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Understanding "mission-driven research" in solar geoengineering as a moral relationship

Timothy Daly[*,1,2], *Xavier Landes*[3]

[1] Bioethics Program, FLACSO Argentina, Buenos Aires, Argentina

[2] CNRS UMR 8011, Science Norms Democracy, Sorbonne Université, Paris, France

[3] Stockholm School of Economics in Riga, Riga, Latvia

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Abstract

Against an investigator-driven or curiosity-driven framework, several authors have put forward a Mission-Driven Research (MDR) model for Solar Radiation Modification (SRM) research. The proposal makes sense from the perspective of funding allocation and research efficiency but also raises questions about who can legitimately attribute a mission to SRM researchers, the content of the mission itself, and procedural issues about the identification and elaboration of the mission. In this piece, we concentrate on a narrower aspect. We claim that, due to the nature of SRM research, its risks, the seriousness of the problem it aims to tackle (potentially catastrophic climate change), as well as populations' vulnerability towards both climate change and SRM, researchers to whom a mission is attributed enter into a moral (not legal) fiduciary relationship with SRM research stakeholders. Though we do not perform an exhaustive moral analysis of this relationship, we contend that its demanding nature needs to be properly acknowledged and taken into account.

Keywords: Solar radiation modification, Solar geoengineering, Mission-driven research, Ethics, Governance.

1. Introduction

The consensus is growing that the widening mitigation gap means that a temperature overshoot scenario that will trigger irreversible and harmful climatic events such as 'tipping points' is likely (Lenton, 2021; UNEP, 2025). Such a perspective has fuelled a sense of urgency in the science-policy community, prompting discussions on strategies such as Solar Radiation Modification (SRM), which increases the reflection of sunlight away from Earth to counter global warming (Futerman et al., 2025). The main SRM technologies (Stratospheric Aerosol Injection (SAI), space-based geoengineering, and marine cloud brightening) are controversial for several reasons: they have been alleged to lower the incentives to mitigate (McLaren, 2016), to present unacceptable risks, such as the so-called termination effect (Parker and Irvine, 2018), to be ungovernable (Hulme, 2014), to threaten democracy (Szerszynski et al., 2013) and global justice (Svoboda et al., 2011).

Due to the mounting temptation to explore SRM, calls to assess and govern SRM research have spread (UNEP, 2023; SAPEA, 2024; Brent et al., 2025). Objections to SRM research have been addressed by a range of counter-arguments (Barrio and Pailos, 2026) within a broader literature on social science research to inform solar geoengineering (Aldy et al., 2021; Tilmes et al., 2024). For example, it has previously been argued that the riskiness of SAI may actually drive stronger mitigation (Long and Shepherd, 2014). The discussions around SRM governance and regulation have also generated attempts at crafting ethical guidelines such as the Oxford Principles (Rayner et al., 2013) or the American Geophysical Union's Ethical Framework Principles for Climate Intervention Research (Williams et al., 2024).

However, due to the growing sense of urgency associated with responses to climate change and the problem of vested interests in research (Long and Scott, 2013), some researchers have been advocating for shifting SRM research from the dominant investigator-driven model, in which priorities and research questions are mostly set by investigators and their scientific curiosity, to a more focused approach based on an explicit "mission" (Long and Scott, 2013; Parson, 2013; MacMartin and Kravitz, 2019; Morrow, 2020). The Mission-Driven Research (MDR) model raises many questions, from the underlying conception of science up to the policy implications. Here, we adopt an ethics perspective on SRM research and limit ourselves to two goals relative to MDR:

1) reviewing the main proposals for MDR and identifying common characterisations; and
2) defending the idea that MDR creates a moral (non-legal so far), fiduciary relationship between researchers and the affected stakeholders (from local populations to the rest of society).

2. The many definitions of "mission-driven research"

MDR is advanced as a counter-model to the allegedly dominant curiosity-, or investigator-, driven model. The curiosity model is presented as resting on the idea that scientific discovery, knowledge creation, and clarification are intrinsically valuable, self-sufficient, ends. This conception of science echoes what philosophers Philip Kitcher (2001) calls "pure science" and Jamie Shaw (2022) "luxury science." While it is true that any research project is driven by *some* goal or purpose, the definition of a mission as a practical goal that imposes a form of prioritisation on the object, conduct, and assessment of research is what distinguishes MDR from the dominant model.

The first proposal for MDR in solar geoengineering came from Jane C. S. Long and Dane Scott, which defined MDR as: "a structured investigation of all interconnected parts of the Earth-human-biosphere systems of interest" (Long and Scott, 2013). In a commentary on Long and Scott's article, Parson (2013) argues that this definition is vague: he claims that MDR should aim at "advancing understanding of the effectiveness and risks of identified CE [climate engineering] approaches" but also recognises that

> *the "mission" of a CE research program cannot be defined without high-level political and democratic input (and hopefully some wisdom), and that any such definition would have to iterate, perhaps repeatedly, between political and scientific inputs. In the absence of some political convergence on goals for climate policy overall, attempts to define a mission for CE research may be not just premature, but risky.*

In both cases, though the overarching goal of the MDR is vague, we can already establish that MDR operates under the assumption that research be oriented towards some kind of pre-defined outcome, along with some public participation (Parson's reference to 'democratic input'). Later formulations by MacMartin and Kravitz (2019) and Morrow (2020) narrow this predefined outcome.

MacMartin and Kravitz (2019, p. 1089) claim that the mission should have "the explicit goal of supporting informed decisions", though it is not clear who the decision-maker is or should be. Nevertheless, this narrower focus motivated by short-term, quasi-utilitarian goals is a response to escalating pressures to enhance research efficiency, i.e. its capacity to deliver results actionable by policymakers in a context of climate urgency.

> *Developing the required knowledge demands a mission-driven research program, which is defined by its explicit end goal of supporting informed*

> *future decisions regarding deployment* […] *while the curiosity-driven research model that has been used to date is appropriate for initial exploration, it lacks a systematic research approach; mission-driven research is designed to be comprehensive, ensuring that the important questions are being asked and addressed, and it explicitly incorporates prioritization, ensuring that limited funding is used efficiently in support of the goal. This prioritization will be different from that of a research program aimed at advancing understanding of the climate system.* (MacMartin and Kravitz, 2019, p. 1090)

According to MacMartin and Kravitz (2019), MDR diverges from the more conventional, curiosity-driven model in three respects: (a) it aims at producing the type of knowledge needed to support “informed future decisions” (e.g. regarding the potential deployability of SRM); (b) the content as well as the hierarchy of topics to investigate are given priority relative to the aim; (c) research resources become allocated according to that prioritisation. Morrow (2020, pp. 619-620)’s definition also adds an institutional dimension.

> *In th[e] ‘investigator-driven’ framework, researchers or research teams largely decide for themselves, in a decentralized way, what to study and how to study it based on their own intellectual interests and sense of what is important. Unlike in a mission-driven research program, an investigator-driven framework lacks a formal mechanism for centralized decision-making, planning, and coordination that can specify an end-goal and direct the collective research enterprise toward it. Because the distinction between investigator-driven and mission-driven research depends heavily on the existence of a mechanism for centralized coordination.*

This account differs to MacMartin and Kravitz (2019) in two respects: (a) it posits a “mechanism of centralised coordination” that would articulate the goals of scientific research and incentivise, or mandate, investigators to pursue them; (b) the MDR mission, understood as the strategy “explicitly aimed at achieving a specific, well-defined objective” (p. 619, Morrow, 2020), that seems to be decided from *outside* science and engineering, or at least not by the research teams alone, insulated from the rest of the society, elaborating on Parson’s democratic input.
All accounts of MDR reject curiosity-driven research with efficiency as a central justification, i.e. the high opportunity costs of dispersing research efforts in a time of mounting urgency. Before introducing our moral analysis of MDR, we briefly draw readers’ attention to three forms of impact that these ideas have had on the science-policy community, where the departure from an entirely investigator-driven

framework is increasingly noticeable. The first is the *Exploring Climate Cooling* (ECC) research programme of the UK Advanced Research and Invention Agency (ARIA), the largest-ever research programme into SRM (funded at £56.8m, approx. USD77 million). ECC explicitly aims at

> *… building an evidence base to support the effective governance of emerging climate cooling approaches. We are funding transparent, public-good research – from ethics to real-world experiments – so the world can make better-informed decisions about this field* (ARIA 2026).

In other words, the largest-ever SRM research programme has clear features of a mission. A second example is the non-profit research organisation *Reflective*[1], who recently launched a large-scale technical risk assessment process open to researchers' voluntary contribution with the objective to inform decisions. Finally, individual researchers have also begun to adopt a more restricted approach, e.g. O'Loughlin and Visioni (2026) propose heuristics to complement MacMartin and Kravitz (2019)'s risk register and determine the pursuitworthiness of specific SRM outdoor experiments (or 'sub-missions').

It is important to note that the question of the *legitimate* source of the mission (the mission giver) is either left out of the picture or remains largely implicit within the scientific literature on SRM. However, before tackling the pressing questions about legitimacy, it seems to us important to hone in on the very particular relationship between researchers and a hypothetical (or actual) mission giver. The eminently moral, fiduciary, nature of that relationship has mostly gone unnoticed.

3. The implicit morality of mission-driven research

To the question of who might be legitimate to determine the mission (i.e. the questions of science and engineering essential to decision making to be answered by the scientists), an easy answer would be: the SRM research community *per se*. However, if researchers set their own missions, it reinforces the self-regulatory tendency of SRM research, which has been termed governance by default (Talberg et al., 2018) or 'de facto' (Gupta and Möller, 2019), (also branded as 'by default governance' or 'de facto governance'), which is regularly pointed out as a long-standing issue in SRM research. Self-regulation implies a lack of democratic oversight, either from elected officials or from the general public. It also raises issues of vested, or conflicts of,

[1] https://www.reflective.org/ (accessed 9 September 2026).

interests, since the researchers then stand as the mission givers and receivers, or as, simultaneously, the principals *and* the agents of the scientific activity.

There are strong reasons to consider that the stakeholders (i.e. the affected parties) should determine the mission: climate change is a global issue that carries adverse consequences for present *and* future generations, hitting the most destitute parts of society harder. SRM could offer respite by cooling some regions (e.g. the Arctic), but at the price of significant risks and uncertainties (e.g. shifts in precipitation patterns, air pollution), the ultimate adverse outcome being a termination 'shock,' i.e. a rapid return to pre-SRM temperatures in the event of terminating deployment (Parker and Irvine, 2018). In that context, the very groups who could benefit and/or suffer from SRM deployment should participate in elaborating SRM research missions. The ARIA ECC is even explicitly framed as undertaking "public-good" research (ARIA, 2026), echoing the 'Oxford principles' and other principles of SRM research (Brent et al., 2025). It is noteworthy that ARIA's ECC programme exists "so the world can make better-informed decisions about this field" (ARIA, 2026), suggesting that the entire world is affected by SRM research.

Our position is that scientific research, especially when the research carries concrete social impacts, as in the case of SRM, creates a 'principal-agent' relationship (Cornell Law School, 2026): a 'principal' (the society or policymakers) entrusts 'agents' (researchers) to pursue specific, potentially beneficial (sometimes harmful) knowledge, on the basis of their expertise. Such expertise combined with the principal's difficulties to adequately monitor, and often simply understand, the agent's (researchers) work creates morally salient features. For example, there are information asymmetries, i.e. situations in which an agent could use their epistemic superiority to take advantage of the principal and other stakeholders, as is evidenced by cases of falsified research.

The information asymmetry is particularly salient in the case of SRM research, which combines cutting-edge engineering with complex climate science. As a result, SRM research is difficult to monitor by outsiders and there is a high risk, at least it is perceived as such by the society, of the agents (researchers) exploiting such a vantage position for their own interests, e.g. for their fame, fortune, etc. as alluded to by Long and Scott (2013) in their inaugural defence of MDR. In the case of SRM researchers, one fear expressed by non-professionals, for example as evidenced in letters to the editor published in magazines and scientific journals (Daly et al., 2026), is that naive or reckless scientists pursue a 'techno-fix' as a response to climate change. In other words, critics perceive researchers as potential 'moral hazards', i.e. individuals who could potentially abuse a situation where society, some groups or policymakers are vulnerable due to information asymmetry and incomplete monitoring (the society cannot watch over the shoulder of each researcher).

MDR takes place in this general context of vulnerability that characterises high-social impact research. But the existence of a mission, i.e. a mandate given by a principal, makes it stand apart. The specific mandate, if attributed by society, actually restricts the options open to the researchers, limiting their scientific freedom. That may facilitate the control of researchers if the mission is clear enough and accompanied by relevant metrics. Therefore, the monitoring problem, one of the key features of a principal-agent relationship, is lessened. But MDR could also be seen as a quasi (social) contract between the principal(s) (the society, the policymakers) and the agent(s) (the researcher or the research team). Then, the kind of relationship set by MDR enters the realm of a promise: SRM researchers commit to investigating questions X, Y and Z and to undertake such tasks *under constraints* (the good of society, the protection of vulnerable regions).

Considering the scale of the challenges caused by climate change, on the one hand, and SRM, on the other hand, we claim that the relationship between researchers and society/policymakers is analogous to a fiduciary relationship with specific duties befalling on the fiduciary, i.e. the agent, i.e. the SRM researcher. Fiduciary duties (care, loyalty, obedience) are answers to principal-agent problems in situations where the principal is particularly vulnerable (due to the impossibility of properly monitoring the agent, significant epistemic asymmetries, and high stakes on the side of the principal). Classical examples include corporate governance (shareholders and executives), investment banking (clients and finance advisors), health care (patients and doctors), and education (children and parents). Due to the high stakes and risks, SRM research could be seen as creating vulnerabilities significant enough to justify imposing an obligation of good faith followed by moral fiduciary duties on SRM researchers. We argue that adopting a principal-agent lens (1) underscores the nontrivial moral nature of MDR, which goes beyond a pure rational decision of efficient resource allocation; (2) provides a vocabulary for contributing to existing attempts to elaborate an ethics of SRM research (e.g. with the *American Geophysical Union Ethical Framework Principles for Climate Intervention Research* (Williams et al., 2024), or the EU-funded initiative *Co-CREATE*[2]; and (3) may assuage some of the qualms critiques have towards SRM.

4. Conclusions

In the context of SRM research becoming increasingly 'mission-driven' rather than 'investigator-driven', MDR establishes a morally loaded relationship between

[2] https://co-create-project.eu/ (accessed 9 September 2026).

the mandate giver (e.g. a funder, society or policymakers) and one or more researchers, defined by a mission constrained by fiduciary duties. MDR constitutes a promise from the research community to deliver on social expectations regarding interventions that could achieve climate cooling fast enough to fend off the negative consequences of an overshoot scenario (e.g. climate tipping points) and to give headroom to mitigation and maybe carbon dioxide removal (CDR) to ramp up.

Our moral analysis is not exhaustive. With this article, we have aimed to invite deeper moral reflections on the adoption of the MDR framework. More specifically, additional work is needed to define the specific constraints of the MDR relationship: epistemological (researchers cannot just study anything), normative (the mission can be legitimate or illegitimate), and practical (e.g. funding priorities). We also emphasise that MDR in the SRM field takes place against a backdrop of power hierarchies, e.g. between the North and the South or between the centre and the periphery of given regions. That relational aspect needs to be taken into account by funders and researchers, and is increasingly being so, as evidenced by initiatives such as The Degrees Initiative, which funds Global South SRM research, and Southern researchers and issues themselves becoming increasingly present in science-policy debates (Dove et al., 2026). We have also not discussed how social science and humanities research aligns with MDR, even though it is increasingly recognised that both natural science and social science criteria should be involved in evaluating SRM experiments (Tilmes et al., 2024; Carabajal et al., 2026).

We also believe that as governance efforts move from informal principles to formal governance (Brent et al., 2025), the specificity of MDR should be explicitly recognised. From the point of view of researchers, MDR is a configuration in which researchers relinquish part of their freedom of enquiry to integrate a potentially large spectrum of voices (some of whom may be hostile to SRM research projects), under the mounting pressure of an ongoing climate crisis.

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References

ARIA, (2026). Exploring Climate Cooling. Advanced Research and Invention Agency, https://aria.org.uk/opportunity-spaces/resilient-climate-and-ecosystems/exploring-climate-cooling (accessed 9 September 2026).

Aldy J.E., Felgenhauer T., Pizer W.A, Tavoni M., Belaia M., et al., (2021). Social science research to inform solar geoengineering. Science, 374(6569), 815-818. https://doi.org/10.1126/science.abj6517.

Barrio E. and Pailos F., (2026). Geoengineering: an analytical review of reasons (Version 1.0). Zenodo. https://doi.org/10.5281/zenodo.19634944.

Brent K., Simon M. and McDonald J., (2025). From informal to formal governance of solar radiation management. Climate Policy, 25(6), 947-964. https://doi.org/10.1080/14693062.2024.2430688.

Carabajal M.I., Castro A.B., Bezerra E., Barbosa E.C., Fiore C., et al., (2026). Rethinking expertise on climate cooling technologies. Environmental Science & Policy, 182. https://doi.org/10.1016/j.envsci.2026.104446.

Cornell Law School, (2026). Fiduciary Duty. Available at https://www.law.cornell.edu/wex/fiduciary_duty (accessed 9 September 2026).

Daly T., Teixeira da Silva J.A. and Nazarovets S., (2026). Letters provide a forum for public engagement with geoengineering. Reviews on Environmental Health, 41(2), 324-326. https://doi.org/10.1515/reveh-2025-0161.

Dove Z., Carabajal M.I., Guivant J.S., Sipra H., Williams P.A., et al., (2026). The expanding roles of Global South countries in solar radiation modification diplomacy: Indicators, cases, and equitable pathways forward. Environmental Research: Climate, 5(3). https://doi.org/10.1088/2752-5295/ae5dfb.

Futerman G., Adhikar M., Duffey A., Fan Y., Gurevitch J., et al., (2025). The interaction of solar radiation modification with Earth system tipping elements. Earth System Dynamics, 16(4), 939-978. https://doi.org/10.5194/esd-16-939-2025

Gupta A. and Möller I., (2019). De facto governance: how authoritative assessments construct climate engineering as an object of governance. Environmental Politics, 28(3), 480-501. https://doi.org/10.1080/09644016.2018.1452373.

Hulme M., (2014). Can Science Fix Climate Change? Cambridge: Polity Press.

Kitcher P., (2001). Science, Truth, and Democracy. New York: Oxford University Press.

Lenton T.M., (2021). Tipping points in the climate system. Weather, 76(10), 325-326. https://doi.org/10.1002/wea.4058.

Long J.C.S. and Scott D., (2013). Vested interests and geoengineering research. Issues in Science and Technology, 29(3), https://issues.org/long-4/ (accessed 9 September 2026).

Long J. and Shepherd J.G., (2014). The Strategic Value of Geoengineering Research. In Freedman B., (ed.), Handbook of global environmental pollution (Vol. 1), Springer, pp. 757-770. https://doi.org/10.1007/978-94-007-5784-4_24.

MacMartin D. and Kravitz B., (2019). Mission-driven research for stratospheric aerosol geoengineering. PNAS, 116(4), 1089-1094. https://doi.org/10.1073/pnas.1811022116.

McLaren D., (2016). Mitigation deterrence and the "moral hazard" of solar radiation management. Earth's Future, 4(12), 596-602. https://doi.org/10.1002/2016EF000445.

Morrow D.R., (2020). A mission-driven research program on solar geoengineering could promote justice and legitimacy. Critical Review of International Social and Political Philosophy, 23(5), 618-640. https://doi.org/10.1080/13698230.2020.1694220.

O'Loughlin R. and Visioni D., (2026). When are small-scale field experiments in solar geoengineering worth pursuing? European Journal for Philosophy of Science, 16, 54. https://doi.org/10.1007/s13194-026-00762-9.

Parker A. and Irvine P.J., (2018). The Risk of Termination Shock From Solar Geoengineering. Earth's Future, 6(3), 456-467. https://doi.org/10.1002/2017EF000735.

Parson E.A., (2013). Forum – Summer 2013. Issues in Science and Technology, 29(4). https://issues.org/forum-2/ (accessed 9 September 2026).

Rayner S., Heyward C., Kruger T., Pidgeon N., Redgwell C., et al., (2013). The Oxford Principles. Climatic Change, 121, 499-512. https://doi.org/10.1007/s10584-012-0675-2.

SAPEA, (2024). Solar radiation modification: evidence review report (Version 1.0). SAPEA. https://doi.org/10.5281/zenodo.14283096.

Shaw J., (2022). On the very idea of pursuitworthiness. Studies in History and Philosophy of Science, 91, 103-112. https://doi.org/10.1016/j.shpsa.2021.11.016

Svoboda T., Keller K., Goes M. and Tuana N., (2011). Sulfate Aerosol Geoengineering: The Question of Justice. Public Affairs Quarterly, 25(3), 157-179. Retrieved from https://digitalcommons.fairfield.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1025&context=philosophy-facultypubs (accessed 9 September 2026).

Szerszynski B., Kearnes M., Macnaghten P., Owen R. and Stilgoe J., (2013). Why Solar Radiation Management Geoengineering and Democracy Won't Mix. Environment and Planning A: Economy and Space, 45(12), 2809-2816. https://doi.org/10.1068/a45649.

Talberg A., Christoff P., Thomas S., and Karoly D., (2018). Geoengineering governance-by-default: an earth system governance perspective. International Environmental Agreements: Politics, Law and Economics, 18, 229-253. https://doi.org/10.1007/s10784-017-9374-9.

Tilmes S., Rosenlof K.H., Visioni D., Bednarz E.M., Felgenhauer T., et al., (2024). Research criteria towards an interdisciplinary Stratospheric Aerosol Intervention assessment. Oxford Open Climate Change, 4(1). https://doi.org/10.1093/oxfclm/kgae010.

UNEP, (2023). One Atmosphere: An Independent Expert Review on Solar Radiation Modification Research and Deployment. United Nations Environment Programme, https://wedocs.unep.org/handle/20.500.11822/41903 (accessed 9 September 2026).

UNEP, (2025). Emissions Gap Report 2025. United Nations Environment Programme, https://wedocs.unep.org/handle/20.500.11822/48854 (accessed 9 September 2026).

Williams B., Gershenfeld J., Goss H., Guillot C., Hanson B., et al. (2024). AGU Ethical framework principles for climate intervention research. American Geophysical Union. https://doi.org/10.22541/essoar.172917365.53105072/v1.

*Corresponding author: **Timothy Daly**

e-mail: tdaly@flacso.org.ar