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Securing the ‘great white shield’? Climate change, Arctic security and the geopolitics of solar geoengineering

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Abstract

The Arctic has been identified by scientists as a relatively promising venue for controversial ‘solar geoengineering’ – technical schemes to reflect more sunlight to counteract dangerous levels of global warming. However, such plans have largely abstracted from increasingly tense regional security dynamics and the relative (in)significance of climate concerns among the key Arctic states. To fill this gap, we juxtapose recently published schemes for geoengineering the Arctic with Arctic security strategies published by the littoral Arctic states and China. This reveals two conflicting security imaginaries. Geoengineering schemes rely on a securitisation of the Arctic’s ‘great white shield’ as a bulwark that – if engineered – could protect ‘global’ humanity against the threat of climatic tipping points (with the Arctic nonetheless exempt from global geopolitics). Meanwhile, littoral states portray the Arctic as an increasingly contested security region of considerable geopolitical peril and economic opportunity. While presented as a relatively politically feasible case in geoengineering research, the deep entrenchment of the ‘geopolitical Arctic’ compared to ‘the global climate Arctic’, and the entangled history of science with geopolitics in the region, suggest that geoengineering schemes in the Arctic and by implication globally risk infeasibility – unless coopted by on-going competitive, extractivist reshapings of societies and natures worldwide.

Nikolaj Kornbech

Olaf Corry

Duncan McLaren.

Introduction

‘The Arctic region plays a key role in the global climate system acting as a carbon sink and a virtual mirror’ (C2G, 2021: 1) - thus reads a typical introduction to the rationale for solar geoengineering in the Arctic. To most, solar geoengineering – interventions that reflect sunlight to counteract anthropogenic global warming, is still an obscure idea. However, it is quickly gaining

traction among some groups of climate scientists, entrepreneurs and even some governments as climate impacts provoke an ever-increasing sense of alarm and urgency.

Debates concerning potential governance of solar geoengineering (SG) routinely acknowledge its potential international governance challenges, but have tended to leave security dimensions mostly unexamined (but see Nightingale and Cairns, 2014), usually by framing the challenge primarily in terms of coordinating efforts and dealing with potentially unwanted side-effects ([anonymised for review]). While climate change itself is often understood as a potential security threat, it has not yet motivated exceptional or decisive state action, but rather seems to produce a series of routine practices through which ‘climate change is rendered governable as an issue of human security’ (Oels, 2012: 201). Geoengineering could potentially change this situation. The potentially high-leverage, transboundary nature of large-scale solar geoengineering has led to suggestions that it would involve disagreements over the methods and intensity of interventions (Ricke et al., 2013), and could lead to international conflicts, not least from uni- or ‘mini’-lateral deployment (Lockyer and Symons, 2019). In addition, with its potential to make climatic changes and catastrophes attributable to (or able to be blamed on) the direct and intentional actions of states, SG could also make the rest of climate politics a more conflictual field ([anonymised for review]). Other scholars have examined geoengineering itself through a human security frame – recently developed as ‘ecological security’ with ecosystems as the main referent object (McDonald, 2023), where the insecurity arising from climate change is seen to go beyond the particularity of state interests. This casts geoengineering as a potential ecological security measure, or even as a potentially ‘just’ one, if it protected groups otherwise vulnerable to climate threats (Floyd, 2023). However, the entanglement of geoengineering, even if framed as an ‘ecological security’ measure, with national and international security dynamics, would remain a distinct risk, in similar ways to how humanitarian aid and development have become entangled with, and for some historically inseparable from, security (Duffield, 2007).

In this article, we seek to move beyond theoretical speculation about the international relations of geoengineering abstracted from historical or regional security dynamics, using a case study of the Arctic to investigate how geoengineering might (not) enter this political space, and derive conclusions of broader relevance to the international debate. We make use of the empirical richness revealed by schemes for Arctic geoengineering to identify how *security imaginaries* – ‘map[s] of social space’ (Pretorius, 2008: 112) reflecting common understandings and expectations about security – are already implicit in scientific and technical visions of geoengineering. We contrast these *scientific* security imaginaries with current *state* security imaginaries that play a dominant role in the anticipation of Arctic futures more generally. As we will show, scientific

security imaginaries consider the Arctic as a best case for geoengineering in terms of political feasibility. This allows for analytical inference based on critical case selection (Flyvbjerg, 2006): if even in the Arctic these scientific security imaginaries have little compatibility with current state security imaginaries, geoengineering faces major obstacles of politically feasible in other regions and globally, unless deployed in pursuit of security – rather than global environmental protection.

Many different ideas for solar geoengineering have been explored as ways to cool the Arctic.¹ These include stratospheric aerosol injection (SAI): spraying reflective aerosols like sulphur or calcite into the stratosphere (Lee et al., 2021)²; marine cloud brightening (MCB): spraying salts from sea vessels to make marine clouds more reflective (Latham et al., 2014); or covering ocean or ice surfaces with reflective materials (Field et al., 2018). Related ideas involve using wind power to pump water onto ice to help thicken it (Desch et al., 2017), underwater ‘curtains’ to protect ice from warmer water streams (Moore et al., 2018), or reintroducing large animals to graze and trample so that dark boreal forest is replaced by reflective snow-cover, protecting permafrost (Beer et al., 2020).³

While geoengineering scientists seek to distance their work from geopolitical concerns (Svensson and Pasgaard, 2019), scientific research in the Arctic – even that involving cooperation between Cold War adversaries – has long been deeply entangled with state security objectives and military interests (Doel et al., 2014; Goossen, 2020). Similarly, weather modification schemes have a history of (largely failed) entanglement with military purposes (Fleming, 2010), while climate modelling evolved partly through and with military scenario-making (Edwards, 2010). Climate modelling occupies a more civilian location in multilateral institutions now but still shares its particular way of seeing the climate – as a space of geophysical flows – with a military gaze (Allan, 2017).

More importantly, the interrelated environmental, economic and geopolitical interests in opening up the Arctic that are emerging with global warming make for a particular set of contradictions and tensions in the region that we argue will be much more likely than global environmental concerns to determine what role (if any) geoengineering could or would play. Arctic SG ideas are emerging largely oblivious to this context, which is understandable, but makes for an interesting comparative analysis that, as will we show, raises questions concerning the overall

¹ See e.g. Centre for Climate Repair at <https://www.climaterepair.cam.ac.uk/refreeze>

² In practice, aerosols distributed in or near the Arctic would likely spread over much of the Northern hemisphere (Duffey et al., 2023).

³ The latter approaches may also be categorised as ‘nature-based solutions’ or adaptation. In this sense they are hybrid measures, and we include them here because they also directly or indirectly affect the radiation balance.

feasibility of SG in the Arctic, especially deployment of it in line with scientific imaginaries. Since scientific literature tends to be central to governance-oriented assessments of SG (e.g. NASEM, 2021), a mismatch between assumptions has potentially serious policy implications, not least in terms of overall feasibility, which in turn augments risks of such schemes failing and contributing to mitigation deterrence (when they were hoped or planned for, delaying emissions reductions ([anonymised for review])). Attention to the geopolitical complexities of Arctic geoengineering could prevent scientific work being translated into policy prescriptions in unintended ways or having unexpected effects – if the complexities can be foregrounded when interpreting such work, and be considered in designing future research.

Approach

We analyse both Arctic geoengineering schemes and state strategies for the Arctic as *security imaginaries*. This concept draws on Charles Taylor’s notion of the social imaginary, ‘the ways people imagine their social existence, how they fit together with others, how things go on between them and their fellows, the expectations that are normally met, and the deeper normative notions and images that underlie these expectations’ (Taylor, 2004: 23). Imaginaries, in this sense, are *worldviews* – sets of assumptions that may or may not correspond to social reality but affect it in significant and material ways. They are not simply subjective constructions to be weighed against some objective reality, but (often competing) ways of constructing and institutionalising the world. Following Pretorius (2008: 112), a security imaginary is then ‘that part of the social imaginary as “a map of social space” that is specific to society’s common understanding and expectations about security and makes practices related to security possible’. Regrettably, social imaginaries are often theorised through ‘internalism’: as if a society is determined by factors originating within that society alone (Rosenberg, 2016).⁴ This makes it difficult to explain why different societies often have similar security imaginaries. By breaking with internalism, national imaginaries can be understood as inherently international in the sense that they are deeply affected by coexistence with other societies. For Pretorius (2008: 112), “the security imaginary is ... open to influence from perceptions, beliefs and understandings of other societies about security” due to “trans-societal exchanges” such as travel. But in a deeper way, the mere existence of multiple societies is fundamental to the whole idea of (national) security (Rosenberg, 2016). In addition, if the Arctic is considered a ‘regional security complex’ (Lanteigne, 2016) such that the security imaginary of societies in a region ‘cannot be reasonably analysed or resolved independently of each other’ (Buzan and Wæver, 2003: 44) then relations between societies become constitutive, even,

⁴ For an influential example of internalism, see Jasanoff (2015).

of security imaginaries of that region. Scientific communities – in this case geoengineering researchers – can produce a different ‘map of social space’ from national ones, since the groups (in one version ‘epistemic communities’ (Haas, 1992)) producing these are not necessarily national, and use different tools and concepts than national security communities. At the same time, scientists are rarely unaffected by their backgrounds, and their technical and conceptual tools for producing such a ‘map’ reflect traces from state priorities and international structures, including colonial legacies (Mahony and Hulme, 2018). State and scientific security imaginaries are thus distinct but not separate, and as we shall see, can clash or draw upon each other, often implicitly.

The security imaginary concept captures three important characteristics of our empirical materials. First, geoengineering ideas and state security strategies are *performative* (rather than purely descriptive) in their anticipation of (Arctic) futures (Anderson, 2010). Second, they are based on understandings of social order which merge factual and normative claims – what is and what should be (Taylor, 2004). Third, they construct threats and necessary responses in terms of the security of that social order, irrespective of whether those threats are of a military nature or otherwise (e.g. a climatic threat); in other words they can *securitise* a variety of referent objects (Buzan et al., 1998). In investigating scientific and state security imaginaries, we focus on the difference in the construction of two objects: *climate* and the *international order*. We ask: how is the ‘Arctic climate’ articulated and made legible in relation to the planetary climate and other factors, and further, how is the Arctic climate problematised and related to concerns of desirable or undesirable futures? What political, economic, and international infrastructures are presumed? In sum: what threatens and what defends Arctic and international order?

To explore the security imaginaries of Arctic geoengineering, we gathered materials that construct Arctic futures through searches in the peer-reviewed literature with the search terms ‘Arctic’ and ‘geoengineering’ using Web of Science, as well as search hits on the term ‘Arctic’ in the archive of the Climate Engineering Newsletter run by the Kiel Earth Institute,⁵ which also covers grey literature and press coverage on the topic.⁶ We manually excluded texts exclusively focused on carbon removal forms of geoengineering, except those with positive effects on the surface albedo. For the state security imaginaries of the Arctic, we consulted policy documents and other official government publications looking for the most recent policy statement in each of the littoral states: Canada, the United States, Russia, Norway and Denmark (which controls

⁵ Now the ‘carbondioxide-removal.eu’ newsletter, available at <https://carbondioxide-removal.eu/news/> (last accessed 1 August 2023).

⁶ Searches were conducted in the spring of 2022.

the security and foreign policy of Greenland) concerning their respective Arctic security strategy.⁷ Public documents are often used as data in security studies as testaments to state preferences or intentions, despite the often performative character of such documents. Such documents generally attempt to portray the institutions that produce them as competent and coherent – and of value to particular external audiences. As such they are potentially unreliable as sources for underlying *intentions*, levels of capacity and commitment behind policy goals. However, as documents set out to *perform* a future which is seen as desirable – either by the authors themselves or the audiences they appeal to – they are a useful guide to the underlying assumptions of social and international order guiding Arctic security politics – the state security imaginaries, in other words. We therefore study them for their performative content, with particular emphasis on the intended audiences and messages (Coffey, 2014). Similarly, geoengineering publications also perform a material and political Arctic future to advance scientific or research agendas, and we therefore analyse the underlying imaginary of their desired futures, without prejudice to the climatological or technological feasibility of the envisioned schemes. In so doing, we must acknowledge the highly consequential difference in the power to securitise between the actors which produce the imaginaries. The state apparatuses producing the state security imaginaries are more aligned with, and therefore more likely to influence, actors with the power to securitise (Floyd, 2021). We read both sets of imaginaries in this light.

The ‘great white shield’: scientific security imaginaries

In geoengineering studies and policy papers, the Arctic is foremost understood as a part of the *global* climate system ([anonymised for review]), with focus placed on potential tipping points in terms of alarming above-average warming, the sea ice albedo feedback, and the potential release of methane and carbon dioxide from thawing permafrost or undersea clathrates. These may push the Earth into feedback cycles of further warming. The Arctic is therefore seen as a ‘great white shield’ for the global climate, but a fragile one: ‘the weakest link in the chain of climate protection’ (Zaelke, 2019: 241).

Those advocating exploration of Arctic geoengineering argue that emissions cannot be reduced in time to prevent tipping points. One paper contends that cryospheric tipping points ‘are essentially too late to address by standard political processes that usually require 30-year time-scales’ (Moore et al., 2021: 109). This pessimistic assessment spawns a complementary opposite: hopes that geoengineering might prove especially feasible and desirable in the Arctic, with

⁷ We later chose to include China’s Arctic policy for important additional context.

associated aspirations for near-term experimentation and potential deployment. One researcher coined the term ‘Arctic Premium’, arguing that the particular climatic characteristics of the region will enable ‘a dividend for regionally based climate interventions that could be less expensive, more effective and achieve faster results than if they were targeted over the whole earth’ (Littlemore, 2021: 2) – the Arctic imagined as an effective and relatively accessible lever for operating on the global climate system as a whole. While regional benefits such as the preservation of ice-dependent Indigenous ways of life are sometimes mentioned (Moore et al., 2021: 110), this tends to occur when regional benefits align with what are understood as global climatic interests. This instrumental attitude can also be seen in proposals that see the Arctic as a testing ground, including ‘SCoPEX’, which would have tested SAI equipment over Indigenous Sámi land, and the suggested use of the Sermeq Kujalleq glacier in Greenland – Inuit territory – as a prototype for more substantial glacial geoengineering in the Antarctic. The Sermeq Kujalleq proposal is justified on the basis of ‘fewer global environmental impacts’, despite the considerable amount of local socio-environmental impacts and acknowledgement that ‘the reactions of local people would be mixed’ (Moore et al., 2018: 304). In a quote that sums up the assessment of most researchers Bodansky and Hunt (2020: 601) argue that: ‘as bad as Arctic melting is for the Arctic itself, its global effects are more concerning’.

The concern with global effects infuses scientific security imaginaries with urgency. The ostensible ‘speed’ (Zaelke, 2019: 244) of solar geoengineering is contrasted with the slowness of politics, emissions reductions and large-scale carbon removal.⁸ In many cases such invocations of urgency lead to claims that geoengineering is necessary: that ‘excluding polar ice restoration could make the 1.5°C goal impossible to achieve’ (Field et al., 2018: 883), or that ‘more and more people see geoengineering as a necessity more than an option, making it a matter of when rather than if’ (Barclay, 2021: 4). One proposal notes that ‘these are expensive propositions, but within the means of governments to carry out on a scale comparable to the Manhattan Project’ (Desch et al., 2017: 121); others also specify funding by rich states as the way to move forward on research and deployment (Moore et al., 2021). The urgent threat of Arctic climate change is seen as a job for decisive state action, and thus it is argued to be salient in so far as it appears as a universal threat to state interests. At the same time, the causes of climate change are downplayed and depoliticised across the literature. Attributing climate change to emissions from ‘human societies’ (Beer et al., 2020: 1), the literature frames out the vastly unequal responsibility for climate change and the social and economic dynamics driving historical and continued emissions.⁹ One policy

⁸ For the latter see Desch et al. (2017).

⁹ There are some limited exceptions (Baiman, 2021; Moore et al., 2021).

paper neglects social causes of climate change altogether, contrasting geoengineering only to ‘conventional mitigation policies’ (Bodansky and Hunt, 2020: 597) and ‘decarbonisation of the global economy’ (616). In this way Arctic climate change is constructed as a global security threat, seen as stemming from the ‘tight couplings within global systems, processes, and networks’ (Miller, 2015: 278) rather than the actions of any specific group of humans, and as a threat to global ‘human security’ and therefore not subject to the division and distrust of international politics. In this, the imaginary resembles much liberal environmentalism in international relations, characterised by a ‘global cosmopolitanism’ which does not seriously engage with inequalities of power and intersocietal difference (Chandler et al., 2018: 200).

This imaginary is probably adopted to construct scenarios for technical research, since it fits neatly with modelling tools that produce visions of geoengineering in purely technical Earth system terms. But the liberal imaginary also shapes assessments of political feasibility and could impinge on the technical design of geoengineering schemes, including in ways that can be hard to unpick when the research enters the political sphere. Most publications entirely omit considerations of state security, including some papers that focus on governance (Bodansky and Hunt, 2020; Moore et al., 2021). The mentions of security that do exist are brief and vague: C2G (2021: 2) notes that ‘evidence suggests potential security issues may arise’ in the case of stratospheric aerosol injection. Another paper notes as an example of ‘geo-political ... friction’ that ‘Arctic regions such as Russia, Alaska and the Canadian Yukon would be providing a global public good ... which would add a major new dimension to international relations’ (Macias-Fauria et al., 2020: 10), suggesting that geoengineering can be adequately grasped through rationalist decision frameworks where global public goods offer non-rival and universal benefits, which is disputed (Gardiner, 2013).

In the research, the omission of geopolitics is justified by relegating it as a problem which only concerns the ostensibly more controversial techniques such as SAI deployed globally. There is a hope that ‘Arctic interventions pose less of a governance challenge than global climate interventions’ (Bodansky and Hunt, 2020: 609). This rests on the twin claim that the physical effects of Arctic interventions will be more limited and therefore less risky, and that the Arctic’s political environment is more conducive to geoengineering than the ‘global’ polity as a whole.

In terms of physical effects, many Arctic interventions are argued to be ‘low-risk’ (Barclay, 2021: 4) due to fewer and less severe environmental side effects. What Zaelke calls ‘soft geoengineering’ (Zaelke, 2019: 243) approaches are presented as ‘more natural’ (Littlemore, 2021: 2) than the most commonly considered SG techniques such as SAI or MCB which involve physical and

chemical manipulation of the atmosphere.¹⁰ In particular, efforts to restore sea ice without atmospheric interventions are promoted highlighting the ostensibly more ‘natural’ character of their intervention (Field et al., 2018: 899). ‘Unlike other [SG] methods, thickening sea ice is attractive because it merely enhances a naturally ongoing process in the Arctic’, claims one proponent (Desch et al., 2017: 112). Efforts at ecological intervention in ecosystems to halt permafrost thaw are also described as ‘a return to a more “natural state”’ (Moore et al., 2021: 111). ‘Soft’ geoengineering concepts are in many cases linked to discourses of conservation, with the sometimes-explicit expectation that this will make them more benign and less politically controversial: ‘Since it is rooted in the preservation of the existing state rather than introducing new and undeniably controversial elements into the atmosphere, it likely presents easier governance challenges’ (Moore et al., 2021: 116).

Such distinctions between ‘natural’ and ‘unnatural’ interventions may well facilitate cooperation around some methods, but notions of ‘natural’ are also situated, making distinctions inevitably difficult to maintain in practice. For example, if significant Arctic cooling occurs without a proportional cooling of the Antarctic,¹¹ the change in hemispheric heat balance would most likely shift the Intertropical Convergence Zone (ITCZ) southwards, leading to severe decreases in rainfall across the Sahel, parts of the Amazon and northern India (Duffey et al., 2023: 14). In this way an ostensibly ‘natural’ Arctic intervention would lead to unprecedented anthropogenic – and for others therefore ‘unnatural’ – climatic outcomes elsewhere. This reveals an imaginary at work in the scientific discourse: a distinct construction of ‘natural’ emerges to bridge aspirations of technical manipulation of the climate with what scientists see as palatable to (or believe to be) social ideals of ‘nature’.

In addition, the adjectives used to describe ‘soft’ geoengineering – ‘targeted’ (Moore et al., 2021: 108), ‘localized’ (Latham et al., 2014: 3), ‘reversible’ (Barclay, 2021: 4), ‘intelligent’ (Field et al., 2018: 900), all point to an imaginary where aspirations towards the ‘natural’ are combined with expectations of fine-grained, scientifically-calibrated control. As one commentator explicitly suggests, ‘in other words, we have control over soft geoengineering’ (Zaelke, 2019: 243) – the

¹⁰ Although many invocations of soft geoengineering explicitly exclude SAI and MCB, arguments that employ the core distinction between global, risky approaches and more targeted benign ones have also been used to justify Arctic-specific MCB, due to the “vastly reduced levels of seeding” making negative side effects “vastly reduced or eliminated” (Latham et al., 2014: 9). Former UK Chief Scientific Advisor David King has also recently referred to MCB as “a biomimicry system” (*The Current*, 2022). While much rarer, arguments about reduced side effects have also been applied to Arctic-specific SAI (Lee et al., 2021).

¹¹ Techniques such as ice restoration or marine cloud brightening would be particularly susceptible to such asymmetry, but even SAI (scarcely seen as ‘natural’ anyway) would be practically more difficult to counterbalance with Antarctic operations.

‘we’ here left ambiguous. The idea of having a relatively large degree of control originates in restraint vis-a-vis ‘global’ SG, in that it recognises large risks from attempting to control the global climate system as such. But this sense of fine-grained control may also encourage more Promethean dreams of a ‘designer climate’ (Oomen, 2021), as speculation over future possibilities of ‘fine-tun[ing] the flows of heat, air and water’ using localised MCB indicates (Latham et al., 2014: 10).

In terms of the Arctic’s political environment, discourse on the feasibility of geoengineering reveals further elements of a liberal imaginary, relying on (existing or imagined) international law and institutions, distributive justice and consequentialist ethics (Baiman, 2021; Barclay, 2021), a focus on cost minimisation (Desch et al., 2017; Field et al., 2018) and market-based approaches such as payments for ecological services (Moore et al., 2021) or carbon credits (Macias-Fauria et al., 2020) in the implementation of geoengineering schemes. Taken together, such measures rather well resemble a ‘liberal cosmopolitan framework through the advocacy of managerialism rather than transformation; the top-down coercive approach of international law; and use of abstract modernist political categories’ (Chandler et al., 2018: 190).

Distributive notions of justice and consequentialist ethics are arguably also at the root of claims that local populations in the Arctic, including its Indigenous peoples, may be uniquely receptive to geoengineering schemes. While many advocate public engagement (Desch et al., 2017; Macias-Fauria et al., 2020) and stress that ‘Northern people who use and depend upon the existing landscape need a strong voice’ (Littlemore, 2021: 3) there is a general expectation that such engagement will not be prohibitively conflictual. One policy scholar suggested that ‘given that Northern people are already seeing the effects of climate change, the North may be a place for a more pragmatic, constructive, and legitimate deliberative discussion on Arctic interventions’ (Ted Parson, quoted in Littlemore, 2021: 5). Other researchers have concluded that using SAI would conserve ‘indigenous habits and lifestyles’ in the Arctic (Chen et al., 2020: 1) as a direct consequence of reducing permafrost thaw. These assumptions were strained by the SCoPEX controversy, where the Sámi Council strongly opposed the experiment planned in their territory (Cooper, 2023). Equally, Arctic populations (Indigenous and non-Indigenous) have varied interests that cannot be assumed to be oriented to preventing or reversing Arctic climatic change, some seeing new opportunities for economic development and potentially political independence in the case of Greenland (Jacobsen, 2020).

Political feasibility of geoengineering plans is often assessed through legal analyses that weigh up specific techniques and target environments in relation to existing treaties and other legal regimes (Barclay, 2021; Bodansky and Hunt, 2020). Some place hope in techniques such as

permafrost/glacier preservation that may be deployed within the bounds of a single nation's territory, which would in their view sidestep the need for international governance altogether: 'for example, Russian and Canadian policies could change the carbon released from thawing permafrost. Similarly, Greenland's ice sheet would be the primary responsibility of the Greenlanders' (Moore et al., 2021: 109). While such techniques might be localised in effect, and only intended to slow climate feedback effects such as the rate of ice loss, inclusion of such measures in market credit schemes, as attempted by the Real Ice project (*for Tomorrow*, n.d.), could prove controversial and under some conditions undermine any SG-based climate effect (Fearnough et al., 2020: Ch. 3).

For cross-border geoengineering schemes, the Arctic Council¹² is in some cases highlighted as a favourable site for governance (Desch et al., 2017). One paper calls it an 'obvious institution' for international governance of Arctic geoengineering in general, contending that 'because of its relatively small size, the Arctic Council has been a relatively effective forum to develop regional policies relating to the Arctic' (Bodansky and Hunt, 2020: 610). However, in a later article one of the authors described the Arctic Council as 'an informal institution that lacks any regulatory powers and shows no signs of being up to the task of taking significant action' on Arctic climate change (Bodansky and Pomerance, 2021: 2). Moore et al. (2021: 113) similarly contend that 'the Arctic Council is not a true international organization with rule-making power'. Yet Moore et al. still argue the Arctic is a politically tractable space for geoengineering due to the low number of states that would need to come to an agreement – in contrast to global SG which 'would ideally need at least near-global consensus' (2021: 109).

This reveals an important complexity in the concept of globality that permeates the geoengineering imaginaries. While the Arctic, as we showed above, is instrumentalised for a global community – operated on to mitigate climatic effects across the planet – it is also differentiated from 'global interventions' that take the global Earth system as their direct object of intervention (Bodansky and Hunt, 2020: 597). As Moore et al. (2021: 109) state explicitly, 'targeted geoengineering is done on regional scales but aims to conserve the various parts of the global climate and earth system'. The politically salient objects are imagined to be the *methods* of intervention, spatially bounded in the Arctic region while the intended global climatic effects are in effect rendered unproblematic and therefore without need for governance. Arguably this reflects a common assumption that governance is only relevant in the case of 'adverse or unintended effects'

¹² Composed of the littoral states, Finland, Iceland, Sweden, and six 'permanent participants' representing Indigenous groups: the Aleut, Athabaskan, Gwich'in, Inuit, Sámi, and the Russian Association of Indigenous Peoples of the North.

(Barclay, 2021: 5) - the intended effect of albedo modification implicitly understood as an unambiguous global public good. On a technical level, the risk of a southward ITCZ shift described above obviously puts this assumption into question. But more crucially, the assumption projects exactly those liberal rationalist norms which are argued to be especially present in the Arctic on to the wider geopolitical context. The specific imaginary constructed to justify regional geoengineering interventions as politically feasible while still being part of a global solution to climate change cannot work without a general liberal imaginary of international politics. Otherwise, the global effects of regional interventions would threaten to undo the validity of the 'regional feasibility' argument.

Arctic state security imaginaries

The history of scientific research in the Arctic reveals the liberal security imaginaries underlying Arctic geoengineering to be a relatively recent phenomenon. Doel et al. (2014) describe the intertwinement of twentieth-century Arctic research projects and three broad state goals, shared to varying degrees by all littoral states: national security, exploitation of natural resources, and extension of territorial sovereignty to disputed areas. When intercontinental and submarine-launched ballistic nuclear missiles were introduced from the late 1950s, the Arctic became a 'buffer zone' between the Cold War powers, experiencing a continuous period with low military activity and absence of conflict that likely paved a way for increased cooperation after the Cold War, with Mikhail Gorbachev famously declaring the Arctic a 'zone of peace' (Gjørsv and Hodgson, 2019: 2). The Arctic came to be seen as an 'exceptional' region in the post-Cold War period, where institutionalised multilateral cooperation on regional issues, particularly environmental and scientific activities, could blossom (Lackenbauer and Dean, 2020). In this section, we examine recent state strategies and developments in the Arctic to assess the contours of the current leading security imaginary among Arctic states.

The key characteristic of Arctic exceptionalism is that geopolitical conflicts and tensions from outside the Arctic are excluded from affecting cooperation on internal Arctic issues and that, as a corollary, specifically 'Arctic issues' are compartmentalised: 'Actors ... can talk about everything *except* contentious issues, not least military security' (Gjørsv and Hodgson, 2019: 3, emphasis in original). However, this compartmentalisation is hard to find in recent state assessments. The US emphasised in 2019 that 'The Arctic remains vulnerable to "strategic spillover" from tensions, competition, or conflict arising in these other regions' (USDoD, 2019: 6). In 2020, the Danish Minister for Foreign Affairs spoke of 'a new security-political dynamic in the region. Disagreements and conflicts originating in other areas of the world are also being

expressed in the Arctic’ (Kofod, 2020: 1).¹³ For the four NATO members in the Arctic littoral, such concerns were obviously directed at the only non-NATO state: Russia (even before the invasion of Ukraine). Denmark expressed concern over ‘the Russian build-up of military capabilities’ which ‘is primarily defensive, but increasingly includes elements that can be used for offensive operations’ (Kofod, 2020: 2). Norway stated that ‘Russian build-up of forces and military modernisation can challenge the security of Norway and allied countries directly’ (RMFA, 2020: 23). It cited the Russian annexation of Crimea as a key moment in increased tensions and deteriorating optimism regarding peaceful cooperation in the Arctic (RMFA, 2020: 10). Russia, for its part, described ‘military buildup by foreign states in the Arctic and an increase of the potential for conflict in the region’ as a ‘challenge’ (OPRF, 2020: 5).

Amongst the NATO states, these assessments have for several years been accompanied by a call for deeper military cooperation. Denmark has pledged to ‘support NATO’s role in the Arctic and the North Atlantic’ (DMFA, 2022: 23), a change from previous strategy documents which stressed that ‘enforcement of the realm’s sovereignty is fundamentally the responsibility of the realm’s authorities’ (DMFA et al., 2011: 20). Canada aims to ‘increase surveillance and monitoring of the broader Arctic region’ in collaboration with the US, Denmark, and Norway (GoC, 2019: 77), while Norway in 2021 negotiated a deal with the US to allow it access to two Arctic military installations, the Ramsund Naval Base and the Evenes Airfield.

Trust has only deteriorated further since Russia’s full-scale invasion of Ukraine in 2022. All Arctic Council member states except Russia announced they would suspend participation in council meetings because of the invasion, subsequently announcing a ‘limited resumption’ of projects without Russian participation (*Global Affairs Canada*, 2022). The recent U.S. Arctic strategy describes ‘increasing strategic competition in the Arctic ... exacerbated by Russia’s unprovoked war in Ukraine’ (White House, 2022: 3), and claimed that ‘Russia’s war of aggression against Ukraine has rendered government-to-government cooperation with Russia in the Arctic virtually impossible at present’ (White House, 2022: 14). Russia interprets Arctic politics on similar terms; the Arctic ambassador has stated that the Finnish and Swedish bids to join NATO ‘will of course lead to certain adjustments in the development of high altitude [sic] cooperation’ (quoted in Staalesen, 2022).

This dynamic of *de-exceptionalisation*, where Arctic is increasingly reintegrated into great power politics, is the contemporary context in which the littoral states interpret the region’s present and future climatic changes. The state goals associated with early and mid-twentieth century

¹³ All quotes from Danish and Norwegian sources are authors’ translations.

Arctic science are reappearing as a background for envisioning the impact of climate change. Of the three goals identified by Doel et al. (2014), assertion over disputed territories is arguably of lesser importance today. All states have indicated a willingness to settle territorial continental shelf disputes via international law, and such statements are generally accepted by commentators as genuine (Østhagen, 2018). But the goals of military national security and extraction of natural resources are growing in salience, and changing in character, as the ice melts and the permafrost thaws.

In contrast to the geoengineering literature, climate change is rarely addressed as a primary threat in state policies but described in more restricted terms. Adaptation problems from ‘sea-ice loss, permafrost thaw and land erosion’ (GoC, 2019: 63) are emphasised, and both Canada (GoC, 2019: 18) and Norway (RMFA, 2020: 14) describe climate change as a cultural threat to Indigenous peoples. Nonetheless, the task of emission reductions does not figure as a specifically Arctic objective (e.g. RMFA, 2020: 14). In this way climate change figures less as a problem that must urgently be dealt with, and more as an unavoidable condition of Arctic politics. In the context of military security objectives, climate change is understood primarily as a driver of increased navigability and accessibility of the Arctic. The US Navy anticipates an increasingly ice-free ‘blue Arctic’ where ‘peace and prosperity will be increasingly challenged by Russia and China, whose interests and values differ dramatically from ours’ (USDotN, 2021: 2). Cold War-era interpretations of the Arctic’s geographical significance are being reinvigorated: Canada stresses the importance of maintaining air and missile capabilities in its Arctic region due to its location along the shortest path from Russian to US territory (GoC, 2019: 77). And as the region becomes more accessible, it rises in strategic importance. The US Department of Defense presents the Arctic as ‘a potential corridor – between the Indo-Pacific and Europe, and the U.S. homeland – for expanded strategic competitions’ (USDoD, 2019: 6), and stresses that ‘maintaining freedoms of navigation and overflight are critical to ensuring that ... U.S. forces retain the global mobility guaranteed under international law’ (USDoD, 2019: 13).

The increased accessibility of the Arctic also brings new hopes of further use of the region’s natural resources as a vehicle for economic growth (Keil, 2014). Such goals have become intertwined with development discourses and policies that focus on lack of modern infrastructure, low employment, and population decline, and in this way align the economic objectives of faraway capitals with local concerns. Canada aims to ‘close the gaps and divides that exist between this region, particularly in relation to its Indigenous peoples, and the rest of the country’ (GoC, 2019: 36) and presents these gaps in a consumerist national imaginary where being ‘full participants in Canadian society’ means having ‘access to the same services, opportunities and

standards of living as those enjoyed by other Canadians’ (GoC, 2019: 36). The Russian government frames its Arctic policy goals in terms of avoiding a dystopia of a depopulated region lacking economic growth, and such fears are directly presented in security terms: ‘population decline’ and ‘insufficient development’ of infrastructure and business are named ‘primary threats to national security’ (OPRF, 2020: 4–5). In Norway, Northern depopulation is presented as a key concern to be addressed through investment in public education and business infrastructure (RMFA, 2020: 11).

The emphasis in such ‘development’ is on natural resources such as fossil fuels and rare earth minerals, trans-Arctic shipping routes, and tourism. Russia is particularly clear in its focus on fossil fuels; ‘increasing oil and gas extraction rates, advancing oil refining, and producing liquefied natural gas and gas-chemical products’ are considered ‘primary objectives for the economic development of the Arctic zone’ (OPRF, 2020: 7). The development of the Northern Sea Route as a ‘competitive national transportation passage in the world market’ is named a ‘primary Russian national interest’ (OPRF, 2020: 4). Other states also emphasise ‘new economic opportunities, e.g. in the form of new maritime routes and extraction of natural resources’ (Kofod, 2020: 1). In some states, the role of fossil fuels in extractive ambitions is arguably receding. In its previous Arctic strategy, the U.S. anticipated the Arctic’s role in ‘future United States energy security’ through its ‘proved and potential oil and gas natural resources that will likely continue to provide valuable supplies to meet U.S. energy needs’ (White House, 2013: 7). Now, ‘the Arctic’s significant deposits of in-demand minerals essential to key technology supply chains’ (White House, 2022: 6) have ostensibly replaced fossil fuels as the main extractive interest. Yet such shifts leave intact visions of major extractive operations, dependent on (or facilitated by) a warming Arctic. More generally, there is an assumption of compatibility between interests in extractivism and economic growth and climate and environmental policies. Imagined futures contain ‘safe and environmentally-responsible shipping’ (GoC, 2019: 49), ‘the sustainable use of natural resources’ (OPRF, 2020: 9), and ‘sustainable tourism’ (DMFA et al., 2011: 24). Technological innovation is, unsurprisingly, anticipated as the main way to realise the sustainability of these activities.

In contrast to this assumed compatibility with environmental objectives, the economic opportunities are portrayed as in need of protection against interests from other states. The US expresses commitment to protect ‘freedom of navigation’ in the Arctic against perceived Russian threats, alleging that Russia ‘is attempting to constrain freedom of navigation through its excessive maritime claims along the Northern Sea Route’ (White House, 2022: 6). As described above, this interest in freedom of navigation is partly military, but also acts to protect an economic order. The US argues for ‘a shared interest in a peaceful and stable region that allows the Arctic

nations to realize the potential benefits of greater access to the region's resources' (USDoD, 2019: 4), underpinned by US military power. Russia, for its part, has named 'actions by foreign states and (or) international organizations to obstruct the Russian Federation's legitimate economic or other activities in the Arctic' a 'primary challenge to national security' (OPRF, 2020: 5). Here China is also constructed by Western states as an economic security threat. While under President Biden the US threat perception in the Arctic appears to have shifted to an almost exclusive focus on Russia (White House, 2022), the prior Trump administration indicated strong concerns that 'China is attempting to gain a role in the Arctic in ways that may undermine international rules and norms, and there is a risk that its predatory economic behavior globally may be repeated in the Arctic' (USDoD, 2019: 6), a sentiment shared by Denmark and Norway (DMFA, 2022: 23; RMFA, 2020: 11). China is certainly explicit about its ambitions in the Arctic, which it portrays as an increasingly 'global' space. It argues that due to the changing environment and increased accessibility 'the Arctic situation now goes beyond its original inter-Arctic States or regional nature', and the stress on 'global implications' is used to justify China's identification as a 'Near-Arctic State' and 'important stakeholder in Arctic affairs' (*english.gov.cn*, 2018). Yet contrary to the impression given by Western states, Chinese material and institutional visions for the future are strikingly similar to those of the littoral states: development of shipping routes, materials extraction, and tourism under promises of sustainable development and governed by international law (*english.gov.cn*, 2018). Hence the mistrust expressed by other states does not concern explicit differences in visions of Arctic futures. Rather, the imaginary of economic development is securitised along the lines of geopolitical blocs, with economic cooperation across these blocs rendered problematic.

Implications for the security politics of solar geoengineering

Our analysis has revealed stark differences between scientific security imaginaries in the geoengineering literature and the security imaginaries of Arctic states. First, climate change is constructed as a concern in different ways. In the scientific imaginaries, climate change, and especially the prospect of Arctic tipping points, are front and centre. The Arctic is primarily interpreted through its climate-restorative potential, as imagined through computational Earth system models that imagine futures of controlled Arctic climates – and by extension, controlled global climates. By contrast, state imaginaries of the Arctic are not oriented towards preventing climate change but anticipate a mixture of desirable and undesirable outcomes from rising temperatures, which are seen as an inevitable background for the region's future. Responses to climate change – such as increased demand for rare earth minerals – are becoming issues of concern and

questions of security, more so than climate change itself (cf. [anonymised for review]), which stands as an unquestioned precondition for other strategic decisions. Whether the Arctic *should* be a venue of increased activity is not in doubt. This stands in sharp contrast to ideas of geoengineering which presuppose that hindering accessibility in the region for economic and military purposes, for example by restoring sea ice, would be acceptable to all states involved.

Second, the scientific security imaginaries exhibit a liberal institutionalist understanding of international politics and rely on a view of the Arctic as a global commons to be leveraged for the needs of an ostensible global humanity. In this, imaginaries of Arctic geoengineering do not differ from their planet-scaled counterparts ([anonymised for review]), except perhaps in the immediacy of imagined experimentation and deployment. Yet the Arctic case contains a unique contradictory claim. Geoengineering in the Arctic is justified partly by claims that it would be more politically tractable, drawing on discourses of Arctic exceptionalism that see it as a special region where inter-state cooperation on common interests can be shielded from exterior geopolitical dynamics and conflicts. But while the envisaged methods of geoengineering are bounded in the Arctic, they still aim to achieve global climatic effects. Prospective geoengineers thus make two further assumptions: that effects outside the Arctic are overall benign, and/or that governance is only relevant in the case of unfavourable effects. The latter relies on a liberal rationalist imaginary of *world* politics where costs and benefits are readily identified and acted upon, coordinated by institutions if required, undermining the initial presumption that the *Arctic* can be shielded from global conflictual geopolitics. Especially with the Russian invasion of Ukraine, this idea of Arctic exceptionalism is also increasingly obsolete – the Arctic is undergoing *de-exceptionalisation*, as indicated by the de facto collapse of the flagship of Arctic multilateralism, the Arctic Council.

Schemes that envision deployment of Arctic geoengineering as market-driven are also likely to be less immune to geopolitical obstacles than their developers imagine. Such interventions assume an international order governed by multilateral institutions including markets for carbon removals or ‘cooling credits’. But even for those states which subscribe to similar liberal aspirations, this order is subject to uncertainty, in the Arctic and elsewhere, and is consequently understood as something which must be *secured*. The mistrust from Western states about China’s interests in the Arctic, though ostensibly similar and compatible with Western aspirations of Arctic futures, highlight the current and increasing uncertainty over the future of such a Western-dominated liberal economic order.

Taken together, these differences reveal a deep disjuncture between the security imaginaries of Arctic geoengineering and state strategies. Given the relative strength of state security

actors and institutions compared to environmental ones, the political feasibility of Arctic geoengineering appears to preclude a purely environmental logic driving development and/or deployment. It raises the question of which rationales and scenarios would become subject to modification – or disappear completely – to take account of economic, geopolitical, security and other aims.

In this light, it is notable that there is one point of convergence between the state and scientific security imaginaries: technological solutionism. States might conceivably adopt geoengineering to partly mitigate Arctic warming (or ice degradation) while still leaving the environment accessible enough for increased resource extraction, transcontinental shipping, and tourism. However, such a scenario – a form of [anonymised for review] – is hardly an expression of the scientific security imaginary, which, having securitised Arctic tipping points as a threat to a global humanity, sees the protection and restoration of the Arctic climate as the overarching priority. Further, far from prospective geoengineers' expectations that envision the interventions as supported by local and Indigenous populations, this scenario would further instrumentalise the Arctic to the ends of interests *outside* the region, which clearly amounts to a continuation and intensification of the neo-colonialism that characterises many parts of the Arctic to this day (Greaves, 2016). As clearly indicated by Sámi-led opposition to SCoPEX and opposition to the Arctic Ice Project led by Arctic Indigenous organisations (IEN, n.d.), many Arctic Indigenous persons consider solar geoengineering incompatible with their understandings of sustainability.

As a case study, the Arctic provides more general lessons for solar geoengineering and security. The region has attracted the attention of geoengineering researchers in part because they understand it as a political best case, and the legacy of multilateralism and science diplomacy in the region might seem to support such an assessment. However, even in a such a best case, the underlying imaginaries of geoengineering clash directly with the political ambitions of the states which would need to support, if not implement, the geoengineering interventions. In other words, SG is unlikely to be implemented for the purposes envisioned in scientific circles, in the Arctic context or elsewhere, least of all in the kind of globally 'optimal' manner envisaged in computer model experiments. Should further climatological research reveal SG to be technically feasible and climatically desirable – a question not yet settled – the technology would enter the quagmire of an increasingly competitive and conflictual planetary geopolitics, and would need to be integrated with state policies that, for the moment, show no signs of adopting climate change as a primary issue.

Our conclusions also have implications for McDonald's (2023: 566) contemplation of geoengineering albeit only 'in the service of *ecological security*: a concern with the resilience of

ecosystems themselves'. While McDonald acknowledges the problem of finding political purchase for making nature itself the object of security, he does not explore in detail the particular form geoengineering would take as a security measure. Here, we have studied the work of researchers and others who, arguably, invoke ecological security through appeals to necessity or emergency with Arctic ecosystems as the referent object. Through their work to develop geoengineering from general principles into workable interventions (i.e. which technique would be used, how it would be designed, who would be deploying it and where, and with what purpose), they appeal to particular understandings of international security. This demonstrates how even attempts to make nature itself the referent object of security in practice depends on understandings about human societies – here theorised as imaginaries. Importantly, these scientific security imaginaries do not appear to align with state security imaginaries.

In drawing our conclusions, we do not suggest that state imaginaries alone will determine the future of Arctic geoengineering. We afford more power them relative to the scientific imaginaries, since the former are backed by considerably more institutional, material and discursive power. But imaginaries are dynamic entities subject to change in unpredictable ways. There are prior examples of scientific cooperation between nations under geopolitical strife, including in the Arctic during the Cold War (Bertelsen, 2020), and a scenario where technical cooperation on solar geoengineering leads to 'spillover effects' inducing restorative and sustainable forms of peacebuilding has been suggested as a hypothesis to be investigated (Buck, 2022). Still, there is also a long and consistent history of science being a proxy for and entangled with geopolitics and economics in the region (Doel et al., 2014; Goossen 2020) and our analysis of Arctic de-exceptionalisation suggests that 'geoengineering peacebuilding' is getting increasingly unlikely as tensions continue to rise.

A different vein of uncertainty concerns the internal contradictions of state security imaginaries – between the willingness to seize new opportunities for resource extraction and shipping, and other policy goals of environmental protection and national security. How these contradictions are managed, and which aspects are ultimately prioritised, will play a key role in forming the future of the Arctic (cf. Albert and Vasilache, 2018), and in deciding the opportunities for and political desirability of geoengineering interventions. Therefore, while analysing imaginaries can only take us so far in anticipating the security implications of solar geoengineering, they provide an important foundation for conceptualising the very problems at stake in this anticipation. As climate impacts intensify and the incentives for geoengineering deployment increase – whether as a technocratic 'climate policy option' (Irvine and Keith, 2021), as a way of defending empire

(Surprise, 2020) or [anonymised for review], the imaginaries outlined in this article will be increasingly likely to collide, in the Arctic and elsewhere.

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