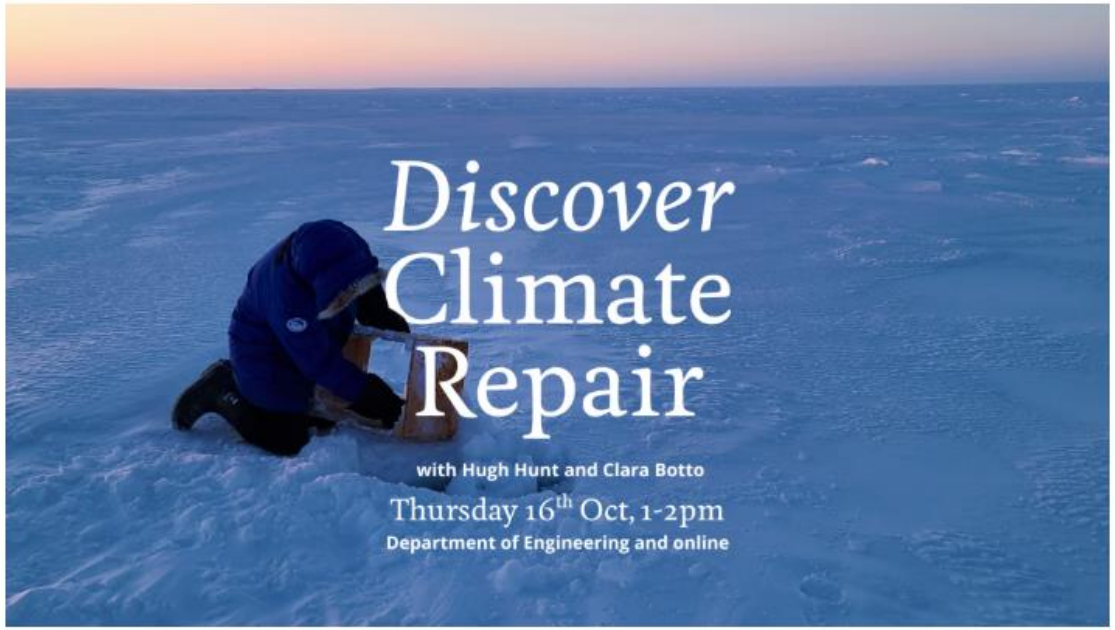

Discover
Climate
Repair
with Hugh Hunt and Clara Botto
Thursday 16th Oct, 1-2pm
Department of Engineering and online

Autumn Lecture Series

Thu, Oct 16 2025, 1pm - Mon, Dec 1 2025, 2pm



Good COP, Bad COP

Reflections on COP30

with

Prof Piers Forster (UK's Climate Change Committee),
Dr Natalie Jones (CSER), **Dr Joanna Depledge (CSAP),**
Prof Emily Shuckburgh (Cambridge Zero), and a **student rep**

Monday 1st December, 1-2pm

Department of Engineering and online

Another kind of climate action

can we refreeze the Arctic?

Cambridge, October 2025

Hugh Hunt
Deputy Director, Centre for Climate Repair

Cambridge University
Engineering Department

Deep and rapid emissions Reduction

Centre for Climate Repair

climaterepair.cam.ac.uk

Deep and rapid emissions Reduction

Greenhouse gas Removal

Centre for Climate Repair

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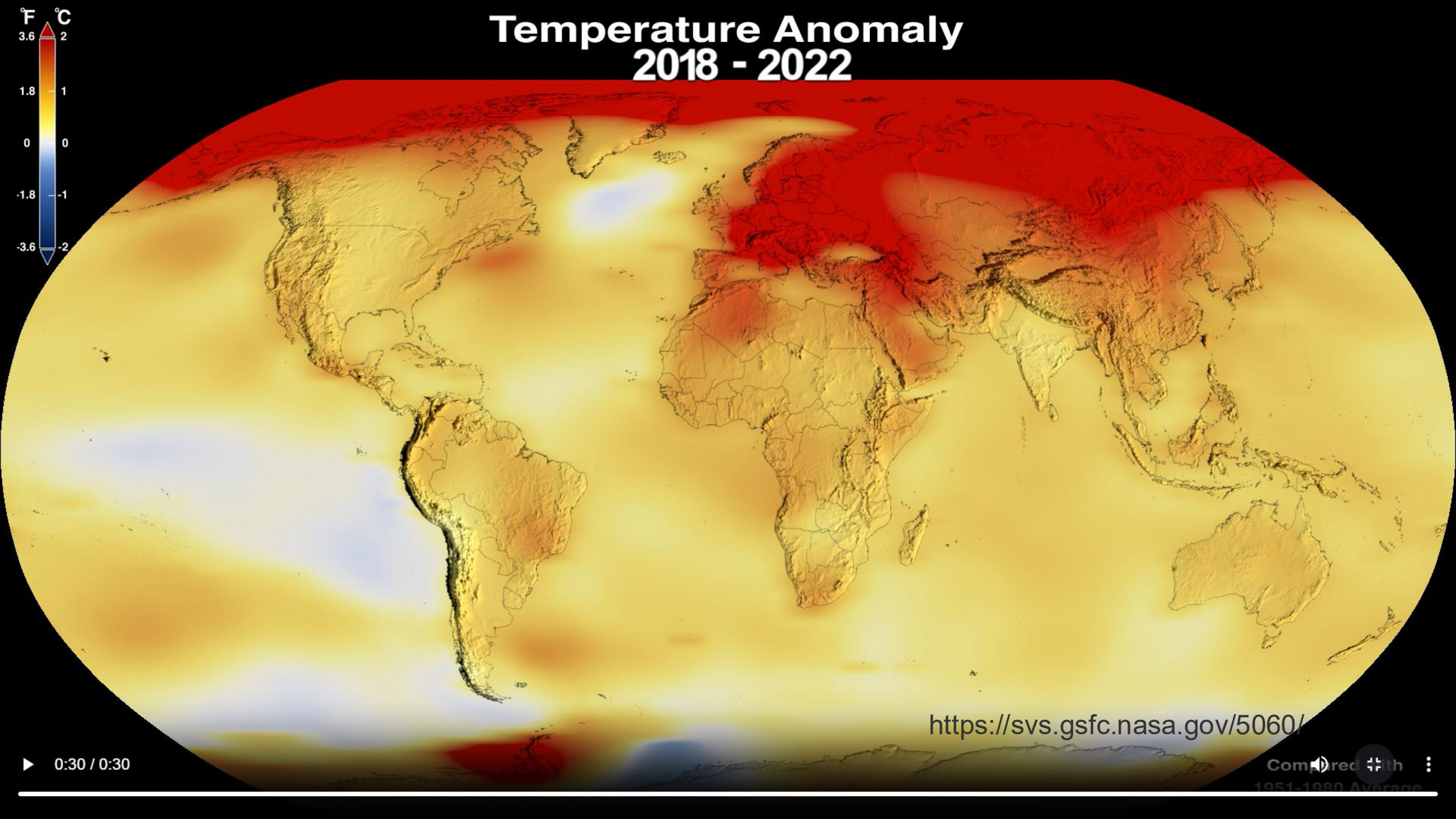
Deep and rapid
emissions
Reduction

Greenhouse gas
Removal

Centre for
Climate Repair

Refreeze
the Arctic

climaterepair.cam.ac.uk


Temperature Anomaly
2018 - 2022
°F
°C
3.6
2
1.8
1
0
0
-1.8
-1
-3.6
-2
https://svs.gsfc.nasa.gov/5060/
0:30 / 0:30
Compared with
1951-1980 Average

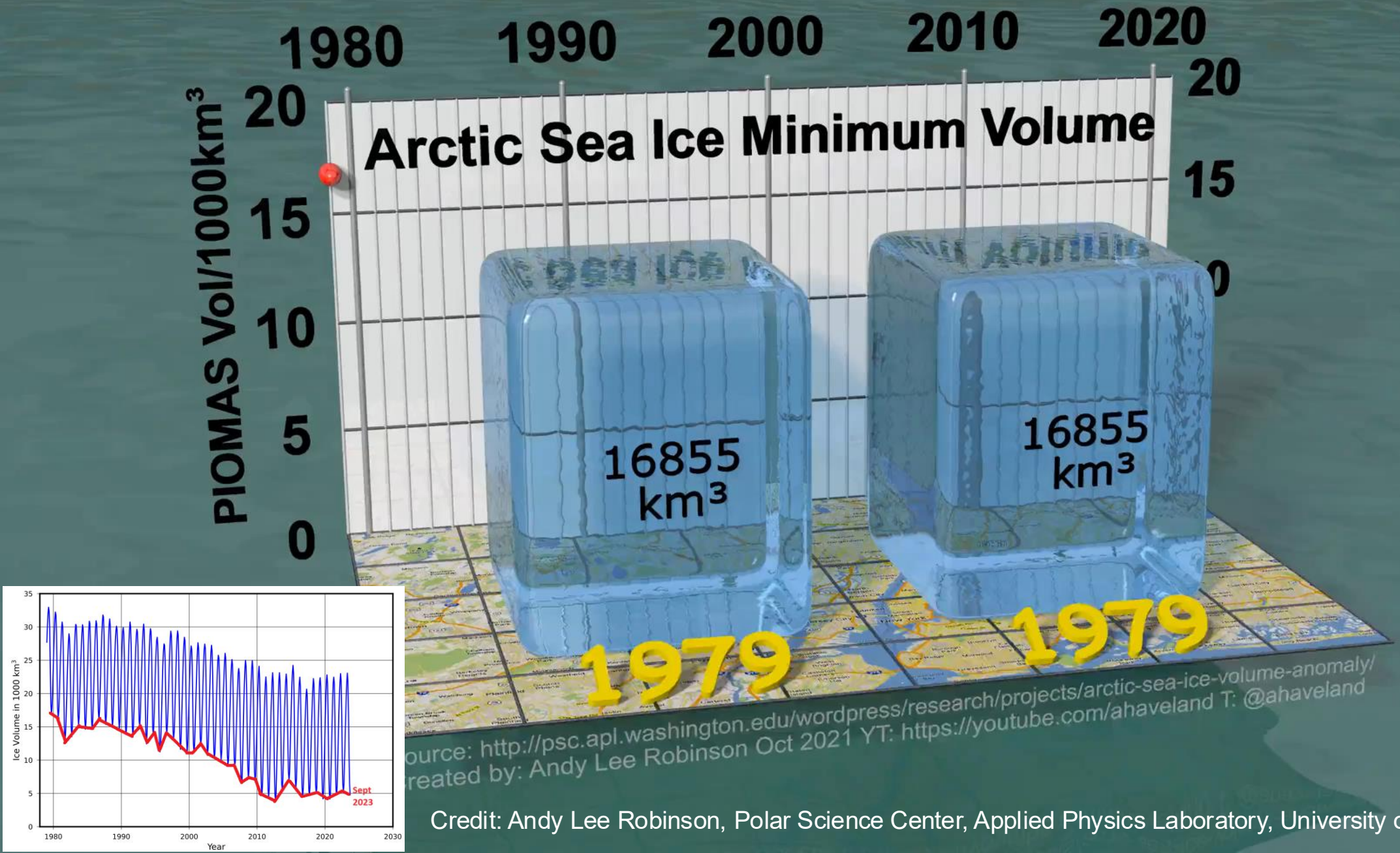
The Arctic problem

Arctic ice yielding to open water, albedo (reflectivity) drops from 0.6 to 0.1

Arctic Ocean is shallow, melting permafrost, triggers release of methane, 80 times more potent a GHG as CO_2

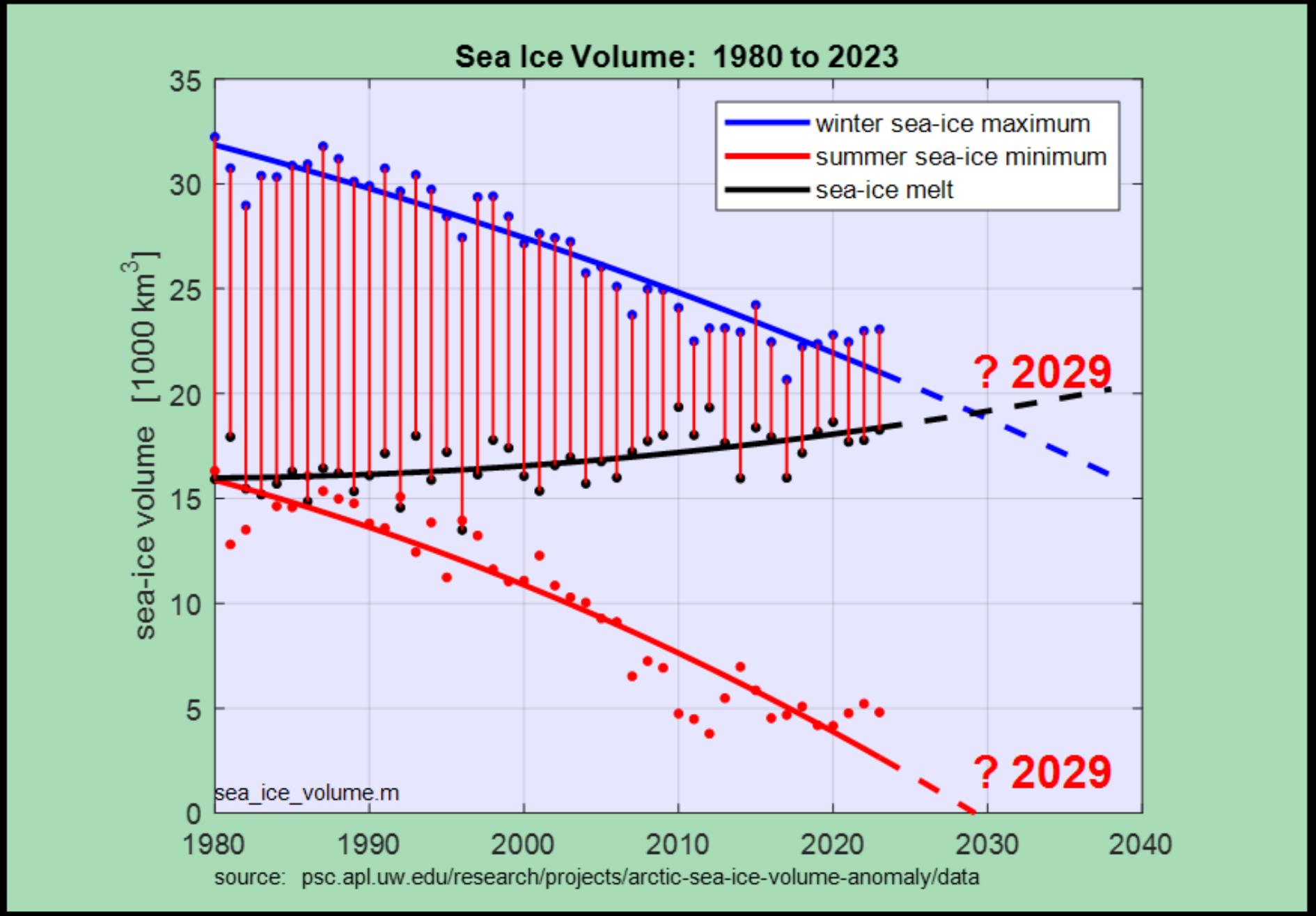
Greenland ice shelf holds 2m km^3 of ice. If it melts → sea-level rise of 7.2m

Ice-free arctic alters jet stream and ocean circulations → changes in climate



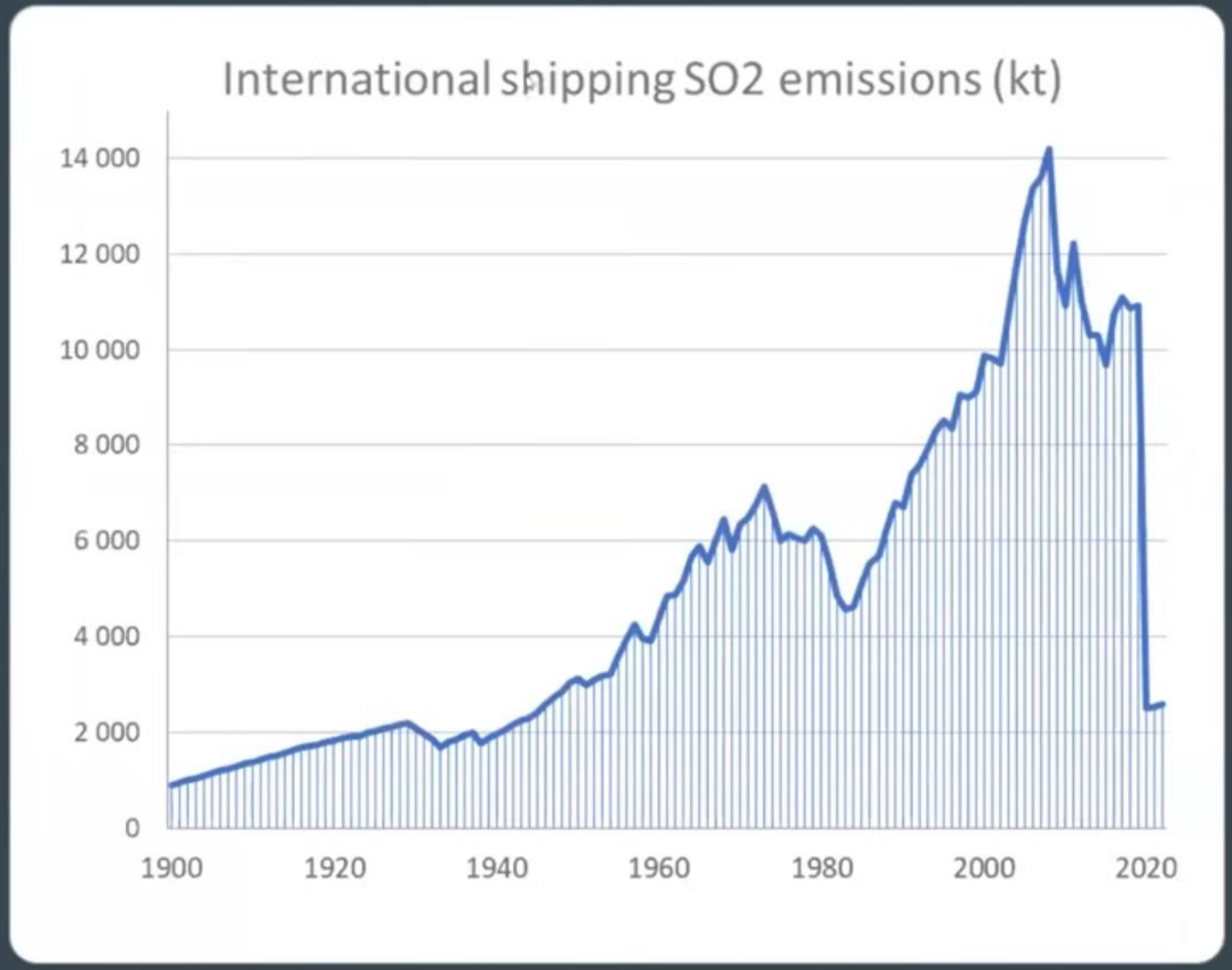
Credit: Andy Lee Robinson, Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle

Summer sea ice in the Arctic may vanish very soon



James Hansen: Global Warming in the Pipeline (Nov 2023)

Changes in international sulfur dioxide emissions



Satellite image of "Ship Tracks" caused by sulphur emissions

Global annual CO_2 emissions – 40 billion tonnes

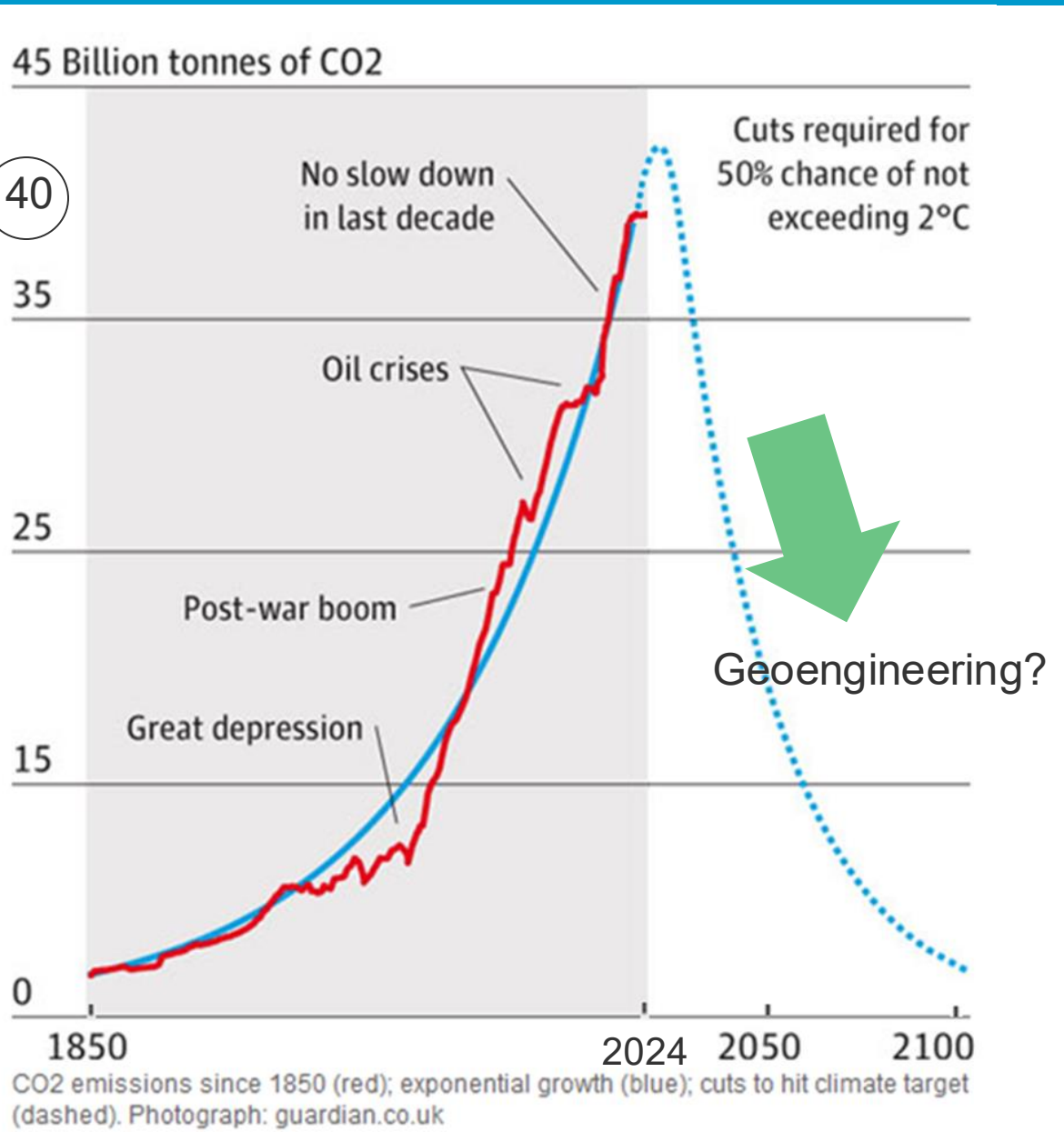
40 billion tonnes/year

World pop = 8 billion

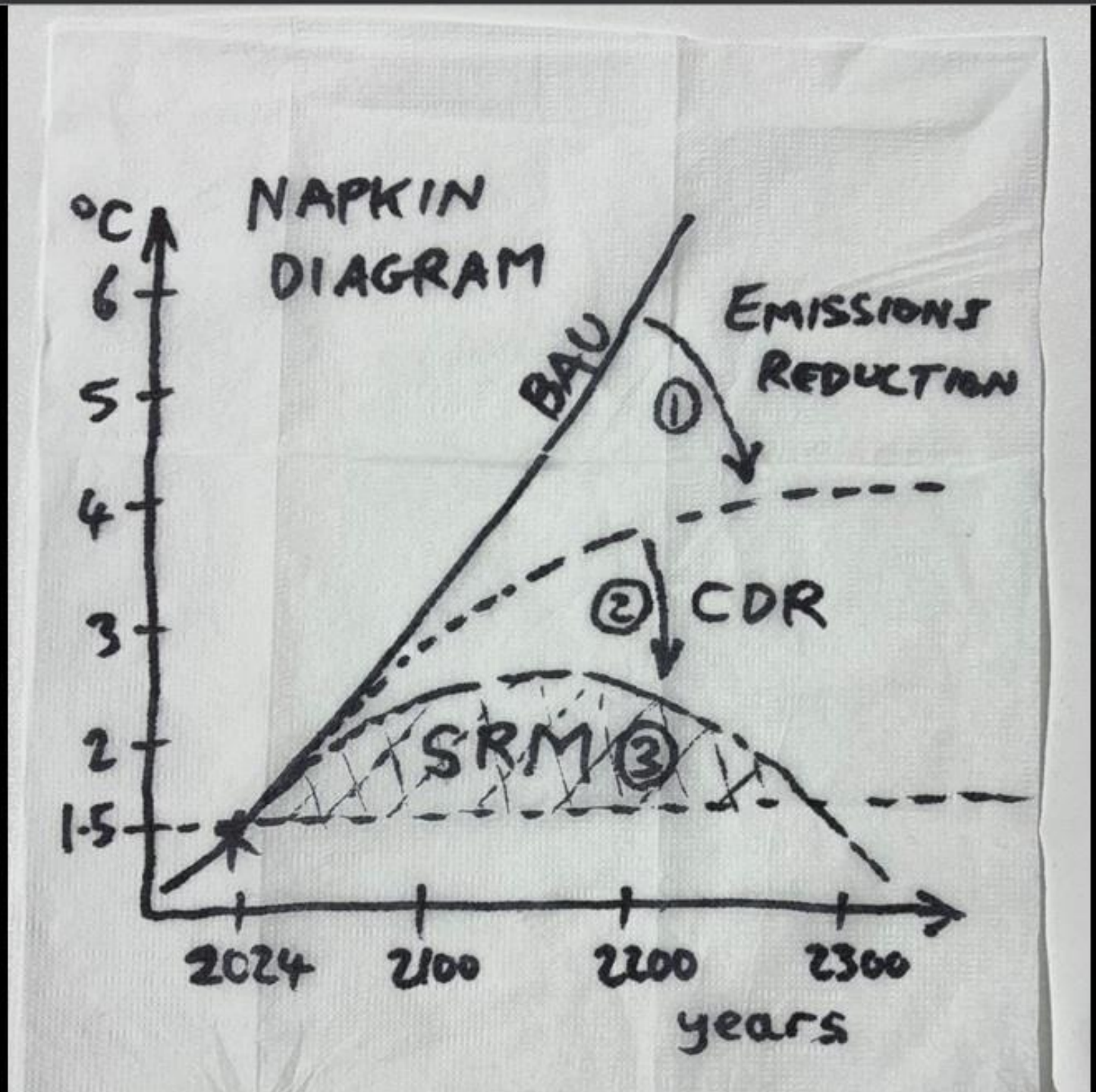
Global average
5 tonnes/person/yr

my trash: 500kg/yr ?

my poo:
200kg/yr ?



CO2 emissions since 1850 (red); exponential growth (blue); cuts to hit climate target (dashed). Photograph: guardian.co.uk



The Napkin Diagram

John Shepherd 2010

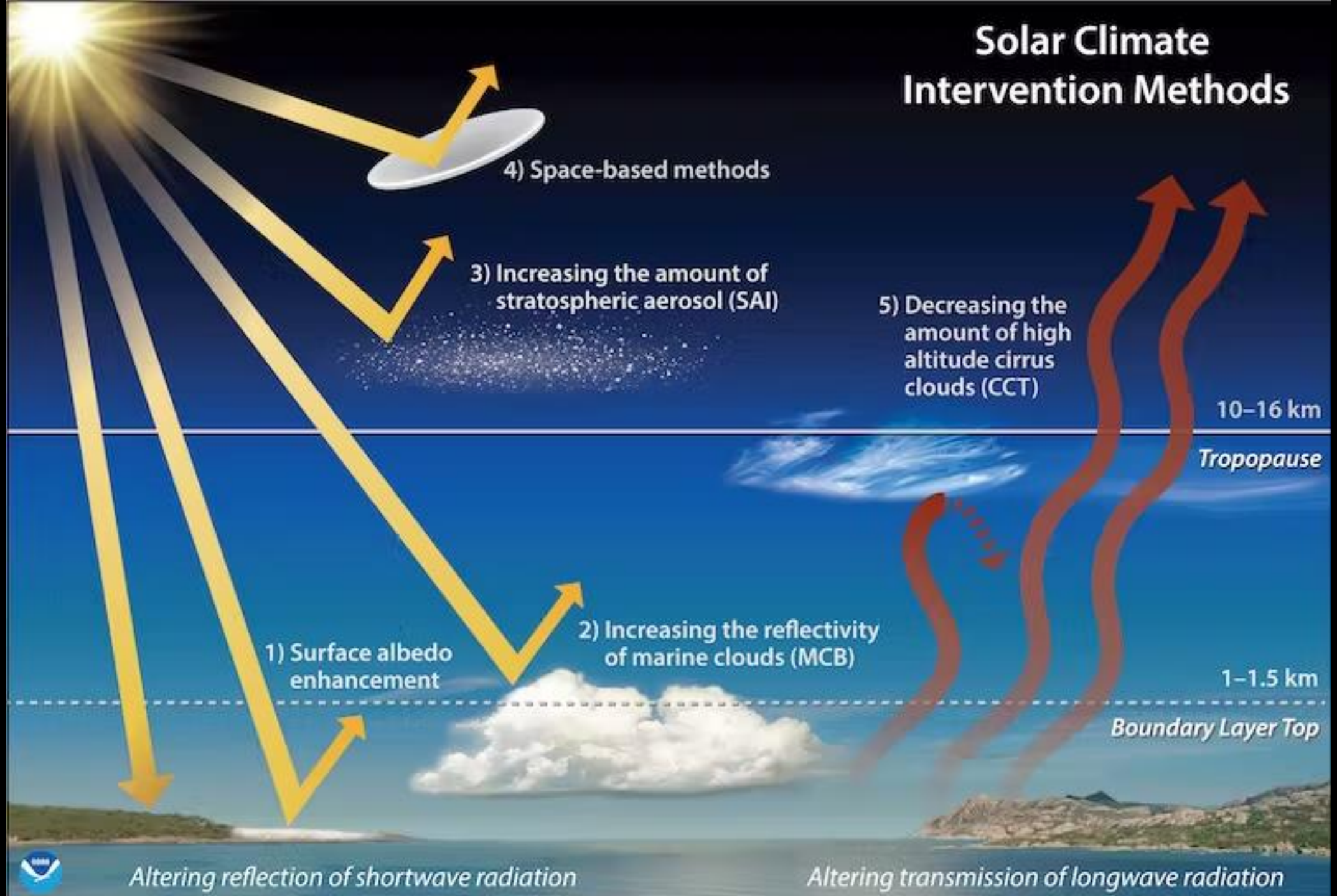
(1) Emissions Reduction

(2) Carbon Dioxide Removal CDR

(3) Solar Radiation Management SRM

All three are necessary to avoid catastrophic warming.

Emissions-Reduction alone is not enough


Solar Climate Intervention Methods
4) Space-based methods
3) Increasing the amount of stratospheric aerosol (SAI)
5) Decreasing the amount of high altitude cirrus clouds (CCT)
10–16 km
Tropopause
1) Surface albedo enhancement
2) Increasing the reflectivity of marine clouds (MCB)
1–1.5 km
Boundary Layer Top
Altering reflection of shortwave radiation
Altering transmission of longwave radiation

Marine Cloud Brightening

CLIMATE REPAIR

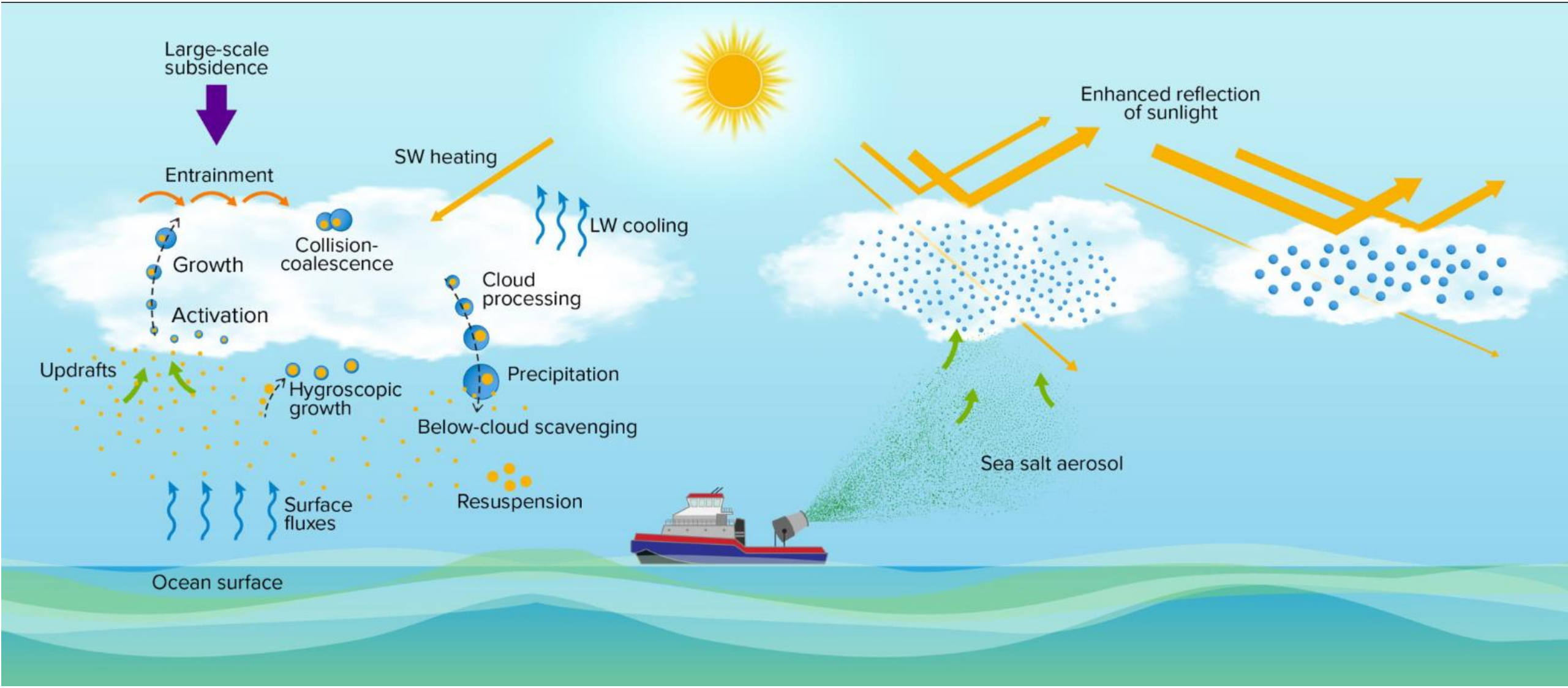


Image: Feingold et al 2024

Marine Cloud Brightening

CLIMATE REPAIR

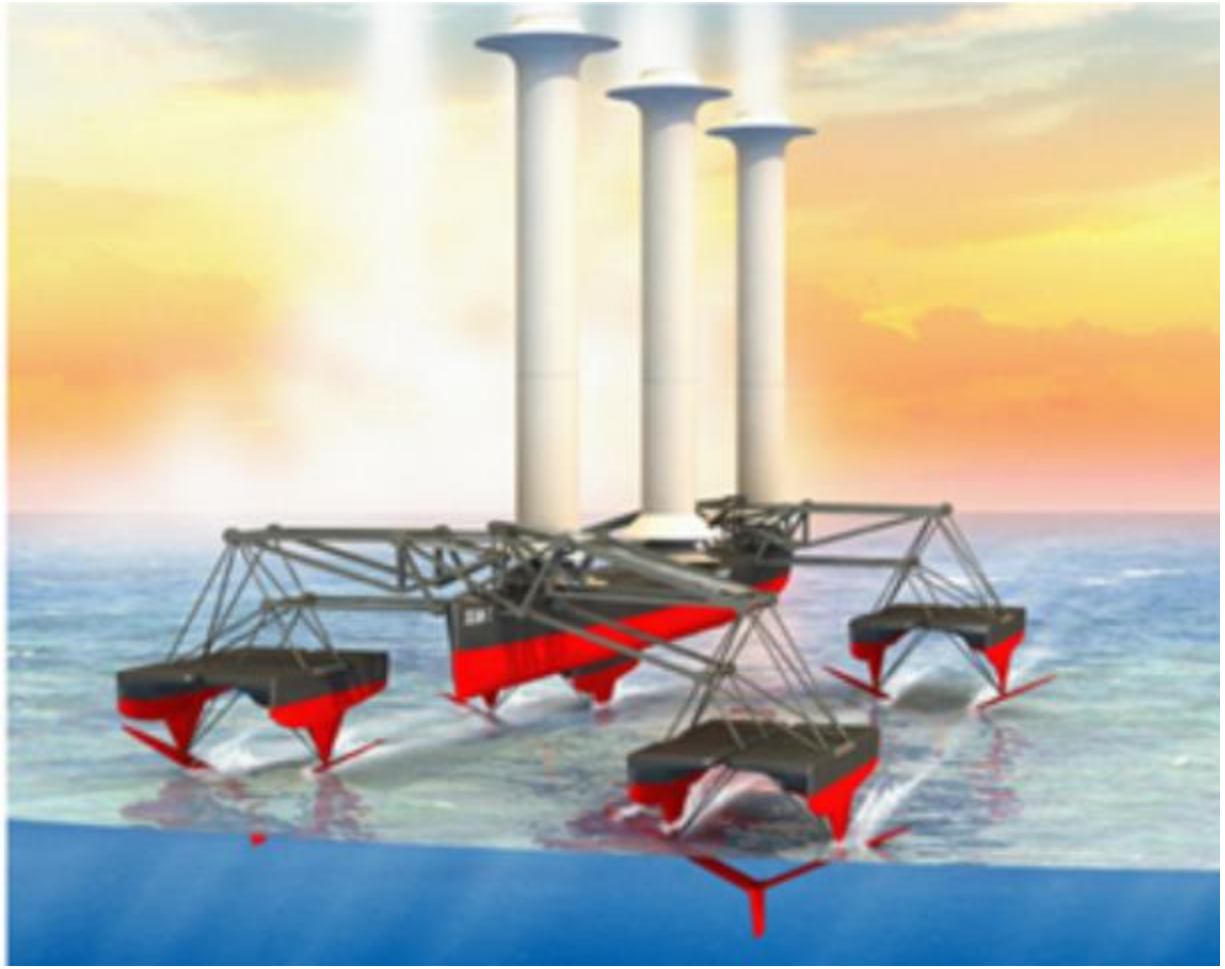
Ship tracks

cooling the Great Barrier Reef

https://www.facebook.com/watch/?v=649247286453748

Stephen Salter 1938-2024

CLIMATE REPAIR



Evidence on Marine Cloud Brightening
Commons Select Committee **2012**

Power rating:	350kW
Nozzle diameter	0.43 micron
Droplet diameter	0.8 micron
Nozzle Pressure	85 bar
Spray rate	30 kg/s
Drop rate	110 x 10^{15} per second
Cost:	£2-3m

Where we are in 2025

CLIMATE REPAIR

	Salter sums	**Great Barrier Reef field trials (approx. figures)**
Power rating:	350kW	**300kW**
Nozzle diameter	0.43 micron	**effervescent spray**
Droplet diameter	0.8 micron	**0.2 micron (50nm salt crystals)**
Nozzle Pressure	85 bar	**>100 bar**
Spray rate	30 kg/s	**0.1 kg/s (6 kg/min)**
Drop rate	110 x 10^{15} per second	**20 x 10^{15} per second**
Cost:	£2-3m	

Southern Cross University, Australia
Reef Restoration and Adaptation Programme

Where might we be in 2040?

CLIMATE REPAIR

Scaling up:

Energy from sun is 341W/m^2 31% reflected by clouds, ie 105W/m^2

1% change in albedo 1W/m^2

Need to pump 1 billion tonnes of sea water per year (globally)
(for comparison, global desalination plants produce about 40 billion tonnes of drinking water per year, 1% of worlds supply, 15GW)

Need 300,000 Barrier Reef vessels
total power 100GW (global electricity = 4000GW)

Other issues

CLIMATE REPAIR

1. Water filtration (desalination plants have figured this out)
2. Surfactants – properties of sea water are variable
3. Susceptible clouds – not many places are “ideal” for MCB
4. Opposition to research and outdoor experiments
5. Regional interventions vs global cooling
6. Governance, ethics, public perception

Can Cloud Brightening work?

CLIMATE REPAIR

1. Yes, MCB scaled up to to 2°C cooling is *possible …*
2. but the power requirements are prohibitive
3. we'd need 300,000 "barrier reef" boats running continuously
4. none of this is likely by 2040

5. But we can't be despondent,
   The research must go on!

Ice Thickening

SRM – eruption of Mt Pinatubo, 1991
Solar Radiation Modification

August 30, 1984

August 8, 1991

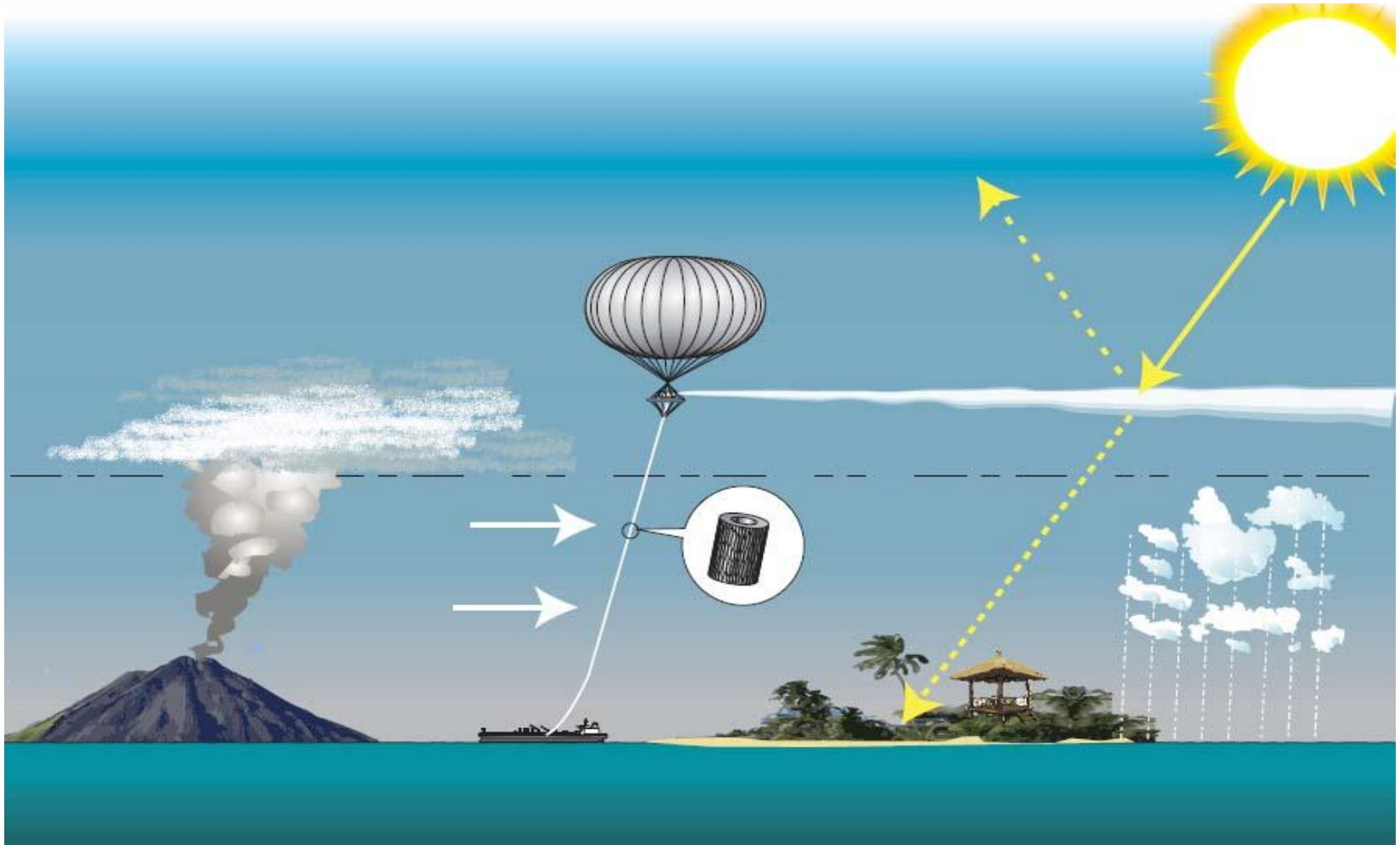
SPICE

SPICE: aerosol delivery system for 2°C cooling

Stratospheric **P**article **I**njection for **C**limate **E**ngineering

Tethered balloon – height 20km

maybe 10 balloons worldwide each delivering 30kg/s of aerosol



OPTIONS:

- Aircraft
- Airships
- Towers
- Tethered balloons

SPICE “cancelled” ? Controversial?

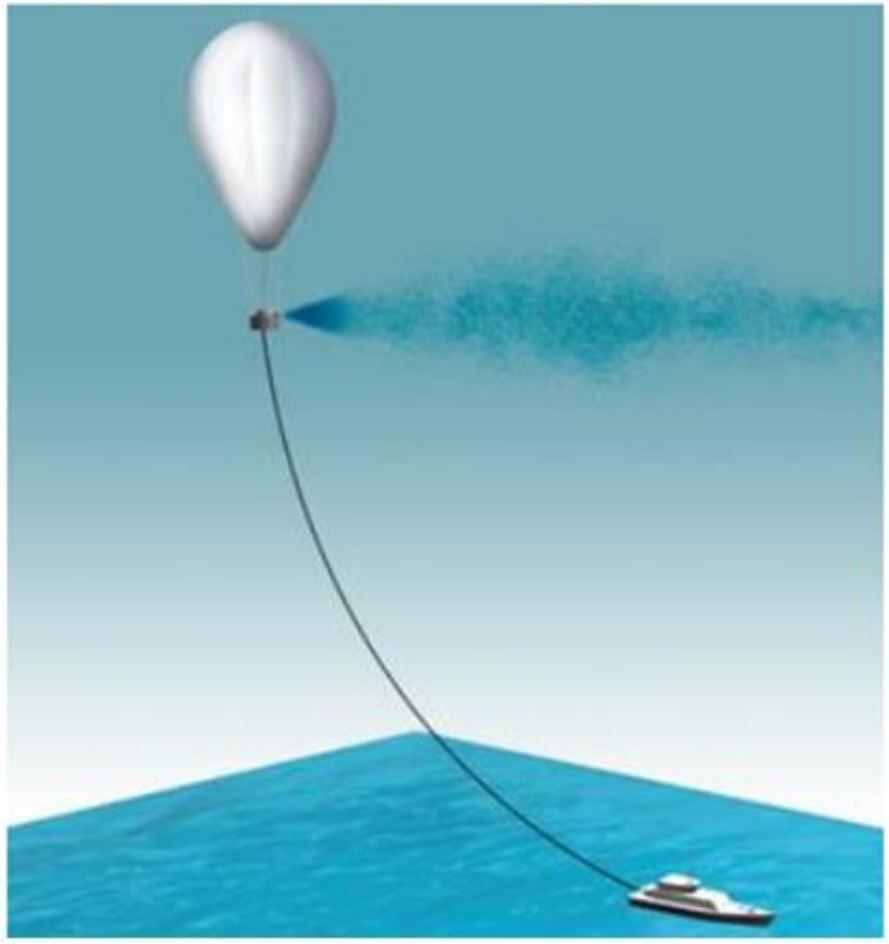
NewScientist **Environment**

search New Scientist Go » Log

Controversial geoengineering field test cancelled

PRINT SEND SHARE

17:30 22 May 2012 by **Michael Marshall**



THE balloon will not go up. A controversial geoengineering field test has been cancelled after the lead scientist learned of a patent on the technology held by several of his collaborators.

The Stratospheric Particle Injection for Climate Engineering (SPICE) project, run by researchers at three UK universities, is investigating cooling the planet by releasing aerosol particles into the stratosphere. The field test would have tested the feasibility of the delivery system – a hose lofted by a balloon – by pumping out water spray at an altitude of 1 kilometre.

In October 2011 the field test was postponed for six months, after an oversight panel decided more public engagement was needed.

Now lead scientist Matthew Watson at the University of Bristol, has cancelled it altogether.

At issue was a patent on the technology, filed in 2009 by independent consultant engineer Peter Davidson. Watson only learned of the patent late last year.

Arctic Repair Conference 2025

Thu, Jun 26 - Sat, Jun 28 2025, All day

Arctic Repair Conference 2025

Thu, Jun 26 - Sat, Jun 28 2025, All day

Thank you!

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Centre for
Climate Repair

Get connected

Governance of SRM within the Climate Response Portfolio

October 16, 2025

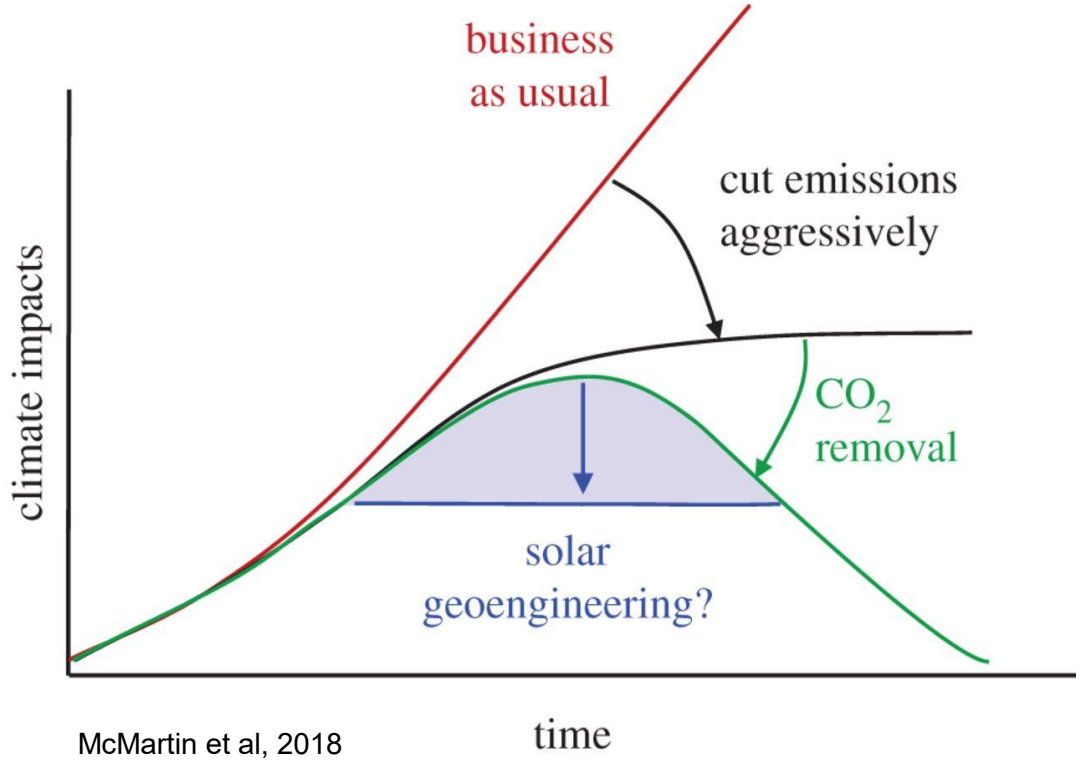
The Alliance for
Just Deliberation on Solar Geoengineering

Clara Botto
Director of Outreach

Presentation Outline

- Context setting
- State of the SRM field globally & high-level governance challenges
- Overview of SRM Governance
- Governance gaps
- Examples

In Context



McMartin et al, 2018

A Small but Growing SRM Field

SRM is receiving growing attention in popular media

SG is beginning to enter mainstream climate discussion through publications in the New York Times, the Washington Post, the Guardian, CNN, MIT Technology Review, CNBC, CBS Morning, Axios, and more.

Intergovernmental bodies and assessments call for more research, engagement

IPCC, UN bodies, and government institutions highlight large gaps in knowledge needed to make informed decisions, and endorse efforts to include broader public in research and discussion

Countries are increasingly engaging in/funding SRM research

National interest, plans, and/or funding is taking place in the U.S., UK, EU, Canada, and China

Fast rise in private sector involvement

Companies are actively moving forward with little to no transparency, outside of norms and standards in scientific research with venture capital investment

Outdoor activity is growing

Small-scale outdoor activity/proposals expanding across sectors (academia, public, private, civil society)

Media headlines

The global conversation about solar geoengineering just changed at the UN Environment Assembly. Here's how.

Startups want to cool Earth by reflecting sunlight. There are few rules and big risks

Sun block: The promise and peril of solar geoengineering

Solar geoengineering is becoming a respectable idea

One way to fix an accidentally altered climate is to alter it again deliberately

DSG

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Major Assessments: inclusion and engagement

2023 UN Environment Programme *One Atmosphere* Report

"…research and deployment decisions require an equitable, transparent, diverse and inclusive discussion … this process would need to involve discussion with, and more research from, all stakeholders as most from the global south are not sufficiently engaged in current discussions"

2023 IPCC Sixth Assessment Report

"…more can be done to enable participation from diverse peoples and geographies in setting research agendas and research governance priorities, and undertaking research"

2023 UN Human Rights Council Advisory Committee Report

"Access to information and public participation in global environmental decisions is of utmost importance when approaching geoengineering proposals."

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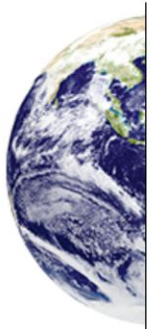
UK funding: Advanced Research + Invention Agency

7 May, 2025



Exploring Climate Cooling

Motivated by the possibility of encountering damaging climate tipping points, and backed by £56.8m, this programme aims to transparently explore – under rigorous oversight – whether any climate cooling approaches that have been proposed as potential options to delay or avert such tipping points could ever be feasible, scalable, and safe.

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Challenges in Solar Geoengineering

Global North centric

Engagement in the Global South is sparse, limited in scope and purpose. Most SG research and activity is based in the Global North with limited efforts with little focus on how to center the climate vulnerable communities and countries

Extremely limited governance

Formal governance does not exist on an international level across the RDD&D spectrum. Awareness and research remains low, and engagement is geographically uneven.

Lack of civil society involvement

CSOs across all regions have largely been unable or unwilling to find pathways to productively engage, leaving the space empty of constructive civil society voices - a key sector to both building policy and holding actors accountable.

Deeply contentious and advocacy oriented

The contentious nature of the field is the main driver of how SG is perceived. With only the loudest and most oppositional voices heard, it is challenging to build a legitimate discourse around governance and research.

Overview of SRM Governance

Governance refers to the structures, processes, and actions through which public and private actors work or interact to address goals around solar geoengineering research or potential deployment.

(DSG, 2023)

Research Governance

Under what conditions should research proceed? What are relevant research questions from different regions? How should research be funded? How should funding and data be shared? How should publics be engaged?

Deployment

Should SRM be deployed? If so, when, how, by whom? If not, what frameworks are necessary to prevent its use? How to monitor potential use by other actors? What are reporting structures? How do we ensure democratic decisionmaking?

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(DSG, 2023)

Public Engagement/Participation

Engagement describes a set of approaches by which researchers, funders, and governance bodies can aim to inform, understand, and draw input from publics and stakeholders

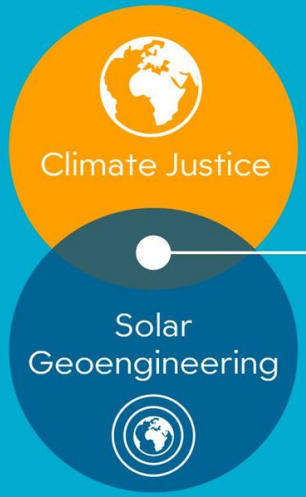
Inclusion

Inclusion requires improving participation for those who have been disadvantaged, marginalized, and vulnerable through enhanced opportunities, access to resources, and respect for rights.

SRM and Justice

Justice demands the protection of basic rights, the fair treatment of individuals, and equal opportunity of all to participate in the decision-making processes that govern their lives.

Solar geoengineering governance should be designed to ensure that research and deployment follows the principles of climate justice.



Important questions at the intersection of climate justice and solar geoengineering include:

- Are the benefits and costs of research or potential deployment distributed fairly while protecting the basic rights of the most vulnerable?
- Do the most vulnerable have an opportunity to participate and have a say in solar geoengineering decision-making?
- Are powerful actors held genuinely accountable for their actions?
- Are there plans for those who could be harmed by solar geoengineering to be compensated, rehabilitated, or restored?

SRM and Human Rights

SRM has the potential to impact **human rights** in many ways, both positive and negative.

- On the one hand, the impacts of climate change and environmental degradation are devastating for the enjoyment of human rights (e.g., the right to life, food security, health) for people today and in future generations. Therefore, the use of SRM to mitigate harms associated with climate change could enhance enjoyment of human rights.

- On the other hand, manipulating Earth's climate through SRM may cause unforeseen and uncontrollable consequences that would further threaten human rights.

SRM and Human Rights

Procedural human rights: governments have a responsibility to ensure individuals have access to relevant information and the opportunity to participate in decisions about SRM that may impact their human rights.

Substantive human rights: When it comes to the right to life, health, food, water and a healthy environment, SRM has the potential to enhance and/or undermine all of these rights. Human rights related to scientific research

Human rights related to scientific research: Everyone has the right to enjoy the benefits of scientific progress, which would include the benefits associated with SRM. We must also consider the freedom of scientific research, and the moral and material interests resulting from scientific work.

What is *good* Governance?

- **Aligns with and promotes justice:** frameworks are inclusive with robust public participation, climate vulnerable and marginalized communities are empowered to represent their interests
- **Begins early:** early development of norms and standards are built that can address potential risks and harms relevant across a range of scenarios
- **Builds legitimacy:** equitable processes are put in place that promote responsibility, transparency, and diversity of thought
- **Ensures alignment within climate response portfolio**: the field is built in such a way that research or potential deployment does not deter emissions reductions, CDR, and adaptation efforts

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Overarching Governance Gaps

01

Knowledge

Foundational, balanced knowledge in science and policy is required across the global north and south as a baseline to move the SG conversation forward

02

Participation

Participation across sectors and geographies is needed to set research priorities, generate research questions, develop policy priorities, understand regional needs

03

Decision-making

Frameworks for equitable decision-making are needed for both research and deployment to create norms, standards, and oversight

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Engagement: Challenges in SG

- **Lack of transparency**: There must be transparent mechanisms around the use of public input, a clear understanding of what public engagement is for, and what eventual outcomes are.

- **Necessary knowledge and capacity:** Communities or organizations that are sought after for engagement often don't have the bandwidth and resources to build the capacity for legitimate, meaningful engagement

- **Biased facilitators, funders, planners:** organizations, corporations, or scientific institutions are often those planning engagement and seeking a particular outcome (e.g. social license or stopping research).

- **Lack of empowerment**: Very rarely are there avenues for co-decisionmaking (e.g. engagement before site selection vs after) or ensuring that engagement is sustained throughout a process

Participation gaps lead to lack of trust in research

Open and transparent dialogue between researchers, policymakers, and communities is crucial to ensuring that SRM is developed in a way that is understood and trusted.

Proactive engagement can prevent unnecessary opposition and ensure that governance frameworks are developed thoughtfully, in a way that anticipates and addresses public concerns.

Thank you!

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The Alliance for
Just Deliberation on Solar Geoengineering