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Spotlight on risk

A risk-risk assessment framework for solar radiation modification

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Concern about the increasingly high-probability, high-impact risks posed by global warming is driving the exploration of new techniques to artificially cool the planet through an approach known as solar radiation modification (SRM). Would the world be better off with or without such techniques? Would there be winners and losers? And how can we sufficiently compare the relative risks presented in a future with SRM against the risks faced in a future without it?

Such 'risk-risk' assessment poses particular challenges given uncertainties around the techniques and the extent of human-induced changes to the climate system that might be expected in the future. These uncertainties are further compounded by differences in stakeholders' framing and risk tolerance, as well as the level of complexity and the intertemporal nature of such assessment.

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To help address these questions, mindful of such challenges, we present here a basic risk-risk assessment framework providing a structure to help strengthen risk management considerations in the design of future climate response strategies.

The world faces an increasing number of global risks with cascading impacts that are testing the resilience and adaptability of natural and human systems, and stretching the capacity of national and international governance. Some of these risks pose clear and present danger in the short term, while others catastrophic, existential threats in the longer term.[1,2]

Climate change, in particular, presents both short- and long-term risks that whilst increasingly well understood,[3] continue to be insufficiently mitigated with a huge gap persisting between international commitments and the action needed to avoid[4] or adapt[5] to overshooting global warming of 1.5°C. Despite widespread awareness of these risks,[1,6,7] ongoing efforts to increase mitigation and adaptation[9] and a growing focus on the importance of large-scale carbon dioxide removal (CDR),[9] current international responses continue to place us on a trajectory way beyond 1.5°C global warming, where climate impacts pose increasing risks to natural and human systems[3] and to our ability to deliver sustainable development.[10]

The potential role of SRM in addressing climate risk

Concern about our increasing exposure to climate impacts is driving exploration of new techniques to artificially cool the planet through approaches known as 'solar geoengineering' or solar radiation modification (SRM).[11] SRM seeks to deliberately change the albedo of the Earth system, reflecting solar radiation back into space or allowing more heat to escape from the atmosphere to reduce peak temperatures resulting from climate change.

Examples of SRM include artificial injection of stratospheric aerosols, marine cloud brightening and land surface albedo modification.[3] The most researched SRM technique[3] is stratospheric aerosol injection (SAI), which proposes the dispersal of aerosols in the stratosphere to reflect solar radiation, imitating the global cooling observed following large volcanic eruptions.[12]

Recent research assessments suggest that SAI theoretically has the potential to limit global warming to below 1.5°C. While it would not address the root cause or all global risks resulting from climate change, it might be able to reduce some risks with potentially rapid large-scale effect at relatively low financial cost of deployment.[3,11,13] However, assessments also emphasise that the literature only supports SRM as a supplement to deep mitigation and highlights that the technique faces large uncertainties, knowledge and governance gaps, as well as substantial risks and institutional constraints to its deployment.[3] Uncertainties include issues relating to cost affordability, climate and environmental impacts, permanency, deployment mechanisms and social acceptability,[14] as well as implications for delivering societal objectives such as the Sustainable Development Goals (SDGs).[10] As many as 28 potential SAI-associated risks and concerns have been identified relating to physical and biological systems, human impacts, aesthetics, governance, ethics and other 'unknowns',[15] many of these raise governance challenges for which we do not currently have comprehensive international mechanisms to address. For example, consideration of SAI might delay or deter current mitigation efforts,[16] unilateral deployment might precipitate geopolitical tension or conflict,[17] and impacts from premature termination might occur if long-term deployment were not managed sustainably.[18]

In addition to intensifying efforts for emissions reductions, removals and adaptation, should SAI also be considered to help reduce risk from climate impacts? Would the world be better off with or without it? And who or what might be the winners or losers? While some argue it should not even be considered,[19] others propose that it should be further explored.[11,20] These are fundamental policy and governance questions that will need to be answered if SAI or other SRM techniques are to be rejected as too risky or explored further. So, how can we sufficiently compare the relative risks presented in a future with SAI against the risks faced in a future without it?

The challenge of uncertainty

Assessing climate risk is a highly complex, interdisciplinary endeavour.[21,22] Assessing the relative risks in different climate response strategies that include or exclude SAI presents additional challenges, given the large uncertainties around the potential feasibility, risks, and benefits of the technique, and the ex-ante and intertemporal nature of such assessment.

The assessments undertaken by the Intergovernmental Panel on Climate Change (IPCC) provide increasing levels of scientific certainty about the risks associated with different global warming pathways and possible mitigation and adaptation options to address them.[3] However, the substantial uncertainties and knowledge gaps around SAI[3] create an information asymmetry rendering normative comparison of risks highly challenging until such uncertainties are resolved. In particular, this uncertainty poses challenges to decision-makers needing to make intertemporal choices,[23] trading-off costs and benefits of different approaches at different points in time.

In the face of accelerating climate impacts, such choices are increasingly urgent and consequential, and both the tolerance of uncertainty and the valuation of costs and benefits of different options are likely to change over time, particularly as and when such impacts intensify.

For many, uncertainties and risks around SAI imply the application of a precautionary approach to its exploration or consideration[24] to avoid risk-risk trade-offs that create new problems while solving existing ones.[25] However, given the uncertainty around the extent of future human-induced changes to the climate system and whether or not global emissions will be sufficiently mitigated in time to avert catastrophic climate impacts, others suggest that the exploration of SAI is itself part of a precautionary approach to addressing the uncertainty around sufficient and timely climate action.[26]

The challenge of framing

The challenges for comparative risk assessment posed by uncertainty around SAI are further compounded by a range of individual and societal differences in the tolerance and framing of risks. Perceptions of risk are filtered through personal values and social context, leading different stakeholders to interpret risks differently based on perceptions of the consequences they will have on things that matter to them and the probability of this occurring.[27] Decision styles and risk attitudes vary[28] and assessments under uncertainty may also be subject to heuristic reasoning errors and cognitive biases such as ambiguity-aversion,[29] loss-aversion,[30] confirmation bias[31] and groupthink.[32] Cultural differences and understandings can also influence tolerances and framing around climate risk[22], and interpretation of risk can change as understanding changes.[33] Consequently, individual and societal perceptions can differ widely,[27] hence why some regard SAI as a responsible technological option in the face of a climate emergency, while others view it as a hubristic attempt to play God, posing disastrous consequences for the planet and humanity.[34]

A risk-risk assessment framework

Comparing risks presented by climate response strategies that include or exclude SRM techniques, such as SAI, is complex and challenging. Established literature explores risk-risk trade-offs across a variety of domains[35] and more recent literature explores them in relation to SRM[36,37] considering what implications they might have,[10] how they might be addressed[38] and what tasks and actors might be involved in their governance.[39,40] Addressing the challenges highlighted above, we propose here a basic risk-risk framework providing a structure to guide comparative risk assessment to strengthen risk management in the development of future climate response strategies. It is intended as a starting point rather than a final word and a framework rather than a sequential process. It raises more questions than it answers and will undoubtedly benefit from refinement as our understanding of climate risk management and governance evolves in the future.

1. **Identify common objectives**
   Base assessments on internationally agreed objectives for global common goods broadly valued by all and based on shared personal and societal values to minimise contestation over “what matters” when assessing risk. A sustainable development frame might provide a useful starting point,[34] and a pragmatic basis at the international level could be found in the Sustainable Development Goals (SDGs) and whatever follows them after 2030.

2. **Strengthen common understanding**
   Strengthen and agree on the evidence base to help reduce uncertainty and contestation, mindful of concerns that even the most neutral and careful research or deliberation of SRM

may affect future mitigation efforts.[16] While uncertainty cannot be completely removed, strengthening understanding can help to reduce ambiguity and uncertainty and increase risk tolerance. Including both science-based analyses as well as social appraisal through processes such as participatory deliberation[41] could help to strengthen agreement and reduce contestation. This might, for example, include more transdisciplinary research to better understand: (i) if and how SRM might be technically feasible and socially acceptable, (ii) positive and negative impacts (and their likelihood) on global common goods (as mentioned above) arising from different climate response strategies (with and without SRM) over time, and (iii) whether and how SRM can be governed. Assessments incorporating both research and inclusive social appraisals[42] engaging globally diverse and transdisciplinary perspectives could help to address the high level of complexity, variance in perceptions and to avoid groupthink and other biases. International assessment processes such as those undertaken by the IPCC could facilitate addressing knowledge gaps and building common understanding towards consensus on the evidence base. At the same time international discussions could be catalysed to raise awareness and broaden understanding of the potential risks, benefits and governance challenges around different climate response options (with and without SRM).

3. **Build consensus**
   Convene international discussions for deliberations to strengthen common understanding and build consensus in assessing risks. Broad-based, inclusive and transparent participation, incorporating diverse international perspectives and mindful of power differentials between actors[43] could increase the likelihood of reaching consensus around common objectives and understanding (as mentioned above), and consequent assessment of risk in different climate response strategies (with and without SRM). Such deliberation could be facilitated through existing intergovernmental processes but may also require novel processes or institutions to be developed for the purpose. Governments, through the United Nations, could initiate informal or even formal processes with such aims. Based on reviews of the risks, benefits and governance challenges of the various techniques by entities like the UN Environment Assembly (UNEA) and through assessments of the latest science by the IPCC, initial consideration by the UN General Assembly (UNGA) of how SRM could be addressed in a broad sustainable development framework would be optimal. The UNGA is the main deliberative, policymaking, and representative organ of the only truly universal global organisation and is able to deliberate transparently on such issues and policy that cut across traditional sectors and national boundaries and cannot be resolved by any one country acting alone.

Conclusion

Strengthening international governance around managing climate risk to safeguard global common goods requires increasingly urgent attention, and assessing the relative risks presented by emerging SRM approaches such as SAI against those posed by the impacts from our current climate trajectory is at the heart of such governance considerations.

↦ To learn more about the governance of solar radiation modification, visit c2g2.net

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