

What is Marine Cloud Brightening?

(The bulk of this article is a simplified version of the topic in Wikipedia)¹

Marine Cloud Brightening (MCB) is also known as ‘Marine Cloud Seeding’ and also as ‘Marine Cloud Engineering’.² It is a proposed solar radiation management engineering technique that would make clouds brighter, so they reflect a small fraction of incoming sunlight back into space in order to offset Anthropogenic Global Warming³. Along with injecting aerosols in the upper atmosphere (Stratospheric Aerosol Injection)⁴, it is one of the two solar radiation management methods that may feasibly have a substantial impact on reducing Climate Change.⁵ The technique behind MCB is to increase Earth’s reflection of incoming sunlight (known as albedo)⁶. In combination with the reduction of greenhouse gas emissions, carbon dioxide removal, and adaptation, MCB could reduce Climate Change and its risks to people and the environment. If implemented, the cooling effect on the seas is expected to be felt rapidly and is anticipated to be reversible on a fairly short time scale. However, technical barriers remain for large-scale Marine Cloud Brightening to be carried out. There are also risks with such modification of complex climate systems.

Basic Principles

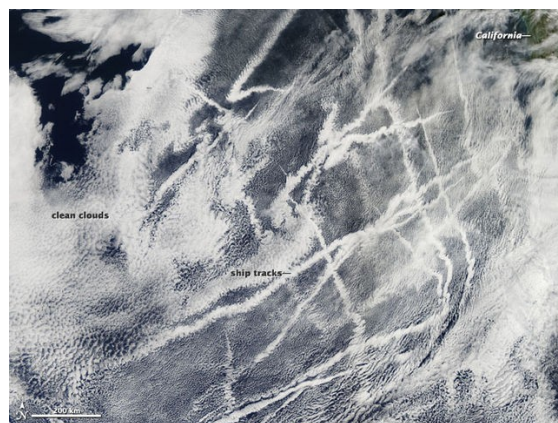
Marine Cloud Brightening is based on phenomena that are already being observed in the climate system of the world. Today, dust and particles for emissions mix with clouds in the atmosphere and increase the amount of sunlight they reflect, reducing warming of the planet. This ‘cooling’ effect is estimated to be between 0.5°C and 1.5°C, and is one of the most important unknowns that impacts our global climate. MCB proposes to generate a similar effect using harmless material (e.g. sea salt) which is introduced to clouds that are most able to create more shading of the sea (viz. marine stratocumulus clouds)⁷.

Most clouds are quite reflective, redirecting incoming solar radiation back into space. Increasing the albedo of clouds would increase the amount of incoming solar radiation that is reflected, which in turn should cool the planet. Clouds are only a collection of water droplets, and those with smaller droplets are more reflective, because of the ‘Twomey Effect’⁸. For clouds to form, it’s necessary for atmospheric water vapour to condense on airborne particles (called ‘aerosols’) so that water droplets to form and make clouds. The central idea underlying BCB is to add aerosols to the atmosphere in locations where clouds form. These aerosols would then act as particles for water vapour condensation, which would increase the amount of cloud, and so increase the cloud’s albedo.

The environment over the ocean doesn’t have enough aerosols for cloud condensation because of the lower levels of dust and pollution at sea, so MCB is expected to be effective over the ocean. In fact, MCB on a small scale is already occurring unintentionally as it happens with the aerosols that are released from the engine exhaust of ships, producing what’s know as ‘ship tracks’⁹.

(See lines in the clouds →)¹⁰

The UN International Maritime Organization’s (IMO) shipping regulations to reduce certain aerosols are believed



1 – “Marine Cloud Brightening” en.wikipedia.org/wiki/Marine_cloud_brightening

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2 – “What is Marine Cloud Brightening?” (21-2-2023) www.barrierreef.org/news/explainers/what-is-cloud-brightening

3 – The warming component of Anthropogenic Climate Change

4 – en.wikipedia.org/wiki/Stratospheric_aerosol_injection

5 – Gunnar Myhre & Drew Shindell (Feb. 2018) “Anthropogenic and Natural Radiative Forcing”

www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

6 – en.wikipedia.org/wiki/Albedo

7 – en.wikipedia.org/wiki/Stratocumulus_cloud

8 – en.wikipedia.org/wiki/Twomey_effect

9 – “Emissions from Ships with respect to Their Effects on Clouds” (9 July 1996) oceanrep.geomar.de/5437/1/2006GL028139.pdf

10 – PHOTO: NASA’s Earth Observatory “Ship Tracks off the California Coast - NASA Earth Observatory.jpg” CC BY 2.0 via Wikimedia Commons commons.wikimedia.org/wiki/File:Ship_Tracks_off_the_California_Coast_-_NASA_Earth_Observatory.jpg

to have led to a reduction in cloud cover over the oceans, and therefore producing an increase in ocean warming. This theory provides support for the proposal of MCB being used to modify ocean temperatures.¹¹ Different cloud conditions are likely to produce different results with brightening strategies, with low, layered clouds over oceans (marine stratocumulus clouds) being the most responsive to the increase in aerosols.¹² These marine stratocumulus clouds are typically proposed as the suitable targets for MCB. They are common over the cooler regions of subtropical and mid-latitude oceans, where they can cover more than 50% of the year.

The leading substance to use as an aerosol for additional cloud condensation nuclei is salt from seawater, although there are others.¹³

Even though the importance of aerosols for the formation of clouds is generally well understood, many uncertainties remain. In fact, the latest Intergovernmental Panel on Climate Change (IPCC) report #5¹⁴ considers the interaction between aerosols and cloud interaction to be one of the major challenges for current climate modelling. In particular, the number of cloud droplets does not increase proportionally when more aerosols are present, and it can even decrease.¹⁵ Extrapolating the effects of aerosol particles on clouds observed in the laboratory to the scale of a ocean regional, so that it can affect the climate, is not as easy as it would seem.

Climatic Impacts

Reduction in global warming

The modelling of the global climatic effects of MCB remains basically inconclusive,¹⁶ although current modelling research indicates that it could possibly cool the planet in a substantial way. One study estimated that it could reduce the amount of sunlight reaching the surface by 0.37%.¹⁷ This is estimated to counteract the warming caused by a doubling of atmospheric carbon dioxide concentration that is believed to have occurred since the Industrial Revolution, or an estimated 3°C rise in global temperature¹⁸ (although models have indicated less capacity)¹⁹. A 2020 study found a substantial increase in cloud reflectivity from shipping in southeast Atlantic basin, suggesting that a test on a regional scale of MCB in regions dominated by stratocumulus clouds could be successful.²⁰

The impacts of MCB on climate is believed to be rapidly responsive and reversible. If the brightening activity were to change in intensity, or stop altogether, then the cloud's brightness would respond within a few days to weeks, as the aerosols causing cloud condensation naturally dropped from the sky.²¹

Unlike aerosol injection straight into the upper atmosphere (Stratospheric Aerosol Injection), MCB might be able to be used regionally, however, that would be in a limited way.²² Marine stratocumulus clouds are common in some regions, particularly the eastern Pacific Ocean and the eastern South Atlantic Ocean. A

11 – Paul Voosen (2-8-2023) “We're changing the clouds.' An unforeseen test of geoengineering is fueling record ocean warmth”

www.science.org/content/article/changing-clouds-unforeseen-test-geoengineering-fueling-record-ocean-warmth

12 – Lazaros Oreopoulos & Steven Platnick (27-7-2008) “Radiative susceptibility of cloudy atmospheres to droplet number perturbations...”
Journal of Geophysical Research: Atmospheres 113 (D14): D14S21

13 – Oliver W. Wingenter, & others (2-10-2006) “Unexpected consequences of increasing CO₂ and ocean acidity on marine production of DMS and CH₂ClI: Potential climate impacts” oceanrep.geomar.de/id/eprint/5437/1/2006GL028139.pdf

14 – March 2014

15 – Y.C. Chen (12-9-2012) “Occurrence of lower cloud albedo in ship tracks” acp.copernicus.org/articles/12/8223/2012/

16 – “Climate Intervention: Reflecting Sunlight to Cool Earth” (2015)

nap.nationalacademies.org/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth

17 – Down 3.7 W/m² (Solar irradiance is measured in watts per square metre (W/m²) in SI units. The Sun's rays are moderated as they pass through the atmosphere, leaving maximum normal surface irradiance at approximately 1000 W/m² at sea level on a clear day.)

en.wikipedia.org/wiki/Solar_irradiance

18 – Stephen Salter & others (13-11-2008) “Sea-going hardware for the cloud albedo method of reversing global warming”.

Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences. 366 (1882)p:3989–4006.

19 – Andy Jones & others (27-5-2009) “Climate impacts of geoengineering marine stratocumulus clouds”

Journal of Geophysical Research: Atmospheres. 114 (D10)p:D10106.

20 – Michael Diamond & others (24-3-2020) “Substantial Cloud Brightening From Shipping in Subtropical Low Clouds”

agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019AV000111

21 – “Climate Intervention: Reflecting Sunlight to Cool Earth” (2015)

nap.nationalacademies.org/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth

22 – John Latham & others (28-12-2014) “Marine cloud brightening: regional applications”

Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences 372 (2031): 20140053

typical finding among MCB simulation studies was a persistent cooling of the Pacific, similar to the “La Niña” phenomenon. In addition, there was an increase in polar sea ice, despite the local nature of the change in albedo.^{23 24} Recent studies aim to be able to compare the findings from simulations produced from different models.²⁵

Side Effects

There is some potential to change the patterns and amount of precipitation (viz. rainfall) with MCB,^{26 27 28} although modelling suggests that the changes are likely to be less than those for stratospheric aerosol injection and considerably smaller than if Anthropogenic Global Warming is to continue unabated.²⁹

Research

Marine cloud brightening was originally suggested by John Latham in 1990.³⁰

One research project released smoke behind ships in the Pacific Ocean and monitored the soot particles’ impact on clouds.³¹ Although this was done in order to better understand clouds and Climate Change, the research has implications for marine cloud brightening.

A research coalition called the Marine Cloud Brightening Project was formed in order to co-ordinate research activities. Its proposed program includes modelling, field experiments, technology development and policy research, in the study of cloud-aerosol effects and MCB.

The shipping industry may have been carrying out an unintentional experiment in MCB due to the emissions of ships, which is believed to have reduced global temperatures by as much as 0.25°C.³² A 2020 study found a substantial increase in sunlight reflected from cloud due to shipping in the southeast Atlantic basin.³³ This suggested that an MCB test on a regional scale, one dominated by stratocumulus clouds, could be successful.

MCB is being examined as a way to shade and cool coral reefs, such as the Great Barrier Reef.³⁴

My Analysis

Sounds wonderful, but...there are a lot of ‘maybes’ and ‘possibly’s’ with this process at the present time. It’s in a very early stage of development, so a great deal of research needs to follow on from the recent reportings.

The amount of Global Warming that it will reduce is debatable. The study that estimates that MCB could reduce warming by 0.37% is minuscule and speculation, not really effective and not fact (that’s what an

23 – John Latham (13-11-2008) "Global temperature stabilization via controlled albedo enhancement of low-level maritime clouds" *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences* 366 (1882) p:3969–3987.

24 – Philip Rasch & others (1-1-2009) "Geoengineering by cloud seeding: influence on sea ice and climate system" iopscience.iop.org/article/10.1088/1748-9326/4/4/045112

25 – Ben Kravitz & others (16-8-2013) "Climate model response from the Geoengineering Model Intercomparison Project (GeoMIP)" publications.iass-potsdam.de/pubman/faces/ViewItemOverviewPage.jsp?itemId=item_134078

26 – Philip Rasch & others (1-1-2009) "Geoengineering by cloud seeding: influence on sea ice and climate system" iopscience.iop.org/article/10.1088/1748-9326/4/4/045112

27 – G Bala & others (24-6-2010) "Albedo enhancement of marine clouds to counteract global warming: impacts on the hydrological cycle" *Climate Dynamics* 37 (5–6) p:915–931.

28 – Andy Jones & others (1-4-2011) "A comparison of the climate impacts of geoengineering by stratospheric SO₂ injection and by brightening of marine stratocumulus cloud" *Atmospheric Science Letters* 12 (2) p:176–183.

29 – "Climate Intervention: Reflecting Sunlight to Cool Earth" (2015) nap.nationalacademies.org/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth

30 – John Latham (1990) "Control of Global Warming?" *Nature* 347 (6291) p:339-340

31 – Lynn Russell & others (1-5-2013) "Eastern Pacific Emitted Aerosol Cloud Experiment" authors.library.caltech.edu/39251/1/bams-d-12-00015.1.pdf

32 – <https://authors.library.caltech.edu/39251/1/bams-d-12-00015.1.pdf>

33 – M.S Diamond & others (2020) "Substantial Cloud Brightening From Shipping in Subtropical Low Clouds" *AGU Advances* 1(1)

34 – "Scientists trial cloud brightening equipment to shade and cool Great Barrier Reef" (17-4-2020) www.theguardian.com/environment/2020/apr/17/scientists-trial-cloud-brightening-equipment-to-shade-and-cool-great-barrier-reef

estimate is).

Estimates and projections that rely on modelling and simulations are always speculative. We know this because they are always altered to make their predictions more accurate. However, their results are promoted as scientifically significant, which is not factual science. The results are always determined by the data put in them, the assumptions that stack the coding behind them, and the inaccurate mathematics behind the code which tries to mimic chaotic meteorological phenomena.

As with other techniques to push back the effects of Climate Change – notably renewable electricity sources – the cost with MCB will be hidden and enormous, and it will be funded (subsidised) by ‘the public purse’ (i.e. our taxes).

All up, MCB sounds ‘fantastic’ as a means of reducing the warming involved in Anthropogenic Climate Change, but there’s still no immutable proof that humans are responsible for all the changes that are occurring in our weather patterns in the first place. On top of that, there’s the problem of what happens to the planet if we reduce the sunlight and we cool it too much, or MCB triggers a cooling episode that we can’t stop, leading to a mini ice age.³⁵

MCB VIDEOS

- “Cloud Brightening project”
www.youtube.com/watch?v=B0KeUlvWakg
- “Cloud Brightening 2021: plume”
www.youtube.com/watch?v=0DgB88_BtUY
- “Cloud brightening: First-in-nation tech aims to cool our warming planet”
www.youtube.com/watch?v=MtshM4qubVk
- “How Cloud Brightening Protects Australia's Great Barrier Reef”
www.youtube.com/watch?v=qjya_arTWjs
- “Great Barrier Reef: Could cloud brightening slow impact of coral bleaching?”
www.youtube.com/watch?v=P4BftwhQpbk
- “Cloud Brightening Field Trip 2021”
www.youtube.com/watch?v=qjya_arTWjs

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35 – SEE: “The Problem with Blocking Sunlight to Counteract Global Warming” (23-7-2023)

canberraforerunners.org/wp-content/uploads/The-Problem-with-Blocking-Sunlight-to-Counteract-Global-Warming.pdf