frontiers | Frontiers in Science

TYPE Frontiers in Science Editorial
PUBLISHED 09 September 2025
DOI 10.3389/fsci.2025.1698907

OPEN ACCESS

EDITED BY
Frontiers in Science Editorial Office,
Frontiers Media SA, Switzerland

*CORRESPONDENCE
Mike Hulme
mh903@cam.ac.uk

RECEIVED 04 September 2025
ACCEPTED 04 September 2025
PUBLISHED 09 September 2025

CITATION
Hulme M. The false promises of polar geoengineering (research).
Front Sci (2025) 3:1698907.
doi: 10.3389/fsci.2025.1698907

The false promises of polar geoengineering (research)

Mike Hulme *

Department of Geography, University of Cambridge, Cambridge, United Kingdom

KEYWORDS

climate engineering, ice protection, arctic, global, politics, governance, risk, ethics

An Editorial on the Frontiers in Science Lead Article

Safeguarding the polar regions from dangerous geoengineering: a critical assessment of proposed concepts and future prospects

Key points

- There is a very checkered history of previous attempts at deliberate climate control beyond very small local scales.
- More research into climate intervention technologies cannot resolve the cultural, ethical, and political challenges complicating decisions around their deployment.
- Decisions on whether to research or deploy polar geoengineering technologies must account for the rights of Arctic dwellers, while also considering broader global interests.

There is a long history of societies seeking to deliberately alter—to reengineer—the basic features of their climatic environment. These efforts have been undertaken at different scales, either to enhance a desirable climate feature (e.g., cloud seeding to enhance local precipitation) or to mitigate or attenuate an undesirable characteristic (e.g., fog dispersal technologies) (1).

As these climate engineering projects grow grander in scale and ambition, they often emerge from broader ideological or political projects aimed at controlling or exploiting the natural world. However, despite their grand visions, such ambitious schemes have rarely, if ever, been successfully executed. Philipp Lehmann outlines this history in his book *Desert Edens: colonial climate engineering in the age of anxiety* (2), including the visionary Atlantropa Project proposed by German architect Herman Sörgel during the fascist era of the 1930s. This plan aimed to create a climate-engineered Afro-European super-continent. And while such ideas have often been associated with imperialists or nationalists, figures from other ideological backgrounds, capitalists and communists alike, have been drawn to similar concepts. For example, in the 1940s, American scientist Irving Langmuir, working for General Electric, sought to modify hurricane tracks in the western Atlantic. Similarly,

Soviet communists in the 1960s proposed diverting northward-flowing Arctic rivers to the arid plains of Central Asia. Hubert Lamb described this plan in 1971 as "a climate-engineering scheme to meet an emergency" (3).

This scale of thinking about, if not executing, climate engineering persisted into the post-colonial (and post-Soviet) era. A paper written 50 years ago by William Kellogg and Steven Schneider in *Science* summarized several climate engineering schemes circulating at the time (4). Two of these proposals were particularly relevant for the polar regions: damming the Bering Strait and spreading black particles on Arctic sea ice, both aimed at eliminating the Arctic ice pack, deemed to be a desirable outcome at the time. Kellogg and Schneider also highlighted the Soviet idea of Arctic river diversion to raise ocean salinity and thus also reduce Arctic sea ice.

In the first decade of the 21st century, Paul Crutzen revitalized the idea of large-scale climate engineering by proposing that sulfate aerosol injection (SAI) could assist "international policymakers, who are confronted with the task to clean up air pollution while simultaneously keeping global climate warming under control" (5). This proposal from a respected atmospheric scientist unleashed a series of reports and assessments about a range of climate engineering schemes seeking to either offset or defuse anthropogenic global warming.

Several of these ideas have gained significant attention over the last 5 years. In their Frontiers in Science lead article, Martin Siegert and colleagues summarize and evaluate five such schemes in relation to polar regions (6). Three of these putative interventions are of recent origin and apply specifically to icy polar marine environments: undersea artificial walls to buttress ice shelves in Greenland and Antarctica, techniques for sea ice thickening in the Arctic, and slowing ice-sheet flow through basal water removal, especially in Antarctica. The remaining two ideas, SAI as put forward by Crutzen and iron fertilization of nutrient-poor ocean regions to enhance carbon uptake, have been proposed for more than 20 years and seek to modify the global climate.

These ideas have gained increased media and public attention in recent years, along with greater research funding, both public and by private philanthropy. As they attract the growing attention of policymakers, they also generate controversy among scientists, social scientists, public intellectuals and environmental non-governmental organizations (NGOs), and Indigenous groups. I stated my own position in relation to the most widely touted of these ideas, SAI, in *Can science fix climate change? A case against climate engineering* (7). I argued that such global-scale climate intervention was "undesirable, ungovernable, and unreliable". More recently, opposition to climate engineering research and implementation has intensified, particularly against schemes designed to alter the global radiation balance through SAI and related technologies. In January 2022, 400 scientists and social scientists proposed an International Non-use Agreement on Solar Geoengineering, which outlined five core principles: no public funding of research into such technologies, no outdoor experiments, no patents, no deployment, and no support in international institutions (8).

The lead article by Siegert et al. proceeds in four parts, the first of which evaluates the five selected climate intervention technologies against five criteria: scientific (in)feasibility; environmental risks; financial costs; governance challenges; scale and time constraints; and the political and moral risk of them offering false solutions to climate change. They then debunk arguments made in favor of geoengineering, assess the international governance and decision-making challenges, and offer an alternative approach for protecting the polar regions without geoengineering. They conclude that "the interventions discussed here are extremely *unlikely* to mitigate the effects of global warming in polar regions and *are likely* to have serious and unintended consequences" [my emphasis].

Proponents of large-scale climatic engineering—whether regional (polar) or global—misunderstand both the *nature* and *scale* of the political challenge involved in implementation, offering a false promise of what scientific research into these technologies can and cannot resolve. They assert that these putative climate and sea ice engineering technologies must be researched so that, ultimately, we can determine their safety and effectiveness before deciding whether to deploy them. This position misreads the nature of the issues at stake and the ways in which risk is perceived and acted upon. Neither scientific nor social scientific research can reconcile the competing cultural values, ethical judgments, and political interests that influence large-scale climate engineering decisions. Whether to deploy or research such schemes is inherently political, and political decisions cannot be resolved by undertaking more scientific research. For example, as Siegert et al. highlight, there is a danger of what they term "predatory delay," but there is no way of knowing, through research, whether this would become a significant problem.

In addition to misinterpreting the relationship between science and political decision-making, proponents of these technologies misread the scale of the political dilemma that underlies the decision to research and deploy them. This holds true whether the proposed interventions are intended to deliver local, regional or global benefits, or to mitigate similarly scaled harms. Sophie Crump, in her accompanying policy outlook article, argues that Arctic Indigenous peoples have the right to be heard and to retain the right of veto over research or deployment (9). However, a rights-based approach to decision-making does not necessitate that climate intervention technologies ought to be proposed in the first place, let alone researched. Furthermore, if global climate and polar ice are considered global goods—as John Moore and colleagues argue in their viewpoint article, see (10)—, the final arbiters regarding research or deployment are not only *Arctic* dwellers, but *planetary* dwellers. And here, the full nature of the political challenge of deliberate climate intervention is revealed: the absence of effective governance mechanisms and institutions capable of facilitating international coordination and decision-making without exacerbating existing geopolitical tensions.

The lead article by Siegert et al. does not revisit "the checkered history of weather and climate control." Yet history matters. A historical sensibility helps us understand why human

imagination about what *could* be done with climate intervention technologies often far exceeds humanity's technical, ethical, and political ability to safely implement and govern them at scale. As history shows, the risk of failure is substantial, though ultimately unquantifiable. It is not scientific evidence—always incomplete and contested—that lies at the heart of the governance dilemma. Rather, it is ethical and value-based judgments about risk, safety, technical ability, and political stability. Historically, the nations and peoples of the world have not demonstrated a strong track record of safely navigating the mistrust and rivalry between them.

Statements

Author contributions

MH: Writing – review & editing, Writing – original draft, Conceptualization.

Funding

The author declared that no financial support was received for this work and/or its publication.

Conflict of interest

The author is a signatory to the International Solar Geoengineering Non-Use Agreement (8).

The author declared that this work was conducted in the absence of financial relationships that could be construed as a potential conflict of interest.

The author declared a shared affiliation with one of the lead article authors, CN.

Generative AI statement

The author declared that no generative AI was used in the creation of this manuscript.

Publisher's note

References

1. Fleming JR. *Fixing the sky: the checkered history of weather and climate control*. New York, NY: Columbia University Press (2010)

2. Lehmann P. *Desert Edens: colonial climate engineering in the age of anxiety*. Princeton, NJ: Princeton University Press (2022)

3. Lamb HH. Climate-engineering schemes to meet a climatic emergency. *Earth-Sci Rev* (1971) 7(2):87–95. doi: 10.1016/0012-8252(71)90083-3

4. Kellogg WW, Schneider SH. Climate stabilization: for better or for worse? *Science* (1974) 186(4170):1163–72. doi: 10.1126/science.186.4170.1163

5. Crutzen PJ. Albedo enhancement by stratospheric sulfur injections: a contribution to resolve a policy dilemma? *Clim Change* (2006) 77:211–20. doi: 10.1007/s10584-006-9101-y

6. Siegert M, Sevestre H, Bentley MJ, Brigham-Grette J, Burgess H, Buzzard S, et al. Safeguarding the polar regions from dangerous geoengineering: a critical assessment of proposed concepts and future prospects. *Front Sci* (2025) 3:1527393. doi: 10.3389/fsci.2025.1527393

7. Hulme M. *Can science fix climate change? A case against climate engineering*. Cambridge: Polity Press (2014)

8. Solar Geoengineering Non-Use Agreement [website]. Available online at: https://www.solargeoeng.org/

9. Crump S. A critical lens on geoengineering in Inuit Homelands [in press]. Frontiers Policy Labs (2025). doi: 10.25453/plabs.30052270

10. Moore JC, Macias-Fauria M, Wolovick M. A new paradigm from the Arctic. *Front Sci* (2025) 3:1657323. doi: 10.3389/fsci.2025.1657323