UNEP–WMO

Consultative Workshop and Science-Policy Dialogue on

Solar Radiation Modification

SUMMARY REPORT

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Executive Summary

The joint UNEP-WMO consultative workshop on Solar Radiation Modification (SRM), held over two days in May 2025, brought together a diverse group of experts, researchers, and practitioners working on SRM as well as Member State and Major Group and Stakeholder representatives from international coalitions and organizations for a structured dialogue on the state of SRM science and research. Organized around knowledge-sharing plenaries and facilitated science-policy dialogues, the workshop aimed to foster a shared understanding on the status of SRM and support a balanced, inclusive, and evidence-informed discussion on the potential implications, uncertainties, and governance considerations surrounding SRM research and deployment.

Day 1 featured six thematic plenary sessions, each exploring distinct dimensions of SRM, from fundamental principles and monitoring capabilities to environmental and socio-economic impacts. Panelists provided rapid-fire knowledge and perspectives followed by moderated discussion, highlighting the state of scientific understanding and key uncertainties. Day 2 shifted the focus to policy, social and ethical dialogue, with structured roundtable discussions centered on collaboration, equity, transparency, and public trust. These sessions underscored the need to integrate developing country perspectives, promote inclusivity in decision-making and governance considerations, and maintain transparency in research and communication. The potential impacts of SRM are likely to vary across locations and contexts. This underscores the importance of accounting for regional vulnerabilities as well as differences in scientific capacity, research priorities, and development progress when assessing SRM options.

Throughout the workshop, panelists acknolwledged the uncertainties and knowledge gaps surrounding SRM. There was strong consensus on the need for transparent, inclusive, and internationally coordinated research governance, clearly distinct from the governance of potential deployment, and capturing all aspects of research including small-scale experiments, trials, modellings, monitoring and control measures for field trials. Some member states outlined the desire for strong action to prevent deployment of SRM. Participants reaffirmed that SRM is not a substitute for essential climate actions, but agreed that the emerging field of SRM research warrants careful reflection on the need for anticipatory and participatory governance.

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Background and Objectives

Background

Climate change continues to accelerate despite increasing global mitigation efforts. In this context, interest is growing in climate-altering technologies, including SRM, as potential supplementary and temporary tools to help reduce climate risks. SRM encompasses a range of proposed techniques designed to reflect a portion of sunlight back into space, with the aim of cooling the planet. Examples include stratospheric aerosol injection, marine cloud brightening, and surface albedo modification.

Considering the complex technical, ethical, and political dimensions of SRM, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) jointly organized a consultative workshop to foster informed, inclusive, and impartial dialogue among key stakeholders.

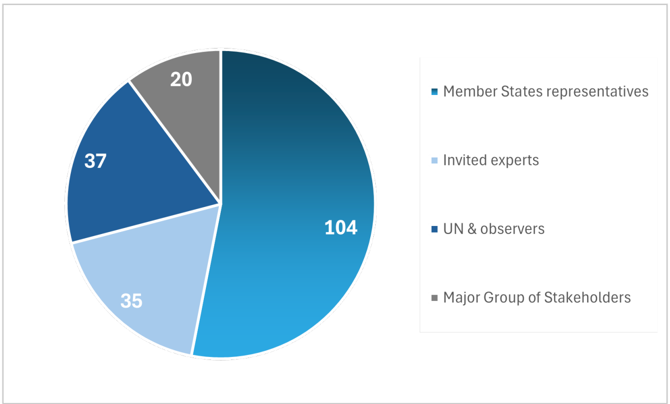
Objectives

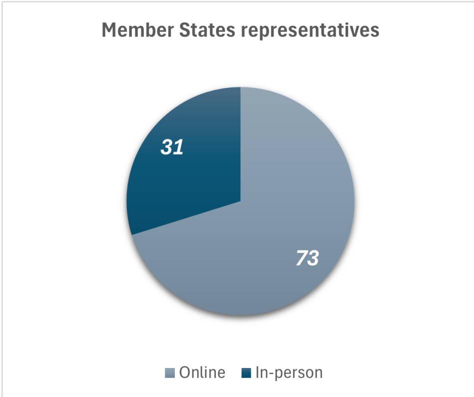
- Provide space for international dialogue, knowledge sharing and exchange on SRM with a view to help build a shared knowledge base enabling more effective and inclusive engagement.

- Inform and support UNEP and WMO on how each agency would consider this issue in the future and any subsequent work.

Overview of Participants

The two-day consultative workshop brought together a diverse and representative group of **United Nations (UN) Member States, invited experts, Major Groups and Stakeholders (MGS)**, and other observers to engage in a structured dialogue on SRM. A total of **196 participants** attended the workshop, with **124 joining online** and **72 participating in person**. The workshop saw representation from **54 Member States**, including **31 from developing countries** and **23 from developed countries**, reflecting a broad geographic and developmental spectrum. In addition, **35 invited experts** contributed scientific and technical insights, while **57 representatives from UN agencies and observer organizations** provided institutional and policy perspectives. A complete list of experts and panelists is provided in Annex 1.





Summary of Proceedings

Opening Session

The first jointly convened workshop by WMO and UNEP on Solar Radiation Modification marked a significant milestone in providing structured, inclusive dialogue on a topic that is both technically complex and politically sensitive. In opening remarks, WMO underscored the urgency of these discussions, noting that 2024 replaced 2023 as the hottest year on record in the 175 years of observations. Rising global temperatures, shrinking polar ice, and unprecedented ocean heat are clear indications of accelerating climate change with impacts affecting communities worldwide. UNEP underscored its core mandate to keep the environment under review, which includes assessing the potential environmental and societal implications of emerging technologies such as SRM. While UNEP does not view SRM a solution to climate change—given that it does not address the root causes of greenhouse gas emissions— it outlined the importance of improving understanding of SRM's risks, limitations, and knowledge gaps given research is occurring and as global interest in the topic continues to grow. Both organizations made clear that the workshop was not intended to promote or oppose SRM, but rather to facilitate a balanced, science-based exploration of what is currently known, unknown, or uncertain. Participants were encouraged to engage in open and respectful dialogue, with diverse perspectives— including critical, contrary or skeptical views—recognized as essential to advancing collective understanding. Effective knowledge sharing was highlighted as a critical element in strengthening the science-policy interface, ensuring that decision-making is informed by the best available evidence while acknowledging existing gaps and uncertainties. The workshop was not designed to reach consensus, but rather to capture the range of views, exchange emerging insights, and identify priority questions and concerns, as reflected in this Summary Report.

Chapter 1

Knowledge Sharing Sessions

1.1 Introducing Solar Radiation Modification

Objective: To introduce SRM as a climate intervention technique, clarify its core principles and approaches, and present the scientific rationale for research, limitations, and emerging concerns guiding research efforts.

1.1.1 Key Discussion Points

1.1.1.1 What is SRM and how does it work?

SRM refers to large-scale interventions intended to increase Earth's reflectivity, reducing incoming solar radiation and thereby cooling the planet. Two primary techniques are:

- Stratospheric Aerosol Injection (SAI): Injecting reflective particles into the stratosphere to mimic the cooling effects observed after major volcanic eruptions.
- Marine Cloud Brightening (MCB): Enhancing the reflectivity of marine stratocumulus clouds through aerosols, inspired by ship track observations where clouds seem brightened by the pollution (aerosols) emitted.
- There are several other proposed SRM methods, such as mirrors in space, cirrus cloud thinning, and surface reflectivity modification, but these receive less attention due to their significantly higher levels of technological and scientific uncertainty.

Observational analogs (e.g., Mount Pinatubo eruption, ship emissions) suggest that SRM could feasibly reduce global temperatures quickly, though these naturally occurring events are imperfect proxies for full-scale deployment.

1.1.1.2 Why are we talking about SRM and why it is being discussed now?

SRM is being explored by scientific communities as a potential planetary emergency measure to temporarily cool the planet, particularly in the context of persistently high global emissions and rising temperature, with the prospect of breaching a consistent 1.5°C above pre-industrial levels. Emission reductions (including negative emissions) translate only gradually into temperature decreases over multiple decades. While there is wide agreement that SRM is not considered as a substitute for emissions reductions, discussions around SRM are emerging primarily because of the persistent gap between climate mitigation ambitions and current progress. Based on current knowledge, modelling studies show SRM to be a possible approach to reduce temperatures temporarily, with potential to reducing specific risks associated with accelerating climate change, such as the rapid melting of the polar ice. Some caution that invoking the concept of a 'climate emergency' could be used to justify accelerated research or even potential deployment under extreme scenarios. Others caution that framing SRM in terms of emergency may increase the risk of premature action, heighten public distrust, or marginalize vulnerable voices in decision-making. At the same time, SRM also raises fundamental questions of governance, legitimacy, and risk. Participants therefore emphasized that open and inclusive dialogue is essential to ensure that any consideration of SRM remains grounded in science and informed by inclusive, transparent evidence-based policy discussions.

1.1.1.3 What can SRM not do?

SRM does not address the root cause of climate change, greenhouse gas emissions, and cannot solve impacts such as ocean acidification, biodiversity loss, or climate injustice. It does not reduce greenhouse gas (GHG) emissions and is not a replacement for mitigation or adaptation, and if initiated, it would likely require long-term continuation to avoid abrupt warming or the so-called termination shock.

1.1.1.4 What is the technical feasibility of SRM and timescale if considering deployment?

According to recent modelling studies, in the context of a planetary emergency, SRM could reduce global temperatures within a period of 2-5 years, although the actual effects would depend on scale, delivery method and regional climate feedbacks.

One of the most studied approaches, SAI, would require an estimated 10 million tons of sulfur dioxide (SO_2) to be released/injected annually into the stratosphere, delivered via hundreds of aircraft. While this scale is considered technologically feasible, it presents considerable logistical complexities. Once in the stratosphere, SO_2 would convert into sulfuric acid droplets that efficiently reflect sunlight. For comparison, current human activities already emit around 50 million tons of SO_2 annually into the troposphere. While SO_2 in the troposphere remains for about 10 days, when introduced into the stratosphere, it can persist for one to two years, enhancing its potential cooling effect thereby reducing global temperatures.

MCB, another proposed technique where several experiments are underway, would require thousands of ships—equivalent to 2 to 10% of the current global merchant fleet— to operate continuously in specific ocean regions. MCB technology has limited body of scientific research so far and remains less developed with uncertainties regarding its potential effectiveness and feasibility.

1.1.1.5 What are the environmental, social and climatic concerns of its deployment?

- Potential changes to monsoon systems and rainfall patterns, with uneven regional impacts. In the case of SAI, initial modeling studies suggest that aerosols would need to be distributed approximately equally between both hemispheres to minimize shifts in the Intertropical Convergence Zone (ITCZ) that can potentially disrupt global precipitation patterns.
- Risks to the Sahel's climate recovery, food security, and ecosystem dynamics in regions such as Africa.

- Ozone depletion and acid deposition are linked to SAI.
- Mitigation deterrence (moral hazard). The mere discussion of SRM could reduce public or political urgency to cut emissions.
- Governance and responsibility. No country or global framework currently regulates SRM research or deployment, complicating ethical oversight.

While scientific research has established that climate change is already altering these systems, researchers considered it essential to better understand the potential unintended consequences of SRM, some of which could, in certain scenarios, pose risks that differ from, and in certain cases may exceed, those associated with ongoing gradual warming. In the absence of agreed international governance frameworks, these concerns raise serious questions around climate justice, sovereignty, and decision-making authority over deployment risks and benefits. The panel stressed that more research is needed to comprehensively assess these potential consequences before any consideration of deployment.

1.1.1.6 What is the current state of SRM research?

- Most research on the efficacy and risks of SRM to date has focused on climate modelling.
- Climate modelling shows that SRM is capable of rapidly lower global temperatures.
- Most existing SRM research has focused on the natural sciences and climate modeling, with increasing work on impacts modeling (e.g., effects on agriculture, ecosystems, and health). Research on social dimensions, and integrated assessment models (IAMs) remain limited and underdeveloped. These remain highly dependent on the robustness and resolution of underlying climate models, which are still evolving, particularly regarding regional and sectorial effects. Existing IAMs lack sufficient SRM-specific parameters, limiting their ability to support policy-relevant scenario analysis and planning.
- In statistical impacts modeling, the reliability of results depends on identifying suitable historical analogues to help infer how changes in radiation and cooling —often accompanied by shifts in precipitation—which could affect critical sectors such as agriculture, health, or ecosystems. However, this area of research remains at a very early stage.
- Emphasis on the need for regional expertise and capacity building, particularly in vulnerable regions, to ensure inclusive governance and appropriate context-specific assessments.

1.1.1.7 What is the status of field experiments and analog studies?

There are currently no large scale SRM field experiments underway. MCB field experiments —such as those conducted for the Great Barrier Reef and off the West Coast of California—are small-scale and, focused on improving process-level understanding (e.g., microphysical processes of aerosols dynamics), rather than testing deployment or producing climate scale impacts. Such research aims to inform how larger-scale interventions might work in theory and for future modelling, but no known experiments to date seek to alter local, regional, or global climate. It is a common misconception that such MCB experiments, or field trials are designed to test or advance SRM deployment.

Volcanic eruptions and recent regulatory changes in shipping emissions offer partial insights into atmospheric processes but cannot replicate the full scope or scale of potential SRM interventions.

1.1.1.8 What is termination shock and what can we learn from volcanoes and similar analogs to SRM?

Termination shock—the rapid warming that would follow an abrupt halt in SRM—has been identified in modeling studies as a major risk. Recent studies suggest that a sudden termination of SRM deployment could significantly alter precipitation patterns and weaken monsoon systems across tropical regions. While empirical evidence remains limited, simulations suggest that abrupt termination could produce severe adverse impacts, including reductions in monsoon rainfall during the first years after cessation.

Natural analogues provide important insights: for instance, the recent reduction of sulfur in ship fuel has provided a valuable opportunity to study the resulting decrease in cloud brightening and past volcanic eruptions such as Mount Pinatubo have been used to study short-term cooling and rainfall effects. Events that trigger sudden, significant changes in the system are particularly useful for scientific research, as they help disentangle meaningful signals from the background variability (noise) and enhance our understanding of key atmospheric processes, including the potential dynamics of termination shock.

Although such analogues and observational data offer useful insights, no real-world experiment can fully replicate the scale required to capture its global effects.

1.1.2 Key Questions and Interventions from Member States and Observers

1.1.2.1 Environmental and operational risks

Member States and some participants raised questions about possible unintended environmental effects of SRM deployment. One intervention, in particular, asked whether the environmental costs of activities associated with SRM could outweigh potential benefits. It was noted that while SRM techniques might produce localized or regional cooling effects, the climate system is globally interconnected, and such interventions could have far-reaching impacts through atmospheric teleconnections.

Several participants highlighted the importance of further research to understand these potential consequences, including ecosystem-level assessments of effects and unintended consequences. Some online interventions also called for greater attention to the risks of privileging techno-centric approaches over just and inclusive responses to climate crisis. Several interventions also pointed to the blurring between research and deployment and urged clearer separation.

1.1.2.2 Role of the Intergovernmental Panel on Climate Change

Member States inquired about the role of the Intergovernmental Panel on Climate Change (IPCC) in shaping international understanding of SRM. It was clarified that SRM is now being considered in the Seventh Assessment Report (AR7) under:

- Working Group I, which addresses Earth system responses and methodologies related to SRM, including SAI and MCB.

- Working Group II, which focuses on risks, impacts, and ethical considerations.

It was further noted that SRM is not included in Working Group III, as it is not classified as a mitigation strategy under the IPCC framework.

1.1.2.3 Nature-based Solutions and SRM

One Member State questioned how SRM compares with Nature-based Solutions (NbS), noting concerns about further interfering with natural systems. In response, it was explained that NbS such as mangrove restoration or reforestation are generally understood as part of mitigation and adaptation strategies, seeking to manage climate risks by working with ecosystems. NbS are also associated with clearer co-benefits, such as coastal protection and carbon sequestration, with less uncertainty around their value. By contrast, SRM involves large-scale technological interventions in the climate system, where potential outcomes and risks are less certain currently.

1.2 SRM observational, monitoring and detection capabilities and gaps

Objective: To assess the current state of global observational systems and their ability to detect, monitor, and attribute potential SRM interventions and impacts, focusing on both technical and governance challenges.

1.2.1 Key Discussion Points

1.2.1.1 What observational capabilities do we currently have?

Today's global climate observation system, including satellites, aircraft, balloons, and ground-based instruments, is highly advanced and provides data on aerosols, stratospheric temperatures and water vapor. These tools allow scientists to detect changes in the climate system and begin to attribute them to possible drivers. For SRM, particularly SAI, while existing instruments can monitor key stratospheric variables, there is limited ability to observe early plume dispersion, aerosol particle microphysics and chemistry, and natural variability in aerosol properties. Existing systems also lack rapid-response capacity to capture sudden events and do not yet provide the continuity or detail that long-term SRM monitoring would require.

Natural analogues like volcanic eruptions (e.g., Mount Pinatubo eruption in 1991) and pyrocumulonimbus events (fire thunderstorms) offer valuable insights but differ significantly from SRM—eruptions are short-term and localized, whereas SRM would involve continuous, large-scale interventions over decades. As such, future consideration of SRM would require more targeted and sustained observation capabilities.

1.2.1.2 What additional capabilities would be needed to monitor SRM effectively?

Monitoring Scenarios:

- **Declared SRM activity:** Easier to observe and attribute as it enables coordinated monitoring campaigns using aircraft, balloon-based platforms and other Earth observation and remote sensing tools.

- **Undeclared or covert activity:** Much more challenging to detect; would require long-term, high-quality baseline data and comprehensive global observational coverage to detect deviations from natural variability.

Investments are needed in:

- Sensitive aerosol monitoring stations and long-term high-quality observations with global reach.
- Standardized, continuous satellite coverage with redundancy to avoid data gaps.
- Robust data-sharing systems and international coordination.
- Quick response capability systems such as air balloons and aircraft to capture events as they occur.

1.2.1.3 Can current systems detect SRM deployment?

Detecting the injection of aerosols at climatically relevant scales would likely be feasible with current technologies—observing systems, especially for SAI. However, detecting and attributing SRM's climate impacts (e.g., radiative forcing, surface temperatures, energy distribution, precipitation changes) is more complex and may take years or even decades, especially at regional scales.

For techniques like MCB, detection is even more difficult due to natural variability in sea salt concentrations and cloud behavior. Here, expanded remote sensing and in situ measurements to detect changes in cloud albedo, structure, and coverage would be critical to monitoring efforts. Furthermore, panelists emphasized that gaps in historical and baseline data limit the ability to detect or attribute new SRM deployments, particularly for subtle or small-scale activities.

1.2.1.4 What is the role of climate modelling in detection and attribution?

Attributing observed changes to SRM requires combining observations with climate models to simulate both the world with and without SRM (counterfactuals). This is similar to current approaches in climate attribution science but would be more complex, as it would involve disentangling the overlapping effects of greenhouse gas-driven climate change and any SRM interventions. Existing climate models, which have been developed primarily for studying climate change, are being applied to SRM scenarios, but some processes particularly relevant to SRM are not yet optimized such as:

- Regional impacts of aerosol forcing
- Coupling between greenhouse gases and SRM interventions
- Long-term feedbacks and risks (e.g., termination shock)

Therefore, model development must be advanced in parallel with observations.

1.2.1.5 What governance, equity, and data-sharing issues and needs are involved?

Discussions highlighted that monitoring SRM moves beyond scientific capability into questions of trust, legitimacy, and governance.

Systemic barriers:

- Lack of global agreements on acceptable practices or shared monitoring responsibilities. Existing platforms such as the IPCC were mentioned as potential vehicles to help frame what is considered acceptable or not.

- Significant regional disparities in monitoring capabilities, weak regional cooperation and limited data-sharing frameworks, especially in the Global South.

- Equity and justice concerns, given that different SRM deployment strategies could alleviate climate risks in some regions while exacerbating them in others.

- Concerns regarding non-optimal or unilateral deployment scenarios where powerful actors may act without transparency, accountability, or regard for transboundary consequences.

- Need for regional-scale monitoring, equitable access to data and modelling tools, and inclusive decision-making structures to ensure fair distribution of risks and benefits.

Beyond technical readiness, public and political trust in observational systems and modelling frameworks is vital. Among other things, this would require:

- An internationally coordinated, transparent monitoring system.

- Open access to data and modelling outputs.

- Clear communication strategies and public engagement.

1.2.2 Key Questions and Interventions from Member States and Observers

1.2.2.1 Timescales and detectability of SRM effects and impacts

Given the complexity of climate systems and the influence of natural variability, questions were raised on how long it would take to detect whether SRM was producing a measurable cooling effect.

Experts clarified that under realistic (e.g., gradual) and cautious SRM scenarios—those that aim to avoid abrupt or large-scale temperature changes —it could take upwards of 5 to 10 years to detect (and differentiate) global-scale effects, amid natural climate variability, and even longer to attribute SRM regional impacts in other variables beyond global average temperature. The absence of a real-world control experiment further complicates detection efforts, though events such as volcanic eruptions and changes in shipping regulations provide partial analogues.

Some researchers also noted that indirect environmental signals (e.g., changes in stratospheric aerosol concentrations, alterations in atmospheric optical properties, shifts in ozone chemistry), particularly in the stratosphere, could enable earlier detection of aerosol injections, even before measurable changes and climate signals appear.

1.2.2.2 Scientific basis for focusing on SAI and MCB

Member States asked why scientific focus was set around SAI and MCB, and what distinguishes these from other SRM proposals like cirrus cloud thinning or space mirrors. In response, experts explained that:

- SAI and MCB benefit from existing real-world analogs (e.g., volcanic eruptions and ship tracks), providing observable evidence and more advanced understanding of physical processes.

- Other SRM concepts, such as cirrus cloud thinning, remain entirely theoretical, with limited understanding of underlying cloud microphysics and a lack of technological readiness.

- Proposals such as space-based mirrors are still entirely conceptual, with no foreseeable development or deployment, even in the medium-to-long term for a range of reasons including feasibility.

1.2.2.3 Global monitoring and attribution systems: Feasibility and Purpose

Member States questioned the feasibility, political viability, and purpose of establishing global monitoring systems for SRM. Concerns were expressed that some states have opposed similar international monitoring efforts, such as those for methane or ozone detection, raising the question of whether SRM monitoring could be misused–for example, as a tool for assigning blame, imposing sanctions, or potentially even legitimizing deployment. In response, experts emphasized that:

- The core rationale for enhanced monitoring is fundamental to climate monitoring, and that long-term, high-resolution, continuous observations of aerosols, the Earth's radiation balance, and cloud properties are critical for understanding both SRM and broader climate change. Without such data, differentiating between natural variability from anthropogenic interventions would not be possible.

- The design and governance of such monitoring systems must be international, transparent, and grounded in trust to avoid politicization and ensure scientific credibility. They must also actively address existing North-South disparities in infrastructure, technical capacity and decision-making power.

Some governmental agencies and international organizations are already investing in atmospheric observation systems to improve the baseline understanding of the Earth's current climate state needed to assess potential SRM impacts. The National Oceanic and Atmospheric Administration of the United States of America (NOAA) Earth's Radiation Budget project[1] monitors the balance of solar and thermal energy in the atmosphere, while the European Space Agency (ESA) supports projects like ACtIon4Cooling[2], focused on aerosol-cloud interactions, and the STATISTICS project[3], which integrates satellite observations with advanced modeling to improve the reliability of SRM assessments.

1.2.2.4 Concept of 'Non-Optimal Deployment Scenarios'

In the context of modeling, the term 'non-optimal deployment scenarios,' does not refer to real-world deployment, but rather to modelling exercises that explore different hypothetical injection strategies (e.g., releasing aerosols in one location versus another) to assess where unintended consequences might occur and be minimized. These exercises are not intended

[1] NOAA Earth's Radiation Budget Project: https://csl.noaa.gov/research/erb/

[2] ESA ACtIon4Cooling Project: https://climate.esa.int/en/solar-radiation-modification/action4cooling/

[3] ESA STATISTICS Project: 'STATISTICS project', https://climate.esa.int/en/solar-radiation-modification/statistics

to advocate for deployment but serve as tools to improve understanding of regional risks and distributional impacts, which are critical for informing risk assessment and the development of effective governance frameworks.

1.3 SRM Modelling – Challenges, Opportunities, and Regional Perspectives

Objective: To explore the capabilities and limitations of climate models in simulating SRM's potential impacts, address questions about model reliability, and assess the feasibility of downscaling techniques for regional and local projections. The session also examined scenario design, model uncertainties, and the interplay between modeling, field experiments, and policy-relevant outcomes.

1.3.1 Key Discussion Points

1.3.1.1 How reliable are climate models for understanding SRM efficacy and impacts?

Climate models are currently the most powerful tool available for understanding how the climate system responds to external drivers, including greenhouse gases, land-use change, and potential SRM interventions. These crucial tools are based on well-documented physical processes to simulate the transfer of energy and materials through the climate system, and their performances are continually evaluated against observational data allowing better representation of key processes and thereby helping to improve their reliability.

In the context of SRM, climate models enable researchers to test hypothetical scenarios, assess potential benefits and risks, and identify key sensitivities at global and regional scales. While climate models are not designed to provide precise or localized prediction, coordinated multi-model experiments (e.g., CMIP, GeoMIP) help to reduce uncertainty and build confidence in their results.

1.3.1.2 Models simulate the Earth's climate response to external forcings, such as greenhouse gases or aerosols

All climate projections involve uncertainty, not only SRM modelling — but the scale, complexity, and unique risks associated with SRM amplify those uncertainties. Despite inherent approximations, models remain central to understanding SRM's global and regional climate responses and potential sectoral implications (e.g., water resources, ecosystems, economy). They are best viewed as tools for exploring scientific understanding under specific 'what-if' scenarios rather than for exact forecasting. Nonetheless, structural, computational, and scenario-based limitations and uncertainties persist, especially at regional scales.

1.3.1.3 How are SRM scenarios built?

In practice, SRM scenario experiments are constructed by pairing existing Shared Socioeconomic Pathways (SSPs) used in climate models with an imposed SRM forcing in the model such as a representation of stratospheric aerosol injection or an idealized solar reduction. The SRM runs are then compared with corresponding no-SRM baselines to examine differences in temperature, precipitation, radiative balance, and other variables. These exercises explore system sensitivities and risks under stated assumptions; they do not constitute predictions nor recommendations for deployments.

1.3.1.4 What are the limitations of these models?

Although climate models carry limitations, they remain the most crucial tool for investigating SRM:

- Climate models typically have coarse resolutions (50–100 km) preventing them from resolving fine scale processes, which limits their ability to accurately represent regional and local phenomena such as precipitation patterns or extreme weather events.
- Many physical processes (e.g., aerosol-cloud interactions, turbulence, or drizzle formation) are parameterized, not directly simulated, due to scale limitations.
- For SRM specifically, the degree of representation differs across techniques. SAI is better constrained drawing on analogues such as volcanic eruptions while MCB is less well represented in models due to their complexity and the limited understanding of low-level cloud processes.
- Natural internal variability (e.g., El Niño Southern Oscillation (ENSO), monsoon dynamics) complicates interpretation by making it difficult to distinguish SRM-induced changes from background natural fluctuations. This limitation applies not only to model simulations but also to observational data.
- Impact modeling such as assessments of effects on water resources, agriculture, and health carries forward the uncertainties inherent in the underlying climate simulations.

Nonetheless, coordinated climate modelling efforts remain essential for systematically comparing assumptions, reducing uncertainties, and building confidence in the potential impacts of SRM under different scenarios.

1.3.1.5 Do current SRM scenarios reflect the full range of possible outcomes and risks?

Current SRM modeling frameworks provide useful insights but are limited in scope:

- Current modeling frameworks do not yet fully capture the diversity of SRM applications, particularly those that consider sub-optimal or geopolitically driven deployments (e.g., unilateral, poorly coordinated or regionally targeted interventions schemes) which differ significantly from scientifically optimized designs.
- Models rely on assumed socio-economic scenarios (e.g., SSPs) which are hypothetical and not predictions. They serve to test how the climate system might respond under certain forcings, not to indicate desirability or likelihood.
- Existing scenarios (e.g., from Geoengineering Model Intercomparison Project - GeoMIP) generally assume idealized or globally uniform interventions. They help isolate scientific signals but do not reflect real-world deployments that may be asymmetrical and politically constrained.

Usage of model ensembles helps highlight robust responses and identify where results diverge most strongly (e.g., precipitation patterns, Arctic changes). This helps researchers understand risks and sensitivities but cannot capture every possible pathway or deployment strategy. Several participants underscored the importance of expanding the diversity of scenarios and modelling, incorporating political and ethical dimensions where relevant.

1.3.1.6 What processes specific to SRM are not well captured in models?

- For SAI, the microphysical formation of particles, their interactions, and evolution remain poorly constrained by observations.
- For MCB, cloud microphysics and dynamics (including drizzle formation and turbulence) are poorly represented, particularly in high-latitude cloud systems where future SRM deployments might target.

Field observations and process-level experiments are critical to better understand these uncertainties and improve model representation.

1.3.1.7 How can global model results be used to assess local impacts?

Global climate model outputs are translated into regionally relevant information using statistical and dynamical downscaling methods. Among those two methods, statistical downscaling is relatively accessible, and allows assessment of potential SRM impacts on water availability, food production, and health at local and basin scales.

All such analyses, however, also inherit the uncertainties of the underlying global climate models.

1.3.2 Key Questions and Interventions from Member States and Observers

1.3.2.1 Modelling of ecosystem and biodiversity impacts

- The potential impacts of SRM on biodiversity and ecosystems are not yet adequately represented in current models. The complex ecological interdependencies and cross-ecosystem effects such as those related to pollination, food webs and species interaction remain largely unmodeled.
- This is an early and emerging area of research with some research teams beginning to explore:
  - How changes in solar radiation and temperature may affect ecosystems (e.g., fisheries, diffuse radiation, plant productivity).
  - Potential consequences of ozone depletion or SRM-related atmospheric changes.
- Greater collaboration between ecological modelers and the SRM modeling community will help address these knowledge gaps.

1.3.2.2 Transparency, caution, and ethical considerations in SRM modelling

- SRM modelling must be approached with caution, transparency, and responsibility.
- Models are tools, not forecasts, and their limitations must be clearly communicated, especially for policy relevance.
- Public and policy-facing outputs must avoid overstating certainty or downplaying complexity of results and should acknowledge existing gaps in current knowledge.

1.3.2.3 Scenario framing and comparison bias

- The goal of model and scenarios comparison is to explore a range of possible outcomes.
- SRM scenarios (e.g., in GeoMIP) often compare high-warming pathways to hypothetical SRM-moderated outcomes. While this framing is useful for exploring possible impacts, these comparisons are not meant to imply that SRM is preferable. Concerns were raised that there is a risk that focusing on high-emission baselines may overstate the potential benefits of SRM's benefits while downplaying its deployment risks. Coordinated use of a wider range of scenarios is needed to provide a more balanced view of possible outcomes.

1.4 Scale matters – From small-scale experiments, pilot testing to deployment

Objective: To explore the role of SRM field experiments in improving scientific understanding and identifying risks, while addressing key questions around their purpose, scale, governance, and limitations.

1.4.1 Key Discussion Points

1.4.1.1 What are the different types and purposes of SRM field experiments?

There are currently no large-scale SRM field experiments underway, and the topic remains at the stage of scientific exploration. SRM field experiments can be grouped into three categories:

- Scientific experiments— aimed at improving understanding of atmospheric processes such as aerosol-cloud interactions and atmospheric chemistry.
- Technological experiments— focused on testing delivery systems and monitoring platforms.
- Scaling experiments— designed to assess whether small atmospheric perturbations are detectable and measurable and hence whether they could produce environmental impacts.

These experiments can vary in their purpose, scale, duration, material used and intended outcomes. Typical ranges may involve releasing between less than a kilogram and up to one ton of material (e.g., SO_2). For context, this is small compared with the estimated $\sim$100 million tons of SO_2 released annually through human activities.

1.4.1.2 Why does scale matter in field experiments?

Scale is a critical factor in discussions of SRM field research, both spatially and temporally. Current concepts of small-scale experiments are limited to areas as small as a football field and typically lasting from minutes to a few hours. These are not interventions in the climate system, but controlled trials designed to address specific research questions. Their purpose is to generate direct observations in areas where models lack empirical constraints, thereby improving model representation of small-scale processes and informing assessments of potential risks.

1.4.1.3 What is the scientific value of small-scale SRM experiments?

Small-scale experiments (typically minutes to hours in duration and spatially limited to the size of a football field or less) are not designed to influence climate, but to address specific research questions:

- Help test, validate and/or refine model assumptions while models in turn help design experiments.
- This reciprocal process enhances understanding of climate system feedback.
- Help identify potential risks or limits before considering large-scale research.

Examples include UK-funded ARIA projects investigating Arctic ice reflectivity and marine cloud brightening using seawater sprays or dust, none of which aim to alter climate but rather explore physical feasibility and monitoring capabilities.

1.4.1.4 How important is community involvement and co-design in field experiments?

Experiments involving co-design with local communities and rights holders, such as MCB over the Great Barrier Reef or surface albedo trials in Cambridge Bay, have proven successful, where the community helps shape the design and monitoring. Community engagement ensures tangible local benefits, enhances legitimacy, and transparency. Such co-designed approaches also provide opportunities to integrate indigenous and local knowledge with scientific inquiry and help researchers anticipate potential impacts that matter most to local stakeholders.

Participants from the Global South also highlighted that many regions, particularly in Africa, have limited involvement in SRM research design, thereby raising concerns about representation and knowledge equity.

1.4.1.5 Can small experiments capture the complexity of the Earth System?

An expert outlined that small-scale SRM experiments would provide valuable opportunities to study specific processes, validate aspects of models, and build confidence in simulation results. However, they cannot fully represent the nonlinear and interconnected nature of the climate system. Certain effects—such as shifts in cloud dynamics, monsoon patterns, sea surface temperatures, ocean circulation, or carbon cycle feedbacks—may only emerge gradually and well beyond the scope of limited trials.

Field experiments should therefore be considered as complementary to modeling rather than predicting long-term or large-scale outcomes. Transparency about their scope, limitations, and conditions is essential to ensure responsible research and maintain public trust.

1.4.1.6 How should risks be framed and evaluated?

SRM field experiments should be evaluated using a risk-risk framework, comparing the potential risks of conducting small-scale trials and the risks of not advancing knowledge in this area. Small-scale experiments pose minimal physical environmental risk, but concerns remain about their political implications, such as perceptions that experimentation could lead towards deployment.

Responsible research must balance precautions with the need to understand SRM's potential impacts, especially in the face of worsening climate risks and requires transparency.

1.4.1.7 Can small-scale experiments lead to deployment?

Field trials are not equivalent to deployments nor precursors to deployment. Such experiments are designed to test specific processes over very limited scales of space and time, and their results do not provide a direct pathway to operational intervention.

The path from experimentation to any operational intervention would involve decades of gradual, iterative research, assessments and governance, with many steps and safeguards. Making the leap directly from a football-field-sized trial to deployment is neither scientifically sound nor ethically justifiable. Small-scale trials should therefore only be seen as tools for inquiry.

1.4.2 Key Questions and Interventions from Member States and Observers

1.4.2.1 Impacts of Small-Scale experiments

Concerns were raised about whether small-scale SRM experiments, some comparable in size to a football field, could trigger wider environmental changes, given the interconnected nature of the Earth system? Experts acknowledged that real-world impacts at such small scales are likely negligible, and where approaches to affecting localized benefits with say MCB, could enhance safety for example of Arctic communities where sea ice loss could be reduced for example.

Participants also expressed strong interest in how risks are assessed both before and after SRM field experiments. Experts explained that this is typically done through a combination of climate modeling, scenario analysis, and, where applicable, environmental impact assessments (EIAs), following procedures similar to those used for other environmental research activities and projects, where researchers were required to evaluate ecological risks, consult affected communities, and obtain permits from environmental agencies (e.g., MCB over the Great Barrier Reef, under the Reef Restoration and Adaptation Program, underwent formal risk assessment and domestic regulatory authorization).

1.4.2.2 Community engagement and the integrity of consent processes

Several participants raised concerns about free, prior, and informed consent in SRM field studies. Experts underscored that active community participation is essential, citing positive examples in Cambridge Bay and the Great Barrier Reef, where local stakeholders were directly involved in co-designing and supporting the implementation of experiments.

The discussion also highlighted the challenge of addressing entrenched power asymmetries and the importance of trusted, independent intermediaries to ensure that processes and subsequent decision-making are genuinely informed, inclusive and equitable.

1.4.2.3 Limitations of experiments in assessing long-term and systemic risks

Some Member States expressed doubts about the ability of small-scale field experiments to capture the complex and potentially far-reaching impacts of SRM, such as possible changes to precipitation patterns, wind systems, or stratospheric dynamics.

In response, experts acknowledged these concerns and clarified a common but important misunderstanding: small-scale experiments are not intended (nor designed) to simulate operational/ large-scale deployment. Instead, their purpose is to improve understanding of specific physical processes that are critical and remain poorly represented in current models. These targeted experiments help refine climate models that remain the primary —and currently only— tool for exploring how SRM might influence the climate system under different emission pathways and intervention scenarios. Importance of clear and transparent communication on small scale experiments was also emphasized.

1.5 Identifying environmental, social and economic uncertainties and impacts from potential SRM deployments

Objective: To identify the uncertainties, potential impacts (both positive and negative), and gaps in knowledge about the environmental, social, and economic aspects of SRM experimentation and deployment.

1.5.1 Key Discussion Points

1.5.1.1 What are the key environmental and socio-economic uncertainties associated with SRM, especially for the Global South?

- Persistent uncertainty about SRM's potential outcomes generates widespread concern. Concerns focus on how SRM might affect ecosystems, agriculture, biodiversity, and human livelihoods. Model results suggest significant regional variability in SRM outcomes, for example, the possibility of temperatures moderation in some areas alongside rainfall disruptions in others, in vulnerable regions like Southeast Asia, Indonesia, and Latin America.

- Unequal impacts even within regions and countries (e.g., some parts of Indonesia experiencing both drought mitigation while other face increased drought severity) highlighting the importance of localized, context-specific studies rather than relying solely on global models.

- Research capacity remains limited in many parts of the Global South, though new initiatives (e.g., the African Climate Intervention Research Hub) are working to build locally led expertise and ensure regional perspectives inform SRM research.

1.5.1.2 What does current climate modelling tell us about potential impacts of SRM?

- Most SRM research to date has modeled climate hazards (e.g., temperature-related and precipitation), but fewer studies have explored downstream impacts on health, agriculture, and ecosystems.

- For agriculture: Limited studies suggest that SAI could reduce crop productivity in higher latitudes while benefiting some tropical regions. Findings remain uncertain due to the small number of studies and the complex interactions between cooling, precipitation, and CO_2 fertilization effects.

- For ecosystems: Early research indicates that SAI or MCB could reduce heat stress on coral reefs, but they do not address ocean acidification. For terrestrial ecosystems, decoupling greenhouse gas concentrations from temperature changes could disrupt large-scale biogeochemical cycles, but these processes are still poorly understood.

- On public health, only a small number of studies have explored SRM's implications for health. These include research on how SAI could influence near-surface air pollutants (sometimes increasing, sometimes decreasing risks), as well as potential effects on UV exposure and related health outcomes such as skin cancer. While projected impacts from these studies appear relatively small, they remain highly uncertain and context specific.

- A major gap exists in understanding how SRM could shift the geography of vector-borne diseases such as malaria, with models suggesting that optimal transmission zones could move significantly across the Global South, though overall burdens remain uncertain.

1.5.1.3 How could SRM increase regional inequalities or climate injustice?

- SRM's heterogeneous effects would create different outcomes across regions, as does climate change.

- In Latin America, research capacity on SRM remains very limited, making it difficult for local scientists and policymakers to assess risks and shape responses.

- Participants from Africa emphasized the importance of avoiding patterns of external control, noting the need for Global South–led research and decision-making.

- These disparities raise significant ethical and governance challenges, underscoring the urgent need to prioritize equity, justice, and regional voices in shaping SRM discussions and decision-making processes.

1.5.1.4 How can scientific capacity in the Global South be strengthened to address SRM risks?

- Current research communities in regions like Latin America are small and overburdened, limiting the ability to study SRM alongside other climate issues. Academic capacity-building is a long-term need, and is critical to ensuring inclusive research.

- Africa's example, with its emerging network of $\sim$50 SRM researchers and the newly launched African Climate Intervention Research Hub is a model that can be followed.

- Experts and panelists called for investment in research autonomy, regional networks, and South-led science-policy agendas.

- In terms of infrastructure, there is a need for access to higher-resolution climate models, improved observational networks, and interoperable climate data systems, enabling researchers in the Global South to carry out regionally relevant analyses.

- Beyond technical capacity, there is also a need to improve public awareness and education about SRM, so that communities can engage meaningfully in debates and decisions.

1.5.1.5 What risks does SRM pose in diverting focus from mitigation and adaptation?

- Moral hazard concerns:
  - That SRM research and discourse may undermine efforts to reduce emissions (mitigation).
  - That might also deter investment in adaptation, especially in vulnerable regions.
- SRM must not be viewed as a substitute for either emissions reductions or adaptation, but at best a temporary supplementary measure.
- Some philanthropic organizations, particularly those with significant financial and technological capacity and influence, fund SRM[4] and mitigation efforts[5], but not adaptation, reflecting a potentially unbalanced approach to risk-reduction.

1.5.1.6 What are the most urgent research and policy needs going forward?

- Localized, high-resolution climate modelling is needed to capture regional variability and to better assess regional SRM potential impacts.
- Interdisciplinary research is essential, combining climate science with social sciences, ethics, and governance studies.
- Public education and awareness on SRM are lacking, especially in the Global South. Transparent, accessible communication is needed to enable informed public discourse and to build trust.

1.5.2 Key Questions and Interventions from Member States and Observers

1.5.2.1 Economic feasibility and funding of SRM deployment

Member States asked about the operational cost of SRM deployment and who would ultimately bear that financial responsibility. In response, experts noted that existing literature shows that SRM deployment costs are generally significantly lower than the costs associated with mitigation. However, they emphasized that the cost is inherently tied to current policies and cannot be separated from governance considerations.

The financial responsibilities would presumably vary greatly depending on the deployment model, whether a single nation, a coalition, or global consensus, and would depend heavily on the governance architecture and institutional arrangements that emerge in the future.

[4] SRM Funding Overview, May 2025. https://srm360.org/article/srm-funding-overview/

[5] ClimateWorks Foundation. Climate Philanthropy Trends. April 2024. https://www.climateworks.org/press-release/climate-giving-surges-20-percent-in-2023-outpaces-growth-in-global-philanthropy

1.5.2.2 Moral hazard, the risk to mitigation and adaptation efforts and limits of research

Member States expressed concerns that the growing focus on SRM could detract from existing efforts to reduce emissions and implement climate mitigation policies. They also warned of the risk that discussions around SRM risk diminishing the sense of urgency required to cut emissions. In response, experts reiterated that emission reduction and adaptation remain the highest priorities. They also noted that global CO_2 levels continue to rise, despite decades of scientific warnings, underscoring that the core problem has been insufficient action on mitigation. Therefore, the very discussion of SRM should serve as a wake-up call to spur stronger action on emissions.

Other Member States expanded on these concerns by questioning how risk and mitigation are framed within SRM research and discussions. They cautioned against the tendency to label every challenge as a 'research gap,' arguing that not all risks should be reframed as research opportunities. They cautioned against framing SRM as part of the climate protection portfolio, arguing that this inclusion could undermine mitigation by creating false equivalencies between fundamentally different approaches. They further cautioned that funding SRM from climate protection budgets risks diverting resources away from proven mitigation efforts. Finally, they challenged whether such high-risk and potentially inequitable technologies should receive any public investment at all, particularly from developing countries already facing disproportionate climate impacts.

Expert responses emphasized that while concerns about mitigation deterrence are valid, the record so far suggests that scientific practice has acted cautiously, with projects halted when risks or governance issues were too great. For example, both the SCoPEx project and proposals for hollow glass microspheres in the Arctic were discontinued by the research teams themselves. On financial implications, experts also responded that SRM research should be supported through public rather than private funding, which would help establish clearer safeguards and accountability. They also noted that the current scale of SRM research funding is very small compared to overall climate finance, and that in practice, scientific self-regulation has already led to projects being discontinued when adequate consent or safety could not be assured.

1.5.2.3 Governance, legitimacy, and oversight of SRM research and experiments

Member States asked about the future of funding for SRM research in the Global South and the governance of small-scale experiments. In response, experts suggested that building legitimacy requires fostering collaboration and trust between scientists and policymakers through inclusive, ongoing dialogues. They emphasized the importance of building relationships face-to-face engagement and involving governance actors early in the process, noting that inclusive co-development processes take time but are essential for establishing trust and legitimacy.

1.5.2.4 Knowledge gaps and capacity building in the global south

Member States raised concerns about the substantial uncertainties surrounding SRM and emphasized the importance of identifying critical knowledge gaps, especially concerning vulnerable regions. They also raised the issue of limited access to SRM research and information in the Global South.

It was further stressed that the lack of environmental data on SRM's effects on ecosystems and questioned how such information could be incorporated into models that are largely temperature focused. Experts responded by underlining the fundamental limits of predictability in regional and ecosystem modeling. It was noted that some risks cannot simply be resolved through additional research. They added that signal detection becomes difficult in moderate SRM scenarios, complicating the attribution of impacts (e.g., to coral reef damage) complex and problematic for climate litigation and governance.

1.5.2.5 Socioeconomic dimensions and public engagement in SRM research

Member States asked how socioeconomic dimensions can realistically be integrated into outdoor experiments, especially considering people who may not be directly involved. They also questioned why social dimensions have been historically neglected in SRM research. Experts explained that the early SRM research was dominated by physical sciences and conducted in the Global North, where social aspects were not considered at that time. Greater attention to these dimensions has only emerged in recent years, as researchers from the Global South have become more engaged and have pushed the field to consider impacts on people and communities.

It was suggested that public perceptions should be formally assessed and captured, even for communities not directly affected by experiments. This could help anticipate community responses and guide ethical research. Inclusive and transdisciplinary approaches are essential, and effective research must be co-developed with stakeholders from the outset. Building trust through sustained dialogue among scientists, policymakers, and communities was seen as critical to ensuring legitimacy in this area of research.

1.6 Reducing Uncertainties in SRM Research

Objective: To identify critical scientific uncertainties in current SRM research. This discussion will focus on key areas where scientific knowledge is still evolving, the challenges in quantifying SRM's climate impacts, and the advancements needed in observational data, modeling, and experimental research to enhance confidence in future assessments.

1.6.1 Key Discussion Points

1.6.1.1 What are the most critical scientific uncertainties in SRM Research?

Regional climate impacts remain one of the most critical uncertainties in SRM research. The uncertainties remain difficult to assess because of internal climate variability, biases in climate models, and the limited temporal scale of current simulations, many of which only project a few decades ahead. This creates gaps in knowledge about the potential long-term implications of SRM, which could span centuries if ever deployed.

Uncertainties are also linked to processes that models do not represent well, such as cloud–aerosol interactions and the evolution of aerosols post injection. Addressing these gaps requires both high-resolution modelling and well-designed field experiments. Another challenge is the lack of necessary granularity to support analysis at the local level, such as how SRM might affect agricultural productivity or community livelihoods, issues that are central to social science and policy debates.

Panelists noted that observational baselines for SRM-relevant metrics are limited and often noisy, while real-world analogs such as volcanic eruptions offer only partial insights, making attribution and validation challenging.

1.6.1.2 How can we improve the understanding of regional and localized effects of SRM?

To reduce uncertainty in regional SRM outcomes, experts recommend using larger ensemble of global climate models, higher-resolution regional climate models, and downscaling techniques. Initiatives like GeoMIP 6, where multiple models run standardized SRM experiments, improve cross-comparability and provide deeper insights into potential regional impacts. Coordinated global, multi-model comparisons remain essential for advancing understanding.

One region of concern is the monsoon zone, which is both highly sensitive to SRM and poorly represented in current models. While exact changes may remain uncertain, comparing different models can at least illuminate process-level understanding of underlying dynamics.

New research networks are now enabling Global South scientists to analyze SRM's regional impacts in their own contexts, helping to ground model results in local realities.

1.6.1.3 What do we know about the interactions between different SRM techniques?

Most SRM modelling studies examine one technology at a time, either SAI, MCB, or mitigation pathways—rather than their combined effects. A limited number of studies have begun to explore these combinations, even though different technologies vary by cost, scale, deployment speed, and atmospheric lifetime and hence impact.

Experts noted that advancing research to better understand how these multiple approaches interact with each other counteract one another is important as they could provide policymakers with more comprehensive, decision-relevant insights to design more effective strategies that minimize risk while maximizing potential climate benefits.

1.6.1.4 How can we better integrate natural and social sciences in SRM research?

While social science has been part of SRM discussions, most scenario development remains grounded in natural science assumptions. To ensure SRM research reflects real-world needs, there is a strong case for inverting the traditional approach: starting with community-defined risks and priorities and then designing SRM modelling scenarios that remain within locally acceptable thresholds. This would require co-developing research and planning from the outset with affected communities, a practice that remains rare and is not yet implemented at scale.

Experts noted that recent SRM modelling experiments are increasingly linked to SSPs, and small-scale collaborations between scientists and policymakers have begun, though still limited. Experts stressed the importance of co-developing scenarios with communities and stakeholders from the outset, rather than treating social impacts as secondary. This would help align research with locally relevant concerns, such as public perception, agricultural livelihoods, or governance legitimacy and strengthen the credibility of future assessments.

1.6.1.5 Can emerging technologies like Artificial Intelligence and emulators reduce uncertainty in SRM research?

Artificial Intelligence (AI) and machine learning offer promising avenues to reduce the significant computational demands of climate modelling, especially in expensive areas like aerosol-chemistry interactions. If successful, they could enable more simulations, higher-resolution model runs and hence outputs, and greater insight into regional SRM impacts.

Climate emulators—simplified models capable of simulating multiple SRM scenarios quickly—are also increasingly being developed to provide rapid, accessible insights into regional outcomes. While not substitutes, these tools complement existing models, and may help broaden participation in SRM research by lowering the barriers to entry for analyses by researchers and increasing public trust through easier access to research-based information.

Publicly available tools, such as **Reflective's SAI Emulator**[6], already allow users to explore the SRM consequences under different conditions, making potential outcomes more accessible to communities and decision-makers alike.

1.6.1.6 How should we address risk–risk trade-offs in SRM research?

Experts emphasized that to effectively assess the trade-offs involved in SRM, coordinated and standardized modelling experiments are essential. Current studies often use differing assumptions, making it difficult to compare findings or draw conclusions from the findings. A more systematic approach would involve running multiple climate models across a range of scenarios and SRM techniques, such as SAI and MCB, to help improve comparability and provide clearer insights into potential regional impacts.

Rather than comparing SRM to historical climate baselines, assessments should focus on projected climate futures under continued global warming, as climate change itself poses substantial and ongoing risks. Mitigation remains the most effective and proven way to reduce both climate and SRM-related risks, emphasizing that SRM does not fix the fundamental drivers of climate change and is not a substitute for deep decarbonization or adaptation, noting residual risks will persist. Panelists also noted that perceptions of risk are shaped by regional and social contexts. For example, in parts of the developing world, existing threats like food insecurity or conflict may shape SRM risk tolerance differently than in more stable regions.

Understanding these dynamics requires broadening research beyond physical science and incorporating social and political dimensions. Existing research on the connections between extreme weather events, migration, and conflict can offer valuable insights that can help in evaluating SRM impacts more holistically and support more equitable, informed decision-making.

1.6.2 Key Questions and Interventions from Member States and Observers

1.6.2.1 Risk-risk trade-off framing

Member states expressed concerns about the 'risk-risk trade-off' framing (between impacts from SRM deployment against impacts from climate change as the dominant effect) used in SRM discussions. They argued that comparing the risks of SRM to those of global

[6] Reflective's SAI Emulator GitHub repository: https://github.com/Reflective-org/sai-simulator & Reflective simulator: https://simulator.reflective.org/

warming might obscure the fact that SRM does not solve climate change but rather creates a different climate with its own risks. Instead, they suggested shifting the conversation toward evaluating SRM risks on their own terms, rather than always in comparison to climate change.

Experts emphasized that trade-off framing is more aligned with real-world decision-making, which requires weighing different risks under various scenarios. They emphasized that decisions around SRM would account for both the risks of action and inaction, and that mitigation remains the most effective strategy to reduce both sets of risks. However, trade-off acceptability may differ by region: for instance, SRM risks may appear more tolerable in areas facing severe conflict or food insecurity compared to more stable regions. If policy delays continue and climate sensitivity reaches 3°C or higher, a modest incorporation of SRM into the policy mix could offer debatable trade-offs compared to a mitigation-only pathway.

1.6.2.2 Equity, power, and the feasibility of SRM research governance

A major group stakeholder questioned whether SRM deployment would be any more politically feasible than mitigation, given the geopolitical barriers that have long hindered climate finance and equity discussions. Concerns were raised that powerful countries could dominate SRM research and decision-making, sidelining the interests of middle and low-income countries, not least vulnerable populations.

Experts clarified that no one was suggesting SRM deployment would be easier than mitigation. Rather, the aim is to generate better information about potential regional climate impacts through coordinated international research—using multiple models and scenarios— so that governments can make informed choices at some time in the future. Experts proposed building SRM research capacity within the developing world and civil society to help democratize science and foster more inclusive governance of potential SRM pathways.

Experts emphasized that SRM discussions must not remain confined to scientific communities but must engage with the real concerns and constraints of decision-makers, civil society groups and affected communities. A coordinated approach across the science-policy-practice interface is essential to ensure better-informed decisions and more inclusive climate governance.

1.6.2.3 Responsible research and research ethics in SRM

Member States questioned whether the scientific community has adequately addressed what constitutes 'responsible research' in the context of SRM, including concerns around moral hazard, prior informed consent, and ethical experimentation.

Experts acknowledged that while these are critical issues, they are not unique to SRM and relevant across many scientific domains (e.g., AI, biotechnology, GMOs). However, given SRM's global scope and its potential for uneven impacts, early, inclusive engagement with stakeholders—particularly communities most likely to be affected, is especially important to ensure that research design, implementation, and governance reflect ethical standards and diverse perspectives.

1.6.2.4 National research gaps and data sovereignty

One Member State highlighted the lack of domestic SRM research and raised concerns about how countries without active programs can avoid becoming data-blind or overly reliant on external interpretations. They asked what safeguards or systems could help ensure national level understanding and agency.

In response, experts noted that global initiatives such as GeoMIP already provide open access to SRM model outputs, allowing any country to engage with the data. National assessments, such as those undertaken in the UK[7], US[8], UNEP[9], EU[10] or planned in IPCC AR7, can also serve as valuable references for countries without dedicated research programs. However, they acknowledged the pressing need for greater regional support and funding to enable more countries to independently analyze, interpret, and apply SRM data and information in their own context. This further underscores the importance of independent, international, and comprehensive assessment processes to ensure balanced, transparent, and globally representative evaluations of SRM risks, benefits, and governance needs.

1.6.2.5 Integrating social sciences and policy into SRM research

Experts and participants stressed the importance of integrating social science into SRM scenario planning. There was broad agreement that most SRM modeling remains rooted in natural science assumptions, with limited input from social sciences, humanities, local knowledge or affected communities on which risks are most pressing or acceptable. Experts noted that this lack of interdisciplinary engagement can limit the relevance of scenarios for decision-making at the local level.

To address this, panelists proposed co-development of scenarios, beginning with community-defined risk thresholds and then designing interventions that remain within those boundaries. This approach would require breaking down disciplinary silos and reorienting research to reflect societal priorities from the outset.

[7] The Royal Society. Geoengineering Project: Solar Radiation Governance. 2011: https://royalsociety.org/news-resources/projects/solar-radiation-governance/

[8] National Academies of Sciences, Engineering, and Medicine. Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance. 2021: https://nap.nationalacademies.org/catalog/25762/reflecting-sunlight-recommendations-for-solar-geoengineering-research-and-research-governance

[9] United Nations Environment Programme (UNEP). One Atmosphere: An Independent Expert Review on Solar Radiation Modification Research and Deployment. 2023: https://www.unep.org/resources/report/Solar-Radiation-Modification-research-deployment

[10] Science Advice for Policy by European Academies (SAPEA). Solar Radiation Modification: Evidence Review Report. 2024: https://scientificadvice.eu/scientific-outputs/solar-radiation-modification-evidence-review-report/

Chapter 2

Science-Policy Dialogue Sessions

Collaboration, equity and inclusion in discussing SRM research and development

2.1 Bridging knowledge gaps and addressing global asymmetries in SRM science

Objective: To examine how disparities in resources, technical capacity, and access to data shape who is able to produce, access, and influence the development of SRM-related knowledge.

2.1.1 Key Discussion Points

2.1.1.1 How do global research disparities affect SRM knowledge and decision-making?

- SRM research remains dominated by institutions in the Global North, reinforcing long-standing epistemic and geopolitical inequalities.

- Communities most vulnerable to climate change impacts, particularly in the Global South, are often excluded from shaping SRM research agendas despite facing the greatest potential risks.

- Even within the Global South, existence of power asymmetries, with urban and elite institutions receiving disproportionate support thereby marginalizing rural, indigenous and grass root voices.

- Disparities in funding, modeling access, institutional infrastructure, and participation create a fragmented and unjust global research environment.

- These gaps highlight the need for capacity building, equitable funding, and co-development of research agendas to ensure more inclusive knowledge production and decision-making.

2.1.1.2 Whose knowledge counts and who decides what research questions matter?

- Scientific agendas are still largely shaped by technical and natural science priorities, often without input from social sciences or local communities.
- Social scientists must not be appended late in the research process; they should co-define the questions from the beginning.
- Social sciences offer essential tools to analyze power, justice, legitimacy, and governance but remain underrepresented in SRM conversations.
- Greater inclusion of diverse disciplines, indigenous knowledge systems, and affected communities is needed to ensure research questions reflect broader societal concerns and values.

2.1.1.3 How can we move from capacity building to capacity sharing?

- True inclusion requires locally led and sustained research capacity, not just participation in externally driven projects.
- Programs such as the Degrees Initiative support this shift by funding 37 Global South-based SRM research teams, promoting South-South and interdisciplinary collaboration.
- Building sustainable research ecosystems demands long-term funding, infrastructure, labs, access to modeling, and publication support, not just project grants.
- Capacity sharing also involves co-developing research agendas between Global North and Global South institutions, ensuring leadership and ownership are not concentrated in a few elite or external centers.

2.1.1.4 What does inclusive knowledge co-production actually look like?

- Those most affected by climate impacts must be genuine partners in research, design and implementation, not subjects of study.
- Communities, particularly those facing multiple vulnerabilities, must be engaged as co-researchers and knowledge holders.
- Inclusive processes require time, trust-building, flexible funding, and sustained support for civil society as an essential part of the science-governance ecosystem.
- Funding mechanisms and research agendas should be jointly designed by institutions from both the Global South and Global North to ensure equity and shared ownership. Research agendas must be co-hosted and co-developed, moving beyond one-way capacity building toward mutual collaboration.
- Greater investment is needed in regional institutions, Indigenous knowledge systems, and equitable access to publishing opportunities.
- Dedicated platforms should be established to support interdisciplinary and transdisciplinary exchange, including qualitative research and traditional knowledge systems.

2.1.1.5 What role does civil society play in SRM governance and research?

- Civil society encompasses advocacy groups, science societies, and community organizations with deep local knowledge and key accountability roles.
- Policy innovation and accountability often emerge from civil society, rather than government institutions.
- Empowering civil society within SRM research and dialogue can enhance local ownership and broaden the range of perspectives represented.

2.1.1.6 How should we address structural inequalities in climate knowledge production?

- The current system risks reproducing power asymmetries, especially if knowledge is generated only through technocratic or elite-driven channels.
- SRM research must not repeat the failures of other technological transitions, that overlooked the distributive and justice dimensions of impacts.
- Scientists and policymakers alike must question their assumptions and embrace disagreement and deliberation as part of knowledge creation.

2.1.1.7 What framing should guide SRM research going forward?

- Avoid false binaries such as ‘climate change vs. SRM’; instead, assess how both sets of risks interact within shared, value-laden contexts.
- SRM is often framed as a short-term fix, yet its potential impacts are uncertain, delayed, and unequally distributed.
- Scientific framing should avoid technocratic reductionism and instead reflect complex social, ecological, and ethical realities.
- Research agendas should be guided by inclusive, co-developed questions, rather than solely by technical feasibility or natural science priorities.

2.1.2 Key Questions and Interventions from Member States and Observers

2.1.2.1 Equity, inclusion, and power asymmetries in SRM research

Key Questions Raised:

- How can SRM research be designed to avoid reinforcing global power imbalances and historical climate injustices?
- What mechanisms can ensure meaningful inclusion of Global South voices and marginalized communities in SRM discussions and decisions?
- Given the shortcomings of mitigation efforts, is it reasonable to assume SRM would be implemented responsibly and equitably?

- Should a precautionary—or even preventive—approach guide our engagement with SRM?

Experts emphasized that SRM exists within a broader context of deep structural inequality. They cautioned against repeating historical patterns in which Global South actors and climate change and SRM vulnerable communities were either excluded or only superficially included. Instead, they advocated for co-creation and local ownership of both knowledge and governance systems, noting that meaningful inclusion requires communities to be involved in framing research questions from the outset.

Drawing on past shortcomings of mitigation and adaptation, several experts stressed the need for a precautionary—or even preventive—approach to SRM, rather than relying on optimistic assumptions that governance will succeed this time. Others highlighted the need to engage in governance discussions proactively to avoid leaving decisions to unaccountable actors. Social sciences, particularly from the Global South, were viewed as essential for critically interrogating assumptions, power dynamics, and value-laden framings in SRM discourse.

2.1.2.2 Capacity building versus capacity sharing

Key Questions Raised:

- What is the difference between 'capacity building' and 'capacity sharing'?
- How can we avoid reproducing paternalistic or colonial models of knowledge transfer?

The distinction between capacity building and capacity sharing lies in power dynamics and reciprocity. Capacity building often positions the Global South as passive recipients of expertise from the Global North and traditional Western scientific knowledge.

In contrast, capacity sharing acknowledges that knowledge and innovation exist across all regions and knowledge systems and promotes mutual exchange. Experts emphasized that institutional and financial support should aim for long-term sustainability, rather than short-term involvement, and must encompass infrastructure development, publishing support, and meaningful community-level engagement.

2.1.2.3 Climate justice and funding priorities

Key Questions Raised:

- Should public funds go to SRM when mitigation and adaptation are underfunded?
- How can we prioritize urgent climate needs over speculative research?

While SRM funding currently represents only a small fraction (approximately 0.5%) of overall climate research funding, its pace of growth is notable and increasingly significant. Experts emphasized that climate justice requires reallocating resources toward proven mitigation and adaptation solutions, especially those that benefit vulnerable populations. At the same time, the growth of SRM funding, particularly from private or philanthropic actors, needs public oversight. Some participants called for stronger funding for governance and capacity-building efforts, not just technical modeling or deployment feasibility.

Some experts mentioned new tools like the SRM360 funding database (a private initiative) are emerging to map global SRM research funding. However, some other experts proposed to create an international forum or organization to screen private funding for SRM research to ensure and prevent undue influence on research outcomes.

2.2 Improving data sharing and transparency across sectors and borders

Objective: To explore key technical, institutional, and political barriers to effective data sharing in SRM-related research, including proprietary constraints, intellectual property concerns, national security sensitivities, and disparities in digital infrastructure and research capacity.

2.2.1 Key Discussion Points

2.2.1.1 What data do we need?

Before data can be shared, there must be agreement on what to observe—otherwise, existing power structures determine priorities. Co-design between global South and North was emphasized as essential. Without it, some actors might dominate by default, determining unilaterally what is relevant to measure, thereby perpetuating data and knowledge asymmetries through default practice. The data problem is political as much as technical. It is not only about availability, but about what kinds of knowledge are deemed valuable, why and by whom. Collecting data for SRM research would not require fundamentally new systems. Instead, it could build upon and strengthen existing climate observation infrastructures to better monitor data (e.g., from volcanic eruptions, ocean circulations, wildfire emissions) that help to understand SRM impacts as they are natural analogues.

2.2.1.2 Capacity gaps and inequity in data access

Many researchers, especially in the global South, face technical and structural barriers that limit their access to key modeling and data tools. For example, Coupled Model Intercomparison Project (CMIP) models are too coarse, large, and computationally demanding to adequately support Global South research community. Additionally, researchers frequently lack access to relevant local datasets, particularly in sensitive areas like public health. Without these data, they cannot adequately assess the impacts of SRM in their specific contexts, which undermines the legitimacy of the research.

Proposed solutions:

- Lightweight emulators that can run on local machines, though they are still subject to availability of digital infrastructure.
- Open-access platforms jointly governed by governments and academia.
- Training and interpretation support, rather than simply providing raw data.

Equitable access to data is not just about downloading a file, it is about giving researchers the tools and political cover to interpret and act on that data.

2.2.1.3 Can data transparency build trust?

Some experts warned against seeing transparency as a magic bullet. Publics must understand why data is being generated and who benefits. Without agreed oversight and goals, data transparency might even enable harmful actions (e.g., legitimizing experiments), not reduce risks.

Also, data misuse is a major risk (e.g., cherry-picking favorable model outputs). Transparency must include education on limitations and uncertainties.

2.2.1.4 Who is the 'client' for SRM research and how should science be managed?

SRM research is fundamentally an applied science and engineering challenge, motivated by concerns for future climate impacts rather than mere curiosity. As such, it requires a radically different science-management culture, unlike historically mission-driven science (e.g. nuclear labs) where engineers were paired with scientists to address urgent problems. The current academic landscape, driven by publish-or-perish incentives, often leads to fragmented and abstract research. Consequently, without a defined mandate from a multilateral body, SRM research risks drifting, producing data without clear ownership, accountability, or benefit to the broader public. A shift toward public oversight and mission-driven organization was suggested as important for ensuring that any SRM research remains responsive to societal rather than narrow institutional interests.

2.2.1.5 What should come first: governance frameworks or scientific exploration?

Panelists emphasized the close interconnection between governance and research. Some experts and member states strongly advocated for a 'governance first' approach, arguing that the risks are too great to allow SRM research to proceed without established rules. Several participants noted that not all SRM-related research carries the same level of risk. Low-risk activities such as climate modelling or certain observational studies could proceed and may in fact be essential for developing appropriate rules and best practices.

While SRM presents unique challenges, panelists highlighted that there are relevant precedents in other domains—such as the Biosafety Clearing House, the Global Earth Observation System of Systems (GEOSS), the Nagoya Protocol, and adaptive management models—that can provide lessons for building oversight structures.

2.2.1.6 Can we separate 'safe' from 'risky' research?

Panelists discussed the distinction between relatively low-risk research (e.g., modelling, observational studies, or use of natural analogues like volcanic eruptions) and activities that involve deliberate outdoor interventions. Modelling work and related foundational science should continue, as they are non-risky and are essential for understanding the climate system. However, the transition to deliberate outdoor intervention (e.g., releasing particles), dramatically escalates governance complexities and associated risks. These physical interventions, unlike purely theoretical studies, introduce actual perturbations and can carry the perception of a 'slippery slope' towards eventual deployment.

This highlights the importance of a legally binding international governance framework that fully accounts for the complex, intergenerational and often disproportionate environmental, social, ethical, and geopolitical impacts. Some experts suggested exploring whether governance frameworks could categorize research activities by risk level, allowing low-risk activities such as modelling to continue while applying stricter oversight to higher-risk outdoor interventions.

2.2.1.7 What is the role of the private sector: partner, threat, or both?

Some experts supported public-private partnerships, where private entities are contracted within internationally governed programs, to enhance open-access data tools and monitoring platforms. When done properly, these collaborations could strengthen scientific efforts.

However, voluntary transparency by companies is insufficient; mandatory oversight and public disclosure are essential to avoid repeating the opaque dynamics seen in the biotech or energy sectors. Under international human rights law, states are obliged to regulate private actors, while private entities themselves must also uphold rights directly, including transparency, risk assessment, and grievance mechanisms.

2.2.1.8 Who funds SRM, and should this be public knowledge?

The need for transparency in funding flows was strongly emphasized. Currently, donor transparency is partial and voluntary. While projects like the Degrees Initiative list funders, not all recipients disclose their sources. Without financial transparency, public trust will remain low, especially if profit-driven motives are suspected.

SRM360, a non-profit knowledge hub, provides clear breakdowns of who is funding SRM research, and how much, across public, philanthropic, and private domains. This initiative is a positive step toward mapping financial flows more comprehensively. It was proposed to establish global registry of funders and grants, national laws obligating recipients to disclose sources and goals, civil society watchdogs.

2.2.2 Key Questions and Interventions from Member States and Observers

2.2.2.1 Institutional roles in SRM observation and oversight

Key Questions Raised:

- Which international bodies would be responsible for coordinating, managing, and interpreting SRM-related data?
- Would such responsibilities fall to existing institutions such as the WMO, UNEP, or the WCRP?
- Would new structures be required for data management?

Experts responded that no single agency currently holds a formal mandate for SRM monitoring and oversight. However, they emphasized that any future system must rely on multilateral cooperation, ideally building on existing international climate monitoring frameworks. Institutions like WMO, UNEP, and the WCRP could play complementary roles, provided clear mandates and coordination mechanisms are defined.

Experts also stressed that observational data must be openly shared across institutions, following standardized protocols and with transparent attribution pathways. This is essential not only for scientific credibility but also to detect any undeclared or unilateral SRM activities and to maintain public trust in any research process.

2.2.2.2 Data transparency and open access

Key Questions Raised:

- Are there open-access platforms for SRM data?
- How is observational data shared and accessed globally?
- How can data gaps be addressed transparently and inclusively?

Experts emphasized that transparency must be understood broadly, not only as open access to publications, but also as clarity and transparency around who is funding research, what questions are being studied, and what findings are emerging. Initiatives like the Degrees Initiative and others are working to build platforms that promote open data and funding transparency. However, systemic barriers persist, particularly for researchers in the Global South who often lack access to expensive modeling tools and datasets. Experts stressed the urgent need to make data infrastructure more accessible, equitably governed, and responsive to regional research priorities.

2.2.2.3 Justice, language and access to knowledge and data

Key Questions Raised:

- How can we ensure equitable access to knowledge when scientific research published in English and often locked behind paywalls?
- Does it not create significant barriers for researchers in the Global South?
- Who owns the data produced— public institutions, private funders, or the researchers themselves?
- Will data be treated as a public good, or as intellectual property?

Experts emphasized that language barriers and high publishing costs significantly hinder equitable research participation, particularly researchers in the Global South. They emphasized the need for open-access publication models, translation tools, and capacity-building in non-English speaking communities. It was also noted that data ownership depends on funding sources and institutional policies: public funded research typically leads to public-domain data, while privately funded projects may demand intellectual property protections. They also emphasized the need for regional data hubs and not centralizing data ownership in Global North. Experts also stressed the importance of establishing data use/sharing agreements from the outset, including data licensing and access protocols.

2.2.2.4 Attribution of impacts, risks and research pathways

Key Questions Raised:

- If SRM causes long-term effects, how will we attribute these impacts years later amidst multiple variables?
- How should concerns about the irreversibility of SRM impacts affect how we approach data governance and transparency?

Experts clarified that while some SRM impacts could manifest early, reliable attribution and verification may take many years. As such, data strategies and planning must include long-term monitoring and modelling commitments. Particular caution was advised for data related to irreversible risks, such as long-term impacts on the ozone layer or ecosystems. The importance of differentiated governance based on varying levels of risk levels was also emphasized. Several experts and member states highlighted the value of risk-tiered governance frameworks, suggesting that low-risk activities, such as modelling, could continue with minimal oversight, whereas higher-risk research, especially outdoor field trials with potential irreversible impacts, would necessitate stringent regulatory controls.

2.3 Centering ethical and justice considerations in SRM: supporting public trust and accountability

Objective: To explore how principles of equity, precaution, and intergenerational justice could inform the design and conduct of SRM research and potential deployment, with a particular focus on the rights of local communities.

2.3.1 Key Discussion Points

2.3.1.1 What are the key ethical and justice concerns regarding SRM?

- **Intergenerational Justice:** SRM research and deployment are recognized as inherently multi-generational, raising critical questions about justice for future generations, including those not yet born. Existing political institutions are often not designed to represent the interests of future people, especially those most vulnerable to climate injustice. Decisions today must not constrain the agency or opportunities for future generations. Meaningful youth engagement requires more than symbolic participation; it calls for investment in education, knowledge access, and safe spaces for dialogue. The 'moral hazard of inaction' is especially salient for younger generations experiencing climate anxiety, as current climate efforts fail to guarantee a viable future. Experts highlighted that blocking conversations about SRM is by some means a counterproductive development but could also leave some communities unprepared; whereas transparent engagement helps ensure future generations can make informed decisions.

- **Rights of Nature:** The potential impact of SRM on non-human nature which cannot represent its own interests— underscores the importance of incorporating frameworks such as like the 'rights of nature' into considerations and future decision-making processes.

- **Precautionary Principle:** Panelists discussed how the precautionary principle should shape SRM research. It requires that potential risks—such as serious or irreversible environmental or social impacts—be considered even where scientific certainty is lacking. At the same time, they emphasized that precaution does not mean halting all research. Low-risk activities such as modeling or observational studies can proceed, provided they are transparent, inclusive, and responsibly governed. The discussion also noted the importance of avoiding 'lock-in,' where research pathways could unintentionally narrow future choices, underscoring the need for vigilance and strong governance frameworks.

- **Human Rights Framework:** SRM debates are unfolding in a broader context of rising inequality, eroding human rights, and weakening multilateralism amid a deepening climate crisis. Human rights obligations— binding on Member States, businesses, and international organizations require proactive steps to avoid negative impacts on people through their climate-related actions. The principle of 'do no harm' is central, requiring that SRM research and governance frameworks safeguard health, ecosystems, and rights. At the same time, it was noted that applying human rights principles should not hinder scientific progress beneficial to society but instead provide clear guardrails for responsible research and decision-making.

2.3.1.2 How should ethical frameworks shape our decisions around SRM research and potential deployment? What mechanisms need to be in place to ensure these frameworks guide SRM research to avoid unintended societal and environmental harms?

Discussions on SRM emphasized the critical need to prioritize ethical and justice considerations in the design, conduct, and potential deployment of SRM or research. This includes examining how principles such as equity, precaution, and intergenerational justice can be meaningfully applied, with particular attention on protecting the rights of local communities.

Experts emphasized that ethics and justice warrant dedicated attention and should not be subsumed under broader categories like science communication or public engagement, as they require specialized expertise and consultation. The Ethical Framework for Climate Intervention Research developed by the American Geophysical Union (AGU) was highlighted as a valuable step toward addressing ethical dimensions in SRM research. The framework outlines five core principles to guide decisions at all levels, from national ministries to independent researchers:

- **Responsible research:** Requires clear public justification for activities, including technology development, implementation, and transparent communication.
- **Climate justice:** Necessitates considering whether SRM technologies might shift climate impacts from one group to another.
- **Inclusive public participation:** Emphasizes co-creation from the outset, actively including communities historically excluded from scientific processes.
- **Transparency:** Calls for openness regarding data handling and accessibility.
- **Informed governance:** Requires funders to mandate independent and thorough review of technologies and their deployment, integrating social science insights and developing appropriate evaluative metrics.

2.3.1.3 What kind of process needs to be involved in creating an ethical framework? Who needs to be involved?

The AGU's ethical framework, for example, was grounded in existing knowledge that included diverse voices beyond traditional geoscientists —drawing on the expertise of social scientists, policy experts, and public health experts from around the world. Co-creation was a central element, involving early-career scholars and communities contributing both quantitative and qualitative data and perspectives.

Developing an ethical framework requires formative evaluation throughout the research process to ensure that guiding principles are upheld, accountability is maintained, and relationships are fostered across diverse groups—intergenerational, multinational, and transdisciplinary. Despite the existence of such frameworks, their uptake into formal policy and funding mechanisms remains limited.

SRM is highly intersectional with human rights, health, food, and geopolitics, requiring multilateral governance to prevent unregulated development. This underscores the need for governance approaches that are cooperative, multilateral, and designed to ensure accountability and broad legitimacy.

2.3.1.4 What might the ethical implications be of not pursuing SRM, and what responsibilities or consequences could arise from a decision not to use SRM?

Experts noted that ethical considerations extend not only to SRM research itself, but also to the decision not to pursue it. Some experts approached the issue from an economic perspective, emphasizing the concept of 'residual damage' harms that cannot be addressed by other climate interventions. They argued that not researching SRM carries the risk of leaving future generations without a potentially necessary tool and/or the ability to safeguard society from its potential risk and unintended consequences. Rather than taking a limited view of future options, today's decisions should aim to preserve agency and expand opportunities for those to come. It was also noted that making decisions on behalf of others, especially future generations, without their full understanding or capacity to participate, is fundamentally problematic. A growing interest in learning about and considering SRM options, among young people (ages 18-24), compared with previous years, reflects a shift in public sentiment and highlights the importance of open dialogue rather than shutting down conversation.

2.3.1.5 How can the approach to governance be grounded in existing bodies of law, governance approaches, or ethical frameworks?

Existing human rights law provides a strong foundation, with states having obligated to respect, protect, and fulfil human rights, including through the duty of due diligence and the precautionary principle. As such, human rights mechanisms should be more fully utilized/ integrated into SRM discussions to ensure transparency, accountability, and meaningful participation in assessing risk and guiding research.

Values and agency must be embedded in every stage of the SRM process and conversation. However, insufficient knowledge currently prevents a definitive decision on SRM use, necessitating further broad, collaborative, and global research to understand SRM's potential and dangers. There is also a growing recognition of the need to develop governance frameworks for SRM, in order to ensure that research and potential activities are conducted transparently and cooperatively, and to avoid risks associated with uncoordinated or unilateral initiatives.

2.3.1.6 How does the SRM issue compare with other areas of contested science and policy, such as vaccines or AI? What makes it distinct or harder/easier in terms of public legitimacy and governance needs?

Experts observed that SRM debates often take place in a context of urgency and 'argument from desperation,' reflecting the gravity of the climate crisis. This was contrasted with other emerging fields, such as artificial intelligence, where such urgency is less evident. The notion that urgency can lead to a lower threshold of acceptable risks was raised. It was emphasized that if desperation is indeed warranted, it should be directed toward accelerating emissions reductions, an area where effective solutions already exist, and the primary obstacle is political will rather than technological limitations.

The SRM discussion highlights a broader need to discuss how scientific research is conducted across all disciplines, integrating diverse perspectives beyond traditional science to provide richer context and ensure ethical practices.

2.3.1.7 What is the current governance landscape for SRM, and what challenges does it face?

The Convention on Biological Diversity (CBD) resolution from October 2010 invites parties to refrain from undertaking climate-related geoengineering activities that may impact biodiversity, unless 'science-based, global, transparent and effective control and regulatory mechanisms' are in place and supported by an 'adequate scientific basis.' While the resolution reflects a strong precautionary stance, it is non-binding, does not apply to small-scale experiments without known biodiversity impacts, and notably excludes countries such as the United States, which is not a Party to the CBD.

A central governance challenge is ensuring that research developments do not outpace oversight frameworks. Experts noted the risk of 'socio-technical lock-in,' where research momentum could limit future choices. However, examples like SCoPEx, where an experiment was halted due to ethical, social, and cultural objections, offer cautious optimism that responsiveness to public input can shape outcomes and may serve as a model for how governance and accountability could function in practice.

2.3.2 Key Questions and Interventions from Member States and Observers

2.3.2.1 Legal frameworks, moratoriums, and Human Rights

Key Questions Raised:

- How does the CBD decision on geoengineering, specifically its clause about an 'adequate scientific basis,' apply to SRM activities? Does it permit activities if such a basis exists?
- How do the potential negative impacts of SRM (e.g., on the ozone layer, agriculture, water cycles, food security, human health, and biodiversity) relate to the UN General Assembly Resolution 76/300 on the human right to a clean, healthy, and sustainable environment?
- Could the emerging concept of 'rights for nature' be a way to account for the ecosystem impacts of SRM deployment? Is there research on this in the SRM context?

While the CBD resolution is non-binding—inviting rather than obligating Parties to act—it nonetheless reflects a valuable expression of international consensus relevant for global governance. The resolution states that, in the absence of 'science-based global, transparent and effective control and regulatory mechanisms for geoengineering,' no climate-related geoengineering activities that may affect biodiversity should proceed until there is an adequate scientific basis to justify such activities, along with appropriate consideration of associated environmental, biodiversity, social, economic, and cultural risks.

Importantly, the CBD should be interpreted in conjunction with other applicable international legal frameworks, including binding human rights law, as the interdependence between human well-being and healthy ecosystems is well established within human rights obligations.

The precautionary principle is crucial: in the absence of full scientific certainty, if an action like SRM may lead to unacceptable harm (e.g., threatening human rights/health, serious and irreversible impacts), actions should be taken to avoid or diminish that harm. This principle does not preclude scientific research on SRM; rather, it requires that research be conducted in ways that transparently assess risks and safeguard human rights and the environment.

Chapter 3

Cross-cutting Themes

3.1 Governance and ethics of SRM research

3.1.1 Ethical foundations and responsible research practice

Member States raised questions about what constitutes responsible SRM research. They expressed concern about whether the scientific community has fully addressed issues such as moral hazard, prior informed consent, and the ethics of experimentation that, while potentially local and low-risk in physical terms, can carry global governance and legitimacy implications.

In response, experts noted that while ethical concerns are not unique to SRM, having also arisen in fields such as artificial intelligence, biotechnology, and genetic modification, SRM's global reach and potential for regionally differentiated effects make ethical engagement even more critical. Experts emphasized the need for early, inclusive involvement of stakeholders, particularly those most likely to be affected by potential interventions.

Clarification was also sought on existing practices for research ethics and governance, especially for field experiments. Experts noted there is no single, dedicated global governance framework for SRM research but pointed to voluntary initiatives—such as those led by the AGU and the U.S. National Academies—that promote transparency, funding disclosure, and responsible research conduct. They stressed that governance structures must evolve in tandem with research activities to ensure transparency, accountability, and global inclusivity.

3.1.2 Governance and oversight mechanisms

Member States and participants asked who governs SRM research and how oversight can be ensured, especially in field trials. There was particular concern about the lack of legal accountability and defined procedures should unforeseen impacts occur, or research require premature termination. Experts highlighted examples such as the Harvard-led Stratospheric Controlled Perturbation Experiment (SCoPEx[1]) and the Arctic Ice Project (Ice911[2]), both of which were voluntarily halted due to ethical or procedural concerns. These cases were framed as examples of science exercising caution and responsiveness in the context of ongoing debates about safeguards and governance.

[1] "An Update on SCoPEx," Salata Institute for Climate and Sustainability, Harvard University, March 6, 2024, https://salatainstitute.harvard.edu/an-update-on-scopex/.

[2] "A Final Chapter," Arctic Ice Project, March 12, 2025, https://www.arcticiceproject.org/a-final-chapter/.

Participants also raised concerns about how small-scale research can maintain legitimacy without implying support for eventual deployment. Experts stressed that research framing is critical, transparency in communicating research objectives and clear boundaries between basic inquiry and deployment pathways are essential to sustaining public trust and managing perceptions.

Additionally, some participants questioned whether a moratorium or non-use agreement should be considered in advance of SRM research activities. In response, some experts argued that such mechanisms could help build public trust and define ethical boundaries, while others cautioned that excessively restrictive frameworks might prevent the collection of vital scientific knowledge needed to inform future decision-making.

3.1.3 Compatibility with international legal frameworks

Member States expressed concerns about the legal status of ongoing SRM research, especially in light of the CBD decision (CBD XI/20[3]), often described as a de facto moratorium, which was reaffirmed in 2024. They questioned whether current field trials comply with requirements for controlled experimentation and scientific legitimacy.

In response, experts noted that small-scale experiments currently underway are primarily designed to understand fundamental physical processes and are not intended to simulate or promote deployment. As such, experts described these trials as incremental, risk-informed research efforts, not as violations of international law. Nonetheless, experts recognized the need for more explicit procedures and legitimacy criteria under international legal instruments, including the CBD and the London Protocol. Existing international laws—such as the Law of the Sea and human rights frameworks—were cited as already imposing precautionary obligations, but further legal clarity and institutional guidance were deemed necessary.

3.1.4 Equity, justice, and inclusive participation

Participants questioned how SRM research could be governed equitably, particularly given the historical marginalization of the Global South in international science and climate governance. Concerns were voiced about power asymmetries, especially the possibility that powerful states or private actors might dominate research and decision-making processes, excluding the most affected and least-resourced populations.

Experts emphasized that SRM governance must center equity. This includes ensuring meaningful participation from low- and middle-income countries, enhancing research capacity within underrepresented regions, and embedding civil society in all phases of governance. They stressed that inclusive governance is not just about consultation, but about enabling real influence over decision-making. Experts noted that the aim of research governance should be to generate robust and regionally informed knowledge to support future decision-making by governments and communities.

Furthermore, experts warned that SRM debates must not remain confined to scientific circles; rather, they must address the real concerns of decision-makers and frontline communities. The governance of SRM should move beyond the technocratic to embrace social legitimacy, intergenerational justice, and cross-sectoral dialogue across the science-policy-practice interface.

[3] CBD decision XI/20 - https://www.cbd.int/decision/cop?id=13181

3.1.5 Public trust, deliberation, and political feasibility

Throughout the discussions, participants emphasized that governance frameworks must also address how public perspectives and consent are incorporated into SRM research discussions. Some asked whether public consent should be secured before any data collection occurs and whether non-use agreements might serve to build trust and define ethical boundaries.

Experts noted that public engagement should not merely aim to inform or persuade but should involve deliberative, two-way processes that give the public a real voice in shaping research trajectories. Effective communication should include disclaimers about the limitations of current knowledge and make clear distinctions between research and deployment intentions.

Participants questioned whether SRM governance could succeed given the challenges faced by traditional climate governance. They questioned how society could regulate rapidly advancing technologies when political will is often weak, and when civil society spaces are under threat. In response, experts noted the need to build multilateral governance structures that could provide oversight and reduce the risk of unilateral or uncontrolled actions. They highlighted the need for formative evaluation of research processes to maintain accountability, uphold inclusive principles, and strengthen relationships across diverse communities and disciplines.

3.1.6 Transparency, data access, and knowledge sharing

Questions were raised by Member States regarding the transparency of SRM research, including how observational data is accessed globally, whether open-access platforms exist, and how data gaps, particularly in the Global South, are addressed.

Experts emphasized that transparency should extend beyond open publications to include funding sources, research objectives, and emerging findings. While initiatives like the Degrees Initiative are working to improve open data and funding transparency, systemic barriers remain—particularly for researchers lacking access to high-cost modelling tools or datasets. Experts called for urgent efforts to make data infrastructure more accessible and responsive to diverse regional priorities, including the creation of equitable, well-governed data-sharing mechanisms.

Concerns were also raised about who owns the data produced by SRM research, whether it belongs to researchers, funders, or public institutions, and whether such data will be treated as a public good. Experts responded that data ownership often depends on institutional and funding arrangements, and that clear data-sharing agreements, licensing protocols, and open-access commitments are needed from the outset. They also pointed to structural inequities in knowledge dissemination, such as the dominance of English in scientific publishing and paywalls that limit access in lower-income regions. Translation tools, open-access publishing, and non-English knowledge dissemination were recommended as practical ways to address these challenges.

3.2 Key uncertainties in SRM

3.2.1 Observational and empirical uncertainty

Member States asked what current gaps exist in monitoring infrastructure, and how those gaps affect the ability to identify SRM impacts. Experts noted that important knowledge gaps remain, particularly in understanding aerosol behavior in the first minutes and hours after injection—such as plume dispersion and microphysical evolution—due to the limited availability of real-time observational tools. Current satellite and ground-based systems have limited resolution, particularly in the Southern Hemisphere and developing regions. This limits the ability to calibrate or validate models, or to fully evaluate small-scale experimental outcomes.

Experts emphasized the need for enhanced rapid-response capabilities, expanded ground and airborne observational networks, and greater investment in globally distributed monitoring tools to close these gaps.

Experts also noted that small-scale SRM activities may be difficult to distinguish from natural climate variability, highlighting challenges for verification and accountability.

3.2.2 Uncertainty in physical and chemical processes

Some Member States raised questions regarding the robustness of SRM modelling, and how it compares to traditional climate models used by the IPCC, as well as how well-understood the underlying science is, particularly regarding aerosol dynamics and stratospheric chemistry, and how these uncertainties affect model representation and projections.

Experts clarified that SRM research relies on the same Earth System Models (ESM) as broader climate science, but SRM research introduces new layers of complexity. For example, aerosol microphysics—such as chemical interaction in the stratosphere remains an area of active research, as these processes are not yet fully represented in many global models and are challenging to study empirically.

3.2.3 Modelling and scenario uncertainty

Member States questioned how reliable SRM modelling results are, and how uncertainty is quantified and communicated in scientific outputs. Experts explained that model-based uncertainty in SRM has three main components:

- Natural variability, which includes the internal 'noise' of the climate system that can obscure or amplify SRM signals.
- Model uncertainty, stemming from structural limitations (e.g., coarse resolution, incomplete processes).
- Scenario uncertainty, which refers to unknowns in future emissions trajectories, deployment strategies, or governance responses.

To address these, researchers use ensemble modelling strategies, such as GeoMIP that compare multiple models running identical scenarios. This approach provides a mean estimate and a range that captures inter-model spread. While this is analogous to the CMIP used by the IPCC, experts highlighted that SRM-specific results are sensitive to model design and assumptions, underscoring the importance of using multiple approaches and maintaining transparency when communicating findings.

3.2.4 Ecological and biodiversity uncertainty

Member States expressed concern over how well current models account for SRM's potential impact on ecosystems and biodiversity, especially at regional scales. Experts explained that while climate variables such as temperature and precipitation can often be downscaled, ecological systems are highly complex and influenced by many interacting factors that are difficult to represent in global models. For instance, ocean temperature effects may be included, but impacts on ocean pH, nutrient cycling, or species interactions are often not represented at the global scale.

Experts highlighted that addressing these challenges requires interdisciplinary collaboration—where ecologists, modelers, and policymakers co-design models based on real-world policy questions. While no model can capture all ecosystem dynamics in full detail, continued integration of ecological expertise and clear communication of uncertainties can support more robust and policy-relevant assessments.

3.3 The precautionary principle in SRM

3.3.1 The precautionary principle in SRM research

Some Member States expressed deep concern about the direction and implications of SRM research and experimentation, underscoring the relevance of the precautionary principle and emphasized the importance of applying the precautionary principle to SRM research and experimentation.

Experts responded that this principle is widely seen within the scientific community as a guiding framework for responsible inquiry. While SRM raises complex questions—scientific, governance-related, and societal—researchers noted that the precautionary principle can help ensure that exploration proceeds carefully, transparently, and with appropriate safeguards.

3.3.2 The precautionary principle and hypothetical framing

Concerns were expressed about the implications of even discussing observational systems for SRM, questioning whether such discussions within international fora might contradict the precautionary principle. In response, experts clarified that the focus on observational systems relates to assessing scientific readiness and is not indicative of endorsement nor does it imply SRM deployment.

Applying the precautionary principle also involves anticipating and preparing monitoring needs in advance of any deployment scenario, should it ever arise. Developing frameworks and tools early ensures that, should SRM deployment ever proceed, systems for oversight and accountability are already in place. Waiting until after activities have begun would limit the ability to track impacts effectively and could compromise both scientific integrity and public trust.

3.3.3 Precautionary governance and Non-Use approaches

Member States raised concerns that ongoing SRM research may contribute to the technology's 'normalization', shaping perceptions and pre-empting political decisions about its desirability or legality. References were made to the de facto moratorium under the CBD as signal of the need for caution. They questioned whether research activities would create momentum towards deployment before ethical and legal concerns are fully addressed.

Experts clarified that in the case of SRM, 'non-use' does not imply a lack of research or information, but rather, the deliberate choice to explore impacts and feasibility without presuming that deployment will follow. From this standpoint, knowledge generation and the precautionary principle are complementary, and both must be carefully balanced. Experts also emphasized that research must remain clearly distinguishable from endorsement. Strong safeguards, such as public registries, transparency protocols, independent oversight, and clear distinctions between fundamental inquiry and applied research, are essential to maintaining this distinction.

Chapter 4

Main take aways

4.1 Science-related

- SRM is not a substitute for reducing greenhouse gas emissions; decarbonization and emission cuts remain the priority to address the root causes of climate change.
- SRM is currently being explored in the scientific and policy communities as a potential emergency response option. It refers to a set of intentional, large-scale interventions aimed at reflecting a portion of sunlight back into space, with the objective of temporarily cooling the planet. However, its feasibility and consequences remain under investigation, and research is proceeding in a careful, stepwise manner.
- Major scientific challenges remain, especially in:
  - Modelling long-term and regional effects,
  - Representing key small and fine scale processes (e.g., aerosol–cloud interactions)
  - Limitations of natural analogues (e.g., volcanic eruptions), which cannot fully represent SRM processes.
- Robust, long-term, and high-quality climate observations are essential for both SRM and global climate monitoring efforts.
- Climate models are currently the most powerful tool available for understanding general climate system processes and projecting future climate change. In the context of SRM, climate models help to assess how interventions might influence the climate system. While they remain the primary tools continued improvements are needed to better capture small-scale or regional phenomena, through enhanced downscaling methods.
- Distinction between SRM experiments and deployment must be clear, experiments should be designed to advance understanding of impacts, without implying deployment intent.
- Current modelling experiments vary in scope and design, thereby making comparisons difficult; more coordinated and standardized approaches across models and scenarios are needed.
- Uncertainties persist in both global climate models and future scenarios, including questions of how local experiments feed into global insights and how to manage impacts that may be unevenly distributed and hard to detect.

- AI and machine learning could reduce modelling costs and open access to SRM analysis for under-resourced regions.
- Social, ecological, and public health impacts are not yet systematically integrated in many studies and should be integrated from the start of any SRM research process.
- Time lags in attributing to the global impacts of SRM may be significantly longer than initially anticipated, with meaningful effects potentially taking 10 years or more to detect and attribute to SRM.

4.2 Ethics and justice

- Equity and justice are central to SRM research, requiring support for regional research leadership in the Global South and efforts to address disparities in funding, data access, and capacity.
- Existing climate solutions already available (e.g., energy efficiency, short-lived climate pollutant reductions) could yield near-term climate benefits and remain essential alongside any exploration of SRM.

4.3 Governance and oversight

- Transparency and open data sharing are essential for public trust. Current gaps in global governance mechanisms particularly affect low-capacity countries and should be addressed.
- Some views consider that trade-offs in SRM must be assessed using a risk–risk framing, comparing SRM's risks against the risks of worsening climate change, not against historical baselines.
- SRM research raises fundamental governance questions:
  - Should research itself be governed?
  - How should small-scale experiments be assessed in regions without environmental impact regulations?
  - How can global coordination on monitoring, modelling, and data sharing be improved?
- Decision-making must be science-informed, inclusive, and transparent, integrating environmental and societal considerations from the outset, not as an afterthought.
- Effective SRM governance requires bridging science, policy, and practice—actively engaging decision makers, civil society, and affected communities—to achieve informed, inclusive climate strategies.
- A governance framework is needed: without it, research could be misinterpreted as normalization of SRM, while without research, governance risks being uninformed or overly reactive.

Concluding Remarks

Following two days of intensive dialogue, UNEP and WMO concluded that the expert discussions fostered open, cross-disciplinary exchanges on the scientific, governance, and ethical dimensions of SRM. These conversations promoted greater mutual understanding between science and policy communities, helping participants better appreciate each other's perspectives, including the underlying concerns, priorities, and the intended goals of specific lines of research and inquiry. The discussions also helped clarify what is currently understood, progress in SRM research, highlighted key uncertainties, and identified critical areas where further inquiry is needed.

The discussions reinforced that SRM is a highly complex and evolving group of technologies situated at the intersection of science, ethics, justice, and international law. Addressing it responsibly requires coordinated, multidisciplinary collaboration rooted in the best available evidence. Trust emerged as a foundational element—built through transparent communication, explicit acknowledgment of uncertainties and knowledge gaps, and a commitment to adaptive processes that can adjust research pathways as new knowledge or risks emerge.

Participants emphasized the importance of co-developing research agendas, clearly defining objectives and funding sources, and being transparent about who may benefit or be exposed to risks. While views on SRM varied, there was broad agreement on the critical role of governance—particularly the duty of states to uphold human rights, including the UN-recognized right to a clean, healthy, and sustainable environment. Existing ethical frameworks and examples of multilateral cooperation were noted as valuable foundations that can be adapted and applied in this context.

Importantly, many participants emphasized that SRM does not address the root causes of climate change. There was clear consensus that the global priority must remain focused on urgently reducing greenhouse gas emissions, accelerating adaptation efforts, and addressing pollution and unsustainable resource use. SRM research and governance discussions should proceed alongside—but never as a substitute for—urgent action on greenhouse gas reductions, adaptation, and sustainable resource management. Responsible research requires caution, transparency, and impartial global oversight to ensure it supports informed decision-making in the context of broader climate action.

Annexes

Annex 1: Invited Experts and Panelists

	**Adam Day** Head of Policy and Research at the United Nations University Centre for Policy Research
	**Aarti Gupta** Professor in Global Environmental Governance at Wageningen University
	**Amanda Maycock** Professor in Climate Dynamics at the University of Leeds
	**Andrea Hinwood** UNEP Chief Scientist
	**Anna M. Stewart Ibarra** Executive Director of the Inter-American Institute for Global Change Research

	**Babatunde Abiodun** Professor of the Atmospheric Science Programme at the University of Cape Town
	**Bala Govindasamy** Researcher at the Centre for Atmospheric and Oceanic Sciences - Indian Institute of Science
	**Brandon Jones** President, American Geophysical Union; Director, National Science Foundation
	**Catriona McKinnon** Professor of Political Theory at University of Exeter
	**Christopher Lennard** Climate scientist at the Climate System Analysis Group, University of Cape Town
	**Christopher Trisos** Senior Research Officer at the African Climate and Development Initiative at the University of Cape Town
	**Daniele Visioni** Research Associate at Cornell University and co-chair of the Geoengineering Model Intercomparison Project

	**Dhanasree Jayaram** Professor at the Department of Geopolitics and International Relations at Manipal Academy of Higher Education
	**Dimiter Chalev** Director, Rule of Law, Equality, and Non-Discrimination Branch, Office of the High Commissioner for Human Rights (OHCHR)
	**Elisa Morgera** UN Special Rapporteur on Climate Change and Human Rights, Professor of Global Environmental Law at the University of Strathclyde
	**Frank Keutsch** Professor of Engineering and Atmospheric Science at Harvard University
	**Godwin Ayesiga** Climate scientist at the Uganda National Meteorological Authority
	**Graciela Raga** Senior Scientist at the Institute for Atmospheric Sciences and Climate Change at the Universidad Nacional Autónoma de México
	**Heri Kuswanto** Associate Professor at the Department of Statistics of the Institut Teknologi Sepuluh Nopembe

	**Inés Camilloni** Professor at the Department of Atmospheric and Ocean Sciences of the University of Buenos Aires and Vice-Chair of IPCC's Working Group I for the seventh assessment cycle
	**Jane C.S. Long** Fellow, Center for Global Security Research; Former Associate Director, Lawrence Livermore National Laboratory
	**Jesse Reynolds** Scholar of international environmental policy focusing on the governance of SRM; Degrees Initiative
	**John Moore** Research Professor at Arctic Centre, University of Lapland in Finland
	**Joshua Amponsem** Climate activist and Co-Director of the new Youth Climate Justice Fund initiative
	**Juan Moreno-Cruz** Associate Professor and Canada Research Chair in Energy Transitions, University of Waterloo
	**Julia S. Guivant** Professor at the Department of Sociology and Political Science, Federal University of Santa Catarina

	**Kate Ricke** Associate professor at the School of Global Policy and Strategy at UC San Diego California
	**Katja Fennel** Professor at the Department of Oceanography, Dalhousie University
	**Ko Barrett** WMO Deputy Secretary-General
	**Laura Wilcox** Associate Professor at the National Centre for Atmospheric Science at the University of Reading
	**Nana Ama Browne Klutse** Vice-Chair of IPCC's Working Group I - AR7 and Senior Lecturer at the Department of Physics at the University of Ghana
	**Obed Ogega** Programme Manager at the African Academy of Sciences
	**Pengfei Yu** Professor at the Institute for Environmental and Climate Research at Jinan University

	**Pornampai (Ping-Ping) Narenpita** Researcher at the National Electronics and Computer Technology Center of Thailand
	**Shuchi Talati** Scholar in Residence, Forum for Climate Engineering Assessment; Executive Director, The Alliance for Just Deliberation on Solar Geoengineering
	**Sikina Jinnah** Professor of Environmental Studies at UC Santa Cruz