org/

Endnotes

1 Crook, et al. (2016) Can increasing albedo of existing ship wakes reduce climate change, in: JGR Atmospheres, Vol. 121(4): 1549 – 1558, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015JD024201#jgrd52751-bib-0008; ETC Group and Heinrich Böll Foundation (2020) Geoengineering Map: Microbubbles and Sea Foams, https://map.geoengineeringmonitor.org/

2 Seitz (2010) Bright Water: Hydrosols, Water Conservation and Climate Change, in: Climatic Change, Vol. 105(3-4): 365 – 381, https://link.springer.com/article/10.1007/s10584-010-9965-8; Kintisch (2010) Could Tiny Bubbles Cool the Planet?, in: ScienceMag, published online: March 26, 2010, https://www.sciencemag.org/news/2010/03/could-tiny-bubbles-cool-planet; Edwards (2010) Bright water proposal to cut global warming, in: Phys.org, published online: March 29, 2010, https://phys.org/news/2010-03-bright-global.html

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4 Ortega and Evans (2018) On the energy required to maintain an ocean mirror using the reflectance of foam, in: Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, Vol 233(1): 388 – 397, https://journals.sagepub.com/doi/abs/10.1177/1475090217750442?journalCode=pima&; Rowland, et al. (2015) Sea salt as a potential ocean mirror material, in: RSC Advances, Vol. 5(49): 38926 – 38930, https://pubs.rsc.org/en/content/articlelanding/2015/RA/C5RA03469H#!divAbstract

5 Gabriel, et al. (2017) The G4Foam Experiment: global climate impacts of regional ocean albedo modification, in: Atmos. Chem. Phys., Vol. 17: 595 - 13, https://www.atmos-chem-phys.net/17/595/2017/acp-17-595-2017.pdf

6 Ibid (Crook, et al. (2016), Gabriel, et al. (2017)); Evans, et al. (2010) Can oceanic foams limit global warming?, in: Climate Research, Vol. 42(2): 155 - 160, http://www.int-res.com/abstracts/cr/v42/n2/p155-160/; Robock (2011) Bubble, bubble, toil and trouble. An editorial comment., in: Climatic Change, Vol. 105: 383 - 385

7 Ibid (Crook, et al. (2016), Gabriel, et al. (2017)); Evans, et al. (2010), Robock (2011))

8 Carrington (2014) Reflecting sunlight into space has terrifying consequences, say scientists, in: The Guardian, published online: November 26, 2014, https://www.theguardian.com/environment/2014/nov/26/geoengineering-could-offer-solution-last-resort-climate-change

9 Ibid (Crook, et al. (2016), Robock (2011))

10 Sheppard (2010) BP's Bad Breakup: How Toxic is Corexit?, in: Mother Jones, published online: September/October 2010 issue, https://www.motherjones.com/%20environment/2010/08/bp-ocean-dispersant-corexit/

11 Ibid (Crook, et al. (2016))