

A New Threshold in Climate Research: Solar Radiation Modification (SRM)

The main policy axis in the fight against climate change is the reduction of greenhouse gas emissions, the development of carbon removal capacity, and adaptation to climate impacts. However, the fact that global mitigation efforts are not progressing at a pace consistent with the objectives of the Paris Agreement, that temperature rise is approaching critical thresholds, and that extreme weather events are becoming more visible has brought certain intervention ideas, previously discussed within limited circles, back onto the agenda of climate research. One of these controversial areas is Solar Radiation Modification, or SRM.

In recent years, interest in SRM has not remained limited to academic literature; it has evolved into a broader climate governance agenda through public funding, reports by international institutions, private sector initiatives, ethical assessments, and public dialogue studies. The United States, the United Kingdom, the European Union, the United Nations system, scientific advisory mechanisms, and environmental organisations are evaluating this field from different perspectives; on the one hand, they are discussing the boundaries of research, and on the other, the potential risks of deployment and gaps in global governance. These developments do not mean that SRM is an implemented or accepted climate solution. On the contrary, the increasing discussion of the subject also demonstrates the magnitude of its uncertainties, ethical questions, and risks that need to be governed.

For this reason, the SRM debate should be addressed not merely as the idea of a technical climate intervention, but together with its dimensions of sustainability, climate policy, international law, ethics, and social legitimacy. The purpose of this article is to assess SRM, which has become increasingly visible on the climate agenda, together with its scientific uncertainties, governance efforts, public concerns, and policy debates.

The Place of SRM Within Climate Policy

SRM is a general concept used for methods that aim to limit global temperature rise by reflecting a small portion of the solar radiation reaching the Earth back into space. In the literature, it is also referred to by different terms such as solar geoengineering, solar radiation management, or sunlight reflection methods.

SRM differs from the classical mitigation policies used in the fight against climate change. Emissions reduction aims to limit the release of greenhouse gases into the atmosphere. Carbon removal focuses on removing carbon dioxide that has accumulated in the atmosphere. Adaptation policies, on the other hand, aim to increase the resilience of societies, economies, and ecosystems against the unavoidable impacts of climate change. SRM, unlike these three areas, is based on the idea of creating a temporary cooling effect on the energy balance of the climate system without reducing the accumulation of greenhouse gases in the atmosphere.

For this reason, SRM is not considered a solution that eliminates the root cause of climate change. As long as the concentration of carbon dioxide in the atmosphere continues to increase, it is assessed that ocean acidification, ecosystem pressures, and other environmental impacts associated with the use of fossil fuels will also continue. What SRM theoretically aims to achieve is not to eliminate these causes, but to limit some of the effects of temperature rise by reflecting a portion of solar radiation. Indeed, UNEP defines SRM as a speculative approach that cannot replace real climate action and carries high uncertainties; the Royal Society has also emphasised that SRM can only temporarily mask part of the warming caused by greenhouse gases and does not address the root cause.

This distinction lies at the centre of the SRM debate. On the one hand, some researchers argue that the possible effects of SRM should be understood if temperature rise approaches critical thresholds. On the other hand, many institutions and civil society organisations warn that such research may weaken political pressure for emissions reduction, normalise the technology, and open the path toward deployment. For this reason, SRM is considered not only as a proposal for technical climate intervention, but also as a field of research debated in terms of the limits, priorities, and ethical responsibilities of climate policy.

Main Technological Approaches

Under the heading of SRM, reference is made not to a single method, but to a group of approaches based on different technical assumptions. The common feature of these approaches is that they aim to influence the Earth's energy balance through solar radiation. However, the level of scientific maturity, feasibility, risk profile, and governance needs of these methods differ considerably from one another.

One of the most widely discussed methods in the literature is stratospheric aerosol injection. This approach is based on the idea of releasing reflective particles into the stratosphere, drawing on the temporary cooling effect of particles dispersed into the atmosphere following major volcanic eruptions. Another method is marine cloud brightening, which aims to reflect more sunlight back by increasing the brightness of marine clouds. In addition to these, less mature proposals such as cirrus cloud thinning, making land or ocean surfaces more reflective, and space-based sunshields are also being discussed.

These methods are not currently considered implemented, proven, and globally accepted climate solutions. While some are examined mainly through computer models and natural analogues, others are at a much earlier stage in terms of technical feasibility. Therefore, in the SRM debate, it is necessary not only to list the names of the methods, but also to state that they are largely at the research stage and that their possible effects involve significant uncertainties.

In particular, stratospheric aerosol injection and marine cloud brightening stand out as two approaches that have been examined more extensively in the scientific literature. However, the fact that they have been researched more extensively is not considered sufficient to conclude that these methods are safe, governable, or deployable. Current research indicates that this field requires a multilayered assessment not only from a technical perspective, but also from environmental, ethical, legal, and political perspectives. For this reason, in the SRM debate, it is important to draw a clear distinction between the examination of methods at the research level and possible deployment scenarios.

Scientific Uncertainties and Potential Risks

One of the main issues in the debate on SRM is that assessing its potential impacts solely through global average temperature may not be sufficient. The fact that a method may theoretically reduce temperature rise does not necessarily mean that it will produce the same outcome in different regions. The climate system is a complex structure involving multilayered relationships among the atmosphere, oceans, precipitation cycles, wind systems, cloud formation, agriculture, water resources, and ecosystems. For this reason, the

literature emphasises that the consequences of an intervention in solar radiation should be assessed not only through its “cooling effect”, but also by taking regional and sectoral impacts into account.

Research indicates that SRM may create different impacts on precipitation regimes, monsoon systems, regional temperature distributions, the ozone layer, biodiversity, agricultural productivity, and water availability. While temperature pressure may decrease in some regions, new risks may arise in other regions in terms of precipitation patterns, food security, or ecosystem balances. This situation transforms the SRM debate from a technical climate intervention into an issue of justice and risk sharing.

Another important uncertainty is the possibility that SRM may be an intervention requiring continuity. Particularly in aerosol-based approaches, the application may need to be maintained regularly in order to preserve the cooling effect. If such an intervention is initiated and then suddenly stopped, the risk may arise that the suppressed temperature increase could return rapidly. This possibility, discussed in the literature as “termination shock”, makes not only the question of initiating SRM, but also the questions of how it would be maintained and how it would be terminated, critical.

For this reason, the scientific uncertainties concerning SRM are not seen as being limited solely to whether the method is technically possible. In the literature, how such an intervention may produce consequences across different geographies, sectors, and social groups is an important subject of debate. Without these uncertainties being sufficiently understood, caution is exercised against presenting SRM as an applicable, safe, or governable climate instrument.

Ethics, Governance, and Social Legitimacy

One of the important dimensions of the SRM debate is not only what the technology can do, but by whom and with what legitimacy such a research or potential intervention process would be governed. Considering that the potential impacts of SRM may not remain confined within national borders, it is emphasised that issues such as decision-making authority, oversight, responsibility, attribution of harm, and public participation should be addressed together with technical feasibility.

One of the main ethical concerns in this field is the possibility that SRM may weaken political pressure for emissions reduction. It is debated that, if SRM is presented as an option that could temporarily limit temperature rise without addressing the root causes of the climate crisis, it may weaken policy priorities regarding greenhouse gas mitigation. This risk, discussed in the literature as “moral hazard” or “mitigation deterrence”, strengthens the view that SRM should be considered not as an instrument that could replace climate policies, but as a limited and cautious research topic.

Another important subject of debate is the possibility that research may create its own momentum over time. There are concerns that studies initially conducted as modelling or limited scientific examination may, at later stages, pave the way for larger field experiments, private sector investments, patents, and commercial expectations. For this reason, some civil society organisations argue that even SRM research carries the risk of normalising the technology. According to this view, SRM research should be addressed not only in terms of its present scientific purposes, but also together with the deployment expectations it may generate in the future.

One of the prominent questions from a governance perspective is decision-making authority. Since the potential impacts of SRM may produce different outcomes in different regions, the emergence of only technologically capable countries or private companies as decisive actors may bring legitimacy debates with it. It is stated that Global South countries, despite being more vulnerable to the impacts of climate change, are often represented more limitedly in the scientific capacity, financing, and decision-making processes in this field. This situation causes the SRM debate to be addressed also in the context of climate justice.

Social legitimacy is also considered an important part of this framework. In addition to informing the public, it is emphasised that affected societies, local communities, scientists, policymakers, and civil society should be meaningfully included in decision-making processes. In a field with high uncertainties such as SRM, the insufficient consideration of trust, transparency, and accountability may increase social concerns regarding research processes.

For this reason, the debate on the future of SRM is not limited solely to laboratories or climate models. The main issues highlighted in the literature are shaped around the ethical boundaries of this research field, oversight mechanisms, which societies will be included in decision-making processes, and how the priority of emissions reduction will be preserved.

Institutional Approaches: The United States, the United Kingdom, the EU, and International Institutions

The increasing interest in SRM is not interpreted in the same way by different countries and institutions. One of the common points is the emphasis that SRM should not replace emissions reduction and adaptation policies. However, there are different approaches regarding the boundaries within which research may be conducted, how open-air experiments should be approached, and to what extent potential deployment should be restricted.

In the United States, the issue is addressed primarily within the framework of a research plan and research governance. In the report prepared by the White House Office of Science and Technology Policy, it is stated that SRM research should be conducted in accordance with the principles of transparency,

public participation, safety, international cooperation, and periodic review. This approach is considered not as a policy decision toward the deployment of SRM, but as a preparatory framework aimed at understanding its potential impacts, risks, and the steps that other actors may take in the future.

In the United Kingdom, the issue has become visible particularly along the axis of publicly funded research and public dialogue. While the studies supported by UKRI/NERC focus largely on modelling and risk assessment, public dialogue studies reveal that society approaches SRM research conditionally. It is observed that participants find controlled research, such as computer modelling, more acceptable; whereas with respect to open-air experiments and deployment, they emphasise ethical principles, transparency, international governance, and the condition of not deviating from emissions reduction.

The European Union's approach has a more cautious framework. In EU documents, SRM is addressed as a controversial field that does not solve the root cause of climate change, but needs to be monitored from scientific and governance perspectives. In scientific assessments at the European level, the priority of greenhouse gas reduction and adaptation policies is emphasised; a moratorium is proposed for the use of SRM, while an ethical, transparent, responsible framework open to public participation is recommended for research. One of the main concerns in EU-level assessments is to prevent SRM from being presented as a climate solution and to address it, in the foreseeable future, within the framework of responsible research and governance rather than deployment.

A similarly cautious approach also comes to the fore in the assessments of UNEP, UNESCO, and the United Nations system. These assessments draw attention to the speculative nature of SRM, scientific uncertainties, climate justice issues, and the global governance gap. In particular, transboundary impacts, the possibility of military or geopolitical use, the role of the private sector, attribution of harm, and the inclusion of vulnerable communities in decision-making processes are among the prominent issues.

This picture demonstrates that a common and binding global governance framework for SRM has not yet been established. Research is increasing, institutions are taking positions at different levels, and public debates are expanding. In contrast, scientific, ethical, and political legitimacy regarding deployment remains contested. For this reason, SRM is currently considered not as an established "solution", but as a sensitive field carefully monitored in terms of climate research and global governance.

Conclusion: SRM as a Governance Test Rather Than a Solution

Solar Radiation Modification is not currently considered a climate solution that has been implemented, whose effects have been proven, or that has been accepted at the global level. The current debate is shaped more around the question of how such intervention ideas should be researched and how they should be limited in a period in which climate change is deepening, mitigation efforts are not progressing at a pace consistent with the objectives of the Paris Agreement, and critical temperature thresholds are increasingly coming onto the agenda.

In this framework, addressing SRM solely as a technical cooling method would constitute an incomplete assessment. SRM does not reduce greenhouse gas emissions, does not remove carbon dioxide from the atmosphere, and does not solve the root cause of climate change. Nevertheless, the fact that it finds a place on the research agenda due to the possibility of temporarily limiting temperature rise makes visible the pressure faced by climate policies. At this point, the main debate is shaped around the question of whether SRM research will create a warning that strengthens emissions reduction and adaptation policies, or a distraction that carries the risk of postponing these policies.

It is likely that the SRM debate will come further onto the agenda in the coming period. Public funding, private sector initiatives, scientific reports, assessments by international institutions, and public dialogue studies are making this field more visible. However, the literature emphasises that visibility alone does not mean legitimacy. Therefore, it is assessed that every new step concerning SRM should be addressed together with scientific uncertainties, ethical principles, social participation, international law, and global justice dimensions.

In this framework, SRM may be regarded not as an easy way out of the climate crisis, but as an important governance test concerning how science, politics, the market, and societies will debate the idea of an intervention at the planetary scale. While emissions reduction, carbon removal, and adaptation policies continue to constitute the main axis of the climate struggle, the approach that SRM should only be addressed within a transparent, cautious, and internationally legitimate research debate that does not overshadow this axis comes to the fore.

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1. UKRI - Solar radiation modification: a public dialogue - <https://www.ukri.org/publications/solar-radiation-modification-a-public-dialogue/>
2. Hopkins Van Mil. (2026). Solar radiation modification: a public dialogue. Public views on SRM research & potential deployment.- https://www.ukri.org/wp-content/uploads/2026/05/NERC_280526-PublicDialogueonSRM-Report.pdf
3. Center for International Environmental Law | CIEL - Recent Solar Geoengineering Developments Highlight Dangers of Normalization and Need to Advance Non-Use - <https://www.ciel.org/solar-geoengineering-developments-spring-2026/>
4. Hernandez-Galindo, I., Määttänen, A., Redmond Roche, B. H., Boucher, O., Irvine, P. J. and Moore, J. C. - Past Field Experiments of Solar Radiation Modification: A Review of the Scientific and Technical Aspects for Governance - <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2025EF007254>
5. The Royal Society - Solar radiation modification: summary briefing - <https://royalsociety.org/news-resources/projects/solar-radiation-modification/summary-briefing/>
6. United Nations Environment Programme - Solar Radiation Modification - https://www.uncclearn.org/wp-content/uploads/library/Solar_Radiation_Modification.pdf
7. SAPEA. (2024). Solar Radiation Modification: Evidence Review Report. Science Advice for Policy by European Academies.- https://portal-cdn.scnat.ch/asset/3af0316d-c0f2-5ca6-b543-c9bdba33baa5/srmerr.pdf?b=1a54ebf0-d17b-58d4-83e1-85f5398d42f6&v=e2ea2551-3ad3-5f12-b1fa-7b2186c451ac_0&s=fJfNsyMUR9K_f6uCXANpiGCsvDyfKsq_GGt0MWCxbXogTDpY-iBc8A4aCTRcl20wEVGHFEtBmxDKBcLGlmguviMmcizn3k0u9ypV-qYjVGTZ3jvU4uHBIQTGd9zU-bKvxPedKTfNGLy-tNvuFXZQia9Aaw6hWLuKuCu4ULbwM
8. Oomen, J. (2024). Producing the Inevitability of Solar Radiation Modification in Climate Politics. - <https://www.cambridge.org/core/journals/ethics-and-international-affairs/article/producing-the-inevitability-of-solar-radiation-modification-in-climate-politics/402F719990D3BE9A4FEC1A68FF85F04B>
9. European Commission- Solar radiation modification technologies cannot fully address climate change, and responsible research on impacts is needed - advisors tell the European Commission- https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/solar-radiation-modification-technologies-cannot-fully-address-climate-change-and-responsible-2024-12-09_en
10. OSTP. (2023). Congressionally Mandated Research Plan and an Initial Research Governance Framework Related to Solar Radiation Modification. Office of Science and Technology Policy, Washington, DC.- <https://bidenwhitehouse.archives.gov/wp-content/uploads/2023/06/Congressionally-Mandated-Report-on-Solar-Radiation-Modification.pdf>