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THE NATIONAL SECURITY CASE FOR U.S. LEADERSHIP IN SRM TECHNOLOGY

GEORGE DAVID BANKS • FEBRUARY 2026

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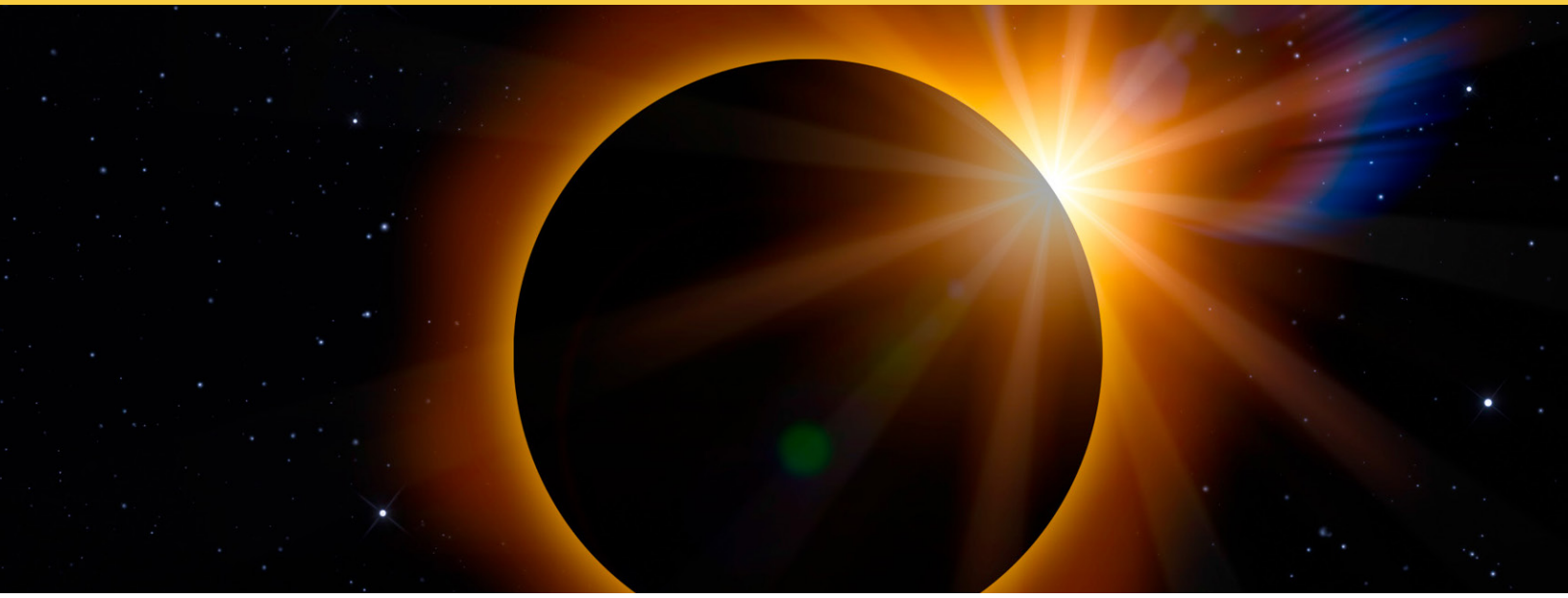

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EXECUTIVE SUMMARY

Solar Radiation Management (SRM) – a suite of geoengineering techniques to reflect sunlight and cool the planet – presents a double-edged sword: a potential tool to mitigate increases in global temperatures, yet a profound risk for national security, economic stability, and global order. As SRM transitions from fringe concept to potential geopolitical flashpoint, the United States faces a critical choice: lead in shaping transparent, democratic norms or cede ground to adversaries like China, whose military-civil fusion strategy could eventually weaponize dual-use technologies for climate disruptions in a conflict.

This paper distinguishes SRM from benign weather modification like cloud seeding – decades-old, localized programs enhancing U.S. agriculture and water security in states like California, Texas, and Utah – while debunking "chemtrails" myths that fuel state bans threatening drought resilience. Drawing on historical precedents like Operation Popeye and ENMOD's outdated framework, it warns of SRM's amplified weaponization potential, paired with AI advancements: transboundary precipitation alterations and attribution ambiguities that could escalate conflicts.

U.S. interests are at stake across agriculture (e.g., Midwest droughts), Indo-Pacific alliances (e.g., Tibetan Plateau tensions), intelligence, public trust, and technological primacy. Global governance remains fragmented, with voluntary principles lacking teeth amid rogue actors and unilateral risks.

To counter these threats, the United States must enact a federal strategy: (1) EPA-NOAA regulating, monitoring, enforcement, and compliance; (2) a G7+ SRM Compact for global-scale allied norms; (3) modernization of international agreements to include SRM; (4) enhanced attribution via NASA/DOE; and (5) transparent research agendas. Proactive leadership will avert SRM as a vulnerability, fostering stability and innovation. The window is narrow – act now to govern this technology by democratic values, not authoritarian opportunism.

SCENE SETTER

Solar Radiation Management (SRM) is emerging as a potential high-impact – but contentious – technology. SRM refers to a suite of geoengineering techniques intended to reduce temperatures by increasing Earth's reflectivity and limiting the amount of solar radiation absorbed by the atmosphere and surface.[1] A leading SRM method is stratospheric aerosol injection (SAI), which builds on dispersing sulfur dioxide (SO_2)[2] or its alternatives[3] into the stratosphere that scatter sunlight. SAI is modeled on the observed cooling effect following major volcanic eruptions, such as the 1991 eruption of Mount Pinatubo, which reduced global temperatures by roughly 0.5°C for more than a year.[4][5] SRM also includes marine cloud brightening, which enhances the reflectivity of low-lying marine clouds by spraying seawater into the atmosphere, and cirrus cloud thinning, designed to increase heat escape.[6]

In addition to the potential strategic value of SRMresearch and possible deployment, it also raises profound scientific, governance, and national security questions. Interventions at stratospheric scales could alter rainfall patterns, shift monsoons, affect ozone chemistry, or trigger "termination shock" if aerosol injection were abruptly halted. Despite growing global interest, SRM remains untested at scale in the United States. Federal activity is limited to climate modeling and small laboratory experiments conducted by the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA).[7] Yet as of early 2026, thirty-six U.S. state governments have pursued legislation restricting or banning SRM-related activities, often driven by public misinformation, conflation with "chemtrails,"[8] and fears of unintended side effects.[9] Three of those states, Florida, Louisiana, and Tennessee, have passed them, while efforts in ten other states have failed or died in committee.[10] The fragmented domestic landscape has created a vacuum in which private actors and foreign governments, such as China, are already influencing the trajectory of SRM in ways that may undermine U.S. interests and global stability.

SRM raises profound scientific, governance, and national security questions. Interventions at stratospheric scales could alter rainfall patterns, shift monsoons, affect ozone chemistry,[11] or trigger "termination shock" if aerosol injection were abruptly halted.[12] Attribution challenges (i.e., distinguishing natural climate variability from intentional intervention) create pathways for miscalculation and geopolitical escalation. In addition, the country that first develops the technology and requisite infrastructure will have significant leverage if pressure builds to deploy SRM to avoid climate impacts. These dynamics underscore why SRM research and potential use should not proceed in an ungoverned space.

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1 NOAA Science Council, "Solar Radiation Modification: NOAA State of the Science Factsheet," October 3, 2024. Solar radiation modification: NOAA State of the Science factsheet | NOAA Climate.gov.

2 SO2 irritates lungs, triggers asthma attacks, and elevates risks of heart and respiratory diseases, especially in children and the elderly. The EPA regulates it via Clean Air Act standards, enforcing emission limits on industries to protect public health and reduce acid rain. The use of sulfates in SAI is controversial due to its negative environmental impacts on the ozone layer and acid rain risks. Those risks have sparked research interest in exploring non-sulfate alternatives that achieve a cooling effect without such negative repercussions.

3 Karl Mathiesen and Corbin Hiar, "The Strange and Totally Real Plan to Blot out the Sun and Reverse Global Warming," Politico, November 21, 2025 at The Strange and Totally Real Plan to Blot Out the Sun and Reverse Global Warming - POLITICO.

4 Alan Robock, "Volcanic Eruptions and Climate," *Reviews of Geophysics* 38, no. 2 (2000): 191–219; Intergovernmental Panel on Climate Change (IPCC), *AR6 Working Group I Report* (2021), Chapter 4.

5 Hansen, J., A. Lacis, R. Ruedy, and M. Sato, 1992: Potential climate impact of Mount Pinatubo eruption. Geophys. Res. Lett., 19, 215-218, doi:10.1029/91GL02788.

6 Intergovernmental Panel on Climate Change (IPCC). *AR6 Working Group I Report: The Physical Science Basis*. Chapter 4: Solar Radiation Modification (2021). https://www.ipcc.ch/report/ar6/wg1/.

7 White House Office of Science and Technology Policy, "Congressionally Mandated Research Plan and an Initial Research Governance Framework Related to Solar Radiation Management," June 2023. Congressionally Mandated Research Plan and an Initial Research Governance Framework Related to Solar Radiation Management

8 'Chemtrails' are a visible trail left in the sky by an aircraft that some believe consists of chemical or biological agents released as part of a secret, covert operation designed for nefarious purposes. The conspiracy theory dates to the 1990s.

9 SRM360, "US Proposals to Ban Solar Geoengineering" (2025). https://srm360.org/us-bans/.

10 "U.S. Proposals to Ban Solar Geo-engineering" at US proposals to ban solar geoengineering | SRM360.

11 Peer Nowack et al. "Stratospheric ozone changes under solar geoengineering: implications for UV exposure and air quality," Volume 16, Issue 6, Atmospheric Chemistry and Physics, 16, 4191–4203, 2016. ACP - Stratospheric ozone changes under solar geoengineering: implications for UV exposure and air quality.

12 Termination shock is the rapid and substantial warming that would occur if a large-scale solar geoengineering system were suddenly stopped. See National Academies of Sciences, *Reflecting Sunlight*.

This paper argues that the United States – regardless of its position on climate policy – must lead in establishing transparent, science-based, and security-conscious norms for SRM research and governance. Without U.S. leadership, adversaries could unilaterally deploy or potentially weaponize SRM technologies, while domestic misinformation threatens to undermine legitimate U.S. atmospheric research and even essential drought-resilience tools such as cloud seeding. Clear federal guidance and preemption is essential to prevent harmful experimentation and counter foreign strategic risks.

DISTINGUISHING WEATHER MODIFICATION FROM GEOENGINEERING: WHY IT MATTERS

Public confusion between cloud seeding (a long-standing weather modification practice) and SRM (a broader-scale climate intervention) has fueled political backlash and motivated U.S. state bans. Clarifying this distinction is essential for developing responsible federal governance.

Weather modification, such as cloud seeding or hail depression, targets localized and short-term weather events. These programs use small amounts of silver iodide or other condensation nuclei to coax additional moisture from clouds, typically during storms already favorable for precipitation.[13] Effects last hours to days, fall within natural variability, and do not meaningfully affect regional or global climate patterns.

The United States has operated cloud seeding programs for over 70 years.[14] Pioneering research in the 1940s[15] led to federal support through the Weather Modification Reporting Act of 1972,[16] which mandates public disclosure of cloud seeding activities. Today, multiple states run effective, transparent cloud seeding operations:

- California enhances Sierra Nevada snowpack by 5–15%,[17] generating an estimated 200,000–300,000 acre-feet of additional water annually and supporting agriculture and urban supply.[18]
- North Dakota's Cloud Modification Project, operating since the 1970s, reduces hail damage by up to 50% and increases precipitation by 10–15%, protecting critical grain and oilseed sectors.[19]
- Texas operates one of the longest-running state-sanctioned weather-modification programs in the United States, with cloud-seeding activities dating back more than 50 years; enhanced crop yields in agriculture and reduced irrigation costs far exceed program expenses—often $34 in returns for every $1 invested.[20]
- Utah's program, running since the 1950s, is the world's largest remote-controlled cloud seeding effort, deploying ground generators to disperse silver iodide into mountain storm clouds for 5-15% more winter snowpack, bolstering reservoir and aquifer water.[21]

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[13] U.S. Government Accountability Office, "Technology Assessment: Cloud Seeding's Potential and Challenges" (GAO-11-290, 2010; updated context in 2024 briefings). https://www.gao.gov/products/gao-11-290.

[14] William R. Cotton and R. A. Pielke Sr., Human Impacts on Weather and Climate, 2nd ed. (Cambridge University Press, 2012). Human Impacts on Weather and Climate

[15] U.S. National Oceanic and Atmospheric Administration (NOAA). "The 1946 General Electric Cloud Seeding Experiments." NOAA Historical Archives. https://library.noaa.gov/.

[16] Weather Modification Reporting Act of 1972, Pub. L. 92-205. Full statute: https://www.govinfo.gov/content/pkg/STATUTE-85/pdf/STATUTE-85-Pg735.pdf.

[17] French, Jennifer R., et al. "Quantifying snowfall from cloud seeding." *Proceedings of the National Academy of Sciences* 117, no. 10 (2020): 5172–5178. https://www.pnas.org/doi/10.1073/pnas.1917204117.

[18] California Department of Water Resources, "Precipitation Enhancement Resource Management Strategy" (Draft, 2023). https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2023/PRD/RMS/Draft-Precipitation-Enhancement-RMS.pdf.

[19] North Dakota Atmospheric Resource Board, North Dakota Cloud Modification Project Annual Report (2023). https://www.swc.nd.gov/arb/.

[20] West Texas Weather Modification Association, *"Rainfall Enhancement & Hail Suppression Program,"* accessed November 2025, https://westtxwxmod.com/?page_id=23.

[21] Utah Department of Natural Resources, "Utah Holds its First Cloud Seeding Symposium," September 28, 2023, Utah holds its first cloud seeding symposium – Utah Division of Water Resources.

These programs demonstrate that atmospheric interventions can be transparent, safe, publicly beneficial, and regulated at state and federal levels.[22]

In contrast, SRM is broader in scope (up to planetary scales), potentially years in duration, and capable of producing regional to global climate effects. Its hypothetical consequences include suppression of extreme weather events, shifts in monsoons and storm tracks, regional precipitation changes, impacts on ozone chemistry, and international disputes related to weather impacts.[23] Unlike cloud seeding, SRM requires robust international governance, multilateral review, transparent experimentation, and federal monitoring.

Unfortunately, state-level "geoengineering bans" (e.g., Florida and Tennessee) have already threatened legitimate cloud seeding programs due to misunderstanding and 'chemtrail' conspiracy fears.[24] This creates risks for state and local drought resilience, ongoing agricultural stability and predictability, and necessary atmospheric research unrelated to SRM. These bans also threaten legitimate SRM research, including small- scale, transparent, federally regulated studies that are essential for the informed governance the paper advocates. This reinforces the case for federal preemption and connects directly to the congressional strategy for authorizing relevant legislation.

DEBUNKING MISCONCEPTIONS: NO SECRET SPRAYING CAMPAIGNS

While persistent claims of secret aerosol spraying lack any empirical basis,[25] misconceptions about 'chemtrails' continue to distort public debate in the United States. Peer-reviewed studies have repeatedly refuted these claims by showing that aircraft trails are contrails formed by water vapor from exhaust condensing into ice crystals under cold, humid conditions.[26] Contrail patterns and persistence depend on atmospheric conditions, not chemical additives.

The Trump administration's EPA, led by Administrator Lee Zeldin, has provided public information that explicitly debunks the 'chemtrail' conspiracy theory.[27] Agency efforts have provided transparent, science-based answers to address public concerns and restore trust in federal environmental monitoring. Importantly, the Federal Aviation Administration (FAA)[28] and the EPA[29] conduct ongoing environmental monitoring – including air emissions inventories, dispersion modeling, and ambient air quality sampling through the EPA's Air Quality System (AQS) – consistently detecting only trace levels of pollutants and particulates from routine industrial and transportation sources, with no evidence of engineered aerosols or secret spraying programs. While FAA focuses primarily on aviation-specific assessments and AQS on air, EPA's broader contaminant detection programs extend to soil and water sampling, reinforcing the absence of anomalous substances tied to 'chemtrail' claims.[30]

Legitimate aerial chemical applications, such as wildfire retardants, cover crops or cloud seeding, are publicly documented, localized, and fundamentally different from SRM. Strengthening public scientific literacy is essential to counter misinformation and maintain trust in legitimate atmospheric research.

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[22] For a detailed list of states, programs, and regulations, see North American Weather Modification Council.

[23] Kravitz, Ben et al. "A Multi-Model Assessment of Regional Climate Changes Under Solar Geoengineering." *Nature Climate Change* 4, 7 (2014): 659–665. https://doi.org/10.1038/nclimate2374.

[24] Evan Bush, "Tennessee Lawmakers Vote to Ban Geoengineering, with allusions to 'chemtrail' conspiracy theory," NBC News, April 1, 2024. Tennessee lawmakers ban geoengineering, with allusions to 'chemtrails'. Rylan DiGiacomo-Rapp, "Florida Bill moves to ban weather modification activities following conspiracy theories," The Alligator, January 27, 2025. Florida bill moves to ban weather modification activities following conspiracy theories - The Independent Florida Alligator.

[25] Shearer, Christine et al. "Quantifying Expert Consensus Against the Existence of a Secret, Large-Scale Atmospheric Spraying Program." Environmental Research Letters 11, no. 8 (2016). https://doi.org/10.1088/1748-9326/11/8/084011.

[26] Jordi Bueso et al. "Aircraft Clouds from Chemtrail Pseudoscience to the Science of Contrails," Mètode Science Studies Journal, September 1, 2017 at Aircraft clouds: From chemtrail pseudoscience to the science of contrails.

[27] Environmental Protection Agency. "EPA Releases Online Sources Giving Americans Total Transparency on the Issues of Geoengineering and Contrails," July 10, 2025. EPA Releases New Online Resources Giving Americans Total Transparency on the Issues of Geoengineering and Contrails | US EPA.

[28] Federal Aviation Administration. *Aviation Environmental and Emissions Reports* (2023). https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/.

[29] Environmental Protection Agency. Air Quality System (AQS) Data Reports (2024). https://www.epa.gov/aqs.

[30] Environmental Protection Agency. *Information on Contrails* from Aircraft at Information on Contrails from Aircraft | US EPA.

THE PERILS OF WEAPONIZATION: HISTORICAL LESSONS AND EMERGING THREATS

Geoengineering and weather modification technologies, if militarized, could devastate economies and ecosystems. Operation Popeye (1967–1972), a U.S. cloud seeding campaign during the Vietnam War, successfully extended monsoons along the Ho Chi Minh Trail to disrupt enemy logistics.[31] The program's revelation spurred international condemnation and directly contributed to the 1977 negotiation of the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) Convention.[32]

While ENMOD prohibits purposeful manipulation of natural processes for military harm (e.g., inducing floods, droughts, or earthquakes), it is widely considered a "sleeping giant" with limited verification mechanisms and outdated definitions that do not fully account for modern SRM technologies.[33]

SRM's weaponization risks eclipse those of weather modification because of scope. While the latter has a documented history of military use (e.g., Operation Popeye), its effects are typically localized, short-term, and easier to verify, limiting its strategic appeal. In contrast, SRM methods could be harder to pinpoint to a perpetrator, although it has limitations as an instrument of war.

SAI deployment needs a fleet of hundreds of specialized high-altitude aircraft (e.g., modified Boeing 777s) and 4-6 airbases near various latitudes for aerosol dispersal, requiring years for development and infrastructure buildout.[34] Hence, in a conflict, other aviation powers could respond by intercepting the SAI fleets and by destroying their bases. Additionally, SRM remains blunt and unreliable compared to conventional arms, largely because of the imprecision and unpredictability of its impact on the climate.[35] Concerns about collateral damage, including those against the deployer, serve as a deterrent.

Advancements in AI and allied technologies, nonetheless, could dramatically narrow SRM's unpredictability envelope from days to weeks and months. Machine learning hybrids are likely to reduce the chaos inherent in climate forecasts to yield greater confidence bands.[36] Paired with SRM, reinforcement learning could optimize aerosol dosing in real-time, for example, by simulating SAI's global drift to minimize self-harm while reducing precipitation in adversarial farmlands.[37] Likewise, quantum sensors and edge AI might enable adaptive delivery by adjusting drone routes in real-time using live satellite data, while cutting far-reaching climate ripple effects (like the "butterfly effect," where small changes cause big distant impacts) through graph neural networks that trace those connections.[38]

While these scenarios are largely "what ifs" and physics and chaos constraints will certainly remain, technological breakthroughs in AI could be a gamechanger for SRM as it pertains to its utility in warfare. These risks underscore the need for the United States to act today to generate a modernized framework anchored in transparency, monitoring, and international cooperation. While technology almost always outpaces regulation,

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31 State Department, "Weather Modification in North Vietnam and Laos (Project Popeye)," Office of the Historian, 1964-1968. Historical Documents - Office of the Historian

32 United Nations. *Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)* (1977; entered into force 1978). UNTC

33 J. B. Wiener, "The Environmental Modification Convention: A Sleeping Giant?" *Journal of Peace Research* 56, no. 4 (2019): 515–528. https://doi.org/10.1177/0022343319842159.

34 Josh Horton and Pete Irvine, "The Technical Feasibility and Cost of SAI," November 26, 2024, SRM360 at SRM360 | The Technical Feasibility and Costs of SAI.

35 Josh Horton, "Could SRM Be Weaponized," November 26, 2024. SRM360 | Could SRM Be Weaponised?

36 Ilan Price et al. "Probabilistic weather forecasting with machine learning." Nature 637, 84–90 (2024). Probabilistic weather forecasting with machine learning | Nature

37 Keith, D. W., et al. "Solar Geoengineering Strategies Based on Reinforcement Learning." Earth System Dynamics Discussions (preprint, April 21, 2025). https://doi.org/10.5194/egusphere-2025-940.

38 Marco De Lucha. "Artificial intelligence for climate teleconnections: a graph neural network approach with interpretable attention mechanisms." Master's Thesis, Politecnico di Torino (2025). tesi.pdf

SRM is a rare case where governance must lead — establishing guardrails for large-scale research and deployment before capabilities mature, to ensure SRM cools crises, not ignites them.

Chinese Civilian Programs and Potential Military Risks

China operates the world's largest weather modification system, seeding 5.5 million km^2 annually for rainfall enhancement and hail suppression.[39] [40] Much of this activity occurs on and around the Tibetan Plateau, the headwaters of major South and Southeast Asian rivers. These programs have triggered growing concerns in the region, particularly in India. After catastrophic flash floods in Ladakh in July 2023, public speculation in India questioned whether Chinese seeding upstream influenced local rainfall patterns.[41] [42] Although no causal evidence exists, the incident demonstrates how opaque atmospheric interventions can spark disinformation and inflame geopolitical tensions.

China has rapidly scaled SRM-related research, motivated by climate vulnerabilities such as Himalayan glacier melt, Yangtze River flooding, and extreme heatwaves, as part of broader efforts under the 14th Five-Year Plan to advance climate adaptation technologies.[43] For instance, the plan prioritizes innovations in climate management and self-reliance in science and technology to mitigate these escalating risks, including through enhanced atmospheric modeling and geoengineering assessments.[44]

Chinese institutions, including the Chinese Academy of Sciences (CAS), have advanced Earth system models to analyze stratospheric aerosol injection (SAI) scenarios, such as those involving sulfate aerosols for regional climate impacts. A 2024 study found that SAI could reduce extreme daily precipitation by up to 20 mm in eastern China and mitigate southern droughts relative to high-emissions scenarios, but it risks exacerbating northern and northwestern droughts – equivalent to potential 10–20% effective precipitation shortfalls in high-latitude regions during dry periods.[45] This aligns with the Intergovernmental Panel on Climate Change's (IPCC) assessment that notes solar radiation management techniques like SAI would likely produce uneven regional effects, including disruptions to precipitation and hydrological cycles.[46]

A greater concern related to potential Chinese leadership in SRM technology would be its relationship to the Military-Civil Fusion (MCF) strategy, which was elevated to a national priority in 2017 under Xi Jinping. The MCF systematically merges civilian innovation ecosystems – spanning universities, state-owned enterprises, and private firms – with People's Liberation Army (PLA) requirements to accelerate military modernization across dual-use domains like AI and quantum technologies. The strategy effectively turns presumably peaceful R&D into potential warfighting enablers without clear boundaries.[47] This integration heightens SRM weaponization risks because China's burgeoning geoengineering efforts leverage civilian climate research for aerosol

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[39] Xinhua News Agency. "China to Expand Weather Modification Program Across 5.5 Million Square Kilometers." (Dec. 2020). http://www.news.cn/english/ (Note: Widely reported; see also CNN coverage at https://www.cnn.com/2020/12/03/asia/china-weather-modification-cloud-seeding-intl-hnk).

[40] State Council Information Office of the People's Republic of China. "China's Weather Modification Capabilities to Cover 5.5 Million Square Kilometers by 2025" (related announcement, 2021). https://english.www.gov.cn/policies/latestreleases/202012/02/content_WS5fc76218c6d0f7257694125e.html.

[41] Tibetan Review. "India Querying Whether China May Be Behind Rising Himalayan Natural Disasters Hitting It." (January 21, 2024). https://www.tibetanreview.net/india-querying-whether-china-may-be-behind-rising-himalayan-natural-disasters-hitting-it/.

[42] Observer Research Foundation (ORF). "Is China Modifying the Weather? India Has Concerns." (March 15, 2024). https://www.orfonline.org/expert-speak/is-china-modifying-the-weather-india-has-concerns.

[43] Wang, Can et al. "Research on China's technology lists for addressing climate change: Mitigation and adaptation." Journal of CO_2 Utilization 52 (2021): 101665. https://doi.org/10.1016/j.jcou.2021.101665.

[44] Geoengineering Monitor. "Solar Radiation Management: Regional Briefing – Asia." (2018). https://www.geoengineeringmonitor.org/wp-content/uploads/2018/11/SRMRegionalBriefing-Asia_EN.pdf.

[45] Ou Wang et al. "Projected future changes in extreme precipitation over China under stratospheric aerosol intervention in the UKESM1 climate model," Volume 24, Issue 21, Atmospheric Chemistry and Physics, pg. 12355-12373, 2024 at ACP - Projected future changes in extreme precipitation over China under stratospheric aerosol intervention in the UKESM1 climate model.

[46] IPCC. AR6 Working Group I Report (2021), Chapter 4 at Chapter 4 | Climate Change 2021: The Physical Science Basis.

[47] U.S. Department of State. Military-Civilian Fusion and the PRC," May 2020 at What-is-MCF-One-Pager.pdf.

dispersal technologies that could be repurposed by the PLA for deniable operations. By embedding SRM-related advancements (e.g., high-altitude delivery platforms) within MCF's framework, Beijing could achieve asymmetric advantages in hybrid warfare, where environmental manipulations evade traditional arms control.

CLIMATE RISK PERCEPTION AND SRM FIRST-MOVER ADVANTAGE

Regardless of the U.S. position on climate change, other countries may feel compelled to use the technology to preempt climate impacts that are deemed existential risks. While these threats are unlikely to be abrupt, once they are triggered, they are irreversible. The potential collapse of the Atlantic Meridional Overturning Circulation (AMOC),[48] for example, is viewed as such a problem,[49] as well as sea-level rise that submerges low-lying islands. Over the next few years, the failure of the international community to rein in global emissions is likely to drive increased interest in using SRM to mitigate these risks.

Thus, the nation that first dominates SRM-related intellectual property and scalable infrastructure – such as high-altitude aerosol delivery fleets or advanced AI-driven modeling systems – could gain unparalleled economic leverage, controlling global access and monetizing licensing or operational services. This parallels China's dominance in battery production, where mastery of patents and supply chains has positioned it as a linchpin in various technologies, such as electric vehicles and renewables.

The United States should be prepared for security concerns related to climate impacts to shape views on SRM deployment across the international community. In this scenario, American leadership would be essential to steer outcomes. This is particularly salient amid the erosion of climate multilateralism, positioning the security domain as one of the few viable arenas for coordinated global action.

ADVANCING STRONG GOVERNANCE AMID INTERNATIONAL GAPS

Global governance frameworks for SRM remain fragmented or nonexistent.[50] The Climate Overshoot Commission's 2023 voluntary recommendation for a precautionary pause on large-scale SRM experiments or deployments with transboundary risks[51] has not been formalized or renewed into binding international law, leaving national efforts siloed. Existing voluntary principles, such as the Oxford Principles or the AGU ethical framework for SRM Research[52], offer helpful ethical guidance but lack enforcement mechanisms, monitoring, or verification.[53]

Without robust governance, the world faces four risks:

1. **Rogue experimentation** by private companies or subnational actors
2. **Unilateral deployment** by foreign governments
3. **Misattribution and escalation** during weather-related disasters
4. **Single state dominance** of the technology or dominance by a bloc hostile to U.S. interests

These risks underscore the need for a coherent U.S.-led governance strategy to shape global norms before adversaries establish their own.

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[48] This current brings warm water from the tropics northward toward the Arctic and helps keep Europe's winters mild.

[49] Alison Withers, "Iceland Deems Possible Atlantic Current Collapse a Security Risk," Reuters, November 12, 2025 at Iceland deems possible Atlantic current collapse a security risk | Reuters.

[50] Carnegie Climate Governance Initiative, Solar Radiation Modification: Governance Gaps and Challenges," Carnegie Council for Ethics in International Affairs, March 2022 at 202203-C2G-GovGaps.pdf.

[51] https://www.overshootcommission.org/_files/ugd/0c3b70_bab3b3c1cd394745b387a594c9a68e2b.pdf

[52] https://www.agu.org/learn-about-agu/about-agu/ethics/ethical-framework-for-climate-intervention

[53] Manon Simon et al. "Can Formal SRM Governance Be Built From Informal Principles," SRM360, April 24, 2025 at Can Formal SRM Governance Be Built From Informal Principles? | SRM360.

U.S. INTERESTS AT STAKE

SRM is not merely a technical or environmental issue; it implicates core national interests across multiple domains.

1. *Agricultural and Economic Stability*
   U.S. agriculture depends on predictable rainfall patterns, stable hydrology, and manageable extremes. If deployed unilaterally or weaponized, SRM could disrupt precipitation in critical regions such as California's Central Valley or the Midwest, threatening U.S. food supply chains, commodity prices, and rural economies.

2. *Strategic Alliances and Indo-Pacific Stability*
   SRM activities in Asia, particularly on the Tibetan Plateau, could inflame tensions between China, India, and downstream nations, requiring the United States to engage diplomatically or through coalition structures.

3. *Technological Leadership and Rule-Making Power*
   If the United States abstains from SRM governance, China and other actors may set the norms – potentially creating permissive standards, opaque reporting requirements, or dual-use pathways that disadvantage U.S. interests and global transparency.

4. *Intelligence and Attribution Requirements*
   Attributing climate and weather anomalies to natural variation versus SRM use is extremely difficult. Adversaries could exploit this ambiguity to mask coercive environmental interventions, complicating U.S. intelligence assessments and crisis management.

5. *Domestic Resilience and Public Trust*
   Misinformation about SRM and weather modification threatens U.S. water management, wildland firefighting support, and drought resilience. Clear governance is necessary to maintain trust in legitimate atmospheric research and avoid politicized backlash that undermines state and federal programs.

POLICY RECOMMENDATIONS: A U.S. FRAMEWORK FOR RESPONSIBLE SRM LEADERSHIP

To protect national security, advance scientific integrity, and prevent destabilizing use of SRM technologies, the United States should adopt a coherent federal strategy based on transparency, international engagement, and responsible oversight.

1. *Establish a Federal Oversight and Permitting Framework.*

The United States should adopt a cohesive federal oversight system for SRM research and experimentation, grounded in transparency and public accountability. The EPA, using its existing authority under the Clean Air Act, should regulate any release of aerosols or precursor materials into the atmosphere for the purpose of SRM research or deployment, while NOAA provides technical assessments, climate modeling, and monitoring. Together, these agencies should develop a permitting structure, require advance notice and post-activity reporting, and enforce compliance through civil penalties. A clear regulatory regime would prevent unauthorized or unsafe experimentation, reassure the public, and set a high global standard for responsible SRM governance. Effective federal leadership should also discourage state bans, as they undermine research dominance of the U.S. private sector and university systems.

2. *Lead the Formation of a G7+ SRM Governance Compact.*

The United States should work closely with allies and partners to develop shared standards for SRM research and oversight. A G7+ SRM Governance Compact would enable its member governments to coordinate transparency norms, modeling protocols, monitoring expectations, and reviewing any proposed field tests. Establishing these norms early – before SRM technologies mature – will ensure that global governance reflects scientific rigor and democratic values rather than unilateral actions by authoritarian states.

3. *Retool and Modernize ENMOD and Other International Agreements.*

The 1977 ENMOD Convention, which prohibits the hostile use of environmental modification, predates modern SRM technologies and contains outdated definitions that do not address current scientific realities. The United States should lead a diplomatic effort to update ENMOD to explicitly include SRM, strengthen transparency requirements, and establish consultative mechanisms for states that believe they may be affected by another country's atmospheric activities. Modernization would reinforce international norms against coercive or covert use of SRM and reduce misinterpretation or escalation during weather-related crises. Other international agreements, such as the Outer Space Treaty, Montreal Protocol, and Convention on Environmental Impact Assessment in a Transboundary Context, could also play a relevant role in regulating SRM-related activity.

4. *Expand U.S. Attribution Science and Monitoring Capabilities.*

Attribution – the ability to distinguish natural variability from intentional atmospheric intervention – is foundational to both national security and global governance. The United States should invest in expanding NASA's and NOAA's monitoring infrastructure. Additionally, the Department of Energy's national laboratories should enhance their ability to identify clear signatures of SRM activity. Improved attribution capabilities will strengthen intelligence assessments, treaty verification, and crisis diplomacy.

5. *Advance a Focused and Transparent U.S. SRM Research Program.*

To ensure that future decisions are grounded in scientific evidence, the United States should develop a targeted federal research agenda that emphasizes transparency and public trust. Priority research areas include aerosol–cloud interactions, regional climate sensitivity (especially for monsoon-dependent regions), termination-shock dynamics, and improved attribution science. All federally supported research should follow strict data-sharing, public-reporting, and community-engagement requirements, establishing a global benchmark for responsible SRM research governance.

CONCLUSION

The United States stands at a pivotal moment. SRM is no longer a fringe scientific idea but an emerging geopolitical reality – one that intersects climate strategy, national security, great-power competition, technological governance, and public trust. Absent U.S. leadership, actors such as China and other foreign adversaries will shape SRM's trajectory in ways that may not align with American interests or global stability.

Proactive U.S. engagement can establish norms that prevent hostile or reckless use, promote transparent and science-based research, protect allies and vulnerable regions, and ensure international rules are written before adversaries fill the vacuum. At home, clear federal guidance can build public trust, counter misinformation, and safeguard legitimate atmospheric research from politically motivated restrictions.

A strong federal governance strategy – anchored in transparency, oversight, multilateral cooperation, and responsible innovation – can transform SRM from a source of uncertainty into a domain governed by democratic values and global stability. The United States must lead now, while the technology remains in its infancy, to avoid a future where SRM becomes a strategic vulnerability exploited by adversaries or distorted by misinformation.

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