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Climate Conflicts 2.0? Climate Engineering as a Challenge for International Peace and Security

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Abstract: This article reviews the conflict potential of climate engineering (CE) against the background of possible security implications of climate change. A conceptual framework is used to compare the technologies for carbon removal and solar radiation management regarding different characteristics and to assess the causes and drivers of potential conflict. Although CE measures may possibly reduce climate-related conflicts, they could also intensify already existing international conflict structures or add new dimensions of conflict, in particular if their impacts are highly uncertain, quick, strong and heterogeneous, where the severity can vary regionally. While carbon engineering requires large resources and thus may contribute to resource conflicts, solar engineering is usually less costly and more efficient, but has numerous anticipated side-effects that could cause novel conflicts and security implications in the international system. To avoid serious conflicts, regulative mechanisms and institutional structures are needed, building on the ENMOD-Convention that restrains military or hostile use of environmental modification. Given the high uncertainties, anticipative and adaptive governance structures that involve stakeholders and their perspectives are necessary.

Keywords: Climate conflict, climate engineering, security risks
Klimakonflikt, Klima-Engineering, Sicherheitsrisiken

1. Introduction and Overview

In July 2011, the United Nations Security Council (UNSC) identified climate change as a possible risk for international peace and security (UNSC 2011). Many other international bodies, such as the European Union and the Organization for Security and Co-operation in Europe did so before, and a significant amount of scientific literature on the security risks of climate change has emerged (see Scheffran et al. 2012a). Though much research needs to be done to better understand how climate change affects violent conflict (see Scheffran et al. 2012b), it has been widely acknowledged that climate change has the potential to increase the risks of violent conflict and create multiple threats to human security and livelihood, including increasing food insecurity, water scarcity and natural disasters (e.g. WBGU 2008).

Against this background, climate engineering (CE)[1] could be considered as an instrument for conflict prevention and risk mitigation, should emission reductions occur not fast enough or climate sensitivity be higher than expected. Also, CE could

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1 Of the many terms proposed (see Bellamy et al. 2012 for an overview) we use climate engineering, as it most accurately reflects the focus, i.e. intervening into the climate systems.

alleviate the conflict risks which may result from mitigation (see Scheffran/Canaday forthcoming) and adaptation (cf. Tänzler et al. 2010) measures, particular when these are implemented in a conflict-insensitive manner.

However, several authors caution against the possible conflict potentials of CE (e.g. Maas et al. 2012; Rickels et al. 2011; Blackstock/Long 2010; Robock 2008). Furthermore, there is historical evidence that during the Cold War weather and climate manipulations were actively researched for offensive and defensive purposes – though never globally implemented – leading among others to the creation of the Convention on the Prohibition of Military and Any Other Hostile Use of Environmental Modification Techniques (ENMOD) (Fleming 2010). With growing attention to climate engineering, as indicated by the upcoming fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, see Edenhofer et al. 2012), assessing related conflict potentials and security risks is necessary to fully appraise CE options.

In this paper, we will first develop a conceptual framework to assess the implications of CE to peace and security. Subsequently, we will analyse how climate engineering may directly or indirectly contribute to conflict, and we will specifically focus on identifying which types of conflicts may result from which type of climate engineering. Against this background, we will finally asses how CE may contribute to mitigate climate-induced risks to international peace and security.

Regarding terminology, with conflict we mean real or perceived disputed interests with varying level of intensity, thus including also non-violent conflicts. Given the limited space, we will not review each CE technique in detail. Aside from the Cold War, no empirical data on conflict potentials exist, and as climate engineering has never been used on a planetary scale so far, analogues from other areas will be used to underline our argument.

2. Assessing Climate Engineering: A Conceptual Framework

Currently, no internationally agreed upon definition of climate engineering exists, though a consensus appears to be emerging on large-scale intervention into the earth's climate system (see Edenhofer et al. 2012; Bellamy et al. 2012). Yet, the idea of technically intervening in the climate on a planetary scale is polarizing and controversial. A specific criticism is that it could be used as an excuse to continue with fossil-intensive, "business-as-usual" economic patterns, in particular by highly industrialised countries. Indeed, the risk has been repeatedly highlighted that it could slow down emission reductions by providing an incentive for high-emitting countries to wait and see whether CE could provide a solution or not (see e.g. Rickels et al. 2011).

Commonly, the techniques are divided into (1) measures aiming to remove greenhouse gases (GHG) from the atmosphere and in particular carbon dioxide, and (2) those addressing symptoms of climate change such as global warming, in particular affecting the reflection and absorption of sunlight in the atmosphere. Following Bellamy et al. (2012), we use the terms "carbon engineering" and "solar engineering" for these two approaches.

These two categories include a host of different methods and approaches which may also overlap with adaptation and mitigation measures, such as using biomass or reducing local heat stress (Edenhofer et al. 2012). Most assessment reports outline the following technologies or measures (Rickels et al. 2011; GAO 2011; Royal Society 2009):

- Solar engineering: (1) space-based reflectors, (2) stratospheric aerosols, (3) increasing surface albedo, (4) increasing cloud albedo
- Carbon engineering: (1) direct capture of CO_2, (2) ocean fertilization, (3) afforestation, (4) enhanced weathering, (5) biochar, (6) bioenergy with CO_2 capture and sequestration (BECS).

To compare the different technologies with regard to their conflict potential, we use six axes highlighting different characteristics:

1. **Point vs. diffuse approaches:** Point approaches are those which affect only a clearly defined place, such as direct capture or leaves of trees removing carbon. Diffuse approaches do not have such a clearly defined "area of operation", such as introducing aerosols into the atmosphere or cloud whitening which drift over time and scatter. Naturally, the more diffuse an approach is, the less controllable it is.
2. **Long- vs. short-term results:** Some methods, such as removing carbon, take decades before they have a recognizable effect, while others such as solar engineering may have an impact within just a few years.
3. **Low vs. large influence on the climate:** CE measures differ significantly with regard to their actual influence on the climate. For example, enhanced weathering requires spreading pulverized minerals into the oceans at the level of gigatons, while only a few megatons of aerosols are needed to affect global temperatures (cf. Rickels et al. 2011).
4. **Small-scale vs. large-scale resource needs:** Concurrent to low and large influences, different measures require different amounts of resources. Particular solar engineering measures have been estimated as comparatively cheaper than carbon engineering methods.
5. **Homogenous vs. heterogeneous regional impacts:** While all CE methods aim at changing the global climate, they may have different impacts on regional climates. For example, removing CO_2 anywhere in the world will result in an even concentration of carbon everywhere in the world in a short time span. In case of solar engineering, keeping global temperatures stable may result in radically altered precipitation patterns and different levels of regional warming (Schmidt et al. 2012).
6. **Low vs. large uncertainties:** The possible uncertainties for different methods vary strongly. While in the case of afforestation the likely impacts and consequences are quite foreseeable, many solar engineering approaches, but

also ocean fertilization, may have various unintended and unknown consequences (Royal Society 2009).

Table 1 highlights where we locate the approaches along these axes, based particularly on information provided in Royal Society 2009; Rickels et al. 2011 and GAO 2011.

Deliberately, we have not included a scale for table 1, as research on all methods is still in an early phase. The categorization in table 1 therefore indicates a tendency, particular when comparing different CE methods. We will use this framework in assessing direct conflicts regarding climate engineering itself and conflicts resulting from the side effects of climate engineering when deployed.

3. Potentials for Direct Conflict: Competition, Anticipation and Control

Building on previous work (Scheffran/Cannaday forthcoming; Maas 2012), three types of direct conflict revolving around climate engineering can be identified.

Type 1: Competition for Scarce Resources

CE techniques have often been considered as "cheap" compared to other options to cope with climate change, but nevertheless require financial resources in the area of multiple billion US dollars (USD) per year (Rickels et al. 2011). While the cheapest may be as small as just a few billion, some methods such as space reflectors are considered to cost hundreds of billions of USD (ibid.). With regard to carbon engineering, using direct air capture on a scale capable to counter anthropogenic GHG would require an infrastructure similar to the current energy infrastructure, requiring massive investments (cf. Royal Society 2009). A particular risk that has been highlighted is that investment in CE would crowd out funds for mitigation and adaptation (Rickels et al. 2011).

Aside from the financial costs, CE measures may also require substantial other resources. For instance, enhanced weathering does require components similar to fertilizers – and very large quantities of it – while afforestation may need large areas of land to have a substantial impact. While fertile or marginal lands would be better suited, some have argued to plant the Sahara or the Australian outback with trees (Ornstein et al. 2009), which would require massive amounts of fresh water, or desalinization of ocean water and which is an energy-intensive process. Beyond the financial costs, such measures may compete with other priorities, such as food and energy security.

While such conflicts may be national in case of competing spending priorities, in an economically globalized world it could have large ripple effects: Similar to biofuels, CE could drive up food prices, catalyzing local conflicts and riots, such as during the 2008 and 2011 food price hikes (Messer 2009). Yet, large-scale international and perhaps militarized disputes appear unlikely given the concrete and strongly localized impacts.

Particular prone to resource competition are CE methods with high resource needs, a diffuse approach affecting multiple sites when deployed, only small level of influence or a long time to show effects – and thus accumulating costs over time. These include especially carbon engineering measures, but also some solar engineering approaches such as increasing surface albedo and space reflectors.

Type 2: Anticipation of Negative Impacts

Much of the controversy about climate engineering revolves around negative side effects and unintended consequences.

Table 1: Categorisation of CE approaches along six axes of characteristics

Point approach	Direct capture; afforestation; biochar, BECS	Space-based reflectors; stratospheric aerosols; surface albedo; cloud albedo; ocean fertilization; enhanced weathering	**Diffuse approach**
Long-term results	Ocean fertilization; enhanced weathering; direct capture; afforestation; biochar; BECS	Space-based reflectors; stratospheric aerosols; surface albedo; cloud albedo	**Short-term results**
Low influence	Ocean fertilization; enhanced weathering; direct capture; afforestation; biochar; BECS; surface albedo	Space-based reflectors; stratospheric aerosols; cloud albedo	**Large influence**
Small resource needs	Stratospheric aerosols; cloud albedo	Space-based reflectors; surface albedo; direct capture; afforestation; ocean fertilization; enhanced weathering; biochar; BECS	**Large resource needs**
Homogenous impacts	Ocean fertilization; enhanced weathering; direct capture; afforestation; biochar; BECS	Space-based reflectors; stratospheric aerosols; surface albedo; cloud albedo	**Heterogeneous impacts**
Low uncertainties	Afforestation; direct capture; biochar; BECS	Space-based reflectors; stratospheric aerosols; surface albedo; cloud albedo; ocean fertilization	**Large uncertainties**

In particular, large uncertainties exist how solar engineering may affect global and regional precipitation patterns (Irvine et al. 2011), such as a change of the Indian monsoon that would affect the food security and livelihoods of hundreds of millions in South Asia (WBGU 2008). Similarly, in case of ocean fertilization the question is how it may affect ocean ecosystems and food chains and thus fish stocks (Rayfuse et al. 2008). Specifically in the latter case did non-governmental organisations (NGOs) lobby strongly for regulation or complete banning of this approach, including a general moratorium on research and deployment (Fleming 2010).

As a consequence, conflicts over climate engineering can emerge to avoid deployment and possible negative consequences. A specific challenge hereby is that certain events may not be clearly attributable to CE, but may occur due to climate change. For example, the identification of whether a hydrometerological disaster occurred because of CE, anthropogenic climate change or neither of both is unlikely.

Such conflicts may emerge from the local level, such as citizen groups and direct action, to the international level, when states fear that their national interests may be negatively affected by CE. Internationally, however, there is currently no regime to address such disputes, increasing the chance of uncooperative behavior if no ad hoc solutions are found.

Particularly controversial are CE measures with large uncertainties, diffuse and heterogeneous impacts – by creating for example clear "winners" and "losers" – and a potentially large influence on the climate. This includes first solar engineering measures, but also carbon engineering measures such as ocean fertilization affecting oceanic food chains.

Type 3: Regional Climate Control

Aside from addressing global climate change, climate engineering could also be used to pursue specific political interests, such as attempting to produce a desired regional climate. For example, it has been proposed to use regional-scale CE approaches to moderate specific climate parameters, such as mitigating heat waves (cf. MacCracken 2009).

An interesting example in this regard is the Arctic: The Arctic Methane Emergency Group (AMEG) called specifically for deployment of climate engineering to protect the Arctic from further warming and thus release of the powerful GHG methane (AMEG 2009). Yet, at the same time the opening of the Arctic does offer new opportunities for resource exploration, new shipping routes and new possibilities for agriculture and settlements (Emerson/Lahn 2012). Indeed, some authors did already consider potential benefits of regional-scale CE for Canada, particular in reaffirming its sovereignty in the region vis-à-vis the USA and China (Chalecki/Ferrari 2012). These competing interests may form geopolitical conflict constellations in the Arctic that include climate engineering (cf. Lee 2009). These could contribute to an uncooperative political climate and tensions between countries, but whether this leads to violent conflict is unclear. Judging from past environmental modification events, such as damming on rivers which may affect downstream countries negatively, there have been threats and tensions, but never violent interstate conflict (WBGU 2008).

A specific regional focus with a clear added value also increases the chances of a uni- or mini-lateral application of climate engineering in contrast to multilateral measures with a global scope. Since CE measures in one region have trans-regional consequences, it has been suggested that middle powers and regional blocs could invest into climate engineering, because it would enhance their relative power and reputation (Chalecki/Ferrari 2012; Irvine et al. 2011).

In this context, CE measures with comparatively large, quick and cost-effective influence on the climate are particular attractive, such as stratospheric aerosol injection and increasing cloud albedo. Yet, both approaches are also diffuse and have heterogeneous impacts, thus they are likely hardly controllable with many uncertain side effects. Though ideas like using artificially created nanoparticles to increase controllability have been put forward (Keith 2010), they are yet hypothetical. While it is repeatedly highlighted that climate engineering may be abused for military purposes (e.g. Robock 2008), this appears unlikely given (1) the perhaps large collateral damage drawing many new conflict parties into the fray; (2) the time delay of still months or years between initial deployment and results; (3) the highly indirect effect, by impacting ecosystems and then only later agriculture and finally societies.

Finally, intensified research into climate engineering and its controllability may create a dual-use problem similar to nuclear energy and bio-technology. The military or hostile use of environmental modification techniques, which would include climate engineering, is explicitly prohibited by the ENMOD convention. While treaties alone do not stop determined actors, it is in fact one of the few areas of CE which is already internationally regulated.

However, ENMOD is a dormant treaty, though additional countries have signed and ratified it over the past years. Neither a secretariat nor a formal review process exists, as in the case of the nuclear non-proliferation treaty or the climate negotiations. The final declaration of the second review conference opted for a third review conference based on the views of its member states, but the last review conference was held in 1992, as a result of UN General Assembly resolution 46/3 (UN 1992). While it provides a possible platform, it would require the initiative by one or multiple countries to reinvigorate the treaty.

4. Limited Coping Capacities as Drivers of Conflict

No CE approach can recreate the pre-industrial climate. Solar engineering techniques only address a symptom and removing carbon dioxide affects one parameter, atmospheric CO_2 concentration, but not other indicators of climate change. Though it may for instance be possible through aerosol injection to limit global average temperature to 2°C or lower, compared to pre-industrial times, it would still cause regionally differing consequences, which could be radically different from historical climates (Schmidt et al. 2012; Irvine et al. 2011). Thus, CE should be conceptualized as a form of intentional climate change and contrasted to unintentional or "accidental" climate change as a by-product of a fossil-based economy.

Concurrently, it is appropriate to draw from the current debate on the security implications of climate change to understand the conflict potentials of CE. The empirical evidence of violent conflicts induced by climate change remains disputed (e.g. Theisen et al. 2012; Gleditsch 2012; Bernauer 2012; Scheffran et al. 2012b; Buhaug 2010). Yet, climate change may result in so-called "conflict constellations", for example availability of water or agricultural production, shifting population patterns, changing maritime borders due to sea-level changes or increases in extreme weather events (WBGU 2008; Maas/Carius 2012).

Climate change is a challenge for political, social and economic institutions built upon predictable environmental conditions – such as the UN Convention on the Law of the Sea lacking any guidance on how to address changing sea-levels and the consequent impacts on maritime territories (Paskal 2009). Whether environmental changes result in political instability and ultimately violent conflict depends to some degree on the institutions available for mediating disputes as well as the strategies for coping with and adapting to change (Brauch/Scheffran 2012; WBGU 2008; Smith/Vivekananda 2011). For instance, a significant part of the global population is food-insecure and lacks access to fresh water of sufficient quality and quantity. Yet, neither food nor water is actually scarce, but current distribution mechanisms dramatically affect marginalized people around the world. This challenge, however, is aggravated by changing demographic patterns and a growing population which are concurrent with increases in demands for food, water, energy and other resources. Thus, climate changes will in particular affect "human security", i.e. the possibilities of individuals to pursue a life free from a number of threats to survival and well-being, thus limiting their development potential (see e.g. Brauch/Scheffran 2012).

In summary, while the linkages between climate change and conflict are diffuse and indirect, the capacity to cope with change and mediate conflicting interests resulting from changes in resource availability is important in determining whether a situation devolves into conflict or not.

As climate engineering implies intentional change of the climate, governance structures must mediate its consequences. If the effects on the climate are not immediate, modest with low uncertainties, homogenous and to some degree predictable, as in case of carbon engineering approaches such as air capture and afforestation, this would give sufficient time for societies and governance structures to adapt and innovate socio-political processes for managing its impacts.

Conversely, CE measures whose impacts are highly uncertain, quick, strong and heterogeneous would challenge governance structures. CE impacts could negate past adaptation efforts to unintentional climate change and also create incentives to not invest into adaptation: If CE could likely work and have the desired climate impact, it may be prudent to wait and see and thus not "waste" funds on adaptation, with the exception of no-regret measures. Yet, if CE is then not implemented, adaptation efforts may come too late and thus aggravate the possible security implications of insufficiently mitigated climate change.

A particular challenge in this regard is the termination problem (Rickels et al. 2011): Once CE measures are implemented, they cannot be simply shut down. Specifically in case of solar engineering, terminating operations would result in rapid global warming. This would create on the one hand high responsibility for those operating CE measures, but also give them a significant amount of power, which could be abused. Indeed, once CE measures are implemented, the resulting consequences of discontinuing may create as much conflict potential as the original implementation, as (1) they result in a (again) changed climate with new needs for adaptation and possible resource management issues; (2), but also could create anticipatory fears of a possible discontinuation like in conflict type 2 (see above).

Concurrently, protecting the respective infrastructure needs special care, as it could be an attractive target for terrorist groups interested in creating structural instability and inciting public anxiety.

5. Assessing and Comparing the Conflict Potentials of Climate Engineering

In comparing the potentials of climate engineering as a cause or driver of conflict, carbon engineering approaches are likely to contribute to existing competitions over scarce resources, which are already under stress due to climate change. While carbon engineering primarily affects existing types of conflict, solar engineering adds a new quality to the security implications of climate change and has an array of possible conflict potentials due to the anticipated negative effects of intentional climate change and climate control. Consequently, solar engineering creates new challenges for the international community in managing the security implications of climate change. Table 2 summarises these findings:

Table 2 highlights the different types and levels of conflict potentials for the CE measures and criteria. For example, when small resource needs, large influence and short-term results are conducive for climate control, a measure with large resource needs, low influence and long-term results such as ocean fertilization and direct air capture is largely ineffective for uni- or mini-lateral climate control.

In addition, an important difference with regard to the conflict potentials is the scalability of each approach: Obviously, planting 10,000km² of forest has different resource needs than 100,000km² or 1,000,000km². In addition, the likelihood of conflicts could be reduced with the level of predictability of a CE measure. For example, afforestation and direct air capture have long-term effects, low uncertainties, a point approach and homogenous impacts, which may provide sufficient opportunity to develop adequate policy and mediation approaches to minimize conflicts, including balancing resource needs. Other measures, particular solar engineering, are less predictable in their impacts.

The severity and geographical scope can vary depending on the CE measures, but can range from local to global levels. Tensions between states could interfere with inner-societal conflicts, e.g. when CE measures to protect domestic farmers from droughts provoke opposition from other countries; local protests and direct action or perhaps even terror attacks might undermine joint CE actions. The asymmetric distribution of benefits, costs and risks of CE measures could combine with the security risks of climate change in multiple and unpredictable ways, leading to cascading events and tipping points in the international system. Furthermore, the complex and uncertain causal chains and events make it difficult to attribute certain events such as natural disasters as a consequence of intended CE, opening the possibility of endless quarrels about causation and responsibility. Further research, including a life-cycle assessment and analysis of the plausibility, relevance and governance of critical pathways of the different measures are necessary to identify possible conflict hot spots across the globe.

6. Reflection and Policy Implications

In this paper, we have reviewed the conflict potentials of climate engineering against the background of possible security implications of unintentional climate change. While we generally see a possibility for CE measures to reduce climate-related conflicts, the intentional manipulation of the climate may also intensify already existing international conflict structures or add novel dimensions of conflict. Most likely, multiple measures will be pursued in parallel, such as direct air capture in addition to afforestation. Still, given the broad range of conflict potentials, priority should be given to address the consequences of solar engineering due to its high impact, relative short time frame and modest resource needs. Moving ahead with regulation and creation of adequate dispute settlement mechanisms is necessary, as prior to any deployment the actual research and anticipated deployment can create political frictions. This is also necessary as the intensified research, particularly into higher degrees of controllability of solar engineering, increases its potential as dual-use technology.

A securitarisation of climate engineering appears then quite probable, even if it is still years away from deployment. Indeed, after the UN Security Council and many other organisations have identified unintentional climate change as a possible risk for international peace and security, it is plausible to assume that these organisations will do so as well for intentional climate change, using the existing statements and declarations as a basis. They may also provide an additional entry point for addressing governance questions relating to climate engineering. This is particular important for primarily international dimensions of solar engineering, while the more national-oriented carbon engineering approaches could be addressed with existing national jurisdictions and frameworks.

To avoid climate engineering becoming a cause or driver of conflict, regulative mechanisms and institutional structures are needed. The ENMOD-Convention could serve as starting platform by adding a "do no harm" perspective in addition to the ban on hostile use of environmental modification. Given the high uncertainties, anticipative and adaptive governance structures capable of treating the environment as variable instead of a constant will be necessary (Scheffran/Cannaday forthcoming; cf. Paskal 2009). Throughout the process, stakeholders and their perspectives and concerns need to be included into the discussion and decision process.

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Table 2: Summary of Climate Engineering Methods and Conflict Potentials

Conflict Potential	Key Criteria	Corresponding Measures[2]	Level
Direct Conflict	Various (see below)	Carbon and solar engineering	Various (see below)
Competition over Scarce Resources	Large resource needs, small influence, long-term results, diffuse approach	All carbon engineering measures, surface albedo	Primarily national
Anticipation of Negative Impacts	Large uncertainties, heterogeneous impacts, large influence, diffuse approach	All solar engineering measures, ocean fertilisation	National and international
Regional Climate Control	Small resource needs, large influence, short-term results	Stratospheric aerosols, enhancing cloud albedo	International
Driving Conflict	Large uncertainties, short-term results, large influence, heterogeneous impacts	All solar engineering measures	National and international

2 Measure fulfills at least three criteria

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Will Geoengineering Bring Security and Peace?

What does History Tell us?

James Rodger Fleming*

Abstract: Ours is not the first generation to ponder geoengineering. Intentional weather and climate manipulation has a checkered history linked, in many cases, to militarization of the atmosphere. This paper examines proposals, practices, and warnings about geoengineering from the Cold War era in order to derive lessons applicable to today's situation. In the two decades following 1945, the new transformative technologies of nuclear power, digital computing, chemical cloud seeding and access to space emboldened a generation of scientists and engineers seeking control of nature and dominance over their superpower rivals. If today's would-be geoengineers are seeking security and peace, they need to study this history.

Keywords: Geoengineering, history, military, weather change
Geoengineering, Geschichte, Militär, Wetterveränderung

The nuclear age brought with it the idea that technology was becoming powerful enough to allow human intervention in natural systems at a global level. That is, the ancient fantasy of controlling nature might become a reality, and humanity would soon engage in planetary geoengineering. Chemical cloud seeding, the use of computers for weather and climate modeling, and access to space heightened the illusion. The Cold War added a sinister gloss to notions of control as the superpowers raced to weaponize nature. This essay documents some of the early enthusiasm for climate control, describes some proposed and actual geoengineering practices, and asks if the Cold War military origins of these ideas bode well for the future. Will geoengineering bring security and peace? What does history tell us? Why does history matter?[1]

In 1945 the prominent scientist-humanist-internationalist Julian Huxley, one of the founders of the United Nations Educational, Scientific and Cultural Organization (UNESCO), spoke to an audience of 20,000 at an arms control conference at Madison Square Garden about the possibilities of using nuclear weapons as "atomic dynamite" for "landscaping the Earth" or perhaps using them to change the climate by dissolving the polar ice cap. A few months later, World War I flying ace, businessman and entrepreneur Captain Eddie Rickenbacker went on record as advocating the use of atomic bombs for

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1 These issues are addressed in James Rodger Fleming, *Fixing the Sky: The checkered history of weather and climate control* (New York: Columbia University Press, 2010).