Physical Dimensions Keynote

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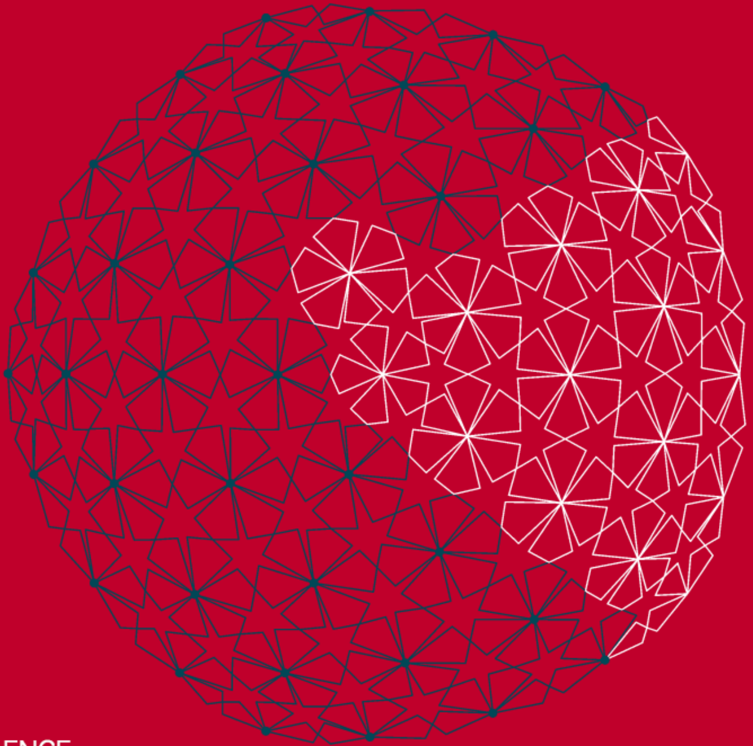
20 June 2023

Geoengineering the climate

Science, governance and uncertainty

September 2009

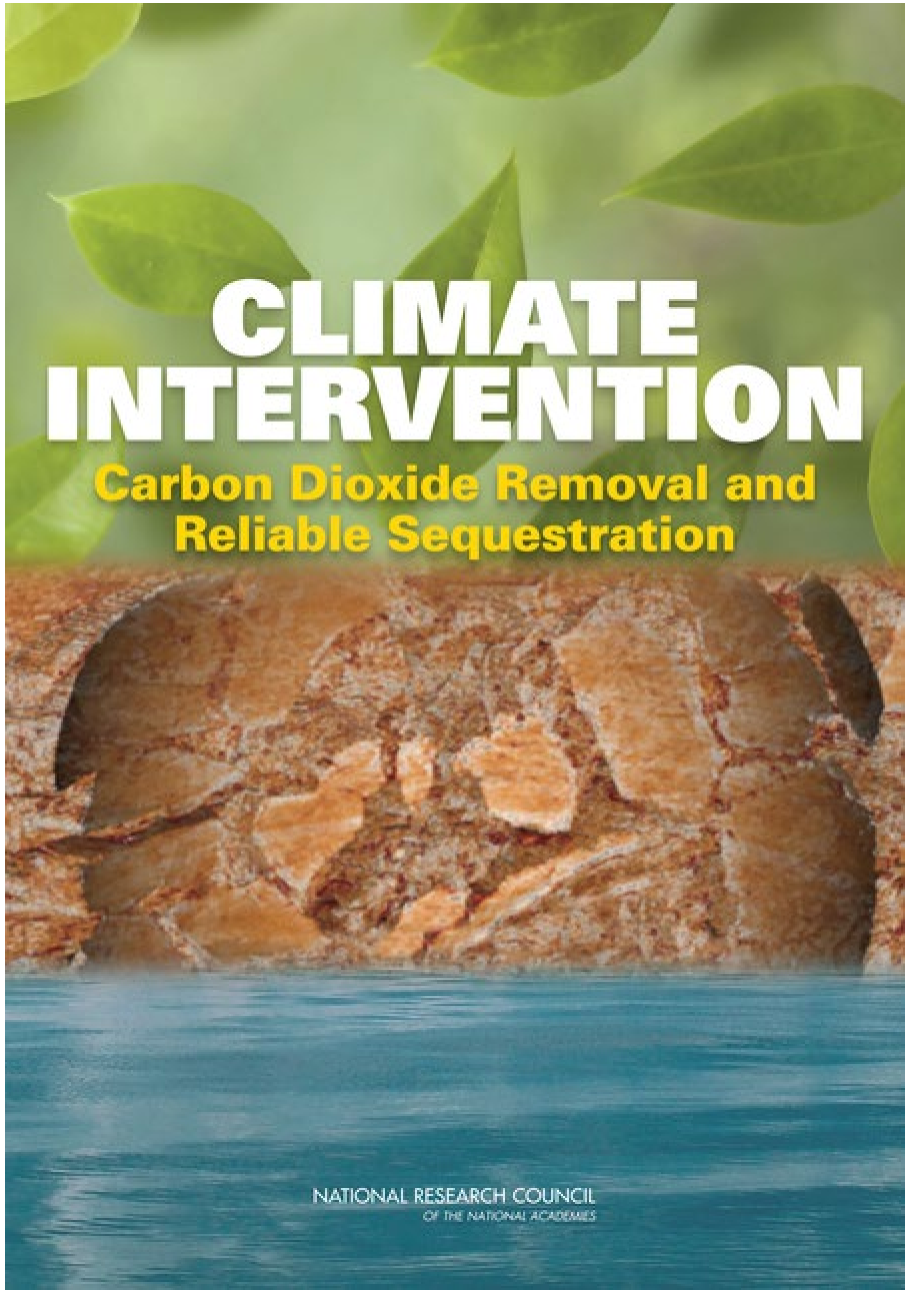


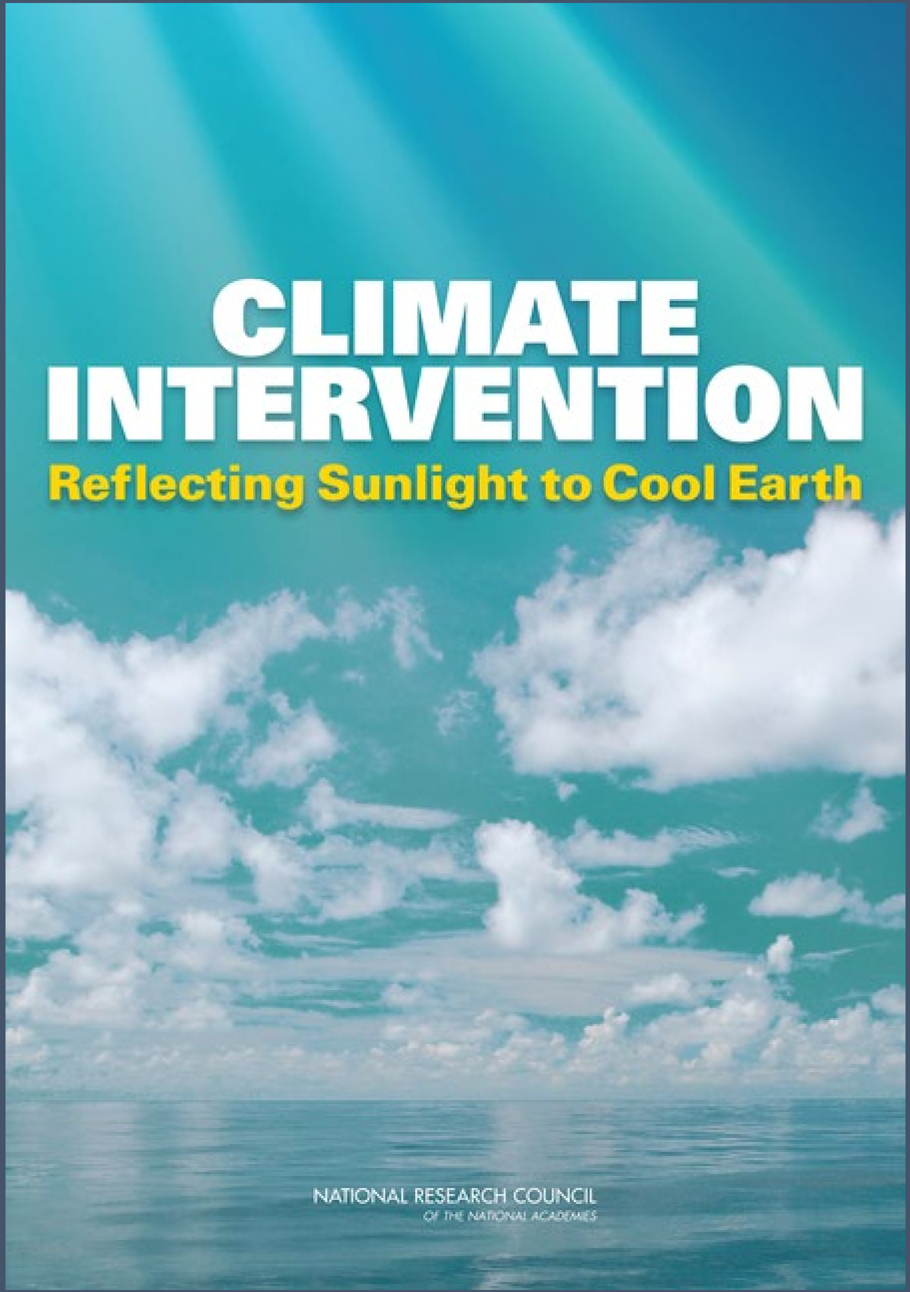
EXCELLENCE IN SCIENCE

THE ROYAL SOCIETY

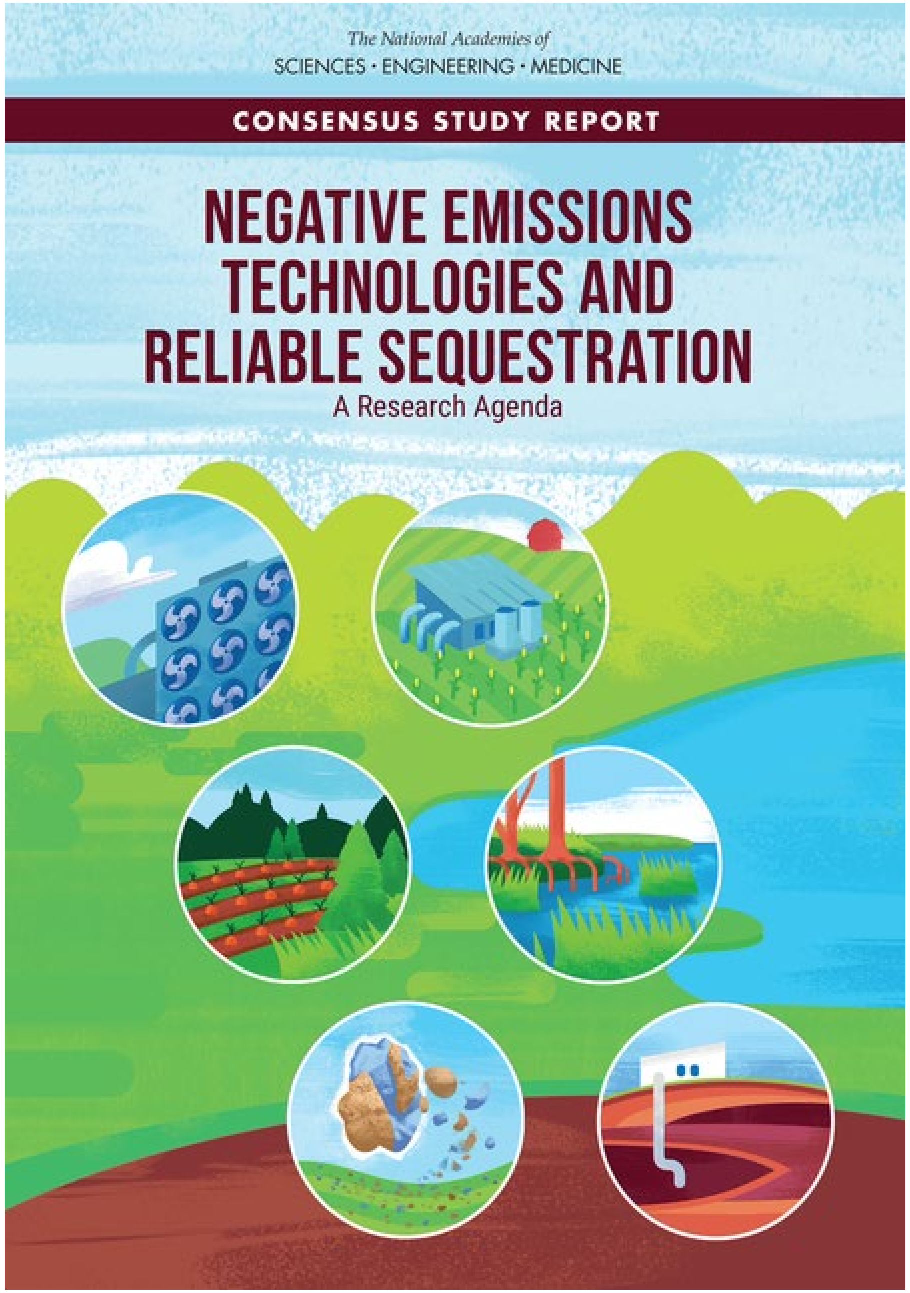
CARBON DIOXIDE REMOVAL

SOLAR GEOENGINEERING

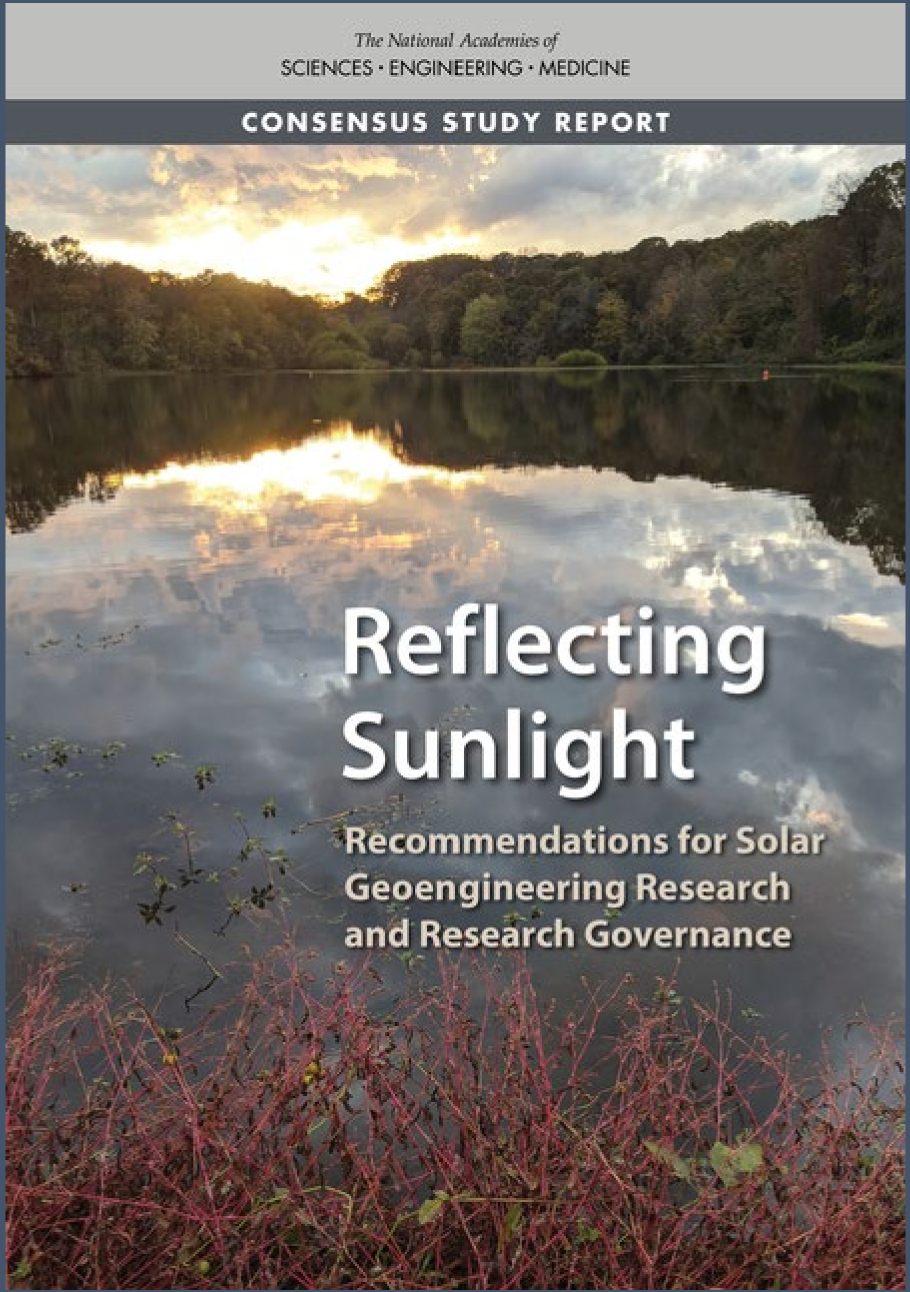

CLIMATE
INTERVENTION
Carbon Dioxide Removal and
Reliable Sequestration
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES


CLIMATE
INTERVENTION
Reflecting Sunlight to Cool Earth
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

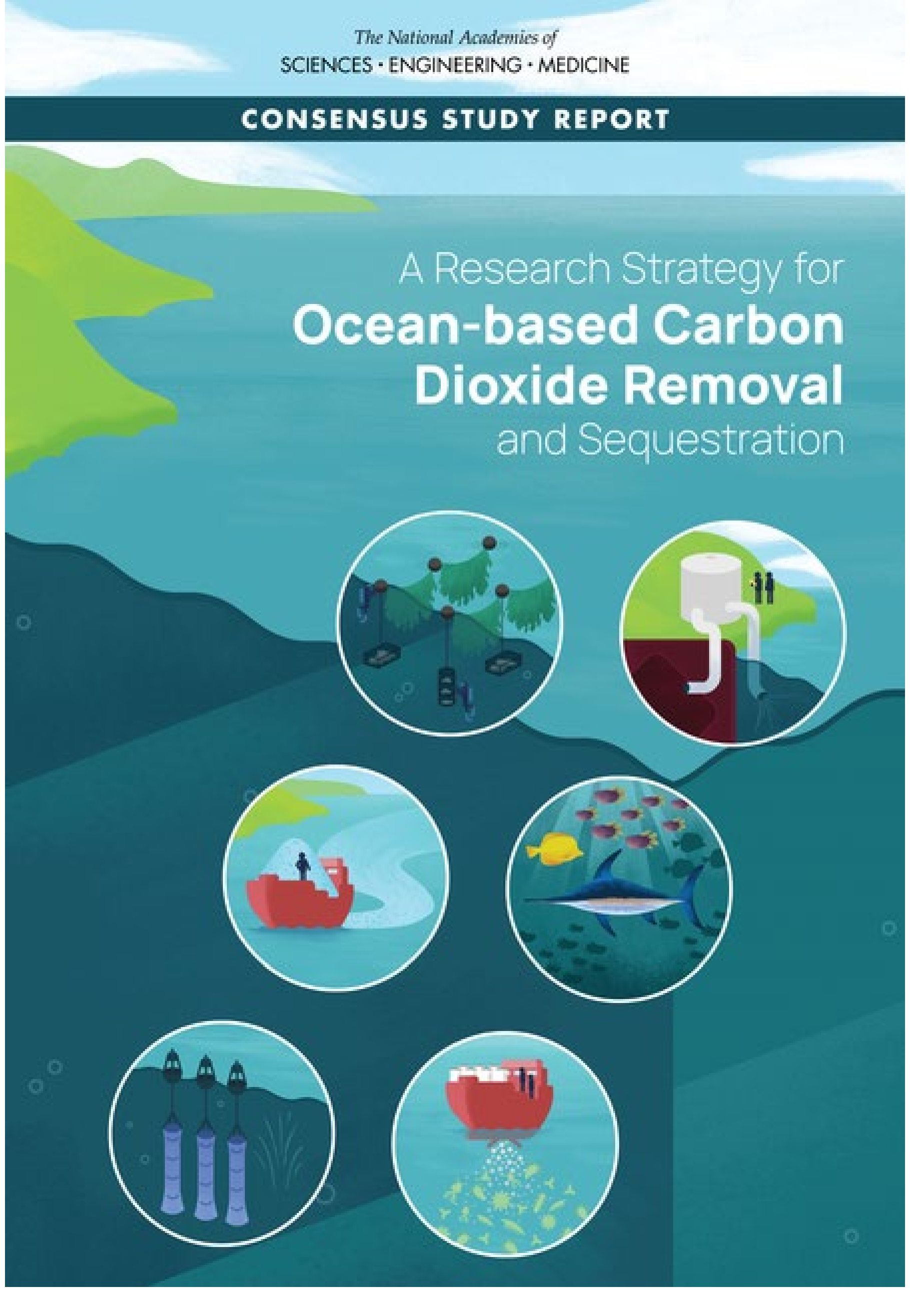
2015


The National Academies of
SCIENCES · ENGINEERING · MEDICINE
CONSENSUS STUDY REPORT
NEGATIVE EMISSIONS TECHNOLOGIES AND RELIABLE SEQUESTRATION
A Research Agenda

2019


The National Academies of
SCIENCES · ENGINEERING · MEDICINE
CONSENSUS STUDY REPORT
Reflecting Sunlight
Recommendations for Solar Geoengineering Research and Research Governance

2021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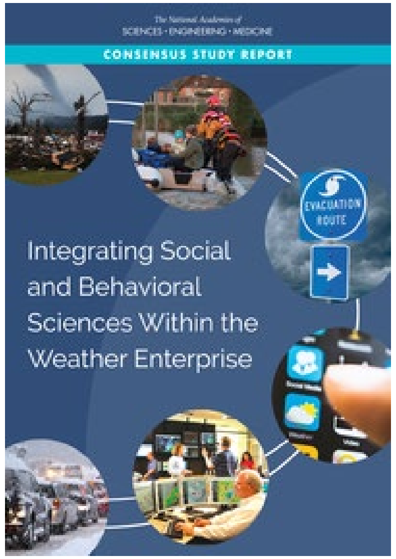
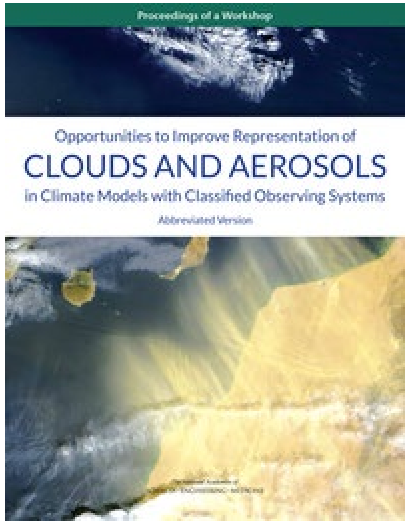
CONSENSUS STUDY REPORT
A Research Strategy for
Ocean-based Carbon
Dioxide Removal
and Sequestration

2022

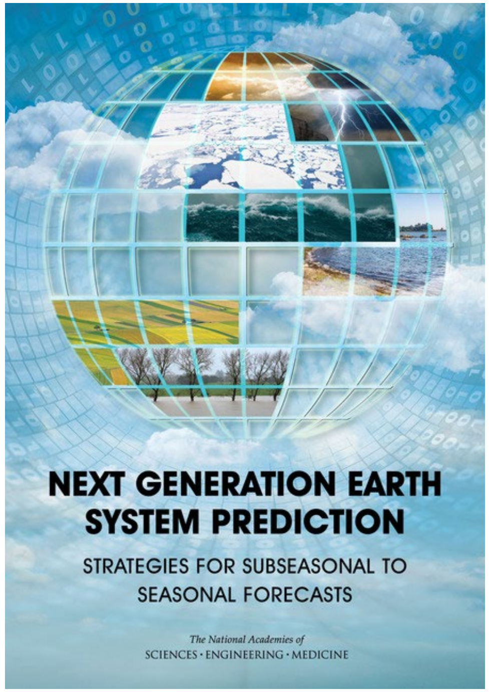
2021



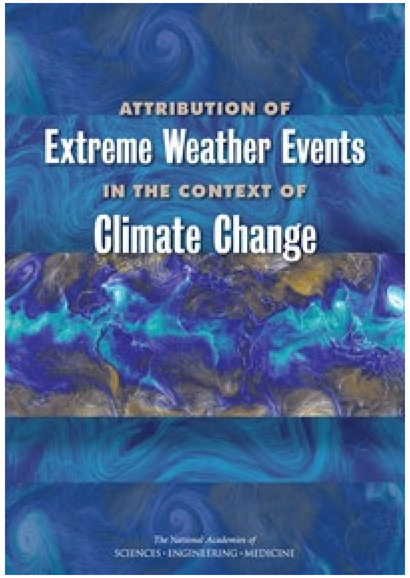
2018



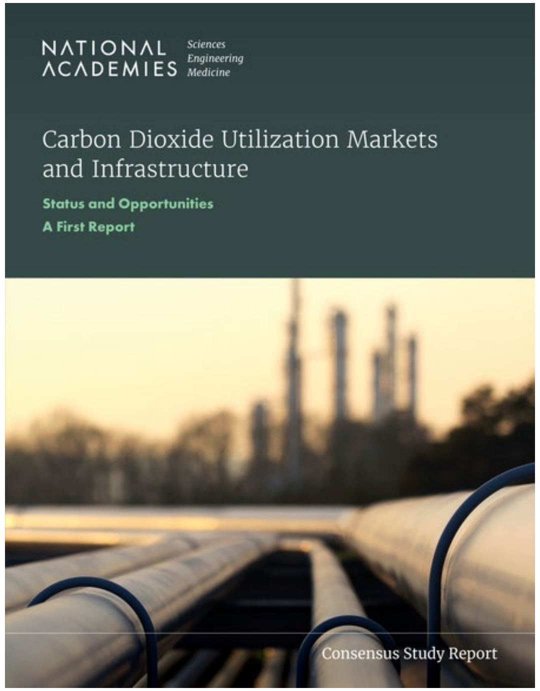
2016



2016



2016



2023

Participants will discuss

- research design,
- how to assess risk (relative to the risks of climate change),
- navigating societal & physical systems implications,
- unintended consequences,
- natural-social system interactions,
- as well as the essential need for governance research.

Additionally,

- earth systems predictive capacity,
- current observation and monitoring infrastructure,
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will be considered.

One Atmosphere:

An independent expert review on Solar Radiation Modification research and deployment

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Illustration of the basic mechanisms involved in the three aerosol-based Solar Radiation Modification (SRM) approaches that have been studied using climate models:

- Stratospheric Aerosol Injection (SAI),
- Marine Cloud Brightening (MCB) and
- Cirrus Cloud Thinning (CCT).

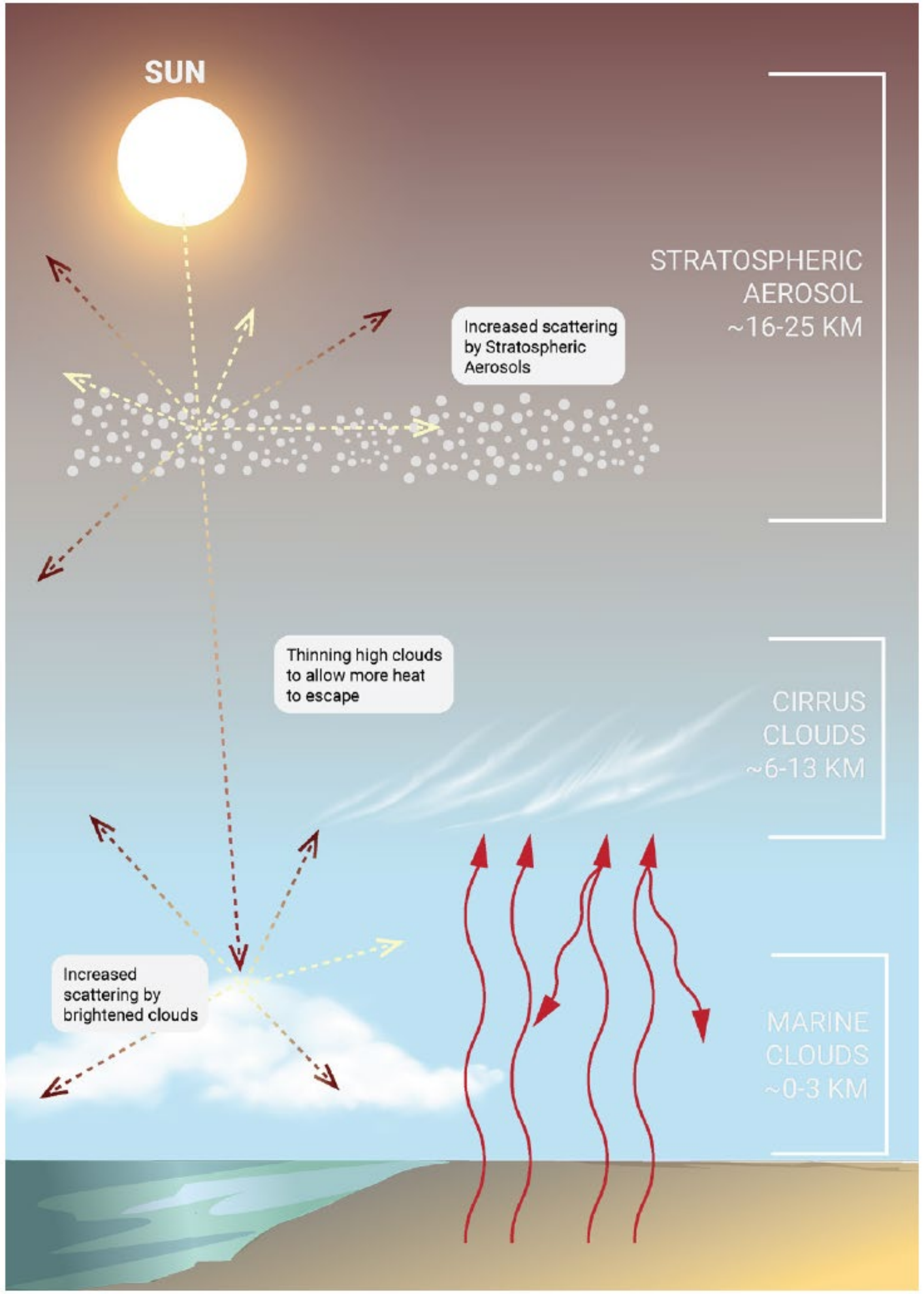

FIGURE 1: Illustration of the basic mechanisms involved in the three aerosol-based SRM approaches that have been studied using climate models: Stratospheric Aerosol Injection (SAI), Marine Cloud Brightening (MCB) and Cirrus Cloud Thinning (CCT).
Source: Adapted from NASEM 2021[9].

Stratospheric aerosol injection (SAI) has been the most studied, and is thought by many to be the most feasible, solar geoengineering proposal.

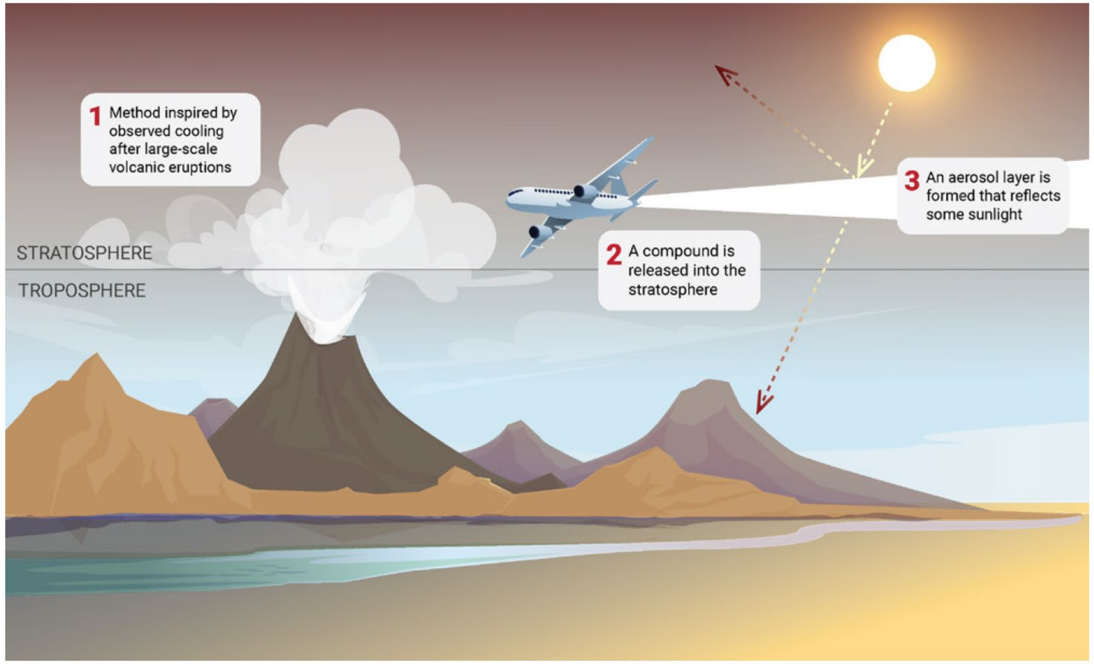

FIGURE 3: Illustration of the most studied SRM approach, and perhaps the most feasible, stratospheric aerosol injection.
Source: Adapted from Edwards 2019[26]; Lawrence et al 2018[27]; Caldeira, Bala and Cao 2013[28].

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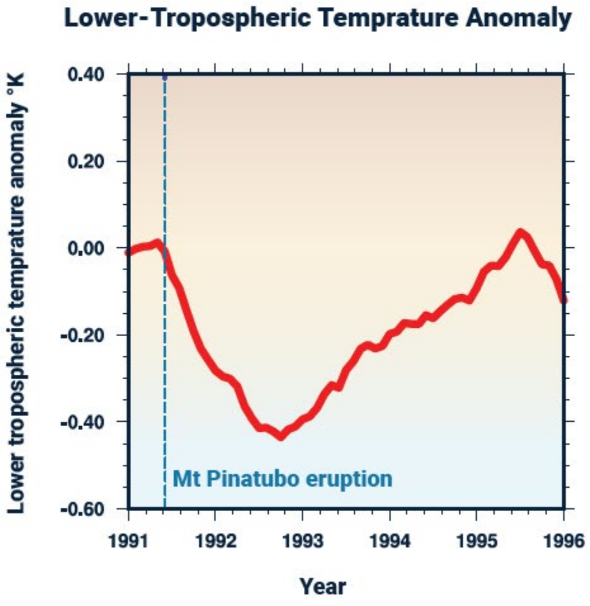
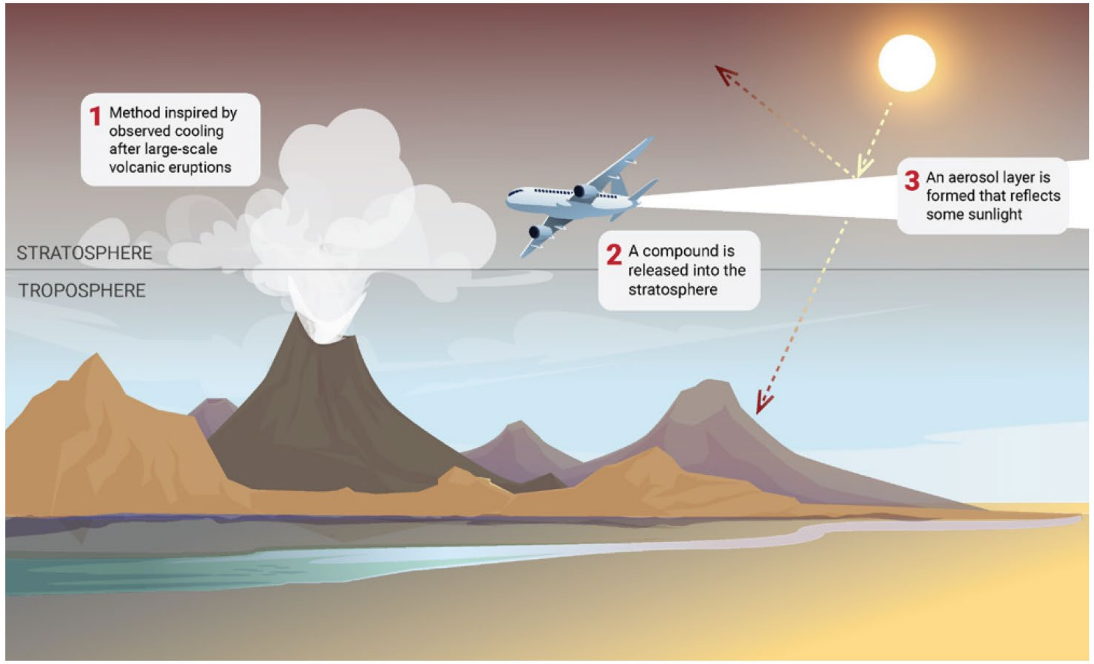


FIGURE 4: Global cooling in the years following Mount Pinatubo volcanic eruption in 1991. While there is confidence that most of the cooling in 1992 is a consequence of the eruption, separation of background natural variability from the volcano signal is challenging, especially because volcanic eruptions affect natural modes of variability such as El Nino. The time series shows the global mean anomalies (using a 1979–1998 base climatology) in monthly-mean tropospheric lower temperature from the microwave sounding unit observations[42]. The data is smoothed using a 7-month running mean. The eruption (June 1991) is marked by the dashed blue line. The observed anomalies are expressed relative to the pre-eruption value, defined here as the mean anomaly for January 1991 to May 1991. *Source: Created for this report using data from Aquila et al. 2021[43]; Mears and Wentz 2017[44].*



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Rising plume of brown ash and white steam from an early stage of the eruption of Sarychev Volcano (Kuril Islands, northeast of Japan) on June 12, 2009. Photo: ©NASA/Goddard

An operational SRM deployment is the only known approach that could be deliberately implemented to cool the Earth within a few years[10,15,16].

Conceptual framings for solar geoengineering

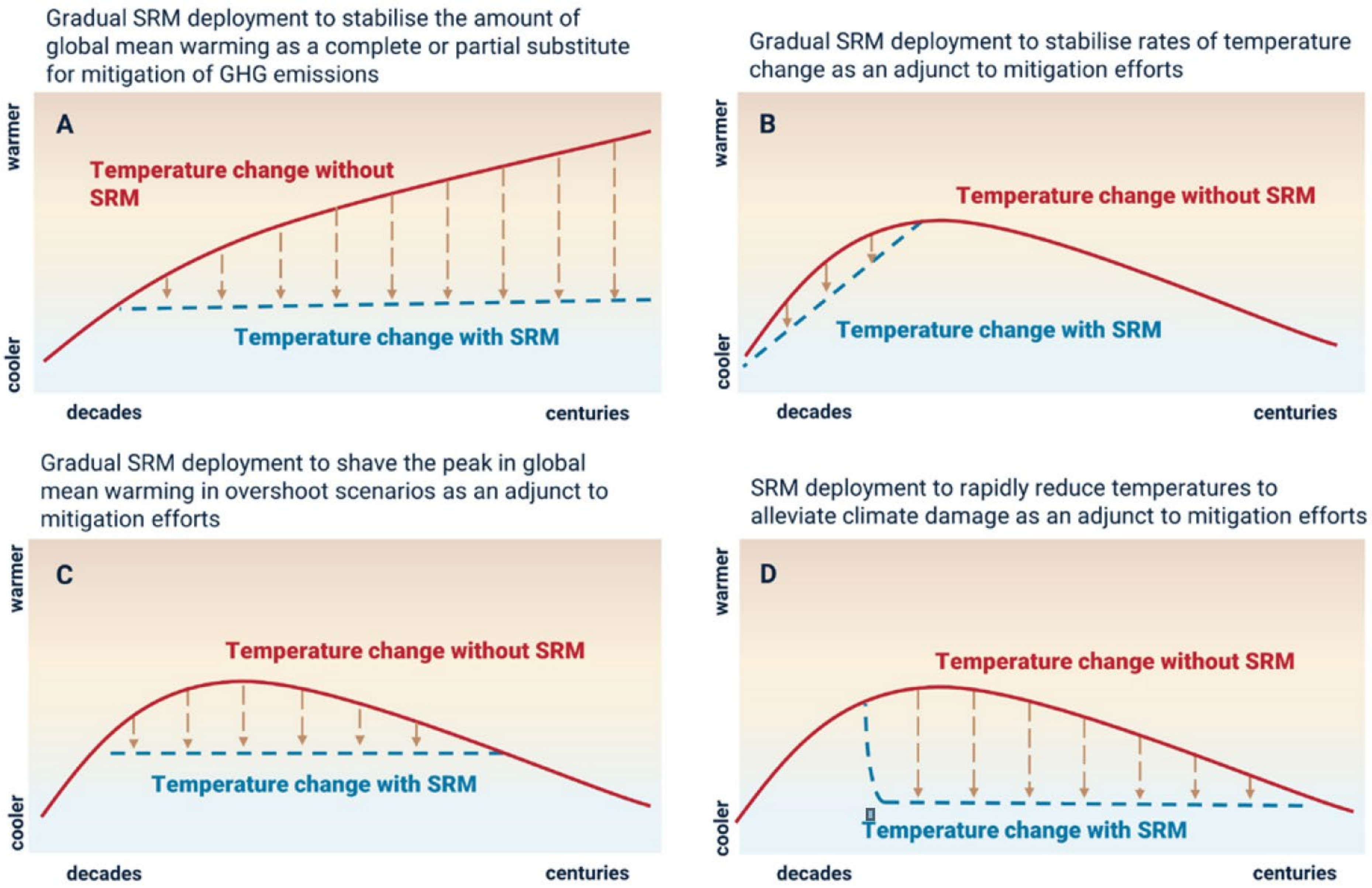

FIGURE 2: Hypothetical SRM deployment framings. Note that, in the absence of SRM deployment (red solid line), declines in global mean temperature on the timescale of decades to centuries would require substantial greenhouse gas removals. The orange arrows show the potential decrease in temperature with SRM deployment which may be able to reduce temperature to a lower level (blue dashed line) within a few years. *Source: Created by the authors of this report*

nature food
ARTICLES
https://doi.org/10.1038/s43016-021-00400-y
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Climate impacts on global agriculture emerge earlier in new generation of climate and crop models

Jonas Jägermeyr[1,2,3], Christoph Müller[3], Alex C. Ruane[1], Joshua Elliott[4], Juraj Balkovic[5,6], Oscar Castillo[7], Babacar Faye[8], Ian Foster[9], Christian Folberth[5], James A. Franke[4,10], Kathrin Fuchs[11], Jose R. Guarin[1,2], Jens Heinke[3], Gerrit Hoogenboom[7,12], Toshichika Iizumi[13], Atul K. Jain[14], David Kelly[9], Nikolay Khabarov[5], Stefan Lange[3], Tzu-Shun Lin[14], Wenfeng Liu[15], Oleksandr Mialyk[16], Sara Minoli[3], Elisabeth J. Moyer[4,10], Masashi Okada[17], Meridel Phillips[1,2], Cheryl Porter[7], Sam S. Rabin[11,18], Clemens Scheer[11], Julia M. Schneider[19], Joep F. Schyns[16], Rastislav Skalsky[5,20], Andrew Smerald[11], Tommaso Stella[21], Haynes Stephens[4,10], Heidi Webber[21], Florian Zabel[19] and Cynthia Rosenzweig[1]

Potential climate-related impacts on future crop yield are a major societal concern. Previous projections of the Agricultural Model Intercomparison and Improvement Project's Global Gridded Crop Model Intercomparison based on the Coupled Model Intercomparison Project Phase 5 identified substantial climate impacts on all major crops, but associated uncertainties were substantial. Here we report new twenty-first-century projections using ensembles of latest-generation crop and climate models. Results suggest markedly more pessimistic yield responses for maize, soybean and rice compared to the original ensemble. Mean end-of-century maize productivity is shifted from +5% to −6% (SSP126) and from +1% to −24% (SSP585)—explained by warmer climate projections and improved crop model sensitivities. In contrast, wheat shows stronger gains (+9% shifted to +18%, SSP585), linked to higher CO_2 concentrations and expanded high-latitude gains. The 'emergence' of climate impacts consistently occurs earlier in the new projections—before 2040 for several main producing regions. While future yield estimates remain uncertain, these results suggest that major breadbasket regions will face distinct anthropogenic climatic risks sooner than previously anticipated.

NATURE FOOD | VOL 2 | NOVEMBER 2021 | 873–885 | www.nature.com/natfood

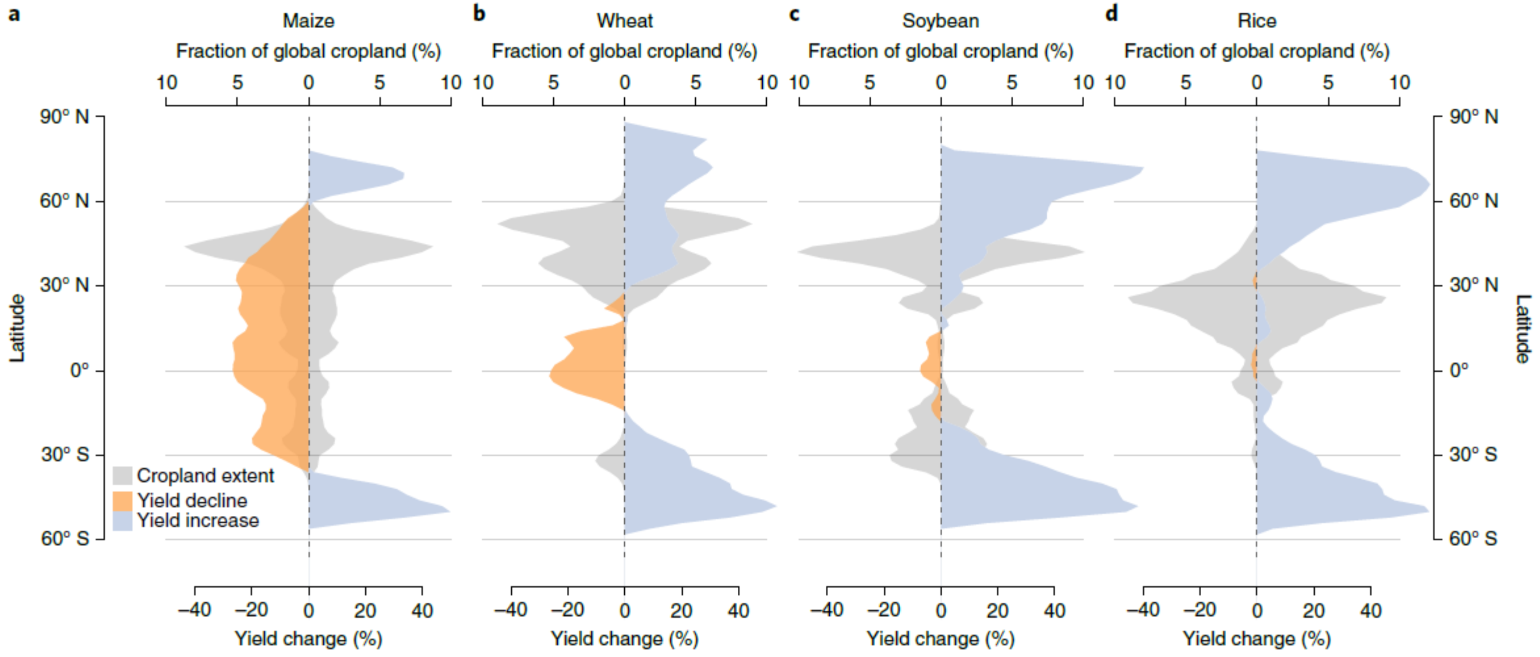


Fig. 6 | Latitudinal profile of crop yield changes. a–d, Yield changes (SSP585, 2069–2099) are shown as latitude averages for maize (**a**), wheat (**b**), soybean (**c**) and rice (**d**), based on crop simulations in all grid cells, unconstrained by current cropland extent (bottom *x* axis). For context, the current cropland extent is shown across latitude bands as fractions of the crop-specific global extent (top *x* axis; mirrored to allow overlaps with both positive and negative yield changes). Yield data are shown as the climate and crop model median (marginal areas with yield lower than the 20th percentile per crop are excluded).

The Washington Post
Democracy Dies in Darkness

ASIA

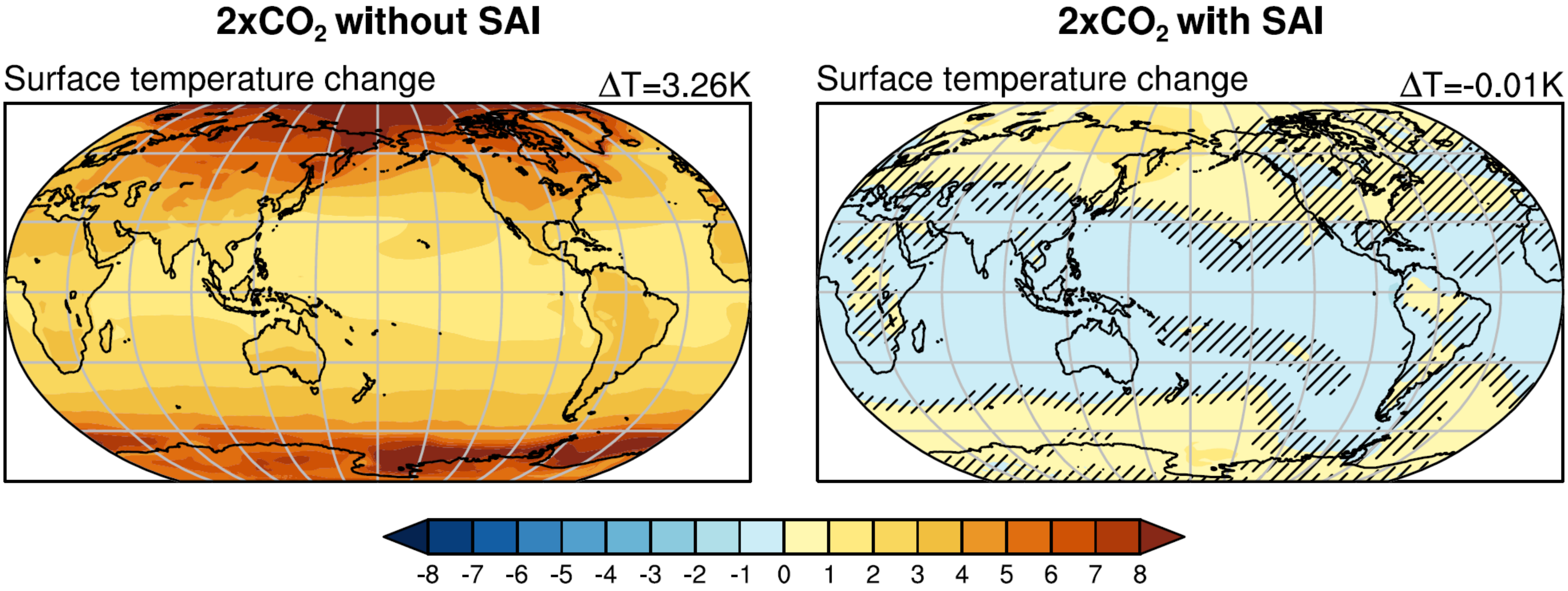
Deaths rise in India as temperatures soar in latest heat wave

By Sammy Westfall

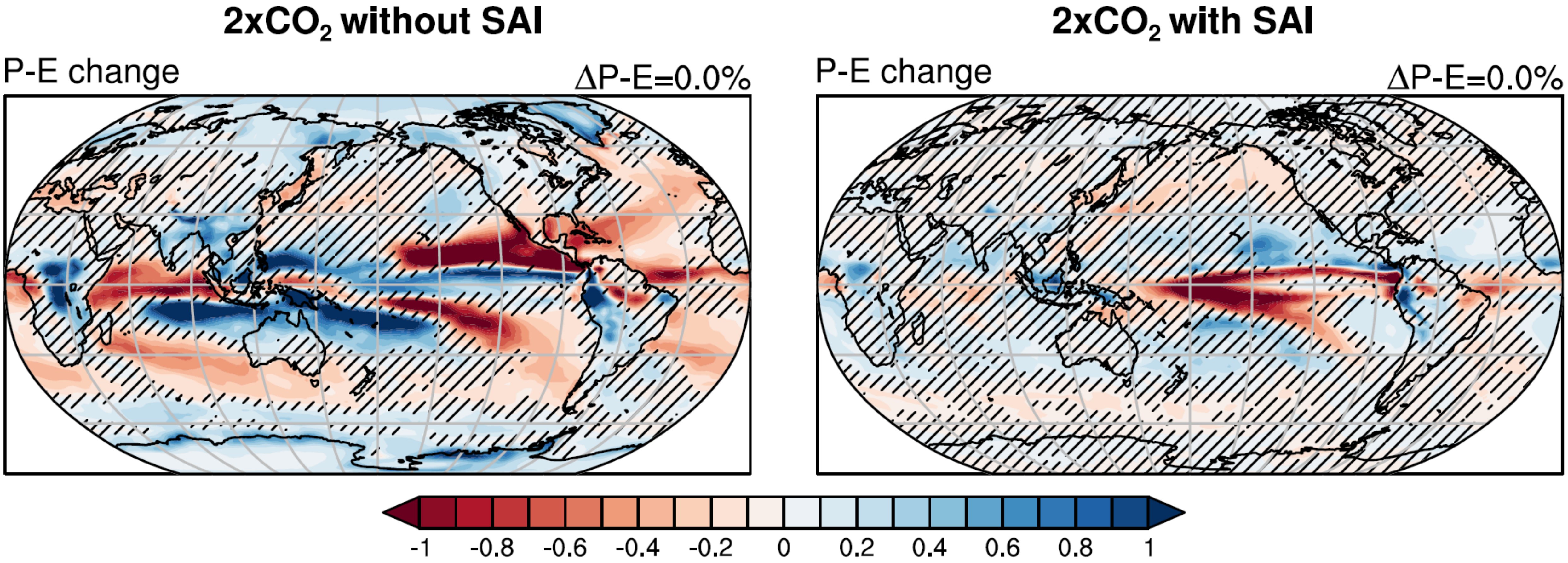
Updated June 19, 2023 at 4:07 p.m. EDT | Published June 18, 2023 at 6:35 p.m. EDT

About half of India's workforce labors outdoors, exacerbating the effects of the heat. Experts say that some places in India may simply become too hot for people to work outside if the world does not drastically reduce emissions that are warming the planet.

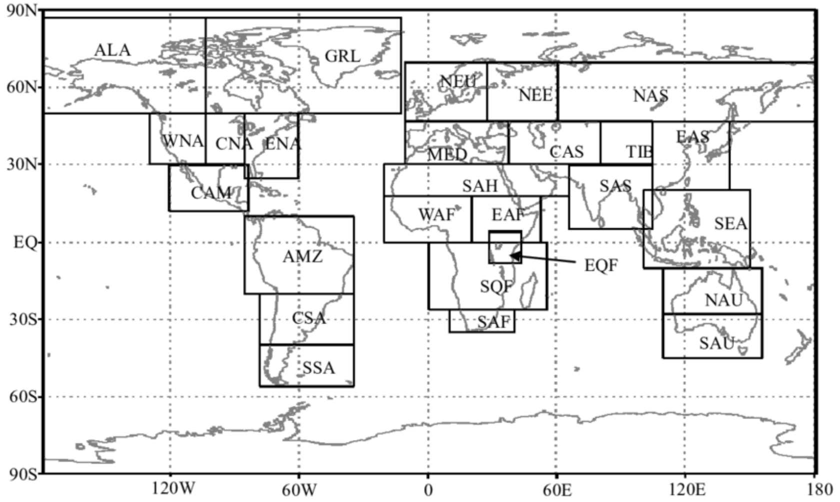
Temperature change with solar geoengineering to offset all of global mean warming …

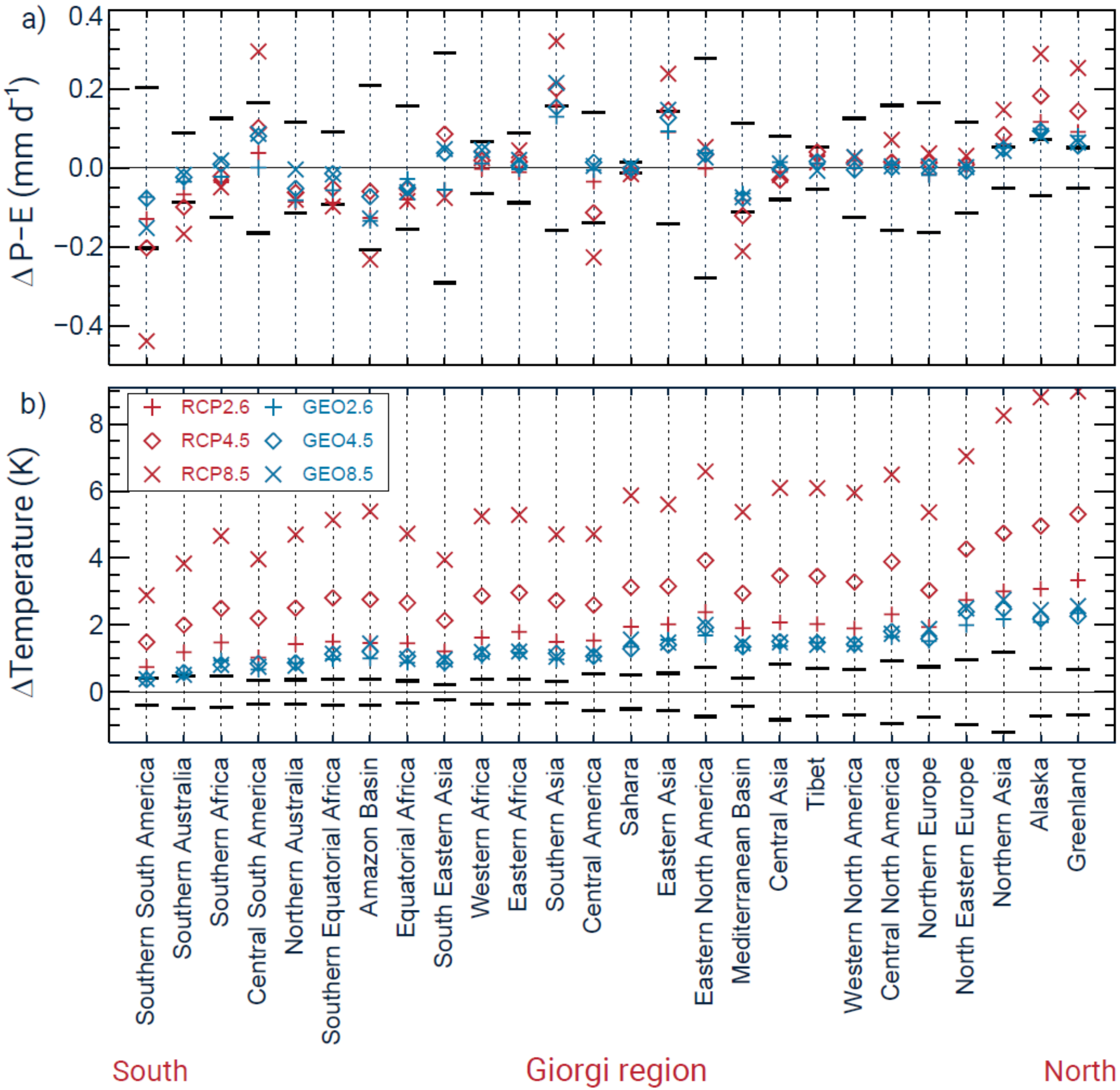


Change in precipitation minus evaporation with solar geoengineering to offset all of global mean warming …



Model results indicate that solar geoengineering could offset most climate change for most people most of the time.





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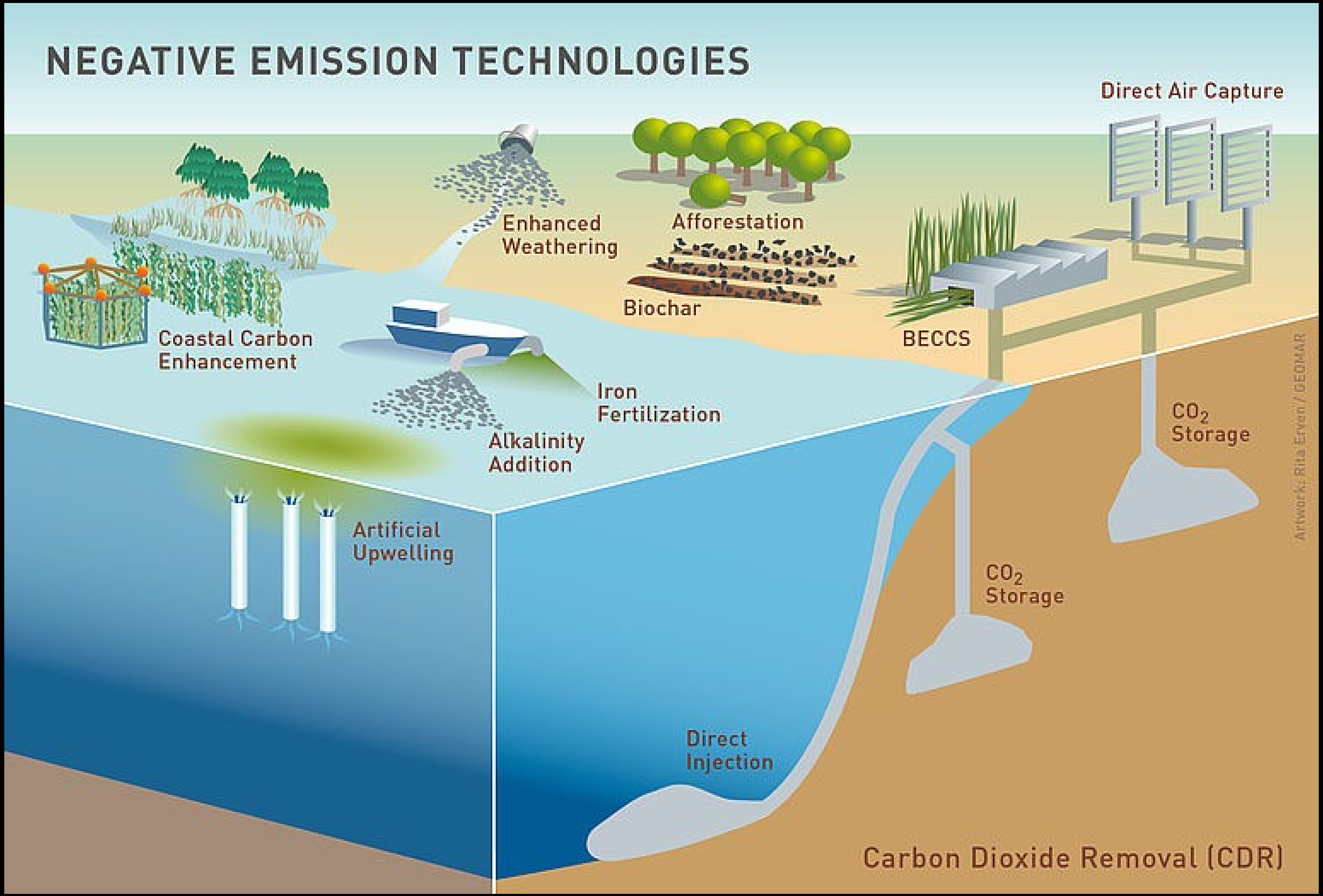
UN environment programme

CARBON DIOXIDE REMOVAL

SOLAR GEOENGINEERING


NEGATIVE EMISSION TECHNOLOGIES
Direct Air Capture
Enhanced Weathering
Afforestation
Biochar
Coastal Carbon Enhancement
BECCS
Iron Fertilization
Alkalinity Addition
Artificial Upwelling
CO_2 Storage
CO_2 Storage
Direct Injection
Carbon Dioxide Removal (CDR)
Artwork: Rita Erven / GEOMAR

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