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Geoengineering, the Climate Threat, and the Canadian Arctic

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The rapid development of climate altering technologies, also known as climate interventions, or geoengineering is a direct response to the rapidly increasing impacts of climate change. However, the implications of deploying geoengineering are still largely uncertain. For Canada this is an especially important area for further research, given the importance of the Arctic, both from the perspective of climate impacts, and potential for deployment of geoengineering technologies.

This analysis is intended to motivate public and governmental action on geoengineering research based on three justifications: First, that unless the Government of Canada acts immediately to establish its own research programme and policy framework, it will be on the receiving end of geopolitical decision making. Second, because of the vital importance of the Arctic for a safe climate future, Canada must understand the Arctic implications of potential geoengineering deployment. Third, by studying the Arctic is a case-study of large geopolitical governance issues, it may be possible to use it as a starting point for developing effective mechanisms for the global governance of geoengineering.

Background

The issue of climate security has arisen from the understanding that not only does climate change threaten the stability of human civilization through economic, social and environmental impacts, but that it will create second order effects. While hard to predict, there is potential for these to cause cascading issues, and further contribute to global polycrisis.[1] Canadian research on climate security and its impacts have begun, but are still in its early stages;[2] one outcome of this research is the founding of the Climate Security Association of Canada.[3]

One area which is currently understudied is the ability for technology to artificially modify the global environment' in particular, the ability to artificially modify the climate is now within technological reach of the world's major powers. Smaller players in the geopolitical sphere are capable of small scale weather modification such as cloud seeding,[4] including the U.A.E where recent hyperbolic headlines have attempted to link these practices[5] with record flooding – despite the inability for current technology to intervene at such a scale. In Canada, cloud seeding has been practiced for decades[6] in the prairie provinces as an effort to minimize crop damage from hail.[7]

What is new is the ability to manipulate not just minor weather patterns, but entire climatic systems by changing solar albedo (and therefore the quantity of incoming sunlight); these technologies are inspired by volcanic eruptions. While accuracy of deployment and side effects are still of significant uncertainty, there seems no doubt that these practices are technically viable using equipment available to most advanced Nation-states. Experiments of these technologies have now been pursued in Mexico, the US, Australia, the Arctic, and inadvertently globally from oceangoing ships, with more projects planned.[8] However, experimentation outside of laboratory testing may be necessary to quantify and qualify risks and uncertainties including the potential that the harms of deployment could conceivably exceed benefits.

These developments present a significant quandary for Canada, particularly as it relates to the Canadian Arctic, for two reasons. First, the Arctic is one of the most plausible locations for deployment due to the relative effectiveness of these techniques in polar locations – both due to presence of sea ice, and lower stratospheric altitudes – which both make climate intervention techniques more viable. Second, deployment of these techniques over polar regions such as the Arctic has a higher benefit than other locations, due to the potential to limit sea ice melt.[9]

For understanding the risks, uncertainties, opportunities and potential for governance, examining the Arctic as a microcosm of larger geopolitical concerns may be a useful exercise, not just for Canadian policy makers, but those concerned about geoengineering writ large. This analysis seeks to explore the Arctic as a case study for understanding Canadian specific concerns and serve as a launching point for broader examination of climate and security concerns relating to geoengineering technologies.

This leads to a series of questions: where does Canada stand on the issue of climate engineering,[10] does Canada have the requisite technological ability to engage in climate engineering, how can Canada address governance of geoengineering,[11] and what mechanisms does Canada possess to play a role in the global leadership of this issue? While the answers to these questions are mostly speculation, the fact is that geoengineering technologies now presents risks to Canadian and Arctic security through several mechanisms.

Key Arctic concerns are centred on conflict and security issues and include the potential for rapid sea ice melt and thereby the opening of the Arctic to economic and military activities, impacts to Indigenous peoples, the loss of biodiversity leading to ecological collapse, and the potential dual use/weaponization dichotomy of these technologies. Unless Canada acts now, it will be on the receiving end of decisions made by other geopolitical actors in this space, with significant real and direct consequences. Here, options for balancing Canada's risks and opportunities for geoengineering are explored, with recommendations for immediate and necessary actions.

Analysis

There are four types of geoengineering which are relevant to Canadian consideration, in this case all types of solar radiation modification (SRM): Stratospheric Aerosol Injection (SAI), Marine Cloud Brightening (MCB), Cirrus Cloud Thinning (CCT), and Surface Albedo Modification (SAM) through ice restoration or enhancement.

SAI is a technique inspired by volcanic eruptions which proposes to use aircraft (or balloons) to place aerosols in the stratosphere, which would reflect incoming sunlight back to space, thereby causing a cooling effect.[12] The stratosphere is important due to the presence of the ozone layer but is problematic due to its relatively high altitude (beginning at 7 000-20 000m depending on latitude – with the caveat that higher deployment is more effective from a cooling perspective) and the fact that it is not yet directly addressed through international law (such as space law) outside the Montreal Protocol. The unique consideration for Arctic contexts is that the stratosphere above the Arctic is at a lower altitude, making is easier to access by conventional aircraft, lowering technological barriers to deployment. However, deployment over a single region such as the Arctic will cause variable outcomes in other regions; it is yet unclear what type of 'optimal' deployment exists to maximize benefits and minimize externalities. This system has the largest potential for global cooling, as well as the largest in terms of concerns for negative effects; however, recent research is improving understanding of deployment at different scales such as latitudes, altitudes and seasonality/periodic deployment which could reduce unintended effects.

Marine cloud brightening has been tested in Australia over the Great Barrier Reef and briefly in the San Fransico Bay harbour.[13] This technique sprays salt water in a fine mist, which thereby contributes to the formation of low-level sea clouds, reflecting light away and thereby reducing ocean temperatures. This technique was accidentally conducted[14] at global scale using high sulphate fuels in large oceangoing vessels, providing a multi-decade real world data set proving its efficacy.[15]

Cirrus cloud thinning proposes to disperse clouds over highly reflective ice, which otherwise traps in atmospheric heat under these cloud layers. This technique can only be conducted over large bodies of ice such as the poles and is only effective seasonally. Of all geoengineering techniques, this is the least developed, and systems to understanding the dissipation of cirrus clouds is limited.

Several systems are currently under exploration, including practical tests in the Arctic,[16] which seek to either expand or increase the reflectivity of Arctic sea ice through surface albedo modification. As noted in cirrus cloud thinning, Arctic sea-ice can be highly reflective and therefore provide a cooling effect, but the increasingly rapid melting of both Arctic and Antarctic sea-ice is reducing this naturally occurring effect. This is the most targeted form of geoengineering, and based on current techniques could not likely be deployed at large scale.

It is vital to note that none of these techniques 'solve' climate change in any way, but rather mask the effects of warming, and potentially delay or mitigate certain effects of climate change. Therefore, no type of geoengineering is a climate solution, and can only be seen as a temporary stop-gap measure, which can reduce some negative impacts and buy time for emissions reduction and mitigation measures.

Sea Ice Melt

Sea ice is melting at an unprecedented rate. Regardless of climate action, the Arctic could see significant summer periods absent of sea ice by 2030.[17] Melting of Arctic sea-ice presents both opportunities and hazards for Canada. Reduced Arctic sea-ice would open new trade routes – particularly to and from Europe via the Northwest Passage – these routes could be contested by members of the international community. While such a dispute would likely be expected of typical competitors like China or Russia, Canada continues to find itself at odds with our closest partner, the US, over sovereign claims of the Northwest Passage.[18] As a result, while the economic opportunities could be a boon, they could also be the cause of significant controversy, if not conflict.

Beyond the Northwest Passage, the opening of the Arctic presents challenges to the entirety of Arctic Sovereignty. While the Antarctic is generally understood to be governed by the Antarctic Treaty (despite concerns about its future),[19] the Arctic has less direct international consensus from The Arctic Council, especially when accounting for recent geopolitical developments such as the war in Ukraine.[20] Russia has made bold overtures in the Arctic, as has China, despite its lack of geographical proximity.[21] Their interests, among others, is most likely spurred by opportunities to exploit natural resources, which may become more available as Arctic sea-ice retreats.

The ability to slow or even stop the rate of sea ice melt may be within technological reach of many Nations with vested interests in the Arctic. Nations such as Russia may have a vested interest in continued retreat of Arctic ice, which would allow them to exploit hitherto unexploited resources, while other Nations may seek technological ability to increase ice and therefore block them. Thus, these technologies which are intended purely for alleviation of the worst of climatic impacts (or to buy time for effective climate action) become inherently tied to conflict and security, as well as invoking significant economic implications.

Indigenous Rights

While Canada asserts a claim of sovereign control over much of the Arctic, it is important to remember the peoples who live there: the Inuit peoples are the historical occupants and stewards of the Arctic. Not only does increased militarization of the Arctic present a real threat to their livelihoods, but their traditional practices are threatened by climate change.[22] Based not only on principles of reconciliation, but constitutional rights, the Government of Canada must engage and consult with Indigenous peoples on issues which will directly affect them and their rights.[23] Given the existential threat posed to Inuit peoples (amongst other Indigenous peoples in Canada), it is then necessary for the Government of Canada to engage directly with Indigenous peoples including the Inuit on issues of climate change, especially within the Arctic. This becomes especially important when considering technologies like geoengineering.

Geoengineering may present a threat to Indigenous peoples, such as in the perspective presented by the Saami Peoples open letter to the Advisory Committee of the Harvard SCoPEx geoengineering project.[24] However, given that geoengineering presents a distinct possibility of assisting in the preservation of Arctic sea ice, and therefore the ability for Inuit and Indigenous peoples to practice their constitutional rights, it should not be taken for granted that Canadian Indigenous peoples will be opposed to geoengineering – in fact a previous ocean fertilisation project under the guise of salmon restoration was previously supported by the Haida people of Old Massett.[25] While geoengineering may be a form of 'playing god' at odds with many Indigenous worldviews, the fact that it is one of the few options left in preserving the existence, livelihood, and traditional practices of those same peoples makes it a challenging moral, ethical and existential quandary.

The resulting challenge is that there will be multiple Indigenous peoples, as well as Nation-states which will hold possibly opposing stances on research and deployment of solar geoengineering. Thus, it is likely that no form of consensus can be reached, which may drive sub-national, as well as international disagreement, and potentially conflict on this issue. For Canada, this is exacerbated by challenges of requiring a Nation-to-Nation relationship with Indigenous groups, potentially a legal duty to consult Indigenous nations; additional considerations include existing international commitments through organizations such as The Arctic Council, and the balance of conflict and cooperation with other Nations ranging from The United States to Russia and China. Historically, Canada has deferred to The United States and allowed our southern neighbor to take leadership on most major geopolitical issues, however it is not clear that Canada and the US will have common interests when it comes to Arctic geoengineering; therefore, it seems inadvisable to allow others to be followers and set policy on our behalf.

Biodiversity

An increasing threat resulting from climate change is ecological collapse. While this is traditionally viewed through the lens of famine, resulting from climatic impacts to crops, broader ecological collapses could have even larger implications. In the Arctic, for example, climate change may eliminate habitat for keystone species such as polar bears;[26] if these apex predators are no longer inhabiting their niche, it is unclear what cascade impacts might unfold over other Arctic species. Other research has pointed to changes in fish populations, which not only directly affects marine ecosystems, but would have immediate ramifications economically and socially for northern fisheries.[27]

Beyond the simple concern of loosing iconic species such as Polar Bears, the potential for ecosystem collapse is real.[28] While it is easy to comment on first order impacts such as economic impacts from changes to fisheries, large scale ecosystem collapse is unprecedented, and as a result the ensuing economic, social, and environmental consequences are unclear.

Given the extreme economic, social, and environmental implications of ecosystem collapse, any measures which could prevent this are worthy of consideration; Geoengineering presents the possibility of not only slowing these processes, but possibly halting them entirely. By maintaining sea ice, and lowering atmospheric and ocean temperatures, critical habitat and environmental conditions for Arctic ecosystems could be maintained. However, these forms of geoengineering do not resolve issues such as ocean acidification, nor could anything short of large-scale deployment refreeze already melted ice. Furthermore, research has yet to be conducted both outside of modeling and laboratory testing, to demonstrate what interventions might be necessary (and what side effects might be involved) and maintaining the climatic stability required to stabilize Arctic ecosystems. Research into ecological aspects of geoengineering is nascent, and currently understudied and under-supported. This is a critical area requiring greater attention, of which Canada could be a leader, through the implementation of an open and transparent research program, conducted in collaboration with Indigenous peoples and international partners.

Dual-Use and Weaponization

Research and deployment of geoengineering technologies will result in externalities. The scale and type of unintended effects depends on the deployment parameters and type(s) of geoengineering techniques used. Even in the case of deployment within Canada, these negative consequences will likely not be constrained to a small geographic area, such as that represented by Canadian jurisdiction. If conducted at scale, technologies like Stratospheric Aerosol Injection have the potential to have global consequences, such as disruption of the South-East Asian monsoon cycle.[29] While to those who deploy these technologies this may be viewed simply as an unfortunate side-effect, those who receive the impacts may view this as the intentional weaponization of the climate; this could lead parties to attempt invoking the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD),[30] or potentially even direct conflict.

While current research suggests that the use of geoengineering for targeted disruption of the climate as a weapon is implausible, the dual use nature of geoengineering means that even a non-weaponized deployment could be perceived as a threat, (possibly even an offensive weapon) by other parties. Even conjecture that attempts to alter precipitation or temperatures of other competing (or even allied) states (and thereby altering conditions for human habitation, agriculture, etc.) could trigger significant dispute or even outright conflict. This can be evidenced from accusations of 'rain theft'[31] already being made between countries, over instances of cloud seeding. While these claims are laughable and not backed up by any plausibility of technological capability, this does not prevent them from being used as contrived justification for other actions. This invokes the possibility of some type of geoengineering arms race, or the development of 'counter-geoengineering' techniques, as well as the potential for various types of conflict related posturing by Nations wishing to coerce and/or deter others from research and deployment of geoengineering.

Recommendations

While it is difficult to fully anticipate the outcomes of emerging technologies such as geoengineering, lessons can be learned from historical contemporaries, and inspiration drawn from opportunities and challenges experienced in these other situations.

Establish Leadership and Excellence in Research

Given current geopolitical challenges involving Nations such as Russia and China, understanding the conflict and security implications of geoengineering technologies is of great importance. Canada should not only take leadership in the research of climate and security issues relating to geoengineering as host Nation to the new NATO Climate Change and Security Centre of Excellence (CCASCOE),[32] but could become the global leader on associated research such as ecological and environmental impacts. As the subject matter leader, Canada could also act as a neutral middle-power, and take a leadership role on the international stage, including leading negotiations on limits to research and deployment. However, this would require initiative on the geopolitical stage – a role which Canada has been hesitant to pursue as of late.

While emerging technologies like geoengineering may in some ways be unprecedented, lessons can likely be learned in terms of preventing the proliferation of these technologies by analyzing historical case studies, such as that provided by international programs relating to nuclear weapons and energy.[33] In particular, the dual use and weaponization potential of nuclear technologies at global scales presents as clear analog to geoengineering.

Additionally, research should be conducted into adapting existing international treaties such as the Environmental Modification Convention (ENMOD)[34] which prohibits the hostile or military modification of the environment; as this treaty already has widespread adoption, and specifically lists the atmosphere is a possible subject of manipulation, updating it to include geoengineering would likely be a rapid and effective mechanism to avert the most significant risks of conflict. This would be a preferable option to following something like the proposed non-use agreement,[35] which would only serve to drive research into private, military and covert spaces, which would in turn increase risk of conflict over geoengineering due to inequal access to information and understandings.

Indigenous Consultation & the Arctic Council

Given the known challenges of Indigenous consultation, the Government of Canada should proceed immediately in developing a program to engage with Indigenous peoples, especially those in the Arctic. Partnering with The Arctic Council which already has precedent and expertise on these issues would benefit Canada and provide an opportunity to develop a leadership role.[36] Specifically, the Government of Canada, through The Arctic Council could learn from the Antarctic Treaty System,[37] to address issues of research and deployment of climate altering technologies, noting their potential for economic, social, environmental and security implications. Additional insight could be gleaned from the International Convention for the Regulation of Whaling;[38] in particular, lessons can be learned from international disputes arising from Norwegian and Japanese whaling practices under the guise of scientific research, as well as exemptions made to Inuit peoples for aboriginal subsistence whaling.[39] This is an applicable allegory because the differentiation between scientific research and application is a moral and legal grey area for both whaling and geoengineering.

By proactively working to engage with other Arctic nations and Indigenous peoples, Canada could set the gold standard for how consensus is achieved, and developing social license for open and transparent research into geoengineering. As there is no precedent for a global public engagement process, proof of concept within a region, such as the Arctic may encourage broader more global initiatives, leading to more effective governance regimes.

Technical Requirements – Aerospace and Atmospheric Monitoring

One of the key uncertainties is what would be required to deploy a geoengineering project. The Government of Canada should launch an investigation into the technical requirements – including research, deployment, and monitoring of various geoengineering techniques, and what geopolitical powers could theoretically engage in deployment. For instance, while stratospheric aerosol injection is relatively simple, it requires aircraft operating at altitudes beyond those typically achievable by civilian aircraft.[40] However, aircraft such as those manufactured by Bombardier in Canada, could theoretically be modified for deployment in the Arctic due to their relatively high operational ceiling, and the comparatively low altitude of the stratosphere over the Arctic. Similarly, an advanced monitoring program – likely using satellites – would be required to determine the effectiveness and impacts of a geoengineering program.

A sufficiently advanced monitoring system would be able to detect covert and rogue efforts at deployment, which could in turn deter these actions.[41] A comprehensive understanding of the technical requirements for deployment would not necessarily lead towards a 'slippery slope' towards deployment, but rather would support the development of an international treaty regulating the use of such technologies, such as The Montreal Protocol – which could either be adapted or replicated for the purpose of geoengineering.[42] A side benefit of an advanced monitoring system, even if one only focused on the Arctic, would be to empower existing Canadian resources and infrastructure in defending Arctic sovereignty by data and information availability, and reduced requirement to rely on resources provided by other organizations such as foreign nations.

Conclusion

Geoengineering can theoretically delay the impacts of climate change for costs in the orders of magnitude less than mitigation. Therefore, these technologies may buy time for effective climate mitigation and adaptation but brings an entirely new set of risks and challenges – particularly when viewed from the lens of conflict and security. Typically, Canada has been content to follow allies and contemporary powers into geopolitical decision making. In the case of geoengineering, this strategy would be most unwise as it could leave Canada powerless on a subject which has the potential to be transformative. While Canada as a Nation may choose to pursue geoengineering, or not, the fact is that other geopolitical powers such as major Nation-states will almost certainly pursue the development of these technologies for their own ends. While the Arctic is not typically seen as the crucible of conflict and security, the potential for geoengineering to reshape economic, social, environment, and military factors makes it critical. Thus, using the Arctic as a case study for broader geopolitical concerns makes it an effective microcosm for study, and trial of governance regimes – such as through The Arctic Council. Additionally, until more research is conducted into the ecological and environmental impacts of climate change (and potential use of geoengineering) in the arctic, it will be impossible to make evidence-based decisions. Therefore, Canada must act immediately to understand the development of these emergent technologies and take a proactive hand in international leadership. Failure to do so will leave Canada on the receiving end of international decision making, which could otherwise have significant and direct impacts on territory within our own sovereign control, and impact Canada and its people in ways that are hard to anticipate.

Endnotes

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