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Desperate Times, Desperate Measures

Advancing the geoengineering debate at the Arctic Council

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Introduction

The abrupt decline of summer sea ice in the Arctic Ocean in 2007 alarmed the scientific community (Kerr, 2007; Revkin, 2007). The sudden decay of the ice cap came as a surprise, because the decline in ice extent and volume over the last few decades had been largely linear and predictable. The 2007 low hinted at climate forces that act in a self-reinforcing manner.

Yet, for many, the why and the how of the Arctic thaw are less interesting than the new opportunities that unfold (Funk, 2009). The Arctic[1] is one of the last frontiers in a world starved for large, unexplored spaces (Beauchamp & Huebert, 2008). As it became apparent that a transformation has begun there, it also became commercially interesting; less ice and more benign weather conditions mean easier access. Ship traffic in the Northwest Passage is increasing and new shipping lanes are being planned straight across the North Pole (Funk, 2009). Oil and gas exploration is also ramping up in the Arctic, as oil executives talk about the quest for the last undiscovered oil on the planet (Hawkes, 2007).[2]

Economic globalization has come to the Arctic at last, fast on the heels of the retreating sea ice, and it is being driven in no small part by its own world-changing impact. We, the human species, have become the greatest force of change acting on our planet's climate. The more impact we have on the climate, the faster the ice will melt in the Arctic. And as the ice melts due to climate change, we will ironically create more climate-changing greenhouse gases (GHGs) through increased shipping and resource extraction. Eventually, the whole Arctic Ocean may be ice-free, to the delight of the shipping and fossil fuel industries.

An ice-free Arctic Ocean, however, would be highly detrimental to animals and people who depend on it, and damaging for the global climate. The question is whether we have the will and the means to prevent it. With a pessimistic nod to the future, a handful of climate scientists have revived the decades-old dream of controlling the planet's climate, a concept known as "geoengineering" (Crutzen, 2006; Lawrence, 2006; Schelling, 1996). They share a growing consensus that as mitigation work is going nowhere, we need an insurance policy against catastrophic climate change. Some even suggest that the Arctic may have to be singled out for special attention from geoengineers, because of its crucial and sensitive place in the climate machinery (Caldeira & Wood, 2008; Robock, Oman, & Stenchikov, 2008).

[1] There are several definitions of what constitutes the Arctic. This paper will follow the norm in Arctic cooperation and define the Arctic as areas north of the Arctic Circle in Europe, and north of 60°N in North America (Koivurova, Keskitalo, & Bankes, 2009).

[2] Thirteen per cent of all oil and 30 per cent of natural all gas left on the planet are in the Arctic, according to the U.S. Geological Survey (Gautier et al., 2009).

Could geoengineering save the Arctic ice cap and the Greenland ice sheet, or might the cure be worse than the disease? Geoengineering is associated with severe side effects, but we will nevertheless argue that it is time the issue is afforded serious consideration, serious research and open public debate. The visceral distaste the environmental and mainstream climate science communities has for geoengineering cannot be allowed to derail the issue, because we cannot afford not to investigate emergency solutions to have at the ready, should we fail to stem the tide of climate change. Being on the front line of impact from both climate change and potential geoengineering intervention, the Arctic countries[3] must not only wake up to challenges that come with the prospect of geoengineering, but must recognize that they have a special responsibility to carry out such investigation. We will argue that the Arctic Council, as the only circumpolar intergovernmental organization, is the natural venue for cooperation among the Arctic Countries. It is essential, however, that the Arctic countries also sort out their priorities when it comes to resource exploitation and commercial development in the high North, and how this conforms to their commitments to prevent climate change, and the Arctic Council's overarching goal of sustainable development.

The state of the Arctic

The Arctic is like the canary in the coalmine; its dramatic melting is a warning that there is too much of certain greenhouse gases in the atmosphere, the effects of which are felt first in the Arctic. The inhabitants of the Arctic are acutely aware of their role as canaries and of the dramatic regional impacts of climate change—to which they have contributed so little.[4]

As a harbinger of things to come, the frozen landscapes and seascapes of the Arctic are thawing. The Arctic Council's *Arctic Climate Impact Assessment* (ACIA) chronicles dramatic changes for the high North, including rising temperatures, increased precipitation, thawing permafrost, declining snow cover, shorter winters, increased flooding, reduced ocean salinity and melting glaciers (ACIA, 2005). If climate change in the Arctic continues apace or accelerates, as is believed, the consequences will be grave not only for the people and animals whose lives and livelihoods depend on the Arctic frost, but also for the world at large. Perhaps most obvious are the consequences on sea levels everywhere if the Greenland ice sheet disintegrates. The Intergovernmental Panel on Climate Change (IPCC) estimates that if all of Greenland's glaciers melted, the oceans would rise by over seven metres (IPCC, 2007a, p. 342). But the melting of the Greenland ice sheet is not an immediate worry; the timeframe is between 2070 and 2090 (ACIA, 2005). There are more arcane things happening in the Arctic, however, working on shorter timescales, and with far-reaching global consequences.

[3] The Arctic countries (also called the Arctic Eight in this paper) are: Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the United States.

[4] To learn more about how indigenous people observe and experience climate change, read "The Earth is Faster Now" (Krupnik & Jolly, 2002) and "Unikkaaqatigiit – putting the human face on climate change: perspectives from Inuit in Canada" (Nickels, Furgal, Buell, & Moquin, 2006).

For the ice cap floating in the sea over the North Pole, the new millennium has been dramatic. In 2007, the minimum summer sea ice extent dwindled to the smallest size ever witnessed, shattering the previous record set only two years earlier, in 2005 (Comiso, Parkinson, Gersten, & Stock, 2008). At the end of the melting season of 2007, in mid-September, the sea ice extent was 24 per cent below the yearly minimum of 2005, and 37 per cent below the recorded average.[5] The sea ice extent at the end of the melting season—the yearly minimum—is a good indicator of the overall health of the ice cap. The ice cap is too vast to disappear overnight, and 2007 could be an anomaly. Yet the ice cap has been shrinking for more than half a century (Vinnikov, Robock, & Stouffer, 1999). Satellite evidence shows the Arctic ice cap declining steadily by about three per cent per decade from when measurements began in 1978 to 1999 (Johannessen, Shalina, & Miles, 1999).

The leading theory, now well documented, is that the accelerating change is increasingly driven by a positive feedback loop known as the ice-albedo effect (Perovich, Richter-Menge, Jones, & Light, 2008; Steffen, 2006; Zhang, Lindsay, Steele, & Schweiger, 2008). Positive feedbacks are self-reinforcing loops, wherein each iteration of the process amplifies the initial condition.

The cryosphere—the Arctic and Antarctic ice caps, as well as glaciers around the world—work as a temperature regulator for the Earth (Winton, 2006). Land and sea surfaces are generally dark in colour and absorb radiation like a sponge, whereas bright white snow and ice are highly reflective. The Earth's reflexivity—known as its albedo—is a powerful factor in Earth's radiative balance, which is the difference between solar radiation that is absorbed and solar radiation that is reflected back into space. What is happening in the Arctic is that as the dark Arctic waters are exposed, the more heat radiation they absorb; as they heat up, the sea ice melts quicker, exposing yet more water. The evidence that the ice-albedo feedback dramatically exaggerated the melting in 2007 is cogent (Perovich et al., 2008; Zhang et al., 2008).

Far worse positive feedbacks could be unleashed as the Arctic continues to warm. Scientists estimate that the permafrost of the tundra is a store of billions of metric tonnes of carbon, which, if it thaws, could be released into the atmosphere in the forms of methane (CH_4) or carbon dioxide (CO_2) (Dutta, Schuur, Neff, & Zimov, 2006; Schuur et al., 2008; Walter, Zimov, Chanton, Verbyla, & Chapin, 2006). They warn that the rate at which carbon is being released from permafrost is already increasing (Schuur et al., 2008). Because positive feedbacks by definition are non-linear, however, at some point they may pass a threshold—a "tipping point"—beyond which the impacts of climate change become unpredictable, more dangerous and hard to reverse (James Hansen, 2006; Kerr, 2007; Lenton, Held, & Kreigler, 2008; Winton, 2006). Scientists cannot predict the exact moment of such a tipping point, or what the proverbial "final straw" will be. The record summer sea ice loss of 2007 was alarming because it suggests that a tipping point in the ice-albedo positive feedback loop

[5] There are two slightly different measures of ice coverage: "sea ice extent" and "sea ice area." For an explanation, see http://nsidc.org/arcticseaicenews/faq.html#area_extent (accessed 5 August, 2009). The more conservative number (if only by a little bit), sea ice extent, is used in this paper.

may be closer than we think. When a tipping point is reached, there may be no going back—at least not without drastic measures.

Business as usual

Despite legitimate scientific concern that critical thresholds in the Arctic may be irreversibly surpassed, most countries ostensibly support the ideal of climate change mitigation. Yet their actions in other areas sometimes belie their official statements. The Arctic is a good example, as countries are scrambling to protect their commercial and territorial interests in the Arctic Ocean, with force if necessary. Russia has announced that they are creating a special military division for the Arctic (BBC, 2009a), and so has Denmark (BBC, 2009b). Canada has hastily rediscovered its "Arcticness," and Prime Minister Stephen Harper quipped that Canada must either "use it or lose it" (Harper, 2007). He said Canada would dramatically increase its military presence in the North, though these plans appear to have been scaled back (Canadian Press, 2009). Tellingly, Canadian defence minister Peter McKay is one of the leading voices in the Canadian cabinet on Arctic issues (Boswell, 2009a, 2009b; Scoffield, 2009). In July 2009, shortly after the Danes released their Arctic military plans, the Canadian government once again announced plans to build a stronger Arctic presence (Scoffield, 2009).

The point here is not to discuss security issues in the Arctic, as Arctic countries may be greatly exaggerating the security threats for political gain at home, but to highlight the doublespeak of Arctic countries. On one hand, they appear fiercely protective of highly uncertain resources that have not even been uncovered yet, and on the other, they and all other countries, companies, organizations and human beings on the planet have a fundamental responsibility to make sure they never will be. The discrepancy between what is said and what is done prompts the question: "to what are they more committed?" Is the Arctic scramble a tacit recognition that, no, we will not be able to stop the poles from melting? Worse, is it an acknowledgement that we do not really have the will?

As was explained in a commentary in *Nature*,

> *It will be very expensive to protect against warming at the upper end of the uncertainty range. We therefore will need to make a judgement about what damage is worth avoiding completely and what we will have to bear (Parry, Lowe, & Hanson, 2009, p. 1102).*

Finding an equitable solution to these questions will be a very tall order. How much can we tolerate, how much are we willing to pay for it and who decides? According to David Victor, professor at Stanford University,

> *These failings arise from a political logic that will soon be difficult to rectify. Deep cuts may be costly and thus politically difficult to organize and sustain; they imply radical changes in energy systems that will be difficult*

> *for many countries to administer effectively even if they could mobilize the needed political support. Moreover, it has proved extremely difficult to design competent international institutions for coordinating and enforcing worldwide efforts to mitigate emissions (Victor, 2008, p. 323).*

Considering the consequences of business-as-usual for the climate and the resource scramble some seem intent on creating, the absence of climate change issues in recent Arctic governance research intended to inform government policy is particularly disconcerting. Such research was recently presented in two reports published by the Canadian International Council (Griffiths, 2009; Huebert, 2009). Neither shows much concern for the intractable nature of the physical transformations underway in the Arctic, notwithstanding that these processes serve as the very foundation of their reports. Both share an emphasis on sovereignty, security concerns, traditional international cooperation and commercial development, constructing the issue of Arctic governance in the traditional frame of international relations. Rob Huebert in particular stresses Canada's "sovereignty and security in a transforming circumpolar world," and sees climate change through the lens of traditional security concerns (2009). Franklyn Griffiths is more balanced, insofar as he warns against Arctic militarism and "fragmented incrementalism" in Arctic governance (2009, p. 4), and calls for better environmental stewardship. He further calls for more attention to the rights and interests of the often marginalized inhabitants of the Arctic. These are recommendations policy-makers should take to heart.

All the same, Griffiths is very cautious in terms of recommendations for the Canadian government; his advice generally boils down to business-as-usual in Arctic politics (Griffiths, 2009). Neither his recommendation of more bilateral cooperation nor his support for a stronger Arctic Council is revolutionary. Besides, they are contradictory. If two of the largest Arctic countries—Canada and the United States—were to embark on a deep bilateral Arctic cooperation project, as he recommends, it is hard to imagine that the Arctic Council would not suffer as a result. Griffiths recommends bilateral cooperation with other countries as well, on a piecemeal basis when it serves Canadian interests, and especially in the realm of commercial development.

It is hard to argue that the Arctic Council does not need fortification, but it is also worth asking why the continuation of existing governance patterns should produce any different results than they have so far. This question is particularly salient considering the fundamental transformation going on right now. The long decade since the Arctic Council was created has been a prosperous and mostly peaceful period (at least in terms of interstate conflict) for the Arctic. How will a fragmented Arctic governance regime be able to deal with the consequences of climate change, if it could not do better during a relatively uneventful period?

The climatic changes underway in the Arctic promise anything but an uneventful future, and may eventually present us with very hard choices. Griffiths, however, seems to think that with proper environmental stewardship in some narrow sense (the proper management of shipping practice, for example), commercial development can go on as usual. He is essentially silent on the contradiction

between fossil fuel exploitation in the Arctic and worsening climate change, referring in passing to "the need for geophysical and chemical engineering to save the climate in which we have thrived" (Griffiths, 2009, p. 19). This rather glib treatment of geoengineering as a climate change solution bespeaks the general failure of the conventional international relations and security discourse to grapple more rigorously with biophysical and policy feedbacks in the Arctic. In a much-cited 2000 article in *Global Environmental Change*, Karen O'Brien and Robin Leichenko introduced the notion of *double exposure* of the joint impacts of climate change and economic globalization (2000). The double exposure concept was applied to agrarian societies in developing countries, who were generally regarded as most vulnerable to climate change (Leichenko & O'Brien, 2008). In the Arctic context, the double exposures are in double feedback: loss of Arctic ice from global warming leads to decreased albedo; and more warming and more ice loss in the Arctic, which, as noted earlier, plays a critical role in global climate regulation. Arctic policy feedback then amplifies the biophysical feedback: loss of ice allows more fossil fuel exploitation and more global warming.

We are not the first to discern the feedback between human and natural systems, or to scrutinize the connection between fossil fuel extraction and climate change in the Arctic (Chapin, Randerson, McGuire, Foley, & Field, 2008; Coates, Lackenbauer, Morrison, & Poelzer, 2008). We do, however, extend the discussion by contemplating what the introduction of geoengineering might mean for climate change governance and the commercial conquest of the Arctic. Recourse to the "geoengineering option" should appropriately be regarded as a worst-case option, necessitated by the failure of proactive policy to reverse the feedbacks, either by mitigating GHG emissions generally, or at least by stemming the urge to exploit the fossil energy reserves believed to be hidden under the Arctic Ocean. The Fourth Assessment Report by the IPCC regards geoengineering options as "largely speculative and unproven and with the risk of unknown side-effects"—and clearly not a rationale for an unimpeded conventional Arctic development trajectory (IPCC, 2007b, p. 15).

The far greater policy failure, however, would be not preparing for a time when last-ditch measures like geoengineering may be needed—in which case we must be extremely well-prepared about their use and implications. The Arctic Council should consider a strong position advocating for more research and a comprehensive scientific review to fill the considerable knowledge gaps that exist.

A geoengineered future?

A short introduction to geoengineering

Geoengineering and its pitfalls and benefits, risks and opportunities, technical details and environmental consequences has been well explained by others, so this introduction is brief.[6] The

[6] For excellent introductions to geoengineering, read David Keith (2000), Michael C. McKracken (2009) and Stephen Schneider (2008), each with their own insights.

term geoengineering lacks a precise and universally accepted definition (Keith, 2000; Schneider, 2008). It has grown into an umbrella term for a diverse collection of projects that "involve large-scale engineering of our environment in order to combat or counteract the effects of changes in atmospheric chemistry" (National Academy of Sciences, 1992, p. 433).

Its broadest definition also spans projects that affect the climate merely as a side effect (Schneider, 2008), but in the context of this paper, geoengineering entails purpose. We can generally categorize geoengineering efforts into two types: those that seek to regulate the temperature, and those that seek to regulate the amount of greenhouse gases in the atmosphere. This paper will focus only on the first type. In more technical terms, this type is often referred to as "solar radiation management" (SRM), because the means of reducing the temperature is through command of the amount of sunlight (more precisely, infrared radiation, or heat) that either reaches the lower atmosphere or is absorbed by the surface of the Earth (MacCracken, 2009). In other words, SRM aims to increase the Earth's albedo, which is a measure of its reflexivity. Picture our planet with a translucent sunshade of atmospheric particles that reflects heat radiation, or a city adorned with white roofs.

It is the idea of a sunshade that is interesting in the context of this paper, as it has two main benefits that might be helpful in the event of a climate emergency: the ability to directly counteract catastrophic warming, a short response time (Crutzen, 2006). Infusing the stratosphere with aerosols—for example sulphur dioxide (SO_2)—is probably the most well-known such concept, and could be deployed while we get emissions under control and perhaps try some other geoengineering tricks like scrubbing the air of CO_2. A stratospheric sunshade of this kind could be a cheap safety valve for runaway climate change. Though no firm cost estimates have been done yet, ameliorating post-Industrial Revolution warming through atmospheric aerosol injection could cost around $30 billion[7] a year (Keith & Dowlatabadi, 1992), or perhaps even less than $10 billion (Barrett, 2008; Keith, 2000).[8] Even the higher end of that estimate is but pocket-change compared to the hundreds of billions of dollars worth of damage climate change is projected to cause every year in the United States alone (Ackerman & Stanton, 2008). The technological barriers are commensurately low (Crutzen, 2006)—and therein is the allure.

SRM schemes have sparked a lot of controversy because they represent the ultimate end-of-pipe solutions, addressing the symptoms of global warming rather than its root causes. The climate is a complex system about which our knowledge is incomplete and uncertain, but scientists do know that changing the radiative balance of the Earth can provoke severe side-effects and climate perturbations (Matthews & Caldeira, 2007). Nature itself does this with regular intervals through volcanic eruptions, some of which have had led to significant worldwide cooling (Trenberth & Dai, 2007). Stratospheric aerosol infusion would mimic a volcano, but because aerosols generally only stay airborne for a few months, it would require a continuous effort. Once begun, the price of

[7] In 1985 dollars.
[8] Neither of the figures, however, incorporates the cost of externalities.

quitting might be steep: the climate would bounce back very quickly, at which time we would also feel the effect of the extra CO_2 that the atmosphere will have accumulated since the experiment began (Matthews & Caldeira, 2007). Not to mention that while temperatures might be returning to more familiar levels, the oceans would continue to absorb CO_2 like before, becoming increasingly acidic and hostile to marine life (Hoegh-Guldberg et al., 2007).

The list of criticisms against SRM goes on; they are far too many to deal with here. The chief criticism, however, is perhaps that we should not "meddle" with a system about which our knowledge is so incomplete and uncertain. For an overview of the most powerful arguments against geoengineering, see Alan Robock's article "20 reasons why geoengineering may be a bad idea" (2008).

Geoengineering and the Arctic

"The Arctic is changing very rapidly so it is an obvious early target for geoengineering," say two pioneers in geoengineering research, Ken Caldeira and Lowell Wood (2008, p. 4040). In the event that we pass a tipping point and a climate emergency ensues, our window of opportunity would be small and our options limited. Given the Arctic's sensitivity to global warming, its role in the Earth's radiation balance and all the other ways it affects the global climate, it has been singled out as a region that could deserve special attention from geoengineers. Their theory is that we can reduce the amount of solar radiation that reaches the Earth's surface—or insolation—in the Arctic and save the ice cap from disintegrating completely. This intervention could possibly be isolated to the Arctic.

The idea first appears on print in a report that followed a NASA workshop, attended by Caldeira (Lane, Caldeira, Chatfield, & Langhoff, 2006, p. 5). The workshop report suggested that aerosols could be emitted at high latitude—"near the North Pole"—to affect the polar region in isolation (Lane et al., 2006, p. 5). Caldeira and Wood went to work running computer models of the climate to figure out how extensive and dense a sunshade would have to be. Caldeira and Wood's study was more on the effects of insolation than anything else. Within the constraints of their model, which they call highly idealized, they show that a 21 per cent decrease in insolation north of 71°N could offset a doubling of the carbon dioxide level in the atmosphere (Caldeira & Wood, 2008, p. 4045). Dimming the sun by more than 20 per cent is substantial, but the area in question represents a mere 2.7 per cent of the Earth's surface.

Other scientists, however, are much less sanguine about our ability to confine atmospheric aerosols to specific regions (Robock et al., 2008). In model runs where SO_2 was injected into the stratosphere at 68°N—roughly the same latitude as Iceland—the effect was highest around that band of latitude but still substantial as far south as 30°N, on the American Gulf coast (Robock et al., 2008). Further, they found that placing the injection site in the tropics was more effective in limiting summer melting in the Arctic, and that the injected particles stayed in the atmosphere nine months longer. Both injection sites were found to create massive distortions in monsoon patterns in the southern

hemisphere. Where Caldeira and Wood were nevertheless vindicated in that aerosol geoengineering *could* ameliorate some global warming in the high North, and prevent disintegration of the ice cap (Robock et al., 2008). And the shorter residence time for particles from a northern injection site has the benefit that should something go wrong, the project could be shut down much faster.

Of course, none of the scientists cited above are saying this is something we ought to do; they are merely exploring the possibility and feasibility. Before we go to work geoengineering the Arctic, we clearly need to know more. Preventing the disintegration of the Arctic ice cap could be a cost-effective way of saving the world, but there are major unknowns and a potential for massive environmental distortion. Changing monsoon patterns, which were mentioned above, could affect hundreds of millions of people, and SO_2 is not harmless in itself: not only is it the ingredient in acid rain, but would be highly deleterious for the ozone layer (Rasch et al., 2008; Tilmes, Mueller, & Salawitch, 2008). Geoengineering could therefore compound problems in other areas, which in turn would demand their own responses, which could create a cascade of problems in yet other areas.

Should these externalities be counted into the cost of geoengineering? As pointed out above, after-the-fact solutions to climate change seem to be orders of magnitude less expensive than abatement measures, in support of the energy industry and climate change sceptics' old mantra that it is less expensive to deal with climate change after the fact than trying to prevent it.[9] The question is then, is geoengineering too dangerous to contemplate at all? Could it derail abatement efforts?

Towards global geoengineering governance

Why take geoengineering seriously?

U.S. President Lyndon B. Johnson received the first report on "made-by-humans" global warming in 1965 (President's Science Advisory Committee [PSAC], 1965). Not to worry too much, was the message; the scientists behind it felt confident that a technological solution would be found. It was the ethos of an era when scientists thought extensive weather modification was not only feasible but the logical next step in our quest for dominion over nature (Fleming, 2006).

We have largely left that sort of reductionist and mechanical thinking behind (Funtowicz & Ravetz, 1993). We should not look for technological solutions to a political and social problem (Sarewitz & R. Nelson, 2008). We fear the distraction and moral hazard that comes with introducing solutions that have no relation to the original problem: what if we become complacent with mitigation efforts, thinking that we can always fix the problem later? The danger is that even people who are normally sceptical about geoengineering might be influenced to not press as hard for mitigation as they otherwise would. For other people inherently sceptical to mitigation as a solution to climate change, geoengineering is a boon. In fact, conservative think tanks with considerable clout in Washington,

[9] See for example the American Energy Alliance's Web site at http://www.americanenergyalliance.org/ (accessed 10 August, 2009) or Bjørn Lomborg's Web site at http://www.lomborg.com/ (accessed 10 August, 2009).

D.C., such as the American Enterprise Institute, the Cato Institute and the Heartland Institute, are taken with the idea (Schnare, 2007a; Furchtgott-Roth, 2008; Taylor, 2007; Thernstrom, 2008). A senior fellow of the Thomas Jefferson Institute of Public Policy gave warm recommendations to geoengineering in testimony to the U.S. Senate Committee on Environment and Public Works (Schnare, 2007b).

Geoengineering was a taboo subject in scientific circles for a long time, yet the cat is out of the bag, posing a dilemma for everyone who distrusts geoengineering, but nevertheless favours cautious evaluation. It is a distraction from mitigation, but a worse alternative is to allow anti-mitigation forces to monopolize and set the terms of the debate. Geoengineering is today widely regarded with scepticism, but also with a resigned acknowledgement that one day, desperate times may call for desperate measures. Because lags in the system would ensure that warming would continue well into the future even if we shut off the carbon spouts today, we must get emissions on a downward trend before 2015, or risk exceeding the ostensibly safe level of 2°C of warming (Anderson & Bows, 2008)—a position recently endorsed by nine out of 10 climate scientists polled by the newspaper *The Guardian* (Adam, 2009). A commentary in *Nature* takes a similarly pessimistic view of the situation, predicting that we will not be able to limit the temperature increase to less than 4°C (Parry et al., 2009). With business-as-usual, they say, our only remaining option seems to be to "overshoot, adapt and recover" (Parry et al., 2009).

On geoengineering governance

Some observers have described climate change as the ultimate tragedy of the commons (Gardiner, 2003). Spurring mitigation efforts has not been easy, and geoengineering risks complicating matters further. Geoengineering does have some features that could simplify collective action, such as ostensibly low costs and low technical barriers, but inequitable distribution of benefits and harm—disruptions in weather patterns, for example—could make it very hard to consolidate collective action around the issue.

Geoengineering is still in its infancy, but building momentum behind new ideas and shoring up international support for tackling collective problems takes time. It took 32 years after PSAC presented its report in 1965 before the international community came together around a climate change treaty, the Kyoto Protocol. A full 44 years after 1965, as we approach the end of Kyoto's commitment period, progress on stemming climate change is still lacking.

Climate change has so far been creeping up slowly, but the dynamics of Arctic ice loss suggest that we may be approaching a critical threshold, and that we will not have the benefit of a long response time. The argument for considering geoengineering governance is therefore all about being prepared to meet a crisis, as many have argued before us (Barrett, 2008; Bengtsson, 2006; Cicerone, 2006; Homer-Dixon & Keith, 2008; Schneider, 2008; Victor, Morgan, Apt, Steinbruner, & Ricke, 2009;

Victor, 2008).

Charles Hermann formulated the classical international relations recipe of a crisis. Three ingredients, or pillars, are generally needed: a high level of threat; a short period of warning; and the need for a rapid response (Hermann, 1969). A climate emergency seems to satisfy all the criteria; adaptation and geoengineering being the only rapid responses possible. The question becomes how you can remove any of the pillars—the opportunity may not yet be lost to undermine the two first pillars and thwart the crisis. We cannot, however, afford to assume that we will, which means we must start building the foundations of the response pillar. With proper preparation and robust governance structures, we could perhaps remove it as a factor in a climate crisis.

It is possible, however, that we would have to add a fourth pillar, or at the very least build supports for the third one. Several authors note the international security risks inherent in geoengineering (Keith, 2000; Schneider, 2008; Cascio, 2008). For example, rapid response of the wrong kind may exacerbate the crisis rather than resolve it. So could rapid but uncoordinated response by several countries at once, to speak nothing of the problems that could arise if a country took umbrage at the geoengineering activities of others—say, because of massive negative consequences for themselves. If we are lucky, a potential climate crisis or tipping point will happen on its own, and not simultaneously with other major world events such as war, natural disasters, a global economic meltdown or a host of other converging stresses that increasingly besiege modern society (Homer-Dixon, 2006). If we are not so lucky, we will have to deal with several of these problems simultaneously.

Climate change is a global problem and so demands a global solution, even if the low technical barriers and seemingly good economics of infusing the stratosphere with SO_2 aerosols means a single country—perhaps one that is about to be inundated by water or one that has been seduced by the low cost—could do it alone. The danger of unilateral geoengineering only strengthens the argument for global regulation.

How should we organize the transnational debate surrounding this difficult issue? This paper argues that the quest for solutions is best informed by the field of global governance, which has sprung forth as a spontaneous response to the inability of the traditional international relations (IR) perspective to resolve increasingly complex transnational issues (Dingwerth & Pattberg, 2006). With its "assumption of sovereign nation-states embedded in an anarchical international system," IR is too rigid and narrowly focused on formalistic relationships between states to allow the flexibility necessary to build effective governance (Dingwerth & Pattberg, 2006, p. 189). IR is actor-centric and sees the world in terms of an international system composed of nation states, each on their own and in competition with other states. Global governance, on the other hand, sees a transnational society, and offers a much broader conceptualization of who is considered members of that society. Yet, the focus of global governance is not on actors but on the "norms, rules, and standards that structure and constrain social activity" (Dingwerth & Pattberg, 2006, p. 199). John G. Ruggie describes this as

the constitution of the new "global public domain" (2004).

Global governance thus allows us to think more flexibly about what solutions we can come up with, both now and in the future. Considering the conflicting and often narrowly defined interests of states, how they prioritize them in the Arctic and the consequences of double exposure, it is particularly important that non-state actors and non-dominant states are brought to the table to balance the discussion. Decisions about the future of the planet, or at the very least about geoengineering, are far too important to be left at the discretion of states only.

Yet the difference lies as much in the methods involved as in the actors. Flexibility, agrees David Victor, is of the essence in the construction of global geoengineering governance. As one of the few people who have started looking at geoengineering governance, he recommends that norm-building is the best option for the near term, and that the process should be bottom-up rather than top-down:

> *A more effective approach to building a relevant regulatory system would concentrate, today, on laying the groundwork for future negotiations over norms rather than attempting to codify immature norms now. Meaningful norms are not crafted from thin air. They can have effect if they make sense to pivotal players and then they become socialized through practice. To be sensible the norms must be based on evidence and reason; they must be relevant and responsive to core interests of pivotal players (Victor, 2008, p. 332).*

Overtly formal governance, he says, should be avoided this early in the game; enacting a formal ban on geoengineering—which has broad support in 2009—would be counterproductive, as countries that disagree could simply choose not to join, rendering the effort meaningless. Soft methods and intelligent use of discursive power would therefore be more useful to the political and social constitution of geoengineering.

Global geoengineering governance so far is spotty, bordering on non-existent—in fact, only two pieces of international legislation have direct bearing on it so far. One is a 1977 treaty banning the use of weather modification as an offensive weapon (Environmental Modification Convention, 1977)[10]; the other is the International Maritime Organization's (IMO) *London Convention*, which in 2007 listed ocean fertilization[11] as illegal marine pollution (IMO, 2008). A piecemeal build-up of regulation in this way is more in line with Victor's recommendation, but there is a pitfall in this approach as well. Geoengineering governance to date has only been covered in forums that are not primarily concerned by climate change. This could become a concern if the issue is hijacked by forums with anti-geoengineering agendas or whose main concern is not climate change. Norm-building and awareness campaigns are the only ways of preventing this.

[10] The magazine *Foreign Policy*, at least, is worried about this; see "Battlefield Earth" (Cascio, 2008).
[11] Another potential geoengineering technique.

Sooner or later, geoengineering may have to be elevated to the governance level in a comprehensive rather than in a piecemeal manner. The world is clearly not well served by confusion around the distribution of authority and legitimacy in an issue already inherently complex. Eliminating Hermann's response pillar thus demands that any such issues have been hashed out well ahead of a crisis. But if it is to have legitimacy and work towards the goal of building consensus, the discourse needs to be public.

A good deal is going to hinge on how the geoengineering debate is constructed in the social realm. If they ever emerge, will future geoengineers be villains or heroes? A taboo against geoengineering is the worst of all our options, as it might constrain those that would otherwise carry out the most responsible research, while turning other, less responsible actors away from international cooperation. It is, however, equally important that we do not leave a governance vacuum. That could lead to many of the same problems.

A role for the Arctic Council?

So if the challenge of geoengineering requires a global solution, why should a regional organization like the Arctic Council ("the Council") be involved? The goal of this paper was to look specifically at the consequences of business-as-usual in the Arctic, and to discuss geoengineering in the context of catastrophic climate change in this vulnerable region. Geoengineering poses dramatic challenges for all of the Arctic countries, which have committed themselves to cooperating through the Council. As the only circumpolar governance forum on environmental issues, the Council is an obvious venue for discussion.

We neither foresee nor prescribe that the Council should reinvent itself as a planetary engineer. It makes little sense that only eight countries—even if they include both the largest country on the planet, and the most powerful one—should dictate the climate of our planet. Quite the contrary: we argue that these countries have a fundamental responsibility to address the biophysical foundations of climate change through mitigation. A corollary is that although geoengineering may be available as an emergency solution, the more they drag their feet on mitigation, the more dramatic an eventual intervention would have to be.

But what can the Council do? Does considering geoengineering in any way even fall within its mandate? At its inception, the Arctic governments declared that the purpose of the Council is to

> *...provide a mechanism for addressing the common concerns and the challenges faced by their governments and the people of the Arctic. To this end, Ministers referred particularly to the protection of the Arctic environment and sustainable development as a means of improving the economic, social and cultural well-being in the North (Joint communiqué, 1996).*

The protection of the Arctic environment is the main driver of the Council, though it is worth noting that its mandate is open-ended, not barring other areas, save military ones (Joint

communiqué, 1996). Given that fact, geoengineering is as appropriate a topic for the Council as any other.

Geoengineering, however, is by definition unsustainable; it is the worst possible end-of-pipe solution. Continuous intervention is required to offset the effects of GHGs through SRM. Although only supposed to be temporary, it would have to be sustained for years, all the while doing nothing to alleviate the real problem and allowing the oceans to become increasingly acidic. That would seem to be the diametric opposite of the Council's sustainable development mandate. Nevertheless, that the day may come when geoengineering is considered the best way of protecting the global and the Arctic environment, and if the Council takes its mandate seriously, it needs to be prepared.

The role of the Council would be moderated by whether the actual act of geoengineering would take place in the Arctic or somewhere else. If there are benefits to placing aerosol injection in an Arctic country, the Council has good reason to become involved. But atmospheric particles know no bounds: they habitually and indiscriminately violate other countries' airspace, so geoengineering anywhere in the northern hemisphere will have a direct bearing on the Arctic. And there is little Arctic countries can do to stop them; at least the smaller ones—the writ of the U.S. or Russia is certainly more global. Conversely, it could be in the interest of the Council to convince the rest of the global community to deploy geoengineering in order to save the Arctic, and it might be met with deaf ears.

The questions that remain unanswered are what exactly the Council can do, and what its role should be. Speaking as the Chair of the Senior Arctic Officials, another piece in the Arctic governance tapestry, Icelandic Ambassador to the United Nations Gunnar Pálsson extolled in 2004 that "that climate change itself could and should be arrested and even reversed through human enterprise" (Pálsson, 2004, p. 4). Although not a direct endorsement, reversing climate change through human enterprise *is* geoengineering. The Council does not need to endorse geoengineering; it should not, however, ignore the issue or pass judgment until the concept and its consequences—both good and bad—are better understood. This paper suggests that there are two areas where the Council can play an important role when it comes to geoengineering: the very obvious one is research; the other is governance. These are discussed below.

Global and regional governance

Smaller countries in particular would benefit from a strong Council. But if they are serious about protecting the Arctic, solving collective action problems and otherwise fostering Arctic cooperation, Arctic states, big or small, cannot act alone or otherwise abandon the Council on this issue. Franklyn Griffiths's Arctic policy paper, discussed earlier, recommends that Canada should cooperate bilaterally with the United States on geoengineering (2009, p. 19). Unilateralism, however, or restricted geoengineer "clubs" of countries or private arrangements of any kind, ought to be avoided, as it could set an undesirable precedent for the handling of this and similar issues.

Yet, as it is based on soft law, the Council cannot compel any of its members to do anything (Koivurova & Vanderzwaag, 2007). The Council has received much criticism for its apparent timidity and lack of teeth (Young, 2009). It can only function if its members agree to use it and control their unilateral and isolationist instincts; the kind which are behind the increasingly hostile tone of some Arctic countries with regard to territorial issues. The Council itself, and its members, have recognized the need for organizational changes; the 2004 Reykjavik Ministerial Meeting concluded that the Council may need to reorganize itself to better deal with climate change (Koivurova & Vanderzwaag, 2007, p. 56). More formal arrangements like an Arctic treaty in the mould of the Antarctic Treaty have been discussed, but most observers regard such prospects as dim (Koivurova & Vanderzwaag, 2007; Young, 2009; Keskitalo, Koivurova, & Bankes, 2009).

Though many focus on the limits of soft law, others argue it has distinct advantages, which are more valuable for Arctic political cooperation at this point in time (Young, 2009). As several scholars argue, the political circumstances in the Arctic not only make a treaty flatly unrealistic, but also undesirable (Young, 2009; Keskitalo et al., 2009). The Council has evolved into a highly unique and dynamic organization, counting among its members not only states but also organizations representing indigenous peoples as permanent participants (Heinämäki, 2009; Tennberg, 2001), and other non-state actors that have been bound together in what Oran Young, a veteran in Arctic affairs, calls the "tapestry of transboundary cooperation in the circumpolar north" (2009, p. 76). The Council is a central element in this tapestry. Rather than spending its scarce resources on navigating the treacherous straits of treaty making, the Council has been able to focus its efforts instead on building community, regional cohesion, a sense of common purpose and scientific consensus—an approach that has had considerable success (Jabour & Weber, 2008; Young, 2009).

Young argues that this may actually be the Council's greatest strength:

> *Where, then, does the comparative advantage of the Arctic Council lie? It may come as a surprise to some to realize that the council's most important role is probably generative in nature. Through its very existence, the council has become a symbol of the emergence of the Arctic as a distinct region in international society (Young, 2000, p. 15).*

He goes on to say that the role of the Council in dictating the "policy agenda for the circumpolar north and in framing the issues that occupy prominent places on this agenda" are important parts of that generative power (Young, 2000, p. 15). Discursive power can thus be said to be the true face of the Council's authority, and in line with what is required in the construction of geoengineering governance—framing the issue is going to be paramount.

It helps the Council's legitimacy that it is not purely an inter-state institution, but counts indigenous organizations as permanent participants; thus it can actually say that it represents the voice of people living in the Arctic and not merely the interests of countries that are only partially in the Arctic, and whose capitals are mostly in the south. Indigenous people have traditionally been among the weakest

and least represented constituents of the North (Heinämäki, 2009; Shadian, 2007), and the recent focus on resource extraction, shipping, territoriality and sovereignty by southern interests illustrates that this is still largely the case. By investing in the Council, the Arctic Eight have a good opportunity to show that they take the opinions of their Arctic inhabitants seriously, since indigenous organizations can communicate with these countries on an equal footing in the Council.

On the other hand, this may have led to the suppression of knowledge and opinions from non-indigenous Arctic inhabitants, who experienced difficulties when trying to register their own concerns with their national government (Nilsson, 2009). The Council has nevertheless shown considerable acumen in bridging the "politics of scale" between the local and regional, and its success in bridging the divide between regional and global also speaks to its advantage (Nilsson, 2009). There are two ways to see this divide between local and global when it comes to geoengineering; it is a sword that cuts both ways: it is at once a local action with global effects, and global changes with local effects. Considering the wildly disparate effects geoengineering might have across the global landscape, and the sensitivity of the Arctic to climate change, bridging the gap between the local and the global should be a central task for the Council. This would include cooperating and creating linkages with other organizations and forums at the Arctic, interregional and global level.

Research

The Council may thus be well positioned to contribute to the social and political construction of geoengineering, but governance is not the only thing the Council can generate. Research, the framing of climate change and the creation of knowledge about climate change in the Arctic context have been important parts of their generative work, and have become core competencies of the Council, central pillars of its existence and legitimacy, and essential to its success as a regional forum. Most of its working groups are oriented around research agendas. The Arctic Monitoring and Assessment Program (AMAP) has been at the core of Arctic cooperation since before the Council was even created, at which point it became the largest working group within the Council (Koivurova & Vanderzwaag, 2007; Tennberg, 2001). ACIA, as mentioned previously, has given the Council a strong foundation in climate research, and AMAP is working on an update called "Climate Change and the Arctic Cryosphere: Snow, Water, Ice and Permafrost in the Arctic," now in the final stages of preparation (Hansen, 2009).

One could say that the Council has become to the Arctic what the IPCC is to climate change, though this comparison can only be taken so far. Part of the Council's (and particularly ACIA's) success stems from its unique structure, which allows indigenous organizations full rights to participate in working groups and in the scientific steering committees that are behind assessment reports (Heinämäki, 2009; Nilsson, 2009; Tennberg, 2001). This had led to the incorporation of knowledge and information that would not otherwise be considered scientific, but which nevertheless adds value to the Council's work. Indigenous observations of climate change are among

the information passed along to the Council.

As a result of the Council, our understanding of the vulnerable North has increased tremendously. The Council had good reason to focus on science and research initially, as knowledge about environmental problems in the Arctic was highly rudimentary (Tennberg, 2001). Our poor knowledge of things like feedbacks demonstrates that research is still necessary, and as noted previously, the scientific foundation of geoengineering in the Arctic and in general is embryonic to say the least. As of yet, we are aware of only three papers that have discussed geoengineering specifically in the Arctic context.

Being a forum that enjoys a high degree of legitimacy, the Council could make itself useful in building trust between the scientific community, policy-makers and the public. "Building trust between scientists and the general public," writes Paul Crutzen, one of the scientists responsible for bringing geoengineering to the fore, "would be needed to make such a large-scale climate modification acceptable, even if it would be judged to be advantageous" (2006, p. 217). Policy-makers may have to deal with a highly skeptical public when it comes to geoengineering, depending on the socio-political construction of the issue. There is ample reason for suspicion. For example, the priorities of the Canadian government in the North of late do not inspire confidence that it is sufficiently concerned about the consequences of climate change.

An evaluation of the merits of geoengineering cannot be done without a firmer scientific foundation, and this is one area where the Council can excel. Its role as a producer of high-quality, impartial and consensus-based research speaks well for its ability to produce good and agenda-free knowledge about geoengineering. In the grand scheme of things, research is relatively cheap[12]; yet, regardless of cost, it would be completely irresponsible not to do this kind of research. An uncomfortable question is whether the Council should concentrate solely on the consequences of geoengineering or whether it should aid and abet the research into actual techniques and engineering implementations. The answer is both. In anticipation that the mitigation strategies we are pursuing might ultimately fail, heavy investment will be necessary to make sure geoengineering is as safe and reliable as possible—unsavoury as that option might be. But geoengineering should only be another leg in the climate change adaptation strategy, not the mainstay of Arctic climate policy.

Going forward, the Council should reflect on its own position in the world, and how it can best consolidate the interests of its members, properly understood, with those of the world and the natural environment. It can begin slowly, by asking critical questions and thinking about difficult issues: threshold criteria, acceptable losses, offsets, resilience and the proper place of geoengineering in adaptation strategies, to name but a few areas. But perhaps more than anything, they should contemplate what their own priorities in the Arctic are, and whose interests they serve.

[12] See for example "Backgrounder - 26 International Polar Year Projects and Funding Churchill Announcement" (Office of the Prime Minister, 2007) for an overview of the costs of various polar research projects.

Conclusion

The Arctic Eight and the world in general are running out of time and options:

a) We can choose to address the biophysical causes of climate change through mitigation.
b) We can choose not to exacerbate the problem with a resource exploitation race.
c) We can choose an uncertain future of dramatic climate change and possible tipping points, where geoengineering may be our only option.

There are no sureties that we will not, at some point, be forced to geoengineer the climate regardless of what we do. Nor are there any sureties that we will ever arrive at a point where geoengineering is necessary or desirable. Nevertheless, the longer mitigation is delayed and the more we exacerbate the problem, the more likely such a situation becomes. Unfortunately, we will only know whether we have passed a crucial climate threshold after the fact.

When current policy papers intended for the highest reaches of government fail to explore and make unequivocally clear the consequences of the double feedbacks in the Arctic, and worse, when their recommendations promise to strengthen the same feedbacks, we have a deep policy dysfunction. Policy-makers see policy options that are divorced from the physical realities; policy options that at best will be inefficient and at worst counterproductive, while providing a false sense of security and control. When geoengineering becomes a policy recommendation on an equal footing with conventional environmental stewardship, it reveals a major epistemic and ontological failure of the policy communities that advise government policy.

Our purpose in this paper is not to deny economic development to the inhabitants of the Arctic. We want this to be a wake-up call for the political communities of the North, and the Arctic Council in particular, to the risks involved in the current development trajectory. The question is therefore whether Arctic inhabitants are ultimately well served by such development. At the same time, the Arctic Eight must be prepared to respond to the consequences of failure in the mitigation strategy. It is therefore time that the Arctic Council placed all facets of geoengineering high on its research agenda. Only through comprehensive, candid and rigorous research can we close the knowledge gaps and reduce the uncertainty surrounding geoengineering, which is a significant source of current scepticism. The risk of calling attention to geoengineering is, as is feared by its detractors, that the discourse lends credence and legitimacy to the concept itself ("if we are considering it, it cannot be all that bad"), and that the very knowledge of it will lead to complacency in mitigation efforts. That is an acknowledged risk, taken by all who choose to write seriously about geoengineering, because the risk of unimpeded climate change is perceived as even greater. The challenge will be to construct geoengineering in such a way that it is neither embraced too warmly nor eschewed too strongly.

We believe the Arctic Council is in a very good position to rise to that challenge. Representing countries that stand first in line to feel the full impact of climate change, the Arctic Council has the

necessary incentives to deal professionally with geoengineering. It has a solid climate science foundation upon which to build, and it may have the right dynamics and generative capacity to be an effective and constructive voice in an immature field, where social norms and perceptions are still being formed. However unsavoury geoengineering is, it is essential that we engage with it, and that we start doing so now, even if we may still have time to avert a crisis. Open and democratic dialogue is an essential tool constructing the issue in terms that are universally acceptable. Arctic indigenous organizations, already vocal in the climate change discourse and experienced in bringing the world's attention to their plight, could be vital in that effort. As permanent participants of the Arctic Council, they could put geoengineering research on the Council's agenda. Meanwhile, as the risks and implications of geoengineering become more apparent, the attention and dialogue ensuing from the Arctic Council's engagement with geoengineering might actually stimulate a re-doubling of mitigation efforts. That would be the best possible outcome of the geoengineering debate.

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