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## Climate engineering responses to climate emergencies

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### Climate engineering responses to climate emergencies

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Scientific uncertainties in the climate system's sensitivity to changes in GHG concentrations do not allow a 'safe' level of atmospheric CO<sub>2</sub> to be defined. Even within the IPCC's "likely" (66% confidence) range of temperature sensitivity (between 2°C and 4.5°C for a doubling of CO<sub>2</sub>), the expected consequences of GHG-induced warming range from mild to severe, and "values substantially higher than 4.5°C cannot be excluded." [1] Although international efforts to stabilize CO<sub>2</sub> concentrations might prove sufficient to prevent or delay severe climate impacts, there is a widely recognized and non-negligible possibility that the climate system could respond rapidly and non-linearly, [2] with catastrophic consequences for human societies and natural ecosystems. [3] The authors of this abstract gathered for a one-week intensive study to explore Short-Wave Climate Engineering (SWCE) technologies as potential insurance against a range of such catastrophic scenarios. In particular, we focused on potential SWCE responses (i.e., reductions in the short-wave solar radiation absorbed by the Earth's) to scenarios wherein severe consequences of climate change manifest too fast to be significantly averted by even immediate and aggressive mitigation efforts. We termed such scenarios Climate Emergencies. This presentation will summarize the main insights and conclusions from that study (to be published in a forthcoming report). The study group defined a range of technical issues that should be evaluated when considering the possible use of an SWCE response to climate emergencies. Examples include: the limited applicability of SWCE to some possible climate emergencies; the expected imperfect compensation of GHG-induced climate change by SWCE; transient versus equilibrium climate responses to SWCE; and questions of reversibility and controllability of SWCE interventions. In each case, our current scientific understanding and critical outstanding questions were elucidated. Underlying our examination of each of these (and several other) issues was a core concern about the current poor understanding of the likely climate impacts of SWCE interventions, which makes any near-term deployment of such concepts quite risky. But given the possibility of climate emergencies threatening catastrophic consequences, societies might choose to initiate research toward reducing this uncertainty and so enable more accurate and confident risk assessments of potential SWCE responses. The study group therefore outlined an agenda of scientific and engineering research that could, within the next decade, maximally reduce uncertainty in one particular SWCE concept, particle-based stratospheric albedo modification. [4] This work is also meant to exemplify the type of comprehensive research necessary to evaluate any SWCE concept. This research agenda involves three major streams:

- (1) Climate Science;
- (2) Climate Monitoring; and
- (3) Deployment Engineering.

Moreover, the components of each stream are clustered into three phases:

- (I) Laboratory/Computer-based Research;
- (II) Field Experiments; and
- (III) Deployment. We explored a handful of technical questions surrounding the design of field experiments, providing some quantitative insight into their scientific value, limitations, and risks.

The study group made no attempt to answer the question of whether SWCE technologies should ever be deployed—or even whether any parts of the proposed research program should be pursued. Such questions are the subject of a vigorous and ongoing debate, [5] involving socio-political and economic issues—including considerations of the impact of SWCE concepts on mitigation efforts—beyond the scope of our

workshop. Instead, by addressing technical questions about the research necessary to reduce the uncertainty surrounding potential SWCE interventions, the authors hope to better inform the ongoing debate about whether (or what types of) climate engineering research should be pursued.

#### References and Footnotes

- [1] Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report*, IPCC Fourth Assessment Report, November 17, 2007, 38.
- [2] *Ibid.*, 65. The IPCC AR4 discusses the 'risks of large-scale singularities' as one of the five 'reasons for concern' about climate change.
- [3] *Ibid.*, 53. Quote: 'Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change.'
- [4] In this study we considered the full range of proposed/possible particles that could be injected into the stratosphere to increase the Earth's albedo. For key examples of such concepts, see: National Academy of Sciences, "Chapter 28: Geoengineering," in *Policy Implications of Greenhouse Warming: Mitigation, Adaptation, and the Science Base* (National Academies Press, 1992), 433-464; DW Keith, "Geoengineering the climate: History and prospect," *Annual Review of Energy and the Environment* 25 (2000): 245-284; Paul J. Crutzen, "Albedo enhancement by stratospheric sulfur injections: A contribution to resolve a policy dilemma?," *Climatic Change* 77, no. 3-4 (August 2006): 211-219. [5] See for example: Paul J. Crutzen, "Albedo enhancement by stratospheric sulfur injections: A contribution to resolve a policy dilemma?," *Climatic Change* 77, no. 3-4 (August 2006): 211-219; R. J. Cicerone, "Geoengineering: Encouraging research and overseeing implementation," *Climatic Change* 77, no. 3-4 (August 2006): 221-226; J. T. Kiehl, "Geoengineering climate change: Treating the symptom over the cause?," *Climatic Change* 77, no. 3-4 (August 2006): 227-228; M. G. Lawrence, "The geoengineering dilemma: To speak or not to speak," *Climatic Change* 77, no. 3-4 (August 2006): 245-248; M. C. MacCracken, "Geoengineering: Worthy of cautious evaluation?," *Climatic Change* 77, no. 3-4 (August 2006): 235-243; Alan Robock et al., "Has the time come for geoengineering?," 2008, <http://thebulletin.org/web-edition/roundtables/has-the-time-come-geoengineering>.