GEOENGINEERING MONITOR

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Cirrus Cloud Thinning (CCT)

Will legions of particle-spraying drones be enlisted to cool the planet?

Description and purpose of the technology

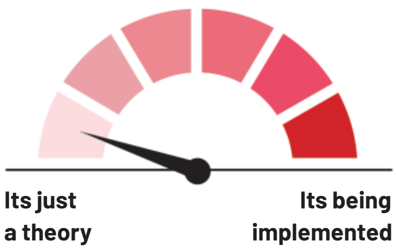
Cirrus Cloud Thinning is a solar geoengineering proposal which aims to eliminate or thin cirrus clouds to allow heat to escape into space. The wispy, elongated "cirrus" clouds are found at high altitudes, and often absorb more sunlight than they reflect, because they form in cold temperatures and consist of ice crystals. If these ice crystals are numerous and small, cirrus clouds prevent long-wave terrestrial radiation from escaping into space, and have a climate impact similar to greenhouse gases. In the presence of natural ice nuclei such as dust, the ice crystals that form are fewer and larger, with a shorter lifespan and fewer climatic effects.

Proponents of the theoretical solar geoengineering technique known as Cirrus Cloud Thinning (CCT) propose injecting ice nuclei – such as bismuth triiodide or aerosol particles as sulfuric or nitric acid – into regions where cirrus clouds form. This, they infer, would produce cirrus clouds with larger ice crystals with shorter life spans, while also reducing their optical depth, which means more long-wave terrestrial radiation would be transmitted into space.[1] Thinning the clouds, according to some researchers could allow more heat to escape into space.

Researchers admit that the injection of "too many" ice-nucleating particles into cirrus clouds may produce the opposite effect – more and thicker clouds may be produced, so that even more heat is trapped, which could lead to increased global warming.[2]

Point of Intervention:

Reality Check:



Other researchers underscore the risks of unpredictable side effects of CCT, including large regional and seasonal changes to precipitation, and the differing effects of seeding in the Southern or Northern Hemispheres.[3]

Actors involved

Studies on CCT are limited to modelling exercises and investigations of cirrus clouds by research institutions. In 2006, the US-based Desert Research Institute started a five-year study on cirrus clouds and examined the concentration of small ice crystals as well as the concentration of natural and anthropogenic aerosol concentrations in cirrus clouds to provide more exact data for global climate model predictions.

GeoMIP and ETH Zurich undertake modelling simulations on CCT. GeoMIP, the Geoengineering Model Intercomparison Project, is an international collaboration between climate modelling centres, among them research institutions in Canada, China, Denmark, Germany, Japan, Norway, UK and the USA. The project is organised in international working groups, modelling various types of solar geoengineering, including CCT.

A research group at the ETH Zurich's Institute for Atmospheric and Climate Science has simulated CCT with a global climate model and is also participating in joint research programs with other research institutions, among them the German research project AWiCiT: Arctic Winter Cirrus Thinning. The modelling study AWiCiT looks at the option to seed arctic winter atmosphere with ice nucleating particles, aiming to reduce the Arctic warming and to slow down the melting of the Arctic ice.

Further studies on CCT are conducted by researchers at the University of Leeds, UK, the university models different areas of solar geoengineering as well as at Zhejiang University, China, within China's Geoengineering Programme.[4]

Impacts of the technology

As with all solar geoengineering techniques, CCT could have considerable impacts on regional climates. In model simulations with combined CCT and CO_2 increases, researchers have found that CCT may enhance the hydrological cycle and therefore could strengthen Sahelian rainfall and the Indian monsoon.[5] This could have devastating impacts on millions of vulnerable people and the livelihoods of many communities. Although CCT is predicted to lower global annual mean change in precipitation, large regional and seasonal changes, including changes to the monsoons, are also shown in models.

> **"The injection of "too many" ice-nucleating particles into cirrus clouds may produce the opposite effect – more and thicker clouds may be produced, so that even more heat is trapped, which could lead to increased global warming. The level at which over-seeding occurs is not known, adding considerable uncertainty to current models."**

If CCT were to achieve a cooling effect, it could also cause unwelcome side effects, such as unwanted changes in the hydrological cycle and atmospheric circulation. The climate system is complex and highly nonlinear in its behaviour, so perturbing one element of it in this way could lead to unforeseen changes.[6]

Another potential problem with CCT is over-seeding, this means too many nuclei are injected and numerous additional ice crystals form. As a consequence, the cirrus clouds become optically thicker and less permeable for terrestrial radiation, leading to additional warming of the atmosphere.

Models that simulate with "Cirrus Cloud Thickening" result in a weaker hydrological cycle, exhibiting a behaviour comparable to CO_2 doubling alone,[7] which would obviously cause serious harm to ecosystems and human life. The level at which over-seeding occurs is not known, adding considerable uncertainty to current models.

Similarly, seeding would need to be avoided in cloud-free regions with high relative humidity where no cirrus clouds form. Here, seeding could lead to cirrus cloud formation rather than thinning, resulting in a warming effect on the climate. These interconnected factors mean that CCT could either increase or decrease global temperatures.

Cirrus clouds
Photo by Hehaden via Flickr

> "A significant concern is that CCT could be operated at a local scale with the intention to create climate responses in certain areas. This kind of localised deployment could cause negative impacts on non-target neighbouring regions and communities potentially precipitating serious conflicts. Climate events likely won't be contained: one country avoiding a heatwave could cause flooding in another."

The influence of CCT on lower-lying clouds is also poorly understood: in this case CCT could enhance or dampen cloud reflectivity or allow more or less heat to escape – and is likely to cause additional climate problems.[8]

Another significant concern is that CCT could be operated at a local scale with the intention to create climate responses in certain areas. This might be attractive to governments as it could theoretically provide an opportunity to target the suppression of some extreme events, such as heat waves,[9] an idea that today seems far-fetched. Another example of small-scale deployment is proposed to avoid further melting of Arctic sea ice.[10] This kind of localised deployment could cause negative impacts on non-target neighbouring regions and communities potentially precipitating serious conflicts. Climate events likely won't be contained: one country avoiding a heatwave could cause flooding in another. Or, rather than stopping Arctic ice melt, the technology could also be used to melt it completely and open up lucrative shipping routes.

Reality check

CCT is a theoretical concept, and research into its effects is currently limited to climate modelling and based on assumptions that could be wrong. Researchers do not even know which substances would effectively seed cirrus clouds and which technological challenges may emerge. Recent studies found that none of the known cloud seeding strategies could achieve a significant cooling through CCT, due to complex microphysical mechanisms that limit the climatic response and due to large uncertainties in both cloud and surface climate responses. These more recent studies directly contradict previous findings that cirrus cloud seeding could be an effective geoengineering method.[11]

Further reading

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

Endnotes

1 Storelvmo, et al. (2013) Cirrus cloud seeding has potential to cool climate, in: Geophys. Res. Lett., Vol. 40(1): 178 – 182, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2012GL054201; Reynolds (2019) Solar geoengineering to reduce climate change: a review of governance proposals, in: Proc. R. Soc. A, Vol. 475, https://royalsocietypublishing.org/doi/10.1098/rspa.2019.0255; ETC Group and Heinrich Böll Foundation (2020) Geoengineering Map, https://map.geoengineeringmonitor.org/

2 Lohmann and Gasparini (2017) A cirrus cloud climate dial?, in: Science, Vol. 357(6347): 248 - 249, https://science.sciencemag.org/content/357/6348/248/tab-pdf

3 Muri, et al. (2014) The climatic effect of modifying cirrus clouds in a climate engineering framework, in: Journal of Geophysical Research: Atmospheres, Vol. 119(7): 4174 - 4191, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013JD021063

4 ETC Group and Heinrich Böll Foundation (2020) Geoengineering Map, https://map.geoengineeringmonitor.org/

5 Kristjánsson, et al. (2015) The hydrological cycle response to cirrus cloud thinning, in: Geophys. Res. Lett., Vol. 42(24): 10,807 - 10,815, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015GL066795; Gasparini, et al. (2020) To what extent can cirrus cloud seeding counteract global warming?, in Environ. Res. Lett., accepted manuscript published online: January 30, 2020, https://iopscience.iop.org/article/10.1088/1748-9326/ab71a3

6 Ibid (Muri, et al. (2014))

7 Ibid (Kristjánsson, et al. (2015))

8 Ibid (Lohmann and Gasparini (2017))

9 Quaas, et al. (2016) Regional climate engineering by radiation management: Prerequisites and prospects," in: Earth's Future, Vol. 4(12), 618 – 625, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016EF000440

10 Ibid (Lohmann and Gasparini (2017))

11 Gasparini and Lohmann (2016), Why cirrus cloud seeding cannot substantially cool the planet, in: Journal of Geophysical Research: Atmospheres, Vol. 121(9), 4877 – 4893, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015JD024666; ibid (Gasparini, et al. (2020))