

Status of global activities relating to solar radiation modification and its governance

Briefing note prepared by the Carnegie Climate Governance Initiative (C2G)¹ summarising key insights into international activities on solar radiation modification and its governance²

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Summary

With climate impacts intensifying and international climate action incommensurate with the risks faced now and in future³, more uncertain climate response measures such as solar radiation modification (SRM)⁴ are coming under increasing scrutiny. This briefing summarises recent developments relating to research and discussions around SRM and its governance, covering two prominent techniques which propose to increase levels of sunlight reflected away from the Earth's surface to reduce levels of warming. The first, stratospheric aerosol injection (SAI) aims to disperse reflective particles in the stratosphere, and the second, marine cloud brightening (MCB) aims to enhance and brighten ocean cloud cover⁵.

The latest scientific assessments by the Intergovernmental Panel on Climate Change (IPCC) published in 2021-22 indicate that while some SRM techniques may be theoretically effective, the risks or benefits they pose are poorly understood and relevant governance is weak or missing⁶.

Over the past year public statements both supporting and objecting to more SRM-related research have increased. Outdoor MCB experiments were conducted in 2020, and in 2021 planned SAI-related experiments were cancelled following objections from Indigenous people and environmental groups.

Recent IPCC and other strategic foresight assessments indicate that the risk of uncontrolled SRM deployment is becoming a cause for concern and with the issue now emerging in intergovernmental processes, the international discussion about SRM and its governance is gathering increasing momentum.

Status of research

- **SRM-related research is underway internationally.** While not yet systematically tracked, notable examples include the USD\$16.2m **Harvard Solar Geoengineering Program** which is planning the world's first outdoor experiments to advance understanding of SAI (**SCoPEX**), and part of the AUS\$100m Australian funded **Reef Restoration and Adaptation Program (RRAP)** which in 2020 began the **first MCB field tests** spraying nano-sized sea-salt particles into the air above the reef. In 2020 the US government funded **Earth Radiation Budget project** received USD\$4m (and a further \$9m in 2021) to for SRM-related research. In 2021 the EUR€9m European Union-funded **GENIE project** began exploring transdisciplinary dimensions of SRM. The **Silver Lining safe climate research initiative** supports physical science SRM research programmes in various US research institutions as well as the **DECIMALS fund** which has been administering small grants to teams of developing country researchers modelling how SRM could affect their regions. In 2021, a consortia of European research institutes led by a German technology company, established a **geoengineering network** for interdisciplinary cooperation and discussion.
- **Previous SRM-related research has been supported by public and private funding in Australia, Canada, China, Finland, the EU, France, Germany, Japan, Norway, India, Sweden, the UK, and the US.** This **analysis** includes⁷ (entirely or in part): Germany's €10.5m Climate engineering project (2016-2019); China's €2m government funded geoengineering research programme (2015–19); the UK's €1.7m Stratospheric Particle Injection for Climate Engineering (SPICE) programme (2010–14) and €1.5m Climate Geoengineering Governance project (2012-14); and the EU's €1.3m Implications and Risks of Engineering Solar Radiation to Limit Climate Change programme (IMPLICC) (2009-2012).
- **SRM research and collaboration is growing, but very slowly.** Published literature on the topic is steadily increasing (e.g. **see bibliography**) and for over a decade an international collaboration of researchers (**GeoMIP**) has been comparing models to better understand expected climate effects of SRM. Other model intercomparison projects have also begin to explore potential SRM impacts, for example on agriculture (**AgMIP**). Researchers continue to collaborate and share learning via e.g. journal **special issues**, **conferences** and dedicated **online fora**.
- **Support for SRM research is growing among some actors.** Recent statements from the **UK Meteorological Office** and **American Meteorological Society** advocate for more research into SRM to ensure any global discussions on addressing climate risk are based on a robust and broad range of evidence. In 2021 a US National Academies of Science report recommended USD\$100-200m for a new 5-year SRM research program and in 2022 USD\$6.6 was proposed for the US Office of Science and Technology Policy to deliver activities including an **interagency working group** to coordinate SRM research.

- **Objection to SRM research is growing among some actors.** In early 2022 a group of academics launched **an initiative** calling for governments to ban funding for SRM experiments and development. In 2021, outdoor experiments planned in Sweden as part of the Harvard **SCoPEx project** were **halted by the Swedish Space Agency** following objections by Indigenous people and **environmental NGOs**.
- **The Intergovernmental Panel on Climate Change (IPCC) has been addressing SRM.** SRM and its governance was addressed⁸ across all three IPCC Working Group reports (2021, 2022, 2022) as part of its most recent **sixth assessment cycle**. SRM was also assessed in the earlier Special Report on 1.5C Global Warming (2018). The IPCC convened a first expert meeting covering SRM a decade ago (2012).
- **Other initial assessments of SRM research have been undertaken**, for example by the US National Academies of Science (2021; 2015); by IGRC for the Swiss Federal Office for the Environment (2020); the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP, 2019); the UN Environment Programme Ozone Secretariat (UNEP, 2018); the Secretariat of the Convention on Biological Diversity (CBD, 2016; 2012); the European Union (2015); the UK Research Council (2013), House of Commons (2010), and Royal Society (2009).
- **Areas for future SRM research to address knowledge gaps have been identified** by various actors including: the IPCC (2022; 2021; 2018); US Council on Foreign Relations (2022) US National Academies of Science (2021; 2015); GESAMP (2019); C2G (2018); Parties to the Montreal Protocol (2018) and Convention on Biological Diversity (2016).
- **The need to govern SRM-related research has received some attention.** The importance of robust SRM research governance is widely emphasised, including in the US National Academies of Science report (2021). Some aspects have been initially addressed through intergovernmental processes such as the **Convention on Biological Diversity** and the **London Convention/Protocol**. Some relevant tools have also been development including the **Oxford Principles** and the **Code of conduct for responsible geoengineering research**.

Status of international discussion

- **SRM is increasingly appearing on the agenda of intergovernmental processes.** In 2019 a **Swiss-led resolution** submitted to the United Nations Environment Assembly (UNEA) during its 4th meeting proposed UNEP prepare an assessment of SRM (following extensive discussion it was **withdrawn** due to lack of consensus); in 2021 the UN Interagency Task Team on Science, Technology and Innovation (IATT) included **SRM implications for the SDGs** in its report to the UN Science, Technology and Innovation Forum. During 2021-22, the UNESCO World Commission on the Ethics of Scientific Knowledge and Technology is addressing ethical dimensions of SRM (UNESCO previously convened an **expert meeting on SRM** in 2010).

- **SRM is increasingly being addressed in international law.** In 2018 a report to the UN General Assembly by the UN Secretary-General (2018) highlighted gaps in environmental law relating to *geo-engineering* and in 2021, the UN General Assembly adopted [resolution 76/112 on the Protection of the atmosphere](#) which includes legal guidelines relating to *intentional large-scale modification of the atmosphere* based on work undertaken by the International Law Commission.
- **SRM is increasingly appearing on the radar of strategic foresight assessments** such as the latest US National Intelligence estimate (2021) that noted the risk of unilateral geoengineering increasing, or the latest World Economic Forum Global Risks report (2022) which highlights the potential geopolitical risks of ungoverned SRM. In 2021, the Paris Peace Forum established an initiative called the [Global Commission on Governing Risks from Climate Overshoot](#), that plans to prepare a report in 2023 addressing SRM.
- **Non-governmental and civil society organisations continue to be engaged around SRM.** Some, like the [DEGREES Initiative](#) or [SilverLining](#) actively promote SRM-related research or cautiously call for more, like the [Union of Concerned Scientists](#) or the [American Geophysical Union](#). Others are critical or opposed, such as the [Climate Action Network International \(CAN\)](#), the [Heinrich Böll Foundation](#), or the [ETC Group](#). In early 2022 a group of academics called for an [international non-use agreement](#) for SRM, echoing similar [concerns made by prominent international environmental campaigners](#) in 2021, and established campaigns such as [Hands off Mother Earth](#) and [Geoengineering Monitor](#). Other actors are focussing on promoting policy-dialogue, such as the [Council on Energy Environment and Water \(CEEW\)](#) which has convened conferences and briefings in India, or the [Carnegie Climate Governance Initiative \(C2G\)](#) that works to catalyse the creation of effective international governance.

For further information

- Further information and learning resources available on C2G's website: www.c2g2.net
- Contact for information: contact@c2g2.net

¹ The Carnegie Climate Governance Initiative (C2G) is a small, foundation-funded initiative of the Carnegie Council for Ethics in International Affairs. C2G seeks to catalyse the creation of governance for climate-altering approaches and is impartial regarding their potential use. See: <https://www.c2g2.net/what-is-c2g/>

² Insights included here are shared in good faith and based on sources available in the public domain at the time of publishing. This is not intended to be exhaustive or a prioritized list but rather to provide a general overview of the current status of research and discussion around SRM and its governance internationally. Corrections are welcomed.

³ See for example: UNEP (2021); Climate Action Tracker (2021); WEF (2022).

⁴ Solar radiation modification (SRM) is also referred to as 'solar radiation management', 'solar radiation intervention', 'climate engineering', 'solar geoengineering', 'geo-engineering' and 'geoengineering'.

⁵ For further detail see: www.c2g2.net/solar-radiation-modification/

⁶ See IPCC AR6 WGII report (2022) SPM and Chapter 16; WG1 report (2021) Chapter 4; and SR15 (2018) Chapter 4.

⁷ Funding volumes converted to EUR for easier comparison.

⁸ For analysis of how SRM was addressed in the recent IPCC reports, see resources on the [IPCC page of C2G's website](#).