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THE DEPARTMENT OF DEFENSE IS POISED TO UPDATE ITS CLIMATE CHANGE ADAPTATION ROADMAP TO CONSIDER "MITIGATION MEASURES": NOW IS THE TIME TO NATIONALLY REGULATE SOLAR RADIATION MANAGEMENT

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As governments worldwide struggle to reduce their greenhouse gas emissions in an effort to mitigate the effects of climate change, many are contemplating supplemental and controversial strategies, including Solar Radiation Management ("SRM"). SRM is a geoengineering technology deployed into the stratosphere that intentionally manipulates the environment to reduce global surface temperatures by reflecting incoming sunlight back into space. Despite initial findings of significant and uncertain environmental risks, no country thus far has elected to regulate SRM, even though more experimentation is necessary to understand the full effects of globally deploying the technology. In the United States, current environmental laws fail, without more, to protect the country from unilateral actors deploying SRM should these actors believe the dire effects of climate change warrant an immediate response, thereby presenting a significant national security threat. However, based on recent policy decisions, Congress appears willing to consider actively regulating geoengineering technologies, such as SRM. Pursuant to Congress's most recent directive in the National Defense Authorization Act for Fiscal Year 2021, which instructs the Department of Defense ("DOD") to consider its approach to "mitigation measures" in its 2022 Climate Change Adaptation Roadmap, this Article proposes that the DOD recommend that the

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federal government formulate a national governance approach to regulate SRM. If a governance approach is established, the United States will be better prepared to deal with the possible conflicts and disputes arising from the inevitable consideration of global SRM deployment as the effects of climate change become more dire.

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"There is no doubt in my mind that to limit the effects of climate change, humanity will geoengineer the planet."[1]

I. INTRODUCTION

The Earth's atmosphere is warmer now than at any other point in human history.[2] Nearly all climate scientists agree: the considerable increase in global surface temperatures is a direct result of unprecedented amounts of greenhouse gas ("GHG") emissions in the atmosphere due to anthropogenic activities.[3] Though international and national policies have been designed to reduce the amount and speed of GHG emissions released into the atmosphere, these efforts have been largely unsuccessful.[4] Meanwhile, wildfires,

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[1] *Healthy Oceans and Healthy Economies: The State of Our Oceans in the 21st Century: Oversight Hearing Before the Subcomm. on Water, Oceans, & Wildlife of the H. Comm. on Nat. Res.*, 116th Cong. 10 (2019) (statement of Deborah Bronk, Ph.D., President and CEO, Bigelow Laboratory for Ocean and Sciences).

[2] DONALD J. WUEBBLES ET AL., U.S. GLOB. CHANGE RSCH. PROGRAM, CLIMATE SCIENCE SPECIAL REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT 10 (2017), https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf [https://perma.cc/Z3GV-62W6].

[3] *Facts: Scientific Consensus: Earth's Climate is Warming*, NASA GLOBAL CLIMATE CHANGE: VITAL SIGNS OF THE PLANET, https://climate.nasa.gov/scientific-consensus/ [https://perma.cc/F2TG-WXAW] (last updated Apr. 5, 2020) (finding that more than 97-percent of published climate scientists agree that humans have substantially contributed to the unprecedented increase in global temperatures); DONALD J. WUEBBLES ET AL., *supra* note 2. Any human activity is considered "anthropogenic" in that it is human-induced or influenced by humans. Anthropogenic emissions "include the burning of fossil fuels, deforestation, land use and land-use changes . . . , livestock production, fertilisation, waste management and industrial processes." *Anthropogenic Emissions,* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2018), https://www.ipcc.ch/sr15/chapter/glossary/ [https://perma.cc/35MM-PJQV].

[4] Stephen Leahy, *Most Countries Aren't Hitting 2030 Climate Goals, and Everyone Will Pay the Price*, NAT'L GEOGRAPHIC (Nov. 5, 2019), https://www.nationalgeographic.com/science/2019/11/nations-miss-paris-targets-climate-driven-weather-events-cost-billions/ [https://perma.cc/5PP2-P7CN]. *See generally* CTR. FOR CLIMATE AND ENERGY SOLUTIONS, CLIMATE ESSENTIALS: SCIENCE AND IMPACTS (Sept. 2019), https://www.c2es.org/site/assets/uploads/2019/09/science-and-impacts.pdf [https://perma.cc/2BWL-2EU5].

rising sea-levels, and other heat-induced climate impacts continue to threaten populations around the world.[5]

In the face of these imminent environmental disturbances, researchers and policymakers are urgently exploring alternative technological methods to supplement their GHG emissions reduction efforts.[6] One of these alternatives is solar radiation management ("SRM").[7] SRM is a geoengineering technology—an "intentional large-scale manipulation of the environment"[8]—that aims to temporarily suppress the increase of global surface temperatures by injecting reflective aerosol particles into the lower stratosphere, so that solar energy is redirected back into space instead of warming the Earth.[9]

Conceivably, SRM could significantly assist global efforts to combat climate change by biding time for countries to scale back on

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[5] *See* DONALD J. WUEBBLES ET AL., *supra* note 2, at 231–49; Blacki Migliozzi et al., *Wildfires in the West*, N.Y. TIMES (Sept. 24, 2020), https://www.nytimes.com/spotlight/california-wildfires [https://perma.cc/H3UL-PEFQ] (providing an interactive timeline of West Coast wildfires within the past decade) (last visited Apr. 7, 2021).

[6] Koen Helwegen et al., *Complementing CO2 Emission Reduction by Solar Radiation Management Might Strongly Enhance Future Welfare*, 10 EARTH SYS. DYNAMICS 453, 453 (2019); Fred Pearce, *Geoengineer the Planet? More Scientists Now Say It Must Be an Option*, YALEENVIRONMENT360 (May 29, 2019), https://e360.yale.edu/features/geoengineer-the-planet-more-scientists-now-say-it-must-be-an-option [https://perma.cc/2TMB-QUVX].

[7] *What is SRM?*, SOLAR RADIATION MGMT. GOVERNANCE INITIATIVE, https://www.srmgi.org/what-is-srm [https://perma.cc/3Y7Y-8F6H] (last visited Mar. 29, 2021).

[8] David Keith, *Geoengineering the Climate: History and Prospect*, 25 ANN. REV. ENERGY ENV'T 245, 247 (2000), https://www.annualreviews.org/doi/pdf/10.1146/annurev.energy.25.1.245 [https://perma.cc/7EP7-K8YS].

[9] Oliver Geden & Susanne Dröge, *The Anticipatory Governance of Solar Radiation Management*, COUNCIL FOREIGN RELS. (July 2, 2019), https://www.cfr.org/report/anticipatory-governance-solar-radiation-management [https://perma.cc/K3V7-BCW8]; Sikina Jinnah & Simon Nicholson, *Introduction to the Symposium on 'Geoengineering: Governing Solar Radiation Management*,' 28 ENV'T POL. 385, 385 (2019), https://www.tandfonline.com/doi/full/10.1080/09644016.2019.1558515 [https://perma.cc/AAW2-MLBN].

their GHG emissions.[10] However, SRM's objective, to directly manipulate the climate, has generated substantial controversy.[11] The pushback has made experimentation difficult, thereby leaving many of SRM's potential risks unknown.[12] Moreover, some of SRM's risks that are understood, including altering the Earth's energy balance, could significantly disrupt weather patterns.[13] As a result of these known and potential dangers, governments have been unwilling to spend political capital to better understand SRM, leading to minimal regulation at the international or national level, and the United States is no exception.[14]

Currently, domestic environmental laws in the United States impose some regulatory restrictions on large-scale SRM activities but ultimately fail to provide sufficient safeguards against the possible mismanagement of SRM.[15] For example, governments or

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[10] *See* NAT'L RSCH. COUNCIL, ADVANCING THE SCIENCE OF CLIMATE CHANGE, DIVISION ON EARTH AND LIFE STUDIES 384–85 (2010), https://www.nap.edu/read/12782/chapter/19 [https://perma.cc/G6Q4-RAWK].

[11] *See id.*

[12] Geden & Dröge, *supra* note 9.

[13] Akihiko Ito, *Solar Radiation Management and Ecosystem Functional Responses*, 142 CLIMATIC CHANGE 53, 53 (2017), https://link.springer.com/article/10.1007/s10584-017-1930-3 [https://perma.cc/MQH2-MWGU] (reporting that the deploying SRM could affect the Earth's energy balance and "exert unexpected influences on natural and human systems"). The Earth's energy balance focuses on the amount of incoming energy from the sun into the Earth's atmosphere and the amount of outgoing energy from the Earth back into space. *The Earth-Atmosphere Energy Balance*, NAT'L WEATHER SERV., https://www.weather.gov/jetstream/energy [https://perma.cc/Z5RH-5FL6]. This process is what drives the weather, as well as life on Earth. *See id.*

[14] Jesse L. Reynolds, *Solar Geoengineering to Reduce Climate Change: A Review of Governance Proposals*, 475 PROC. ROYAL SOC'Y. 1, 9 (2019), https://royalsocietypublishing.org/doi/10.1098/rspa.2019.0255 [https://perma.cc/Y9PC-6234]. *See generally* Jinnah & Nicholson, *supra* note 9, at 385–96 (providing background information regarding SRM governance).

[15] The National Environmental Policy Act ("NEPA") and the Clean Air Act ("CAA"), as well as the Weather Modification Reporting Act ("WMRA") and the National Weather Modification Policy Act ("NWMPA"), *infra* Part V, are the most relevant environmental laws that could apply to SRM experimentation and restrict certain SRM activities. NAT'L RSCH. COUNCIL, CLIMATE INTERVENTION: REFLECTING SUNLIGHT TO COOL EARTH 169–71 (2015), https://www.nap.edu/read/18988/chapter/6#169 [https://perma.cc/5TKP-8TD8]. However, small-scale

nonstate actors[16] who feel compelled to deploy SRM could do so before SRM's risks are fully understood because an enforceable governance mechanism does not exist.[17] This potential for unchecked deployment could lead to domestic and international conflict; in fact, this alarming reality has already made headlines.[18] Therefore, the need to federally govern SRM is essential to U.S. national security—placing this issue directly within the Department of Defense's ("DOD") scope of responsibility to advocate for national SRM regulation.

Notably, the U.S. Congress has recently taken steps to explore SRM, making the pathway toward regulation relatively smooth. In 2019, Congress apportioned funds to the National Oceanic and Atmospheric Administration ("NOAA") to study the potential consequences of SRM.[19] Most recently, the House of Representatives passed the National Defense Authorization Act for Fiscal Year 2021, House Bill 6395 ("H.R. 6395"), which mandated the DOD to update its 2014 Climate Change Adaptation Roadmap by February 2022 and "include . . . a discussion of the current and foreseeable effects of climate change on . . . conflicts and disputes, emerging threats, and instability caused or exacerbated by climate change including . . . geoengineering."[20] Subsequently, the Senate passed an amended version of H.R. 6395, eliminating the specific

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SRM experiments will likely not rise to the level necessary to trigger current domestic environmental laws. *Infra* notes 125–28 and accompanying text.

[16] "Nonstate actors" in the context of SRM governance include: researchers, universities or other institutions that employ the universities, funders, academic publishers, professional societies, and advocacy nongovernmental organizations. Jesse L. Reynolds & Edward A. Parson, *Nonstate Governance of Solar Geoengineering Research*, 160 CLIMATIC CHANGE 323, 329–34 (2020), https://link.springer.com/article/10.1007/s10584-020-02702-9 [https://perma.cc/QB6D-SQG3].

[17] *See* Edward A. Parson & Lia N. Ernst, *International Governance of Climate Engineering*, 14 THEORETICAL INQUIRIES IN L. 307, 319 (2013), https://www7.tau.ac.il/ojs/index.php/til/article/view/871/828 [https://perma.cc/YP8Z-5TQC].

[18] *See id.*; Jacob Wallace, *Foes Erupt Over Bid to Mimic Sun-Blotting Volcanic Dust*, E&E NEWS (Mar. 9, 2021), https://www.eenews.net/climatewire/2021/03/09/stories/1063726949 [https://perma.cc/7HMC-LV9X].

[19] Consolidated Appropriations Act, Pub. L. No. 116-93, 133 Stat. 2317.

[20] National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Cong. § 322(b)(2)(A)(iii) (2020) (as received and placed on Senate calendar).

reference to geoengineering but retaining the directive for the DOD to update its 2014 Climate Change Adaptation Roadmap, and include "a description of the overarching approach of the [DOD] to extreme weather, sea level fluctuations, and *associated mitigation measures*."[21] Those "associated mitigation measures" encompass a wide range of responses to climate change, including SRM and other geoengineering technologies.[22]

Congress's apparent willingness to take a more active role in geoengineering regulation—to protect national security—coupled with the foundational regulatory principles already set forth in domestic environmental laws, creates an opportunity for the United States to formulate a coordinated, national strategy for SRM experimentation and potential deployment. Guided by scholarly discourse in SRM governance, this Article argues that, pursuant to Congress's proposed directive in H.R. 6395, the DOD should recommend in its 2022 Climate Change Adaptation Roadmap that the federal government nationally regulate SRM. If Congress adopts the DOD's proposed policy, the United States will be better prepared to deal with the possible conflicts and disputes arising from SRM and other geoengineering technologies as nations contemplate approaches to mitigate the effects of climate change.

This Article proceeds in five parts. Part II explains the technological attributes of geoengineering, specifically SRM, and outline the primary environmental impacts of SRM experimentation and deployment. Part III discusses the geopolitics of SRM from a global perspective, highlighting two evolving sociopolitical problems surrounding SRM: the "moral hazard" and the "rogue actor." Part IV discusses the United States' path toward national SRM regulation, ending with Congress's recent willingness to assess national security threats related to climate "mitigation measures" pursuant to H.R. 6395. Part V considers how current

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[21] National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283 § 327(b)(1) (emphasis added); *see* H.R. Rep. No. 116-617, at 1571 (2020) (Conf. Rep.).

[22] Evidenced by Congress's 2019 appropriation of funding to the NOAA to explore the consequences of SRM (*see infra* notes 78–79 and accompanying text), Congress has recognized SRM as a possible "mitigation measure" in response to climate change.

domestic environmental laws offer a framework for SRM governance but ineffectively apply to comprehensively regulate SRM. Finally, Part VI concludes that national governance of SRM is essential to national security, and therefore, the DOD should recommend in its 2022 Climate Change Adaptation Roadmap that Congress adopt a federal SRM regulatory framework. Additionally, Part VI proposes several recommendations the DOD ought to include in its 2022 Climate Change Adaptation Roadmap for Congress to consult while promulgating a systemic national strategy to regulate SRM.

II. THE TECHNOLOGY & POTENTIAL ENVIRONMENTAL IMPACTS OF SRM

SRM is one of the two main categories of climate manipulation technologies that scientists are considering to address the impacts related to anthropogenic GHG emissions.[23] The other prominent climate manipulation technology category is Carbon Dioxide Removal ("CDR").[24] While both technologies are geoengineering technologies, the particularized mitigation approaches of SRM and

[23] *Geoengineering as a Response to Climate Change: The London Convention and London Protocol*, NAT'L OCEANIC ATMOSPHERIC ADMIN., https://www.gc.noaa.gov/gcil_geoengineering.html [https://perma.cc/5GC4-J4HW] (last visited Mar. 29, 2021). The term "climate *intervention* technology" is also used to describe geoengineering technologies similar to SRM. *See* Mike Hulme, *Climate Intervention Schemes Could Be Undone by Geopolitics*, YALEENVIRONMENT360 (June 7, 2010), https://e360.yale.edu/features/climate_intervention_schemes_could_be_undone_by_geopolitics [https://perma.cc/8RGK-U9UV].

[24] CDR technologies (also referred to as "Greenhouse Gas Removal" or "Carbon Geoengineering") vary in terms of how significantly they interfere with the environment. *What is Geoengineering?*, OXFORD GEOENGINEERING PROGRAMME, http://www.geoengineering.ox.ac.uk/www.geoengineering.ox.ac.uk/what-is-geoengineering/what-is-geoengineering/? [https://perma.cc/5S5J-B8PD] (last visited Mar. 29, 2021). For example, afforestation is considered a CDR technology, which simply involves "[e]ngaging in a global-scale tree planting effort." *Id.* Ocean alkalinity enhancement falls on the opposite end of the spectrum and involves "[g]rinding up, dispersing, and dissolving rocks such as limestone, silicates, or calcium hydroxide in the ocean to increase its ability to store carbon and directly ameliorate ocean acidification." *Id.* Other examples include: biochar, ambient air capture, and ocean fertilization. *Id.*

CDR significantly differ.[25] CDR aims to reduce anthropogenic GHG emissions levels by directly removing carbon dioxide and other GHGs from the atmosphere.[26] SRM, on the other hand, focuses on offsetting the effects of anthropogenic GHG emissions levels by increasing "the reflectivity of the Earth's atmosphere," thereby reducing the amount of radiation entering the atmosphere from the sun and consequently decreasing the Earth's surface temperature.[27] Targeting solar radiation makes SRM particularly controversial because the technology functions to manipulate the actual climate system, whereas CDR focuses on removing a human-caused pollutant emitted into the atmosphere.[28]

There are a number of SRM techniques, but the most widely-discussed, "stratospheric aerosol injection,"[29] involves deploying reflective aerosol particles into the stratosphere, which operates like a volcano by effectively mimicking the natural cooling that occurs when a volcano discharges sulfur dioxide into the atmosphere.[30] Like volcanic particles, stratospheric aerosols block

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[25] NAT'L RSCH. COUNCIL, *supra* note 10, at 378 box 15.1.

[26] *Id.*

[27] *Id.*

[28] *See id.* at 385.

[29] This Article focuses on stratospheric aerosol injection. However, there are other SRM techniques: surface albedo approaches, cloud-albedo enhancement, and space-based techniques. Some surface albedo approaches encompass (1) white roof methods and brightening of human settlements (e.g., painting roofs white and brightening urban roads and pavements); (2) more reflective crop varieties and grasslands (e.g., planting lighter-colored crops); (3) desert reflectors (covering deserts with reflective polyethylene-aluminum); (4) reforestation; and (5) ocean albedo. THE ROYAL SOC'Y, GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY, 23–36 (2009), https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2009/8693.pdf [https://perma.cc/63S3-Y6NH]. Cloud-albedo enhancement would effectively whiten the clouds over parts of the ocean. Space-based techniques involve placing reflective sun-shields into space. *Id.*

[30] Simon Nicholson et al., *Solar Radiation Management: A Proposal for Immediate Polycentric Governance*, 18 CLIMATE POL'Y 322, 323 (2017), https://www.tandfonline.com/doi/abs/10.1080/14693062.2017.1400944?needAccess=true#aHR0cHM6Ly93d3cudGFuZGZvbmxpbmUuY29tL2RvaS9wZGYvMTAuMTA4MC8xNDY5MzA2Mi4yMDE3LjE0MDA5NDQ/bmVlZEFjY2Vzcz10cnVlQEBAMA== [https://perma.cc/P8SG-CZK8]; Reynolds & Parson, *supra* note 16, at 324; *see How Volcanoes Influence Climate*, UNIV. CORP. FOR

incoming sunlight and therefore reduce the amount of solar energy absorbed by the Earth's surface.[31] This interference alters the Earth's solar energy balance, meaning the relationship between the amount of incoming energy from the sun to the Earth and the amount of outgoing energy from the Earth back into space.[32] Not surprisingly, this effect concerns many climate scientists because, as observed during large volcanic eruptions, a shift in the Earth's solar energy balance impacts the weather, and therefore, life on Earth.[33]

Experts have predicted both positive and negative environmental consequences of SRM deployment but are still uncertain as to where and to what degree those predicted effects could be felt.[34] If deployed continuously and on a large enough scale,

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ATMOSPHERIC RSCH., https://scied.ucar.edu/shortcontent/how-volcanoes-influence-climate#:~:text=Often%2C%20erupting%20volcanoes%20emit%20sulfur%20dioxide%20into%20the,combines%20with%20water%20to%20form%20sulfuric%20acid%20aerosols [https://perma.cc/8RYU-L5GW] (last visited Mar. 29, 2021) (providing a description of the volcanic process whereby sulfur dioxide is emitted into the atmosphere, offering an analogy for the potential consequences of SRM deployment).

[31] Parson & Ernst, *supra* note 17, at 312–14. When the Earth absorbs solar energy—through the Earth's surface, clouds, and atmosphere—the Earth warms. *Id.* By limiting how much solar energy enters the atmosphere, SRM congruently allows the atmosphere to cool, thereby offsetting the warming caused by GHG emissions. *Id.*

[32] When incoming and outgoing energy amounts are the same, the Earth's energy is in balance, and the Earth's temperature will remain stable. *The Earth-Atmosphere Energy Balance*, *supra* note 13.

[33] *Id.*; *see* Reynolds & Parson, *supra* note 16, at 324–25.

[34] Jesse Reynolds, *Climate Engineering Field Research: The Favorable Setting of International Environmental Law*, 5 WASH. & LEE J. ENERGY, CLIMATE & ENV'T 417, 424–25 (2014). *See Award Abstract #1937699: Collaborative Proposal: Workshop on Ecological Impacts of Solar Radiation Management Geoengineering*, NAT'L SCI. FOUND., https://www.nsf.gov/awardsearch/showAward?AWD_ID=1937699&HistoricalAwards=false [https://perma.cc/PV8U-M89J] (last visited Mar. 29, 2021) ("[A]lmost nothing is known about the potential impacts of implementation, continuation or termination [of SRM] on natural systems, their functions, and their biodiversity."). *See also* Karen Harpp, *How Do Volcanoes Affect World Climate?*, SCI. AM. (Oct. 4, 2005), https://www.scientificamerican.com/article/how-do-volcanoes-affect-w/ [https://perma.cc/LJ7G-AHLW] (providing historical context of major volcanic eruptions that caused decreases in global temperatures, subsequently impacting food supplies and threatening the survival of geo-specific populations).

SRM could lead to environmental benefits by reducing global surface temperatures, thereby mitigating the climate change-related impacts associated with rising temperatures, such as sea-ice loss, sea level rise, and the increased frequency of extreme storms.[35]

Still, a global temperature reduction brought about by SRM would not lead to ideal climate conditions for everyone.[36] At the local level, climate experts predict that SRM could cause significant reductions or increases in annual precipitation totals.[37] At the regional level, SRM might transform ecosystems by increasing plant primary productivity, since global GHG emissions (specifically carbon dioxide) would generally remain high while less sunlight would reach plants on the ground.[38]

Other environmental consequences of SRM depend on the "human" variable, specifically how decision-makers might utilize the technology.[39] For example, if decision-makers decide to inject sulfur dioxide (the current leading stratospheric aerosol contender for deployment) into the stratosphere, the sulfur dioxide may consequently alter the chemistry of the lower stratosphere, thereby

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[35] Alan Robock, *Benefits and Risks of Stratospheric Solar Radiation Management for Climate Intervention (Geoengineering)*, 50 BRIDGE 59, 65 (2020), https://www.nae.edu/File.aspx?id=229295 [https://perma.cc/VJA8-CLAL] (outlining the benefits, as well as the risks and concerns associated with large-scale SRM deployment); INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, GLOBAL WARMING OF 1.5°C 347 (Valérie Masson-Delmotte et al. eds., 2018), https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf [https://perma.cc/YF8S-ZDZE].

[36] *See e.g.*, Nathan E. Hultman et al., *Climate Risk*, 35 ANN. REV. ENV'T. RES. 283, 294 (2010), https://www.annualreviews.org/doi/pdf/10.1146/annurev.environ.051308.084029 [https://perma.cc/Q6P6-FNQJ] (suggesting that SRM could disrupt the Asian Monsoon, which would affect billions who depend on the monsoon season for agriculture).

[37] Reynolds, *supra* note 34, at 424.

[38] *See id.*, at 460 n. 264. In ecology, primary productivity refers to "the rate at which energy is converted to organic substances by [trees and other] photosynthetic producers . . . , which obtain energy and nutrients by harnessing sunlight." *Primary Productivity*, BRITANNICA (July 6, 2020), https://www.britannica.com/science/primary-productivity [https://perma.cc/YG5P-AVWY] (last visited Mar. 29, 2021).

[39] In this Article, the term "decision-maker" includes governments, international coalitions, academic institutions, individuals, etc., and refers to any entity with the capabilities of utilizing SRM.

damaging the ozone layer.[40] Additionally, if decision-makers deploy SRM on a global scale and then suddenly stop deployment, the effects of climate change that had been suppressed by continuous SRM deployment would likely accelerate—a phenomenon known as "termination shock."[41] In essence, global temperatures would "bounce back" and trigger even more disastrous environmental consequences than if the effects of climate change had naturally progressed.[42]

These significant and uncertain environmental risks (albeit only a fraction of the adverse possibilities) illustrate why many policymakers initially stalled conversations surrounding the governance of SRM.[43] But as climate change has become a more salient crisis, the environmental consequences of SRM that previously obstructed meaningful governance discussions have taken on less weight, compelling governments to reassess the relative risks of deploying SRM compared to not deploying SRM.

III. THE EVOLVING GEOPOLITICS OF SRM: CONSIDERATIONS & INEFFECTIVE GLOBAL REGULATION

From its conception, SRM has engendered significant controversy as a potential response to climate change. Compared to the perceived danger and uncertain risks of the technology, the benefits of SRM seemed "invisible, indirect, questionable, remote,

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[40] Reynolds, *supra* note 34, at 424–45; Richter et al., *Stratospheric Dynamical Response and Ozone Feedbacks in the Presence of SO_2 Injections*, 122 J. GEOPHYSICAL RSCH.: ATMOSPHERES 12,557, 12,558 (2017) https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2017JD026912 [https://perma.cc/WB54-2ZUJ].

[41] Reynolds, *supra* note 34, at 424–25.

[42] *Id.*; CARNEGIE CLIMATE GOVERNANCE INITIATIVE, EVIDENCE BRIEF: GOVERNING SOLAR RADIATION MODIFICATION 5–6, 19 (2020) https://www.c2g2.net/wp-content/uploads/c2g_evidencebrief_SRM.pdf [https://perma.cc/64PJ-HZPX] ("If a deployment of . . . SRM were terminated quickly, climate modelling indicates that global temperatures would 'bounce back', rapidly warming the global climate. Such rapid warming might have significant implications on, for example, weather, precipitation patterns and the number and scale of extreme events. In addition, biodiversity would be impacted as species, whilst adaptable to slow climate change, are severely stressed by rapid change." (citations omitted)).

[43] *See* Geden & Dröge, *supra* note 9.

artificial, and involuntarily imposed," even more so than other geoengineering technologies.[44] In fact, SRM was initially disregarded as a "reckless science fiction,"[45] leading many policymakers to avoid discussing SRM altogether.[46]

Today, some international policymakers still choose not to consider SRM as a viable technology in need of further discussion for a variety of idiosyncratic reasons.[47] For example, foreign governments that fundamentally oppose large GHG emissions reductions do not want to accept SRM as a viable technology simply because that recognition would mean acknowledging climate change as a serious threat.[48] Other government leaders have not legitimately discussed SRM due to the belief that acting before sufficiently understanding the consequences of SRM would prematurely bind their nations to certain policies.[49]

Although SRM is still viewed as controversial (largely due to the inherent uncertainties and possible risks associated with experimentation and global deployment), SRM "has risen up the political agenda" of many governments as a technology to consider.[50] Below are two primary socio-political dilemmas that

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[44] *See* Bronislaw Szerszynski et al., *Why Solar Radiation Management Geoengineering and Democracy Won't Mix*, 45 ENV'T PLAN. A: ECON. & SPACE 2809, 2810–11 (2013), https://journals.sagepub.com/doi/pdf/10.1068/a45649 [https://perma.cc/Q9Q2-UWTD].

[45] Jonathan Watts, *US and Saudi Arabia Blocking Regulation of Geoengineering, Sources Say*, GUARDIAN (Mar. 18, 2019), https://www.theguardian.com/environment/2019/mar/18/us-and-saudi-arabia-blocking-regulation-of-geoengineering-sources-say [https://perma.cc/HN3N-ZR69].

[46] *See* Geden & Dröge, *supra* note 9.

[47] *Id.* ("The reasons for reluctance [to address SRM] differ substantially."); CARNEGIE CLIMATE GOVERNANCE INITIATIVE, *supra* note 42, at 15 ("[T]he global politics of SRM and climate change are complex and uncertain. In the case of SRM they are not underpinned by a tried and tested governance framework, nor a universally agreed understanding of what the purpose or functioning of the technologies are. Already the range of countries' preferences and perspectives about climate, development, security and other interlinked, broad-scope goals are wide and diverging." (citation omitted)).

[48] Geden & Dröge, *supra* note 9.

[49] *Id.*

[50] Watts, supra note 45; Jinnah & Nicholson, *supra* note 9, at 387 ("[A]lthough climate engineering may emerge as a part of a broader global effort to address

policymakers and SRM experts are grappling with while addressing whether and how SRM should be governed: the moral hazard problem and the rogue actor concern.

A. The Moral Hazard Problem

Many experts worry that deploying SRM would function as an "easy fix" to reduce global surface temperatures without requiring the actual reduction of GHG emissions; i.e., SRM tackles a *symptom* of climate change (elevated temperatures) but does not actually address the *source* of climate change (the release of GHG emissions).[51] Referred to as a moral hazard, this phenomenon cautions that SRM might distract, as well as excuse, governments from engaging in meaningful GHG emissions reduction efforts.[52] Essentially, the moral hazard problem centers around the following question: why would a government restructure its economy—spend capital to create new infrastructure, reinvent its job market, etc., exposing its country to potential risks, such as failed infrastructure investments and job loss—to reduce its GHG emissions, when it can alternatively invest in SRM technology and continue with business-as-usual?[53]

With this problematic consideration in mind, some experts and policymakers oppose even the preliminary research of SRM, thereby hindering SRM governance considerations altogether.[54] Yet,

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climate change, the risks associated with SRM—termination shock and the moral hazard among them—are important enough that they themselves demand governance.").

[51] Jinnah & Nicholson, *supra* note 9, at 385, 387. *See* Soheil Shayegh, *Geoengineering is No Climate Fix. But Calling It a Moral Hazard Could Be Counterproductive*, BULL. OF THE ATOMIC SCIENTISTS (Dec. 10. 2019), https://thebulletin.org/2019/12/geoengineering-is-no-climate-fix-but-calling-it-a-moral-hazard-could-be-counterproductive/ [https://perma.cc/R4BM-28PW].

[52] Jinnah & Nicholson, supra note 9, at 385–86; Shayegh, *supra* note 51.

[53] Shayegh, *supra* note 51. *See* Geden & Dröge, *supra* note 9 (asserting that some climate policy advocates and scientists worry that discussing SRM, and thereby normalizing the technology as a feasible policy measure to address climate change, "could obstruct mitigation efforts by creating the misleading perception that injecting aerosols could be a substitute for reducing emissions.").

[54] *See* Nicholson et al., *supra* note 30, at 325 ("[S]ome have argued that paying any attention to SRM, including via proposals for governance, produces a 'moral

no research to date has indicated that SRM would more likely create a moral hazard than any other mitigation technology aimed at combating the effects of climate change.[55]

Nevertheless, this moral hazard concern in the context of SRM appears to fall short of being a legitimate problem for two reasons. First, the theory assumes that governments are the only actors exploring the viability of SRM technology, but as discussed in more detail below, nonstate actors are also capable of experimenting with SRM.[56] Second, the moral hazard problem does not apply to nonstate actors because these independent experimenters are not incentivized per se to participate in the global effort to reduce GHG emissions.

Accordingly, SRM requires regulation—specifically federal regulation—because the imminent need for SRM governance at the national level directly relates to the safe management of experimentation—specifically concerning nonstate actors—as well as the consideration of future deployment. Moreover, the lack of international governance necessitates national regulation because without national regulation, those engaging in SRM activities will remain entirely unchecked. Thus, choosing to nationally govern SRM should be viewed as a "low-risk way to reduce uncertainties and inform future decisions" of the technology, as opposed to a governance strategy aimed at endorsing the deployment of SRM to combat climate change the "easy way" and forgo GHG emissions reduction efforts.[57]

B. The Rogue Actor Concern

National leaders and SRM experts are also apprehensive about the responsible control and management of SRM from a governance

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hazard' that distracts from the rest of the mitigation agenda and gives legitimacy to a set of technologies that could prove dangerous.").

[55] Anthony E. Chavez, *Using Legal Principles to Guide Geoengineering Deployment*, 24 N.Y.U. ENV'T. L. J. 59, 91–92 (2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2600938 [https://perma.cc/46BL-7SB7].

[56] *See infra* Part III.B.

[57] Reynolds & Parson, *supra* note 16, at 325 (citation omitted).

perspective, specifically the possibility of a rogue actor.[58] The rogue actor concern relates to the fact that SRM technology is relatively cheap and deploying stratospheric aerosols into the atmosphere is fairly rudimentary.[59] Hence, any entity, including a single nation, institution, or company, or even a wealthy individual, can unilaterally deploy SRM.[60]

The possibility of a rogue actor is of particular concern in the current global politics of SRM because no national government has legitimately positioned itself to legally intervene.[61] Policymakers worry that a rogue actor will either lack an incentive to refrain from deploying SRM or independently deploy SRM and subsequently not face repercussions.[62] Amongst nations, this concern may cause

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[58] *See* Simon Nicholson, *Solar Radiation Management*, WILSON CTR. (Sept. 30, 2020), https://www.wilsoncenter.org/article/solar-radiation-management [https://perma.cc/T34U-JHGN].

[59] Nicola Jones, *Solar Geoengineering: Weighing Costs of Blocking the Sun's Rays*, YALEENVIRONMENT360 (Jan. 9, 2014), https://e360.yale.edu/features/solar_geoengineering_weighing_costs_of_blocking_the_suns_rays [https://perma.cc/WN4B-EMJV].

[60] *Id.*; NAT'L RSCH. COUNCIL, *supra* note 15, at 150.

[61] To note, some multilateral agreements have partially addressed SRM's potential as a climate change mitigation technology option but have not considered SRM as a ready-to-deploy technology. Geden & Dröge, *supra* note 9.

[62] Netra Chhetri et al., *Governing Solar Radiation Management*, F. FOR CLIMATE ENG'G ASSESSMENT, AM. UNIV. 23–24 (Oct. 2018), http://ceassessment.org/wp-content/uploads/2018/10/AWG_FCEA_governing-solar-radiation-management.pdf [https://perma.cc/HRW4-NE4G]; Elizabeth Chalecki & Lisa Ferrari, *A New Security Framework for Geoengineering*, 12 STRATEGIC STUDIES Q. 82, 83–84 (2018) ("[G]eoengineering on any but the smallest scale means that one state may be able to substantially change the material conditions in another state or even globally on a unilateral basis. Given the lack of any specific laws, treaties, or norms governing planetary technologies of this type, states must look elsewhere for guidance on whether, when, and how to use them in the interest of national security."); CARNEGIE CLIMATE GOVERNANCE INITIATIVE, *supra* note 42, at 16 ("Currently, there is no in situ governance mechanism, including regulatory frameworks or international law that is suitable for, or capable of providing a framework for SRM. . . . As such, there are no legal constraints that would preclude any state (or other actor) from choosing to deploy [Marine Cloud Brightening] or [Solar Aerosol Injection]. Although there are a range of instruments and international mechanisms that might potentially be amended or operationalized to provide a framework, currently this has not begun." (citation omitted)).

significant tension and operate as a trigger for international conflict in an already contentious state of affairs, where disagreements will likely arise regarding whether, when, and how SRM should be used.[63]

Even assuming, as some geoengineering experts suggest, that SRM might not be as risky a technology as many policymakers or researchers believe, the possibility of disputes surrounding unilateral deployment requires a national strategy.[64] Without sufficient oversight and regulation, the experimentation and potential deployment of SRM poses a national security threat to the United States because, while some actors may adequately self-govern in lieu of international and federal regulations,[65] the United States cannot count on all nonstate actors to follow accordingly.[66] Consequently, possible government or nonstate rogue

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[63] *See* Parson & Ernst, *supra* note 17 (" . . . from unilateral deployment and other nations' responses to it; or from allegations that [SRM] interventions, whether intended for research or operational deployment and whether undertaken with broad international consultation or unilaterally, have caused harms . . . [or] that the interventions were undertaken with reckless disregard for their interests or even with hostile intent").

[64] John Fialka, *Risks of Controversial Geoengineering Approach "May Be Overstated,"* E&E NEWS (July 3, 2019), https://www.scientificamerican.com/article/risks-of-controversial-geoengineering-approach-may-be-overstated/ [https://perma.cc/5DRZ-FNUG] (arguing that insurance programs and "financial risk pools" can protect farmers in smaller countries, for example, from potential economic harms arising from large-scale SRM deployment, should harms related to crop yields arise).

[65] *See, e.g.*, *About*, SCOPEX ADVISORY COMM., https://scopexac.com/ [https://perma.cc/VV9V-9DGY]. Harvard University's SRM research group, called the Keutsch group, appointed an independent advisory committee for its Stratospheric Controlled Perturbation Experiment ("SCoPEx"). *Id.* The independent committee advises the group in several areas, including the scientific quality of the research, the risks associated with experimentation, stakeholder engagement, and other issues deemed necessary by the Committee, and is tasked with determining whether the project ought to continue after each phase. *Id.*

[66] *See* Fialka, *supra* note 64; THE NATIONAL GLOBAL CHANGE RESEARCH PLAN 2012–2021: A TRIENNIAL UPDATE, U.S. GLOB. CHANGE RSCH. PROGRAM 37 (Jan. 2017) ("The need to understand the possibilities, limitations, and potential side effects of climate intervention becomes all the more apparent with the recognition that other countries or the private sector may decide to conduct intervention experiments independently from the U.S. government."); Reynolds & Parson, *supra* note 16, at 323–42.

actors, as well as the uncertain effects of the technology, signal that SRM is not a taboo national policy consideration, but rather a necessary consideration to effectively address the social, moral, and political challenges associated with SRM.[67]

IV. THE ROAD TO NATIONAL REGULATION: FROM AVOIDANCE, TO FUNDING, TO ADDRESSING SRM

The current state of SRM research and regulation in the United States has been shaped by the federal government's passive role regarding geoengineering regulation as a whole. Within the past decade, the United States has failed to expressly address geoengineering in any enacted environmental or climate change policies,[68] largely because "[t]here has been debate on whether and how a federal program . . . may conduct, fund, and oversee future research."[69] For example, in 2014, President Obama signed Executive Order No. 13653, "Preparing the United States for the Impacts of Climate Change," which directed all federal agencies "to

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[67] *See* Reynolds, *supra* note 14, at 2, 6.

[68] Concededly, geoengineering was first mentioned in a hearing held by the House of Representatives' Committee on Science and Technology in November 2009. *Geoengineering: Assessing the Implications of Large-scale Climate Intervention Before the H. Comm. on Sci. & Tech.*, 111th Cong. (2009). The purpose of the hearing was "to provide an introduction to the concept of geoengineering, including the science and engineering underlying various proposals, potential environmental risks and benefits, associated domestic and international governance issues, research and development needs, and economic rationales both supporting and opposing the research and deployment of geoengineering activities." *Id.* at 3. The hearing did not result in the Committee making a policy decision on whether to support experimentation or deployment, *see id.*, and instead, solely served as a "serious review of proposals for climate engineering." Press Release, Homeland Sec. News Wire, U.S. Congress Holds Hearings on Geoengineering (Nov. 9, 2009), http://www.homelandsecuritynewswire.com/us-congress-holds-hearings-geoengineering [https://perma.cc/QP2-65JS]. More recently, in 2017, the Geoengineering Research Evaluation Act was introduced to address geoengineering governance, but the bill did not gain traction after its referral to the Subcommittee on Environment. *See* H.R. 4586, 115th Cong. (2017).

[69] Shuchi Talati, *A Small Provision in the FY20 Spending Package Deserves a Much Bigger Discussion*, UNION OF CONCERNED SCIENTISTS (Jan. 24, 2020, 2:36 PM), https://blog.ucsusa.org/shuchi-talati/provision-in-fy20-spending-package-deserves-bigger-discussion [https://perma.cc/MW7J-TBZK].

develop, implement, and update comprehensive plans that integrate consideration[s] of climate change into agency operations and overall mission objectives."[70] Pursuant to this Executive Order, the DOD promulgated its 2014 Climate Change Adaptation Roadmap.[71] In its Roadmap, the DOD considered how climate change might affect its operations, but significantly, the DOD did not set forth any recommendations to research climate change-related technologies, such as SRM, or geoengineering more generally,[72] even though geoengineering was considered a national security threat at the time.[73]

As concern over the impacts of climate change has grown following President Obama's Executive Order No. 13653, the term "geoengineering," including SRM, has garnered newfound political attention.[74] Congress has not only recognized SRM as a possible technology but also a viable technology, subsequently taking steps

[70] Exec. Order No. 13,653, 78 Fed. Reg. 66,817 (Nov. 6, 2013).

[71] The 2014 Climate Change Adaptation Roadmap operates as an informative document setting forth the DOD's goals and strategies to address climate change in protecting national security. Notably, the DOD considers climate change as a "threat multiplier" because the effects of climate change (e.g., rising global temperatures, sea level rise, more extreme weather events, etc.) can lead to a "wide spectrum of possible threats," such as, food and water shortages, pandemic diseases, global instability, and conflict. *Foreword* to U.S. DEP'T OF DEF., 2014 CLIMATE CHANGE ADAPTATION ROADMAP (2014), https://www.acq.osd.mil/eie/downloads/CCARprint_wForward_e.pdf [https://perma.cc/MBM8-UHHT].

[72] *See id.*

[73] Herb Lin, *Large-Scale Geoengineering and Threats to National Security*, LAWFARE INST. (Oct. 31, 2015), https://www.lawfareblog.com/large-scale-geoengineering-and-threats-national-security [https://perma.cc/53MA-7D7E] ("An important national security concern—unaddressed in most of the discussions about the national security concerns associated with climate change—arises from the fact that . . . [any actor] might be able to undertake such actions unilaterally . . . . And the possibility (indeed, the likelihood) that something might go wrong . . . places the issue of geoengineering squarely into the national security domain.").

[74] *See* John Fialka, *U.S. Geoengineering Research Gets a Lift with $4 Million from Congress,* NEWSBREAK (Jan. 23, 2020, 10:00 AM), https://www.newsbreak.com/colorado/boulder/news/1498521042703/us-geoengineering-research-gets-a-lift-with-4-million-from-congress [https://perma.cc/6D7B-TREC].

to research the effects of global SRM deployment.[75] For example, on November 8, 2017, the Congressional Committee on Science, Space, and Technology convened a hearing on geoengineering.[76] During that hearing, Ranking Member Suzanne Bonamici of Oregon stressed that, "[g]eoengineering is an option our country should look into. The state of current geoengineering research makes it clear that we are decades away from potential deployment and the risks of such a deployment are not well understood."[77]

Just over two years later, Congress took its first major step toward exploring and regulating SRM in its 2020 Consolidated Appropriations Act by apportioning approximately $4 million to NOAA.[78] In an accompanying government document from the House Appropriations Committee, the Committee specifically noted its interest to use the funds for:

> [M]odeling, assessments, and . . . initial observations and monitoring of stratospheric conditions and the Earth's radiation budget, including the impact of the introduction of material into the stratosphere . . . to affect climate, and the assessment of solar climate interventions . . . . [T]he agreement further directs [the Office of Oceanic and Atmospheric Research] to improve the understanding of the impact of atmospheric aerosols on radiative forcing, . . . the formation of clouds, precipitation, and extreme weather.[79]

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[75] *See* James Temple, *The US Government Has Approved Funds for Geoengineering Research*, MIT TECH. R. (Dec. 20, 2019), https://www.technologyreview.com/2019/12/20/131449/the-us-government-will-begin-to-fund-geoengineering-research/ [https://perma.cc/A6M2-2V24].

[76] *Geoengineering: Innovation, Research, and Technology, Before Subcomm. on Energy & Subcomm. on Env't of the Comm. on Sci., Space, and Tech.*, 115th Cong. (2017) (statement of Suzanne Bonamici, Ranking Member of the Subcommittee on Environment), https://docs.house.gov/meetings/SY/SY18/20171108/106598/HHRG-115-SY18-MState-B001278-20171108.pdf [https://perma.cc/8HVV-YLF8].

[77] *Id.* at 1.

[78] Consolidated Appropriations Act, Pub. L. No. 116-93, 133 Stat. 2317.

[79] *Division__–Commerce, Justice, Science, and Related Agencies Appropriations Act, 2020*, at 17–18, https://appropriations.house.gov/sites/democrats.appropriations.house.gov/files/HR%201158%20-%20Division%20B%20-%20CJS%20SOM%20FY20.pdf [https://perma.cc/48VF-BEGX]. *See* Charles Corbett, *Maxing Out NEPA: Environmental Review of Early Solar Geoengineering Field Research*, LEGALPLANET (Feb. 25, 2020), https://legal-

While not endorsing SRM per se, the apportionment constitutes an acknowledgement by Congress that the unknowns surrounding SRM ought to be researched. Representative Jerry McNerney of California affirmed that SRM is "one of the tools we might need . . . . [Thus,] we need to develop the scientific understanding, a firm understanding, of what [SRM] means and what the risks are so that we can decide if it's something we want to use or not."[80]

Although this congressional apportionment is a relatively small amount, the apportionment signifies Congress's interest in obtaining more precise data and increasing observations of the stratosphere to look for potential SRM deployment.[81] Moreover, David Fahey, NOAA's top climate scientist, indicated that Congress's interest in obtaining these measurements specifically concerns detecting changes in the stratosphere in the event that another nation decides to experiment with, or deploy, SRM.[82] Therefore, the $4 million apportionment goes further than providing funding for SRM experimentation; the apportionment explicitly aims to protect national security and prepare the United States to make a political decision if other nations or nonstate actors choose to deploy SRM unilaterally.[83]

The most recent indication of Congress's intent to govern SRM lies in H.R. 6395, known as the National Defense Authorization Act for Fiscal Year 2021, which can solidify a federal SRM governance strategy.[84] The House of Representatives' version of H.R. 6395, which was placed on the Senate's Legislative Calendar on August 5, 2020, required the DOD to update its 2014 Climate Change Adaptation Roadmap by February 1, 2022 to necessarily include:

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planet.org/2020/02/25/maxing-out-nepa-environmental-review-of-early-solar-geoengineering-field-research/ [https://perma.cc/AAM2-3TLP].

[80] Emily Pontecorvo, *The Climate Policy Milestone that Was Buried in the 2020 Budget*, GRIST (Jan. 8, 2020), https://grist.org/climate/the-climate-policy-milestone-that-was-buried-in-the-2020-budget/ [https://perma.cc/D77L-AAHG].

[81] *Id.*

[82] *Id.*

[83] Fialka, *supra* note 74.

[84] *See* National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283 § 327.

> [A]n outline of the strategy and implementation plan of the Department to address the current and foreseeable effects of climate change on the mission of the Department of Defense . . . .[and] a discussion of the current and foreseeable effects of climate change on plans and operations, including conflicts or disputes, emerging threats, and instability caused or exacerbated by climate change, including tensions related to . . . geoengineering.[85]

The Senate passed a revised version of H.R. 6395 on December 4, 2020, which became law on January 3, 2021.[86] The enacted H.R. 6395 still mandates the DOD to update its 2014 Climate Change Adaptation Roadmap; but during the amendment process, the Senate removed the term "geoengineering" from the bill—charging the DOD to instead include "a description of the overarching approach of the [DOD] to extreme weather, sea level fluctuations, and *associated mitigation measures* . . . ."[87] In its description, the DOD must discuss "the current and foreseeable effects of extreme weather and sea level fluctuations on plans and operations, including . . . geopolitical instability . . . caused by climate events . . . ."[88] Moreover, H.R. 6395 directs the DOD to "consider . . . data on, and analysis of, the national security effects of climate."[89]

Although the enacted version of H.R. 6395 does not expressly state "geoengineering," the language inherently encompasses SRM, since the DOD must broadly consider mitigation measures, geopolitical instability, and national security threats related to climate change.[90] Accordingly, H.R. 6395's directive affords the DOD the opportunity to examine the urgent need to nationally regulate SRM and propose recommendations through its 2022 Climate Change Adaptation Roadmap. In sum, the conglomeration of Congress's recent policy decisions—(1) the $4 million

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[85] H.R. 6395, 116th Cong. § 322(b)(2)(A)(iii) (2020) (as received and placed on Senate calendar).
[86] National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283.
[87] *Id.* § 327(b)(1). As noted throughout this Article, SRM is a climate mitigation technology.
[88] *Id.* § 327 (b)(2)(A)(iii).
[89] *See id.* Pursuant to H.R. 6395, the climate data must be prepared by the Climate Security Advisory Council of the Director of National Intelligence. *Id.* § 327 (c)(2).
[90] *See id.* § (b)(1), (b)(2)(A)(iii), (c)(2).

apportionment to NOAA in 2019, (2) the House of Representatives' express interest to consider "geoengineering" in its version of H.R. 6395, and (3) the ensuing mandate in H.R. 6395 for the DOD to discuss climate-change-related national security threats involving mitigation measures in its 2022 Roadmap—indicate Congress's manifest intent to examine geoengineering technology as a potential national security threat in need of the DOD's attention.[91]

V. DOMESTIC ENVIRONMENTAL LAWS PROVIDE A FOUNDATION FOR NATIONAL SRM REGULATION

As Congress has indicated an interest in addressing the current and foreseeable effects of SRM at the national level, it is useful to analyze how existing domestic environmental laws provide some governance structure for SRM regulation.[92] The National Environmental Policy Act ("NEPA") and the Clean Air Act ("CAA") are the most prominent environmental laws that could apply (or be modified to apply) to SRM in certain contexts, while other domestic laws could function as templates to establish a regulatory framework for SRM.[93] Collectively, these domestic laws could effectively guide a national statutory structure for SRM governance.

A. The National Environmental Policy Act

NEPA is the principal procedural statute for the protection of the environment and requires federal agencies to evaluate the environmental consequences of their activities, such as constructing public highways or making permitting application decisions, prior

[91] Consolidated Appropriations Act, Pub. L. No. 116-93, 133 Stat. 2317. *See* National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Cong. § 322(b)(2)(A)(iii) (2020) (as received and placed on Senate calendar); National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283 § 327(b)(1) (2020).

[92] Chhetri et al., *supra* note 62, at 23 ("A critical first step, then, is to have a good understanding of how existing structures relate to the governance of SRM, with the goal of facilitating sharing, cooperation, and co-learning across research and governance communities.").

[93] Albert Lin, *U.S. Law*, *in* CLIMATE ENGINEERING AND THE LAW: REGULATION AND LIABILITY FOR SOLAR RADIATION MANAGEMENT AND CARBON DIOXIDE REMOVAL 154, 155, 157 (Michael Gerrard & Tracy Hester eds., 2018).

to engaging in those activities.[94] Under NEPA, all federal agencies must prepare an Environmental Assessment ("EA") for proposed agency actions, and submit the EA to the Council on Environmental Quality ("CEQ") for the CEQ to either (1) issue a Finding of No Significant Impact ("FONSI"), or (2) determine that the agency must prepare an Environmental Impact Statement ("EIS").[95] An agency must prepare an EIS if the CEQ determines that an agency's proposed activity will significantly affect the environment (e.g., a proposed climate-altering experiment that injects aerosol particles into the stratosphere), as the action will be deemed to have a "significant impact" in need of the CEQ's final approval before proceeding.[96] Thus, NEPA would certainly apply to federally funded or sponsored SRM experiments, which would increase assurances that the government sufficiently accounted for public health and the environment pursuant to a NEPA analysis.[97]

However, the review process established in NEPA does not fully encompass SRM activities and therefore would not be the proper statute under which SRM could solely be regulated. NEPA's jurisdiction is limited to federal agency action and does not create procedures for independent nonstate actors that may conduct SRM experiments, which are currently the primary entities planning SRM experiments.[98] Also problematic, NEPA exempts environmental

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[94] 40 C.F.R. § 1500.1 (2020) ("The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment.").

[95] 40 C.F.R. §§ 1500–18 (2020).

[96] *Id.* The activity's social and economic effects will also be considered in the EIS. 40 C.F.R. § 1508.8 (2020). In the context of SRM, projects that will be of "significant impact" are those that will be significant in size. LIN, *supra* note 93, at 156. Thus far, SRM experimentation has not been significant enough to even trigger obligations under NEPA. *Id.*

[97] LIN, *supra* note 93, at 157.

[98] *Id.* at 156. *But see* Charles Corbett, *Maxing Out NEPA: Environmental Review of Early Solar Geoengineering Field Research*, LEGALPLANET (Feb. 25, 2020), https://legal-planet.org/2020/02/25/maxing-out-nepa-environmental-review-of-early-solar-geoengineering-field-research/ [https://perma.cc/AAM2-3TLP] (highlighting that Congress's $4 million apportionment to the NOAA constitutes a government action under NEPA since those funds came from the federal budget).

assessments during "emergency circumstances,"[99] which could function as a significant regulatory deficiency in the context of SRM, since emergency circumstances under NEPA include "acts of God" and national defense or national security emergencies—activities particularly relevant to large-scale SRM deployment.[100] In these emergency circumstances, the acting agency would need not assess the environmental impact of its action and would instead consult with the CEQ to determine "alternative arrangements" needed to control the emergency.[101]

In sum, even though NEPA might govern certain SRM activities, if NEPA remains the sole "governing" statute for SRM (1) a rogue actor's activities would not fall within the jurisdiction of NEPA, and (2) a federal agency could circumvent the mandate to provide an EA, and even an EIS, by declaring that circumstances have risen to the level of an emergency—either as an "act of God" (e.g., effects related to climate change) or as a "national defense or national security emergency" (e.g., a nonstate actor unilaterally deploying SRM).[102]

B. The Clean Air Act

The CAA is the United States' premiere air quality statute that requires the EPA to implement a variety of programs to reduce pollution with the purpose of protecting public health and the environment from toxic air emissions.[103] Under the CAA, the EPA must review and revise (as needed) National Ambient Air Quality Standards ("NAAQS"), which are categorized as either "primary" or "secondary" depending on whether the pollutant to be regulated

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[99] 40 C.F.R. § 1506.11 (2020); LIN, *supra* note 93, at 156–57 ("Emergency circumstances generally involve a sudden, unanticipated event or unforeseeable conditions demanding unusual or immediate action . . . Whether climate change-related conditions would qualify as emergency circumstances is an open question.").

[100] 50 C.F.R. § 402.05 (2019) (clarifying the applicability of NEPA's expedited review process for "emergencies" under the Endangered Species Act).

[101] 40 C.F.R. § 1506.11 (2020); LIN, *supra* note 93, at 156.

[102] LIN, *supra* note 93, at 156.

[103] Air Pollution Prevention and Control, 42 U.S.C. §§ 7401–7661.

poses a public health risk or has an effect on public welfare.[104] Accordingly, states must promulgate their own State Implementation Plans ("SIPs") that demonstrate compliance with EPA's NAAQS and subsequently submit their SIP proposal to the EPA for approval.[105]

Upon determining that the CAA applies to GHG emissions,[106] the EPA indicated a general willingness to regulate activities that might harm the environment or endanger public health and welfare.[107] Thus, the EPA could likewise interpret the CAA broadly to apply to SRM because SRM (purposefully) alters climate processes just like GHG emissions, and therefore might harm the environment as well.[108] This interpretation would create a legal basis to challenge SRM activities.[109] For example, claimants could assert that deploying stratospheric aerosols violates the CAA by prohibitively emitting a "pollutant" (SRM) or that an actor violated the CAA by not obtaining proper authorization prior to emitting the "pollutant."[110]

However, applying the CAA to SRM raises several questions. Still to be determined is whether stratospheric aerosols fall within the statutory or regulatory definition of a "pollutant" (similar to the debate over GHG emissions) and whether the EPA has the authority

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[104] 42 U.S.C. § 7602(h). *See infra* note 114, for specific information on particulate matter ("PM"), which is the most relevant of the six NAAQS to SRM, specifically SRM that uses sulfuric aerosols.

[105] 42 U.S.C. § 7410. States may set more strict standards in their SIP's than the EPA requires. *See id.*

[106] Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act., 74 Fed. Reg. 66,496, 66,496–546 (Dec. 15, 2009).

[107] Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66,496 (Dec. 15, 2009) (to be codified at 40 C.F.R. Ch. I); Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31,514 (June 3, 2010); Tracy Hester, *Remaking the World to Save It: Applying U.S. Environmental Laws to Climate Engineering Projects*, 38 ECOLOGY L. Q. 851, 876 (2011), https://www.jstor.org/stable/24115125 [https://perma.cc/9GN7-TXX8].

[108] Hester, *supra* note 107.

[109] *Id.*

[110] 42 U.S.C. § 7604(a) (providing a basis for individuals to bring citizen suits against those who violate the CAA); Hester, *supra* note 107.

to make such a finding.[111] If an SRM project involves deploying sulfate aerosols,[112] the project could fall within the CAA under either the "particulate matter" or the sulfur dioxide NAAQS provisions.[113] Moreover, the EPA may find statutory authority to add sulfuric aerosols to its "particulate matter" list in order to trigger CAA provisions, but this authority, as applied to SRM, remains unclear.[114] In concert with the CAA and NEPA, the federal government may be able to use other narrowly tailored, climate-related, domestic environmental laws as a template for SRM governance.

C. Other Domestic Environmental Laws

The Weather Modification Reporting Act of 1972 ("WMRA") and the National Weather Modification Policy Act of 1976 ("NWMPA")[115] provide statutory schemes that could serve as a framework for regulating SRM activities.[116] The WMRA authorizes NOAA to require reporting of activities that "[m]odify[ ] the solar radiation exchange of the earth or clouds, through the release of gases, dusts, liquids, or aerosols into the atmosphere."[117] The NWMPA also establishes a mandatory open-access research policy for domestic field experiments that could modify the weather or

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111 *See* Hester, *supra* note 107, at 877, n. 113.

112 Sulfate is one type of particle under consideration to be used for SRM experiments. *See SCoPEx*, KEUTSCH RSCH. GRP., HARV. UNIV., https://www.keutschgroup.com/scopex [https://perma.cc/6J46-9FEF]. Harvard University's Keutsch group will use frozen water particles for its initial experiment but might subsequently explore injecting sulfate into the stratosphere. *See id.*

113 Hester, *supra* note 107, at 878. *See* LIN, *supra* note 93, at 177.

114 42 U.S.C. § 7403(g) (2019); *see generally Particulate Matter (PM) Pollution*, EPA (Nov. 14, 2018), https://www.epa.gov/pm-pollution [https://perma.cc/B9DX-ZH39] (providing background information on particulate matter ("PM") and the EPA's process of setting, reviewing, and implementing PM standards under the CAA).

115 National Weather Modification Policy Act of 1976, Pub. L. No. 94-490, 90 Stat. 2359 (1976) (codified as amended at 15 U.S.C. §§ 330, 330(e)); Weather Modification Reporting Act of 1972, Pub. L. No. 92-205, 85 Stat. 735 (1971) (codified as amended at 15 U.S.C. § 330(a)–(e)).

116 NAT'L RSCH. COUNCIL, *supra* note 15, at 170.

117 15 C.F.R. § 908.3(a)(3) (2019).

climate.[118] The term "weather modification" is defined as "any activity performed with the intention of producing artificial changes in the composition, behavior, or dynamics of the atmosphere," which is squarely applicable to SRM.[119] Accordingly, a national SRM regulatory scheme could emulate this framework. However, an SRM-specific scheme should have a lower threshold than that provided by the two Acts, so that even the possibility of a climate-modifying activity would mandate disclosure to NOAA or another government agency designated to oversee SRM activities.

Additionally, environmental laws that regulate hazardous substances could guide national SRM regulation, since the uncertainties and potential adverse impacts of SRM justify its designation as a substance that poses a "risk to man or the environment."[120] For instance, the Federal Insecticide, Fungicide, and Rodenticide Act ("FIFRA"), which addresses the distribution, sale, and use of pesticides, requires the applicant manufacturer to first show that the pesticide will not cause "unreasonable adverse" environmental effects prior to the EPA granting registration.[121] Yet, even if the EPA initially grants registration, the EPA may necessarily suspend its registered status "to prevent an imminent hazard," and may subsequently cancel registration upon a final determination.[122]

SRM is similar to a pesticide in the sense that SRM releases a precarious substance with potentially broad adverse impacts into the air and environment. Therefore, in governing SRM, the federal government could employ FIFRA's risk-averse registration scheme and mandate that SRM experimenters (registrants) show that their SRM experiments "will not generally cause unreasonable adverse

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[118] NAT'L RSCH. COUNCIL, *supra* note 15, at 170 ("[T]he U.S. National Weather Modification Reporting Act provides a statutory framework for making an SRM . . . open-access research policy mandatory in the United States, at least insofar as the research entails field experiments that are conducted domestically and are of such a scale that they could actually affect climate or weather.").

[119] 15 U.S.C. § 330(3).

[120] Federal Insecticide, Fungicide, and Rodenticide Act, Pub. L. No. 92-516, 86 Stat. 973 (1972) (codified as amended in scattered sections of 7 U.S.C.).

[121] *Id.*

[122] *Id.*

effects on the environment."[123] If the SRM scheme uses identical language to that of FIFRA, the SRM experimentation permitting process would necessarily take "the economic, social, and environmental costs and benefits" of the experiment into account.[124]

Although existing domestic laws can apply to certain activities associated with SRM, even their amalgamation fails to offer a fortified framework to comprehensively regulate SRM activities because SRM is an unknown, possibly-risky-but-potentially-beneficial technology that insufficiently fits within the federal government's existing environmental statutory scheme.[125] In effect, the lack of systemic regulation has led to a haphazard approach to SRM regulation where researchers and lawyers are left to guess and widely interpret what sort of SRM activities could trigger existing environmental laws and also which of those laws would be triggered.[126] Solely relying on these current laws would lead to more questions surrounding an already uncertain technology.[127] However, existing environmental laws are not useless—the principles and schemes of NEPA, the CAA, and other more specific statutes could serve as a guidepost for national SRM regulation.

[123] *See* 7 U.S.C. §§ 136(bb), 136a(c)(5)(D) (defining "unreasonable adverse effects on the environment").

[124] *See id.*

[125] Elza H. Pell, *Climate Change: Geoengineering Solutions Prompt Debate Over Global Regulation*, INT'L BAR ASS'N (June 10, 2019), https://www.ibanet.org/Article/NewDetail.aspx?ArticleUid=A6FBEDE0-BC2D-4627-8656-A7991617ED76 [https://perma.cc/C9XV-9DUF]. *See* Sarah Fecht, *We Need Laws on Geoengineering, ASAP*, COLUM. UNIV. EARTH INST. (Mar. 20, 2018), https://blogs.ei.columbia.edu/2018/03/20/geoengineering-climate-law-book/ [https://perma.cc/7HWK-GHE7] ("So far, we don't even have national controls, let alone global controls. Today, someone could launch a fleet of airplanes to spray aerosols or other substances into the upper atmosphere, and it arguably would not violate any laws.").

[126] Pell, *supra* note 125 ("In the near term, it is unlikely that a global treaty or framework for any climate geoengineering solution will emerge. 'As a result, . . . we'll see people start to do research and small-scale deployment under existing laws not written for these technologies, such as the US Clean Air Act. That's where lawyers are going to be involved – to figure out what sort of laws apply and to what sort of things.'").

[127] *See id.*

VI. THE DOD SHOULD USE CONGRESS'S DIRECTIVE AS A PLATFORM TO NATIONALLY REGULATE SRM

The DOD is uniquely positioned to set forth recommendations in its 2022 Climate Change Adaptation Roadmap that could result in profound progress toward effective federal governance of geoengineering, particularly with regard to SRM. Subpart A addresses the importance of regulating SRM at the federal level now, although the ultimate objective is to develop an international, collaborative SRM governance regime. Subpart B sets forth recommendations on how the DOD can provide Congress with guidelines so Congress can more easily promulgate a comprehensive approach to regulating SRM.

A. Federal Regulation Sets the Stage for International Cooperation

Many researchers and political theorists have called for a formal international approach to regulating SRM,[128] but national and international governance of SRM need not be mutually exclusive. Any large-scale SRM deployment will inevitably lead to global consequences—compelling the United States to eventually address SRM at the international level.[129] But, by proactively governing SRM nationally and deciding in advance of any climatic "tipping point" whether SRM could be part of a strategic response to climate change, the United States will be better prepared to negotiate calculated SRM decisions at the international level.[130] Incorporating a cohesive, national SRM governance scheme into the U.S. climate agenda will create a foundation for successful negotiations at the

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[128] Parson & Ernst, *supra* note 17, at 320 ("The need for international law and governance to address challenges posed by the prospect of [climate engineering, such as SRM] has been recognized . . . .").

[129] Susan Biniaz & Daniel Bodansky, *Solar Climate Intervention: Options for International Assessment and Decision-Making*, CTR. FOR CLIMATE & ENERGY SOLS. 11 (July 2020), https://www.c2es.org/site/assets/uploads/2020/07/solar-climate-intervention-options-for-international-assessment-and-decision-making.pdf [https://perma.cc/6727-YJEX]; Parson & Ernst, *supra* note 17, at 311; Reynolds, *supra* note 14, at 6.

[130] *See* Biniaz & Bodansky, *supra* note 129, at 3. *See also* NAT'L RSCH. COUNCIL, *supra* note 15, at 175 ("[B]eing proactive rather than reactive could allow for the development of a thoughtful and effective structure that will be commensurate with the needs and risks.").

international level to strategically address the possible conflicts and disputes arising from SRM.[131]

Notably, the United Nations has attempted to address geoengineering, and international coalitions have formed to condemn geoengineering experiments.[132] But, the non-binding international policies formed by these alliances have largely developed on reactive, case-by-case bases—suggesting that the international community is not ready to formulate an enforceable global SRM regime.[133]

Therefore, the United States need not wait for international institutions to emerge before promulgating its own SRM regulations.[134] In fact, the United States should not wait because "national-level policies are often the driver of international policy development as countries are more likely to agree and adhere to international policies that reflect their pre-existing domestic policies."[135] Moreover, it has been observed that "[t]he most

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131 *See* Chhetri et al., *supra* note 62, at 25.

132 *See* Jeff Tollefson, *Geoengineering Faces Ban*, NATURE 13, 13–14 (Nov. 2010), https://www.nature.com/articles/468013a [https://perma.cc/HB7G-DZ77]; *Geoengineering on the Agenda at the United Nations Environment Assembly*, F. FOR CLIMATE ENG'G ASSESSMENT (Mar. 6, 2019), https://ceassessment.org/geoengineering-on-the-agenda-at-the-united-nations-environment-assembly/ [https://perma.cc/FY9T-3349].

133 For example, in 2010, the International Convention on Biological Diversity called for a moratorium on geoengineering, which initially compelled the German government to suspend its ocean fertilization experiment, called LOHAFEX, in the Antarctic Ocean. *See, e.g.*, Tollefson, *supra* note 132, at 14. However, the moratorium allowed for the continuance of small-scale research studies, so Germany's experiment ultimately moved forward. *See id. See also supra* Part III (discussing reasons why governments have been slow to consider SRM as a technology in need of governance, which supports why governments are not ready to formulate a permanent transnational SRM regime).

134 *Id.* at 23.

135 *Id. See* Emily O'Brien & Richard Gowan, *What Makes International Agreements Work: Defining Factors for Success*, CTR. ON INT'L COOP., N.Y. UNIV. 3 (Sept. 2012), https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/7839.pdf [https://perma.cc/WVX3-43CA] ("Agreements are most likely to be successful when there is real political buy-in in advance, and it is important to negotiate new agreements so as to build up a high degree of consent early on . . . . A successful agreement must win the support of key domestic constituencies in the states involved . . . .").

(relatively) successful international agreements on . . . [the] protection of the atmospheric commons [e.g., the stratosphere] have been built on top of the foundation of sound national policies."[136]

Hence, proactively establishing a federal SRM governance approach[137] would serve as "a central pivot for coordination, planning, determining policy priorities and distributing resources" to direct the United States to enter the international SRM governance arena.[138] In so doing, the United States will be more prepared to negotiate internationally with other governments actively considering SRM regulation, because governments participating in activities in the global commons (e.g., the stratosphere) are more vulnerable to policies already implemented by other participating governments.[139]

Accordingly, the DOD should propose a feasible framework in its 2022 Climate Change Adaptation Roadmap for the United States to nationally govern SRM. Contemplating SRM in the near-term will prepare the United States to make principled and informed decisions regarding SRM's potential deployment as the effects of climate change become more dire.[140]

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[136] Chhetri et al., *supra* note 62, at 25 (emphasis added).

[137] Reynolds & Parson, *supra* note 16, at 323–42.

[138] Heleen de Coninck et al., *Strengthening and Implementing the Global Response, in* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, GLOBAL WARMING OF 1.5°C 353 (2018), https://www.ipcc.ch/sr15/chapter/chapter-4/ [https://perma.cc/TD6Q-KCDH].

[139] UN SYS. TASK TEAM ON THE POST-2015 UN DEV. AGENDA, GLOBAL GOVERNANCE & GOVERNANCE OF THE GLOBAL COMMONS IN THE GLOBAL PARTNERSHIP FOR DEVELOPMENT BEYOND 2015 at 3 (2013), https://www.un.org/en/development/desa/policy/untaskteam_undf/thinkpieces/24_thinkpiece_global_governance.pdf [https://perma.cc/H35T-TF3L] (defining "global commons" as areas that extend outside the jurisdiction of one country (e.g., the atmosphere, the ocean, and space), but where governments are nevertheless active).

[140] The degree to which the United States prepares itself for these negotiations will depend on how thoroughly the federal government researches and considers SRM as a viable technology in the near-term, and whether the federal government develops a comprehensive regulatory framework—accounting for both experimentation and potential deployment—before the climate reaches the tipping point: the point where there is finally a consensus amongst decisionmakers that something (e.g., deploying SRM) *must* be done. *See* Nicholson, *supra* note 58.

B. Recommendations for National SRM Regulation

In order to effectuate its recommendation to nationally govern SRM, the DOD must outline feasible steps for the federal government to implement the recommendation. Below are two overarching guidelines—based on empirical research and opinions by experts in geoengineering governance—that the DOD ought to include in its 2022 Climate Change Adaptation Roadmap to guide Congress in promulgating a cohesive regulatory scheme for SRM.

1. Create an Independent Commission

The DOD should recommend in its Roadmap that SRM be regulated by a single, independent commission to oversee the various federal agencies that would deal with SRM in their related capacities (as opposed to an already-existing federal agency charged with the authority to manage federal SRM governance), since SRM inherently concerns many areas of the federal government. NOAA could provide research oversight,[141] the EPA could handle environmental enforcement regarding SRM experiments, and the DOD could address the possible conflicts related to SRM by assessing international perceptions of climate change regarding possible global SRM deployment. Collectively, these agencies would operate under one, independent commission—serving in a managerial capacity—that would be better positioned to facilitate a national, comprehensive SRM regulatory strategy. Geoengineering scholars David Winickoff and Mark Brown similarly argue that "the US would benefit from a national government advisory commission on [SRM], one that is 'independent, transparent, deliberative, publicly engaged and broadly framed.'"[142]

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[141] *See* Atmospheric Climate Intervention Research Act, H.R. 5519, 116th Cong. (2019) ("[NOAA is] to undertake research, . . . and develop increased observations, improved models, new analyses, computing and related technologies, and risk assessment to improve understanding and prediction of the chemistry and dynamics of the stratosphere; Earth's radiation budget; and the impacts of changes in atmospheric aerosol forcing on the Earth's energy balance and climate.").

[142] Reynolds, *supra* note 14, at 9 (quoting David E. Winickoff & Mark B. Brown, *Time for a Government Advisory Committee on Geoengineering Research*, ISSUES IN SCI. & TECH. 81 (2013), https://issues.org/time-for-a-

Authorizing an independent commission to manage and oversee the numerous components of SRM regulation will guarantee that SRM is governed pursuant to sound democratic principles: ensuring due process, providing access to certain public information, and offering an opportunity for stakeholders to participate in decision-making processes.[143] Moreover, delegating ultimate oversite responsibility to an independent entity will make it easier for stakeholders to participate in federal SRM decisions and activities, since stakeholders will know to direct their inquiries to the commission and will hold the commission accountable.[144] Thus, establishing an independent SRM commission will not only strengthen public input and bolster public trust surrounding an already-untrustworthy technology, but will also facilitate the promulgation of holistic, democratic standards to effectively govern and subsequently research SRM.[145]

2. Utilize Environmental Laws & Emphasize Precautionary Principle

The DOD should take the position in its 2022 Climate Change Adaptation Roadmap that, in order to effectively govern SRM at the federal level, the government should utilize the foundational

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government-advisory-committee-on-geoengineering-research/ [https://perma.cc/YU6M-HPKR]). *See e.g.*, *SCoPEx*, *supra* note 112.

[143] *See* ANNA-MARIA HUBERT, CODE OF CONDUCT FOR RESPONSIBLE GEOENGINEERING RESEARCH 6 (2017), https://www.ce-conference.org/system/files/documents/revised_code_of_conduct_for_geoengineering_research_2017.pdf [https://perma.cc/9SKH-Z44D].

[144] *See* Nicholson, *supra* note 58 ("[I]n addition to managing for risks and potential harms, effective governance of SRM is also about creating an appropriate enabling environment for critical, quality research; opening up space for the kinds of societal deliberations that need to be undertaken; and establishing transparency and information sharing mechanisms . . . .").

[145] *See* UNION OF CONCERNED SCIENTISTS, STRENGTHENING PUBLIC INPUT ON SOLAR GEOENGINEERING RESEARCH: WHAT'S NEEDED FOR DECISIONMAKING ON ATMOSPHERIC EXPERIMENTS 5 (2020), https://www.ucsusa.org/sites/default/files/2020-06/Solar%20Geo_WEB_New.pdf [https://perma.cc/TZJ9-YD6D] ("For emerging technologies that pose potential societal risks, researchers and those who fund research (e.g., governments . . .) must incentivize and enforce rules and practices that prioritize their ethical and social responsibilities. Responsible research and innovation include . . . ensuring meaningful public participation . . . . Public participation . . . is an essential component that can legitimize (or delegitimize) research . . . .").

principles of existing environmental laws to establish the statutory purpose for a federal SRM governance scheme.[146] For instance, NEPA's objective is "[t]o declare a national policy . . . to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; [and] to enrich the understanding of the ecological systems and natural resources important to the Nation . . . ."[147] And Congress promulgated the CAA "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare . . . [and] to initiate and accelerate a national research and development program to achieve the prevention and control of air pollution."[148] Collectively, these principles can direct the federal government to develop a national SRM policy that adequately considers public health and the environment, while setting forth standards to safely conduct research and effectively prevent the mismanagement and irresponsible control of SRM.

But unlike the majority of U.S. environmental laws, federal SRM governance (and geoengineering more broadly), should be guided by the precautionary principle, considering that large-scale deployment of SRM could lead to potentially serious and irreversible harms to the public health and the environment.[149] In general, a precautionary approach "requires much more than establishing the level of proof needed to justify action to reduce [potential harms]."[150] In the context of SRM, the precautionary

[146] *See* Exec. Order No. 11,514, 3 C.F.R. § 902 (1966-1970) ("The Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals.").

[147] National Environmental Policy Act of 1969, Pub. L. No. 91-190, 83 Stat. 852 (1970) (codified as amended at 42 U.S.C. §§ 4321–4347).

[148] 42 U.S.C. § 7401(b)(1)–(2).

[149] *See* Clive Hamilton, *SRM: Who Should Control the Weather?*, ONE EARTH (Sept. 5, 2019), https://www.leonardodicaprio.org/srm-who-should-control-the-weather/ [https://perma.cc/9UGD-EQ2J].

[150] EUR. ENV'T AGENCY, LATE LESSONS FROM EARLY WARNINGS: THE PRECAUTIONARY PRINCIPLE 13 (Poul Harremoës et al. eds., 2001), https://www.eea.europa.eu/publications/environmental_issue_report_2001_22/Issue_Report_No_22.pdf/view [https://perma.cc/883U-PPRM] ("Precautionary prevention has often been used in medicine and public health, where the benefit

principle is complex because what constitutes a "precautionary approach" applies differently to SRM experimentation versus SRM deployment.[151] Therefore, the precautionary approach for SRM governance is twofold, and should establish: (1) a sufficient research and monitoring system to effectively detect early harms related to SRM—as a new technology—from an experimental standpoint, and (2) a principled regulatory structure for potential deployment where the likely harms of deploying SRM will not outweigh the benefits.[152]

a. Experimentation

For SRM experimentation, a precautionary approach would mean that the United States establishes a sufficient research and monitoring system to effectively detect early harms stemming from exploring SRM technology and its effects.[153] As researchers move toward outdoor experiments, the research should be conducted with sufficient oversight to detect potential risks to humans and the environment.[154] Should harms arise, researchers ought to immediately investigate and mitigate those harms to avoid adversely impacting the implicated geographical region of deployment.[155] Therefore, the high threshold of using a precautionary approach would subsequently safeguard democratic principles by ensuring the research process is "checked" as experiments inevitably grow in scale to evaluate the effects of global SRM deployment.

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of doubt about a diagnosis is usually given to the patient ('better safe than sorry').").

[151] *See* Hamilton, *supra* note 149 ("With . . . these geoengineering approaches . . . the precautionary principle must be invoked . . . . We certainly don't know enough about the longterm physical effects on our environment from sustained dispersion of [SRM].").

[152] *See* EUR. ENV'T AGENCY, *supra* note 150.

[153] *See id.*

[154] *See id.*; NAT'L ACADS. OF SCIS., ENG'G, & MED., REFLECTING SUNLIGHT: RECOMMENDATIONS FOR SOLAR GEOENGINEERING RESEARCH AND RESEARCH GOVERNANCE 250 (2021) ("Before proceeding, proposed outdoor experiments would need to do a complete accounting of the environmental effects of an outdoor experiment that would consider how long and at what levels sensitive ecosystems might be exposed to a substance and the toxicity of the specific substance to organisms that would be exposed.").

[155] *See* EUR. ENV'T AGENCY, *supra* note 150, at 171–72.

b. Deployment

A precautionary approach for deployment would mean promulgating a principled regulatory structure in the event that environmental circumstances reach the threshold necessary to mitigate the effects of climate change and deploy SRM on a global scale. Regulation of deployment would therefore "involve[ ] a greater willingness to acknowledge *the possibility of surprise*," and "acknowledg[e] [that] the inevitable limits of knowledge lead[ ] to greater humility about the status of the available science, requiring greater care and deliberation in making the ensuing decisions."[156] Consequently, the ultimate inquiry for SRM deployment under the precautionary principle would (1) assess the uncertain effects of SRM, and (2) subsequently balance potential costs and benefits of SRM deployment where, in order to deploy the technology, the likely adverse impacts would not outweigh the positive effects associated with reducing global surface temperatures.[157] In effect, adopting this high threshold for deployment would provide some certainty, thereby decreasing the level of contestation surrounding the general governance of SRM at the federal level.

VII. CONCLUSION

With the effects of climate change becoming more salient globally, SRM could buy humanity time as countries attempt to cut back on GHG emissions.[158] But before countries even consider deploying SRM at a large scale, significant research must be done to understand the technology's effects—or else deployment could have catastrophic and irreversible global implications. Thus far, no national government has taken the initiative to expressly govern the experimentation, development, or possible deployment of SRM.[159] However, the U.S. House of Representatives has unambiguously indicated its intent to explore the governance of SRM, given the technology's sociopolitical concerns, uncertain impacts, and

[156] *Id.* at 169 (emphasis added).
[157] *Id.* at 193–94.
[158] *See* Helwegen et al., *supra* note 6.
[159] *See* Jinnah & Nicholson, *supra* note 9, at 385–96.

alarming potential risks.[160] And now, pursuant to the U.S. Senate's passage of H.R. 6395 in January 2021, the DOD must address "associated mitigation measures" in its 2022 Climate Change Adaptation Roadmap, inherently implicating the consideration of SRM.[161]

H.R. 6395 serves as a catalyst for the DOD to recommend that the United States nationally govern SRM, thereby offering the United States regulatory stability in the face of uncertainty. In effect, Congress has afforded the DOD an opportunity to ensure that the United States is—at the very least—informed, and prepared, when it comes to SRM experimentation and deployment. Existing environmental laws can provide a principled, regulatory framework, and governance research can advise an SRM-specific statutory scheme for the United States to promulgate a comprehensive SRM policy. Accordingly, the federal government can rely on this grounded policy to earnestly engage in international discussions related to SRM experimentation and potential global-scale deployment as the effects of climate change become more dire.

Record-breaking surface temperatures have become normal occurrences;[162] wildfires are engulfing the West Coast;[163] and above-average ocean temperatures are fueling the increased frequency of major hurricanes.[164] It is clear that climate change is not slowing down, and the need to reduce GHG emissions will not go away. With GHG emissions remaining too high to curb any of these climate change effects in the short term, engaging in more

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[160] *See* Consolidated Appropriations Act, H.R. 1158, 116th Cong. (2020); National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Cong. (2020).

[161] National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283 § 327 (2020).

[162] U.S. Glob. Change Rsch. Program, *Executive Summary, in* 1 CLIMATE SCIENCE SPECIAL REPORT, FOURTH NATIONAL CLIMATE ASSESSMENT 1 (Donald J. Wuebbles et al. eds., 2017), https://science2017.globalchange.gov/ [https://perma.cc/V9DL-WSF9].

[163] Blacki Migliozzi et al., *supra* note 5.

[164] Allison Chichar & Brandon Miller, *Climate Change Didn't Cause Hurricane Laura But It Did Make the Storm Worse*, CNN WEATHER (Aug. 30, 2020, 4:00 AM), https://www.cnn.com/2020/08/30/weather/weather-hurricane-laura-climate-impacts-scope/index.html [https://perma.cc/LZS6-J8DD].

unconventional climate "mitigation measures" seems increasingly necessary, and the need to engage in international governance becomes more certain.[165]

Who knows when extreme weather events will reach a point when emergency global deployment of SRM must be considered. But, as Dr. Bronk testified to the U.S. House Committee on Natural Resources on February 7, 2019: "When that time comes, and I fear it will come soon, we need the scientific data to maximize the chance of success and limit the many risk[s]" of SRM.[166]

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165 ANNE OLHOFF & JOHN CHRISTENSEN, EMISSIONS GAP REPORT 2019 1 (2019), https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf?sequence=1&isAllowed=ysee [https://perma.cc/9ZYP-U56L].

166 *Healthy Oceans and Healthy Economies: The State of Our Oceans in the 21st Century*, *supra* note 1 (testifying that, to address climate change, humanity will eventually turn to geoengineering, including "seeding the atmosphere with reflective particles," meaning SRM).