Climate engineering - from atmospheric physics to ethics (and back)

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What this talk will be about

Why are we thinking about climate engineering?

What are options for cooling the climate?

What do we need to do to evaluate climate engineering concepts?

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Where do we stand right now?

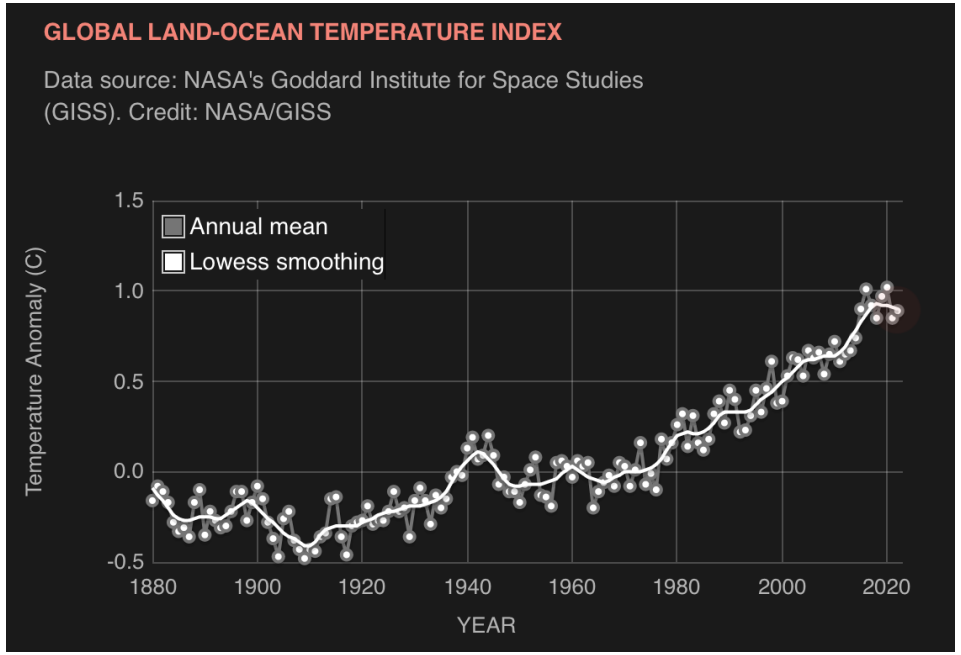


Image credit: NASA/GISS (https://climate.nasa.gov)

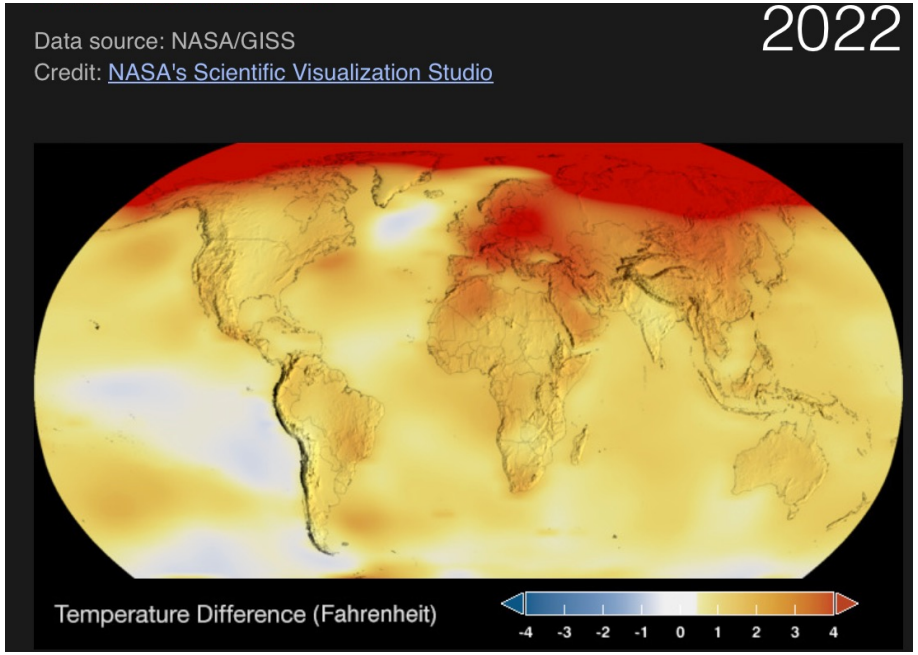
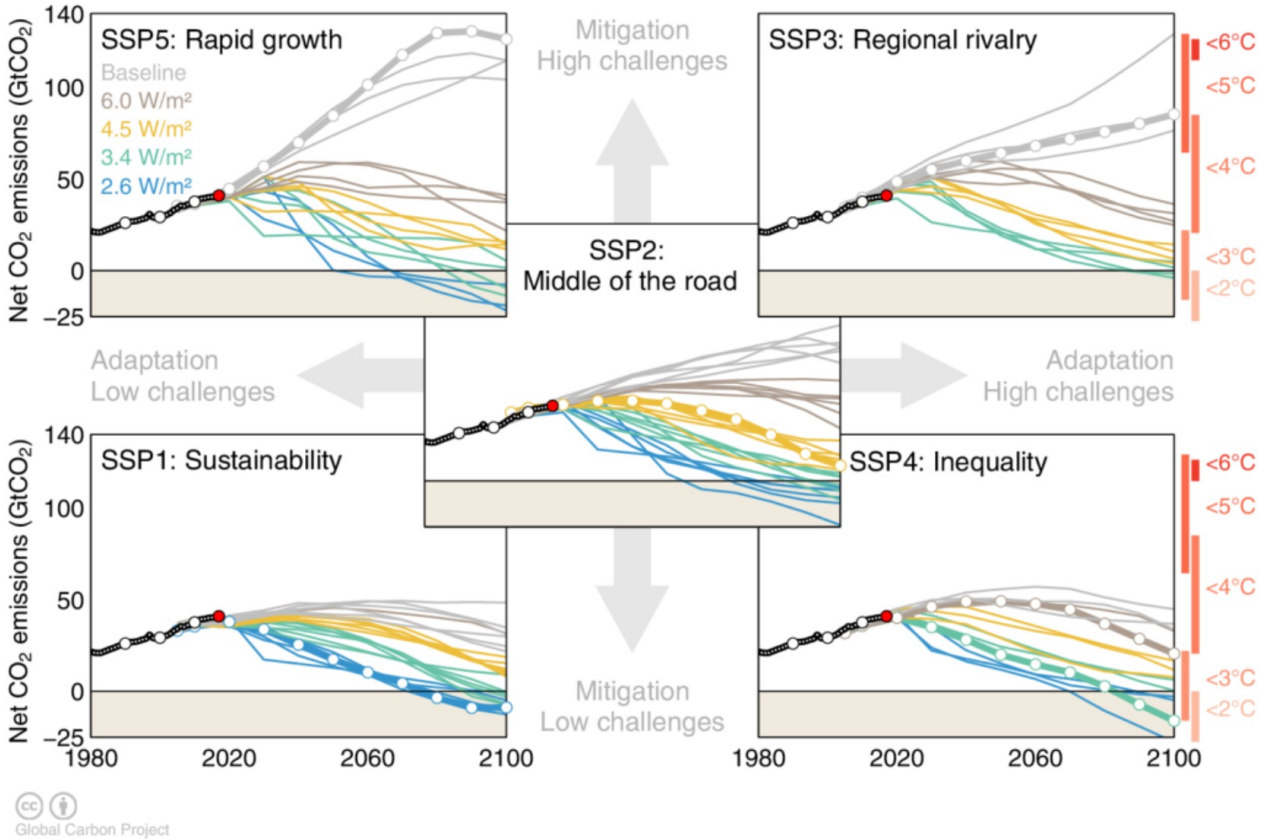


Image credit: NASA (https://climate.nasa.gov)

Temperatures have been increasing since the baseline period between 1951 and 1980, with strong regional patterns

Scenarios as major uncertainty in climate projections – shared socioeconomic pathways (SSPs)

SSP1-2.6
Stays below 2°C warming with implied net-zero emissions in the second half of the century.



Global CO2 emissions (GtCO2) for all IAM runs in the SSP database separated out by SSP. Chart via Glen Peters and Robbie Andrews and the Global Carbon Project.

Image credit: Carbon Brief (https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/)

SSP2-4.5
Approximately in line with the upper end of combined pledges under the Paris Agreement.

SSPs differ in factors such as population, technological, and economic growth

How will climate impacts develop in a warmer world?

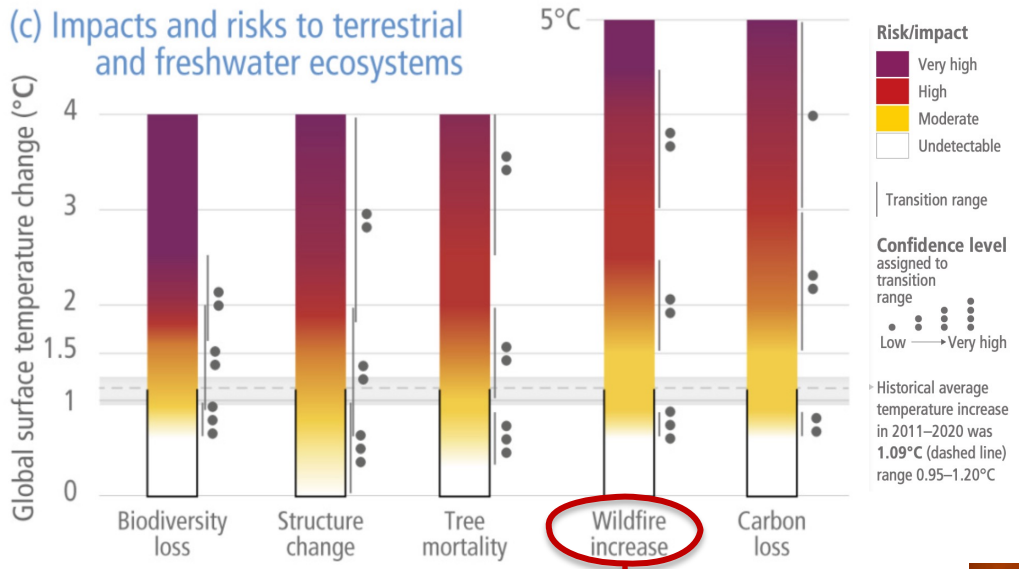


Image credit: IPCC (2022), Figure SPM 3c

Image credit: Tristan Fortsch/KATU-TV via AP

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From radiation management to carbon dioxide removal

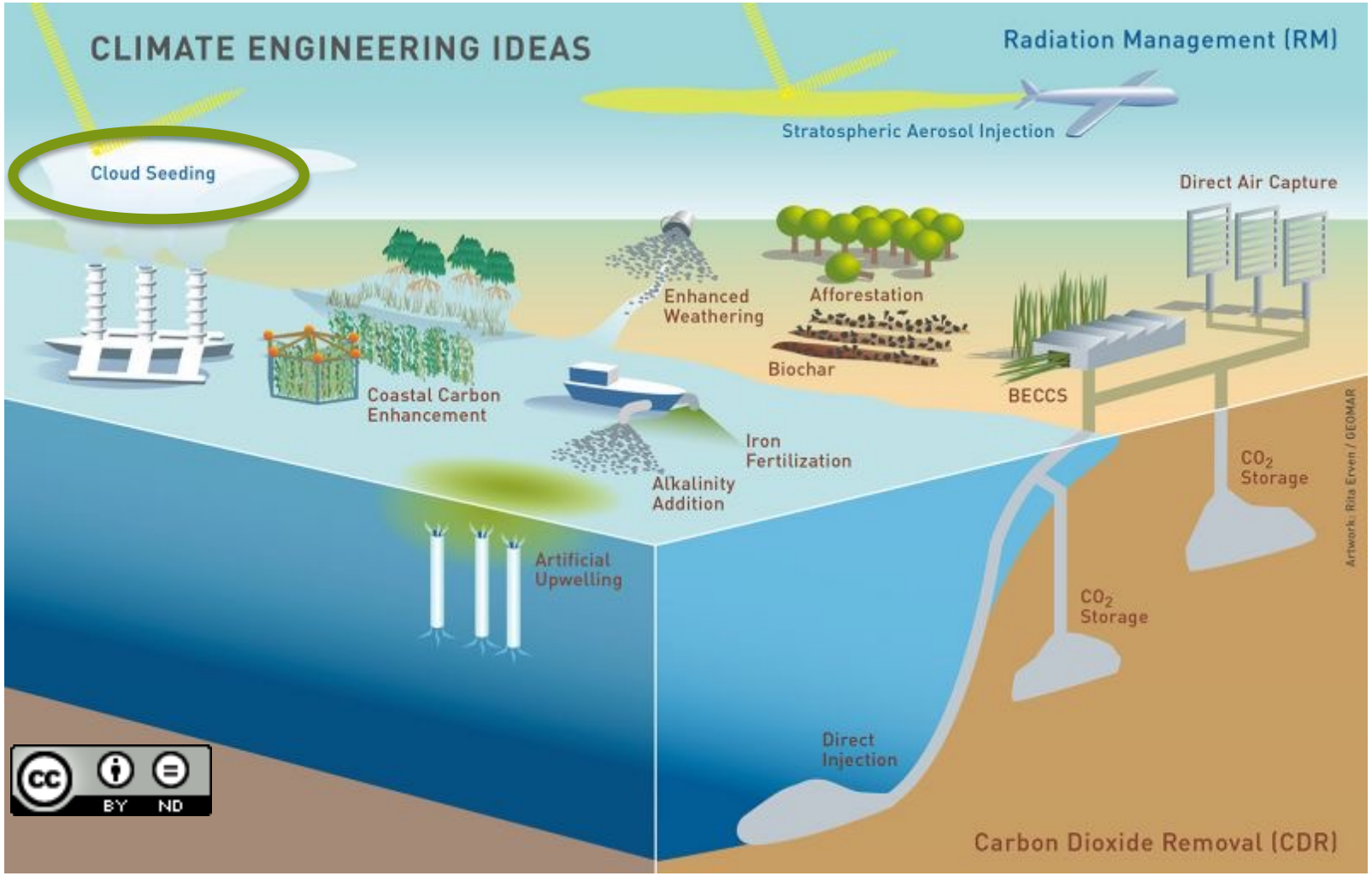

Image credit: SPP1689, DFG (https://www.spp-climate-engineering.de)

What is a cloud?

Clouds are a major part of our climate system and the hydrological cycle…

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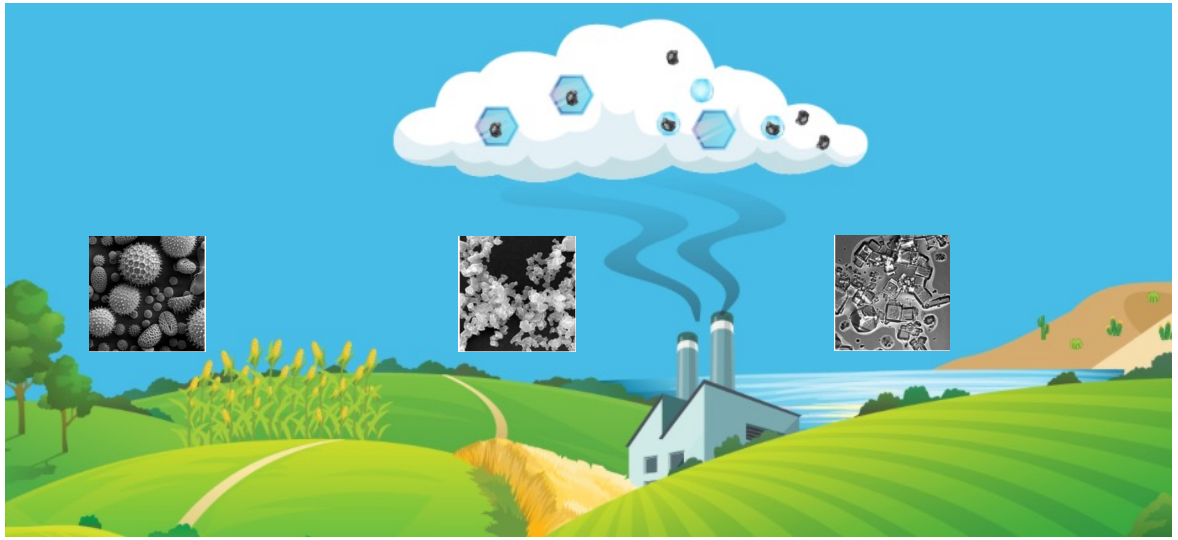

Image credits: Burrows et al., 2022; illustration by Cortland Johnson; micrographs courtesy of USGS, UMBC (Chere Petty), and Arizona State University (Peter Buseck)

…and they consist of droplets and ice crystals forming on tiny particles.

Marine cloud brightening (MCB)

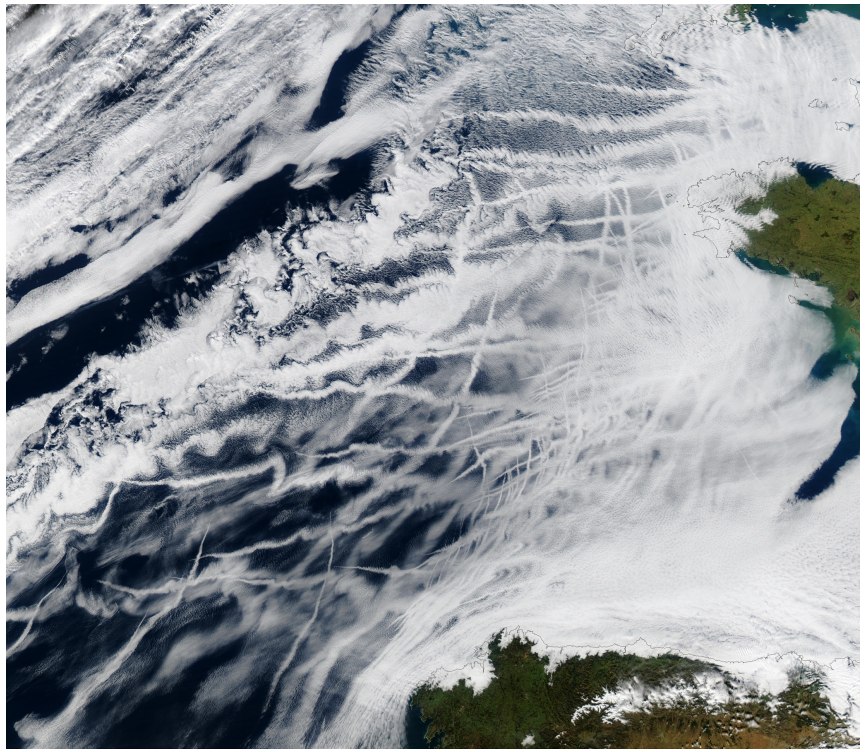

Image credit: NASA Earth Observatory

Marine clouds consist of tiny droplets and reflect the sun
→ **cooling effect**

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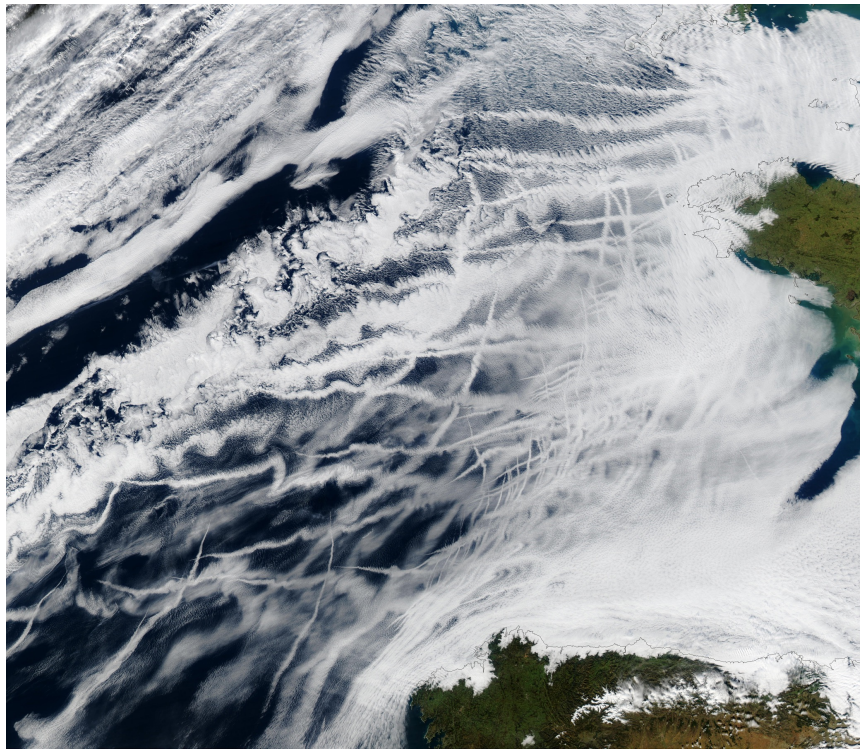

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Marine clouds consist of tiny droplets and reflect the sun
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Adding salt crystals creates smaller droplets
→ **more reflective clouds**

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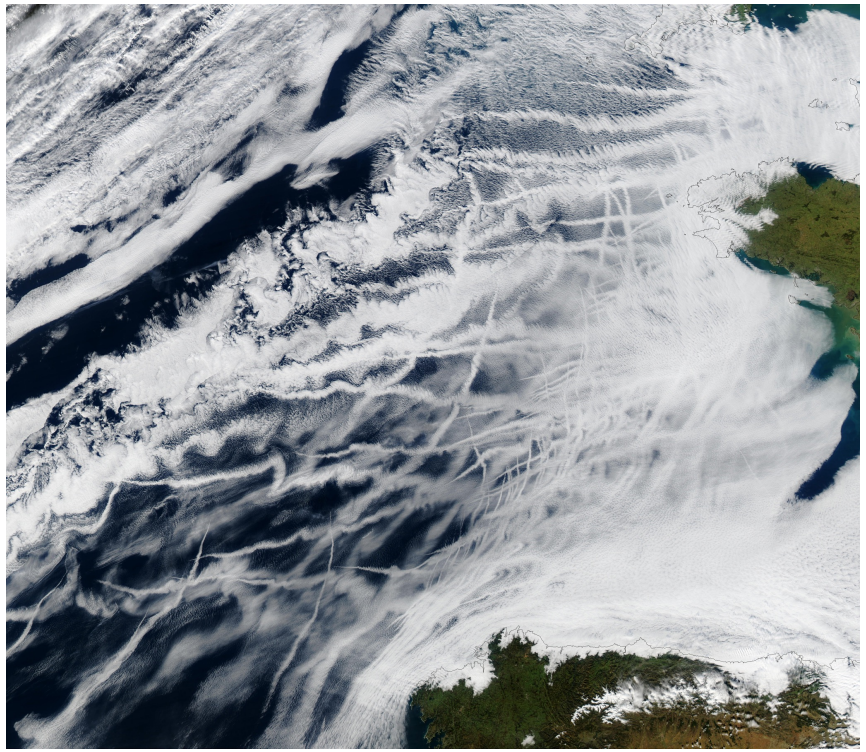

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Marine clouds consist of tiny droplets and reflect the sun
→ **cooling effect**

Adding salt crystals creates smaller droplets
→ **more reflective clouds**

→ **depends on particle size**

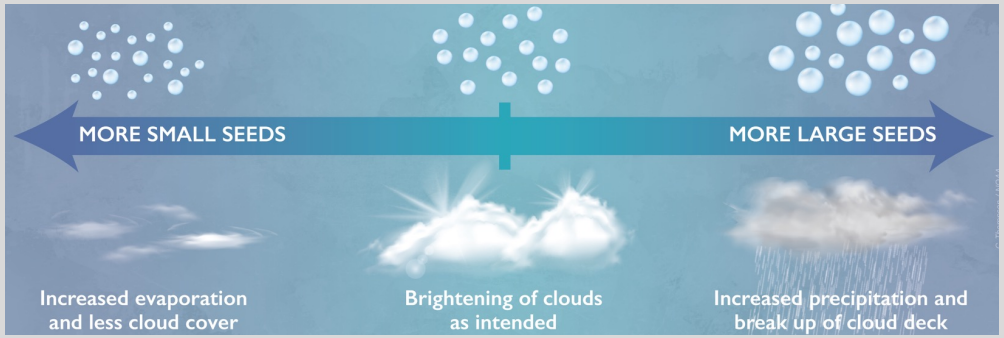


Image credit: Chelsea Thompson, NOAA Chemical Sciences Laboratory

Radiation management through ice cloud thinning

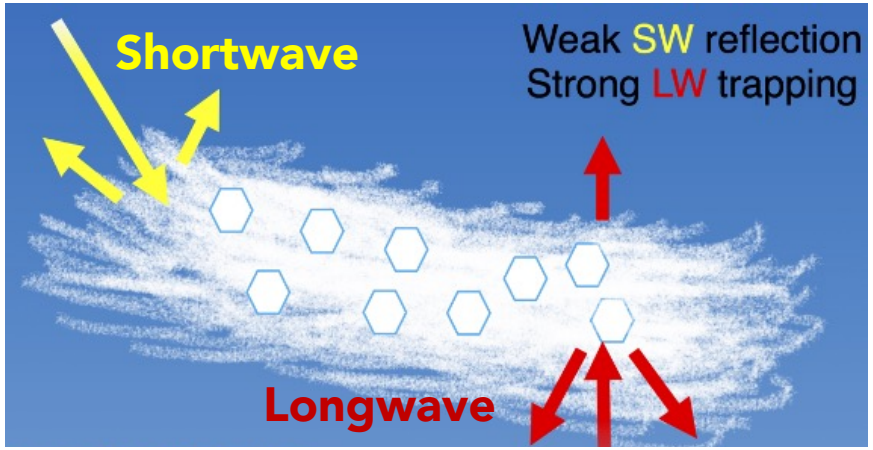
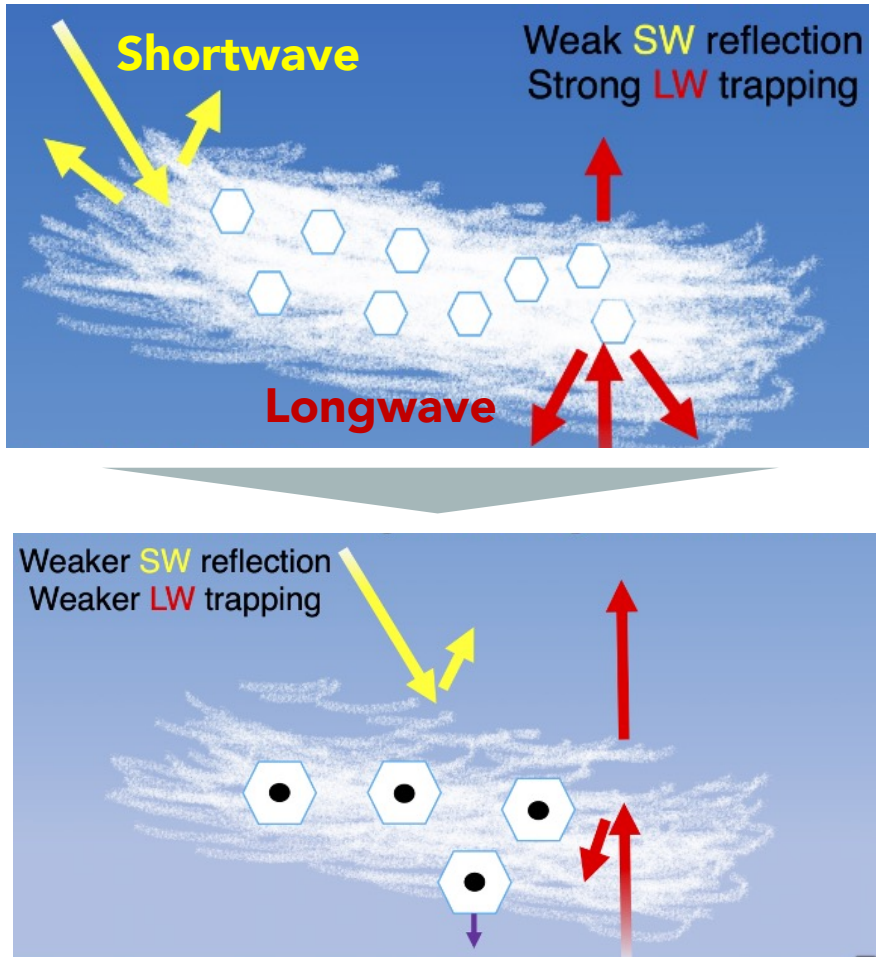


Image credit: IAC, ETH Zurich (https://iac.ethz.ch/group/atmospheric-physics/modelling-group/aerosol-cloud-interactions-aci.html) - adapted

Arctic winter cirrus clouds consist of tiny ice crystals which form on sulfate droplets
→ **warming effect**

Radiation management through ice cloud thinning



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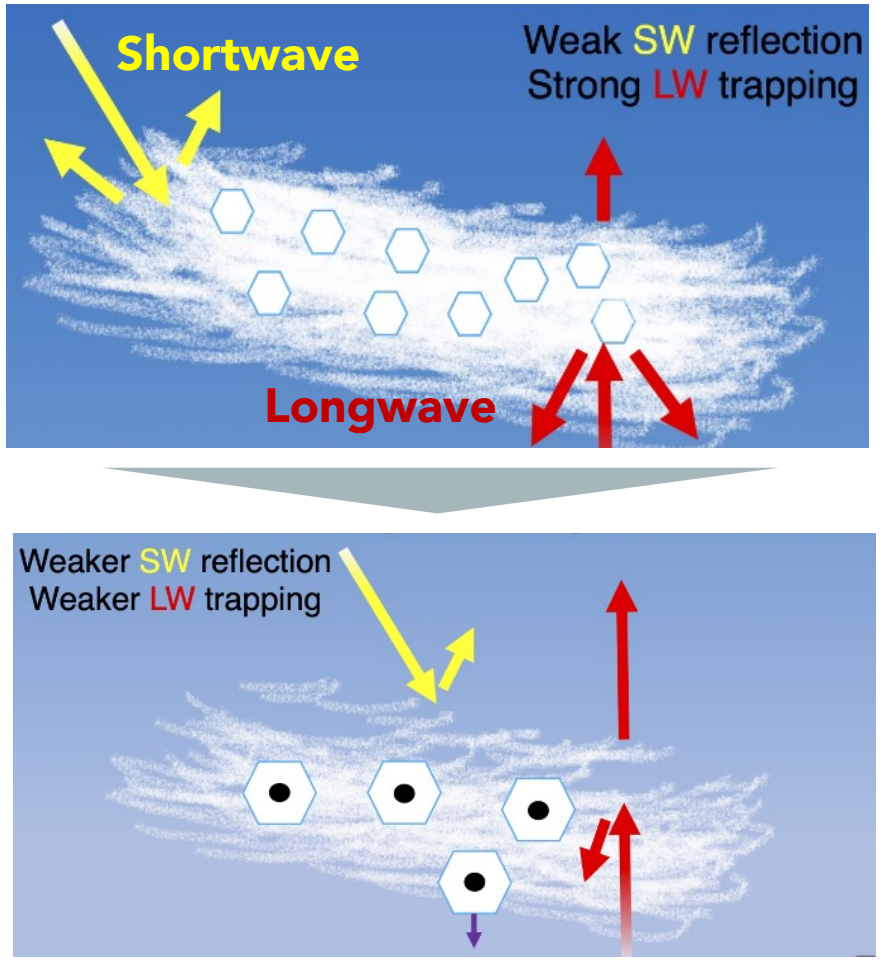
Impacting the balance between different ice formation processes creates larger ice crystals
→ **shorter lifetime & less warming**

Radiation management through ice cloud thinning



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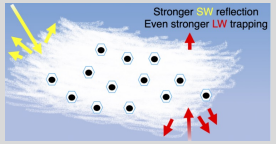
Arctic winter cirrus clouds consist of tiny ice crystals which form on sulfate droplets
→ **warming effect**

Impacting the balance between different ice formation processes creates larger ice crystals
→ **shorter lifetime & less warming**

→ **overseeding is possible**



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Climate engineering research as a linear process?

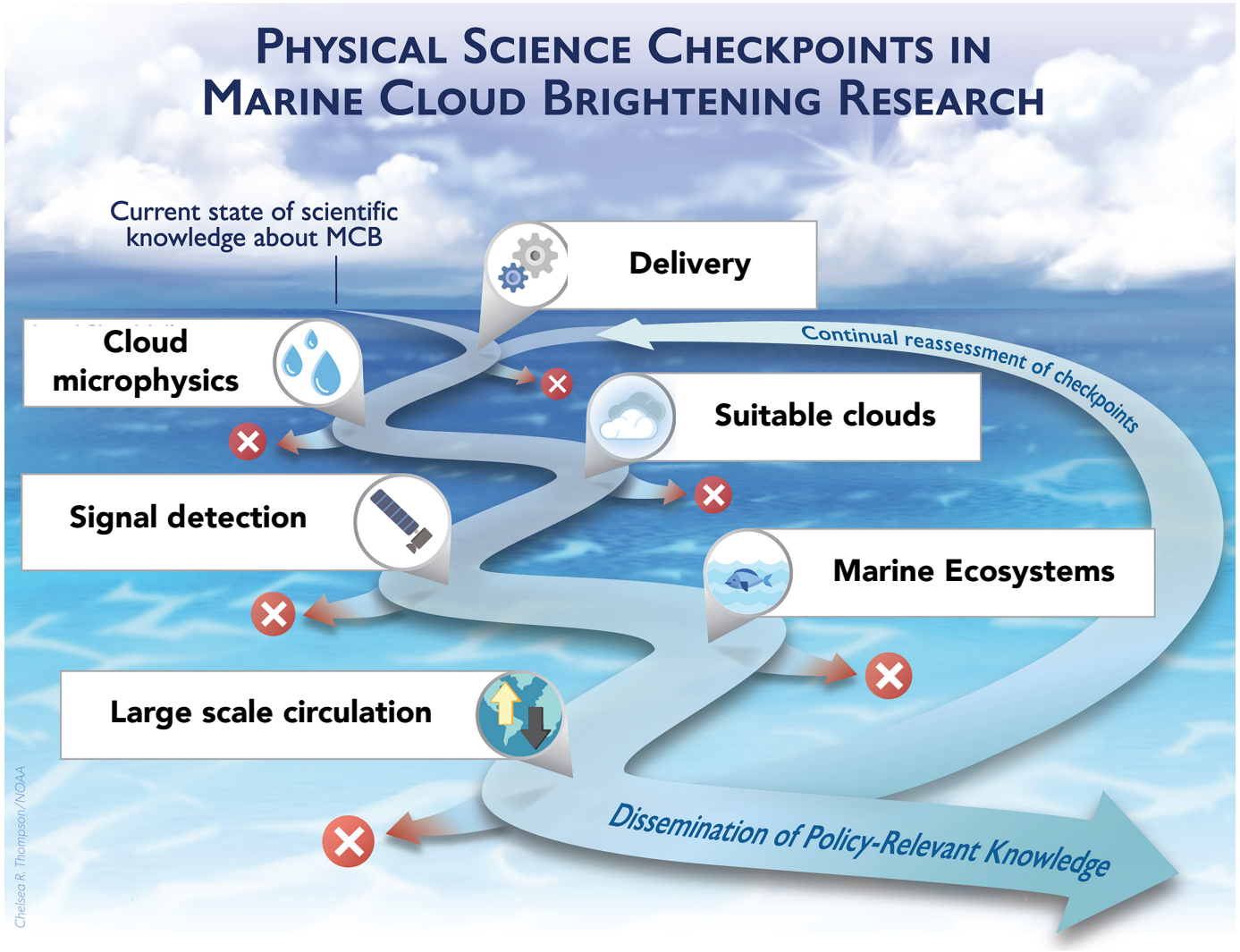
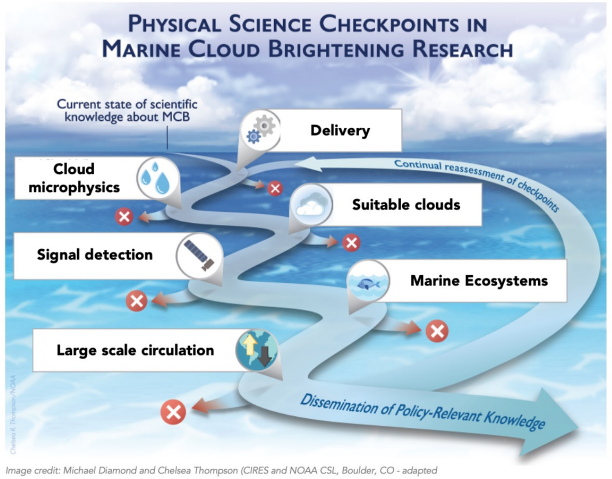


Image credit: Michael Diamond and Chelsea Thompson (CIRES and NOAA CSL, Boulder, CO - adapted

Climate engineering research as a linear process?

Engineering

Atmospheric physics



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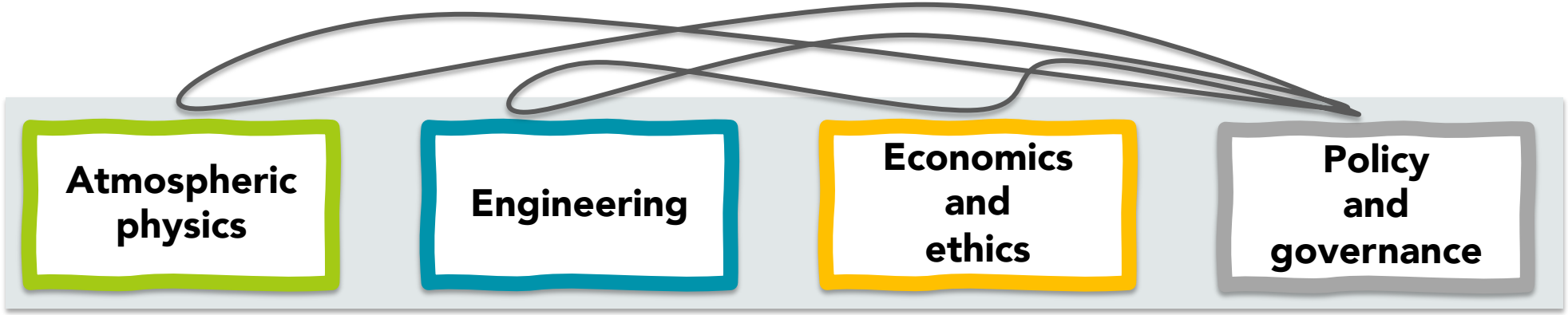
Economics and ethics

Policy and governance

Climate engineering research as a complex and hugely interdisciplinary challenge



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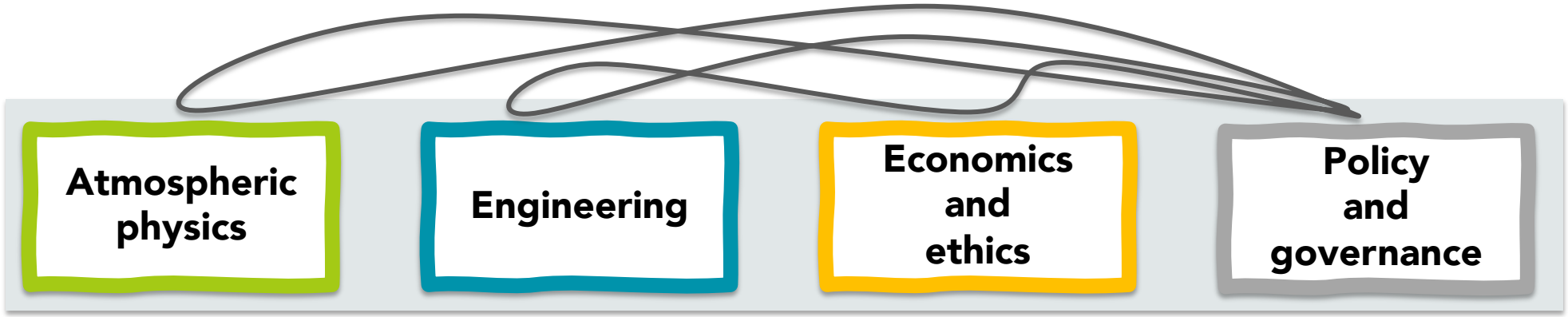


Is there a way to optimize our implementation strategy, and according to which goals?

How can we attribute cooling effects to radiation management?

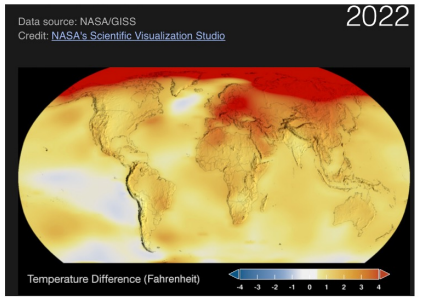
How well do we understand cloud formation?

Which non-toxic materials could we use?

Which regions would qualify for seeding?

What we talked about

Why are we thinking about climate engineering?



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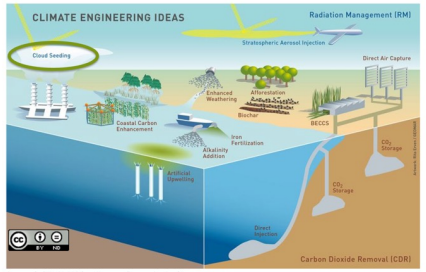
What are options for cooling the climate?



What do we need to do to evaluate climate engineering concepts?