Co-CREATE

Seminar

Towards a European Blueprint for Responsible Solar Radiation Modification Research

14 February 2025

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UK Research and Innovation

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Welcome

Matthias Honegger
Perspectives Climate Research

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Agenda

10:00-10:05	**Welcome** Matthias Honegger (Senior Research Associate - Perspectives Climate Research)
10:05-10:10	**Introductory Remarks** Dušan Chrenek (Principal Adviser - European Commission)
10:10-10:35	**Co-CREATE Lightning Talks:** • **The Range of Scientific Experiments that might need a Governance Framework** Ben Redmond Roche (Research Fellow - UCL) • **SRM Research Ethics and Governance** Dominic Lenzi (Assistant Professor - University of Twente) • **The legal and Regulatory Mapping of SRM Research Governance** Julie Vinders (Senior Research Analyst - Trilateral Research) • **Dimensions of Potential Guidelines and Principles for SRM Research Governance** Matthias Honegger (Senior Research Associate - Perspectives Climate Research)
10:35-11:10	**Open Moderated Discussion**
11:10-11:15	**Closing Remarks**

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“The consequences of the climate crisis can already be felt all over the world.

… the biggest security challenge of our time.”

Annalena Baerbock
Federal Minister for Foreign Affairs, Germany

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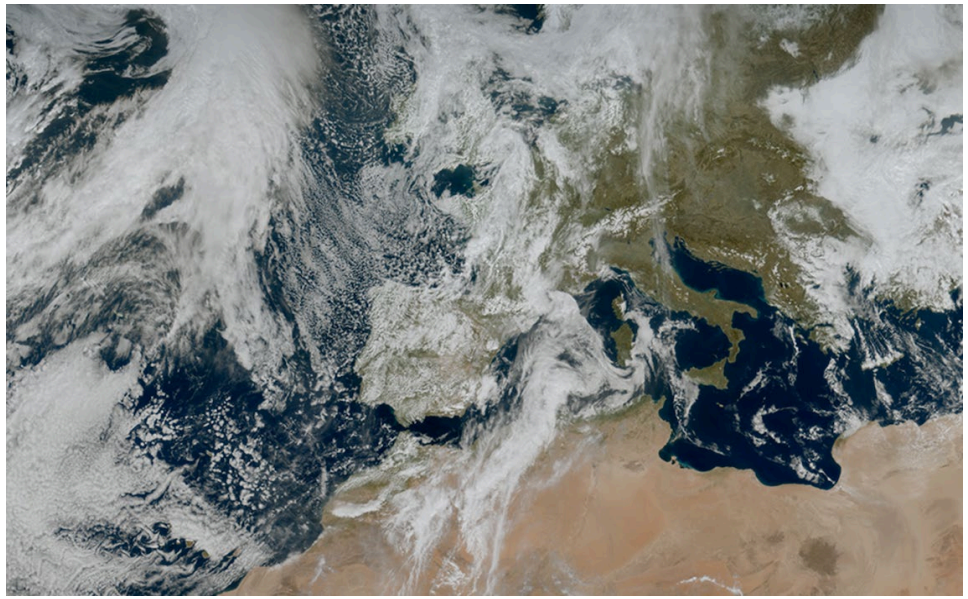
Solar Radiation Modification (SRM)

What is (known about) it?



First image from Europe's 3rd Gen Meteosat (EUMETSAT & ESA).

- European Environment Agency - climate risk assessment: **Europe is not prepared for the coming threats**
- Interest in SRM is growing (public and private)
- Intergovernmental Panel on Climate Change:
  - SRM could reduce some climate change impacts
  - But deployment holds risks; limited confidence in regional climate responses

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The Project's Mission

What we are tasked to do

… explore conditions and a possible governance framework for experimental research on SRM

… whether and how the governance of SRM field research could work

… better understanding of risks and conditions that influence desirability (for stakeholders)

… **without prejudice to its potential use** in policy-making or regulation

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Introductory Remarks

Dušan Chrenek
European Commission

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Co-CREATE Lightning Talks

- What field research?
- Research ethics aspects
- Legal aspects
- Guidelines and principles

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The Range of Scientific Experiments (that may need a Governance Framework)

Dr Benjamin Redmond Roche
University College London

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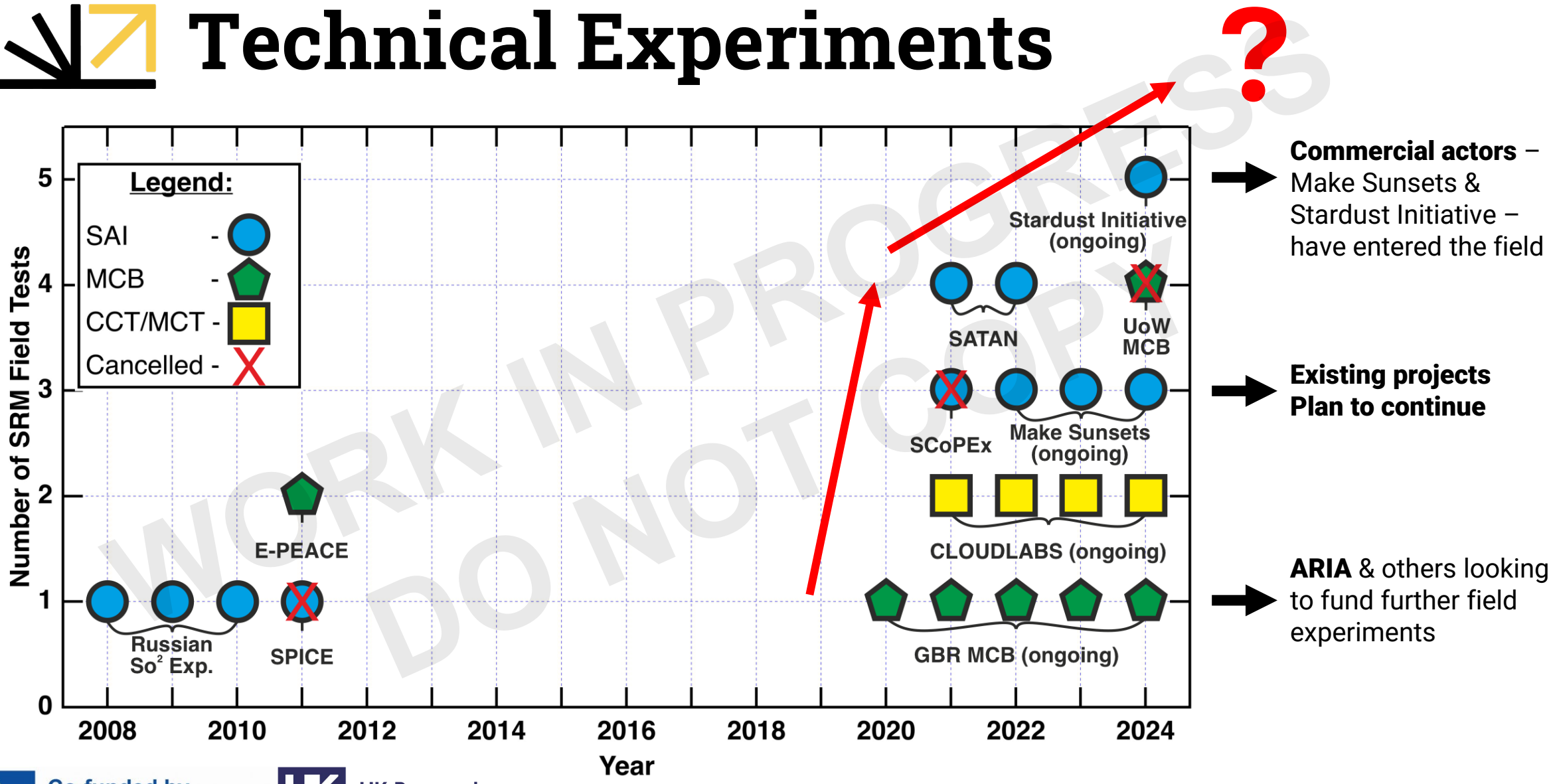
Technical Experiments



Commercial actors – Make Sunsets & Stardust Initiative – have entered the field

Existing projects Plan to continue

ARIA & others looking to fund further field experiments

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Redmond Roche et al. (2025) In Prep.

Scale	Stratospheric Aerosol Injection (SAI)	Marine Cloud Brightening (MCB)	Cirrus Cloud Thinning (CCT)
Near-term Experiments ≤$10m			
Mid-term Experiments $10m – 100m			
Long-term Experiments $100m – $1b+			

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Redmond Roche et al. (2025) In Prep.

Scale	Stratospheric Aerosol Injection (SAI)	Marine Cloud Brightening (MCB)	Cirrus Cloud Thinning (CCT)
Near-term Experiments ≤$10m	**Negligible environmental impacts** **Description and Purpose:** • 10-100s kg released • Technology development e.g. nozzles • Process understanding/feasibility test • Verify models **Governance Issues:** • Stakeholder engagement • Transparency • Follow existing laws e.g., UNCLOS/UNCBD **Field experiments of this scale have occurred and are likely to increase in number**		
Mid-term Experiments $10m – 100m			
Long-term Experiments $100m – $1b+			

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Mid-term Experiments $10m – 100m	**Very small environmental impacts** **Description and Purpose:** • 1 tonne + released • Testing under different conditions/timescales • Refine climate models **Additional Governance Issues:** • Potential minor short-term **local** cooling effects or impacts on precipitation • Environmental Impact Assessment (EIA) likely required		
Long-term Experiments $100m – $1b+			

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Redmond Roche et al. (2025) In Prep.

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Long-term Experiments $100m – $1b+	**Description and Purpose:** • 100-1000s tonnes released • Measure radiative forcing effects • Assess climate impacts • Validate climate models	**Minor environmental impacts** **Additional Governance Issues:** • **Transboundary effects unavoidable**: requires multilateral governance frameworks	

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Redmond Roche et al. (2025) In Prep.

Key Takeaways

- **SRM experiments could progress in three stages**
  - Near-term, Mid-term, and Long-term
- **Each stage raises different governance challenges**
- **These raise key governance questions:**
  - Who are the key stakeholders?
  - How might governance vary for each stage?
  - Which governance level is appropriate (at different scale)?
  - Could stage-specific exit ramps work?

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SRM Research Ethics and Governance

Dominic Lenzi
University of Twente

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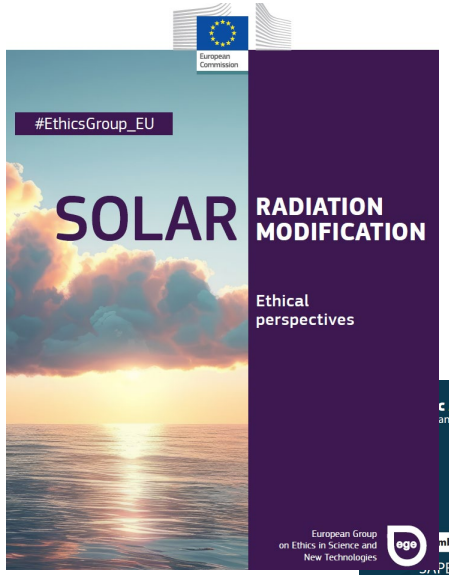
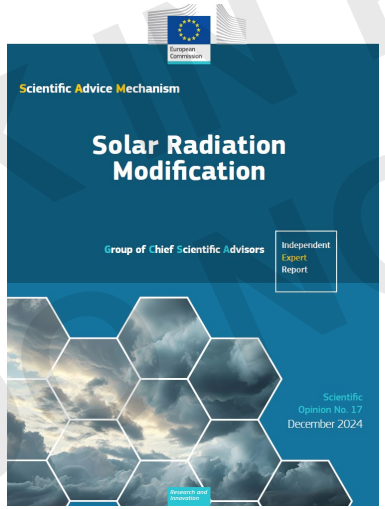
History





2007

Ocean Fertilization under the London Convention
International Marine Organization ●

2010

Ocean Fertilization: A scientific summary for policy makers
UNESCO Intergovernmental Oceanographic Commission , Wallace et al. ●

The Ethics of Geoengineering
Jamieson, D. ●

Asilomar Recommendations
Asilomar Scientific Organizing Committee ●

Climate-related Geoengineering and Biodiversity
United Nations Convention on Biological Diversity ●

2019

Proposed Resolution on Geoengineering and its governance
United Nations Environmental Programme – UNEA 4th Session ●

2021

Reflecting Sunlight
National Academies Sciences Engineering Medicine ●

2023

The Ethics of climate engineering
COMEST – UNESCO ●

One Atmosphere
United Nations Environmental Program ●

A Code of Conduct for marine CDR Research
Aspen Institute ●

Impact of new technologies for climate protection on the enjoyment of human rights
United Nations Rights Council ●

Reducing the Risks of Climate Overshoot
The Climate Overshoot Commission ●

CDR Swiss Policy White Paper
Swiss Carbon Removal Platform ●

Kigali Declaration & Lighthouse Initiative
World Climate Research Program ●

2009

Oxford Principles
Oxford Geoengineering Programme ●

The Anchorage Declaration
Indigenous People' Global Summit on Climate Change ●

Solar Radiation Management Governance Initiative
Royal Society ●

2018

The Tollgate Principles for the Governance of Geoengineering
Gardiners, S.M, and Fragniere, A ●

2020

A Code of Conduct for Responsible Geoengineering Research
Hubert, A.M. ●

2022

CDR Governance Principles
Honegger, M., et al. ●

2024

Proposed Resolution on SRM
United Nations Environmental Programme – UNEA 6th Session ●

Co-CREATE project
European Union ●

Glacial Climate Intervention: A Research Vision
MacAyeal, D. R., Mankoff, K., Minchew, B., Moore, J., and Wolovick, M. ●

Ethical Framework for Climate Intervention
American Geophysical Union and Independent contributors ●

KEY

Climate Intervention or Geoengineering ●
Carbon Dioxide Removal ●
Solar Radiation Modification ●
Emerging Technology and Research ●

Non-exhaustive

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GCSA, EGE, AGU Ethics Recommendations

Key Areas	Overlaps	Differences
Governance	International oversight and regulation	GCSA calls for a global moratorium & permits for limited outdoor experiments; EGE says participatory processes should determine scope of research, incl. when to stop; AGU focuses on enhanced transparency and procedural inclusion
Public/Stakeholder Involvement	Inclusive participation	GCSA mandates citizen assemblies; EGE highlights interests of fut. gens., non-humans & vulnerable groups; AGU stresses vulnerable & indigenous groups
Ethics & Responsibility	Ethics review must expand to cover SRM risks	GCSA says research must follow EU ethics principles & consider indirect and direct effects; EGE highlights legitimacy and precaution; AGU wants research advised by ethicists
Transparency	Need for open data	GCSA calls for transparency (results & funding); AGU for transparency in model scenarios; EGE for int. research registry
Research Limits	Strict oversight for outdoor research	GCSA allows limited outdoor experiments; EGE places liability on researchers, highlights responsibility to society; AGU treats indoor & outdoor research similarly

Expanding Research Ethics for SRM

- All contributions call for significant expansions to research ethics processes; & inclusion of publics

- Lacking clarity and agreement about precise role/s of stakeholders/publics, or their nature (e.g. parallel or prior to research? Representation?)

- GCSA: recommends funding is ‘clearly targeted to support the EU’s position in international negotiations.’ An ethics review criterion?

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A legal and Regulatory Mapping of SRM Research Governance

Julie Vinders
Trilateral Research

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Scoping of Legal Issues

Many existing norms, including legal frameworks and principles, are applicable & relevant to SRM

Identification of legal issues & relevant legal frameworks

Basis for in-depth legal analysis (WP4)

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Method for Identifying Legal Issues

What?

- Intent, effect and scale
- Research type
- Research / deployment
- Materials / chemicals used

How?

- Degree of transparency & consultation
- Level of risk

Who?

- Conducts the research
- Is affected by it
- Governs/controls the activity
- Funds it
- Owns rights and interests
- Is responsible/liable in event of harm

Where?

- Location: land, air, water, ice, space
- On national territory or areas beyond national jurisdiction (international waters, Antarctica or space)
- Transboundary impacts

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Relevant Legal Dimensions

Legal frameworks:

- Human rights law
- Indigenous rights law
- Environmental law
- Climate change law
- Outer space law
- Law of the Seas
- Polar law
- Intellectual property law
- Rules on responsibility and liability

Types of laws:

- Substantive rules
- Procedural rules
- Legal principles
- Rules related to research activities

Governance levels:

- International, national & EU

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Legal Issues

Overarching challenges:

- Ambiguities and conflicts among definitions
- Interpretation of existing laws and legal principles
- Limitations in the suitability of existing legal frameworks for the governance of SRM
- Adequacy of governance mechanisms and their effectiveness
- Tensions between countervailing risks of climate change and of SRM

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The Dimensions of Potential Guidelines and Principles for SRM Research Governance

Matthias Honegger
Perspectives Climate Research

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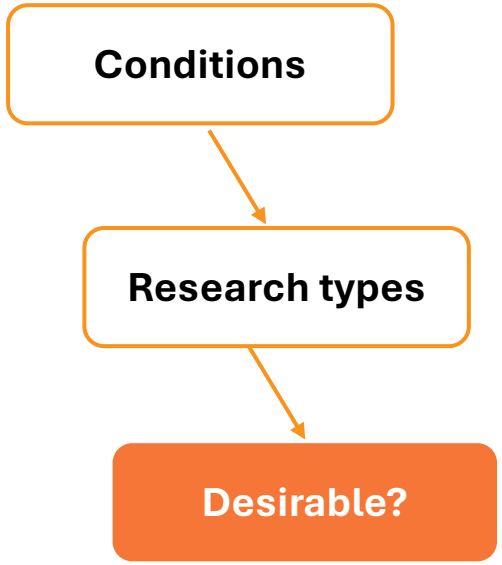
The Question



Under which conditions and governance arrangements would **SRM field research** be desirable for reducing uncertainties and lowering the probability of problematic outcomes including unilateral deployment elsewhere?

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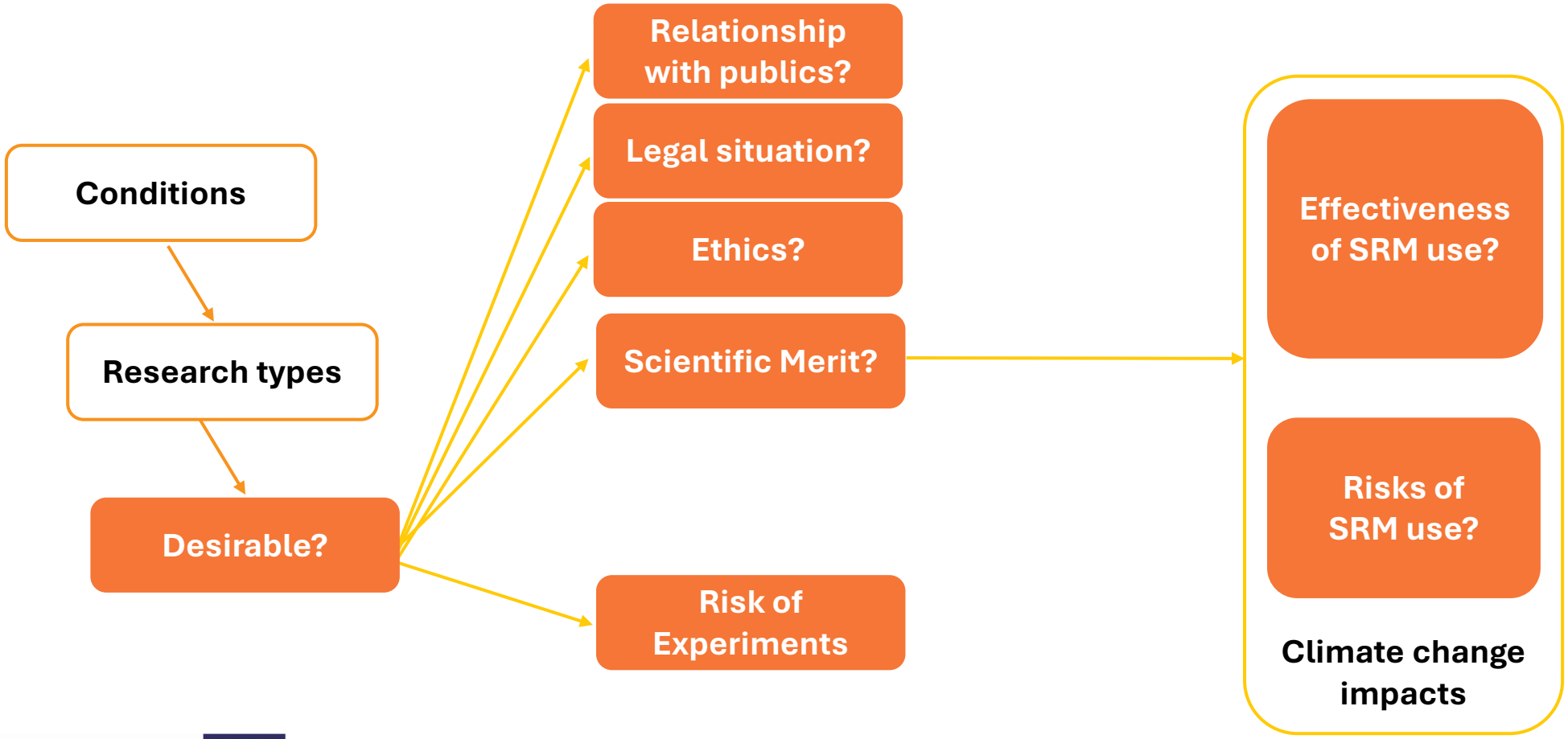
Our Contribution: Structure



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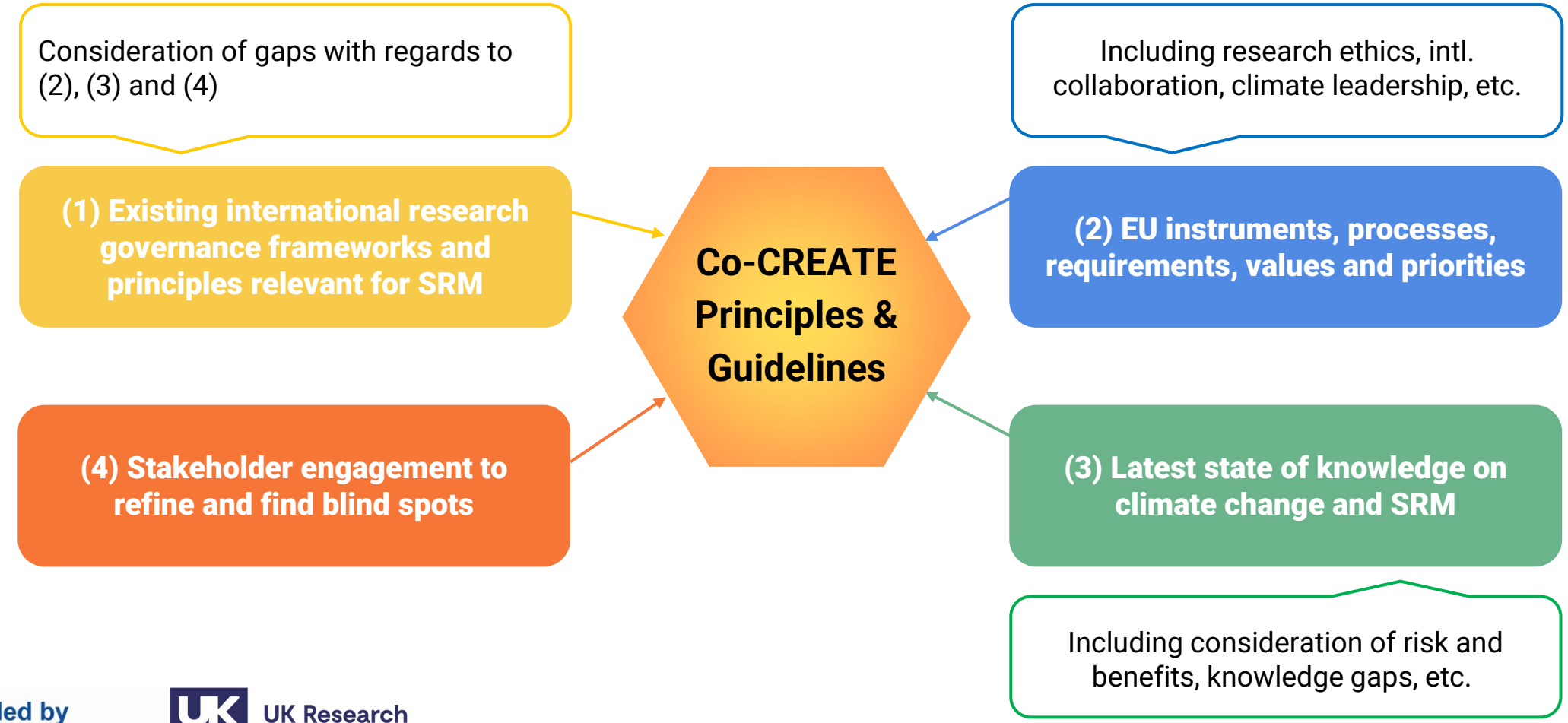
Identifying Principles



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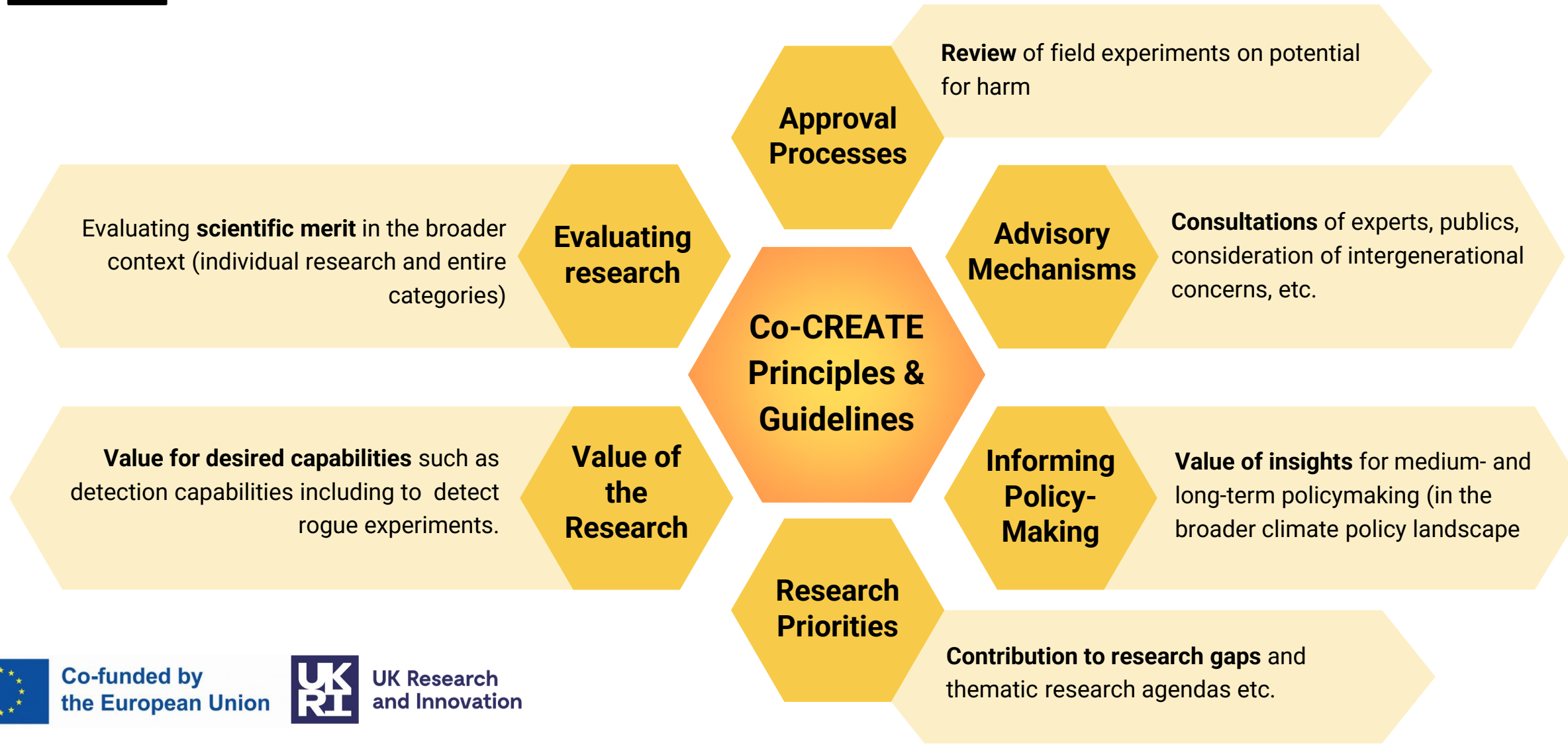
Guideline Use Cases



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Normative Landscape

...feared to **distract from climate change mitigation or leading to dangerous SRM use.**

...desirable for reducing uncertainties and lowering the **probability of problematic outcomes including unilateral deployment elsewhere.**

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Open Moderated Discussion

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Our Rules of Co-creation

1. We **actively listen** to each other and give people time and means to articulate their views.
2. We do our best to **be concise and clear** in our discussion, allowing everyone a chance to participate.
3. We participate with intention and **stay within the topics** of discussion.
4. We **build on each other**'s views, encouraging diverse perspectives.
5. We **channel kindness** and inclusion in our interactions, assuming best intentions and being willing to forgive.

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Guiding Questions

Given what you have heard on our ongoing work:

- Clarifying questions?
- What aspects should the team consider in its work?
- Who should our guidelines and principles be directed toward?
  Research funders, research evaluators, researchers, or others?)

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Thank you for co-creating with us!

Join the Stakeholder Forum!
A platform for diverse parties to connect and exchange on SRM research governance

LinkedIn
Don’t miss out on everyday updates from the Co-CREATE Project!

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Annex: additional information

Extra Slide: Technical experiments

Scale	Stratospheric Aerosol Injection (SAI)	Marine Cloud Brightening (MCB)	Cirrus Cloud Thinning (CCT)
Near-term Experiments ≤$10m	**Description:** • Balloon experiment releasing <1 tonne of material **Purpose:** • Improve understanding of particle properties and cooling effectiveness	**Description:** • Ship-based experiment spraying sea salt into the low atmosphere over 4-6 weeks **Purpose:** • Confirm the feasibility of the particles brightening clouds and develop the technology	**Description:** • Drone experiment releasing 1 kg of material in the upper troposphere **Purpose:** • Confirm the feasibility of the particles thinning clouds and develop the technology
Mid-term Experiments $10m – 100m	**Description:** • Repeatedly releasing 1+ tonne of material with balloons **Purpose:** (Limited) • Increase knowledge of particle processes and efficacy in different conditions	**Description:** • Extended campaign with more improved sea-salt spraying devices **Purpose:** • Evaluate impacts on cloud properties and further develop technology	**Description:** • Drone experiment releasing 100+ kg of material **Purpose:** • Evaluate impacts on cloud properties and further develop technology
Long-term Experiments $100m – $1b+	**Description:** • Releasing 100-1000+ tonnes with modified aircraft **Purpose:** • Quantifying effects on radiative forcing and verifying global climate models	**Description:** • Multiple vessels operating for months to produce consistent cloud modification **Purpose:** • Validate cooling potential and demonstrate efficacy of deployment approach	**Description:** • 1-100 tonnes of material being released by aircraft **Purpose:** • Validate cooling potential and demonstrate the efficacy of cirrus cloud thinning

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Extra slides: SRM Research Ethics

SRM and the ‘Public’

- Special nature of SRM research & urgency of governance
- Universal call for any research to be done in the interests of society, and with publics/stakeholders
  - Calls for ‘inclusive’ participation in research (AGU; COMEST; Chief scientific advisors; EGE)
- Justifications for inclusion differ
- Requirements for inclusion differ
  (as do definitions of the ‘public’)

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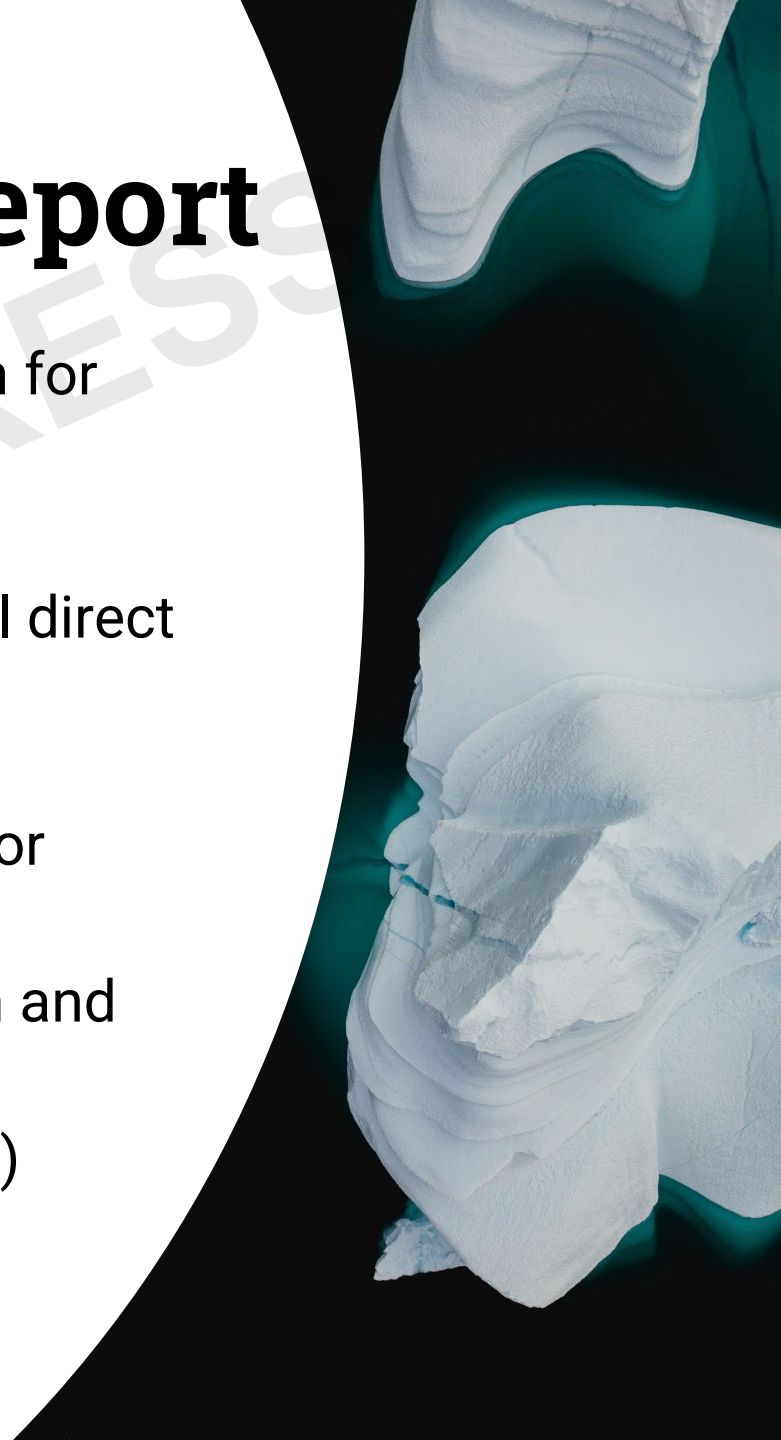
Highlights from GCSA report

- EU should negotiate multilateral global governance system for SRM; propose a moratorium on use
  - Permitting process for limited outdoor research
- Any research must follow EU ethical principles, consider all direct and indirect effects and unintended impacts, including governance and justice issues
- Public consultation among affected populations for small or large-scale outdoor experiments
- Periodic review of risks and opportunities of SRM research and deployment every 5-10 years
- Citizen assemblies for public debate (nationally/across EU)



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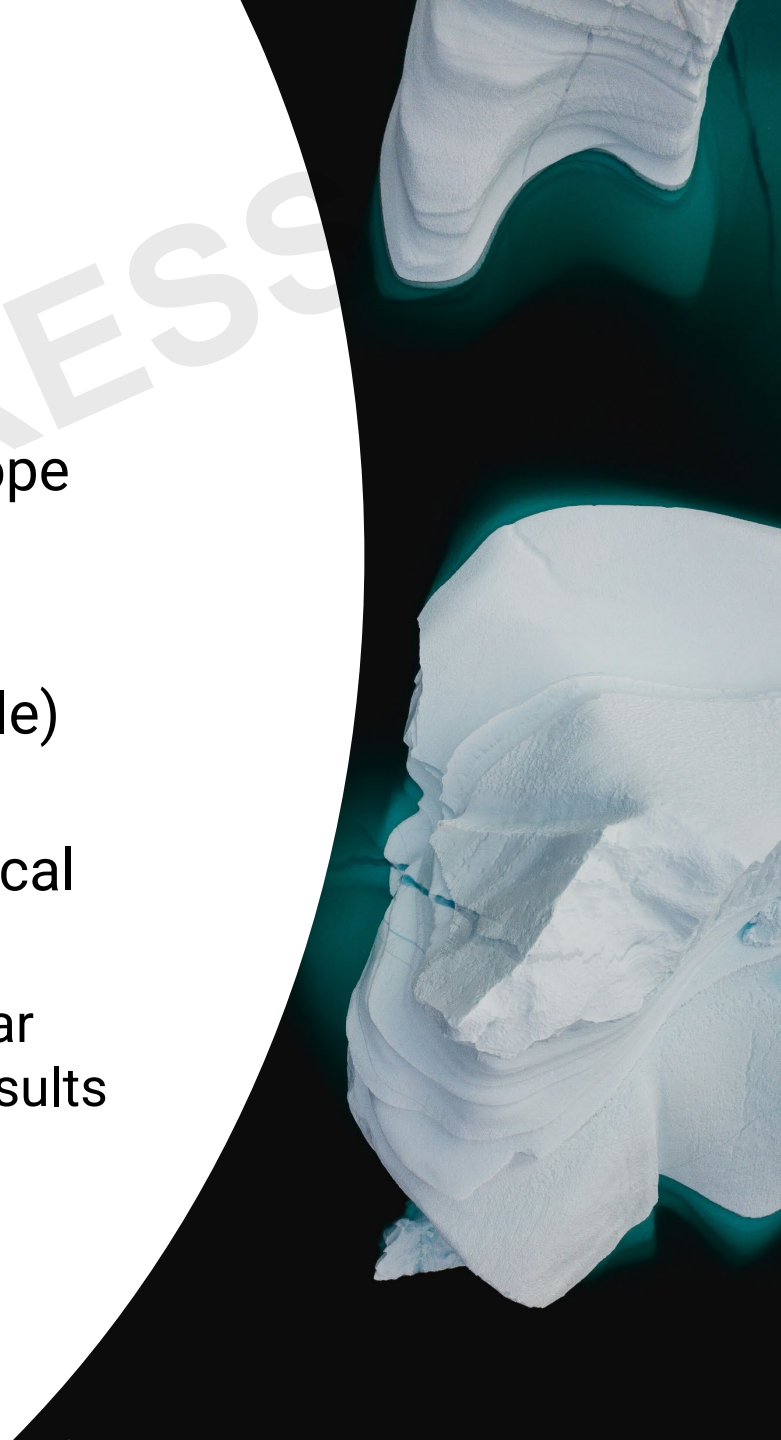
Highlights from EGE

- Scientific freedom within societal limits (echoes UNESCO)
- Participatory and inclusive processes should determine scope of research, including when to halt experimentation
- Set up a global observatory of SRM research
- International agreements (as broad and inclusive as possible) necessary even for modelling
- Expand ethics review processes to include full range of ethical dimensions of research & deployment risks
  - Researchers conducting small-scale outdoor experiments bear full responsibility for outcomes; should avoid advocacy, as results cannot justify deployment



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Highlights from AGU

- Procedural justice: stakeholders involved in ‘discussion’ of ‘purposes and design’ of research
- Expanded transparency, incl. model scenarios
- No distinction b/w ethical requirements for indoor/outdoor
- Research to primarily evaluate effect on climate impacts
  - Tension w/ EGE (& Tollgate Principles): research reflect uncertainty & avoid risk-benefit estimates where impossible
- Research to be advised by ethicists and social scientists
- Wide scope for involvement of indigenous groups; role of other publics and stakeholders under-specified

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Ethics Recommendations

Key Area	Overlaps	Differences
Governance	Need for international oversight and regulation	GCSA calls for a global moratorium; EGE emphasizes scientific freedom within limits; AGU focuses on transparency
Public Involvement	Agreement on inclusive participation	GCSA mandates citizen assemblies; EGE requires broad international agreements; AGU stresses stakeholder discussions but lacks specifics
Ethics & Responsibility	Ethics reviews must expand to cover full SRM risks	GCSA ties ethics to EU principles; EGE holds researchers fully responsible; AGU integrates ethicists into research process
Transparency	Broad agreement on the need for open data	AGU uniquely calls for transparency in model scenarios; EGE proposes an international research registry
Research Limits	All agree on oversight for outdoor research	GCSA allows limited outdoor experiments; EGE places full liability on researchers; AGU treats indoor and outdoor research the same

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