

Geoengineering

- solar radiation management,
- carbon capture and storage -
- Cloud seeding
- risky, unproven and energy-intensive

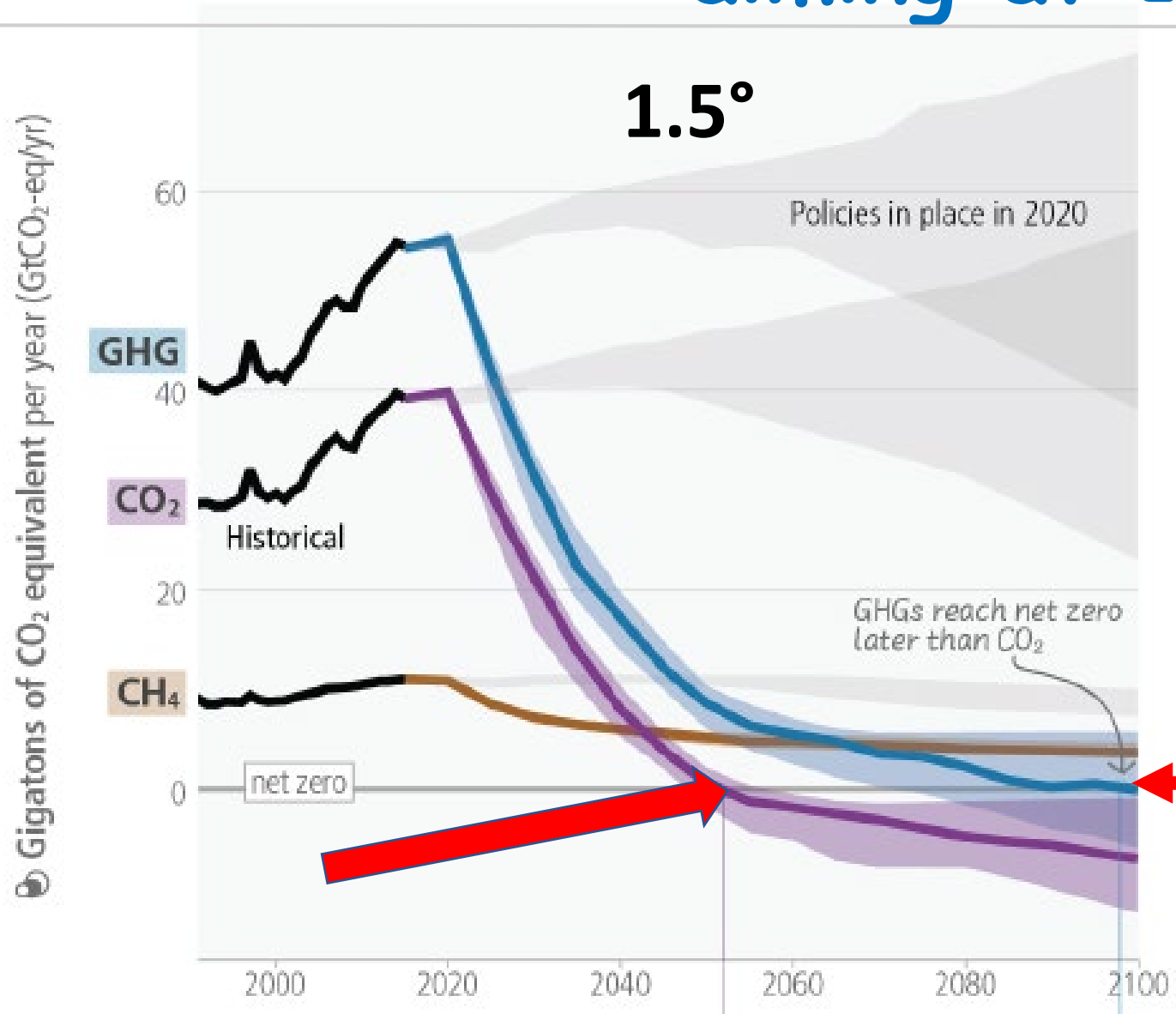
climate mitigation technologies imposed on the Global South

Prof. Dr. sc. agr. habil. Kerstin Wydra
Pflanzenbau im Klimawandel
Fachhochschule Erfurt
Solarinput e.V., Mitglied AbL

Climate Models

Projection of GHG emissions until 2100

- aiming at 1.5°C -

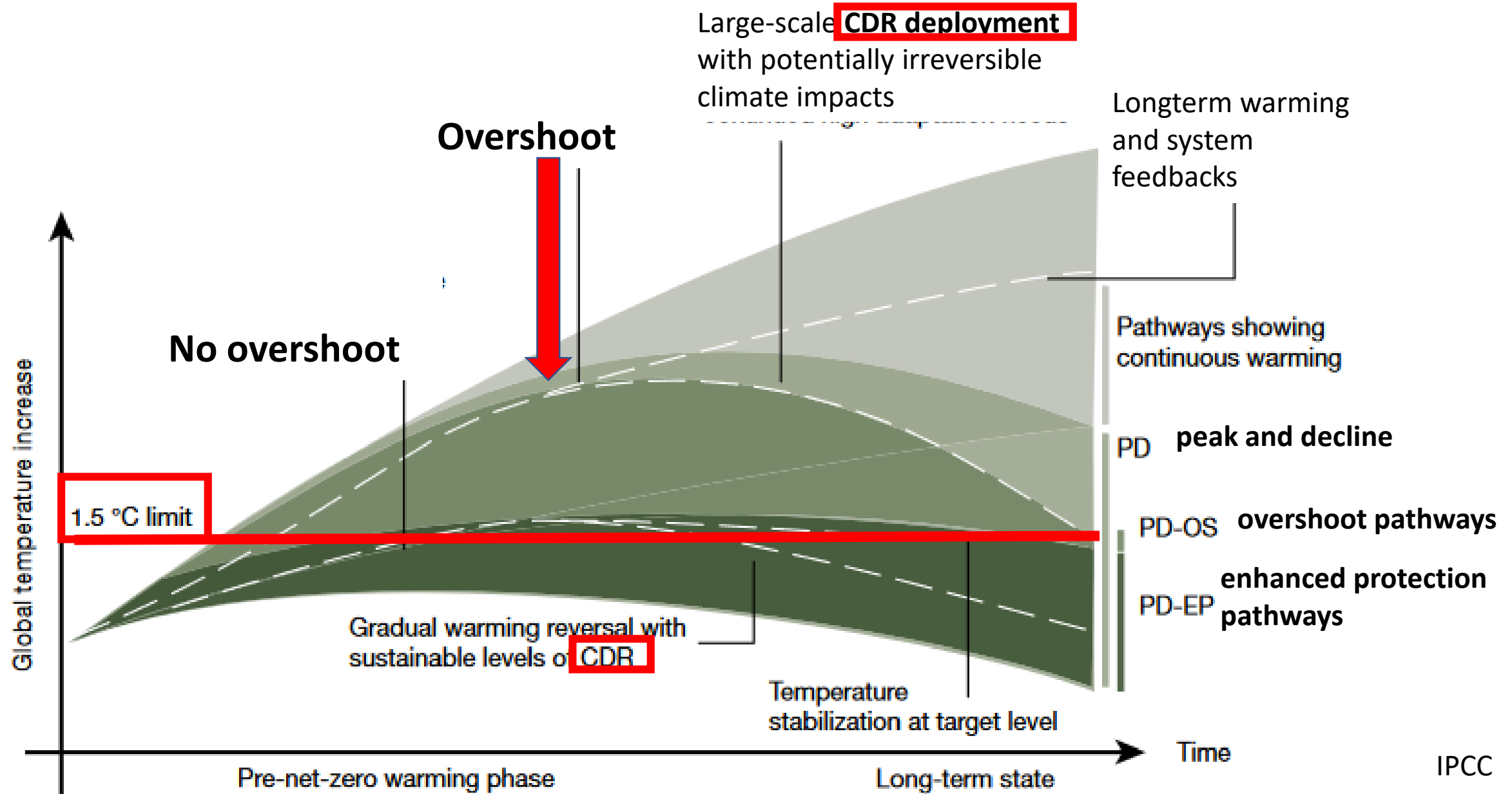


All pathways in IPCC models project the use of carbon dioxide removal (CDR) on the order of **100–1000 GtCO₂** until 2100

net zero in 2050

Climate overshoot

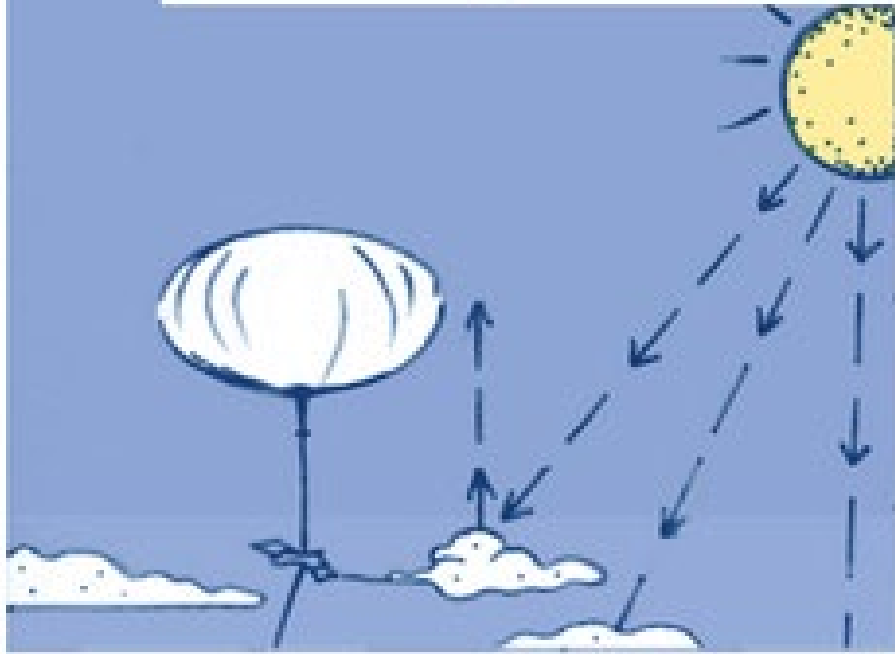
Climate outcome scenarios and decline pathways



Geoengineering

Types of geoengineering

Solar Radiation Management



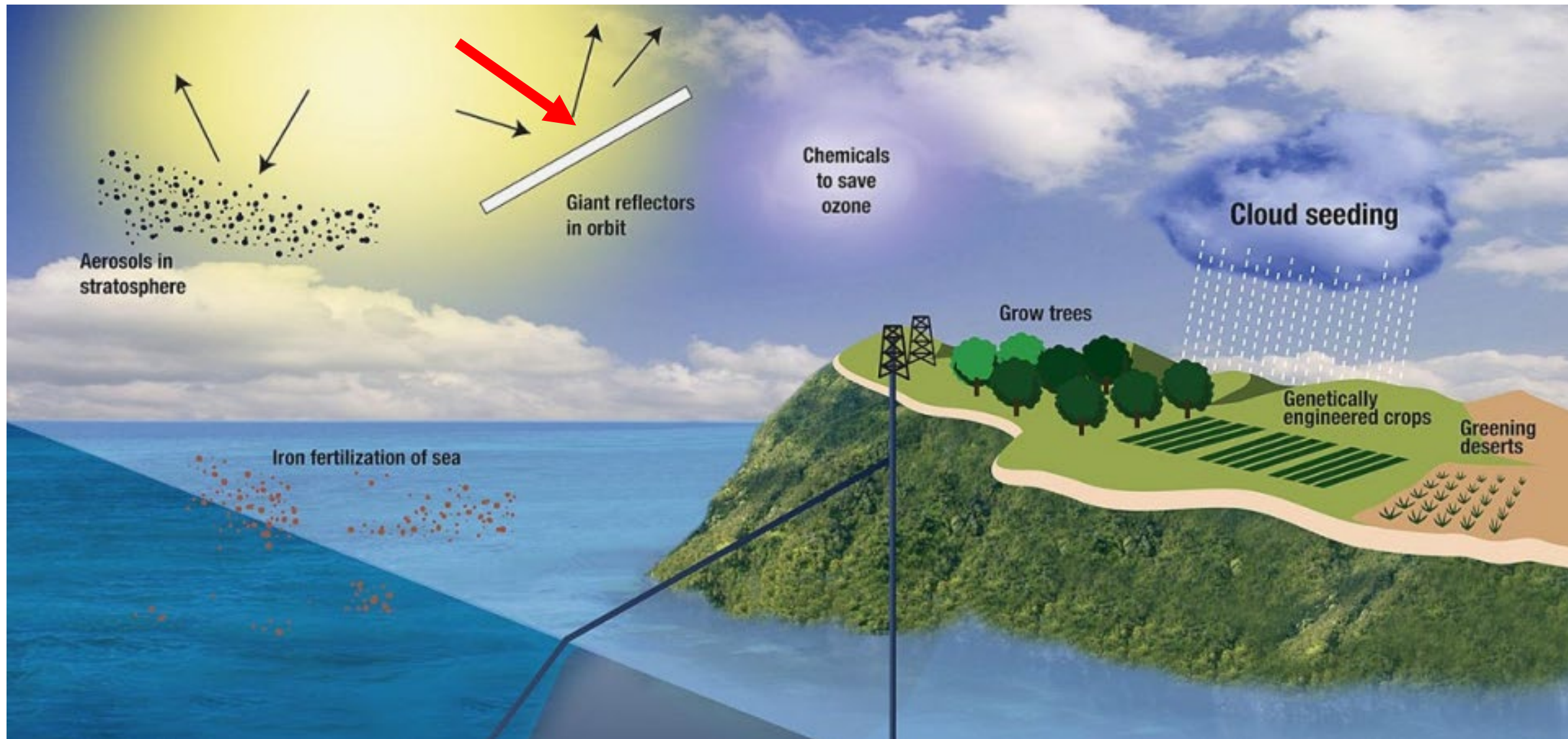
Carbon Dioxide Removal



+ weather modification

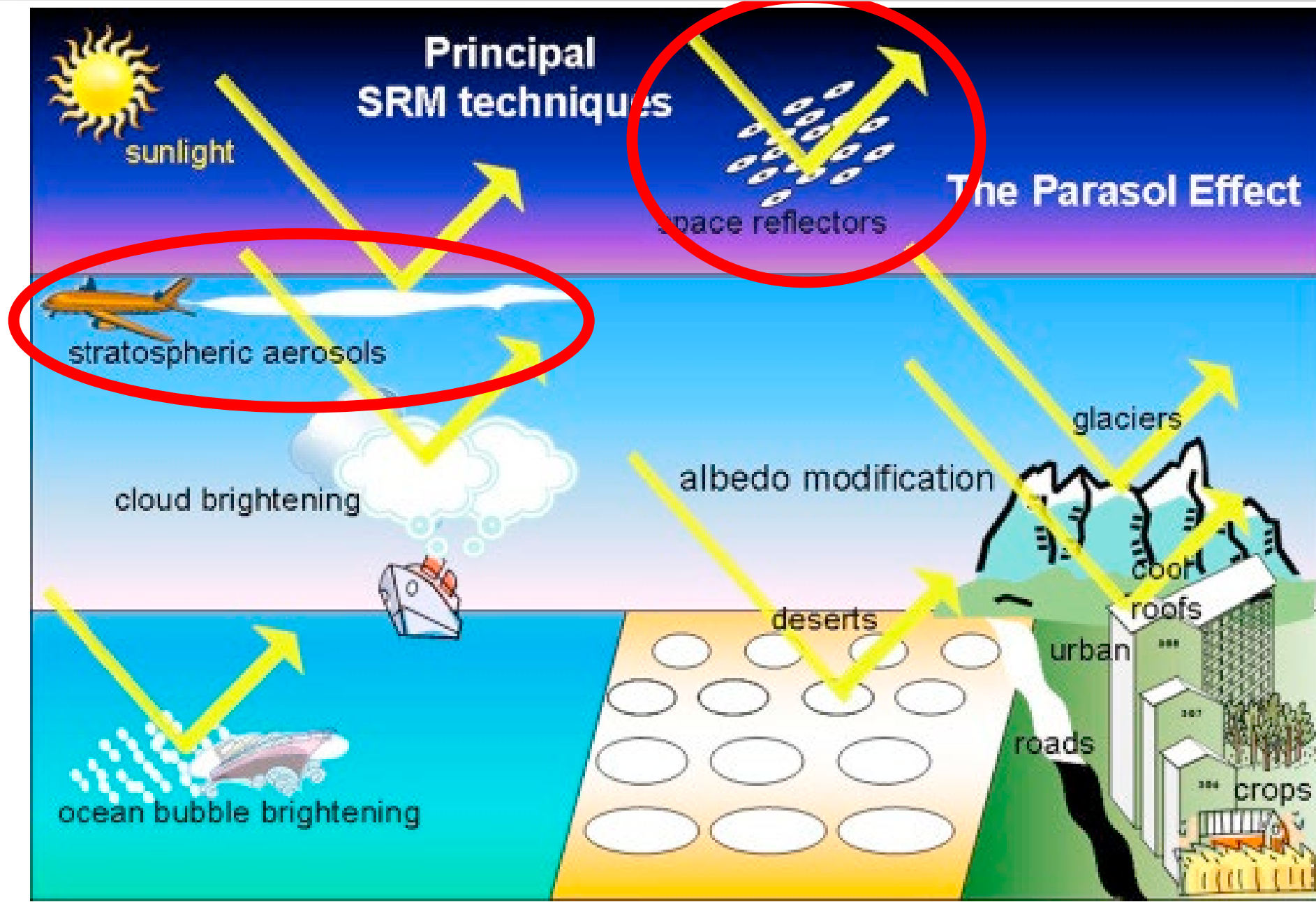
Solar Radiation Management SRM

Solar radiation management (SRM)



55,000 space mirrors in orbit each of 100 km²

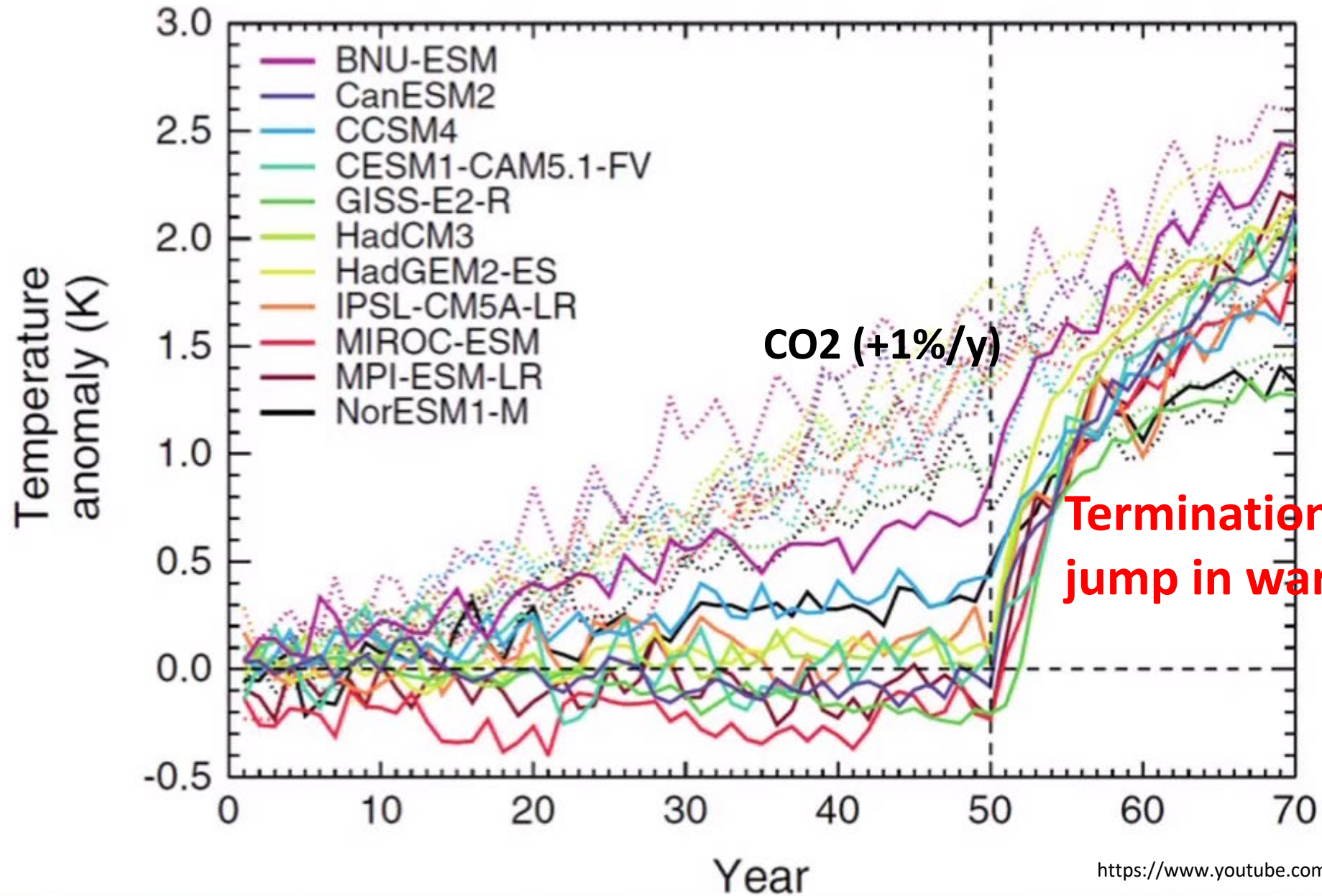
Solar radiation management (SRM)



Solar radiation management (SRM)

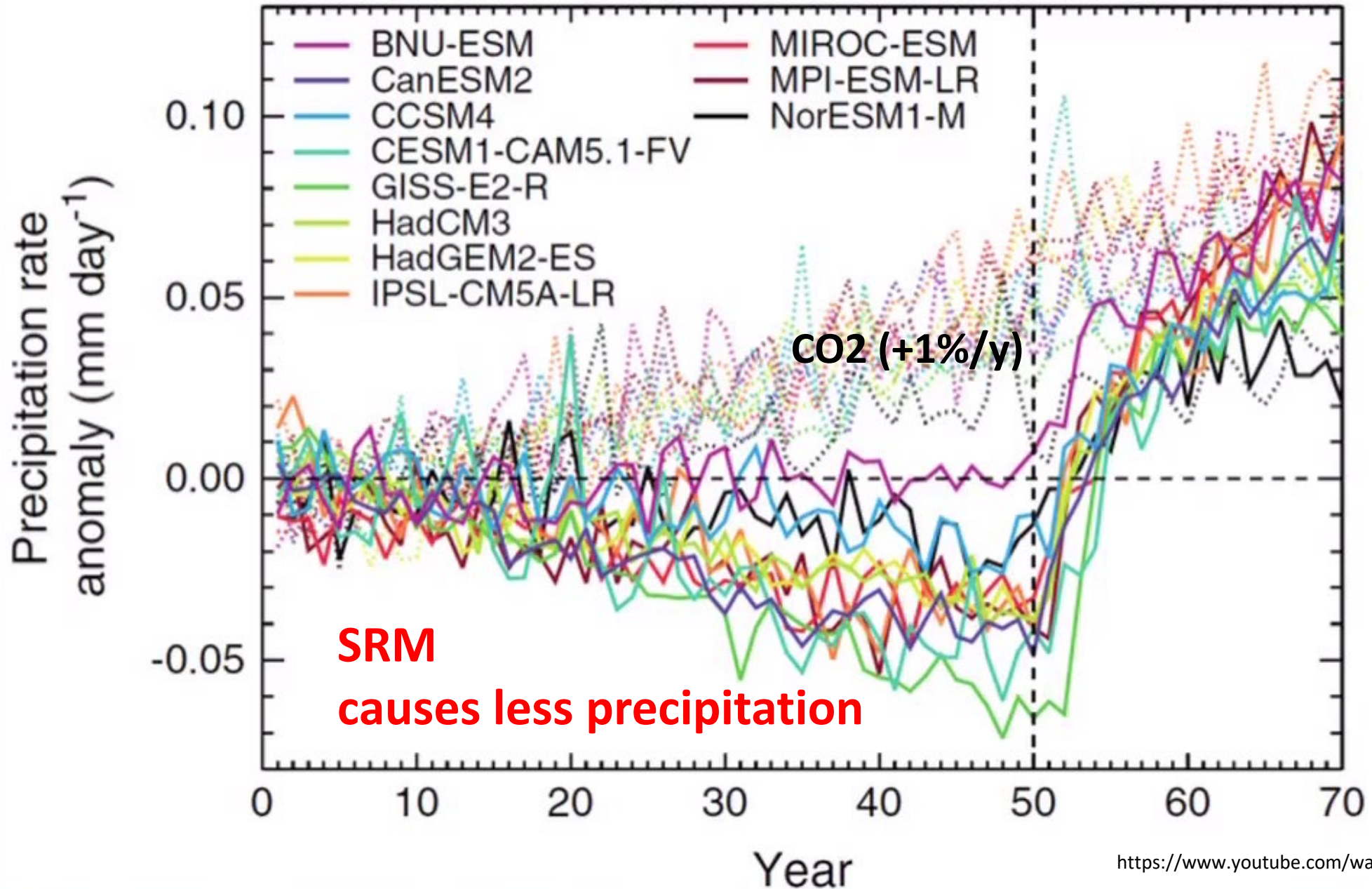
- Estimation: **continuous injection** rates over 100s and 1000s of years of **8–16 Tg of sulphur dioxide (SO₂) per year** (8-16Mio t)
(= Mount Pinatubo eruption in 1991)
would reduce global mean temperature by 1°C.
- Aim: Sulfur Air Injection (SAI) **scaled up** for **global cooling of 2–5°C**
- Aerosols released by SRM deployments persist in the **stratosphere**
for 1–3 years
- Tropospheric aerosols would persist for **about ten days** in the case
of marine cloud brightening

Risk of SRM



**Termination shock:
jump in warming**

Risk of SRM



Risk of SRM

1. Drought in Africa and Asia
2. Perturb ecology with more diffuse radiation
3. Ozone depletion
4. Continued ocean acidification
5. Will not stop ice sheets from melting
6. Impacts on tropospheric chemistry
7. Whiter skies
8. Less solar electricity generation
9. Degrade passive solar heating
10. Rapid warming if stopped
11. Cannot stop effects quickly
12. Human error
13. Unexpected consequences
14. Commercial control
15. Military use of technology

Risk of SRM

16. Societal disruption, conflict between countries
17. Conflicts with current treaties
18. Whose hand on the thermostat?
19. Effects on airplanes flying in stratosphere
20. Effects on electrical properties of atmosphere
21. Environmental impact of implementation
22. Degrade terrestrial optical astronomy
23. Affect stargazing
24. Affect satellite remote sensing
25. More sunburn
26. Moral hazard - the prospect of it working would reduce drive for mitigation
27. Moral authority - do we have the right to do this?

Risk of SRM

16. Societal disruption, conflict between countries
17. Conflicts with current treaties
18. Whose hand on the thermostat
19. Effects on airplanes
20. Effects on agriculture
21. Environmental impacts
22. Justice
23. Accountability
24. Remote sensing
25. Control
26. Unintended hazard - the prospect of it working would reduce drive for mitigation
27. Moral authority - do we have the right to do this?

There is no justification to test a technology that poses such extensive risks while at the same time doing nothing to reduce the drivers of climate change and ocean acidification.

Carbon Capture and Storage

Direct Air Capture (DAC) and liquefaction of CO₂



Air contractor device for direct air capture (Carbon Engineering)

Iceland: World's largest DAC and CO₂ storage plant



Orca CO₂ direct air capture plant in Iceland (source: Climeworks)



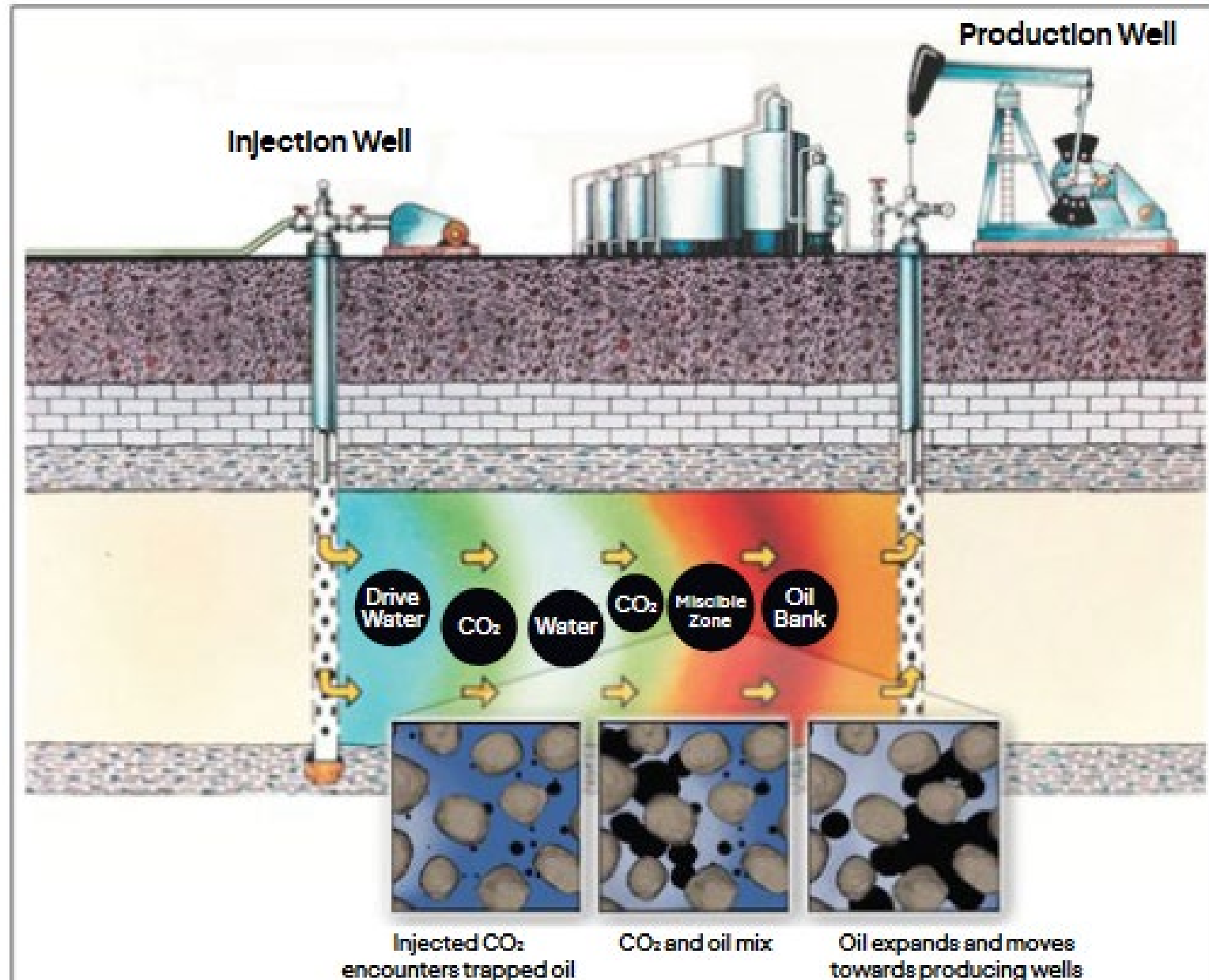
<https://www.carbonbrief.org/around-the-world-in-22-carbon-capture-projects/>

Carbon capture project

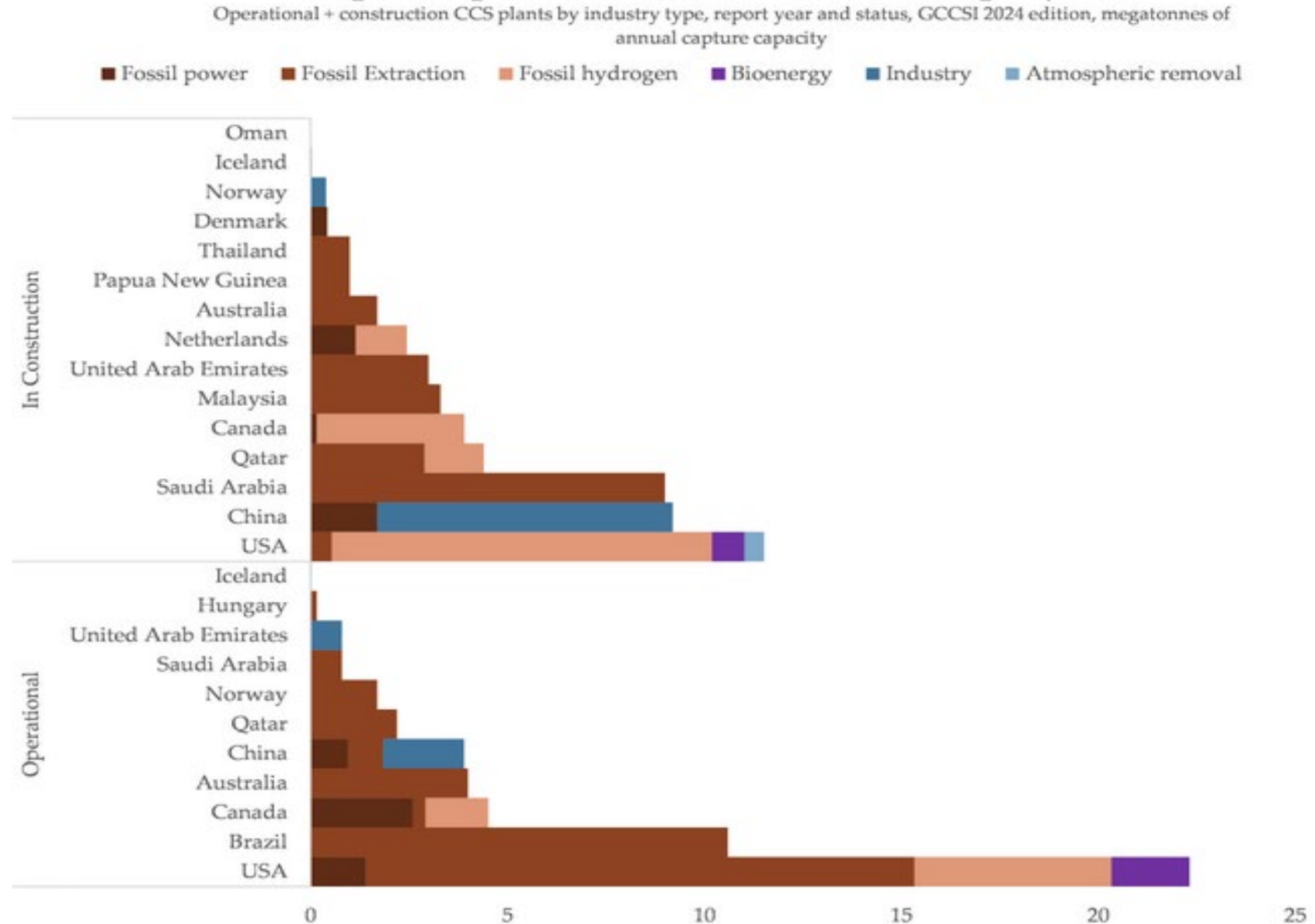
- at full load (,Vollauslastung‘)
up to 4000t/year
= emissions of only 1000 cars !!!!!!!!!!!

<https://www.thinkgeoenergy.com/worlds-largest-direct-air-capture-and-co2-storage-plant-on-in-iceland/>

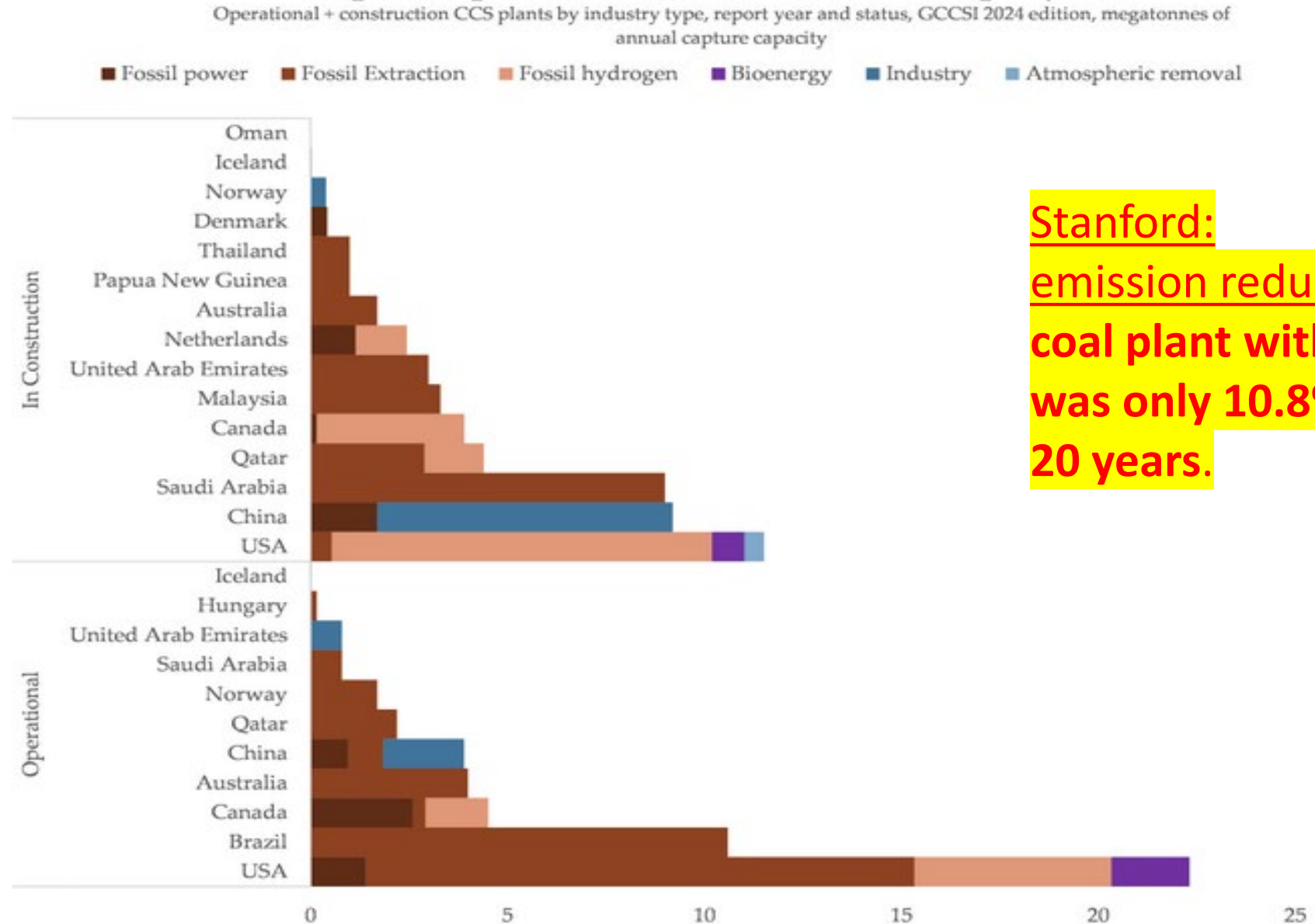
>90% of CCS projects used for enhanced oil recovery



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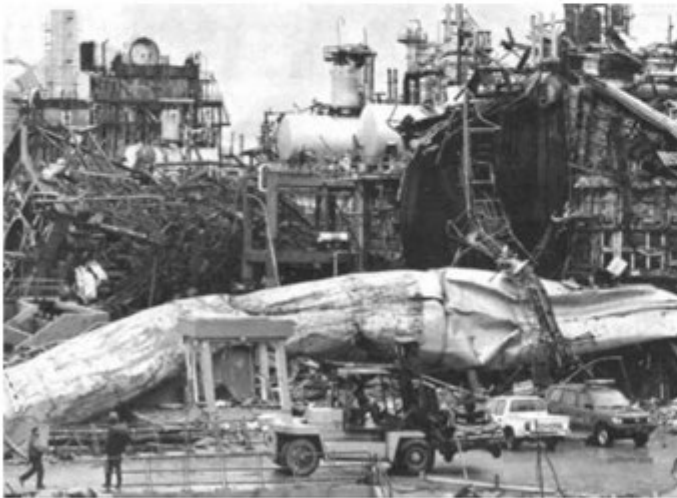
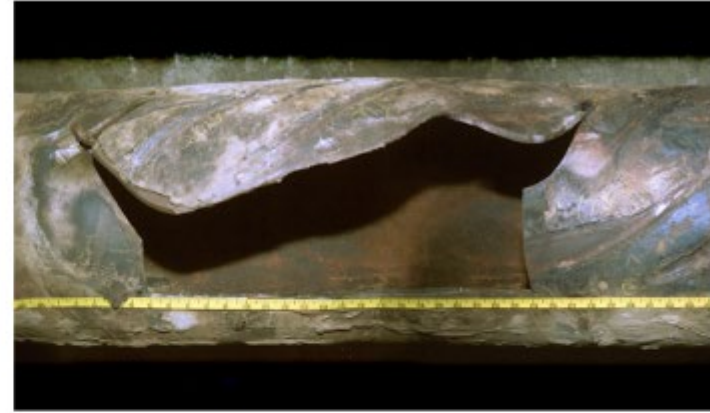
Stanford:
emission reduction of
coal plant with CCS
was only 10.8% over
20 years.

CO₂ transport hazard

A running fracture – result of a test



Fractured gasoline line—
undetected damage

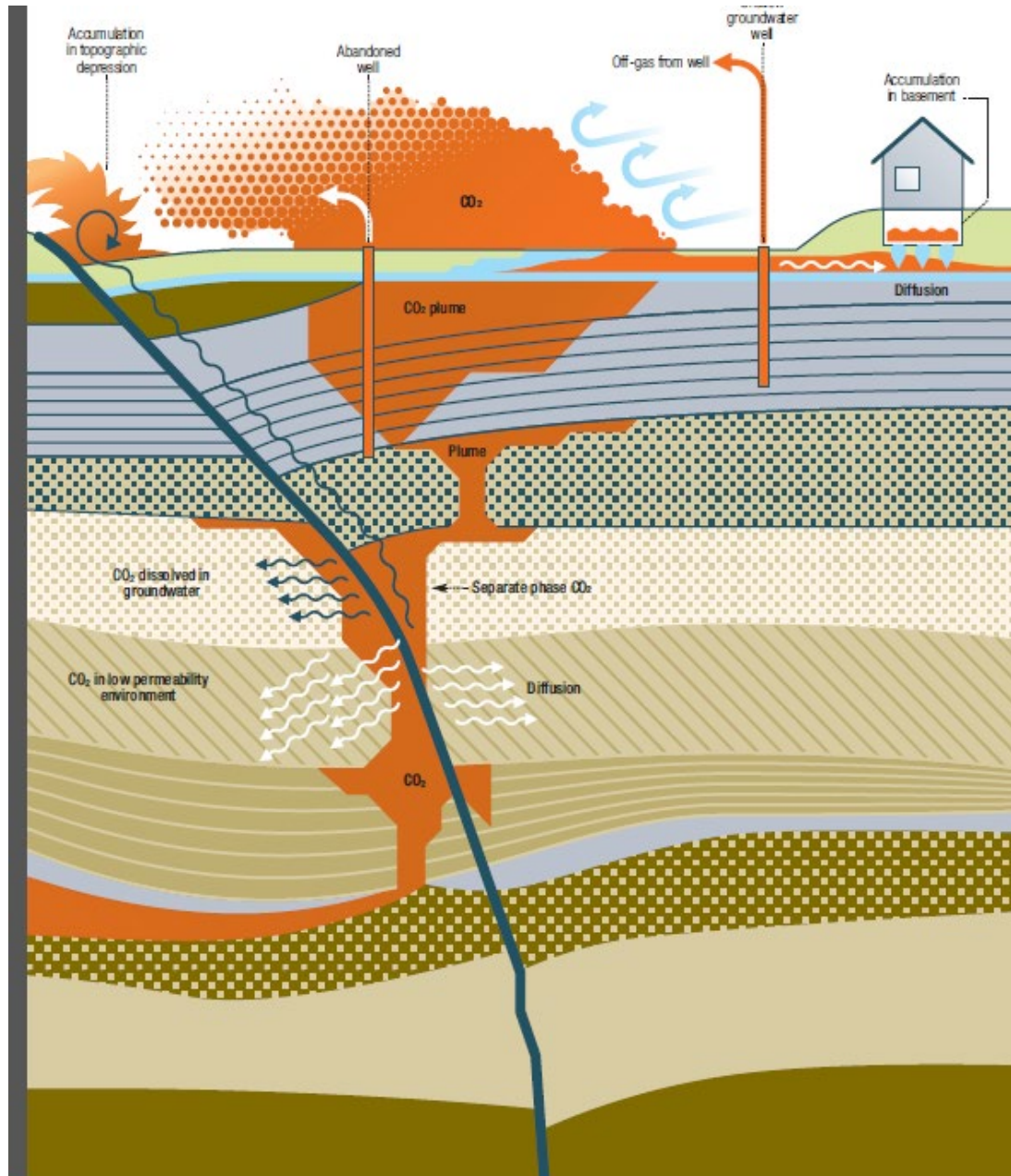


Results of metal embrittlement



15th January 2009 Vancouver-
line rupture

CO₂ storage hazard



CO₂ storage hazard

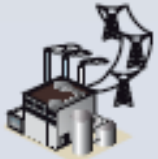
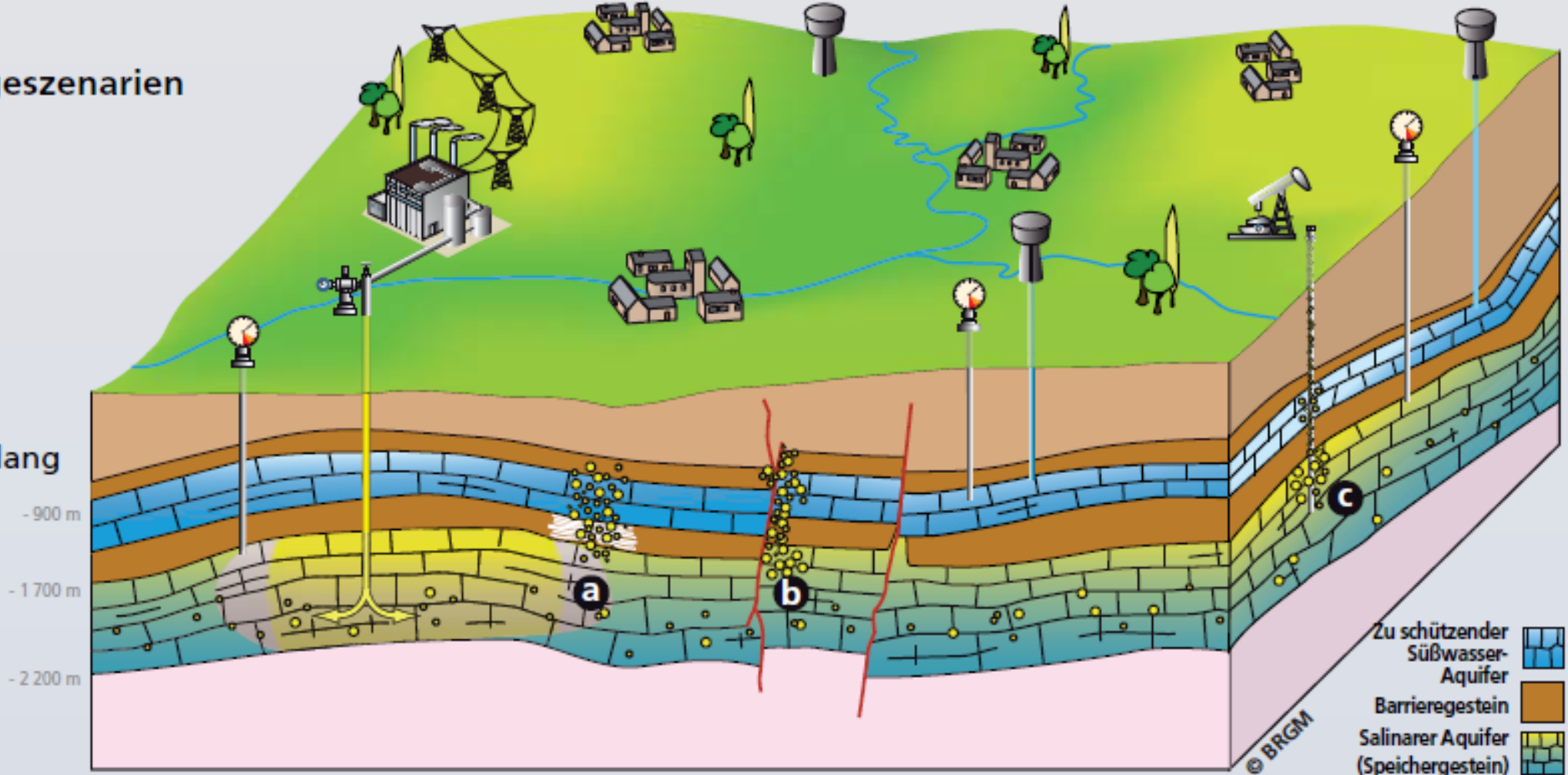


CO₂-Leckageszenarien

a Undichtigkeit des Barrieregesteins

b Undichtigkeit entlang geologischer Störungen

c Undichtigkeit entlang von Altbohrungen



Kraftwerk mit CO₂-Abscheidung



CO₂-Injektionsbohrung



Überwachungsbohrung



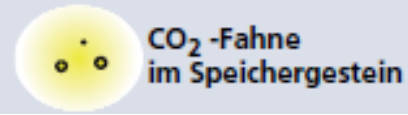
Aufgegebene Erdölförderbohrung



Trinkwassergewinnung



Geologische Störung



CO₂-Fahne im Speichergestein

Leakages and blowout

Utsira Formation (vor Norwegen):

Verpressung von Prozesswasser führt zu Rissen und
Leckagen

5 Leckagen bislang:

- Asgard1997 (Statoil),
- Ringhorne 2004 (EXXON),
- Vsisund2007 (Statoil)
- Tordis2008 (Statoil),
- Veslefrikk(Statoil)

Tordis-Leckage:

30 X 40m 7m tief

Öl und Gas strömt
ins Meer

<http://www.aftenbladet.no/energi/olje/Skivebom-for-avfallsbronner-2097179.html>



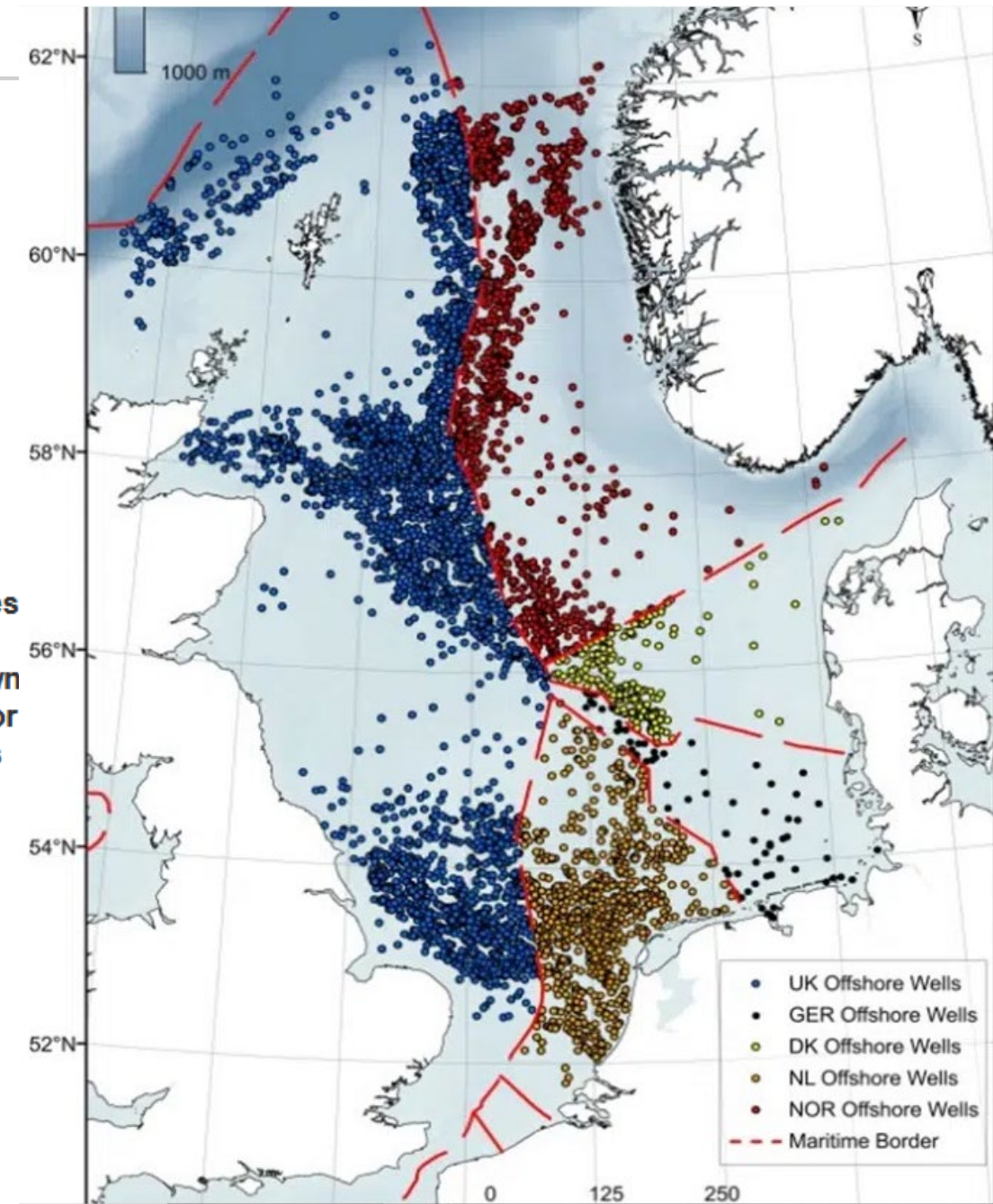
Leakages and blowouts

New study confirms extensive gas leaks in the North Sea

Stricter guidelines for handling of abandoned wells recommended

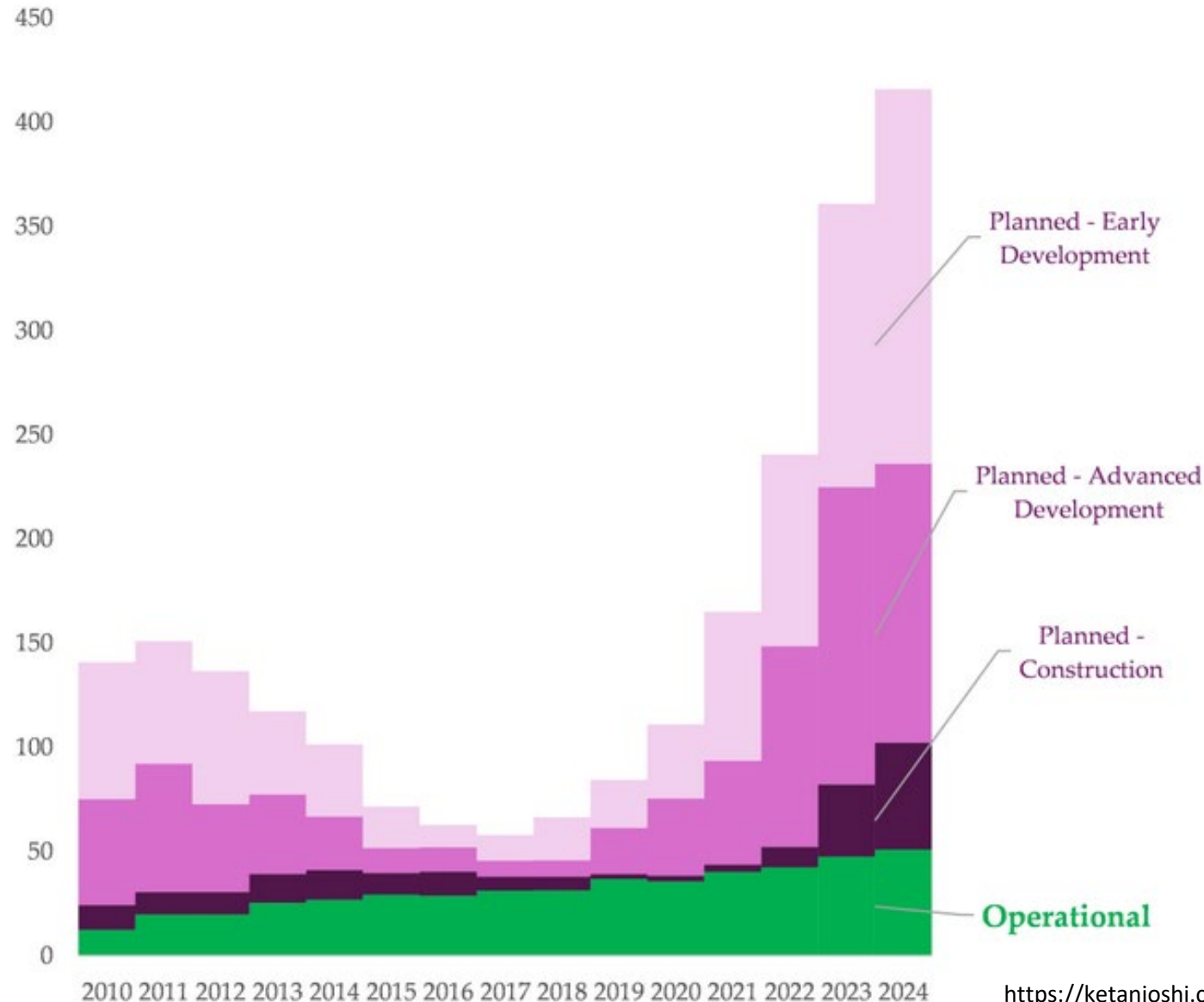
30 July 2020 / Kiel. At abandoned oil & gas wells in the North Sea, considerable quantities of the potent greenhouse gas methane escape uncontrolled into the water. These leaks account for the dominant part of the total methane budget of the North Sea. This is shown in a new study recently published by researchers from the GEOMAR Helmholtz Centre for Ocean Research Kiel in the International Journal of Greenhouse Gas Control. It confirms earlier studies based on a greatly extended data basis.

15.000 boreholes



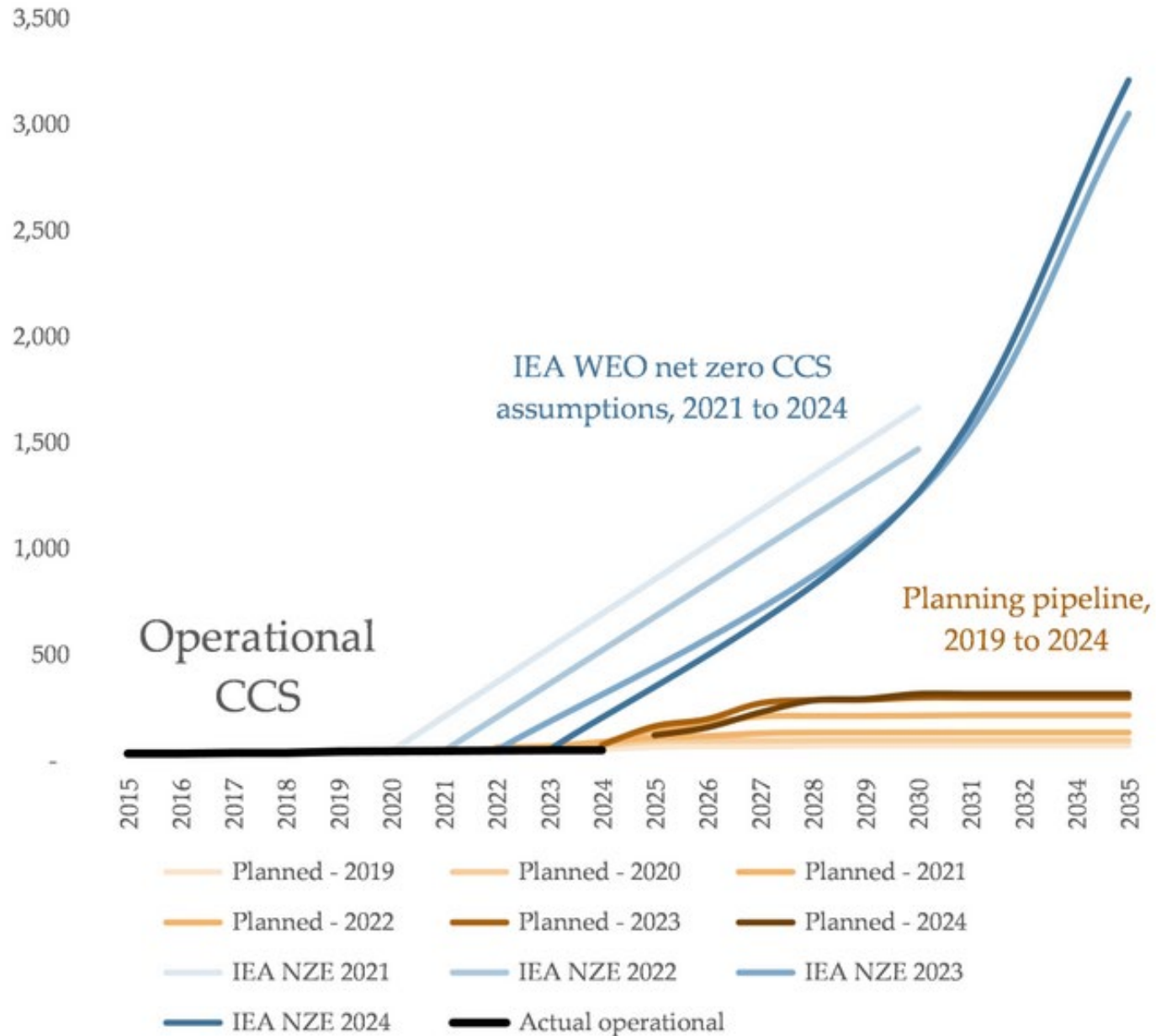
CCS-Project failure

GCCSI Global status report, 2024 / Ketan Joshi



Europäischer Rechnungshof:
All 12 funded CCS projects
did not achieve their goals
(2018)

CCS growth that never happens



<https://ketanjoshi.co/2024/11/24/2024-ccs-update-the-revolution-refuses-to-arrive/>

Energy need

Energy needs

- DAC removal in the U.S. of **850 Mt CO₂** (2% of global energy-related CO₂ emissions/y), would need the equivalent of almost **all current global wind power**
+ vast amounts of water and toxic chemicals
- 30,000 DAC facilities to capture **30Gt CO₂ per year** needs 50 EJ of **electricity/y** – **more than half of what the entire world produces today** (energy for storage not incl.)
- **Energy required for large-scale DAC** is much **greater than the renewable energy capacity likely to be installed by 2050.**

Costs

Costs

COP23:

- 350-600 \$ /t CO₂
= 600.000.000.000 \$ (600 bio \$)
to **2.500.000.000.000 \$** (2.5 trio \$)

to remove CO₂ from **1 year**

> global military budget (1.7 trio \$)

Resistance

Resistance

- **Solar geoengineering is the perfect excuse for inaction on climate change**
- SRM, and geoengineering more broadly, is a “perfect excuse” for **climate change deniers, industries and governments** seeking to **continue business as usual.**

Resistance and cancellation of projects in EU and US

JUNE 2024



The City of Alameda City Council votes unanimously to call off the University of Washington's Marine Cloud Brightening Project (MCBP), which had been conducting an early-stage geoengineering experiment off the coast of California.

Over 100 organisations globally issue a statement on the UN's World Oceans Day, during the Bonn intersessional climate negotiations (SB60), calling for an end to open-ocean marine geoengineering experiments.

JANUARY 2023



Following unauthorised open-air Solar Radiation Modification tests by US start-up Make Sunsets, Mexico upholds the CBD's hard-won solar geoengineering moratorium by banning geoengineering experiments, setting a global example of precaution.

MARCH 2024



The HOME! Alliance celebrates the cancellation of Harvard University's Stratospheric Controlled Perturbation Experiment (SCoPEX), following years of international pressure from civil society and Indigenous Peoples' Organisations.

Marine geoeng., UK

NOVEMBER 2023



The local community around St Ives Bay in Cornwall, UK, protests against Planetary Technologies' Ocean Alkalinity Enhancement (OAE) experiments that have taken place and are planned off their coast, demanding that decision-makers "Keep our sea chemical free."

JANUARY 2022

We Call for an International Non-Use Agreement on Solar Geoengineering

TAKE ACTION NOW



Over 100 scientists, academics and climate experts from around the world issue a call for a non-use agreement on solar geoengineering, arguing that "solar geoengineering deployment at planetary scale cannot be fairly and effectively governed in the current system of international institutions. It also poses unacceptable risk if ever implemented as part of future climate policy. A strong political message from governments, the United Nations and civil society is urgently needed."

Over 100 scientists
issue call for
non-use of SRM

<https://www.geoengineeringmonitor.org/resistance>

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MARCH 2024



The HOME! Alliance celebrates the cancellation of Harvard University's Stratospheric Control and Urban Experiment (SCUE), following years of international pressure from civil society and Indigenous Peoples' Organisations.

STOPPED

Over 100 scientists issue call for non-use of SRM

<https://www.geoengineeringmonitor.org/resistance>

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Resistance and cancellation of projects in EU and US

150 Groups to EPA: Halt Permitting of Carbon Injection Wells After Dangerous Leaks at Nation's First CCS Facility

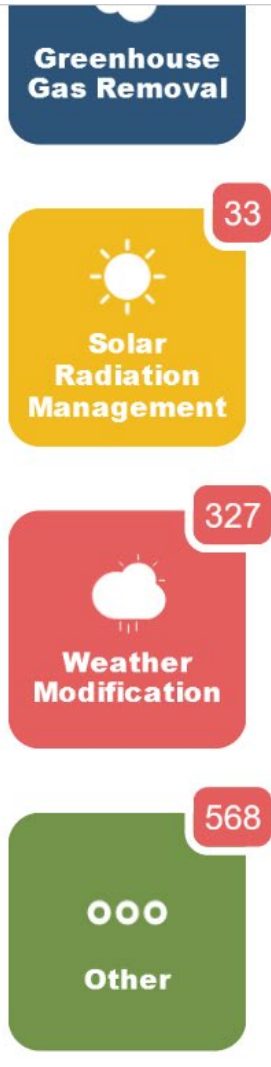
Published Oct 22, 2024  CLIMATE AND ENERGY

USA, Oct. 2024

<https://www.foodandwaterwatch.org/2024/10/22/150-groups-to-epa-halt-permitting-of-carbon-injection-wells-after-dangerous-leaks-at-nations-first-ccs-facility/>

Transfer of geoengineering to Africa

Geoengineering projects in Africa



Ghana

DEGREES Initiative: Ghana

Description

The UK-based DEGREES (DEveloping country Governance, REsearch and Evaluation for SRM) initiative aims to expand the discussion on Solar Radiation Management (SRM) around the world and has launched the DEGREES Modelling Fund (DMF). The DMF provides funding to enable scientists in the Global South to model SRM approaches and analyse the potential impacts of SRM on their regions. In Ghana, the DMF research team is based at the University of Ghana in Accra. Since 2023, the research team is modelling possible effects of SRM on precipitation in West Africa: *"Exploring changes to the Harmattan windy season and precipitation in southern West Africa"*.

Type

Major research project

Status

Ongoing

Scale

Modelling the application of SRM technologies in West Africa.

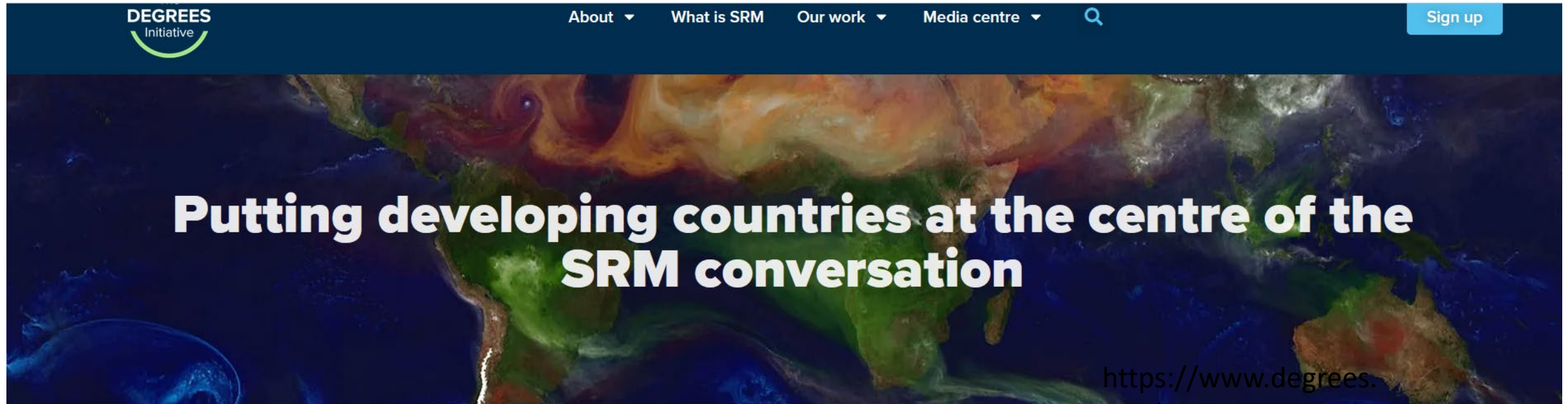


Geoengineering projects in Africa

UK based DEveloping country Governance REsearch and Evaluation for SRM (Degrees) Initiative

- aims to **facilitate the participation** of countries in the Global South in research relating to the deployment and governance of solar geoengineering
- in order **to give** it more legitimacy and the **impression that it isn't dominated by northern interests.**
- published research has focused almost exclusively on SAI deployment
- decision-making structures and funding sources are **dominated by academics and foundations in the Global North.**

UK's Degrees Initiative for Solar Radiation Management in Global South



<https://www.degrees.ngo>



About us

For over a decade, the Degrees Initiative has led the world in building the capacity of developing countries to evaluate solar radiation modification (SRM).

The use or rejection of SRM could be one of the biggest decisions humanity has faced, and this matters most to climate-vulnerable regions.

The world is going to need much more research if it's going to make informed decisions about SRM, and a much broader cc

UK's Degrees Initiative for Solar Radiation Management in Global South

Latest news



SRM could reduce some risks of water deficits in Central Africa, reports Cameroon modelling team

🕒 4 December 2024



Join the largest SRM gathering at the 2025 Degrees Global Forum

🕒 27 November 2024



“If we don’t start to discuss this now, then when?”: Degrees at COP29

🕒 21 November 2024



Degrees autumn update 2024

🕒 22 October 2024



Why African scientists’ perspectives on SRM research are critical

🕒 20 September 2024



India team explores the impact of SRM aerosol injection altitude on precipitation

🕒 19 September 2024

UK's Degrees Initiative for Solar Radiation Management in Global South

News article | 20 September 2024

Why African scientists' perspectives on SRM research are critical

SHARE   

2024 marks an important year for African Science Leadership, with its [coalition launching at the UN Civil Society Conference](#) on May 9, 2024. Its work will be a focus for this year's [Science Summit](#), which will be held parallel to the 79th United Nations General Assembly (UNGA) and coincide with the [Summit of the Future \(SotF\)](#). The SotF will gather leaders to review global challenges and start planning for the post-2030 era. Scientific evaluations will underpin this process.

Climate change remains high on the UNGA's agenda and there is increasing interest in emerging technologies to address climate change impacts. One of those technologies is solar radiation modification (SRM), a proposal for reducing the impacts of global warming by reflecting some sunlight away from the Earth.

Earlier this year, at the Sixth United Nations Environment Assembly, a resolution on SRM was withdrawn. It sought to provide member states with more information on research, deployment capabilities, ethics, and potential impacts, including risks, benefits, and uncertainties.

The next few years will be crucial for SRM research and governance, and climate-vulnerable regions

UK's Degrees Initiative for Solar Radiation Management in Global South

- awarding over \$2.5 million in grants to Southern research projects, supporting over 170 researchers across 37 projects in 22 developing countries.

Influencing UN and UN General Assembly (UNGA)

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Geoengineering projects in Africa

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Completed: 2018-2022



Solar Radiation Management, CCS and ocean-based geoeng.

DEGREES Initiative: Ghana



SRM


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Type
Major research project

Status
Ongoing

Scale
Modelling the application of SRM technologies in West Africa.

DEGREES Initiative: Ivory Coast



SRM

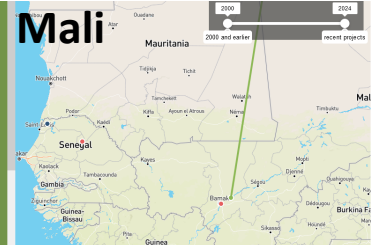
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Type
Major research project

Status
Completed

Scale
Modelling the application of SRM technologies in West Africa.

DEGREES Initiative: Mali



SRM


Description
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Type
Major research project

Status
Ongoing

Scale
Modelling the application of SRM technologies in West Africa.

Brilliant Planet: Morocco




SRM

Description
Brilliant Planet Ltd, based in the UK, sells carbon credits based on a microalgae-based approach that involves growing algae in on-shore, seawater-filled raceway ponds (raceway ponds with a circular and continuous water flow), harvesting and drying the algae and burying it in lined landfills in desert areas. To further develop the concept, Brilliant Planet has leased land and is conducting pilot tests in a production facility outside Agadir in southern Morocco. The company is using artificial seawater to pump nutrient rich deep-sea water into their ponds in order to provide the algae with the necessary minerals and CO₂. According to Brilliant Planet, once the seawater has been used in the ponds it is depleted of CO₂ and is then returned to the ocean. The facilities must be located near the coast. After 20 to 30 days, the algae are filtered, dried and then buried in a lined landfill under desert sand. The company claims that the algae biomass and the CO₂ it contains can be safely stored for more than 1,000 years because the landfill sites are lined with a geomembrane and the biomass is dry, very salty and acidic. **Road more about why the landfill sites are likely to be inadequately lined and therefore risk groundwater contamination.**

Type
Algae projects

World Bank CCS Trust Fund: Nigeria



CCS


Description
The World Bank CCS Trust Fund to support CCS in developing countries was established in 2009 with financial support from the Global CCS Institute and the UK and Norwegian Government. The aim of the fund is to initiate programmes to support the development and deployment of CCS in developing countries. In Nigeria, the programme aims to assess and map CO₂ sources and CO₂ storage sites, address legal issues, support a national roadmap for CCUS development and a pilot project. It also provides training, education and capacity building.

Type
Major research project

Status
Ongoing

Scale
"CCS capacity and knowledge building in developing countries". Total budget for Nigeria: US\$ 45.5 M. Aimed to identify potential CO₂ storage sites, legal advice, training & education.

MACROCARBON SL



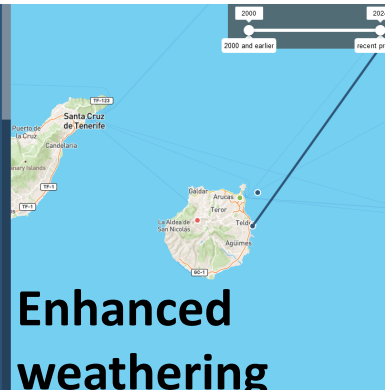
BECCS

Description
MACROCARBON SL was founded in 2023, as a spin-off from the German Alfred Wegener Institute for Polar and Marine Research (AWI) and Capbiothris BSC. The company was formed as part of the C-CAUSE (Chemical Carbon Utilization through Sargassum Economy) project, which aims to provide a proof of concept for sargassum aquaculture in the open ocean, quantify and verify carbon uptake, and convert harvested sargassum biomass into ethanol to replace land-based ethanol feedstocks such as corn, sugarcane and wood. MACROCARBON SL has been created to implement the cultivation and processing of sargassum and is expected to capture CO₂-based carbon. Las Palmas de Gran Canaria was chosen as the company's headquarters because sargassum thrives in the nearby waters and the location offers high sea conditions. Information on the funding, timing and scope of the project is not yet available.

Type
Algae projects

Status
Ongoing

OceanNETs (field trial in Spain)



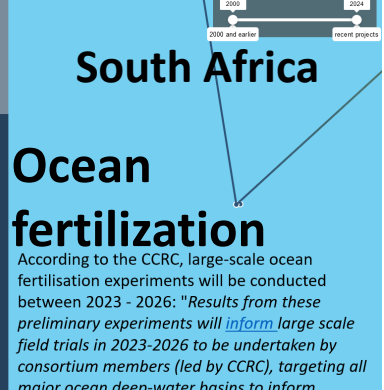
BECCS

Description
The EU-funded research project OceanNETs (Ocean-based Negative Emission Technologies) is coordinated by the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, and conducted in cooperation with 13 academic and research partners. OceanNETs objective is to investigate the feasibility and impact of ocean-based geoengineering approaches, aiming to remove CO₂ from the atmosphere. The project includes experiments in the GEOMAR laboratories as well as offshore experiments off Gran Canaria, Spain, and off Bergen, Norway. In 2021, the offshore experiment was conducted in the port of Tallante on the island of Gran Canaria and lasted for 33 days. Alkaline minerals were dissolved in mine wastewaters ("overlooked test beds") to test enhanced weathering in seawater. The studies focused on how the communities enclosed in the mesocosms responded to the intervention.

Type
OAE (Ocean alkalinity enhancement)

Status
Completed

University of Cape Town - ocean fertilization experiment




Ocean fertilization

Description
In 2020, the Centre of Climate Repair at Cambridge (CCRC) announced plans to test ocean fertilization in the world's oceans and established relationships with various research institutions. In 2022, the collaboration between the CCRC and the University of Cape Town was disclosed. Under the direction of the CCRC, the University of Cape Town is planning to conduct ocean fertilization experiments in the Southern Ocean - information on the exact date, location, scale and duration of these experiments is not publicly available. According to the CCRC, large-scale ocean fertilization experiments will be conducted between 2023 - 2026. "Results from these preliminary experiments will inform large-scale field trials in 2023-2026 to be undertaken by consortium members (led by CCRC), targeting all major ocean deep-water basins to inform potential global deployment starting in 2027."

Type
Ocean fertilization

Status
Planned

DEGREES Initiative: Cameroon



CCS


Description
The UK-based DEGREES (Developing country Governance, Research and Evaluation for SRM) initiative aims to expand the discussion on Solar Radiation Management (SRM) around the world and has launched the DEGREES Modelling Fund (DMF). The DMF provides funding to enable scientists in the Global South to model SRM approaches and analyse the potential impacts of SRM on their regions. In Cameroon, the DMF research team is based at the National Institute of Cartography (NIC). Since 2023, the research team is modelling possible effects of SRM on water deficit in Central Africa. "Assessing the risks of water deficit in Central Africa".

Type
Major research project

Status
Ongoing

Scale
Modelling the application of SRM technologies in West Africa.

World Bank CCS Trust Fund: Botswana



CCS

Description
The World Bank CCS Trust Fund to support CCS in developing countries was established in 2009 with financial support from the Global CCS Institute and the UK and Norwegian governments. The Fund aims to initiate programmes to support the development and deployment of CCS in developing countries. In Botswana, the programme pursued the following objectives:
- Identify potential CO₂ storage sites for the storage of CO₂ captured from coal-fired power plants.
- Assess the institutional and legal arrangements for CCS deployment in the country and make recommendations.
- Provide training, education and capacity building, and a study tour for key personnel.
In Botswana, the programme was discontinued upon completion of Phase 1.

Type
Major research project

Status
Completed

SAT4CCS

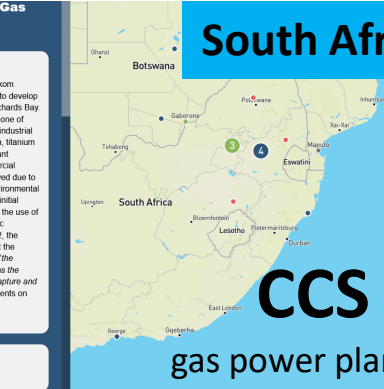


CCS

Description
The SAT4CCS project - South African Tailings for use in Carbon Capture and Storage - was launched in February 2019. Led by staff from the Universities of Pretoria, Southampton and Cape Town, the project aims to assess the suitability of South African mine tailings for the CO₂ mineralisation. Mine sites with suitable rock types are to be identified. The project will also look at ways of accelerating the rate of reaction between rock and CO₂, for example by increasing temperature and pressure, using biotechnology, microbial processes, additives and sorbents, or a combination of these methods. A consortium of mines, including the Ekapa diamond mine, have volunteered to collaborate with the research project by providing access to tailings samples and data. The researchers are working with De Beers, the world's largest diamond producer and trader, headquartered in London and worked the UK's Greenhouse Gas Removal by Enhanced Weathering (GGREW) project. Discussions are also underway with the South African Centre for Carbon Capture and Storage (SACCSS).

Type
Major research project

Phakwe Richards Bay Gas Power 3 CCPP



CCS gas power plant

Description
In 2021, the South African electricity utility Eskom Holdings SOC Ltd (Eskom) announced plans to develop a 3,000-megawatt gas-fired power plant in Richards Bay. Richards Bay is a town in KwaZulu-Natal and one of South Africa's largest ports with an extensive industrial structure, e.g. for the production of aluminium, titanium and paper. The combined cycle gas power plant (CCGPP) project is scheduled to start commercial operation in 2024. The project has been delayed due to court proceedings over deficiencies in the environmental permit for the construction of the project. The initial environmental permit had not fully considered the use of renewable energy as an alternative, and public participation was also flawed. In October 2022, the South African High Court in Pretoria ruled that the proposed CCGPP project was conditional on "the implementation of mitigation measures such as the switching to alternative biofuels and carbon capture and storage". There are currently no public statements on whether and how Eskom will implement this requirement.

Type
CCS (Carbon Capture and Storage)

DEGREES Initiative: Uganda

Description

The UK-based **DEGREES (DEveloping country Governance, REsearch and Evaluation for SRM) initiative** aims to expand the discussion on Solar Radiation Management (SRM) around the world and has launched the DEGREES Modelling Fund (DMF). The DMF provides funding to enable scientists in the Global South to model SRM approaches and analyse the potential impacts of SRM on their regions. In Uganda, the DMF research team is based at the Uganda National Meteorological Authority (UNMA). Since 2023, the research team is modelling possible effects of SRM on rainfall and temperature in East Africa. *"The impacts of SRM on seasonal and intra-seasonal climate variability over East Africa"*.

Type

Major research project

Status

Ongoing

Scale

Modelling the application of SRM technologies in East Africa.



DEGREES Initiative: Kenya

Description

The UK-based **DEGREES (DEveloping country Governance, REsearch and Evaluation for SRM) initiative** aims to expand the discussion on Solar Radiation Management (SRM) around the world and has launched the DEGREES Modelling Fund (DMF). The DMF provides funding to enable scientists in the Global South to model SRM approaches and analyse the potential impacts of SRM on their regions. In Kenya, the DMF research team is based at the University of Nairobi. Since 2022, the research team is modelling possible impacts of SRM on urban areas in East Africa: *"Impacts of SRM on extreme rainfall and urban floods in East Africa"*, focusing on the urban areas of Dar es Salaam, Kampala, Nairobi and Addis Ababa.

Type

Major research project

Status

Ongoing

Scale

R&D: Application of SRM in East Africa; modelling the impact of SRM on climate extremes in urban areas.



Smart Stones Foundation: Tanzania

Description

The **Smart Stones Foundation** was founded to develop, promote and commercialise the use of olivine rock for CO₂ removal. In ~2011, Smart Stones proposed to crush olivine rock, or other silicate minerals, from a Tanzanian mining area, such as gemstone mining, and spread the rock powder on the surrounding rice fields. The project was to be supervised by the universities of Wageningen, Utrecht and Delft. The location of the proposed project was not disclosed, but most mining activities take place in the north-east of Tanzania.

Type

EW (Enhanced Weathering)

Status

Cancelled

Scale

Smart Stones aims to commercialise olivine rock for CO₂ removal and proposed a field trial in a Tanzanian mining area. [Project references are no longer available online.]



Rufiji Cluster

Description

The Swedish ethanol company SEKAB planned to build six large ethanol and power plants in the Rufiji region of Tanzania. The possibility of a CCS network was investigated. The network was intended to capture CO₂ from the planned ethanol plants and store it in a nearby geological formation. The project was never realised because it took a much longer time than expected to develop commercially viable methods.

Type

BECCS (Bio-Energy with Carbon Capture and Storage)

Status

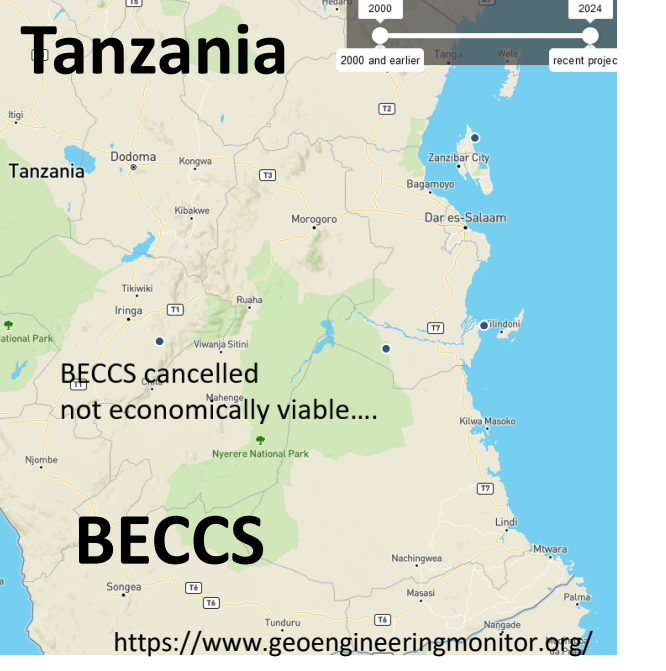
Cancelled

Scale

Planned CO₂ capture capacity: 5-7 Mt per year.

Location

Tanzania



UK's Degrees Initiative for SRM in Global South: research papers...

DMF research papers

As of 14 March 2023

[Fernández et al. 2024: Impact of Solar Radiation Management on Andean glacier-wide surface mass balance](#)

Published in npj Climate and Atmospheric Science

[Narenpitak et al. 2024: Regional impacts of solar radiation modification on surface temperature and precipitation in Mainland Southeast Asia and the adjacent oceans](#)

Published in Scientific Reports

[Xavier et al. 2024: An investigation of the relationship between tropical monsoon precipitation changes and stratospheric sulfate aerosol optical depth](#)

Published in Oxford Open Climate Change

[Odoulami et al. 2024: Africa's Climate Response to Marine Cloud Brightening Strategies Is Highly Sensitive to Deployment Region](#)

Published in JGR Atmospheres

[Tan et al. 2024: Assessment of solar geoengineering impact on precipitation and temperature extremes in the Muda River Basin, Malaysia using CMIP6 SSP and GeoMIP6 G6 simulations](#)

Published in Science of the Total Environment

[Fotso-Nguemo et al. 2024: Projected impact of solar radiation modification geoengineering on water deficit risk over major Central African river basins](#)

Published in Environmental Research Letters

[Usha et al. 2024: Sensitivity of the global hydrological cycle to the altitude of stratospheric sulphate aerosol layer](#)

Published in Environmental Research Letters

[Reboita et al. 2024: Response of the Southern Hemisphere extratropical cyclone climatology to climate intervention with stratospheric aerosol injection](#)

Published in Environmental Research Climate

[Ayissi et al. 2024: Changes in coastal upwelling in the northern Gulf of Guinea under Stratospheric Aerosol Injection](#)

Published in Regional Studies in Marine Science

[Rezaei et al. 2024: Future water storage changes over the Mediterranean, Middle East, and North Africa in response to global warming and stratospheric aerosol intervention](#)

Published in Earth System Dynamics

[Bonou et al. 2023: Stratospheric Sulfate Aerosols Impacts on West African Monsoon Precipitation Using GeoMIP Models](#)

Published in Earth's Future

[Patel et al. 2023: Potential impact of stratospheric aerosol geoengineering on projected temperature and precipitation extremes in South Africa](#)

Published in Environmental Research: Climate

[Rezaei et al. 2023: Changes in global teleconnection patterns under global warming and stratospheric aerosol intervention scenarios](#)

Published in Atmospheric Chemistry and Physics

[Tew et al. 2023: A review of the effects of solar radiation management on hydrological extremes](#)

Published in IOP Conference Series: Earth and Environmental Science

[Obahoundje et al. 2023: Implication of stratospheric aerosol geoengineering on compound precipitation and temperature extremes in Africa](#)

Published in Science of the Total Environment

[Ayissi et al. 2023: Impact of Stratospheric Geoengineering on Sea Surface Temperature in the Northern Gulf of Guinea](#)

Published in Climate

[Tan et al. 2023: Impacts of Solar Radiation Management on Hydro-Climatic Extremes in Southeast Asia](#)

Published in Water

[Obahoundje et al. 2022: Influence of stratospheric aerosol geoengineering on temperature mean and precipitation extremes indices in Africa](#)

Published in International Journal of Climate Change Strategies and Management

[Camilloni et al. 2022: La Plata Basin Hydroclimate Response to Solar Radiation Modification With Stratospheric Aerosol Injection](#)

UK's Degrees Initiative for SRM in Global South: research papers...

DMF research papers

As of 14 March 2023

[Camilloni et al. 2022: La Plata Basin Hydroclimate Response to Solar Radiation Modification With Stratospheric Aerosol Injection](#)

Published in Frontiers in Climate

[Carlson et al. 2022: Solar Geoengineering Could Redistribute Malaria Risk in Developing Countries](#)

Published in Nature Communications

[Alamou et al. 2022: Impact of Stratospheric Aerosol Geoengineering on Meteorological Droughts in West Africa](#)

Published in Atmosphere

[Pomalegni et al. 2022: Response of the Equatorial Atlantic Cold Tongue to Stratospheric Aerosol Geoengineering](#)

Published in Aerosol Science and Engineering

[Abiodun et al. 2021: Impacts of Stratospheric Aerosol Injection on Drought Risk Managements Over Major River Basins in Africa](#)

Published in Climatic Change

[Fauzi et al. 2021: Statistical Downscaling and Bias Correction of the Earth System Models \(ESM\) Outputs for Future Climate Projection under Solar Geoengineering: Case Study Indonesia](#)

Published in Journal of Mechanical Engineering

[Kuswanto et al. 2021: Impact of Solar Geoengineering on Temperatures over the Indonesian Maritime Continent](#)

Published in International Journal of Climatology

[Clarke et al. 2021: The Caribbean and 1.5 °C: Is SRM an Option?](#)

Published in Atmosphere

[Odoulami et al. 2020: Stratospheric Aerosol Geoengineering Could Lower Future Risk of 'Day Zero' Level Droughts in Cape Town](#)

Published in Environmental Research Letters

[Da-Allada et al. 2020: Changes in West African Summer Monsoon Precipitation Under Stratospheric Aerosol Geoengineering](#)

Published in Earth's Future

[Karami et al. 2020: Storm Track Changes in the Middle East and North Africa Under Stratospheric Aerosol Geoengineering](#)

Published in Geophysical Research Letters

[Pinto et al. 2020: Africa's Climate Response to Solar Radiation Management with Stratospheric Aerosol](#)

Published in Geophysical Research Letters

Research and technical reports

[Geoengineering the Climate \[PDF\]](#)

Source: The Royal Society

[Geoengineering in Relation to the Convention on Biological Diversity: Technical and Regulatory Matters \[PDF\]](#)

Source: Convention on Biological Diversity

[Climate Intervention: Reflecting Sunlight to Cool Earth](#)

Source: National Research Council

Influence on Africa

- **Test of technologies which are under worldwide moratorium**
- **Numerous projects in SRM, CCS etc.**
- **Co-financing by African universities (often about 50%)**
- **Influence on and appropriation of African education and NGOs in energy sector (!)**

Resistance in Africa

March 2023

- Over 35 African NGOs publish an **open letter calling on the African Union to not geoengineer Africa**
- citing the fact that the **false promise of techno-fixes** should not provide an excuse for governments particularly in the Global North to avoid deep emissions cuts and continue relying on fossil fuels.

Resistance in Africa

MAY 2020





Additional information

Event “**Solar Radiation Modification**: a conversation on governance and research” at COP29, Baku (Azerbaijan), Science Advisor Thelma Krug:

Thelma Krug participated in an event on the governance and research of SRM at COP29. Other speakers included **Anita Nzeh and Andy Parker of The Degrees Initiative**, Nana Ama Brown Klutse, Vice-Chair of WG I of the IPCC, Matthias Honegger of the Perspectives Climate Group, Hassaan Sipra of the **Alliance for Just Deliberation on Solar Geoengineering**, and Lisa Graumlich, President of the American Geophysical Union (AGU).

Thelma Krug discussed the **inclusion of SRM in successive IPCC assessments**, noting increased references and research over time but no restrictive language. She emphasized the significant gap between modelling and experimental SRM research, expressing doubts about current progress. The **Climate Overshoot Commission** advocates for small-scale SRM simulations and stresses the **need for Global South researchers' involvement**. Krug highlighted the importance of research funding agencies supporting quality studies and called for governance principles to enable responsible research as part of broader climate strategies, with clear communication to the public and policymakers.



Deep Trouble

The Risks of Offshore Carbon Capture and Storage

https://www.ciel.org/wp-content/uploads/2023/11/Deep-Trouble_The-Risks-of-Offshore-Carbon-Capture-and-Storage_CIEL_November_2023.pdf



Nov. 2023

Proposed CO₂ storage hubs are concentrated in areas most prone to leaks.

The single biggest risk of CO₂ leakage comes from the **interaction of injected CO₂ with legacy oil and gas wells**. And yet the sites being heavily targeted for offshore CCS development are zones of long-standing, intensive oil and gas drilling, such as the US Gulf of Mexico and the European North Sea, where old wells abound. **More than half of proposed offshore CCS projects plan to use depleted wells as storage sites.**

Avoiding catastrophic climate change requires immediate measures to accelerate the just and equitable transition away from fossil fuels and to safeguard vital natural ecosystems, like those found in the world's oceans. Offshore CCS does neither.

- In addition to keeping polluting facilities in operation, at least thirteen proposed offshore CCS projects are associated with the **development of new fossil fuel** resources.
- **There is little reason to believe that injecting CO₂ into areas where countless existing leaks from oil and gas wells go undetected or unreported would guarantee “permanent” storage.**

Degrees Initiative

2024 marks an important year for African Science Leadership, with its [coalition launching at the UN Civil Society Conference](#) on May 9, 2024. Its work will be a focus for this year's [Science Summit](#), which will be held parallel to the 79th United Nations General Assembly (UNGA) and coincide with the [Summit of the Future](#) (SotF). The SotF will gather leaders to review global challenges and start planning for the post-2030 era. Scientific evaluations will underpin this process.

Climate change remains high on the UNGA's agenda and there is increasing interest in emerging technologies to address climate change impacts. One of those technologies is solar radiation modification (SRM), a proposal for reducing the impacts of global warming by reflecting some sunlight away from the Earth.

Earlier this year, at the Sixth United Nations Environment Assembly, a resolution on SRM was withdrawn. It sought to provide member states with more information on research, deployment capabilities, ethics, and potential impacts, including risks, benefits, and uncertainties.

The next few years will be crucial for SRM research and governance, and climate-vulnerable regions will need informed and confident representation if they are to effectively advocate for their interests.

The [Degrees Initiative](#) is an NGO that builds the capacity of developing countries to evaluate SRM. Working with a broad coalition of partners and volunteers, it has singularly transformed the field of SRM research, **awarding over \$2.5 million in grants to Southern research projects, supporting over 170 researchers across 37 projects in 22 developing countries and emerging economies.** Beyond research, Degrees also supports Southern experts in informing processes that seek to strengthen governance for SRM.

The SRM researchers supported by Degrees are becoming leaders in the field. They publish their findings in prestigious journals, serve on UN panels and ensure that the Global South has its own SRM expertise and evidence. The power of an informed Southern voice was demonstrated last year when 18 African climate scientists who came into SRM research through the Degrees Modelling Fund [wrote to the New York Times](#), emphasising the importance of Southern SRM research.

The science-policy interface is where the necessary ingredient, 'trust', is built to overcome barriers to progress. The SRM researchers supported by Degrees have built trust and are now recognised as credible voices by ensuring that their evaluations are regional and country context-specific, people-focused and overall sensitive to planetary needs.

As the world advances toward 2030, the world seeks means to reduce risks from one of the greatest challenges, climate change. The voices of scientists from climate vulnerable countries should be amplified amongst decision making processes, so that they are represented, and deliberations are evidence-based.

Description

The UK-based [DEGREES \(DEveloping country Governance, REsearch and Evaluation for SRM\) initiative](#) aims to expand the discussion on Solar Radiation Management (SRM) around the world and has launched the DEGREES Modelling Fund (DMF). The DMF provides funding to enable scientists in the Global South to model SRM approaches and analyse the potential impacts of SRM on their regions. In Côte d'Ivoire, the DMF project was based at the Félix Houphouët-Boigny University in Abidjan. The research team modelled possible impacts of stratospheric aerosol injection (SAI) on West and Central Africa: *“GeoMIP-Africa: impact of SAI on temperature and precipitation extremes over West and Central Africa and implications for water resources”*. The modelling was based on a climate model developed in the Global North (GeoMIP -Geoengineering Model Intercomparison Project).

Modelling the application of SRM technologies (stratospheric aerosol injection (SAI)) in West and Central Africa.

Location

Ivory Coast

Period of time

2018 - 2022.

Sponsor(s)

Please see [DEGREES Initiative](#), University of Félix Houphouët-Boigny.

Websites

- <https://www.degrees.ngo/>
- <https://www.degrees.ngo/dmf/the-projects/ivory-coast/>
- <https://www.emerald.com/insight/content/doi/10.1108/IJCCSM-03-2021-0028/full/html#sec009>
- <https://twas.org/opportunity/twas-srmgi-decimals-funds-research-grants>
- <https://sciafmag.com/2019/06/26/dialing-down-the-sun/>