Emerging Risk Governance for Solar Radiation Management

6th Annual Governance of Emerging Technologies and Science (GETS) Conference
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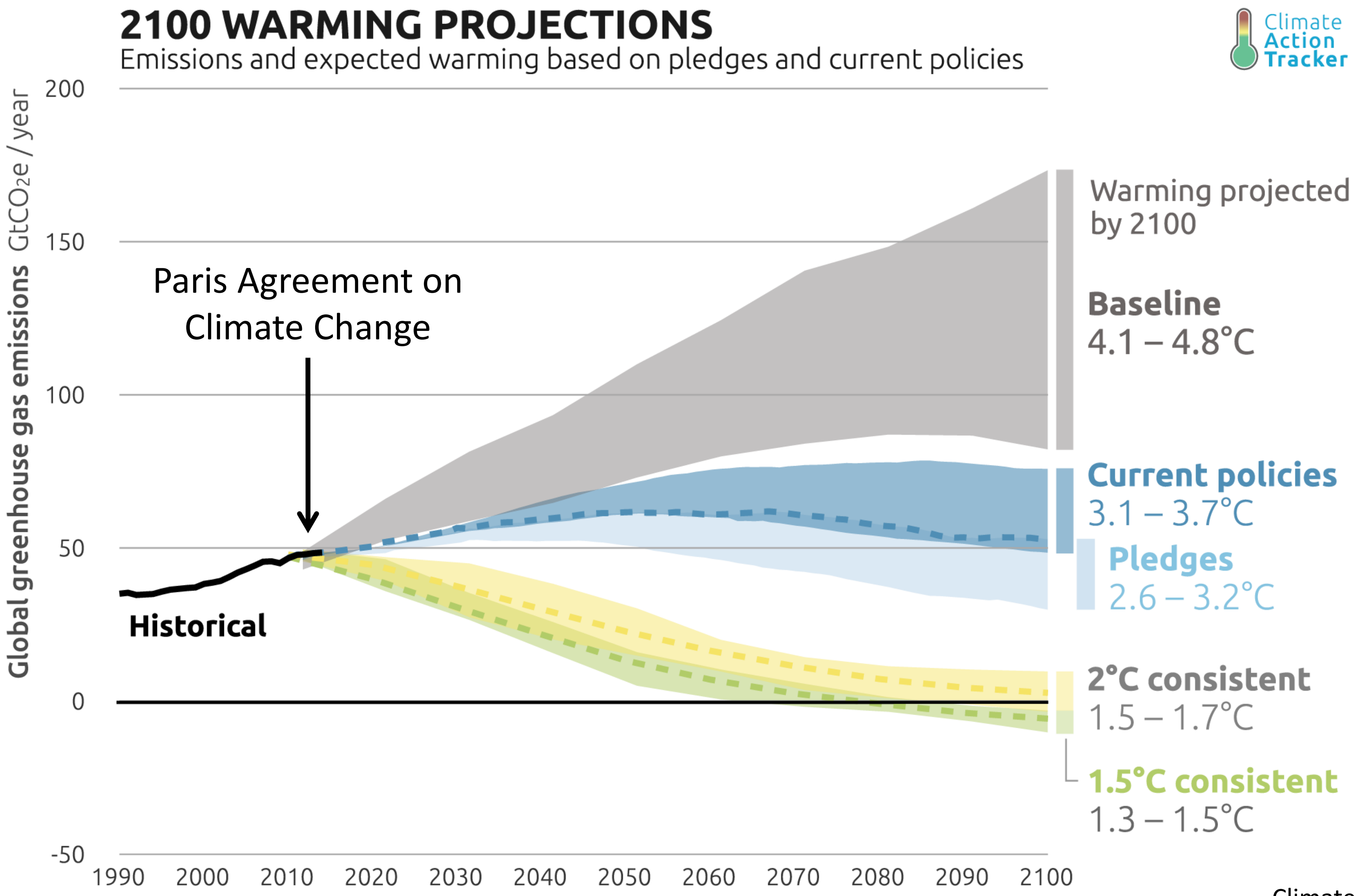

Climate Action Tracker, 2017

How might we increase the earth's reflectivity?

earth layer	technology
space	• space particles • low orbit solar mirrors, or parasols • Lagrange point solar mirror
stratosphere	aerosol injection – via airplanes, balloons, or artillery
troposphere	marine cloud brightening – via fleet of autonomous ships
ocean surface	• distribute floating white plastic disks, other reflectors • create microbubbles
land surface	• paint roofs white • change land use patterns from dark to light • spread white tarps over the Sahara, or other deserts

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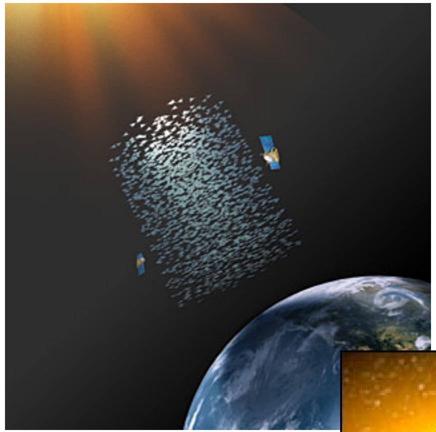
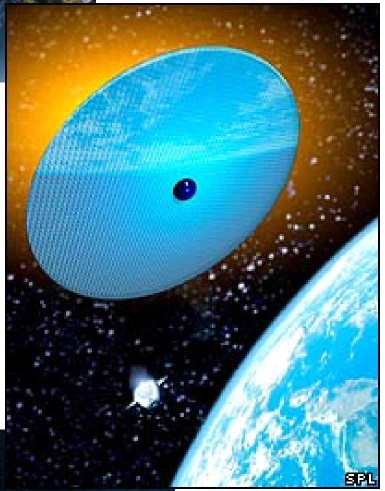


Angel (2006) in Hemming (2012)

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Weather modification history (2015)

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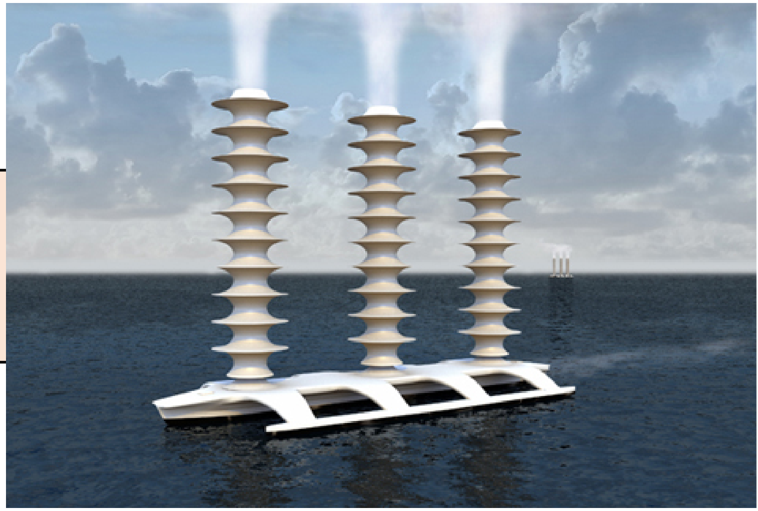

Latham et al. (2012) in Hemming (2012)

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Research and interest in SRM has increased

- Several research programs on geoengineering, SRM in particular
- Research is increasing: on climate (GEOMIP) and economic modeling, policy, governance, and ethics
- Earlier experiments:
  - E-PEACE – Eastern Pacific Emitted Aerosol Cloud Experiment (July-August, 2011)
  - SPICE: Stratospheric Particle Injection for Climate Engineering (2012-14)
- Field experiments scheduled for Summer 2018:
  - Stratospheric Controlled Perturbation Experiment (SCoPEx)
  - Marine Cloud Brightening Project

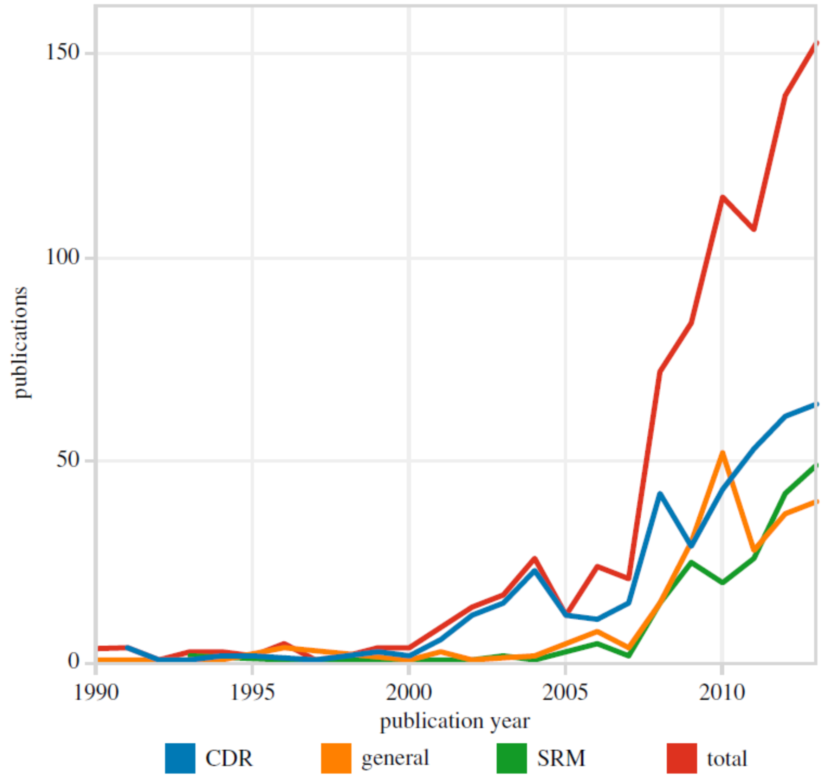


Figure 1. Main trends in scientific publications (Web of Science).

Oldham et al. (2014)

Burger and Gundlach (2018), Keutsch Research Group (2018), Temple (2017), Geoenginering Monitor (2018)

Possible benefits of aerosol sulfate SRM

- extremely cheap
- extremely effective?
- extremely fast acting – a viable emergency response?
- could tweak dosage easily
- could prevent dangerous climate change

(… and beautiful sunsets)

Possible downsides of aerosol sulfate SRM

Environmental Risks

- disparate changes in regional precipitation patterns
  - risk to South Asian Monsoon
  - risk of regional drought
- unknown earth system effects
- ozone depletion
- changed photosynthesis rates / agricultural yields
- higher acid deposition

More certain environmental impacts

- less sunlight for solar power
- direct environmental impacts of deployment
- sky whitening
- does nothing for ocean acidification

Governance and policy risks

- disincentive to mitigate
- stopping problem
- a unilateral selfish or hostile actor
- ethical concerns about:
  - technocratic modification of nature at a global scale
  - unequal distribution of benefits and harms
  - governance with international consent
  - corruptible implementation
  - intergenerational effects

“Governance by default”? What *might* apply to SRM…

Talberg, Christoff, Thomas, Karoly (2015)

International Law	Approach: marine cloud brightening	sulphate aerosols	space-based	other SRM
ENMOD – Convention on the Prohibition of Military or Any Other Hostile use of Environmental Modification Techniques	X	X	X	X
Convention on Biological Diversity, 2010 decision of the Conference of Parties	X	X	X	X
UNCLOS – UN Convention on the Law of the Sea	X			
CLRTAP – Convention on Long Range Transboundary Air Pollution	X	X		
Vienna Convention on the Protection of the Ozone Layer	X	X		
UNFCCC – UN Framework Convention on Climate Change, Paris Agreement text on equity and sustainable development		X		
UNCCD – UN Convention to Combat Desertification	X	X	X	X
OSTs – Outer Space Treaties			X	
ATS – Antarctic Treaty System	X	X	X	X

→ No international or domestic laws or policy statements **directly** applicable to SRM or geoengineering.
No international or domestic monitoring of SRM or other geoengineering projects.

SRM governance recommendations: Common themes

- principles / best practices / codes of conduct
- treat as a "public" good under government authority
- institutional governance before deployment
- allowed zones and thresholds
- more research on full system of geoengineering / societal interactions
- independent, ongoing assessment of impacts
- transparency of intentions, research methods, and data
- public participation
- international research cooperation and stakeholder involvement

Rayner et al. (2013), Morgan and Ricke (2010), C2G2 (2018), Hubert (2017), Parson and Keith (2013)

Hubert (2017)

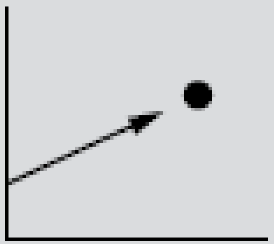
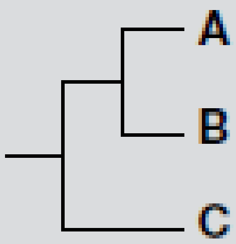
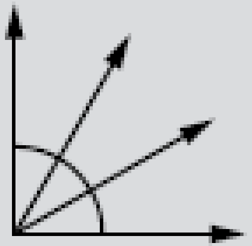
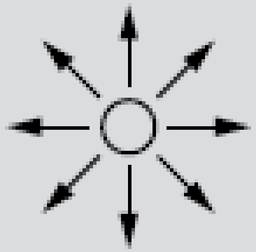
Emerging Risk Governance

emerging risk

- "…new or familiar risks that become apparent in new or unfamiliar conditions." (IRGC 2015a)
- contrasted with familiar risks, which are well understood by risk managers who know how to manage them
- characterized by:
  - high uncertainty and a lack of knowledge about potential impacts with risk-absorbing systems
  - increasing complexity, emerging interactions and systemic dependencies that can lead to non-linear impacts and surprises
  - changes in contexts that may alter the nature, probability and magnitude of expected impacts

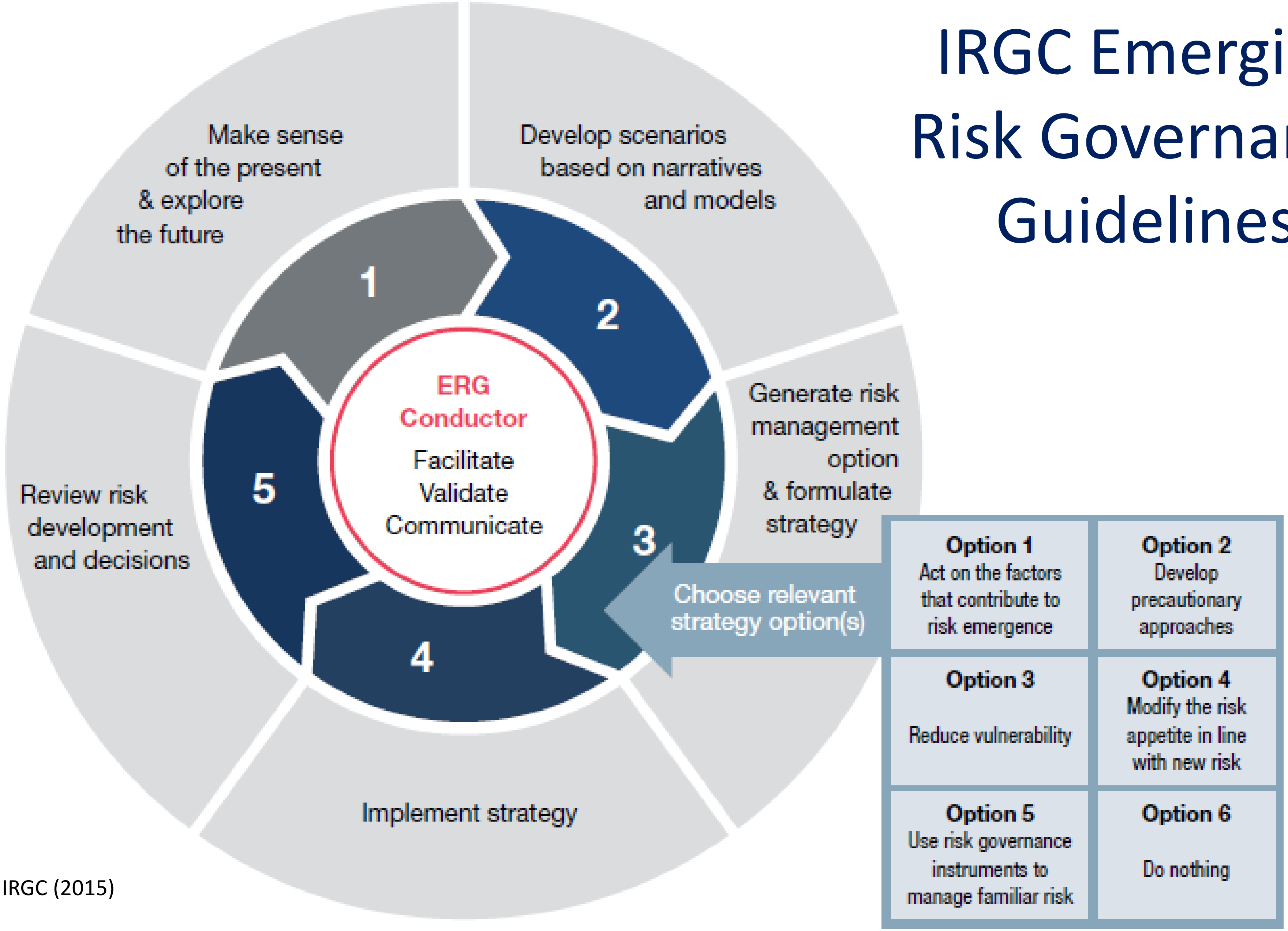
emerging risk governance

Helps decision-makers deal in an anticipatory manner with deeper levels of uncertainty.

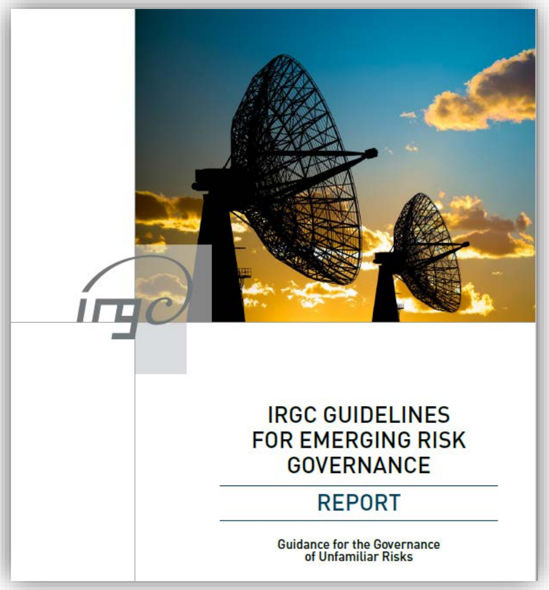
		Level 1	Level 2	Level 3	Level 4	
				Deep Uncertainty		
Determinism	**Context**	A clear enough future 	Alternate futures (with probabilities) 	A multiplicity of plausible futures 	Unknown future 	Total Ignorance
	System Model	A single system model	A single system model with a probabilistic parametrization	Several system models, with different structures	Unknown system model: know we don't know	
	System Outcomes	A point estimate and condifence interval for each outcome	Several sets of point estimates and confidence intervals for the outcomes, with a probability attached to each set	A known range of outcomes	Unknown outcomes: know we don't know	
	Weight on Oucomes	A single estimate of the weights	Several sets of weights, with a probability attached to each set	A known range of weights	Unknown weights: know we don't know	

IRGC (2015), from Walker et al. (2010)

IRGC Emerging Risk Governance Guidelines

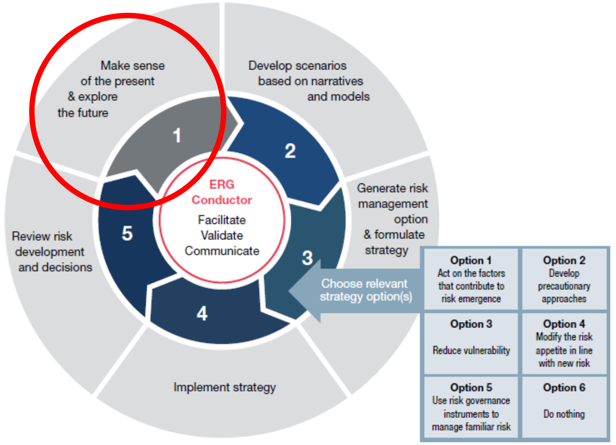


IRGC (2015)



IRGC Emerging Risk Governance:

1. Make sense of the present & explore the future.



IRGC (2015)

Provide <u>early warning</u> by identifying

- potential threats or opportunities
- and their contributing factors

Goal: create an updated list of selected threats and the context in which they develop, as well as other irrelevant threats

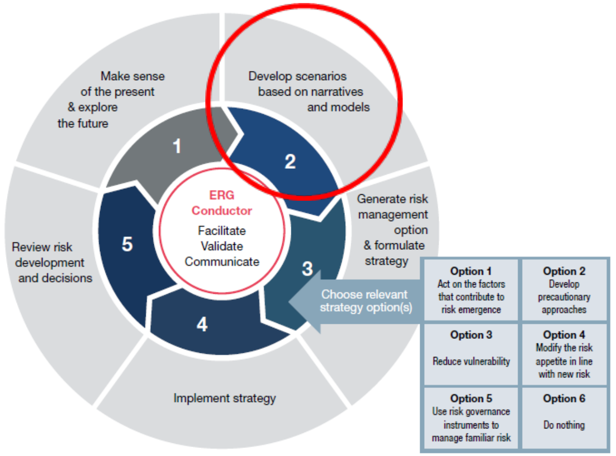
- ecological, health, social, ethical, legal, and technological risks of various SRM approaches are being studied

Threat accelerators:

- Deploying SRM without sufficient understanding of impacts or true costs
- Unilateral/rogue development or deployment
- Reaching a climate "tipping point" in near future, creating greater need for action

IRGC Emerging Risk Governance:

2. Develop scenarios based on narratives & models.



IRGC (2015)

Create a set of <u>updatable scenarios</u> (base case and worst case) that can provide insight into:

- intervention points
- tipping points
- scenario consequences

Goal: support decision-making and build resiliency.

No geoengineering – little R&D, rely on mitigation/adaptation

Only "safe" CDR (no SRM) – CDR developed, SRM rejected as too problematic

Technology transformation – Energy technology and innovation increases enough to reduce emissions quickly, SRM not needed

Insurance policy – Develop SRM as a climate change insurance policy

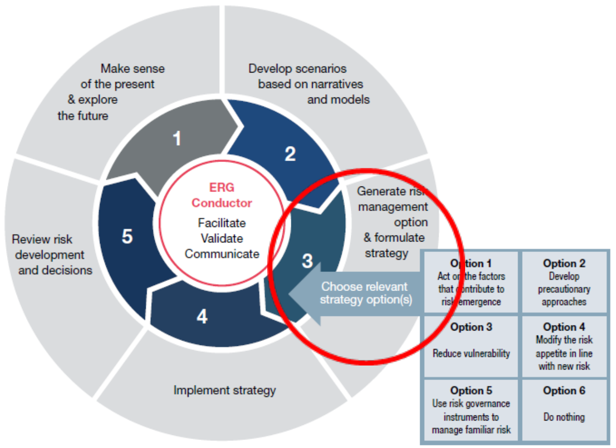
Needed soon – Develop SRM to avoid reaching a climate tipping point

Do it all – International efforts to mitigate and substantial R&D funding for SRM and CDR

(Olson 2011)

IRGC Emerging Risk Governance:

3. Generate risk management options & formulate strategy.



IRGC (2015)

Design <u>strategies for managing</u> early risks that are proactive, effective, cost-efficient, and adaptive.

Goal: For each scenario, identify uncertainties, irreversible thresholds, trade-offs, and final decision

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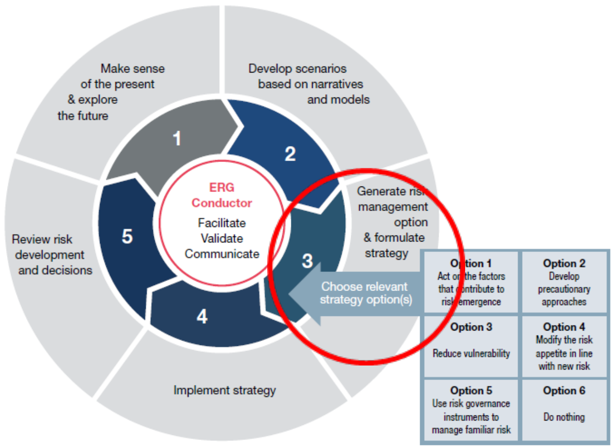


IRGC (2015)

phases of SRM research:

Burger & Gundlach (2018)

laboratory → technology development → process study → scaling test → climate response test

1. Act on the factors that contribute to risk emergence.

2. Develop precautionary approaches.

3. Reduce vulnerability.

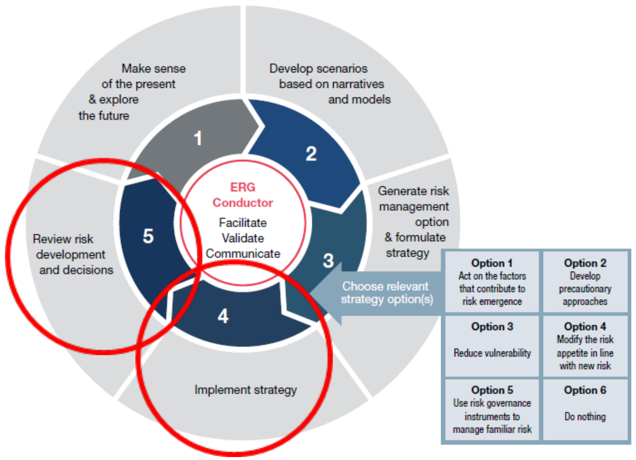
4. Modify the risk appetite in line with new risk.

5. Use risk governance instruments to manage familiar risk.

or

6. Do nothing.

IRGC Emerging Risk Governance:



IRGC (2015)

4. Implement strategy.

... with clear lines of communication and responsibility.

5. Review risk development and decisions.

- monitor
- review, and
- update the strategy

→ **to be determined**

Conclusions on Emerging Risk Governance for SRM

Suitability:

- Yes, in principle, with the complex, uncertain, and ambiguous global risks of SRM
- Steps 1-3 can be completed:
    1. Make sense of present & explore the future
    2. Develop scenarios
    3. Generate risk management options and formulate strategy

Challenges:

- No clear "risk conductor" or risk owner exists for SRM
- Most research is at very early stages, with unknown deployment times
- Steps 4-5 (implement strategy and review decisions) require official adoption of ERG by an organization or risk owner

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Thank you – Questions?

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