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Published in:
Security Dialogue

DOI:
10.1177/0967010617704142

Publication date:
2017

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Corry, O. (2017). The international politics of geoengineering: The feasibility of Plan B for tackling climate change. *Security Dialogue*, *48*(4), 297-315. [2]. https://doi.org/10.1177/0967010617704142

Article

Security Dialogue
2017, Vol. 48(4) 297–315

DOI: 10.1177/0967010617704142
journals.sagepub.com/home/sdi

The international politics of geoengineering: The feasibility of Plan B for tackling climate change

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Abstract
Geoengineering technologies aim to make large-scale and deliberate interventions in the climate system possible. A typical framing is that researchers are exploring a 'Plan B' in case mitigation fails to avert dangerous climate change. Some options are thought to have the potential to alter the politics of climate change dramatically, yet in evaluating whether they might ultimately reduce climate risks, their political and security implications have so far not been given adequate prominence. This article puts forward what it calls the 'security hazard' and argues that this could be a crucial factor in determining whether a technology is able, ultimately, to reduce climate risks. Ideas about global governance of geoengineering rely on heroic assumptions about state rationality and a generally pacific international system. Moreover, if in a climate engineered world weather events become something certain states can be made directly responsible for, this may also negatively affect prospects for 'Plan A', i.e. an effective global agreement on mitigation.

Keywords
Climate change, geoengineering, securitization, security, sociotechnical imaginary

Introduction

A diverse range of new technologies and methods grouped loosely under the label 'geoengineering' (or 'climate engineering') aim to make possible a 'deliberate large-scale intervention in the Earth's climate system, in order to moderate global warming' (Shepherd, 2009: ix). Interest in geoengineering has been rising particularly since 2006 and was given added impetus when the Paris climate agreement was struck in 2015. This all stipulates an upper limit of 1.5 or 2 degrees Celsius of average surface global warming – a goal that is widely thought to be unachievable without some form of climate engineering (Bawden, 2016).

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Although some high-leverage methods are thought to have 'the potential to transform the politics of the climate problem' (Victor, 2008: 325), the political implications of such technologies have so far not been given the same attention as environmental risks. Possible environmental risks such as disruption to global precipitation patterns or damage to the ozone layer have naturally been the central concern for climate scientists modeling responses to solar geoengineering (Keith, 2013; Polson et al., 2014; Ricke et al., 2010; Rob, 2008). The major political concern to figure in the debate so far has been the risk of a 'moral hazard' effect: that having a 'Plan B' for tackling climate change might 'reduce the incentive to take adequate steps to prevent global warming' (Corner and Pidgeon, 2014; Lin, 2013; Reynolds, 2015). Security issues in particular have remained largely peripheral to the debate about climate engineering and climate risk. Thus for Nobel Prize-winning chemist Paul Crutzen, an early advocate of research into solar radiation management (SRM) methods, 'the main issue with the Albedo modification method is whether it is environmentally safe, without significant side effects' (Crutzen, 2006: 212). Similarly, a recent study asks 'could solar geoengineering be designed and deployed in such a way that it could substantially and equitably reduce climate risks?', but expressly excludes risks related to 'governance' (Keith and Irvine, 2016; see also, for example, Moreno-Cruz and Keith, 2013). Although there is concern about 'whose hand should control the thermostat' (Lin, 2012: 173) and the potential for international conflicts (see, for example, Keith, 2013; *Scientific American*, 2008; Zürn and Schäfer, 2013), in the main, geophysical risks have eclipsed geopolitical ones.

This is hardly the fault of individual climate modelers, whose expertise and models are geared to exploring Earth systems rather than political systems. But the most popular framing of climate engineering – namely, as a 'Plan B' in case mitigation fails – has not been conducive to the integration of security issues. To date, only very limited work has been done from inside the discipline of international relations (Horton and Reynolds, 2016). Modeling of climate engineering scenarios typically assumes a 'central planner framing' (see, for example, Keith and MacMartin, 2015: 201) that cuts out the central characteristic of the international: that the world is divided into multiple societies (Rosenberg, 2016). Any future climate-engineered world, were it to come about, would of course have to deal with the many and complex consequences of societal multiplicity.

This article therefore explores how security politics and climate engineering could affect each other. After a first section setting out climate engineering as a 'sociotechnical imaginary', the second section shows how this imaginary and the key idea of 'Plan B' have narrowed down the debate about the technologies and framed them in a particular way, obscuring some possible security implications. The third section then provides a more systematic exploration of climate engineering and security, arguing that the problem of international state conflict, while potentially serious, is not the most likely outcome. What in this article I call the 'security hazard' is more certain to cause dynamics that will be unconducive to successful implementation of climate engineering but could also negatively affect the prospects for international cooperation around mitigation and adaptation. While not necessarily insurmountable or inevitable, the security hazard should be factored into any assessments of whether climate engineering is likely, ultimately, to reduce climate-related risks.

'Reluctant Geoengineering': Climate engineering as Plan B

Climate engineering has been rising up the scientific and political agenda for at least a decade, not just in terms of research but occasionally also in policy fora (Bronson et al., 2009; Duarte et al., 2012; Intergovernmental Panel on Climate Change (IPCC), 2014). One subcategory involves regulating the amount of energy reaching the Earth from the sun ('solar radiation management' (SRM)), for example by injecting aerosols into the stratosphere to increase the Earth's albedo. Others are designed to capture and store carbon dioxide, effectively reversing carbon emissions ('carbon dioxide removal' (CDR)) (Shepherd, 2009). Although still on the margins and far from ready, some forms of geoengineering are gathering support and may be poised to enter the climate research and policy mainstream (Cho, 2016; National Research Council, 2015a,b). As greenhouse gas emissions continue to rise, and as concern over climate 'tipping points' has gathered momentum (Russill and Nyssa, 2009), calls have intensified for scientists and governments to start preparing alternative strategies besides mitigation and adaptation (Crutzen, 2006; Keith, 2013; Shepherd, 2009).

Most methods of climate engineering have yet to be fully designed, let alone tested or implemented, and so it is not possible to examine the security impacts of the technologies as actual, embodied devices. However, understood as a sociotechnical imaginary – a 'collectively held, institutionally stabilized, and publicly performed vision of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology' (Jasanoff, 2015: 4) – climate engineering already exists. As a concept, 'sociotechnical imaginaries' is part of a wider effort to avoid the notion that technologies can be assessed as discrete contraptions, divorced from wider infrastructures and normative, social, and political visions of the future (Bijker et al., 1987). The concept links technology intimately to 'not only visions of what is attainable through science and technology but also of how life ought, or ought not, to be lived' (Jasanoff, 2015: 4). Desired futures are of course correlated with opposite visions of what might go awry. Dystopian visions are thus also part of sociotechnical imaginaries (Jasanoff, 2015: 4), and hence security politics is built into technologies of this kind.

The main climate engineering imaginary analyzed in this article is here dubbed 'Reluctant Geoengineering'. It broadly posits the desirability of a research program into climate engineering technologies framed as a 'Plan B' – that is, as a fallback option or second-best option rather than as a preferred option or replacement for mitigation (which remains 'Plan A'). Reluctant Geoengineering depicts, via modeling and scenarios, certain technologies as possible means to avoid or deal with the dystopian vision of rapid or dangerous climate change in a future suffering from increasing climatic instability and continually failing or inadequate global efforts to curb emissions of greenhouse gases. It is 'reluctant' in that climate engineering is advanced in a 'worth a try' style of argumentation that tends not to hide uncertainties and (environmental) risks. 'Plan B/insurance' is the most commonly used metaphor among experts and in the media (Bellamy et al., 2012; Corner et al., 2012; Luokkanen et al., 2014; Nerlich and Jaspal, 2012; Scholte et al., 2013). In a survey of metaphors, Nerlich and Jaspal (2012: 141) report that they

> found one master argument, according to which geoengineering is the only option to avoid a planetary catastrophe. This is linked more or less directly to two main metaphors according to which geoengineering is the only Plan B we have and the only insurance policy we have for this planet.

The 'Plan B' terminology itself appeared prominently in the Foreword to the seminal report by the Royal Society published in 2009. Here, Astronomer Royal Martin Rees endorsed the need for climate engineering research and expressly conditioned his support on it being a 'plan B': if efforts to reduce greenhouse gas emissions 'achieve too little, too late, there will surely be pressure to consider a "plan B" – to seek ways to counteract the climatic effect of greenhouse gas emissions by "geoengineering"' (Rees, 2009: v). Media reporting of the report also featured 'Plan B'. Among critics, 'Plan B' is also used often to warn about the risk of moral hazard to the preferred 'Plan A' (Hamilton, 2013: 15; House of Commons, 2010: 21).

Though climate engineering has a much longer history (Fleming, 2010; Keith, 2000), it became more prominent from around 2006 when Nobel laureate Paul Crutzen (2006) argued that a scientific taboo around climate engineering was undesirable and unsustainable. A debate ensued (see Kintisch, 2010), and institutional stabilization of the imaginary moved up a notch further with a series of reports and accelerated research, including the landmark Royal Society report in 2009 (Shepherd, 2009) and the US National Research Council (2015a,b) reports of 2015. The Royal Society explicitly rejected a taboo and recommended more (carefully governed) research into a ‘Plan B’ in case a climate emergency develops that requires rapid action to cool the Earth or bring down greenhouse gas concentrations (Shepherd, 2009). The summary for policy makers of the IPCC’s (2014) latest assessment report reserved its final paragraph for CDR methods, and the US Senate has recently passed a bill recommending funding for research into ‘albedo modification’ (i.e. SRM methods) (Cho, 2016). As the technologies move further up the political agenda, so the imaginary associated with them gains institutional stabilization and research standing.

Political implications of ‘Reluctant Geoengineering’

As an imaginary, Reluctant Geoengineering should not be understood as a cohesive narrative, but precisely as a publicly performed vision within which discussions of the relative feasibility and justifications of various methods of climate engineering unfold. Rob Bellamy (2015) identifies five distinct imaginaries around climate engineering, but here I take the imaginary to be the institutionally stabilized backdrop to discussions between diverse positions. While varied in content, Reluctant Geoengineering as a whole nonetheless carries with it some general implications.

First, one implication is that Reluctant Geoengineering provides political space and legitimacy for research into climate engineering. It does this by holding up mitigation as the preferred Plan A option in reaction to fears of moral hazard. For Crutzen (2006: 216), the possibility of albedo modification ‘should not be used to justify inadequate climate policies, but merely to create a possibility to combat potentially drastic climate heating’. The Royal Society report authors were at pains to underline that ‘the safest and most predictable method of moderating climate change is to take early and effective action to reduce emissions of greenhouse gases’ (Shepherd, 2009: ix). They concluded that empirical research should be carried out, ‘clarifying the existence or extent of any moral hazard associated with geoengineering’ (Shepherd, 2009: 39). This is ongoing (Corner and Pidgeon, 2014; Fairbrother, 2016; Urpelainen, 2012).

Less explicitly, the Plan B framing also privileges particular climate engineering options over others by determining that they should be fast-working to be of most interest. This is because, as part of a Plan B, the technologies would only be used once Plan A had already failed – or when it was clear that it was going to fail: ‘Chances are that if countries begin deploying geoengineering systems, it will be because calamitous climate change is near at hand … as a last resort’ (Victor et al., 2009: 70; although see Keith and MacMartin, 2015). For this reason, high-leverage, fast-working technologies such as stratospheric aerosol injection (continuously spraying reflective particles into the stratosphere to reduce the amount of incoming sunlight and thereby offsetting some or all human-induced global warming) have been closely linked with the Plan B framing (Shepherd, 2009: 49–50). Slower procedures, including many CDR methods, tend to drop out of the running under a Plan B framing. For this reason, and because they are widely considered the leading contenders, the rest of this article focuses mainly on the security implications of high-leverage, fast-working solar geoengineering technologies such as stratospheric aerosol injection.

Third, Plan B draws a boundary between two sets of measures grouped into two discrete plans. This encourages a segregation of assessments, ensuring that climate engineering options are not compared systematically to conventional options considered part of Plan A. Thus, climate engineering methods are typically assessed against ‘business as usual’ or in comparison with each other rather than being compared to effective mitigation, adaptation, and renewable energy transition scenarios (Bellamy et al., 2012: 927). The geoengineering imaginary usually posits continued rises in global greenhouse gas emissions rather than at least partial successful mitigation, often assuming a doubling of atmospheric CO_2 compared to pre-industrial levels (e.g. Lenton and Vaughan, 2009; Shepherd, 2009; see also Bellamy et al., 2012).

Most importantly for questions of international politics and security, however, crucial assumptions about the political feasibility of climate engineering are also built into the Plan B framing. A 'Plan B' is by convention a fallback option that can be turned to if and when a Plan A fails or becomes otherwise unavailable.[1] Logically a Plan B must be feasible, since if Plan B were viewed as both less desirable *and* more difficult to realize than Plan A it would not be relevant at all. A Plan B framing therefore establishes climate engineering as overall less desirable, but also less susceptible to the obstacles perceived to be thwarting effective mitigation. Importantly, the Royal Society report lays the blame for the failure of Plan A squarely at the door of *political* difficulties rather than technical or even economic challenges: the failure of mitigation was deemed to be 'largely due to social and political inertia', and climate engineering could therefore 'provide a useful complement' (Shepherd, 2009: 57), which implies that it would not suffer from the same deficiency. Crutzen seems, similarly, to point to the 'grossly disappointing international political response to the required greenhouse gas emissions' (Crutzen, 2006: 214), declaring that the idea that effective mitigation could be achieved amounts to nothing more than a 'pious wish' (Crutzen, 2006: 217). International politics is thus blamed for the failure of Plan A, and in the Reluctant Geoengineering imaginary the relative feasibility of climate engineering – assuming it is studied sufficiently in technical terms – almost becomes a premise rather than a question.

This allows attention to focus on technical obstacles, such as those related to delivery mechanisms (Davidson et al., 2012) and unwanted environmental side-effects (Robock, 2008). In turn, this bolsters the case for an accelerated science and engineering research program in a way that sidelines political issues and risks. With modeling of the climate often assuming a singular global actor, particularly risks related to the international problem disappear further out of view. They do not disappear completely, however, and it is to the ways in which international security figures in the imaginary that we now turn.

Security hazards of climate engineering

If moral hazard concerns the fear that 'the prospect of geoengineeering the Earth in response to climate change might exacerbate the very behaviors contributing to climate change' (Lin, 2013: 674), how can we best conceive of a 'security hazard'? I propose the security hazard as the following: in an attempt to gain security against future risks, new technologies can create security problems that compromise the original aim of preventing risk.

How might this work? It is common in security studies to consider the 'security dilemma' – how attempts to gain security through augmenting security measures actually spur on adversaries to do the same and hence ultimately undermine security (Herz, 1950: 157). Of course, it is not that investing in climate engineering spurs the climate on to wreak more havoc (although the scientists are busy checking the climate risks of climate engineering). More akin to 'blowback', a security hazard arises if geoengineering creates new security problems that counteract or cancel out the overall aim of the technology, namely, to reduce climate risks.

The security issues most commonly associated with climate engineering include the risk of breakdown of interstate cooperation – including, ultimately, war (Horton and Reynolds, 2016). But the following also draws on discursive security theories to ask how stratospheric aerosol injection might change the conditions for climate politics as a whole and thereby affect climate risk politically. In sum, I set out three ways in which the security hazard could arise: (1) by climate engineering becoming an object of interstate conflict; (2) by shortening the causal chain of harm thus facilitating 'securitization' of climate politics; and (3) by expanding the scope for security politics to new areas of social life.

Climate engineering and interstate security

To the extent that security features as a theme in the geoengineering imaginary, it concerns relations between states, most commonly in the form of the risk of war or conflict (see, for example, Dyer, 2010; Hulme, 2014; Maas and Scheffran, 2012; Roberts, 2011). For the futurologist Jamais Cascio (2009), it is the 'combination of differential impact and relatively low cost that makes international disputes over geoengineering almost inevitable', and it is only a matter of time before 'the world's militaries learn to wield the planet itself as a weapon'. Climate engineering critics warn: 'you can imagine the extraordinary risks we would be taking when we turn the global climate system into a theatre of war, but that's one of the scenarios being mooted by strategic experts' (Clive Hamilton cited in Boyd, 2013). Even proponents of research, such as David Keith, are clear that stratospheric aerosol injection poses novel international risks that would require governance mechanisms at levels similar to (or better than) those currently governing nuclear weapons:

> It is so cheap that almost any nation could afford to alter the earth's climate, a fact that may accelerate the shifting balance of global power, raising security concerns that could, in the worst case, lead to war. If misused, geoengineering could drive extraordinarily rapid climate change, imperiling global food supply. In the long run, stable control of geoengineering may require new forms of global governance and may prove as disruptive to the political order of the 21st century as nuclear weapons were for the 20th. (Keith, 2013: x–xi)

One worry is that two great powers end up in conflict or at war, for example 'as a result of a dramatic failure, or sequence of failures, in the Indian monsoon' (Morton, 2015: 364) blamed on solar climate engineering. China's climatic interests might conflict with India's, for example, as they share fates in terms of the monsoon rains (Keith, 2013: 115).

This raises the risk of climate engineering posing a national security threat to vulnerable states and/or a threat to international stability. Non-climate engineering states could object to or feel threatened by climate interventionist states, and the level or mode of aerosol injections could also be a focus for controversy (shared environments and consent are an old theme in environmental security literatures; Dalby, 2002; Deudney, 1999; O'Neil, 2009: 4). Conflict and instability is also sometimes linked to the 'termination problem' – that a solar geoengineering program keeps a lid on temperature rises, and temperatures would rise rapidly if for any reason the program were halted, for example owing to conflict (Zürn and Schäfer, 2013).

Although the Reluctant Geoengineering imaginary includes conflict as part of its dystopian vision, it also includes some form of 'governance' designed to deal with this. Implementation of stratospheric aerosols in particular is imagined to require procedural legitimation and consultation to stave off potential conflicts. Some imagine formal consent (or acquiescence) from affected parties and agreement between would-be climate engineering states about the timing and scale of climate engineering as a minimum. The Royal Society states that,

> it would be highly undesirable for geoengineering methods which involve activities or effects (other than simply the removal of greenhouse gases from the atmosphere) that extend beyond national boundaries to be subject to large scale research or deployment before appropriate governance mechanisms are in place. (Shepherd, 2009: 60)

Ideas concerning governance also include plans to manage disagreement and coordinate research (Zürn and Schäfer, 2013), and sometimes 'normative criteria of global public consent for any decision on SRM' (Lloyd and Oppenheimer, 2014: 52).

How likely are interstate conflicts or cooperation? On this point, the Reluctant Geoengineering imaginary largely follows the contours of the so-called neo–neo debate in international relations, which took shape during the 1980s and 1990s in mainstream US-centered international relations. For both the neorealists and the neoliberal institutionalists who made up the key positions in the debate, states are assumed to be the main actors in an anarchic international system, and the key question is the potential for – and obstacles to – cooperation (Oye, 1986). Both sides argue that with an anarchic international system of self-serving rational states, free-riding and trust are permanent challenges for cooperation. Collectively suboptimal results are likely, but international regimes and institutions could emerge to deal with coordination and cooperation problems. For neorealists, great-power leadership could establish an international regime of rules (Mearsheimer, 2001), whereas for neoliberals rational state behavior could itself lead to cooperation and institutions (Axelrod and Keohane, 1985).

When Reluctant Geoengineering invokes visions of conflict and cooperation, it tends to stay within this neo–neo framework. It emphasizes primarily the perspective of rational, self-interested states in terms of both conflict and possible cooperation. The key problem is assumed to be the potential divergence and coordination of interests among putative climate engineering nations, as well as between such nations and other affected states. In the absence of clear international rules or procedures to establish and enforce such rules, climate engineering becomes a case of potential 'cooperation under anarchy' between rational states, and the challenge is to design the right institutions that secure stability or incentivize cooperation. Rational states try to pass on costs to each other, but the leading solar climate engineering methods are not thought to have the burden-sharing problems that mitigation and infrastructure-intensive CDR methods tend to have (Crutzen, 2006; Keith, 2013: xxi; Snyder-Beattie, 2015). Some early estimates of the cost of stratospheric aerosol injection range from only $1 billion to $8 billion per year to offset global warming (Barrett, 2008). The low price and technical ease of deploying aerosols that is often quoted (see, for example, Keith, 2013; Victor, 2008) is contested, and is based on estimates from a non-peer-reviewed report by a private aerospace consultancy with a potential interest in delivering such a technology (McClellan et al., 2010). But even so, cost is widely assumed not to be a big problem for the international politics of stratospheric aerosols because economic burden-sharing directly concerned with the technology would be manageable. However, problems might still arise from distribution of harms, benefits, and compensations linked to solar geoengineering programs, the magnitude of which could be substantial.

For neoliberal institutionalists, interdependence (such as that caused by climate change) tends to lead to gradual norm development, and eventually this could be followed by institutionalization of collective rules and 'governance'. In one scenario, a geoengineering regime begins small with a select group of key states capable of climate engineering who get together to develop methods, common standards and rules (Lloyd and Oppenheimer, 2014). The dilemma faced by regime-builders is how many parties to initially admit to the regime. For Ricke et al. (2013: 2), a nucleus of states might build an initial regime that may later become more comprehensive: 'Due to the free riding nature of the climate change mitigation game, self-enforced global coalitions are not a likely outcome … but participation in the global coalition can be expanded through side payments or through credible threats of reciprocation.' This allows for the gradual emergence of stronger and more encompassing regimes with wider participation of affected states (Reynolds, 2014a).

In contrast, for those more indebted to neorealist assumptions, ideas about such institutional evolution underestimate cooperation problems, including the 'free-driver' (as opposed to the 'free-rider') problem (Weitzman, 2012): because of the relatively low costs of delivering stratospheric aerosols, preventing unilateral or 'rogue' climate engineering is a major worry. The problem is not so much that some states may wish to exclude others from the regime, but 'that some countries will *want* to stay out of the agreement in order to geoengineer without restraint' (Barrett, 2014: 262, emphasis in original). Climate engineering programs may be launched not to tackle a common threat but in order to engineer a climate that aligns with the particular preferences of the state in question. States may well act or campaign according to their own particular interests. The idea of counteracting or forming balancing coalitions against other states engaged in climate engineering is a possibility from this perspective, since it could be deployed as an instrument of state power (see Horton and Reynolds, 2016: 449). For Joshua Horton (2011: 56–57), the rogue climate engineer scenario is a myth 'grounded more in unexamined policy assumptions than in reasoned analysis', since the incentives to cooperate would outweigh the individual benefits to climate engineering alone. But this assumes cooperation is an option and that states rationally optimize. As a tool of state power, climate engineering is unlikely to be viewed simply as a 'global public good' provided by those able and willing to do so (Bodansky, 2012), since 'rather than underprovision, the main threats [of stratospheric aerosols] are of competitive, predatory, parochial, and other unethical forms of provision' (Gardiner, 2013: 524).

Ultimately, whether geopolitical conflict or cooperation is likely as a result of climate engineering depends largely on assumptions about state rationality and the magnitude of risk thought to exist in the international system in the first place. Of course, the risk of a climate engineering-induced war should not be ruled out, but it seems to depend in the literature mostly on assumptions about the international system in general and on historical conflict levels that could be enflamed by geoengineering. All things being equal, the more uni- or minilateral the eventual imposition of solar climate engineering, the more conflict potential (Zürn and Schäfer, 2013). For example, it is the presence of nuclear weapons and decades of enmity that fuels worries that India and its neighbors might end up at loggerheads over solar climate engineering (Morton, 2015: 366). Were it to spark a major international conflict, this would of course make climate engineering entirely counterproductive in reducing 'climate risks'.

A climate engineering war, although unlikely, would of course be hugely consequential and thus should not be excluded when considering whether climate engineering really would reduce climate risks. The less calamitous but more likely security hazard derives from the difficulties of managing 'cooperation under anarchy'. Even under the neoliberal institutionalist assumptions, building a comprehensive regime would be time-consuming, and prone to setbacks and incessant 'gaming'. Optimists envisage that the best case is minilateral, in which just a small select group begins the process. Consultation processes and compensation schemes and side payments for groups who lose out (or are able to leverage claims for payments) would of course be costly both in political transaction costs and potentially in economic terms, allowing the dreaded 'burden sharing' problem to reappear. For the neorealists cooperation is even less likely, and the political costs, time, and sheer trickiness/impossibility of implementing climate engineering in a way that deals safely and consultatively with the risk of conflicts make it an altogether unpalatable option (among other unpalatable options, of course).

This international security hazard detracts from the main selling points of aerosol injection and other high-leverage methods: fast implementation and light political burden. Global agreements are, as climate politics observers know, hard to achieve – and inclusive ones that give all interested parties a relevant say, especially so (a 'pious wish', to echo Crutzen). Any idea that climate engineering can be used to cut through the Gordian knot of global politics ignores this or imagines ungoverned or imposed climate engineering, which would in itself carry increased risk of conflict – and contravene the 'governance' assumption of the Reluctant Geoengineering imaginary. Either way, the security hazard rears its head and suggests climate engineering may not necessarily be politically easier to implement than a global deal on mitigation and adaptation - even when assuming heroically that rational states are the only significant actors.

Securitization and climate engineering

In another related perspective on the security hazard, climate engineering can be seen as a potential security issue – not because states tend to compete or get into conflict over it, but because it might change the logic of climate politics more generally. In short, climate engineering risks 'securitizing' climate politics.

According to securitization theory, rather than being synonymous with an absence of threats, 'security' is a specific pattern of political actions and way of doing politics involving a logic of necessity and extraordinary measures. For the Copenhagen School, issues become 'securitized' through speech acts that lead an audience to be convinced and accept that an existential threat to a particular valued referent object (e.g. the state or the climate) legitimizes extraordinary measures of some kind (Buzan et al., 1998; Wæver, 1995). Importantly, this implies that more security is not necessarily better. Setting aside normal procedures can be tempting if the threat is existential and the political system needs to force through measures *come what may.* Security measures include undesirable means that are normally forbidden, such as violence, secrecy, or suppression of public debate. For Ole Wæver (1995: 56), 'security and insecurity do not constitute a binary opposition', since 'when there is not a security problem we do not conceptualize our situation in terms of security'. The opposite of securitization is rather desecuritization: removing an issue from the logic of existential threats that legitimate exceptional measures and moving an issue back into 'normal' politics of debate, negotiation, and compromise – or whatever else constitutes 'normality'.

Exhortations to act decisively and in an extraordinary fashion in the face of potentially disastrous global warming are common (Brzoska, 2009), but so far efforts to securitize climate change have arguably been unsuccessful. Armed conflicts and strains on cooperation and international organizations are sometimes envisaged to follow from climate change and its effects (e.g. mass migration and food price spikes) (Burke et al., 2009; Podesta and Ogden, 2008), although this thesis has been challenged vigorously (Selby, 2014). The subject of climate change as a threat has been picked up on by security institutions, including the Pentagon, which in a recent directive instructs US military leaders to 'address climate change-related risks and opportunities across the full range of military operations, including steady-state campaign planning and operations and contingency planning' (Scarborough, 2016). However, the climate is not the threat that the Pentagon is gearing up to combat. Rather, the climate is deemed to be a *facilitator* of things that threaten more traditional referent objects such as state sovereignty and international stability: insurgency, conflict, instability, and migration are the existential threats, merely compounded by climate change (Busby, 2013; CNA Corporation, 2007). In any case, climate change remains a patchy concern in military planning and scenario-building (Depledge, 2010).

Moreover, climate engineering notwithstanding, there appears to be an absence of extraordinary measures in climate politics. Even think-tanks or environmental campaigners such as Al Gore, who in his Nobel lecture drew parallels to the urgency of the Allied efforts during World War II, tend in the end to draw back from recommending exceptional measures. The measures most commonly justified range from better governance, to multilateral negotiations, to mitigating greenhouse gas emissions and more resilient infrastructure. While there is some urgency and dramatic language around the problem of climate change, rather than closing down debate, imposing secrecy, and legitimating the use of force as securitizations tend to, 'climate threat' speech acts have tended to advocate *more* discussion, more extensive governance, less enmity, and more cooperation (Corry, 2012). Although security professionals are now also using climate technologies and modeling – for example, to map likely conflict hot spots – and, conversely, climate experts deploy security methods such as scenario-planning (Oels 2012), there is no(t yet a) threatening 'other' or enemy in climate politics. Climate security, while a common trope, has hitherto been largely 'all dressed up with nowhere to go' (Wæver, 2009: 1).

With Reluctant Geoengineering, however, a securitization of climate change becomes more likely. While it would be technological essentialism to claim that climate engineering *determines* political developments (Heyward and Rayner, 2013), securitization theory does allow that there are 'facilitating conditions' for securitization. 'Facilitating conditions' (Wæver, 2000: 253) refers to the social, technical, and political 'conditions historically associated with a threat' – explaining why tanks, for example, are easier to fit into a securitizing speech act than other things (Hayes, 2013: 19). Chinese tanks are easier to securitize than Chinese coal-fired power stations (although the latter may in the end wreak much more havoc), partly because tanks can be directly linked to intentional harm and damage.

Similarly, whereas climate change is currently the *un*intended result of myriad actions over decadal time spans, fast and high-impact interventions would shorten the causal chain of harm and introduce intentionality. The weather would suddenly be attributable to somebody. With climate change, emissions are known to be harmful, particularly to countries vulnerable to global warming, but the chain of harm is long and complex and there is no intended harm. In contrast, solar climate engineering would introduce conditions that could more easily be articulated as acts of aggression – or at least as willful – since, with such technologies, political choices are linked directly and intentionally. Stratospheric aerosols would not have to be deployed explicitly for the purpose of harming another party in order for them to be taken as 'hostile'. As Victor et al. (2009: 71) put it, 'the side effects of geoengineering projects could be readily pinned on the geoengineers themselves'.

Relatedly, dual use (i.e. military applicability) of 'many geoengineering techniques' (ETC Group, 2009: 51) has been posed as a threat to security and stability, although hostile use of weather-modification technologies is currently prohibited by the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (see Blackstock and Ghosh, 2011), and there are probably cheaper and more precise military methods available in most cases (Nightingale and Cairns, 2014). More importantly, the distinction between dual-use technologies and single-use civilian technologies blurs if harm is politically attributable. As numerous climate engineering skeptics (and David Keith) have asked, if climate engineering were implemented and adverse weather conditions ensued (which they inevitably would), how would affected nations react? Even if it were difficult to prove that harms caused by changed weather patterns or disasters were directly caused by climate engineering, the facilitating conditions would have been created to place political blame at one particular door. Relating to international security hazards and the necessity for broad cooperation, the narrower the group (perceived to be) responsible for the intervention, the stronger this mechanism might become.

These features of climate engineering risk infusing wider climate politics with antagonisms and an us–them logic that it is currently largely free from; although climate negotiations are rancorous, and loss and damage are increasingly salient, the parties do not tend to view each other as enemies. At the very least, liability for climatic disasters would become more politically charged and 'uncertainty about causation could fuel accusations of responsibility' (Blackstock and Long, 2010: 527). If the climate becomes something somebody has done to somebody else, this changes climate politics quite radically. If climate politics were to become securitized, climate engineering might end up pushing global agreements on mitigation even further into the future. Securitization would shift climate politics into the category of politics in which exceptional means are legitimately used, undermining multilateral and cooperative efforts necessary for an effective global mitigation regime.

At the same time securitization could also inject urgency, in effect acting as an adrenaline shot to climate politics. Those who have assumed responsibility by attempting to manipulate the climate might end up not just shouldering blame but also feeling more responsible. If solar geoengineering led to antagonisms between those perceived to be imposing 'natural' disasters and those experiencing them, climate politics might be elevated to the status of 'high politics' and given more urgency and attention. However, this could also work against climate engineering if the technologies themselves are securitized. Opponents depict them as a threat to the global environment (e.g. the ozone layer), human security (e.g. populations dependent upon the Indian Monsoon; see Robock, 2008), international security (threatened by 'sky wars'; see Hulme, 2014: 53), or democracy (Hulme, 2014: 25; Szerszynski et al., 2013). This kind of securitizing move activates a security logic to oppose or limit research into climate engineering.

There are simultaneously attempts to desecuritize climate engineering in order to take it out of the 'special measures' category. Crutzen's original attack on a scientific taboo on climate engineering relied in part on a claimed moral equivalence between deliberate and inadvertent human intervention in the climate (for a critique, see Morrow, 2014). Jesse Reynolds (2014a: 273) concludes that, in terms of international law, climate engineering is not necessarily a pariah: 'those agreements whose substance is most closely related to climate engineering are best interpreted as being favourable to it', although some specific technologies are prohibited. Climate engineering is thus a theatre of both securitizing and desecuritizing moves, which potentially make for a less-than-smooth ride for climate engineers hoping to research and eventually progress to deployment of their technologies.

Climate engineering and expanding security politics

A third notion of security posits it neither as state policy nor as a 'discourse of drama and emergency' (Buzan and Hansen, 2009: 217) but as a tool for the routine governance or refashioning of societies. Approaches like securitization theory that emphasize exceptionality as the core of security politics have been challenged by accounts that focus on the mundane and everyday institutionalization of security. Security politics is in this optic not an exceptional case or confined to a discrete policy area, but a general mode of governing and exercising control over societies (Bigo, 2002; Huysmans, 2006). The field of security is thought to be increasingly concerned with systemic sources of vulnerability and 'different practices that arise from the construction, interpretation and management of contingency' (Aradau et al., 2008: 148). Security has also been infused with logics of risk: security is not limited to dealing with existential threats, but also includes smaller-scale, lower-level, and hypothetical dangers. Risk-based security focuses not on direct causes of harm (threats), but on risks understood as 'conditions of possibility or *constitutive causes* of harm' (Corry, 2012: 235).

This mode of security politics is arguably more readily recognizable in the climate policy domain than the modes of either international conflict or securitization. Climate change as an 'emergency' is in a way a curious idea given the slow and long-term nature of the issue. Risk management involving reducing emissions of greenhouse gasses tackles the root cause of climate change, while adaptation tackles vulnerabilities. Mitigation is a risk-security policy since it seeks to alter the conditions that facilitate what is considered directly dangerous, such as extreme weather events. Adaptation limits underlying exposure to danger through 'enhanced preparedness and resilience' (Oels, 2013: 25). This means that climate politics reaches into myriad fora and in some ways changes or expands the scope of governance of societies. For Foucauldian scholars, climate politics has even fostered a form of carbon 'governmentality': the regimenting and cataloguing of activities, people, and substances for climate purposes bringing a new dimension of life under governmental control and generating new subjectivities and units such as carbon footprints (see, for example, Stripple and Bulkeley, 2013). The very emergence of climate change as a space amenable to governance was in turn dependent upon the emergence of earth systems sciences (Lövbrand et al., 2009) and the gradual development of a 'vast machine' of climate measurement and calculation in the form of ice-core drills, satellites, indexes, models, academic disciplines, and national and global institutions (Corry, 2014; Edwards, 2010).

Seen through this lens, climate engineering technologies create yet more political zones out of previously natural ones, making sunlight and the climate system itself a target of regulation and governmental operations. Risk management logics and security politics are extended to the climate system proper. The very term 'solar radiation management' hints at a governmental approach and draws in a new planetary dimension of global life, even beyond carbon, into the realm of politics and security. Climate scientists investigating and modeling climate engineering are in doing so (inadvertently) creating conditions for the governance of the skies – or, in the case of marine cloud brightening or ocean fertilization, the clouds and the seas.

In an interesting shift *away* from the emergency framing of the Plan B imaginary and towards a more governmental approach, some leading climate engineering researchers have recently argued in favor of a 'temporary, moderate and responsive scenario for solar geoengineering' (Keith and MacMartin, 2015: 201). In this scenario, SRM would be started not as an emergency measure but rather as a precaution while the jury remains out on the ultimate success or failure of mitigation and adaptation. Stratospheric aerosols would be introduced early but gradually to offset only up to half of anthropogenic climate forcing and only for as long as 'acceptable'. For Keith, the threat of climate change is not existential, and he in effect makes a desecuritizing move, stressing that 'the claim that climate change threatens an imminent catastrophe is an attempt to play a trump card of (seemingly) objective science in order to avoid debate about the trade-offs at the heart of climate policy' (Keith, 2013: 24). In this version, SRM is a provider of a 'breathing space' (Morton, 2015: 162). If the breather is used to simultaneously reduce emissions and then eventually to bring down greenhouse gas concentrations until stratospheric aerosols can be phased out again, this also 'smoothes over the PlanA/PlanB dichotomy' (Morton, 2015: 163). This would require routine rather than emergency governance mechanisms. Morton (p. 163) imagines that 'exploring the potential of geoengineering could spur and shape the development of a new way of making planetary decisions'. In other words, used as a tool of risk control and optimization (rather than emergency), climate engineering becomes a potential midwife to new institutions and instruments of global governance: 'Much better, rather than treating geoengineering as a technocratic way of avoiding politics, to use it as a way of reinventing politics' (p. 164).

The security hazard element here is that climate engineering generates more, not less, security politics, potentially giving birth not just to new consultative bodies, but also to undemocratic practices or – for the skeptics – contributing to creating an authoritarian global state. Mike Hulme (2014: 56) declared the technology 'ungovernable' on account of its indiscriminate effects, inherent uncertainty, and politically explosiveness, with global agreement about its deployment 'improbable'. Others argue it may be governable, but only by way of centralized implementation – that is, only via basically undemocratic means and if imposed by a central actor (Hamilton, 2013; Macnaghten and Szerszynski, 2013: 472). It is owing to such worries that to develop the technology and *then* do a risk calculus may not be sufficient to avoid the security hazard, since the politics and the technology co-evolve: 'the argument about whether to pursue a global thermostat has to be political before it can be scientific' (Hulme, 2014: 135). Citing James Lovelock's conclusion that climate change means that it may be necessary to put democracy on hold for a while, Hulme (2014: 136) argues that SRM 'is indeed a project which runs the risk of putting democracy on hold – or of presenting it with a challenge to which democracy is unable to respond, which is equally concerning'. The insurance metaphor in Reluctant Geoengineering invokes the possibility of future calamity and emergency to justify climate engineering (for a critique, see Markusson et al., 2014).

For Reluctant Geoengineering, stratospheric aerosol injection is justified in terms of averting a catastrophe preemptively. Particularly since the advent of the War on Terror, the appeal of preemptory measures has expanded the remit of security politics to potentialities and catastrophic scenarios (Neal, 2009; Prozorov, 2005). The ‘politics of catastrophe’ draws on imagination and sensorial experience as well as statistical forms of calculating risk (Aradau and Van Munster, 2011: 2). Viewed as an instance of the politics of catastrophe, like the fear of nihilistic terrorism or nuclear calamity, climate change promises a potential rupture or interruption to a way of life. Like nuclear weapons or 9/11, it signifies a potential new social order (Aradau and Van Munster, 2013: 5), marking ‘an exception to some form of already existing state of affairs’ (Anderson and Adey, 2012: 26). According to some, this favors precisely interventionism, including military operations, geoengineering, and other ‘large-scale transformational measures’ to ‘reorganize physical and ecological systems, land use, and human behavior on a planetary scale’ (Mayer, 2012: 178). The security hazard here is thus that Reluctant Geoengineering, by activating the politics of catastrophe, attunes societies to radical security politics. This could in turn affect the pursuit of ‘Plan A’ that demands more cooperative, long-term and considered mitigation efforts.

Conclusion: Why climate engineering is not necessarily the politically easy option

As a sociotechnical imaginary, climate engineering is more than a set of technological devices. It has been cast as a ‘Plan B’: only to be used in the event of the failure of the preferred option of effective mitigation against the backdrop of damaging global warming. This has led some to suppose that climate engineering would not be subject to the same political obstacles and could be made available as long as it turned out to be technically feasible. Although it is envisaged that climate engineering could ‘buy time’ for effective mitigation, in the three ways described above, it could also involve a security hazard that might delay mitigation. Whether climate engineering is less of a ‘pious wish’ than effective global mitigation depends not just on whether the technologies can be invented and scaled up, but also on some momentous assumptions about international relations and the scope for cooperation. Effective climate mitigation could be made more difficult by high-leverage climate engineering technologies that introduce intentionality and shorter chains of causation to climate politics. And dynamics of risk and catastrophe that underlie Reluctant Geoengineering and more recent precautionary approaches could promote new forms of security politics. This could *complicate* ongoing efforts to mitigate and adapt, not least by promoting adversarial friend–enemy logics that sour international relations and make collective action on mitigation (and other collective global problems) more difficult, as well as making climate engineering solutions themselves more costly and difficult to implement.

This points to a wider set of neglected issues around how climate engineering might interact politically with other forms of climate policy beyond the moral hazard problem. Deployment of stratospheric aerosols is likely to include a complex mix of interventions and compensatory measures rather than the straightforward models put forward in simulations. Stratospheric aerosol injection will most likely necessitate some means of offsetting unwanted regional effects of stratospheric aerosol injection, for example. This adds to political and institutional demands in scenarios that make use of climate engineering, adding reasons for skepticism about political feasibility.

Conceivably, security dynamics could also turn out to assist the development of climate engineering by fostering research and deployment through the urgency and purpose of the invocation of security, crisis, and catastrophe. Securitization might allow exceptional means, including drastic mitigation. But such scenarios of security-driven policy would most likely challenge another of the assumptions behind Reluctant Geoengineering: that these technologies would only be implemented with some form of broad consent and/or governance. Even without security conflicts currently dogging climate negotiations, few observers are optimistic enough to envisage a comprehensive system of global governance of SRM with high legitimacy. Relatively optimistic scenarios involving heroic assumptions of rationality on the part of states suppose that a small group of states with climate engineering capabilities would proceed alone and with weak legalization, at least at first, perhaps with a qualified majority voting on deployment among a self-appointed group of insiders at a later stage (Weitzman, 2012). Banerjee (2011: 31–32) concludes that climate engineering with cross-border effects (referring to stratospheric aerosols) 'does not look too different from the current, patchy approach to regulating CO_2 emissions' and that 'the same justice, equity, and competitive advantage concerns that plague the climate negotiations' will dog negotiations about rules for how to distinguish hostile from peaceful climate modification. If by drawing on a politics of existential threat and emergency measures there is a risk that climate technologies may also be taken out of the realm of normal political discourse and debate and into the realm of 'necessity' and urgency, and the rest of climate change therefore becomes subject to security logics, these issues of cooperation and agreement would become more, not less, acute.

At the very least, despite the initially much lower economic costs, the security hazard described in this article makes the politics of climate engineering look more costly and decidedly unlike an 'easy option' politically. This does not mean that climate engineering should not be pursued and explored further. But awareness of such risks might help guard against them – and may also help abate any moral hazard arising from an unrealistic assumption about the political feasibility of 'Plan B'. Assessments of whether a technology can reduce climate risks should weigh risks of inaction, on the one hand, against the environmental but also the political risks of geoengineering, on the other.

Acknowledgements

An earlier version of this argument was presented at Climate Engineering Conference 2014: Critical Global Discussions, Berlin, 18th-21st August 2014. I am grateful for feedback from participants in that and later geoengineering conferences, and especially Duncan McLaren who commented also on later drafts. All faults and weaknesses are my own responsibility. I am also grateful for critical comments from Duncan McLaren and three anonymous reviewers at *Security Dialogue*.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Note

1. For the Merriam-Webster dictionary, 'plan B' is 'an alternative plan of action for use if the original plan should fail'; see http://www.merriam-webster.com/dictionary/planb (accessed 26 January 2017).

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