European Journal of Risk Regulation (2025), 1–17
doi:10.1017/err.2025.10025

CAMBRIDGE UNIVERSITY PRESS

ARTICLE

No Governance Is Governance: Mapping Solar Geoengineering Discussions in Latin America & the Caribbean

María Inés Carabajal[1,2], María Florencia Santi[1,3,4], Cintia Rodríguez Garat[3,5], Gian Franco Lisanti[2,3], Julieta Nasi[2,3], Timothy Daly[3], Ignacio Mastroleo[1,3], Florencia Luna[1,3] and Inés Camilloni[6,7,8]

[1]National Scientific and Technical Research Council (CONICET), Argentina, [2]Universidad de Buenos Aires, Facultad de Filosofía y Letras, Instituto de Ciencias Antropológicas, Buenos Aires, Argentina, [3]FLACSO, Programa de Bioetica, Buenos Aires, Argentina, [4]Universidad Nacional de Entre Ríos, Entre Ríos, Argentina, [5]Universidad Nacional de La Plata, Buenos Aires, Argentina, [6]Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Ciencias de la Atmósfera y los Océanos, Buenos Aires, Argentina, [7]CONICET – Universidad de Buenos Aires, Centro de Investigaciones del Mar y la Atmósfera (CIMA), Buenos Aires, Argentina and [8]CNRS – IRD – CONICET – UBA, Instituto Franco-Argentino para el Estudio del Clima y sus Impactos (IRL 3351 IFAECI), Buenos Aires, Argentina
Corresponding author: María Inés Carabajal; Email: micarabajal@gmail.com

Abstract

Global discussions around the risks, benefits and governance of solar radiation modification (SRM) in the climate change response portfolio are accelerating, but the topic remains nascent in Latin America and the Caribbean (LAC). In 2023, a US start-up (Make Sunsets) performed a small-scale, non-research deployment of SRM in Baja California, Mexico, without prior permission or community engagement. Their actions prompted Mexico to announce its intention to ban SRM experimentation, underscoring the need for governance to prevent irresponsible practices that could discredit legitimate research. We perform an empirical and ethical analysis of the landscape of academic discussions and media coverage on SRM in the LAC region, focusing on the Make Sunset case. Our analysis leads us to three conclusions: first, a lack of regulations in LAC that fosters mistrust, fuels perceptions of neo-colonialism and restricts potentially valuable and responsible research; second, we argue that the theatrical Make Sunsets case is not ethically justified in light of the diversity of risks associated with it; third, we offer foundational, participatory recommendations to promote effective, transparent and sustainable governance of SRM, including LAC in global conversations.

Keywords: Risk; Governance; Make Sunsets; Solar geoengineering; Latin America & the Caribbean

Introduction: why study solar geoengineering governance in Latin America and the Caribbean?

Climate change is one of the most relevant crises in modern history. Despite international efforts, greenhouse gas (GHG) emissions continue to increase, and global average temperatures will likely exceed the 1.5ºC Paris Agreement target in this century.[1] Radical

[1] NS Diffenbaugh and EA Barnes, "Data-Driven Predictions of the Time Remaining Until Critical Global Warming Thresholds Are Reached" (2023) 120 (6) Proceedings of the National Academy of Sciences of the United States of America 1, 3. https://doi.org/10.1073/pnas.2207183120 (last accessed 16 December 2024).

responses are being considered to mitigate catastrophic impacts on populations and ecosystems, given the uncertainty of avoiding severe effects at this warming level,[2] especially in the Global South.

Conventional strategies for climate action are usually understood as a form of either mitigation or adaptation. However, solar geoengineering (SG) or solar radiation modification (SRM) – both variations will be used interchangeably – is an umbrella term for emerging technologies intervening in the climate to reduce temperatures and introduces a distinct kind of activity.[3] One of the most researched SRM approaches is Stratospheric Aerosol Injection (SAI), which refers to the release of sulphur dioxide (SO_2) particles into the stratosphere, which would reflect sunlight back into space to cool the planet.[4] This approach would mimic the effect of a volcano eruption, such as Mount Pinatubo in 1991, when, according to the US Geological Survey, the spread of tons of SO_2 cooled the Earth, temporarily dropping the temperature to 0.5ºC between 1991 and 1993.[5] SAI is among the most technically feasible approaches to temporarily offset climate impacts.[6] One key feature of SAI is that it would be relatively inexpensive to develop[7] and might produce rapid results, if data from natural analogs like volcano eruptions are indeed relevant predictors. Hence, its potential feasibility and effectiveness are expected to be high.

Decarbonisation must be prioritised in an adequate portfolio of responses to climate change.[8] SAI does not address the root causes of climate change, and while it could bring potential benefits, it also poses potential unknown risks and uncertainties to humans and ecosystems.[9] Moreover, the distributions of risk will not be equal.[10] It is therefore necessary to explore the risks, side-effects, as well as uncertainties and unintended regional and local impacts of SRMs in order to consider the ethical implications of researching and potentially deploying these technologies. In this article, we adopt the definition of risk as presented by Felgenhauer et al,[11] following the US Department of Homeland Security: "the potential for an unwanted outcome

[2] Intergovernmental Panel on Climate Change (IPCC) Working Group II, "Summary for Policymakers. Climate Change 2022: Impacts, Adaptation and Vulnerability" in H-O Pörtner, DC Roberts, M Tignor M and Others (eds), *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press & Policy 2022) pp 16–20.

[3] World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), *Concept Note of COMEST on the Ethics of Climate Engineering* (2022), available at <https://unesdoc.unesco.org/ark:/48223/pf0000379991> (last accessed 16 December 2024).

[4] I Camilloni, N Montroull, C Gulizia and RI Saurral, "La Plata Basin Hydroclimate Response to Solar Radiation Modification With Stratospheric Aerosol Injection" (2022) Frontiers in Climate. http://doi.org/10.3389/fclim.2022.763983 (last accessed 26 December 2024); National Academies of Sciences, Engineering, and Medicine (NASEM), *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance* (National Academies Press 2021). https://doi.org/10.17226/25762 (last accessed 26 December 2024).

[5] BJ Soden, RT Wetherald, GL Stenchikov and A Robock, "Global Cooling After the Eruption of Mount Pinatubo: A Test of Climate Feedback by Water Vapor" (2002) 296 (5568) Science 727. http://doi.org/10.1126/science.296.5568.727 (last accessed 23 December 2024).

[6] NASEM (n 4) 2.

[7] W Smith, "The Cost of Stratospheric Aerosol Injection Through 2100" (2020) 15 (11) Environ Res Letters 114024. http://doi.org/10.1088/1748-9326/aba7e7 (last accessed 16 December 2024).

[8] WR Lee, D MacMartin, D Visioni and S Adler, *Sunlight Reflection Management Primer* (2021), available at <https://srmprimer.org/srmprimerwiki> (last accessed 16 December 2024).

[9] Intergovernmental Panel on Climate Change (IPCC), *Global Warming of 1.5°C* (2018), available at <https://www.ipcc.ch/sr15/> (last accessed 16 December 2024).

[10] Lee (n 8).

[11] T Felgenhauer, G Bala, M Borsuk, I Camilloni, J Wiener and J Xu, "Practical Paths to Risk-Risk Analysis of Solar Radiation Modification" (2024) 84 Global Environmental Change. https://doi.org/10.1093/oxfclm/kgaf012 (last accessed 9 April 2025).

resulting from an incident, event or occurrence, as determined by its likelihood and the associated consequence."[12] This broad definition acknowledges that risks are diverse in magnitude, scale, type and distribution. Any climate intervention could trigger different types of risks,[13] which refers not only to environmental risks but political and ethical concerns that could exacerbate global conflicts.

In recent years, there have been many advances in global discussions and debates around SAI and SRM, as evidenced by international reports and publications and multilateral forums.[14] Discussions concerning the risks, benefits and governance challenges are growing, especially in academia. Conversely, in the political and social domains, SRM remains an unfamiliar topic.[15] Although in the LAC region there is a growing interest, the expertise and capacity building to make informed decisions is insufficient in most countries. In this region, SRM is in its nascent stages and is not a priority in the climate change portfolio of strategies. Nonetheless, as discussions are growing mainly in the Global North while unexpected events are occurring elsewhere, we argue that governments worldwide need to be part of inclusive conversations to establish oversight processes and anticipatory governance structures.

This article aims to bridge these gaps within discussions around SAI. Our main aim is to highlight that the inexistence of proper regulation of SRM in LAC is itself a form of governance, with important consequences. It can shape outcomes in significant ways – by leaving countries unprepared and vulnerable, increasing dependence on external agendas, or overlooking key ethical considerations. We consider the absence of sufficient information or local expertise a barrier to efficient and ethical action at the level of nation-states and/or international governmental institutions.

We begin by assessing the lack of governance of SRM in LAC (Section I). Second, we present the Make Sunset case based on a thorough literature review focusing on the start-up's own narratives and activities in Mexico (Section II). Third, we define risk and describe some of the types of risk perceived in SRM (Section III). We also make a descriptive analysis of the media coverage and main narratives (Section IV). Then, based on this information, we perform an ethical analysis of the case and argue for inclusive public engagement as a key pillar in fostering democratic governance (Section V). Finally, we propose recommendations to promote effective, transparent and sustainable governance in LAC and elsewhere (Section VI).

[12] US Department of Homeland Security, *DHS Risk Lexicon – 2010 Edition* (Office of Risk Management and Analysis, National Protection and Programs Directorate 2010), available at <https://www.dhs.gov/xlibrary/assets/dhs-risk-lexicon-2010.pdf> (last accessed 9 April 2025).

[13] G Davies and J Vinders, "Geoengineering, the Precautionary Principle, and the Search for Climate Safety" (2025) European Journal of Risk Regulation 1. https://doi.org/10.1017/err.2025.14 (last accessed 22 May 2025).

[14] IPCC (n 9); European Commission, "Solar Radiation Modification Technologies Cannot Fully Address Climate Change, and Responsible Research on Impacts Is Needed: Advisors Tell the European Commission" (European Commission Research and Innovation, 9 December 2024), available at <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> (last accessed 27 December 2024); Climate Overshoot Commission, *Report* (2024), available at <https://www.overshootcommission.org/report> (last accessed 27 December 2024); United Nations Environment Programme (UNEP), *One Atmosphere: An Independent Expert Review on Solar Radiation Modification Research and Deployment* (2023), available at <https://www.unep.org/resources/report/Solar-Radiation-Modification-research-deployment> (last accessed 18 December 2024); COMEST (n 3); COP28 and UNEA 6.

[15] CM Baum, L Fritz, S Low and Others, "Public Perceptions and Support of Climate Intervention Technologies Across the Global North and Global South" (2024) 15 Nature Communications 2060. https://doi.org/10.1038/s41467-024-46341-5 (last accessed 9 April 2025).

I. The lack of SRM governance and the landscape in the LAC region

International concern around the lack or insufficient governance structures for SRM is growing.[16] There is currently no comprehensive governance system, nor a natural forum where this issue can be adequately discussed.[17] As a result, many key questions remain unanswered, such as who will have the authority to deploy SRM technology at a planetary scale and, hence, who will control the planet's metaphorical thermostat, with consequences for the most vulnerable populations. Likewise, other questions focus on who will monitor and regulate the research (at any scale), the funding, the potential testing and eventually the deployment of such technologies. The complexity of SRM raises technical, socio-political and ethical discussions about whether it should be funded, researched or even promoted.[18]

Global governance on SRM is evolving, acknowledging significant governance gaps, both in research – indoor and outdoor – and particularly in potential deployment. Governance can take different forms, depending on the actors involved (governmental, non-governmental, or private sectors), the different stages from research to deployment[19] and the near- and long-term outcomes. As Jinnah et al observe, even the distinction between stages could be considered artificial.[20] Relevant reports highlight the need for responsible research and ethical guidelines on indoor research.[21,22] Defenders argue that for advancing theoretical knowledge on SRM, small-scale outdoor research experimentation could provide a more precise understanding, e.g., of behaviour of reflective particles in the stratosphere, and could improve the models. Therefore, a significant challenge lies in defining where, when and in which circumstances scientists will be allowed to carry out these outdoor field trials and in building participatory mechanisms, as there could be resistance from governments and communities.[23]

So far, the Global North has highly dominated the discussion on SRM.[24] Most of the theoretical research and modelling projections have been made in those countries. In the Global South, particularly in the LAC region, the number of research teams exploring the physical and socio-political dimensions of SRM is growing. While there have been several capacity-building initiatives aimed at raising awareness and fostering engagement with these technologies, such efforts have been largely insufficient and lack continuity. As a result, they have not enabled the development of a sustained, regionally grounded

[16] Z Dove, S Jinnah and S Talati, "Building Capacity to Govern Emerging Climate Intervention Technologies" (2024) 12 (1) Elementa: Science of the Anthropocene. https://doi.org/10.1525/elementa.2023.00124 (last accessed 16 December 2024); UNEP (n 14) 4.

[17] J Reynolds, *The Governance of Solar Climate Engineering: Managing Climate Change in the Anthropocene* (Cambridge University Press, Cambridge, 2019).

[18] F Biermann and Others, "Solar Geoengineering: The Case for an-International Non-Use Agreement" (2022) 13 (3) Wiley Interdisciplinary Reviews: Climate Change. https://doi.org/10.1002/wcc.754 (last accessed 16 December 2024).

[19] Dove (n 16).

[20] S Jinnah, S Nicholson and J Flegal, "Toward Legitimate Governance of Solar Geoengineering Research: A Role for Sub-State Actors" (2018) 21 (3) Ethics, Policy & Environment 366. https://doi.org/10.1080/21550085.2018.1562526 (last accessed 16 December 2024).

[21] Indoor research refers to: modelling, lab experiments, and theoretical analysis, and outdoor research referring to field trials, experimentation in the open air, and also community engagement.

[22] American Geophysical Union (AGU), *Ethical Framework Principles for Climate Intervention Research* (2024). https://doi.org/10.22541/essoar.172917365.53105072/v1 (last accessed 26 December 2024).

[23] S Jinnah and Others, "Do Small Outdoor Geoengineering Experiments Require Governance?" (2024) 385 Science. https://doi.org/10.1126/science.adn2853 (last accessed 26 December 2024).

[24] Jinnah (n 20); Biermann (n 18); EA Parson, "A Dangerous Disruption" (*Legal Planet*, Berkeley Law, UCLA Law, 2 January 2023), available at <https://legal-planet.org/2023/01/02/a-dangerous-disruption/> (last accessed 26 December 2024).

narrative on SRM that reflects LAC-specific priorities, perspectives and concerns. Familiarity with SRM remains limited. In this sense, based on the principles of climate justice, countries from the Global South must be part of the discussions to build equitable and inclusive regulatory and institutional frameworks.

Countries from the LAC region will need to build capacities to anticipate the consequences of planetary technologies.[25] Some groups against SRM state that the topic has been imposed on Global South countries and has deviated attention from decarbonisation.[26] However, we consider that vulnerable countries must be aware of the potential benefits and risks and should play a central role in the discussions.[27] This would entail improving LAC capacities, gaining access to breakthrough information, and understanding the array of impacts of SRM in the region. Additionally, as the technology evolves, new actors emerge and unforeseen events unfold, making anticipatory and participatory governance essential for overseeing and facilitating responsible research and inclusive dialogue, particularly in the Global South.[28]

II. Make sunsets: a small-scale, "theatrical"[29] approach to SAI

According to the December 2024 version of its webpage, Make Sunsets is a Silicon Valley start-up that claims to be "cooling the earth" by selling to the general public and companies "cooling credits" that offset 1 ton of CO_2 emissions per credit.[30] The start-up focuses on SAI as "an effective solution to buy time for other efforts to take hold," including non-fossil energy at scale, "more trees" and CO_2 removal.[31] The company presents itself as a start-up committed to the environment and as an agent of change for taking action to counteract climate change. According to its founder Luke Iseman and co-founder Andrew Song, the policies implemented to address global warming are not working; thus, as an imperative, they "need to do solar geoengineering," as "the world is too hot. We need to cool it off."[32] They frame their work as a cost-effective, immediate SAI deployment:

> "We *deploy* our [sulfur dioxide (SO_2) reflective clouds above 12.4 miles (20 km) from the Earth's surface using balloons. *The reflective clouds stay up for about a year*, reflecting some of the Sun's rays like the natural clouds below. Think of it as applying

[25] H Carlino, A Gogorza and M Carlino, "Strengthening Regional Capacities to Address the Risk of and From Overshooting 1.5°C Global Warming in Latin America and the Caribbean" (C2G/ECLAC 2024), available at <https://www.cepal.org/en/publications/80737-strengthening-regional-capacities-address-risk-and-overshooting-15degc-global> (last accessed 27 December 2024).

[26] A Chalmin, "Global Southwashing: How the Degrees Initiative Is Imposing Its Solar Geoengineering Agenda onto Climate Research in the Global South" (*Geoengineering Monitor*, 16 October 2024), available at <https://www.geoengineeringmonitor.org/the-degrees-initiative> (last accessed 16 December 2024).

[27] UNEP (n 14) 4; A Rahman, P Artaxo, A Asrat and A Parker, "Developing Countries Must Lead on Solar Geoengineering Research" (2018) 556 (7699) Nature 22. https://doi.org/10.1038/d41586-018-03917-8 (last accessed 27 December 2024).

[28] AGU (n 22).

[29] D Keith quoted in R Skibba, "Geoengineering Could Alter Global Climate. Should It?" (Undark.org, 3 December 2024), available at <https://undark.org/2024/12/03/unleashed-geoengineering-climate> (last accessed 27 December 2024).

[30] Make Sunsets, *Home* (23 December 2024), available at <https://web.archive.org/web/20241223090741; http://makesunsets.com/> (last accessed 30 April 2025). (Note: The website changed radically their content in 2025. We leave the Wayback Machine link to explore the previous version).

[31] Make Sunsets, available at <https://makesunsets.com/> (last accessed 27 December 2024).

[32] Iseman quoted in J Simon, "Startups Want to Cool Earth by Reflecting Sunlight. There Are Few Rules and Big Risks" (*NPR*, 21 April 2024), available at <https://www.npr.org/2024/04/21/1244357506/earth-day-solar-geoengineering-climate-make-sunsets-stardust> (last accessed 27 December 2024).

> sunscreen spray to protect your skin from the Sun. Just 2.2 pounds (1 kilogram) of our clouds offset the warming effect of ~2.2 million pounds (one million kg) of CO_2 *for a year.*"[33]

Here, the shorthand formula that Make Sunsets uses to issue cooling credits is that "a gram [of SO_2 in the stratosphere] offsets a ton [of CO_2 in the troposphere] for a year," which is inspired by early work of SRM scientists.[34] However, this formula is misleading. First, the cooling credit scheme does not clarify to potential buyers that if someone only offsets a year or so of CO_2 heating lifetime, "the sulfur is gone but the CO_2 is still there and heating,"[35] remaining for hundreds to thousands of years.[36] Second, the formula is taken out of its original scientific research context, which was intended for discussions of large-scale planetary deployment over decades.

The start-up website combines information about the climate emergency and its risks with the offer of a fast, effective, economical and scientifically grounded solution. In the 2024 version of the website, one reads phrases such as "Are you ready to be part of the solution and prevent warming now?" and "Let's work together to cool our planet for future generations." They acknowledge the unknown effects of SAI and risks but, misleadingly argue that the severity of the climate emergency leads to preferring actions to words ("boldness"): "We believe the best time to field test and scale SAI is now."[37]

In the "What" section under the slogan "Current climate efforts need time, a luxury only SAI can provide," they describe SAI's risks and benefits and explain the origin of this technology linked to the cooling effect of volcanic eruptions. The potential benefits include rapid cooling, cost-effectiveness and supplementing other strategies. The benefits are presented simplistically, although the narrative moderates their scope – for example, stating that "SAI could provide relatively quick cooling effects on the Earth's Surface" – which contrasts with the assertive narrative of the homepage. The potential risks include uncertain effectiveness, ozone depletion, termination effect, moral hazard and international governance challenges. They list the risks but minimise their effects and simplify their solutions.

The focus of the website changed in 2025. The company has reduced the information on the environmental crisis, replaced the references to SAI with the reflective cloud metaphor and focused on the information on cooling credits and balloons. The homepage begins with this phrase: "We cool Earth with reflective clouds."[38] The What and Why sections have been removed. The risks, harms and benefits are briefly mentioned in the FAQ section: "What is the benefit vs. harm of stratospheric aerosol injection? 100 people benefit from, and 1 person is harmed if we deploy enough to cool the Earth by 1C. Source: 'Towards Quantitative Comparison of the Risks and Benefits of Solar Geoengineering.' by Dr. David

[33] Make Sunsets (n 31) (edited & emphasis added).

[34] D Keith and A Parker, "Will Solar Geoengineering Help Us Manage the Risks of Climate Change?" in Katinka Barysch (ed). *Our World and Us: How Our Environment and Our Societies Will Change* (Allianz SE, Munich 2015) 76–92; L Iseman, "Make Sunsets: Clarifications!" (28 December 2022), available at <https://groups.google.com/g/geoengineering/c/l5fmgzA34HY> (last accessed 27 December 2024).

[35] Parson (n 24) 3.

[36] A Buis, "The Atmosphere: Getting a Handle on Carbon Dioxide" (NASA Science Portal, 9 October 2019), available at <https://science.nasa.gov/earth/climate-change/greenhouse-gases/the-atmosphere-getting-a-handle-on-carbon-dioxide> (last accessed 22 June 2025); E Boyle, "How Do We Know How Long Carbon Dioxide Remains in the Atmosphere?" (*MIT Climate Portal*, 17 January 2023), available at <https://climate.mit.edu/ask-mit/how-do-we-know-how-long-carbon-dioxide-remains-atmosphere> (last accessed 27 December 2024).

[37] Make Sunsets (n 31) (last accessed 27 December 2024).

[38] Ibid.

Keith." This quote corresponds to a utilitarian simplification of a slide presented in a YouTube video by geoengineering expert David Keith.

Although Make Sunsets presents itself as a science-based start-up committed to the environment, its relationship with the scientific community is complex. Make Sunsets' main aim is "doing" SRM, not "learning" about SRM. They do not undertake scientific research, understood as developing generalisable knowledge or resolving uncertainties about SRM. From an ethically neutral point of view regarding responsible or irresponsible actions, its activities can be better described as non-research SRM experimentation, an "experimental cooling credit" provider or an "experimental offsetting solution" in contrast to established carbon offset providers, such as those based on forestry. They acknowledge discovering the idea of SAI in Neal Stephenson's 2021 sci-fi novel *Termination shock* but also quote sound authoritative scientific literature, including UNEP and IPCC. They allegedly monitor the efficacy of the biodegradable meteorological balloon that carries the few hundred or thousand grams of SO_2 payload deployment[39] with instrumentation[40] to verify reaching the stratosphere (20 km); they only issue a cooling credit if they do so, because SO_2 gas will form "reflective clouds" at such altitude.[41] However, no independent verification by a third-party organisation has validated the start-up activities.

The company is run only by the founder and co-founder. Iseman acknowledged the lack of scientific support but stated that if the company grows, it will hire scientists.[42] Song expressed in an interview that the start-up wants to collaborate with scientists such as David Keith providing field data, but they are seen "as pariahs."[43] In the same interview, Keith replies that Make Sunsets is a "theater piece [. . .] but stunts can be effective in changing minds."[44] This feature does not stop them from offering and charging for unproven technology with unknown consequences and efficacy. They acknowledged this uncertainty but considered that "uncertainty isn't an excuse for inaction," reinforcing the start-up's main stated value, "boldness."[45]

A controversial deployment occurred in Baja California, Mexico, in April 2023. The company released two balloons with sulphur dioxide without prior consent from the government or the communities. This rogue non-research experiment led the Mexican government to announce its intention to ban "solar geoengineering experiments" in the country.[46] This decision follows the precautionary principle of protecting communities and the environment, in line with other legal instruments arising from the Convention on Biological Diversity (CBD), which encourages parties, governments and relevant organisations not to undertake climate geoengineering activities that may affect biodiversity until there is adequate scientific justification and appropriate consideration of associated risks.[47] However, it should be noted that the CBD includes a specific exception

[39] E.g., Kaymont HAB-TX-1500.

[40] GPS, cameras and other sensors [telemetry].

[41] Make Sunsets (n 31).

[42] Iseman quoted in Simon (n 32).

[43] Song quoted in R Skibba, "Geoengineering Could Alter Global Climate. Should It?" (*Undark.org*, 3 December 2024), available at <https://undark.org/2024/12/03/unleashed-geoengineering-climate/> (last accessed 27 December 2024).

[44] Keith quoted in Skibba (n 43).

[45] Make Sunsets (n 31).

[46] Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), "La experimentación con geoingeniería solar no será permitida en México" (13 January 2023), available at <https://www.gob.mx/semarnat/prensa/la-experimentacion-con-geoingenieria-solar-no-sera-permitida-en-mexico> (last accessed 27 December 2024).

[47] Convention on Biological Diversity (CBD), "X/33.Biodiversity and Climate Change", available at <https://www.cbd.int/decision/cop?id=12299> (last accessed 30 April 2025).

for ethically responsible small-scale scientific research.[48] This position is referred to as a moratorium on SRM deployment. In many ways, the irresponsible procedures of Make Sunsets and the response of the Mexican government have raised the alarm of the research and policy community on the need to find monitoring and regulatory mechanisms to deal with this kind of unexpected activity. Complexity grows as new private actors and vested capitals become involved in research (e.g., Stardust, an Israeli-US startup) and non-research experimentation with SRM, such as Make Sunsets experimental cooling credits.

III. Make sunsets' reception in the media: perceptions of risks

Acknowledging the powerful role that the media play in shaping opinions, perspectives and attitudes towards novel and controversial technologies,[49] we analysed different perceptions of SAI on a diversity of platforms. Make Sunset's experimental cooling-credit scheme based on small-scale SAI deployment resonated in the media, and many scientific articles raised awareness of how SAI research and non-research experimentation should be monitored and governed.[50] In this sense, we delve into the media coverage to analyse how they reflect the actions of Make Sunsets.

This section is based on a search for "Make Sunsets" in Lexis Nexis[51] between January 2022 and December 2024 in English and Spanish. This period reflects the company's main activities and how its small-scale deployment performance in Mexico triggered a debate in the scientific and policy community worldwide. Through the media coverage work, we analysed 89 newspaper articles in English and Spanish. All this information allows us to map the landscape of perceptions and the media and political narratives around Make Sunsets, revealing how the public debate on solar geoengineering is constructed. By examining coverage in different linguistic and geographical contexts, it is possible to identify not only some predominant positions, whether supportive, sceptical or outright rejectionist, but also the nuances and the wide array of considerations, mainly the concerns that arise from this controversial technology.

The focus of our empirical analysis is the representation of SG in the media, following some key elements of the framework proposed by Buck.[52] Particularly, we identified different types of risks characterised in the media. To develop the analysis, we created a Microsoft Excel document with all the material found (see Appendix). The variety of risks that appeared in the news are not isolated categories, but rather a landscape of interconnected perspectives involving a complex technology like SRM. We identified nine classes of risks (Table 1):

[48] Carnegie Climate Governance Initiative (C2G), *Evidence Brief: Governing Solar Radiation Modification* (2020), available at <https://www.c2g2.net/wp-content/uploads/c2g_evidencebrief_SRM.pdf> (last accessed 26 December 2024).

[49] COMEST (n 3).

[50] A De la Garza, "Why a Startup's Controversial Experiments to Cool the Earth Are on Pause" (*Time*, 19 January 2023), available at <https://time.com/6248654/mexico-geoengineering-ban-make-sunsets/> (last accessed 16 December 2024); J Temple, "A Startup Says It's Begun Releasing Particles into the Atmosphere, in an Effort to Tweak the Climate" (MIT Technology Review, 24 December 2022), available at <https://www.technologyreview.com/2022/12/24/1066041/a-startup-says-its-begun-releasing-particles-into-the-atmosphere-in-an-effort-to-tweak-the-climate (last accessed 16 December 2024).

[51] The LexisNexis document used for this media analysis was kindly provided by one anonymous reviewer, which allowed us to enhance our analysis.

[52] HJ Buck, "Climate Engineering: Spectacle, Tragedy or Solution? A Content Analysis of News Media Framing" in M Bäckstrand and E Lövbrand (eds), *Interpretive Approaches to Global Climate Governance* (1st edn, Routledge, Abingdon, 2013).

Table 1. Types of risk identified in the media analysis. *Prepared by the authors*

Type of risk	Definition
Climate change impacts (risk-risk)	The risks of SRM are compared to the risks of the potential future scenarios of increasing temperatures and its impacts on humans and ecosystems. "Perception of the risks posed by climate change compared to the risks posed by SRM"[53]
Moral hazard	Focusing on doing research or non-research experimentation into SRM could lead to a distraction from mitigation or emission reductions.[54]
Unintended planetary effects	Due to scientific and technical uncertainties, SRM implementation could pose environmental, social, political and governance risks. It could also cause new and unintended effects on societies and ecosystems.[55]
Lack of governance structures	International concern around the lack or insufficient SRM governance structures to regulate the research (at any scale), the funding, potential testing, and eventual deployment of any SRM technology at a planetary scale.[56]
Lack of validation and rigour	Generalisable research is necessary to validate SRM. The lack of validation and transparency could undermine scientific research.[57]
Lack of commitment to local communities	Potential perceived or real harm when research or non-research experiments, including potential deployment, are carried out without meaningful engagement, public consent or prior consultation of local communities.[58]
Geopolitical risks	The potential of international and geopolitical conflicts among countries.[59]
Termination shock	If SAI is ever implemented for an extended period and then for any reason abruptly stopped, rapid and sustained warming would trigger significant harm to ecosystems, biodiversity and society.[60]
Health Risks	Potential direct or indirect impacts on human health.

We analysed risk perceptions in news coverage of solar geoengineering interventions. It is observed that the most frequently quoted risk is unintended planetary effects, representing 28.9% of the total (Fig. 1). This indicates strong concern about the potential large-scale unintended consequences that could result from deliberate climate manipulation. These are followed by lack of governance structures (15.6%) and lack of scientific validation and technical understanding (13.9%). Other relevant risks include climate change impacts (11.6%) and geopolitical risks (11%). To a lesser extent, news reports mention ethical issues or moral hazard (7.5%), lack of commitment to local communities (6.9%), the phenomenon known as termination shock (3.5%) and, finally, health risks, with just 1.2%. This distribution reveals a comprehensive view of the risks associated with solar geoengineering, where structural, systemic and ethical-political dimensions predominate over direct impacts on human health.

[53] Felgenhauer (n 11).
[54] COMEST (n 3).
[55] National Research Council, *Climate Intervention: Reflecting Sunlight to Cool Earth* (The National Academies Press, Washington, DC, 2015).
[56] Reynolds (n 17).
[57] National Research Council (n 55).
[58] AGU (n 22).
[59] C2G (n 48).
[60] Lee (n 8).

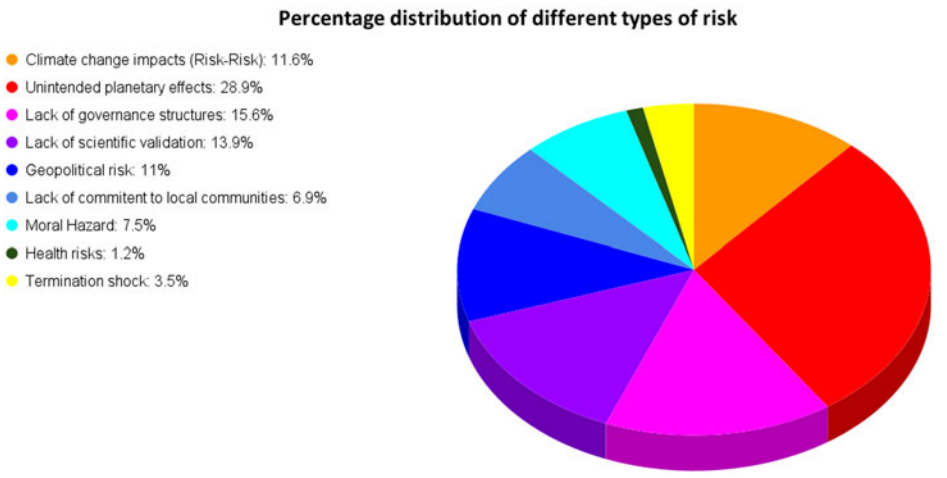

Figure 1. The percentage distribution of different types of risks expressed in perceptions captured in the analysed media about the application of geoengineering or climate interventions, such as the Make Sunsets case.
Source: own elaboration.

IV. Discussion on the media analysis

The Make Sunsets case illustrates the ethical and political challenges of SG, highlighting the importance of widening the margins of transparency and public participation in decision-making. In general terms, media coverage has portrayed this as a turning point in the debate. The dominant narrative condemns the actions of Make Sunsets as irresponsible, premature, and lacking both scientific and ethical legitimacy.

Some of the main narratives used in the media to analyse the controversies of SG emphasise that it is a technology with significant risks and uncertainties. For example, Temple states that "little is known about the real-world effect of such deliberate interventions at large scales, but they could have dangerous side effects".[61] This perception is reinforced by other statements, such as those of ETC Latin America director Silvia Ribeiro, who argues that "because of the risks to biodiversity and the communities that sustain it, the UN Convention on Biological Diversity has called for a moratorium on the deployment of geoengineering since 2010."[62] Along the same lines, Shuchi Talati was quoted by a journalist expressing concern about the potential emergence of groups hoping to profit from unilateral solar geoengineering efforts.[63] The journalist expressed that "Scientists fear that rogue governments could, potentially, strong-arm the world into a solar geoengineering future."[64]

From different viewpoints, these narratives not only emphasise the risks associated with the impacts of climate change along with the risks of SG, but also warn about how

[61] J Temple, "A Startup Says It's Begun Releasing Particles into the Atmosphere, in an Effort to Tweak the Climate" (*MIT Technology Review*, 24 December 2022), available at <https://www.technologyreview.com/2022/12/24/1066041/a-startup-says-its-begun-releasing-particles-into-the-atmosphere-in-an-effort-to-tweak-the-climate/> (last accessed 16 December 2024).

[62] S Ribeiro, "Usan a México para Experimentos de Geoingeniería" (*La Jornada*, 14 January 2023), available at <https://www.jornada.com.mx/notas/2023/01/14/economia/usan-a-mexico-para-experimentos-de-geoingenieria/> (last accessed 16 December 2024). [our translation]

[63] Talati quoted in S Kelleher, "Amid Efforts to Cool the Planet, Solar Geoengineering Draws Heated Debate" (*The New Lede*, 13 April 2023), available at <https://www.thenewlede.org/2023/04/amid-efforts-to-cool-the-planet-solar-geoengineering-draws-heated-debate/> (last accessed 23 Abril 2025).

[64] Kelleher (n 63).

initiatives like Make Sunsets can generate systemic risks for scientific research. They also express the need for robust regulatory frameworks and meaningful public participation in these processes. However, regardless of the doubts surrounding this technology, criticism from some media has focused on the lack of transparency and consent evident in the actions of Make Sunsets. According to Rodríguez and Lo, "the Mexican government said the experiment was carried out 'without prior notice and the consent of the Government of Mexico and the surrounding communities."[65] Similarly, Ribeiro states that "it did not consult anyone, neither the authorities nor the communities whose territory it used for its experiments." Moreover, this case violates the sovereignty of other countries and goes against the precautionary calls issued by the United Nations.[66]

Another key aspect of the media's questioning of the Make Sunsets case relates to the commercial motivations behind the experimentation, such as the sale of experimental 'cooling credits.' This practice has been heavily criticised as a form of 'greenwashing' that distracts from the real solutions to climate change. In this vein, Kelly Wanser, executive director of Silver Lining, a nonprofit organisation that supports research on SRM, states that "from a business perspective, reflective cooling effects and risks cannot currently be quantified in any meaningful way, making the offering a speculative form of 'junk credit' that is unlikely to have value to climate credit markets."[67] As a consequence of this commercial speculation, Ramos stresses that "Mexico has became the first country to reject this practice on a commercial level, as Luke Iseman, founder of Make Sunsets, had begun fundraising in Northwest Mexico to conduct these experiments with the promise of slowing down the temperature rise in the area."[68]

Different positions expressed concerns about the potential risks of SG, the lack of regulatory frameworks for its governance, and the actions of private companies such as Make Sunsets.[69] Some articles highlight the limited knowledge regarding the safety of sulphur dioxide[70] and its potential risk supporting the Mexican decision to ban SG experimentation in the country and bringing in the voices of experts who express support for this measure. Others condemn its premature commercialisation, emphasising the lack of scientific validation and legitimacy.[71] In this context, some voices argue that Make Sunsets' actions could damage the credibility of SG research. As Matt Watson, from Bristol University states, "For people who are trying to do cautious, ethically grounded work, it makes their lives more difficult."[72] Additionally, other

[65] S Rodríguez and J Lo, "Mexico Plans to Ban Solar Geoengineering after Rogue Experiment" (*Climate Home News*, 18 January 2023), available at <https://www.climatechangenews.com/2023/01/18/mexico-plans-to-ban-solar-geoengineering-after-rogue-experiment/> (last accessed 26 December 2024).

[66] Ribeiro (n 62) [our translation].

[67] Wanser quoted in Temple (n 61).

[68] JL Ramos, "México cierra la puerta a empresas de geoingeniería solar" (*El Sol de México*, 24 January 2023), available at <https://www.elsoldemexico.com.mx/finanzas/mexico-cierra-la-puerta-a-empresas-de-geoingenieria-solar-9519302.html> (last accessed 27 December 2024). [our translation].

[69] C Garrison, "Insight: How Two Weather Balloons Led Mexico to Ban Solar Geoengineering" (*Reuters*, 27 March 2023a), available at <https://www.reuters.com/business/environment/how-two-weather-balloons-led-mexico-ban-solar-geoengineering-2023-03-27/> (last accessed 26 December 2024).

[70] M Velásquez, "El Motivo por el que México Prohibió la Experimentación con Geoingeniería Solar" (*Yahoo Finanzas*, 31 January 2023), available at https://noticias/noticias/el-motivo-por-el-que-mexico-prohibio-la-experimentacion-con-geoingenieria-solar-114204585.html (last accessed 16 December 2024); C Clifford, "Mexico Cracks Down on Solar Geoengineering, Forcing Startup to Pause Operations" (*CNBC*, 18 January 2023), available at <https://www.cnbc.com/2023/01/18/mexico-cracks-down-on-solar-geoengineering-stalling-make-sunsets.html> (last accessed 16 December 2024); Ramos (n 67).

[71] Talati quoted in Temple (n 61); Garrison (n 69).

[72] Watson quoted in J Lawton, "ARMAEGGON!; Rotten smell to Save us From Extinction" (*Daily Star*, 13 February 2023. Available on Lexis Nexis. Accessed 23 April 2025.

opinions raise concerns about the lack of transparency and oversight in experiments and related activities.[73] These positions highlight the ethical risks of the lack of regulations that allow private companies to conduct SG experiments without broad public debate and the involvement of potentially affected communities. According to De la Garza, many experts have criticised the company for trying to profit from largely insufficiently proven or tested science.[74]

Make Sunsets' founder, in response to Mexico's announcement of plans to ban geoengineering, said, "We want to be working hard with government partners to buy time for others to solve the shared challenges we have to prevent catastrophic warming."[75] However, the Mexican case suggests that the lack of regulations is exploited by these kinds of companies to develop their own business without any transparency or accountability. The insights presented show two crucial concerns that experts have repeatedly emphasised: the geopolitical potential risks of unilateral geoengineering and the urgent need for international governance. As environmentalist Bill McKibben warns in *The New Yorker*, "Imagine if India started pumping sulfur into the atmosphere only to see a huge drought hit Pakistan (. . .). Two nuclear powers, already at odds, with one convinced the other is harming its people."[76] This scenario illustrates the dangerous potential for climate intervention technologies to exacerbate existing tensions between nations if there is no global governance over their use. According to Janos Pasztor, former Executive Director of C2G, "the current state of science is not good enough [. . .] to reject or accept, let alone implement SG."[77] Pasztor and others in Temple stress that "Make Sunsets' efforts underscore the urgent need to establish broad-based oversight and clear rules for responsible research in geoengineering."[78]

The sources addressed focus their perceptions on aspects that exalt the need to position themselves in an ethical, legal and geopolitical discourse. In this sense, the ethical approach is linked to some criticisms of non-research experimentation without consent, premature commercialisation of unproven technology, and lack of consideration for potentially affected communities. In Temple's article, it is stated that Talati adds "that it's hypocritical for Make Sunsets to assert they're acting on humanitarian grounds, while moving ahead without meaningfully engaging with the public, including with those who could be affected by their actions."[79] Similarly, Garrison points out that "The Mexican government said Make Sunsets' balloon launch highlighted the ethical problems of allowing private companies to conduct geoengineering events."[80] This article also underscores experts' opinion on the importance of considering the implications of SG experimentation from the legal discourse in the absence of a clear regulatory framework. A spokeswoman for the Ministry of Mexico said that the country "has not set a date for implementing its ban" on geoengineering (. . .), and Garrison highlight that it is unclear what effect the ban might have."[81] Moreover, Garrison expresses that "The Mexican government told Reuters it is now actively drafting "new regulations and standards" to prohibit solar geoengineering inside the country."[82]

[73] R Bravender, "NOAA Gets Dire Warning About Solar Geoengineering" (*Político*, 29 March 2024), available at <https://www.politico.com/news/2024/03/29/noaa-warning-solar-geoengineering-climate-00148573>.

[74] De la Garza (n 50).

[75] Iseman quoted in De la Garza (n 50).

[76] McKibben quoted in S Bokat-Lindell, "Should We Block the Sun to Counter Climate Change?" (*The New York Times – The Interpreter*, 11 April 2023), available at <https://www.nytimes.com/2023/01/11/opinion/geoengineering-climate-change-solar.html> (last accessed 23 April 2025).

[77] Pasztor quoted in Temple (n 61).

[78] Ibid.

[79] Talati quoted in Temple (n 61).

[80] Garrison (n 69).

[81] Ibid.

[82] Ibid.

In geopolitical discourse, some sources express concern that SG could become a form of 'climate colonialism,' where rich countries from the Global North experiment with risky technologies in countries from the Global South. Alick Muvundika, African Group chair in climate negotiations, explicitly rejects this dynamic: "There are efforts to use Africa to justify use of this dangerous technology, often with the argument that the risk of climate change must be weighed against the risks of deployment of the technology (. . .) Muvundika called this a "false dichotomy."[83] Similarly, Pasztor states that: "[a] country like Mexico could start pulling together other countries and say: 'Let's work on this together and see how we can ban it together or make it happen properly together."[84] Silvia Ribeiro from ETC Group has reinforced this negative perspective by pointing out the gravity of "businessmen from one of the world's most pollution-emitting countries using a country in the Global South and Indigenous peoples' territories as a testing ground for their private business."[85]

Crucially, this power imbalance is replicated in the very media narratives that critique it. Our analysis shows that a recurring theme in the media coverage is the tension between Global North and South, yet this analysis also reveals a geographic bias in sourcing. Most quoted experts – whether supporting or opposing SG – represent Northern institutions (e.g., Harvard, Silver Lining, NUA signatories), while Southern voices are cited primarily in response to Northern actions (e.g., Mexico's ban, African Group's critiques). This sourcing pattern risks framing SG as a debate 'about' the Global South rather than one 'with' it, sidelining perspectives from those most vulnerable to its impacts.

Media analysis reveals regional differences in perceptions of solar geoengineering. In Mexico, the discourse centers on sovereignty and state regulation, exemplified by the government's announcement of its intention to ban experiments following the Make Sunsets case, interpreted as a neocolonial intrusion lacking local consultation. Mexico's stance, aligned with the precautionary principle, contrasts with debates in countries like the United States, where private innovation is prioritised under incipient ethical frameworks, such as venture capital-backed experiments and discussions on transnational governance to prevent unilateral actions. Media reinforce these narratives: in Latin America, socio-environmental risks and autonomy are emphasised, while in the Global North, outlets like MIT Technology Review analyse technical dilemmas and balances between innovation and regulation. These divergences not only reflect political priorities but also influence the feasibility of global consensus, where distrust of power asymmetries could hinder multilateral mechanisms, particularly if Global South countries perceive exclusion in decision-making. Thus, our study transcends opinion mapping by revealing how local media and political narratives shape heterogeneous responses, anticipating tensions between sovereignty, technological ethics and international cooperation in future climate scenarios.

V. Ethical analysis of the make sunsets case: experimentation, risks and inclusive public engagement

In the media, Make Sunsets has been termed an "experiment." To enhance the clarity of our ethical analysis, we first propose an explicit definition of an SRM experiment and identify the type of SRM experiment that Make Sunsets is. The term "experimentation" in

[83] Muvundika quoted in J Lo, "Nations Fail to Agree on Solar Geoengineering Regulations" (*Climate Home News*, 29 February 2024), available at <https://www.climatechangenews.com/2024/02/29/nations-fail-to-agree-ban-or-research-on-solar-geoengineering-regulations/> (last accessed 23 April 2025).

[84] Pasztor quoted in Garrison (n 69).

[85] ETC Group, "Parar empresa estadounidense que experimenta con geoingeniería en México" (*ETC Group*, 13 January 2023a), available at <https://www.etcgroup.org/es/content/parar-empresa-estadounidense-que-experimenta-con-geoingenieria-solar-en-mexico> (last accessed 26 December 2024). [our translation].

media analysis is an umbrella term with multiple meanings and often carries a negative emotional connotation, particularly from defenders of the strictest forms of SRM monitoring and regulation, underscoring the need for caution and thorough analysis in the field.

There are two main dimensions to unpack here: what an experiment is, and the research vs. deployment distinction. The terms "experiment" and "experimental" are often used to refer to any SRM intervention, including SAI technology, regardless of its research aim (e.g., contributing to generalisable climate knowledge or reducing uncertainty) or non-research aim (e.g., cooling the planet). To avoid negative emotional connotations of the term experiment in public communications, here we use a rhetorically neutral definition:

> An SRM experiment is a deliberate use of an SRM intervention at any scale, with either a research or non-research main aim, and without sufficient evidence of safety and/or efficacy for its regular use in the interconnected physical, chemical and biological processes that shape a planet (e.g., the Earth system).[86]

This definition identifies SRM experiments with activities without sufficient evidence for regular use and thus establishes a practical threshold, allowing us to explicitly distinguish between research and non-research experimentation based on an action's main aim. The distinction between research and non-research (e.g., deployment) is necessary for both ethical and legal reasons because they have different "risks, governance challenges or appropriate responses to these".[87] We consider that only an activity aiming to develop or contribute to generalisable knowledge or diminish uncertainty counts as research, e.g., the SCoPEx "outdoor experiment."[88] Our neutral definition identifies Make Sunsets as a case of a cooling credit scheme based on non-research, experimental, small-scale deployment of SAI performed by a for-profit company. In turn, because of the intended neutrality of our definition, there is conceptual room for reasonable disagreement about whether SRM research or non-research experiments are ethically responsible or irresponsible.

Our position is that this case is an empirical manifestation of the gaps in ethics, governance and regulations on SRM, and it also draws attention to the importance of the links between public engagement, communication and legitimate governance,[89] particularly in the early stages of research and non-research experimentation. At its

[86] This rhetorically neutral "public communication" definition of an SRM experiment is inspired by previous work by one of the authors on the definitions of the terms "innovation" and "experiment" in research ethics and public health where research and non-research activities were conflated under undefined and rhetorically charged terms, respectively, I Mastroleo and F Holzer, "New Non-Validated Practice: An Enhanced Definition of Innovative Practice for Medicine" (2020) 12 Law, Innovation and Technology 318. https://doi.org/10.1080/17579961.2020.1815405 (last accessed 16 December 2024) and I Mastroleo, "Use of Experimental Vaccines Is Ethically Permissible during Public Health Emergencies" (2025) 44 Vaccine. https://doi.org/10.1016/j.vaccine.2024.04.065 (last accessed 16 December 2024). This rhetorically neutral definition does not pretend to replace the usual definition of an SRM experiment within the engineering or academic communities that tend to identify "experiment" exclusively with "research" (what we here call "SRM research experiment") but to challenge the undefined and negatively emotionally charged use of the term SRM experiment in public communication that tends to conflate both SRM research and non-research activities.

[87] Parson (n 24) 3.

[88] The Stratospheric Controlled Perturbation Experiment (SCoPEx) was a Harvard University sponsored, privately funded, small-scale outdoor experiment or field trial of SAI. First proposed in 2014, Harvard cancelled it in 2024 after controversies with environmental groups and the Saami Council (Jinnah et al. n 20). Researchers stated that the main aim of the experiment was to learn more about the efficacy and safety of potential planetary SAI/SRM deployment and validate computer models and laboratory results.

[89] Jinnah (n 20).

most charitable interpretation, the goal of this start-up was to commercialise cooling credits in a "symbolic"[90] way to call attention to our current climate change situation. This activity did not respond to any scientific question and was not a research experiment to advance knowledge or diminish uncertainty about an SRM interaction with our climate.[91] However, its impacts could undermine legitimate scientific endeavours on SRM, if a government response does not correctly distinguish between research and non-research experimentation when designing appropriate regulations and remedying these gaps.

In the LAC region, the low levels of familiarity with SRM methods or technology pose additional challenges that require a holistic understanding of public perception within broader contexts of values and perspectives.[92] For this reason, public engagement is critical to improving transparency in decision-making and supporting democratic governance. Enhancing participation and engagement should be the standard procedure for research and non-research (e.g., credit schemes) experimentation on emerging, complex and uncertain technologies.[93] The challenge, then, is to develop transparency, improve credibility and foster open public deliberations.

VI. Conclusion

The Make Sunsets case in Mexico highlights that the lack or insufficiency of governmental regulations and public participation could lead to ethically permissible outdoor small-scale research experiments being delayed, halted or even banned. Rogue and irresponsible procedures can also affect the climate science community responsible for both indoor and outdoor research experimentation by eroding public trust and exacerbating negative narratives about SRM.[94] In their general analysis of risks associated with SRM, Felgenhauer and colleagues suggested that there was a 50 per cent chance of international tensions.[95] Given the very real international fallout associated with the Make Sunsets case, we consider that it provides an example of an instance of non-research SRM experimentation that is not ethically justifiable.

Concerns about the lack of governance frameworks for SRM are drawing increasing attention from the scientific community, policy makers and communities worldwide. The topic is gaining traction as funding is increasing, and more social and institutional actors are involved in research and non-research experimentation on SRM. The absence of proper regulations becomes a form of governance itself, one that leads to mistrust, fuels perceptions of neo-colonialism and bans – or makes difficult – potentially valuable and responsible research. Hence, nation-states in LAC have a duty to their citizens and other member States of the international community to develop appropriate governance frameworks for monitoring and overseeing the use of SRM technology within their jurisdictions.

As we show in this article, the LAC region needs to be part of the discussion bringing a contextualised perspective to open informed debates and contribute to filling the existing governance vacuum. To ensure meaningful participation, the LAC region must build its capacities, improve access to science-based information and strengthen research and

[90] Parson (n 24) 3.

[91] Jinnah (n 20).

[92] L Fritz, C Baum, E Brutschin, S Low and B Sovacool, "Climate Beliefs, Climate Technologies and Transformation Pathways: Contextualizing Public Perceptions in 22 Countries" (2024) 87 Global Environmental Change. https://doi.org/10.1016/j.gloenvcha.2024.102880 (last accessed 27 December 2024).

[93] S Jasanoff, "Technologies of Humility: Citizen Participation in Governing Science" (2003) 41 (3) Minerva. https://doi.org/10.1023/A:1025557512320 (last accessed 27 December 2024).

[94] Parson (n 24) 3; FS Holzer, "Defending the Social Value of Knowledge as a Safeguard for Public Trust" (2017) 31 (7) Bioethics. https://doi.org/10.1111/bioe.12364 (last accessed 27 December 2024); Temple (n 61).

[95] Felgenhauer (n 11).

professional expertise. This will enable the development of its own narratives, particularly at the national and international levels, where States play a key role in regulating emerging technologies and mediating between diverse interests. Developing these capacities will require not only South–South dialogue but also North–South collaboration and multilateral science and policy processes to address emergent and complex technologies like SRM.

The Make Sunsets case underscores the need to distinguish between SRM research and deployment, establish governance mechanisms and monitor these intertwined stages. We believe that further ethical work remains to be done regarding the use of language, principles and criteria. Additionally, there should be clearer definitions concerning the roles of private companies, academia and national governments among other stakeholders, along with their special obligations and limitations in this context.

This case has triggered a complex debate on SRM, with the media playing a key role in shaping the public narrative and analysing its risks. It has sparked a critical debate about the lack of governance of this emerging technology and the potential role of private companies and venture capitals. The widespread condemnation of Make Sunsets' actions and the Mexican government's response point to the need for a broader and deeper debate on the consequences of irresponsible practices that can trigger negative perspectives of SRM and enhance arguments on its potential ungovernability. Regional disparities in governance priorities, such as Mexico's sovereignty-centric approach versus the Global North's emphasis on private innovation, highlight the urgency of inclusive frameworks that reconcile these divergent narratives. The Mexican decision could negatively affect public opinion in other LAC countries. More research will be needed to delve into the long-lasting consequences of rogue practices in the LAC region and elsewhere.

Geopolitically, a case like Make Sunsets opens the door to discussion about neo-colonialism, as reflected in the media and public discourses. A US start-up performs non-research experiments in the Global South without consideration of governance procedures, respect for communities or insufficient public engagement with local scientists and other relevant stakeholders. These geopolitical tensions are amplified by uneven representation in global media narratives, where Southern perspectives often appear as reactive voices rather than proactive contributors. Addressing this imbalance requires intentional efforts to elevate LAC expertise in both technical governance and public discourse on SRM. The case highlights that the LAC region cannot remain on the margins of the discussions, as doing so may lead to vulnerability risks due to the lack of access to information, expertise and regulatory architecture. The ethics and governance community will need to draw on ethical frameworks for emerging technologies, such as anticipatory ethics frameworks proposed for other disruptive forms of technology.[96]

Finally, public engagement is gaining more prominence to improve the ethical and socio-political deliberations of SRM. Public participation of affected parties is a required normative principle, but its appropriate implementation can take different forms depending on contexts and cultures.[97] More robust forms of participatory processes may be more costly and time-consuming but they will enhance the transparency, relevance and legitimacy of outcomes – not only for the climate science community but also for all those affected by the negative impacts of climate change. Opening discussion in the LAC region does not mean endorsing technological deployment but instead seeking a more

[96] PA Brey, "Anticipatory Ethics for Emerging Technologies" (2012) 6 Nanoethics 1, available at <https://link.springer.com/article/10.1007/s11569-012-0141-7> (last accessed 15 April 2025).

[97] S Rayner, C Heyward, T Kruger, N Pidgeon, C Redgwell and J Savulescu, "The Oxford Principles" (2013) 121 (3) Climatic Change 499. https://doi.org/10.1007/s10584-012-0675-2 (last accessed 26 December 2024).

comprehensive and informed debate to anticipate, shape and guide the future of SRM research and non-research experimentation.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/err.2025.10025.

Acknowledgments. We are grateful to the anonymous reviewer(s) for their constructive feedback, which helped us improve the clarity and scope of the manuscript. We are especially thankful to one reviewer for generously sharing relevant grey literature and for providing the LexisNexis search results on our case study, which significantly enriched our media analysis.

Funding statement. This research was partly funded by grants from the Degrees Initiative's Degrees Socio-Political Fund (Degrees), the World Health Organization (WHO) and the Advance Research + Invention Agency (ARIA). GFL, JN, MIC and MFS are funded by a Degrees grant, PI FL. CRG, FL, IM, IC, TD, are researchers funded by WHO, PI FL. IC, IM, FL, MFS, MIC, TD are researchers funded by an ARIA grant of the Exploring Climate Cooling programme hosted at the Inter-American Institute for Global Change Research (IAI), PI IM. The opinions expressed in this work are solely the authors' and do not necessarily reflect the views of their funders, employers, research hosts, or any other group with whom they might be affiliated.

Competing interests. The author(s) declare none.

Cite this article: MI Carabajal, MF Santi, C Rodríguez Garat, GF Lisanti, J Nasi, T Daly, I Mastroleo, F Luna, and I Camilloni, "No Governance Is Governance: Mapping Solar Geoengineering Discussions in Latin America & the Caribbean". *European Journal of Risk Regulation*. https://doi.org/10.1017/err.2025.10025