

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

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

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Summary

With climate impacts intensifying and no credible pathway in place for international climate action to limit global warming below 1.5°C², additional climate response measures such as solar radiation modification (SRM)³ are coming under increasing scrutiny. This briefing note summarises the current status and developments in research, intergovernmental processes and non-governmental engagement around SRM and its governance⁴.

The latest assessment of the science by the Intergovernmental Panel on Climate Change (IPCC) published in 2021-22 indicate that while some SRM techniques may be theoretically effective in reducing some climate hazards, the risks or benefits they pose are poorly understood and relevant governance is weak or missing⁵. In addition to the recent IPCC assessment, during 2022 other UN bodies published (or begun preparing) reports addressing SRM and its governance, including the World Meteorological Organization, the UN Human Rights Council, and the UN Educational, Scientific and Cultural Organization.

Over the past year public statements both supporting and objecting to more SRM-related research have increased along with private sector engagement and media interest. Outdoor marine cloud brightening experiments were conducted in 2020, and in 2021 planned stratospheric aerosol injection-related experiments were cancelled following objections from indigenous people and environmental groups.

With recent UN and other strategic foresight assessments indicating 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.

Insights included in this briefing note are shared in good faith and based on sources available in the public domain at the time of publication. This is not intended to provide an exhaustive or prioritized list but rather a general overview of the current status of research, discussions, and activities underway relating to SRM and its governance internationally.

Additions and corrections are welcomed. Please send to: contact@c2g2.net

Status of research and research assessments

- **SRM-related research is underway internationally.** While not yet systematically tracked, some notable examples include:
 - the USD\$16.2m **Harvard Solar Geoengineering Program** which is planning the world's first outdoor experiments to advance understanding of stratospheric aerosol injection (SAI) (**SCoPEX**)
 - the USD\$1m/year **Arctic Ice Project** which is exploring ways to restore Arctic sea ice,
 - part of the AUS\$100m Australian-funded **Reef Restoration and Adaptation Program (RRAP)** which in 2020 began the **first marine cloud brightening (MCB) field tests** spraying nano-sized sea-salt particles into the air above the reef
 - In 2021 the EUR€9m European Union-funded **GENIE project** began exploring transdisciplinary dimensions of SRM
 - in 2020 the US government funded **Earth Radiation Budget project** received USD\$4m (and a further \$9m in 2021) for SRM-related research
 - The **Silver Lining safe climate research initiative** is supporting physical science SRM research programmes in various US research institutions
 - the **DECIMALS Fund** is administering small grants to teams of developing country researchers modelling how SRM could affect their regions.
- **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** includes⁶ (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) and the €1.3m European Trans-disciplinary Assessment of Climate Engineering (2015).
- **SRM research and collaboration is growing, but 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 begun 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 the **US Congress** directed the White House's Office of Science and Technology Policy to coordinate delivery of a **five year plan** for a federal research assessment of rapid climate interventions including SRM.

- **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**.
- **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 developed including the **Oxford Principles** and the **Code of conduct for responsible geoengineering research**. In 2022, the **American Geophysical Union**, published a white paper for a potential ethical framework to develop knowledge of interventions such as SRM.
- **National and transnational bodies have undertaken initial assessments of SRM**, for example, the US National Academies of Science (2021; 2015); the Swiss Federal Office for the Environment (2020); the European Union (2015); the UK Research Council (2013), House of Commons (2010), and Royal Society (2009).
- **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. The latest World Economic Forum Global Risks report (2022) highlights the potential geopolitical risks of uncontrolled SRM and the Geneva Science and Diplomacy Anticipator (GESDA)'s latest foresight report identified SRM as a key emerging topic (2022). 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.

Status in intergovernmental processes

- **The Convention on Biological Diversity (CBD)** Parties have **engaged on the topic of climate-related geoengineering (which includes SRM)** for over a decade now, including COP decisions relating to SRM, and the production of technical reports into the potential impacts and regulation of climate geoengineering in relation to the CBD (2016; 2012)
- **The Intergovernmental Panel on Climate Change (IPCC)** addressed SRM and its governance across all three IPCC Working Group reports (2021; 2022; 2022) as part of its most recent **sixth assessment cycle**⁷. SRM was also assessed in the earlier Special Report on 1.5°C Global Warming (2018). The IPCC convened a first expert meeting covering SRM a decade ago (2012).
- **The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)** produced **a report in 2019** that reviewed a wide range of proposed marine geoengineering techniques, including SRM.

- **The London Protocol / London Convention (LP/LC)** Parties to the LP/LC **adopted a statement** in 2022 identifying the need to carefully evaluate marine geoengineering techniques which may have potential for mitigating the effects of climate change but may have adverse impacts on the marine environment (including SRM).
- **The Montreal Protocol** The two most recent scientific assessments prepared for the Parties to the Protocol have addressed SRM (2022; 2018) with the latest dedicating an entire chapter to stratospheric aerosol injection (SAI) and its potential effects on the ozone layer.
- **The Organisation for Economic Co-operation and Development (OECD)** published a **report** in late 2022 including analysis of the potential use of SRM to reduce the risk of crossing climate tipping points.
- **The United Nations Environment Assembly (UNEA)** discussed SRM during its Fourth meeting in 2019 following the tabling of a **Swiss-led resolution** proposing that UNEP prepare an assessment of geoengineering. Following extensive discussion the proposal was **withdrawn** due to lack of consensus.
- **The United Nations Educational, Scientific and Cultural Organization (UNESCO)** World Commission on the Ethics of Scientific Knowledge and Technology (**COMEST**) is preparing a **report on the ethics of climate engineering** expected in 2023). UNESCO previously convened the first **UN-hosted expert meeting** on geoengineering in 2010 with a **policy brief** published in 2011.
- **The United Nations Framework Convention on Climate Change (UNFCCC)** has not addressed the topic directly, but SRM and its governance has begun to emerge in side events during Conference of the Parties, such as this **Silver Lining event at COP26** and these events by **UNESCO** and the **Climate Overshoot Commission** at COP27.
- **The United Nations General Assembly (UNGA)** adopted **resolution 76/112 on the Protection of the atmosphere** in 2021, which includes legal guidelines relating to intentional large-scale modification of the atmosphere based on work undertaken by the International Law Commission. In a **2018 report** to the UN General Assembly, the UN Secretary-General highlighted gaps in environmental law relating to geo-engineering.
- **The United Nations Human Rights Council (UNHRC)** adopted resolution **48/14** in 2021 in which it mandated a Special Rapporteur to prepare a report on **the impact of new technologies for climate protection on the enjoyment of human rights** to be submitted to the Council in its 54th session in 2023. During 2022, Member states and others **submitted contributions** to this report.
- **The UN Interagency Task Team on Science, Technology and Innovation (IATT)** included **SRM implications for the SDGs** in its 2021 report to the UN Science, Technology and Innovation Forum.
- **The World Climate Research Programme (WCRP)** established a **task team on climate intervention/geoengineering** research in 2021 which **reported in 2022** and is expected to make recommendations soon.

Non-governmental engagement

- **Non-governmental and civil society organisations are 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](#). Some, like [Reflective Earth](#) are advocating for SRM development while others are critical or opposed, such as the [Climate Action Network International](#), 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 focus on promoting policy-dialogue, like the [Council on Energy Environment and Water](#) which has convened events and briefings in India, or the [Carnegie Climate Governance Initiative](#) that is working to catalyse the creation of effective international governance.
- **Some private sector actors have begun to engage around SRM.** In 2022, a US-based company [Make Sunsets](#) began selling ‘cooling credits’ to fund small-scale stratospheric aerosol injection interventions with the company website stating it is supported by a number of funders and has already undertaken two test flights. In 2021, the German space and technology group OHB together with a consortia of European research institutes established a [geoengineering network](#) for interdisciplinary cooperation and discussion.
- **SRM is gaining increasing attention in the media** Over the past year there have been an increasing number of articles appearing in prominent publications, including for example in: [Bloomberg](#), [Foreign Policy](#), [The New Yorker](#), [Politico](#), [Science](#), [Thompson Reuters Foundation](#), [Washington Post](#), [Wired](#), [UN Dispatch](#)⁸.

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 UNEP Emissions Gap Report (2022).

³ Solar radiation modification (SRM) is also referred to as ‘solar radiation management’, ‘solar radiation intervention’, ‘climate intervention’, ‘climate engineering’, ‘solar geoengineering’, ‘geo-engineering’, and ‘geoengineering’.

⁴ This briefing focusses on (but is not limited to) developments relating to two prominent SRM techniques which propose 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 cover.

⁵ See IPCC AR6 WGII report (2022) SPM and Chapter 16; WG1 report (2021) Chapter 4; and SR15 (2018) Chapter 4.

⁶ Funding volumes converted to EUR for easier comparison.

⁷ For analysis of how SRM was addressed in the recent IPCC reports, see resources on the [IPCC page of C2G’s website](#).

⁸ Examples provided here are taken from English language, largely US-based publication sources but SRM is also appearing in publications in other languages and other countries.