Perspectives on Marine Cloud Brightening

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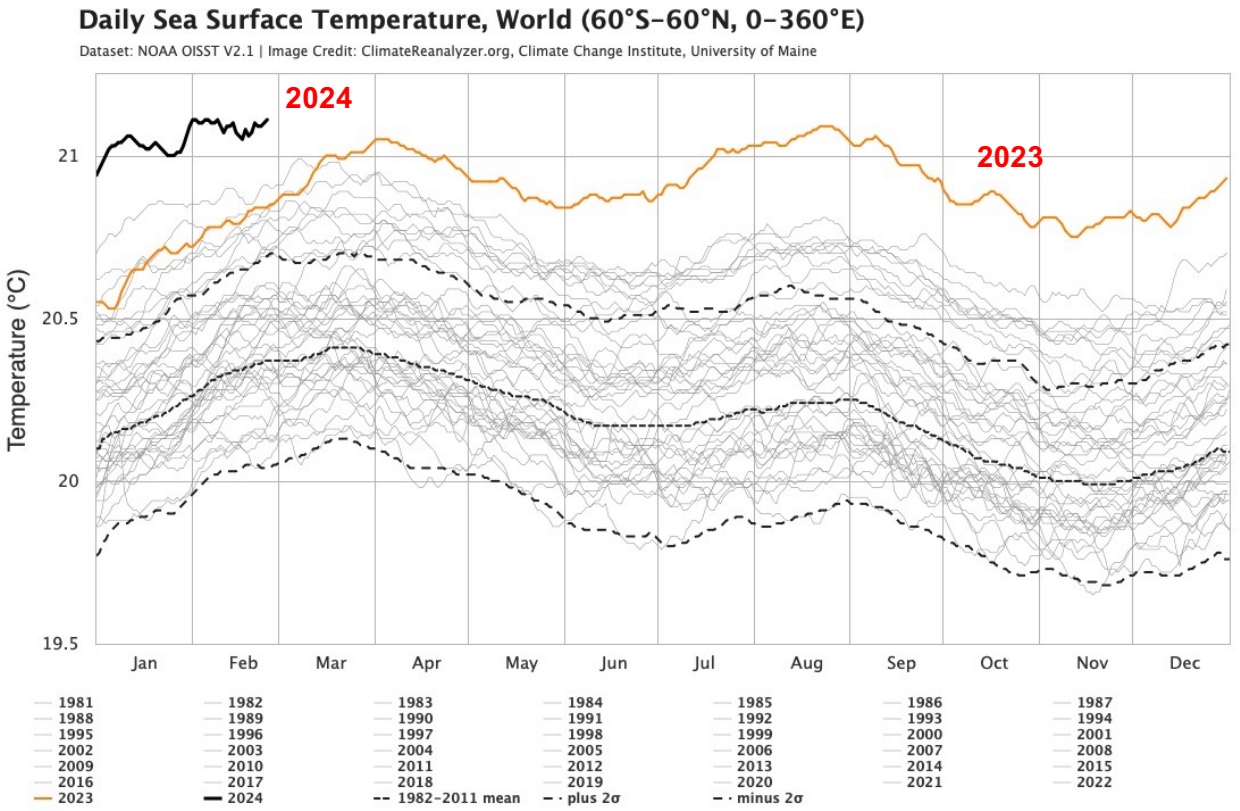
2023 : Climate change moved into a new era

- First year of 1.5°C warming. Second half of 2023 was 1.67°C.
- Sept. breaks record by 0.5°C.
- Devastating extreme heat, storms and floods.
- Sea Surface Temperatures beyond model projections.
- Antarctic sea-ice loss beyond model projections.
- Tipping points passed.



2023 : Climate change moved into a new era

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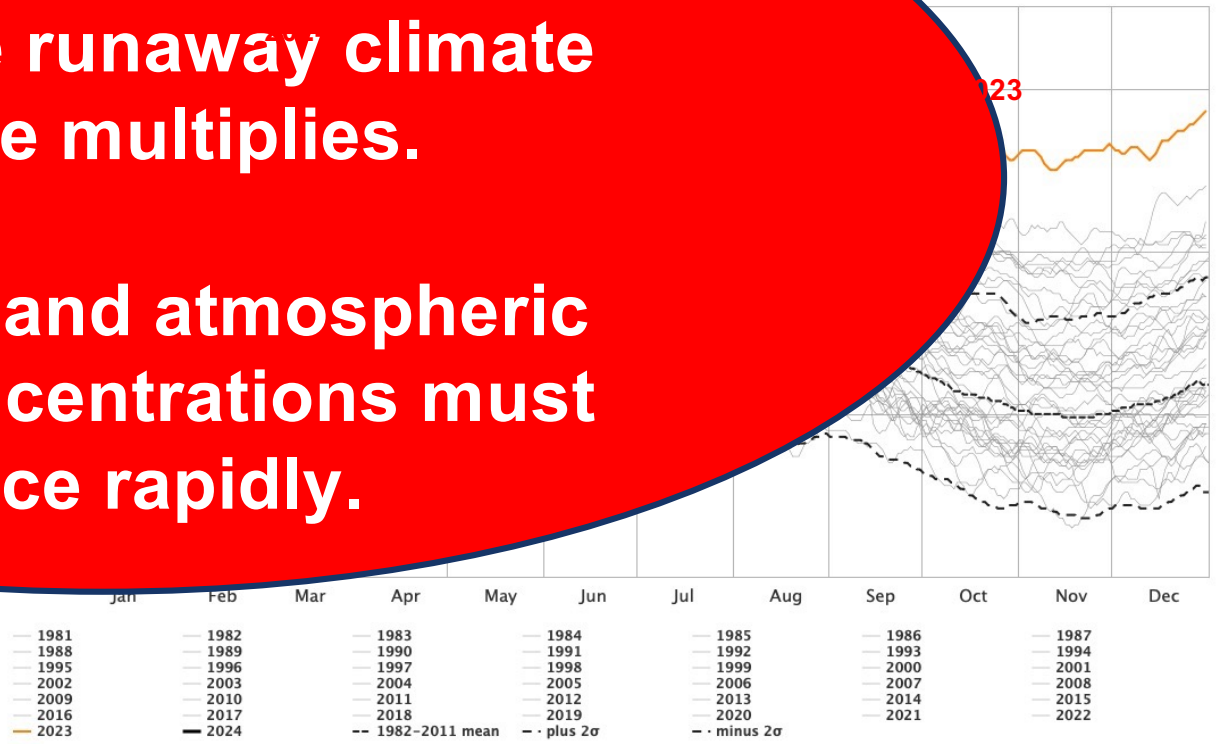
Humanity is now in very big trouble, as the danger of irreversible runaway climate change multiplies.

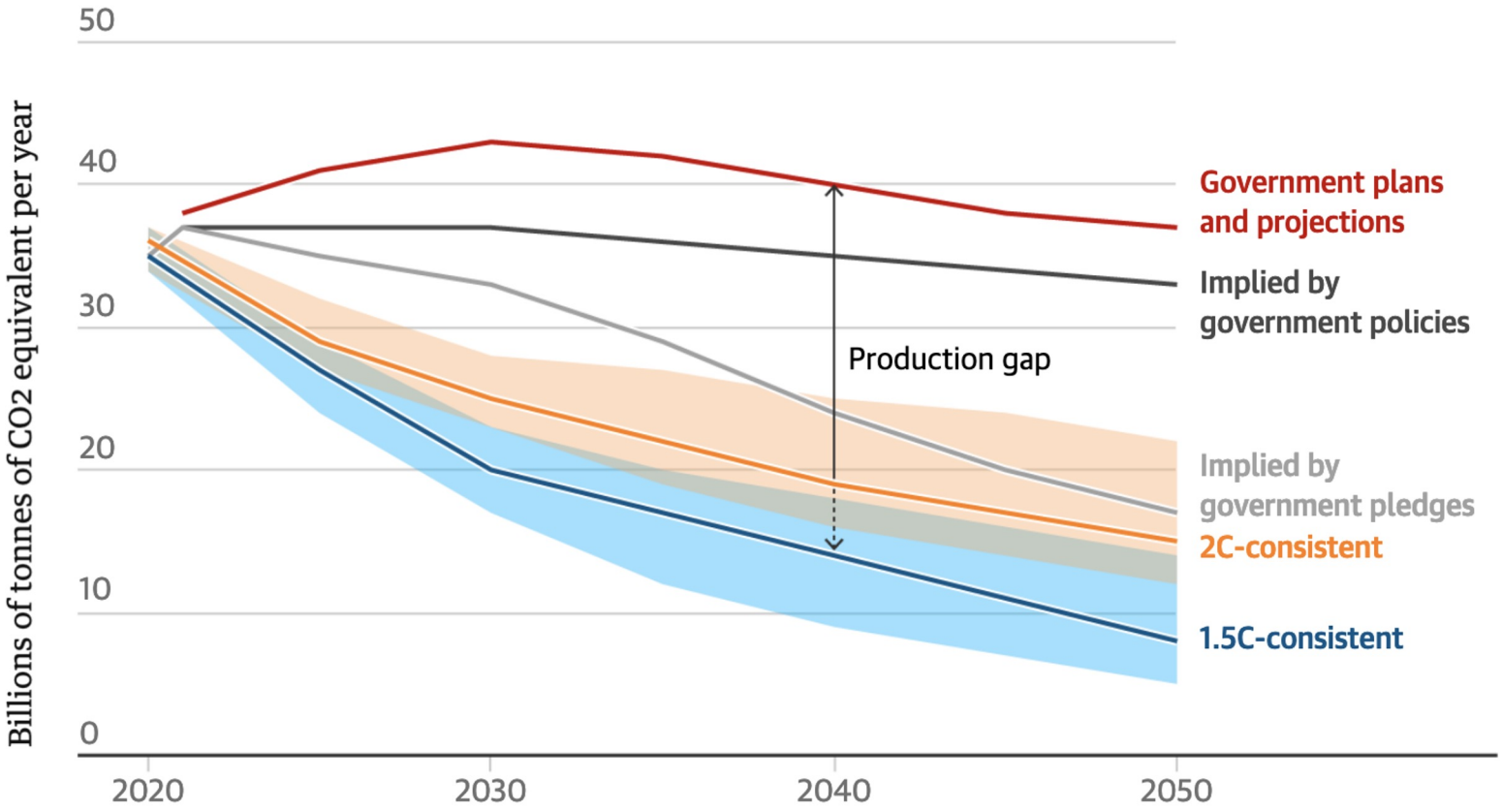
Emissions and atmospheric carbon concentrations must reduce rapidly.

1.67°C.



But global leaders have failed on the very basic issue of understanding climate risk

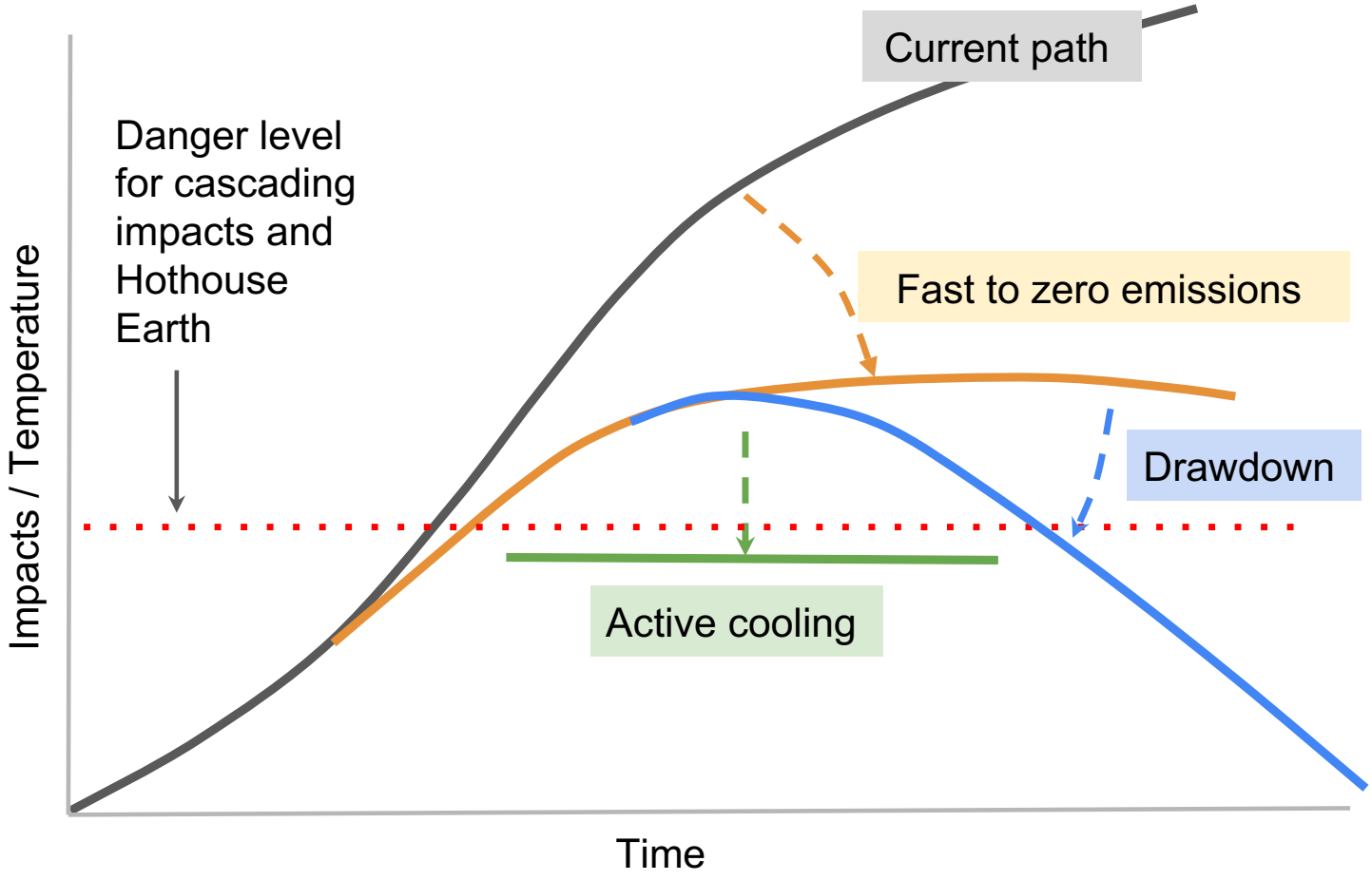
Current government and industry fossil fuel expansion plans worldwide will likely result in emissions in 2050 almost as high as they are today



Guardian graphic. Source: The Production Gap: SEI, Climate Analytics, E3G, IISD and UNEP 2023

Emergency Precautionary Action Essential

Reduce, remove, reflect and repair



Active cooling is vital to buy time to keep Earth below a warming level above which more system tipping points are activated and cascade.

Drawdown

Nature-based solutions

- Ecosystem sequestration
- Regenerative land management practices
- Marine upwelling
- Ocean iron fertilisation
- Enhanced mineralisation

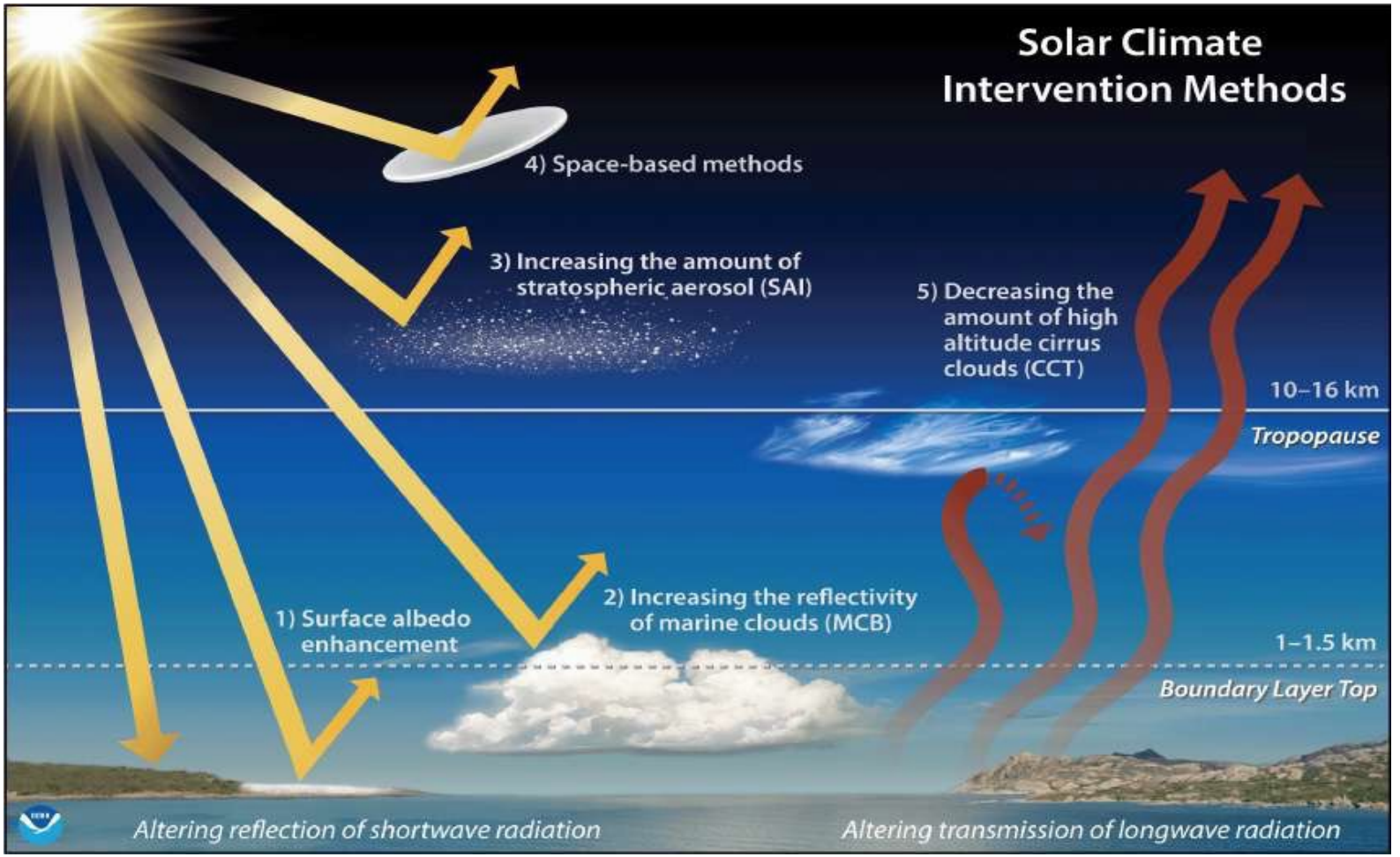
Technical solutions

- Negative emissions construction
- Ocean alkalinization
- Direct chemical capture by machines
- Bioenergy with carbon capture and storage (BECCS)?

Cooling

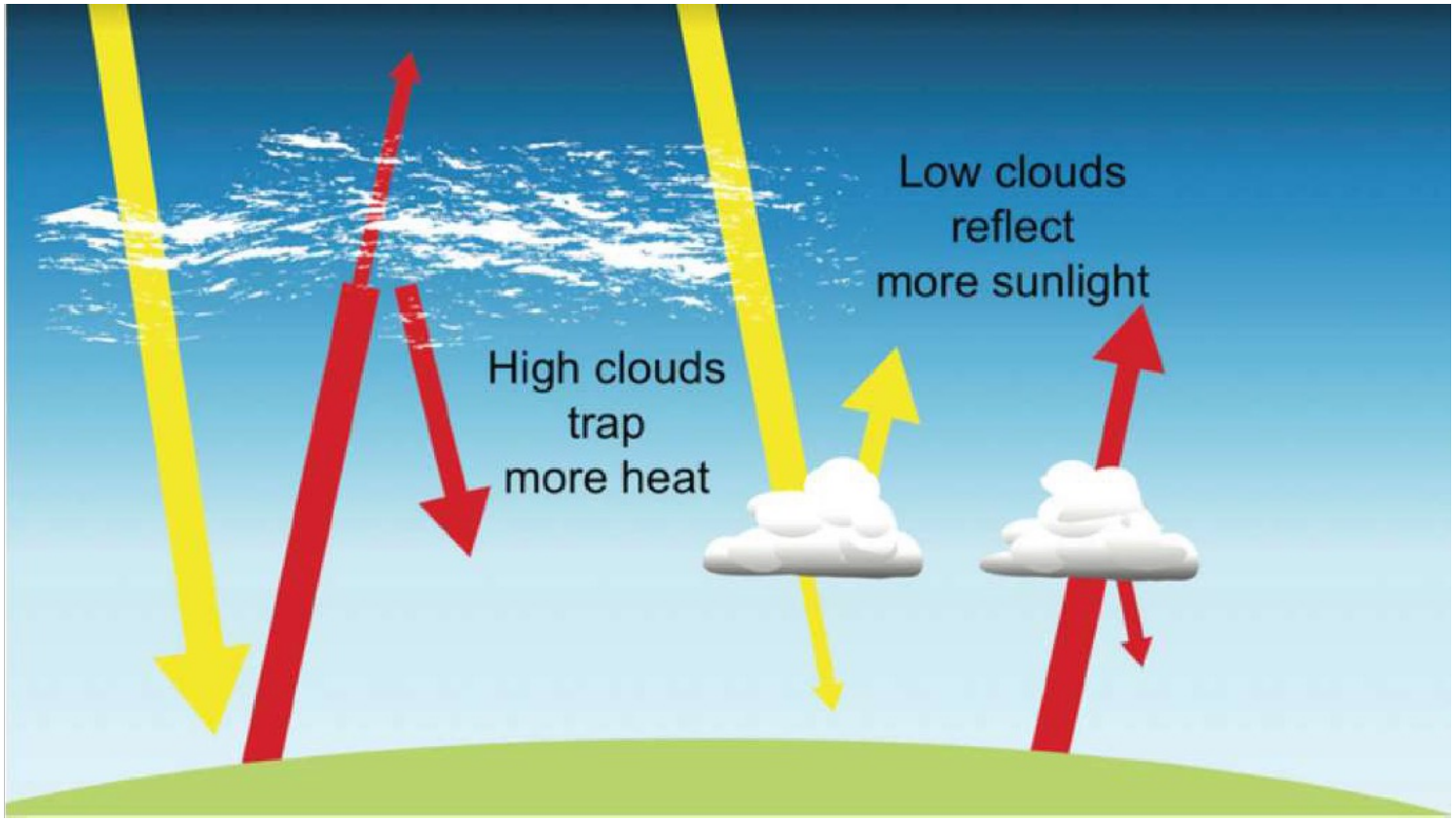
- Enhancing surface reflection with mirrors
- Marine cloud brightening
- Solar radiation management
- Increasing reflection of the terrestrial surface
- Decreasing the amount of high-altitude cirrus clouds

Solar Climate Intervention Methods



Blue Cooling Initiative

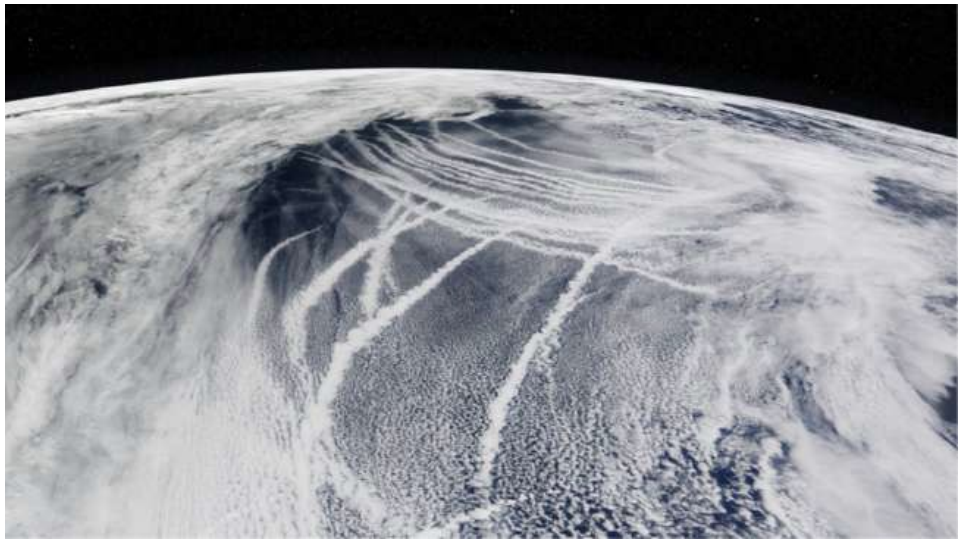
Marine Cloud Brightening Principle



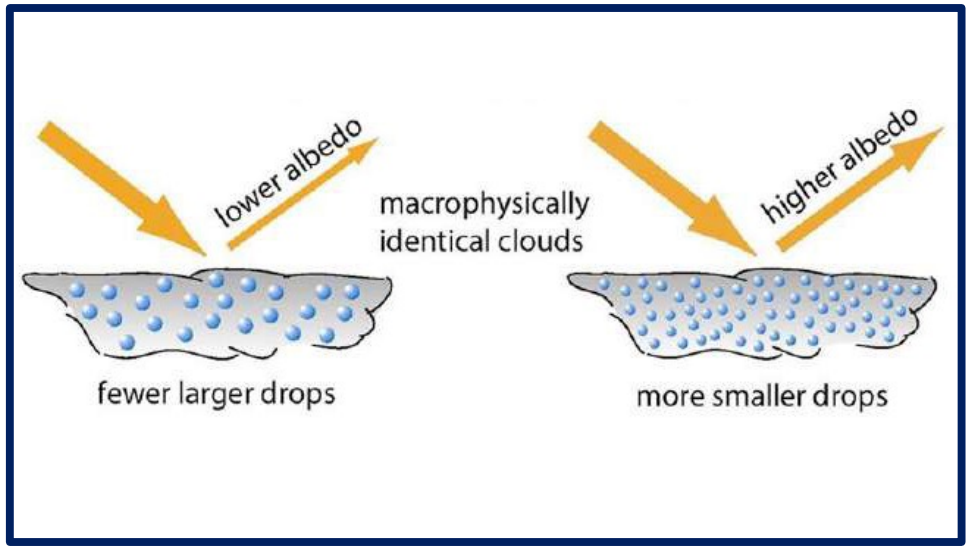
- **Low thick clouds cool the planet**
- **Whiter clouds cool more**
- **Clouds get whiter by adding nanoparticles from sea spray**

Marine Cloud Brightening Mechanism

Cloud Condensation Nuclei (CCN) from ships' chimney exhausts create smaller cloud droplets, resulting in whiter clouds
(*Twomey 1977*)



Use sea salt nano particles as CCN to reduce marine cloud droplets, resulting in whiter clouds
(Latham 1990)



Marine Cloud Brightening in a Nutshell

- Create a sea spray of sea salt nano- particles in the Marine Boundary Layer (0-1.5 km height) below existing clouds
- Nano particles are uplifted into the clouds by natural turbulence
- Nano particles act as natural CCN
- CCN reduce cloud droplets size
- Smaller droplets are whiter
- Whiter clouds reflect more sunlight (greater albedo)

Marine Cloud Brightening – scientific development

Aerosol generation & characterization Lab & modelling

Nano-aerosol generation by nozzles suitable for seawater (lab)

Single plume studies In marine environment Data & modelling

Multiple plume studies Leading to small scale PoC Data & Modelling

Marine Cloud Brightening - testing in Australia

Saving the Great Barrier Reef

- Cooling the Great Barrier Reef through MCB (NE coast of Australia)
- Nano particles spray from 320 nozzles engineered to brighten clouds and block sunlight
- First tests (2021): Technology might perform better than models predict. We are able to get the nano-particles into the clouds

Why is MCB the best option?

Comparison of three options

Space Shield	Stratospheric Aerosol Injection	Marine Cloud Brightening
Thought Experiment	Theoretical modelling	Small Trials already possible
Outer space	Inject 50 thd SO2 MT/day into stratosphere, create H2SO4 particles	Mimic natural sea spray in marine boundary layer
Massive geo-engineering experiment	Massive geo-engineering experiment	Mild “cloud engineering”
Huge engineering challenge	Huge engineering challenge	Engineering technologies under way
Unachievable in timeframe available	Available within 20 years? (too little, too late?)	Available within 5 years? (just in time?)
	Not localized	Localized
	Huge latency	Switch on & off
	Effects difficult to manage	Manageable side-effects
No political license	No political license	Political license achievable
No societal acceptance	No societal acceptance	Societal acceptance achievable
Science fiction	Desperate last resort?	Window of Opportunity closing fast

Critical messages and actions

- **Zero emissions at emergency speed:** with a decade — not 2050 — is the crucial time frame.
- The Earth is already too hot: **large-scale carbon drawdown** is vital.
- Damage is — and will become more — dangerous before long-term solutions are effective.
- **A safe means of immediate cooling** is critical to protect people & nature.

Reduce

Remove

Reflect & repair

Blue Cooling Initiative

The Blue Cooling Foundation intends to prove that cooling the planet based on natural phenomena - like increasing the albedo of clouds with Seaspray (Marine Cloud Brightening) - is possible and governable according to the Oxford Principles of Geoengineering.

Blue Cooling is a success when a broad group of stakeholders understands and supports its goals and when scientific research has been accelerated and coordinated sufficiently to be able to justify the science and to present a working governance model for Marine Cloud Brightening with Seaspray by 2030 at latest, preferably earlier.

BLUE COOLING
INITIATIVE

http://www.geoengineering.ox.ac.uk/www.geoengineering.ox.ac.uk/oxford-principles/principles/index.html

Thank you

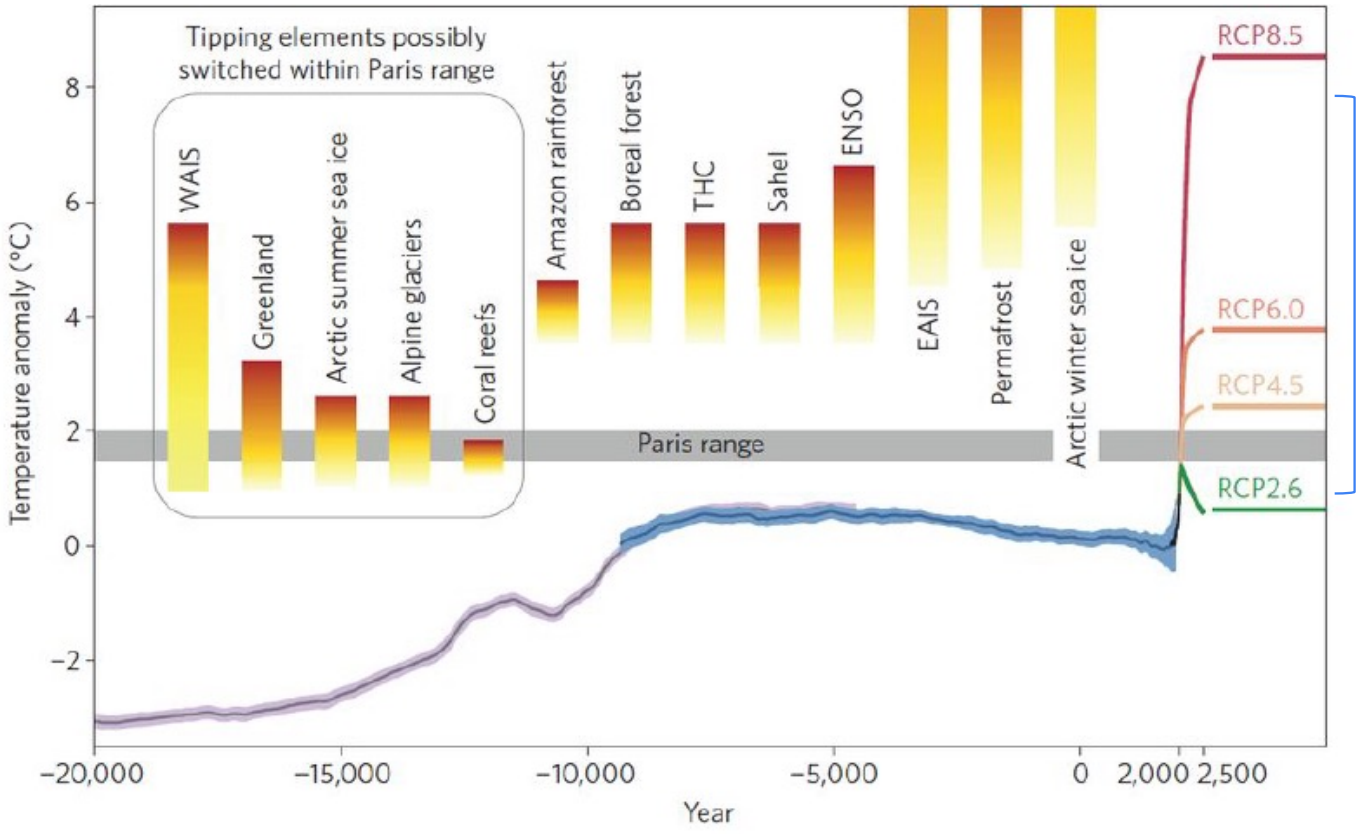
bluecooling.org
clubofrome.org
breakthroughonline.org.au
aslcg.org

The Big Uncertainties – Climate Tipping Points

A tipping point in the climate system is a critical threshold which, when exceeded, leads to large, non-linear and potentially irreversible changes to the system

Source: The planetary commons: A new paradigm for safeguarding Earth-regulating systems in the Anthropocene PNAS Rockstrom et al January 2024

Some Tipping Points may have already triggered



IPCC Scenarios

If the reaction time to prevent tipping exceeds the intervention time left before it occurs, we have lost control

Source: "Controlled Implosion of Fossil Fuel Industries", Schellnhuber, Rahmstorf, Winkelmann, Potsdam Institute, June 2016