Fourteenth Meeting of the SBSTA Research Dialogue

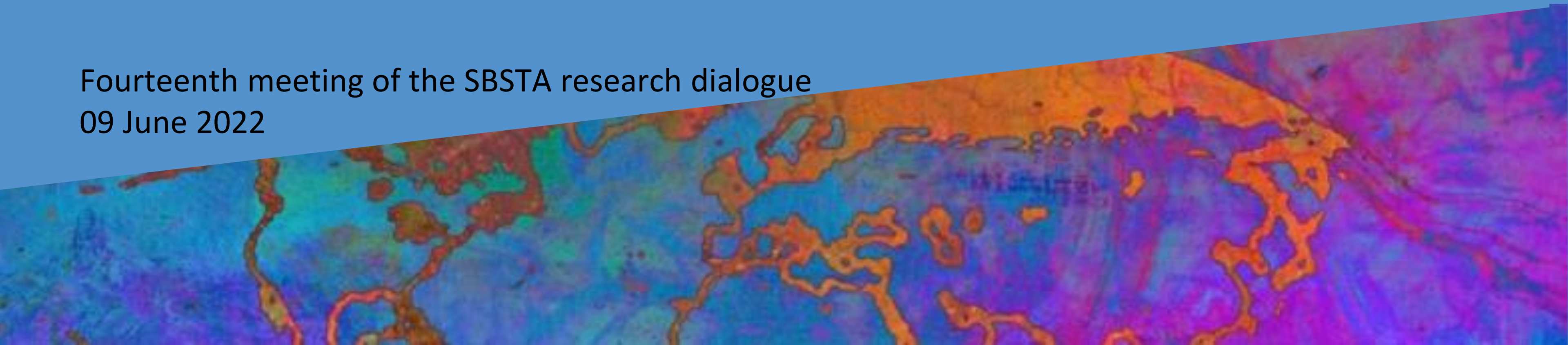
Plenary New York, WCCB
June 09, 11:00

INTERGOVERNMENTAL PANEL ON climate change

Projections of the near-term evolution of the climate system in the AR6 WGI

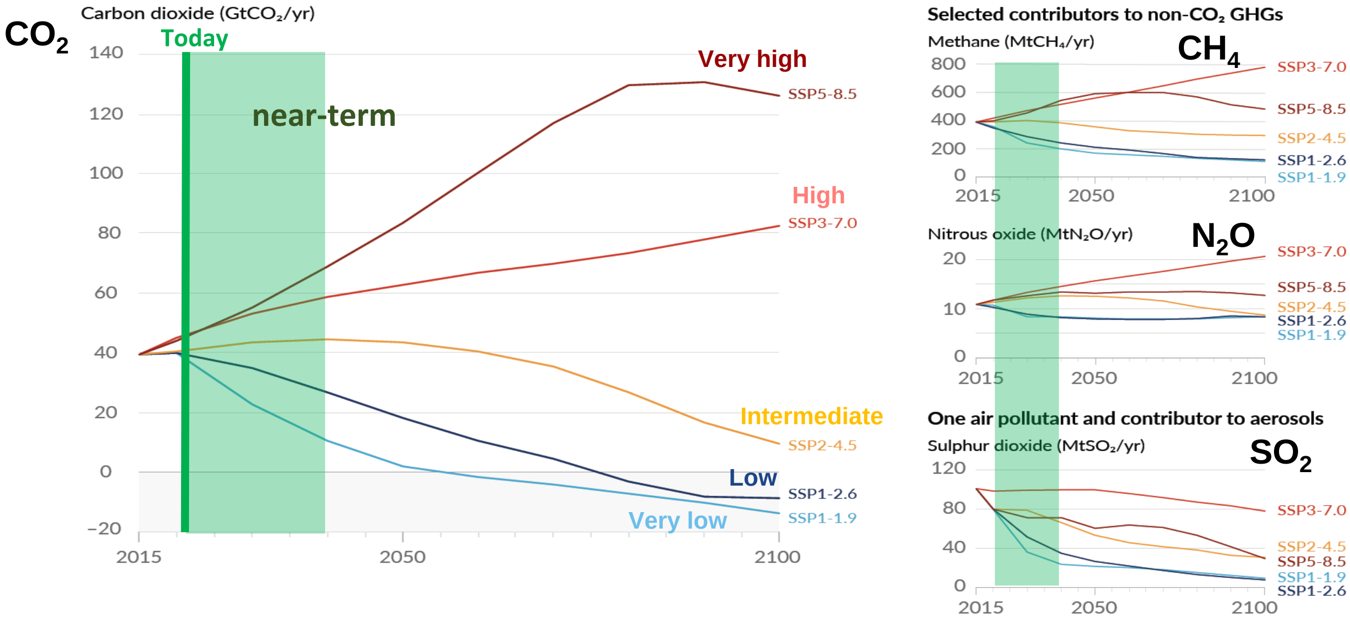
June-Yi Lee (WGI CH4 CLA & SYR CWT), Pusan National University & IBS Center for Climate Physics, Busan
Francois Englebrecht (WGI CH4 LA), University of the Witwatersrand, Johannesburg

Fourteenth meeting of the SBSTA research dialogue
09 June 2022



Advances in identifying drivers for the near-term (2021-2040) climate changes

Future emissions of CO_2 (left) and a subset of key non-CO_2 drivers (right), across five illustrative scenarios in WGI



AR6 WGI Figure SPM.4

AR6 WGI SPM D1.7: In the five illustrative scenarios, **simultaneous changes in CH4, aerosol and ozone precursor emissions**, which also contribute to air pollution, lead to **a net global surface warming in the near** and long term (*high confidence*).

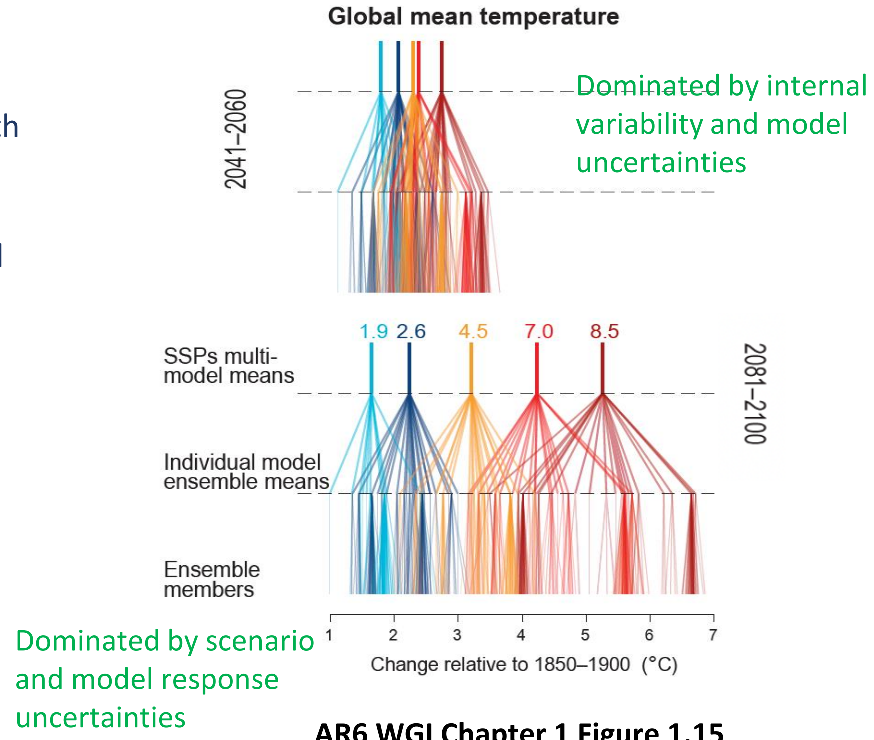
AR6 WGI SPM C.1: **Natural drivers** and **internal variability** will modulate human-caused changes, especially **at regional scales and in the near term**, with little effect on centennial global warming.

Advances in identifying sources of uncertainties in near-term information

Large uncertainties in near-term information due to

- **Internal variability:** Single-model initial-condition large ensembles and storylines approach provide a more comprehensive spectrum of possible changes associated with internal variability
- **Model uncertainty:** Scenario-based projections for global surface temperature are better constrained based on past warming simulations
- **Uncertainties in forcings from natural and anthropogenic aerosols:** The climate impacts from potential large volcanic eruptions are better understood.

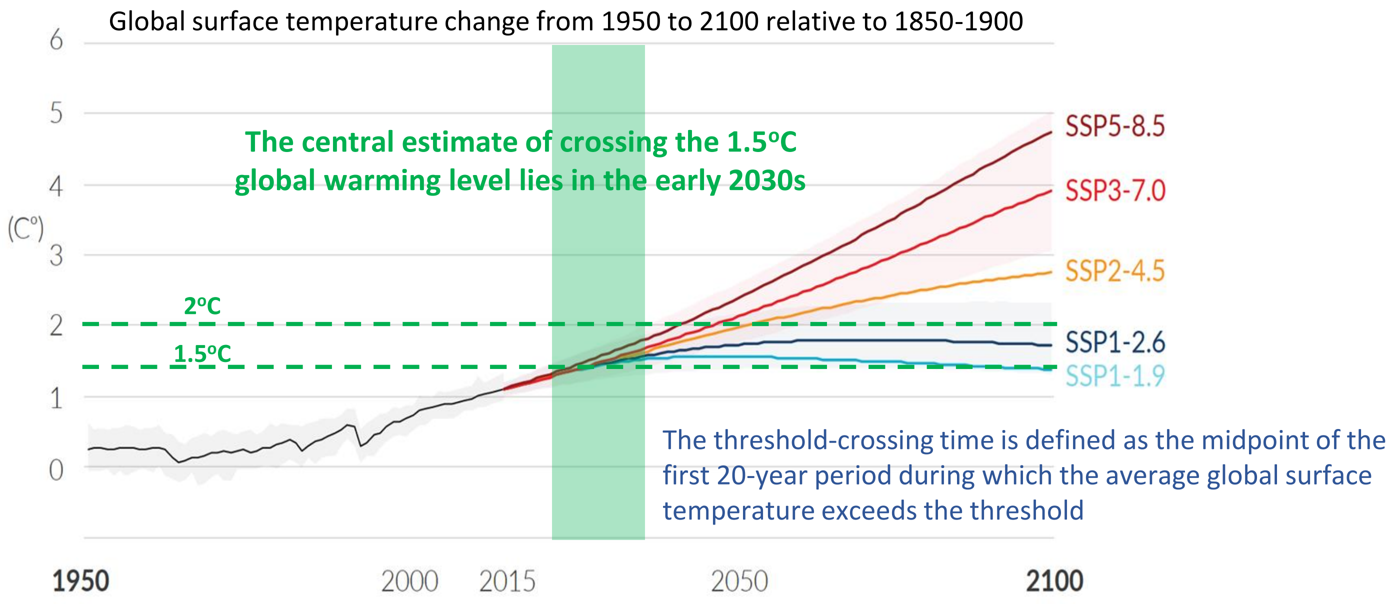
Cascade of uncertainties in climate projections



AR6 WGI Chapter 1 Figure 1.15

Assessment of future global surface temperature change is now based on multiple lines of evidence.

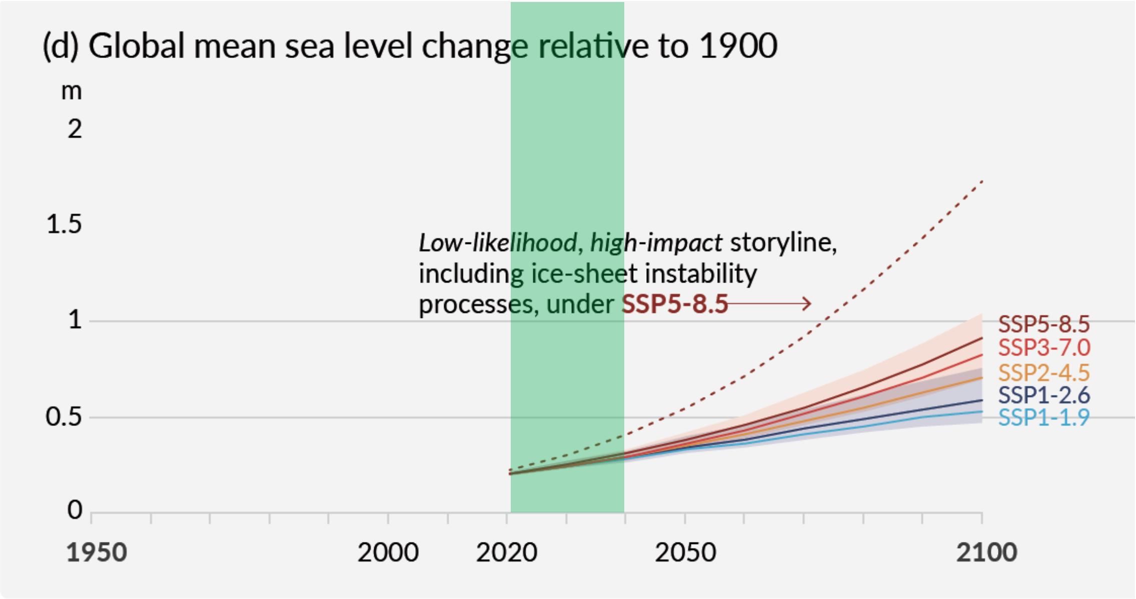
1. Substantially reduced uncertainty. Additional information from initialized decadal prediction.
2. Enabling a new estimate of when 1.5°C global warming is reached/crossed



AR6 WGI Figure SPM.8; Chapter 4

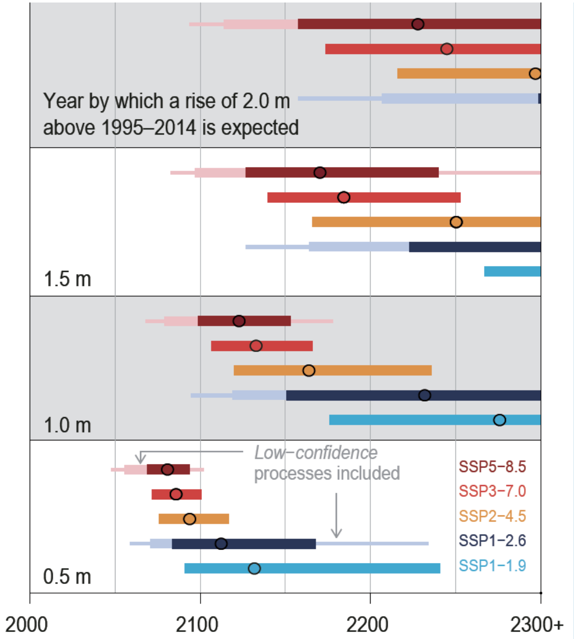
AR6 WGI Chapter 4: By 2030, global surface temperature in any individual year could exceed 1.5°C relative to 1850-1900 with a likelihood between 40% and 60%, across the scenarios considered (*medium confidence*).

Better constraints on the future change of sea level based on multiple lines of evidence



AR6 WGI Figure SPM.8; Chapter 9

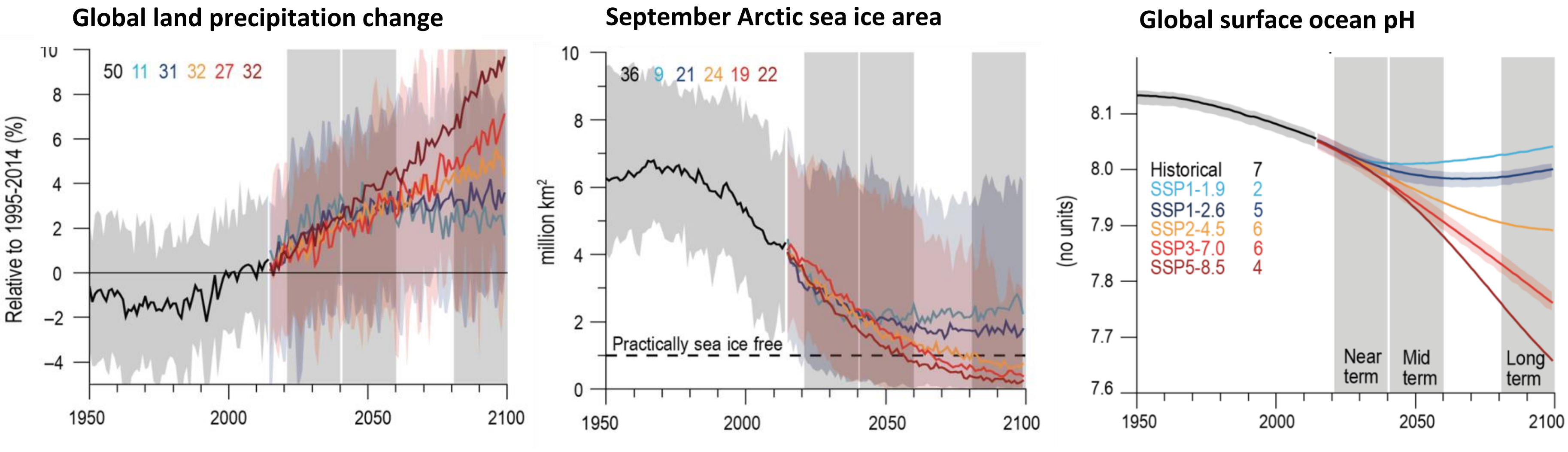
Projected timing of sea level rise milestones



AR6 WGI Box TS.4 Figure 1

The slow response of global sea level with weaker scenario dependence but with long-term commitment

Better constraints are needed for other climate variables and regional changes

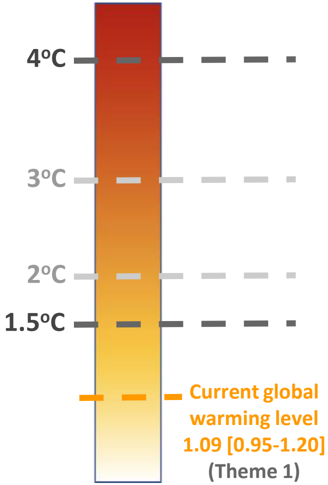


AR6 WGI Chapter 4 Figure 4.2 and 4.8

AR6 WGI Chapter 4: The part of the climate system that have shown clear increasing or decreasing trends in recent decades will continue these trends for at least the next twenty years. However, over a period as short as twenty years, these trends are substantially influenced by natural climate variability, which can either amplify or attenuate the trend expected from the future increase in greenhouse gas concentrations.

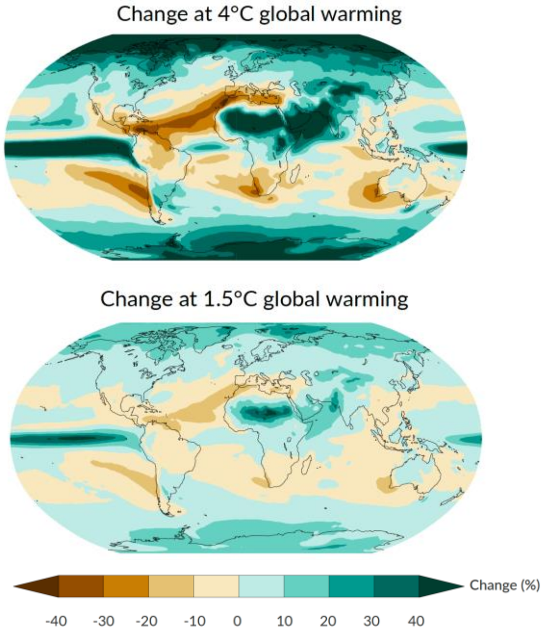
Global Warming Levels (GWLs) are used to assess global and regional climate change, linking to scenarios

- With every increment of global warming, changes in **regional mean temperature, precipitation, and soil moisture and changes in extremes and climatic impact-drivers get larger**.

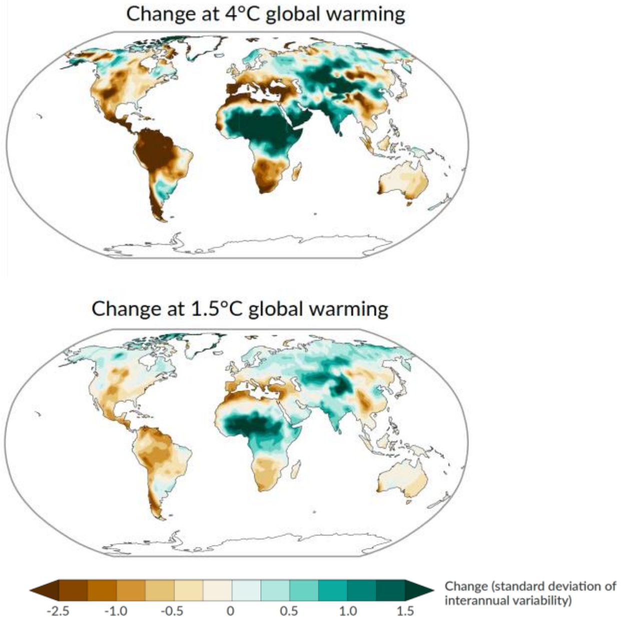


Global Warming Levels relative to 1850-1900

Annual mean precipitation



Annual mean soil moisture



WGI SPM HS.7, SPM HS.11, Figure SPM.5 , Figure SPM.6

Summary and Discussion

- Considerable scientific advances have been made in the improvement of near-term climate information. **The human-caused changes will be modulated by natural drivers and internal variability especially at regional scales and in the near term**.

- For the first time in an IPCC report, **the comprehensive assessment of future changes in global surface temperature and global sea level is provided based on multiple lines of evidence**. This enables a new estimate of when 1.5^{o}C global warming is reached/crossed.

- Future research direction may need to Improve our understanding and prediction/projection of near-term climate change, especially at regional scales;
  - Better information on uncertainties from internal variability that may have implication for global stocktake

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Thank you.

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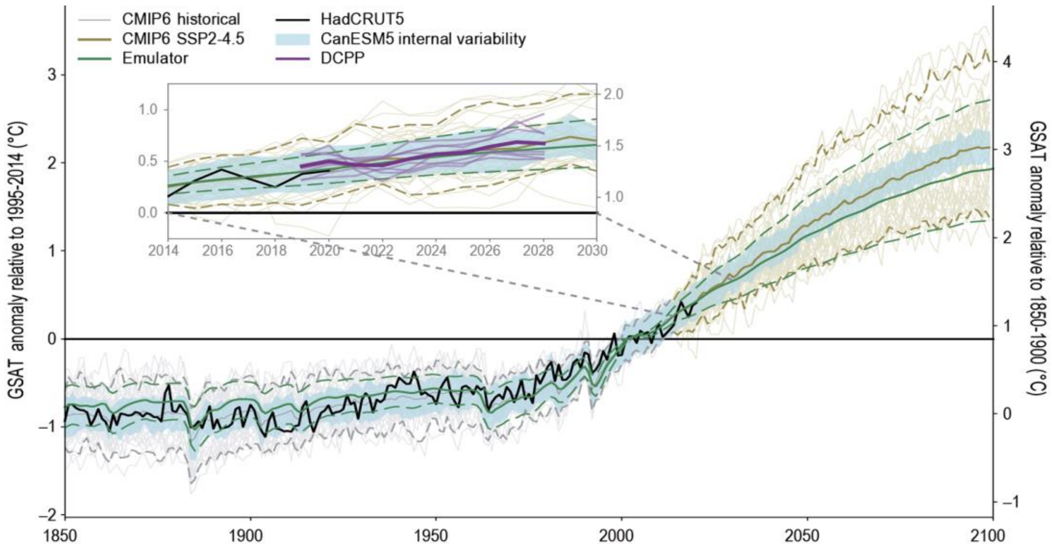
Initialized decadal forecasts as another line of evidence in the near-term assessment

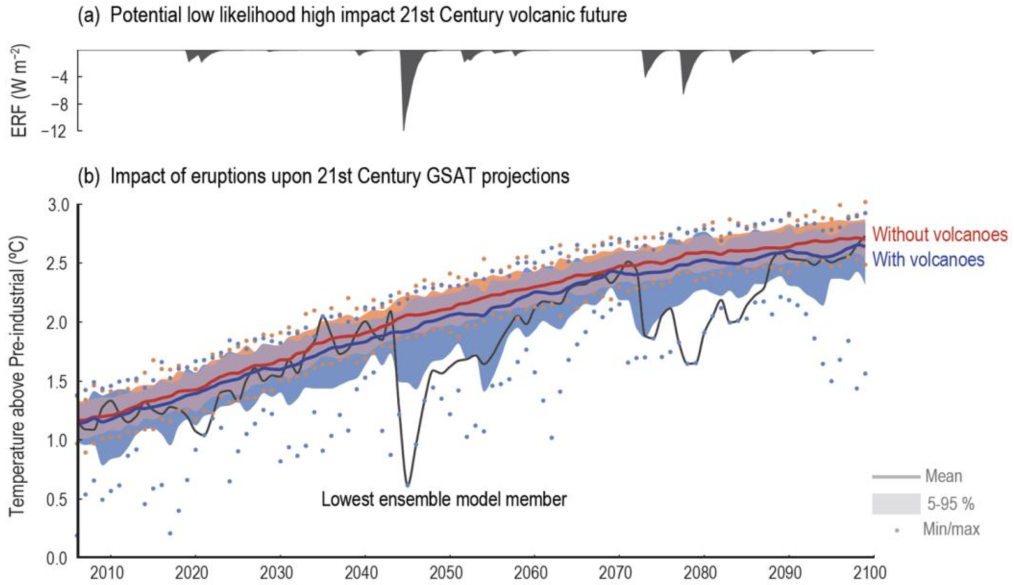
Global surface temperature change



AR6 WGI Chapter 4 Box 4.1 Figure 1

For the near term, initialized decadal forecasts constitute another line of evidence over the period 2019-2028. The forecasts are consistent with the assessed global surface temperature very likely range, strengthening the confidence in the near-term assessment (4.3.4)

The climate effects of potential large volcanic eruption in the near term



AR6 WGI Cross-Chapter Box 4.1

AR6 WGI SPM C.1.4: Based on paleoclimate and historical evidence, it is *likely* that at least on large explosive volcanic eruption would occur during the 21st century. Such an eruption would reduce global surface temperature and precipitation, especially over land, for one to three years, alter the global monsoon circulation, modify extreme precipitation and change many CIDs (medium confidence). If such an eruption occurs, this would therefore temporarily and partially mask human-caused climate change.

Changes in Global Monsoon

- **In response to greenhouse gas-induced warming, it is *likely* that global land monsoon precipitation will increase, particularly in the Northern Hemisphere, although Northern Hemisphere monsoon circulation will likely weaken.**
- Near-term projected changes in precipitation are uncertain, mainly because of **natural internal variability, model uncertainty,** and **uncertainty in natural and anthropogenic aerosol forcing** (*medium confid*ence).

Changes of global land monsoon precipitation and NH summer monsoon circulation index

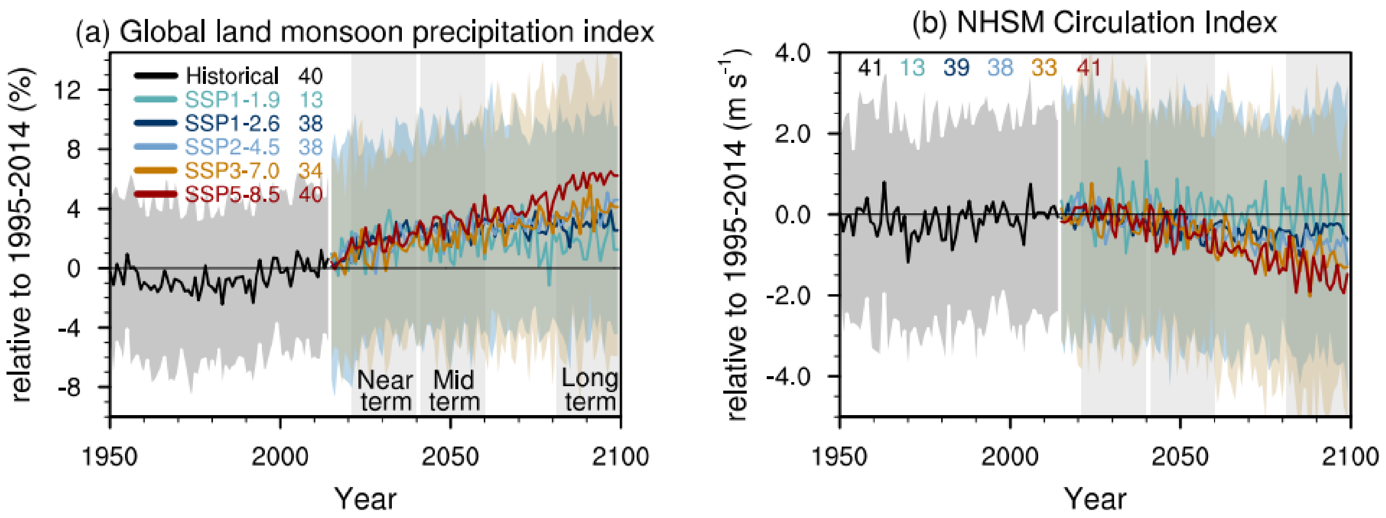
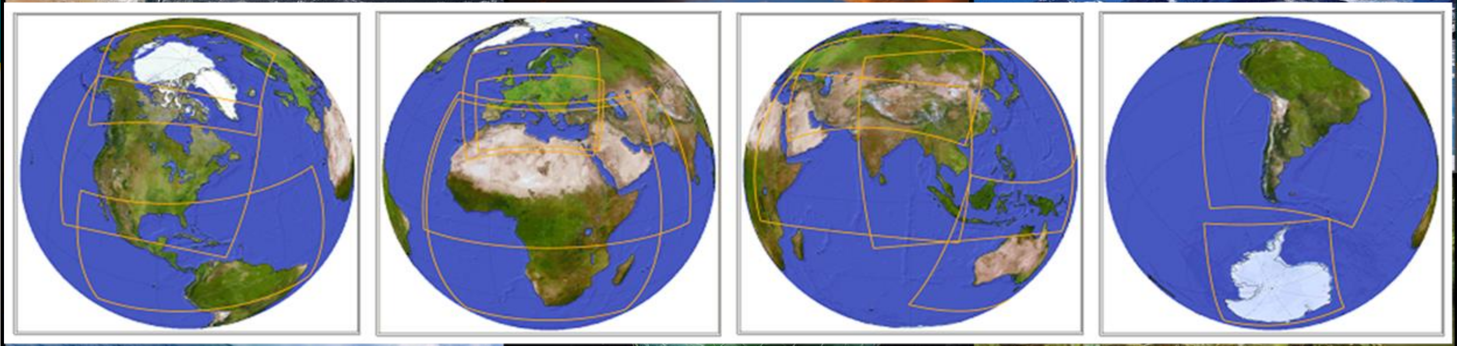


Figure 4.14

Recent WCRP Activities for Further Research Development

Explaining and Predicting Earth System Change (EPESC)

- To design, and take major steps toward delivery of, an integrated capability for quantitative observation, explanation, early warning and prediction of Earth System Change on **global and regional scales** and **multi-annual to decadal timescales**.



WCRP's Coordinated Regional Downscaling Experiment (CORDEX)

SBSTA56

www.cordex.org

CORDEX // Overview

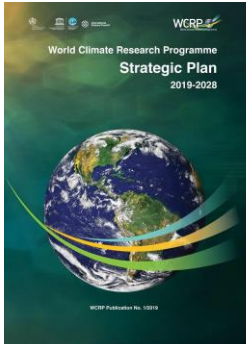
The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships

Goals:

- To better understand relevant regional/local climate phenomena, their variability and changes, through downscaling
- To evaluate and improve regional climate downscaling models and techniques
- To produce coordinated sets of regional downscaled projections worldwide
- To foster communication and knowledge exchange with users of regional climate information

CORDEX & WCRP

CORDEX directly contributes to the new WCRP strategic plan, especially Pillar 4: *“Bridging climate science and society”*



CORDEX is an instrumental part of the new WCRP Core Project: *Regional Information for Society (RifS)*

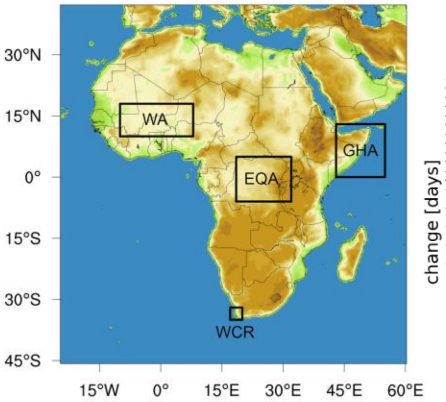
Highlights: CORDEX and Society
Supporting the development of National Adaptation Plans

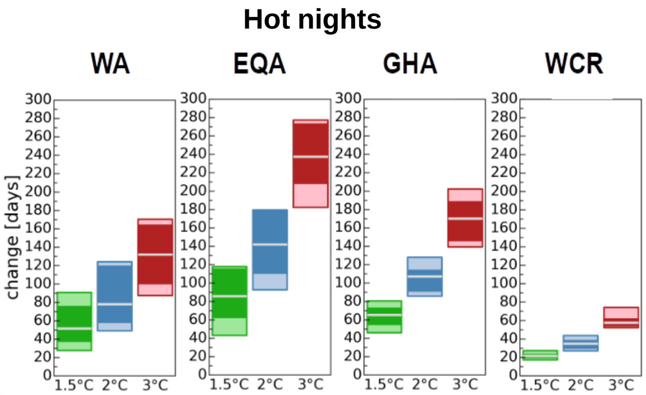
CORDEX can provide robust information to inform applications & decision making

CORDEX products can inform NAPs

CORDEX-CORE
Covers all land regions around the world
25x25km grid size
RCP2.6 & RCP8.5
1970-2100
➔ Particularly interesting for developing nations

Example of analysis CORDEX climate data in Africa





The colours of the boxes: 1.5°C (green), 2°C (blue), 3°C (red) global warming scenario. Ensemble minimum/maximum (light colour), 17th and 83th percentile (dark colour) and median (grey) as field means for focus regions d) West Africa, e) Equatorial Africa, f) Greater Horn of Africa, g) Western Cape Region.

WCRP CORDEX

Weber et al., 2018, https://doi.org/10.1002/2017EF000714

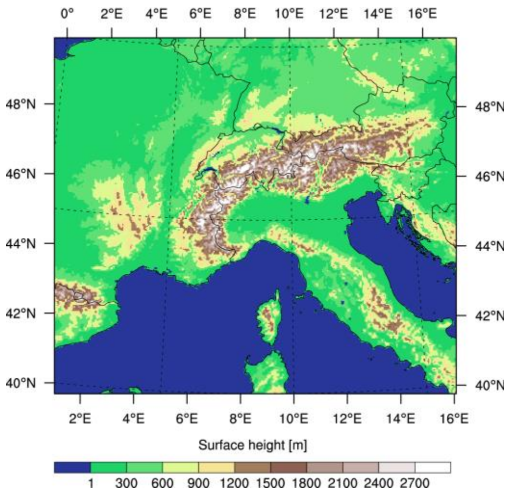
World Meteorological Organization · unesco Intergovernmental Oceanographic Commission · International Science Council · WCRP World Climate Research Programme

Highlight: high-resolution (3km)

CORDEX-Flagship Pilot Study

Convection over Europe and the Mediterranean

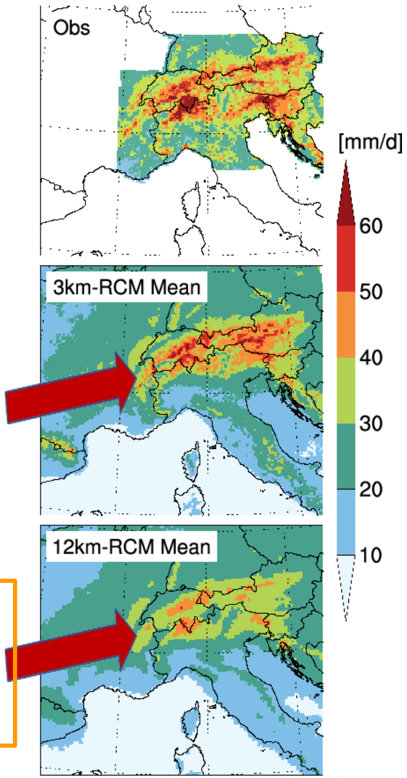
Model domain



23-member ensemble

- Reduces biases & uncertainty ranges;
- Improves diurnal cycles;
- Mitigates the “drizzle” problem;
- Captures heavy precipitation

Clear improvement in heavy precipitation (P99)



More realistic representation of precipitation with convection-permitting models compared to coarser counterparts

Ban et al. 2021
https://link.springer.com/article/10.1007%2Fs00382-021-05657-4

CORDEX data availability (input for AR6 chap/atlas)

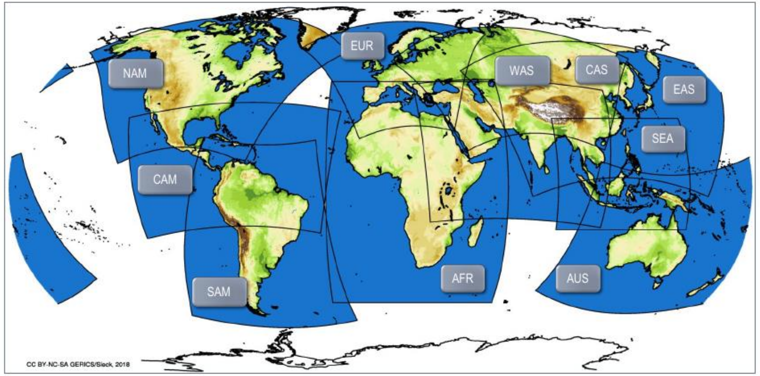
- Open access
- Standardized, quality controlled
- Observational basis for verification
- Community effort
- Inventory of GCM/RCMs on www.cordex.org

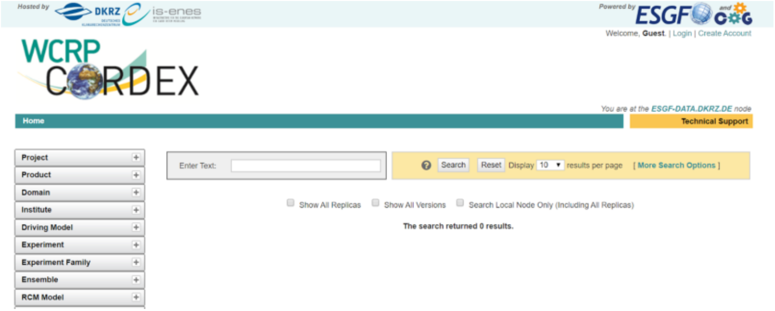
CORDEX model output data is available online via:
- Earth System Grid Federation
- Copernicus Climate Data Store

ESGF

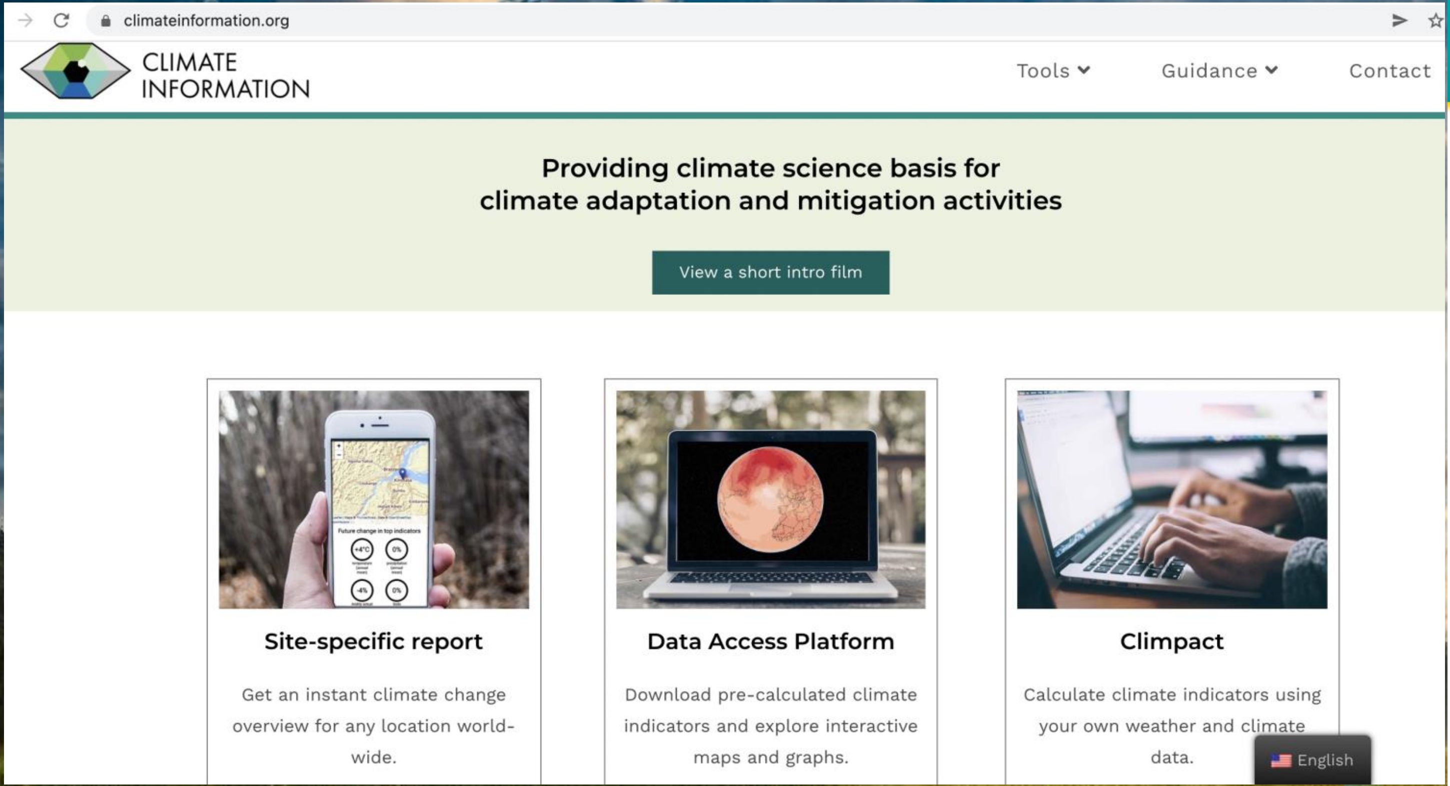
Climate Data Store (CDS)
Climate data at your fingertips

CORDEX-CORE Regions/Domains





WORLD METEOROLOGICAL ORGANIZATION · unesco Intergovernmental Oceanographic Commission · International Science Council · WCRP World Climate Research Programme



WCRP CORDEX
www.cordex.org

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World Climate Research Programme

WORLD METEOROLOGICAL ORGANIZATION
unesco
Intergovernmental Oceanographic Commission
International Science Council

THE UN DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT – A RESOURCE FOR THE PARIS AGREEMENT AND BEYOND

Margaret Leinen, Co-Chair
UN Ocean Decade Advisory Board

UC San Diego
SCRIPPS INSTITUTION OF OCEANOGRAPHY

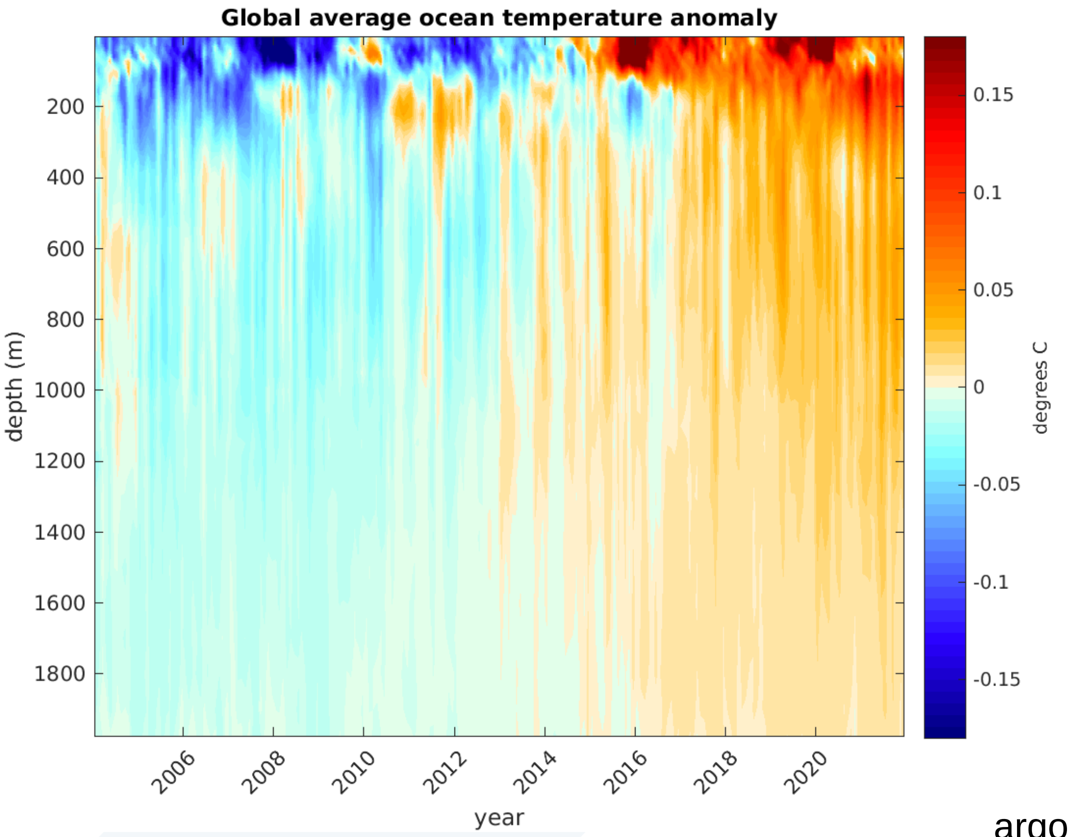
The ocean we need for the future we want

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

IMPORTANT POTENTIALS FOR THE OCEAN DECADE

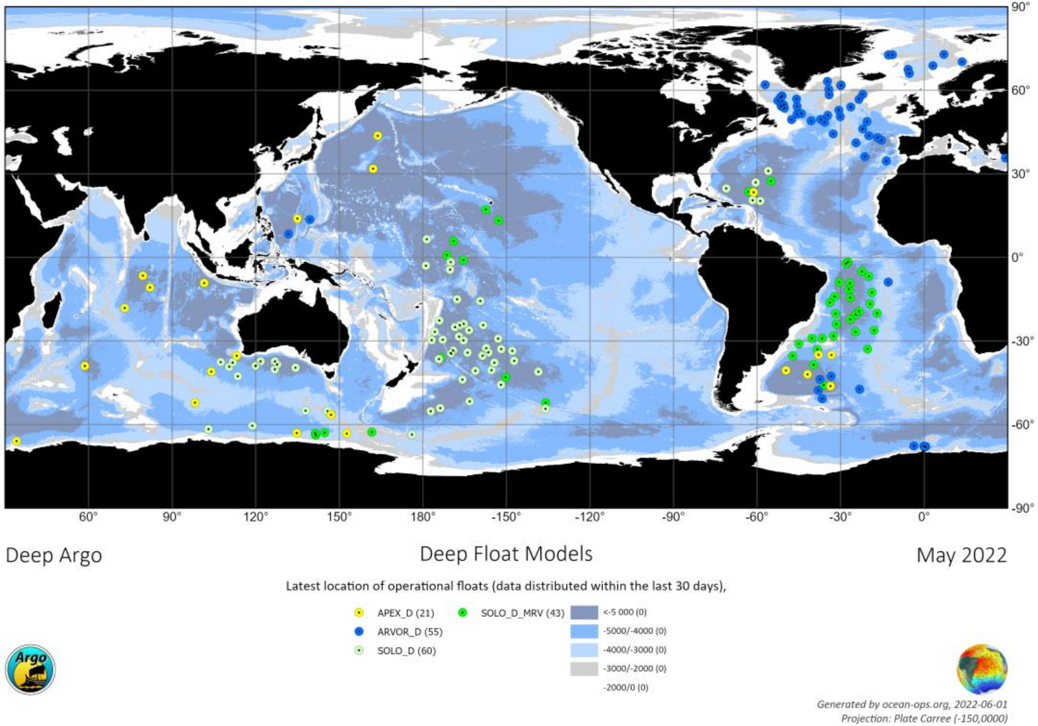
- Variability of the deep ocean
- Unraveling the ocean-climate-biology nexus
- Understanding precipitation in polar regions
- Extreme events in the ocean
- Ocean carbon dioxide removal
- Understanding the southern ocean

UPPER OCEAN WARMING 2005-2022

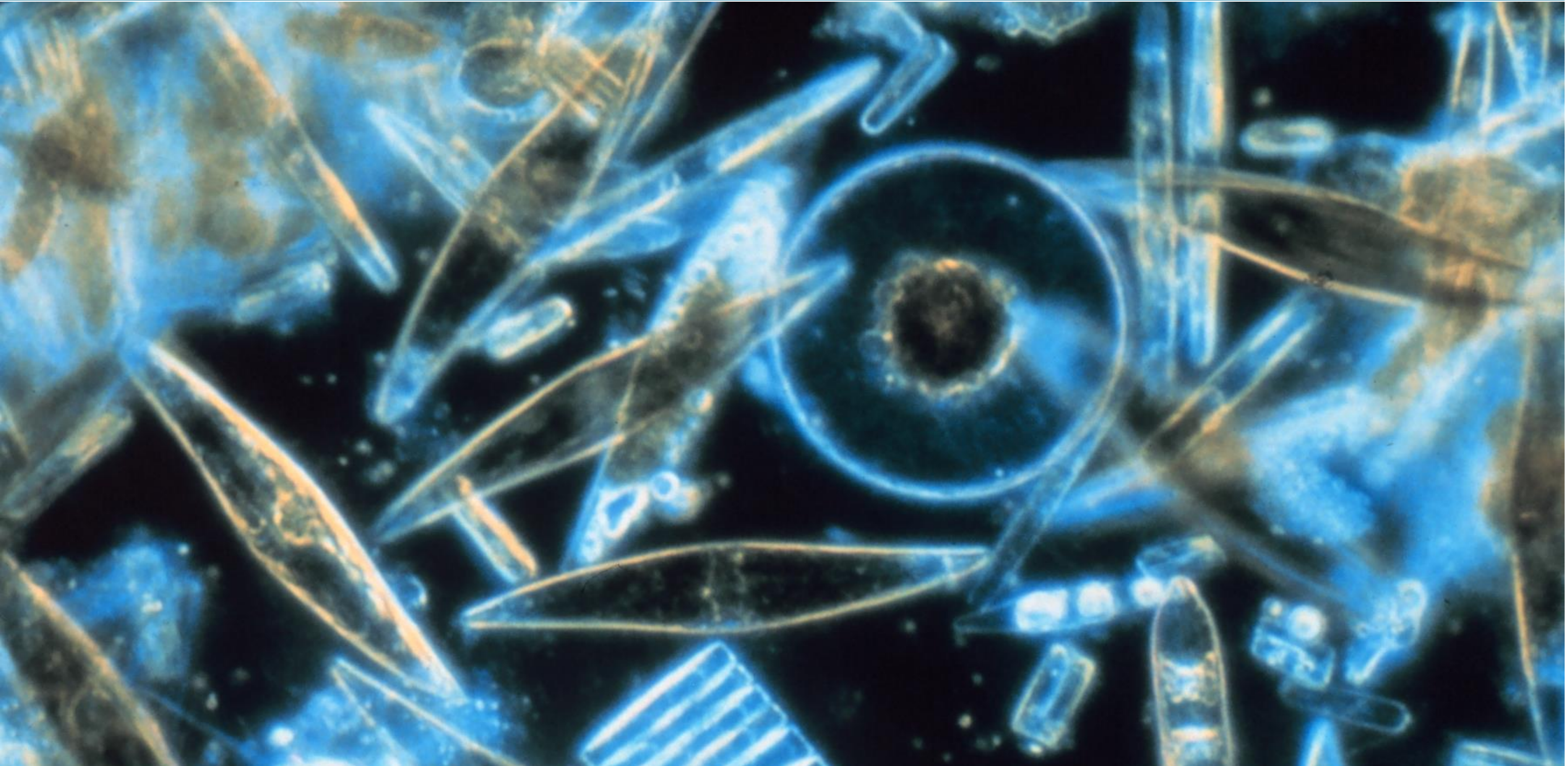


argo.ucsd.edu, 2022

UNDERSTANDING THE STABILITY OF THE DEEP OCEAN – DEEP ARGO



OCEAN-CLIMATE-BIOLOGY NEXUS



OCEAN-CLIMATE-BIOLOGY NEXUS

eDNA Methods

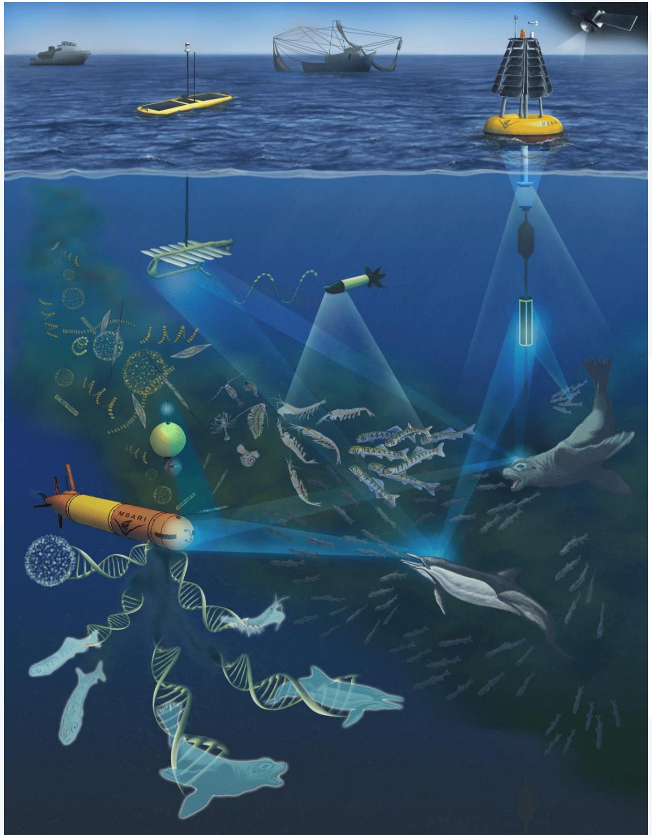
Single-species PCR (qPCR)
+ Simple, cheap, fast
- Only identifies one species

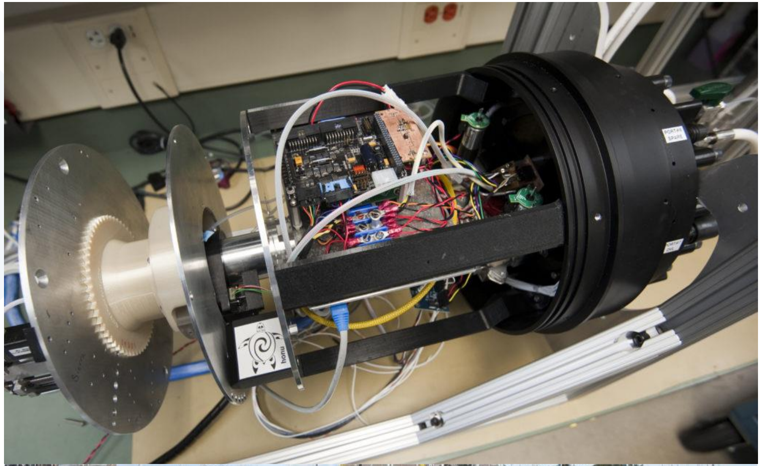
Invasive or rare species

Metabarcoding (amplicon)
+ Identifies multiple species
- More complex, harder to interpret

Community assemblages, trophic structures

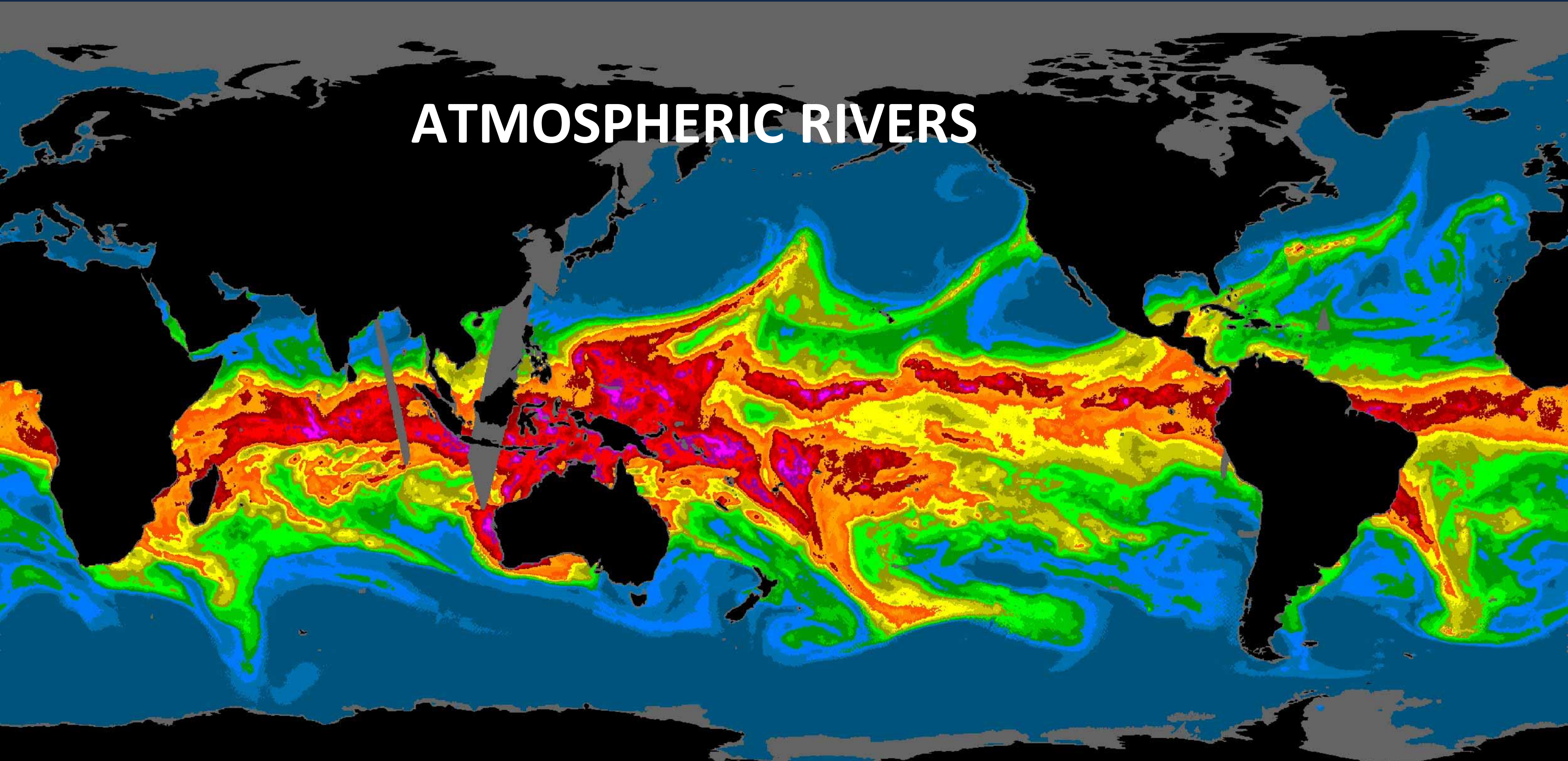
OCEAN-CLIMATE-BIOLOGY NEXUS





UNDERSTANDING PRECIPITATION IN POLAR REGIONS

ATMOSPHERIC RIVERS



Integrated atmospheric water vapor

NASA

Most water vapor transport to the poles occurs over ocean sectors

About 60% of the water vapor transport in those regions is transported by ARs

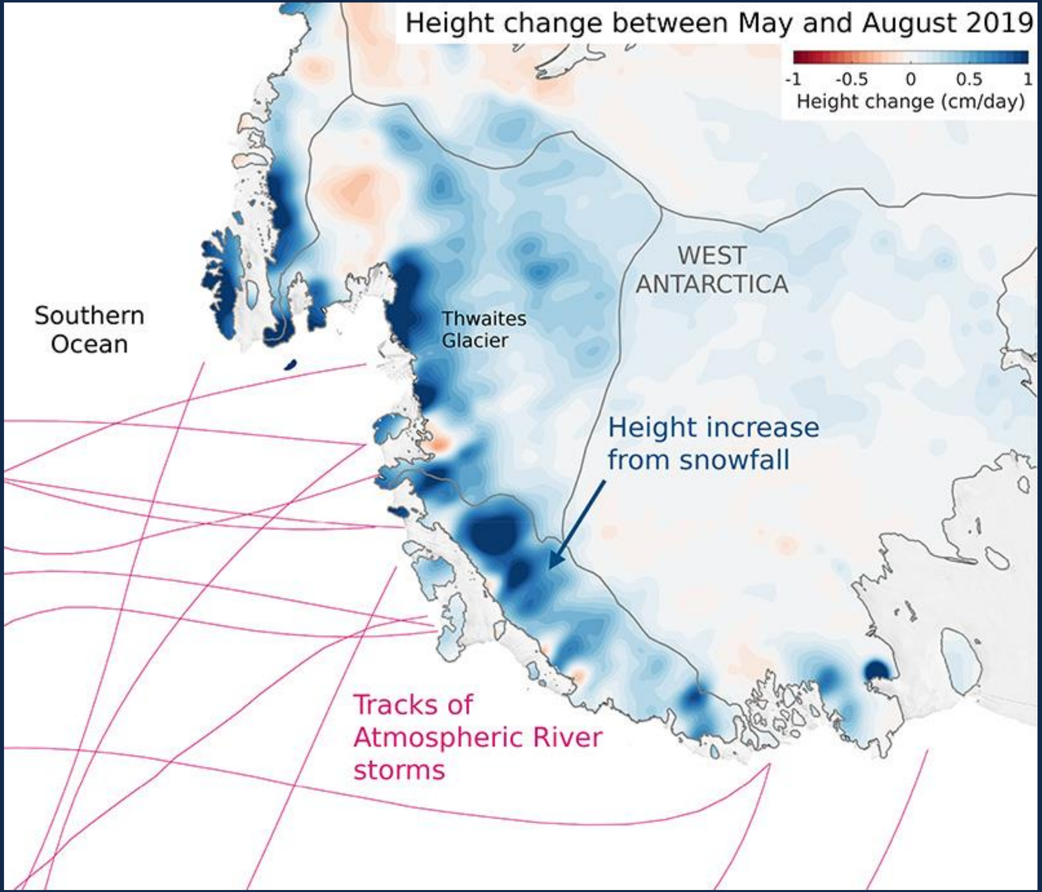
ARs control >70% of the variance above 70° latitude

Nash, Waliser, Guan, Ye and Ralph, 2018

Coupled ocean-atmosphere models suggest that under warmer conditions ARs will:

- be fewer in number, but
- be longer, wider
- carry more water
- and produce more rainfall

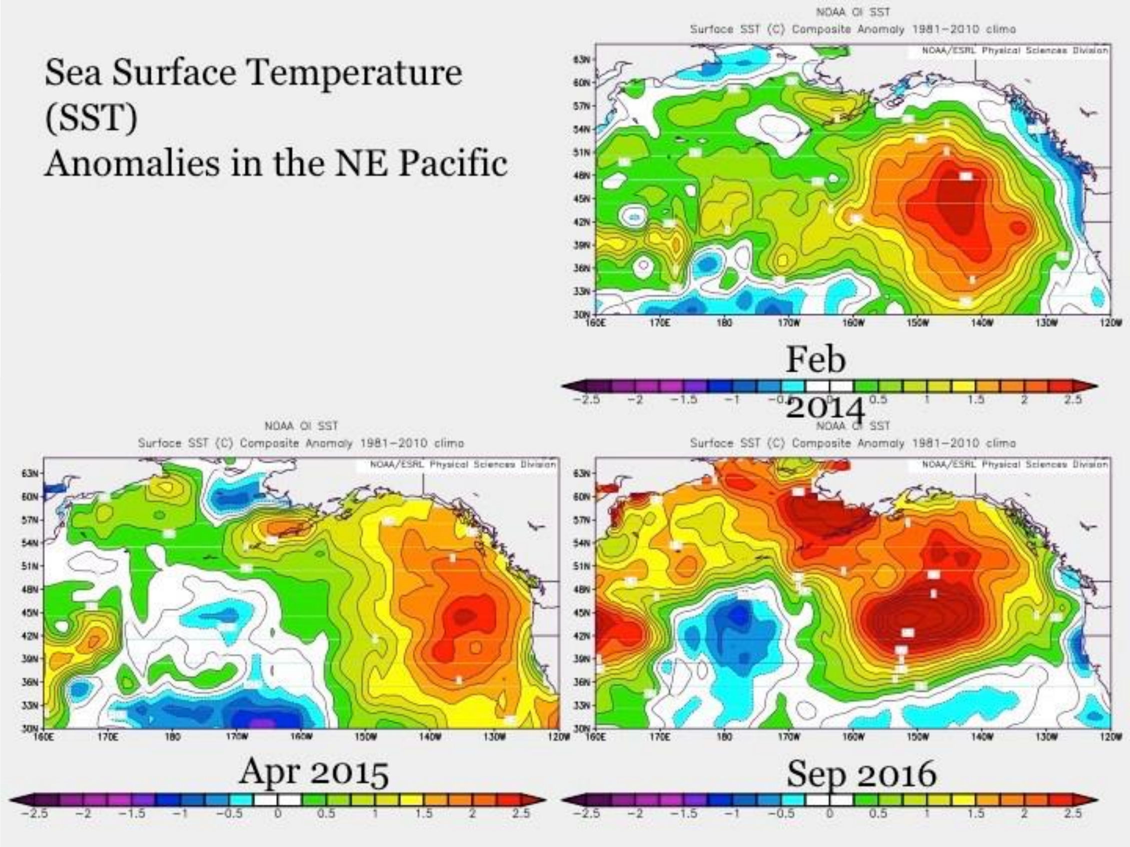
Espinoza, et al., GRL 2018



UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

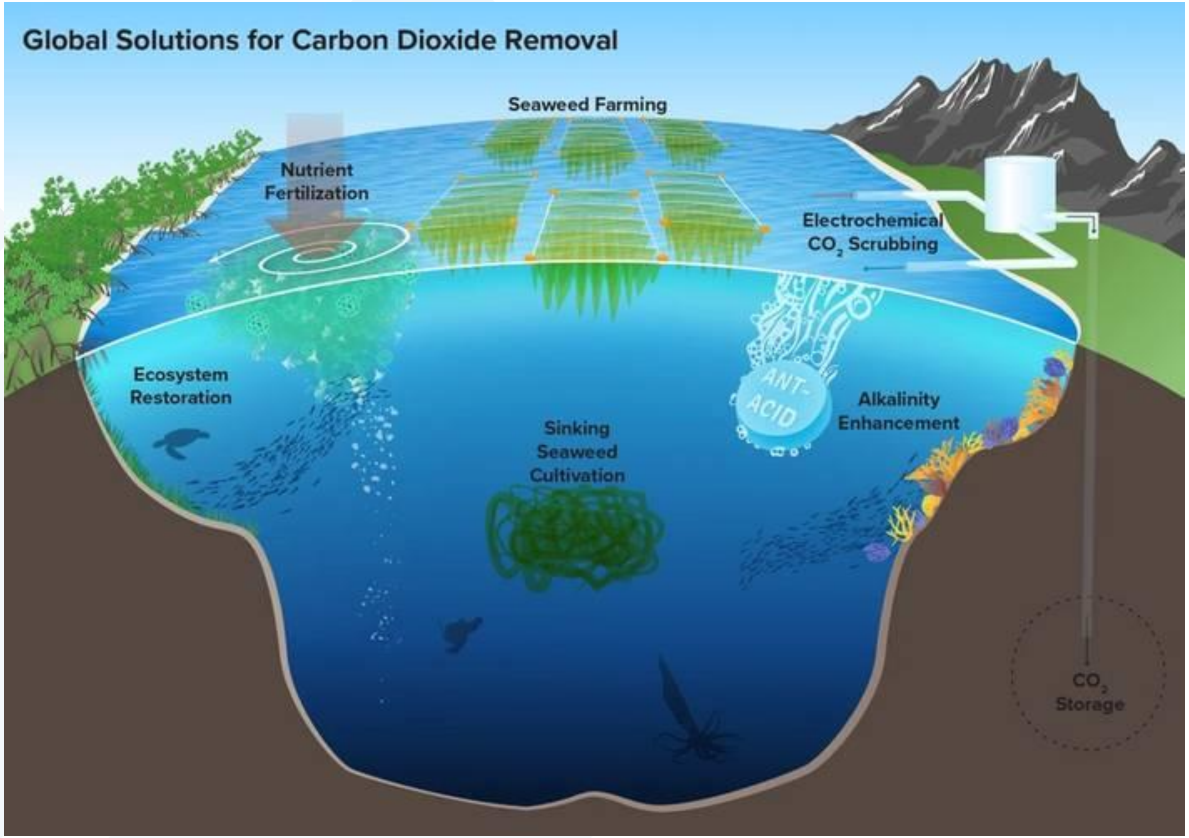
Susheel Adusumilli, 2021

OCEAN HEAT WAVES AND THEIR IMPACT

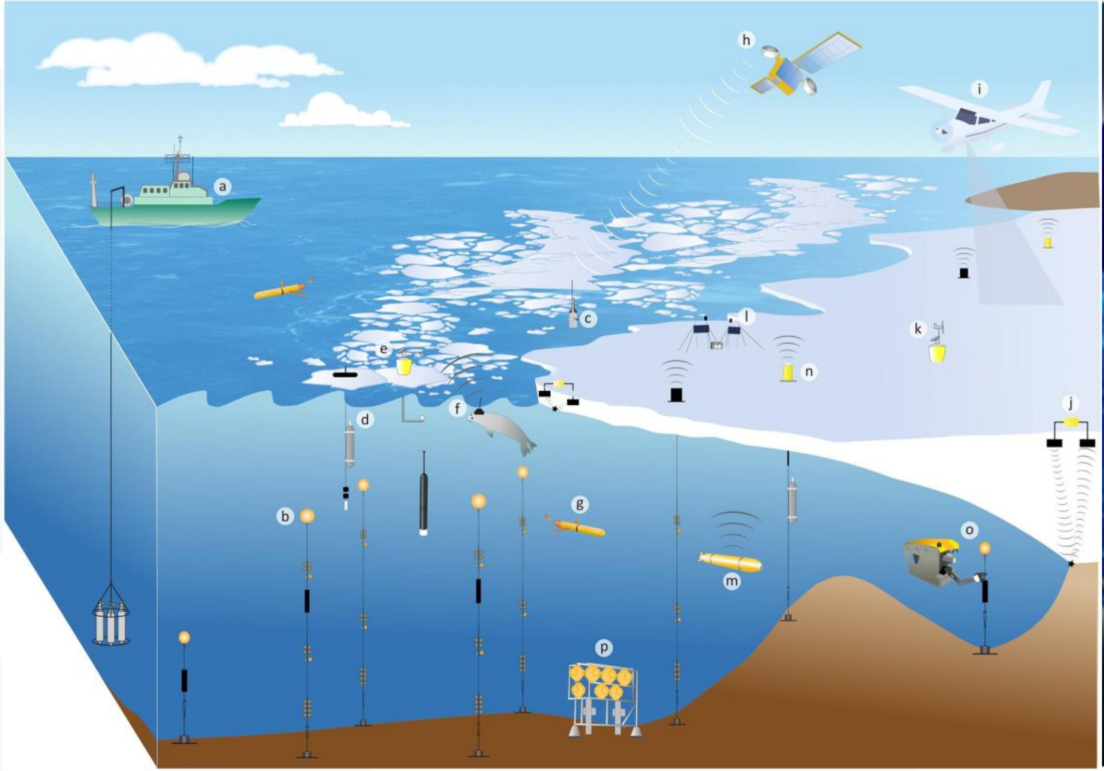


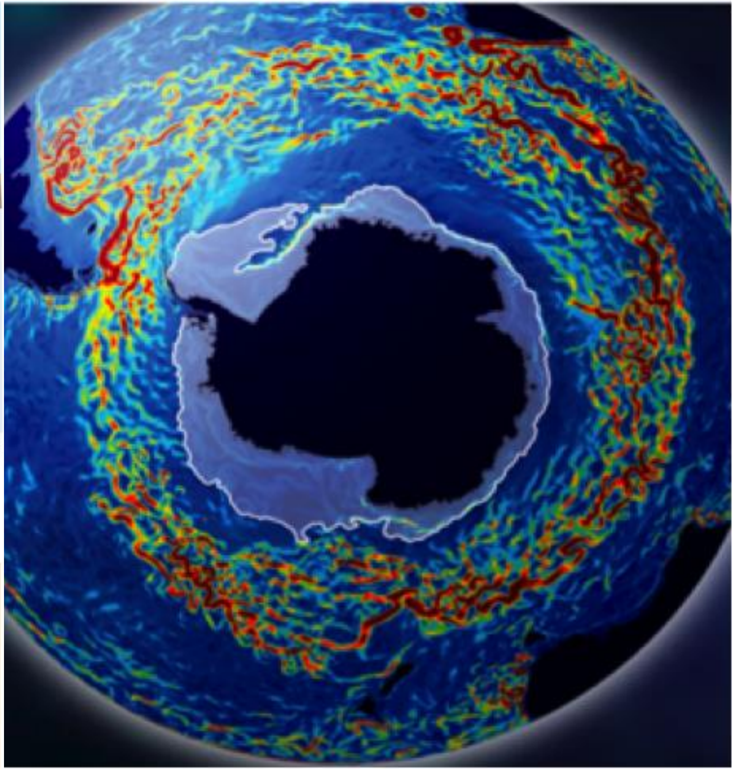
NOAA

OCEAN CARBON DIOXIDE REMOVAL



ACCESSING AND UNDERSTANDING THE SOUTHERN OCEAN



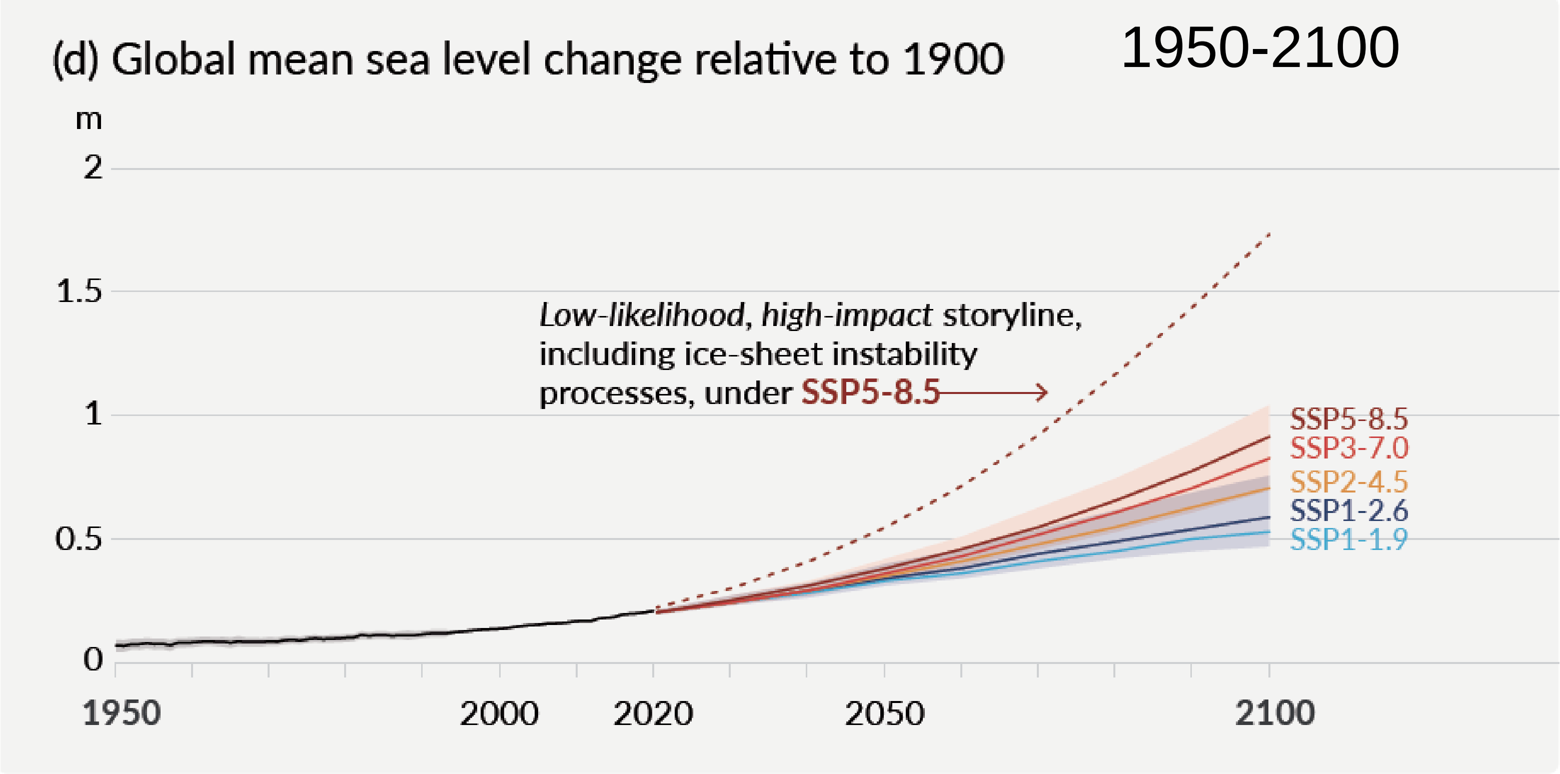


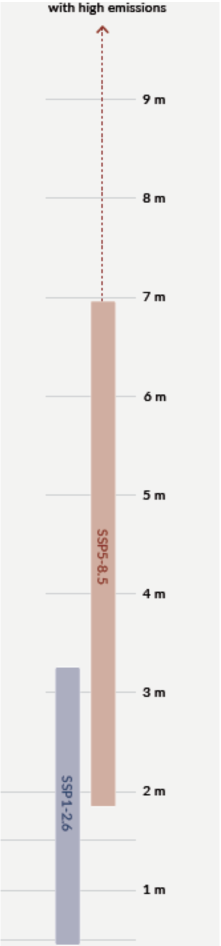
Robert DeConto, University of Massachusetts

School of Earth & Sustainability
UNIVERSITY OF MASSACHUSETTS AMHERST

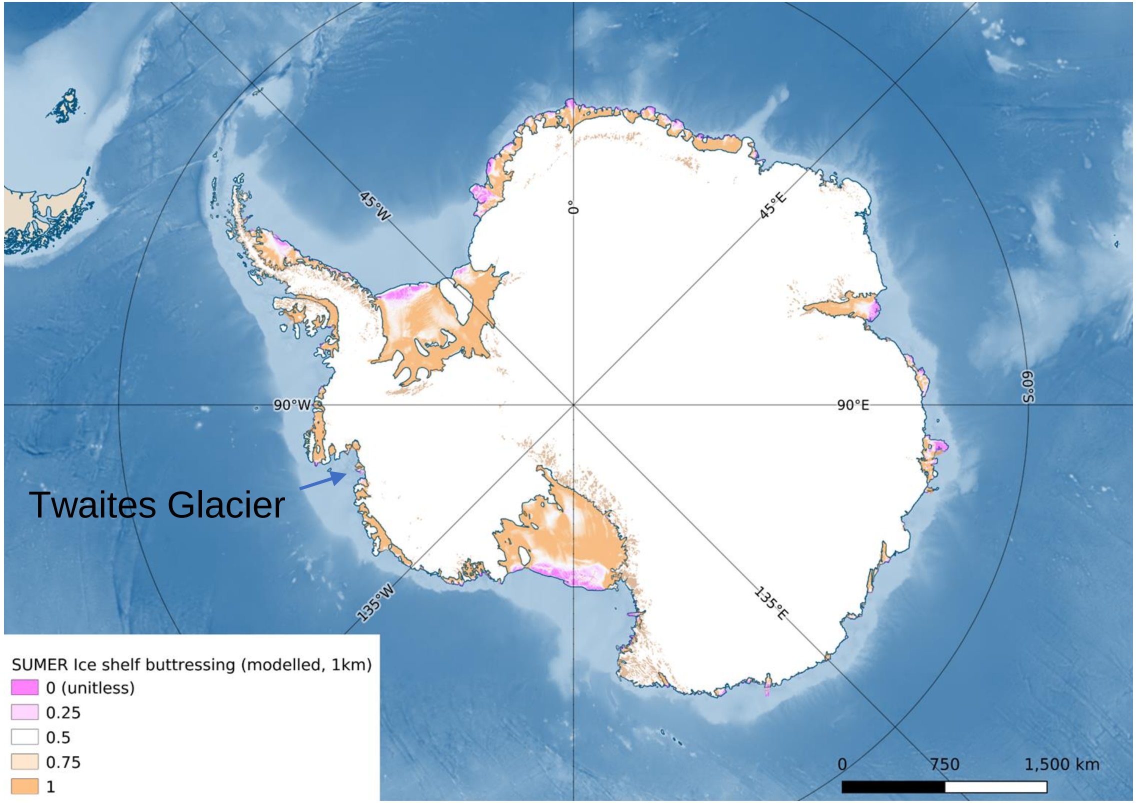
Year 2300:
“15 m cannot be ruled out with high emissions"

IPCC AR6 SPM





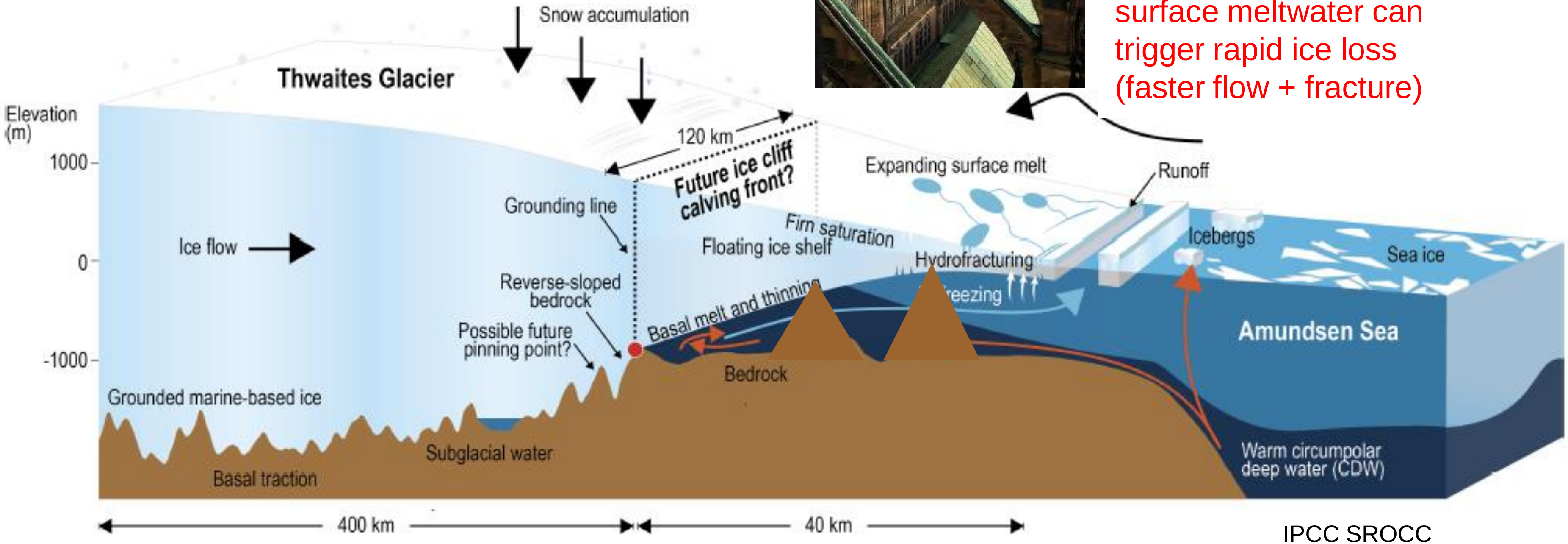
Buttressing ice shelves are Antarctica’s “safety band”



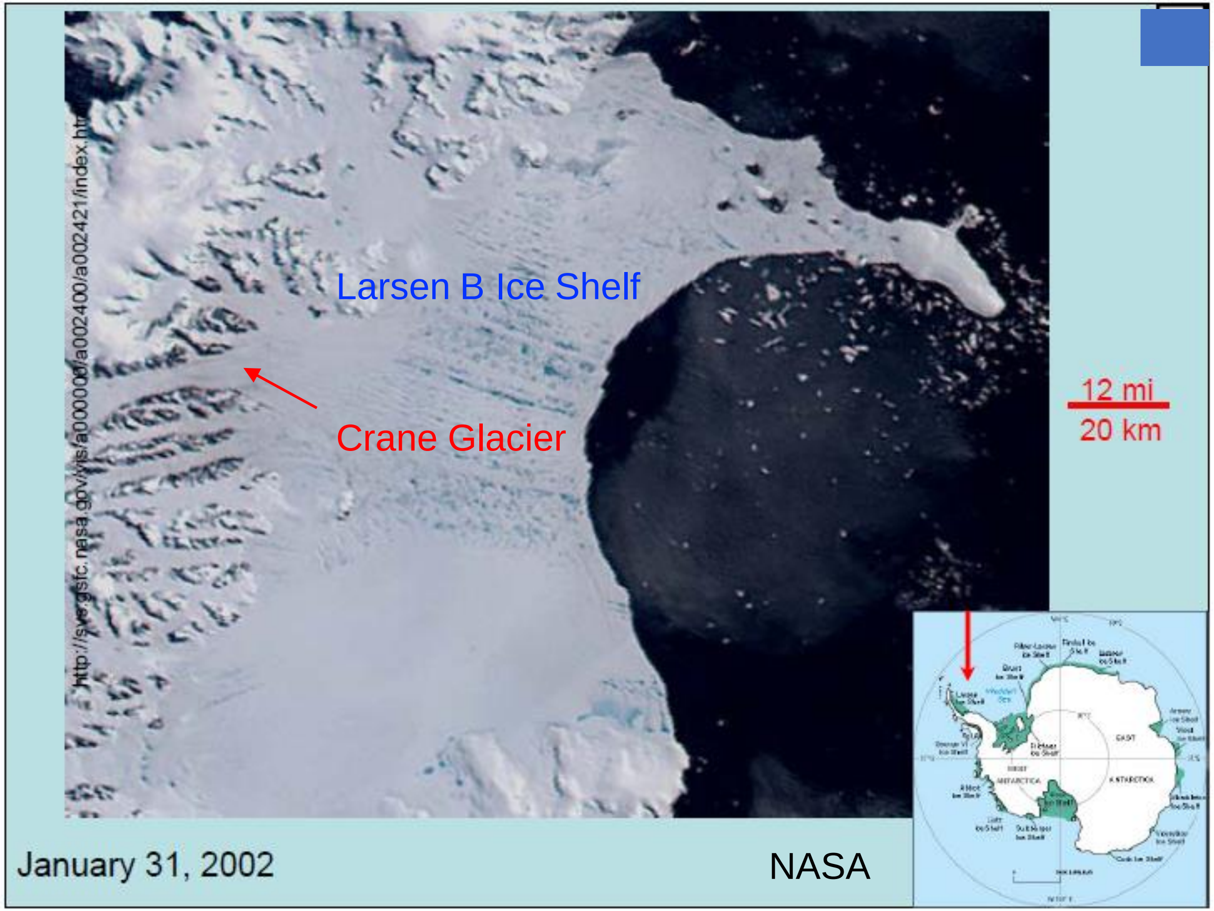
Credit Shaina Sadai, mapped from Fürst et al., 2016, made in QGIS

Buttressing by ice shelves slows seaward ice flow and provides structural support of the ice upstream.

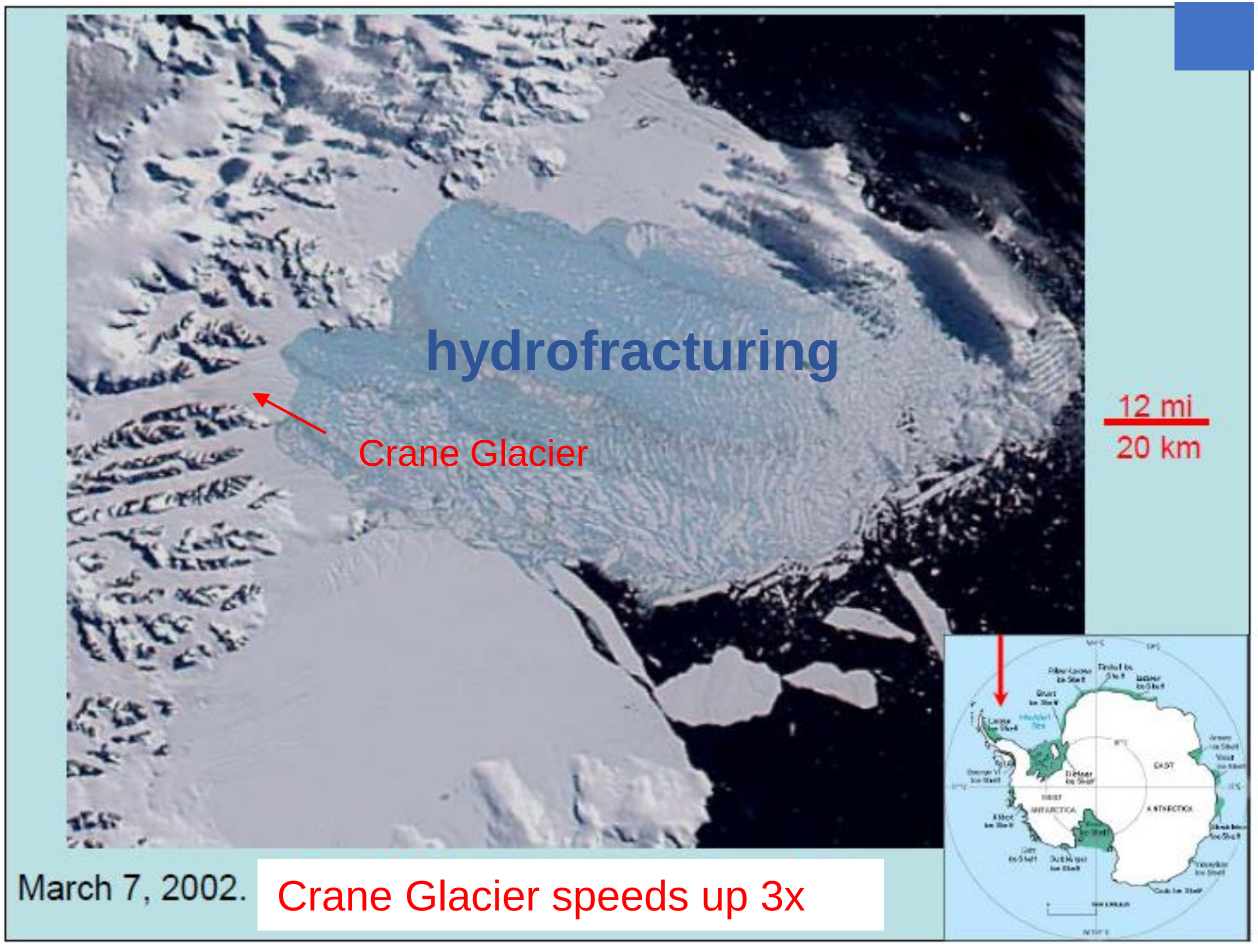
Future loss of ice shelves caused by surface meltwater can trigger rapid ice loss (faster flow + fracture)



IPCC SROCC



Larsen B Ice Shelf
Crane Glacier
12 mi
20 km
January 31, 2002
NASA


hydrofracturing
Crane Glacier
12 mi
20 km
March 7, 2002.
Crane Glacier speeds up 3x

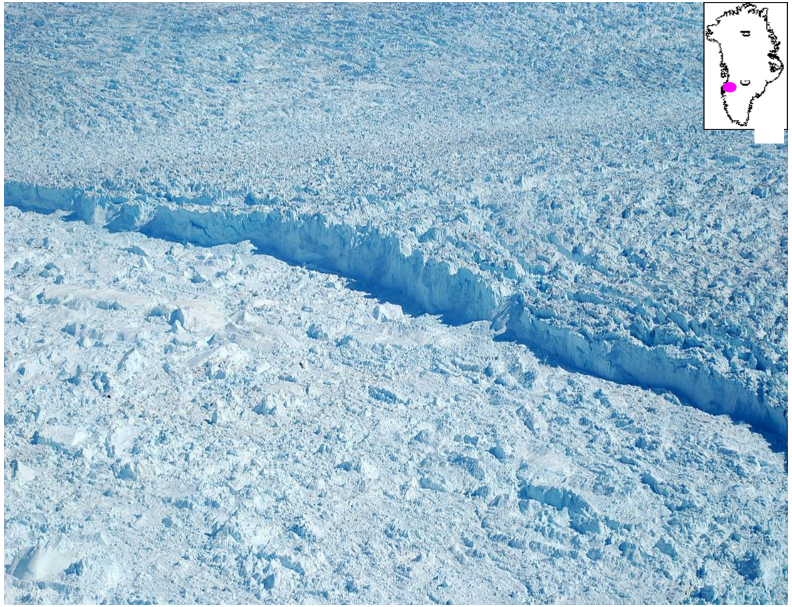
Source, Earth Observatory, NASA; Scambos et al., 2011

Helheim Glacier, SE Greenland

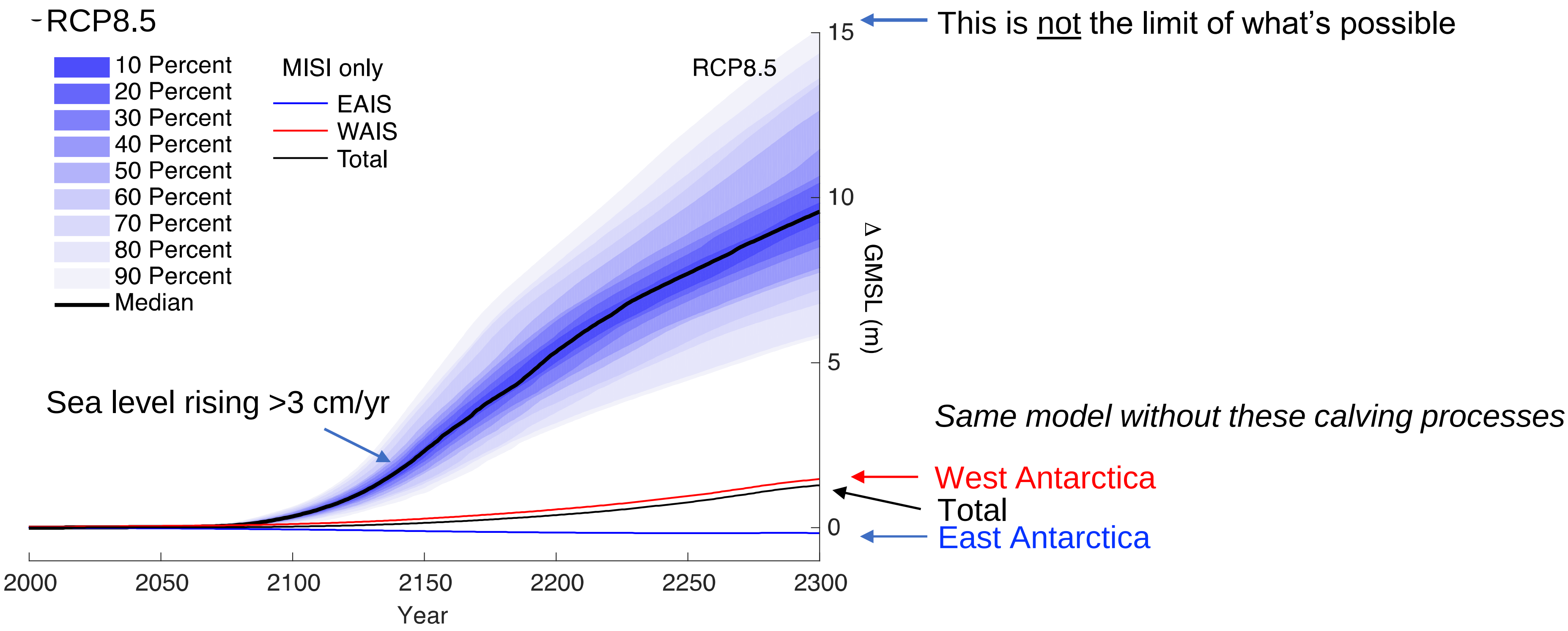
(Photo, Knut Christianson)

Jakobshavn, W Greenland

(http://michaelstudinger.smugmug.com)

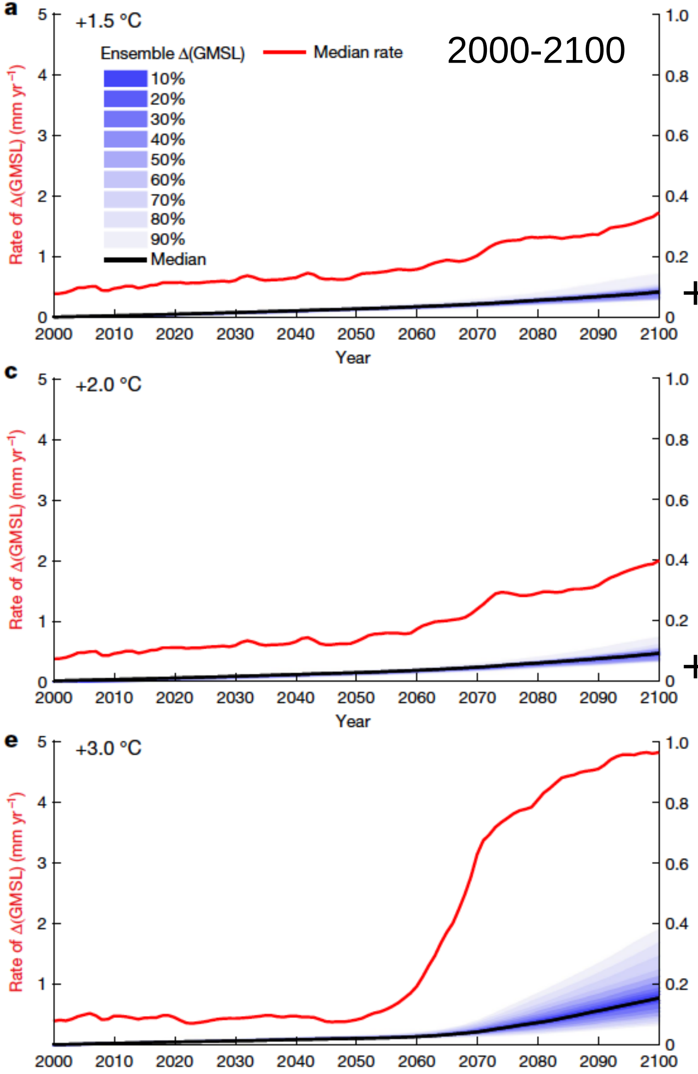


Ice-sheet instability processes continue to drive large uncertainty in long term Antarctic projections, especially under high emissions



DeConto et al., 2021, Nature

Antarctic contribution to sea level until 2100



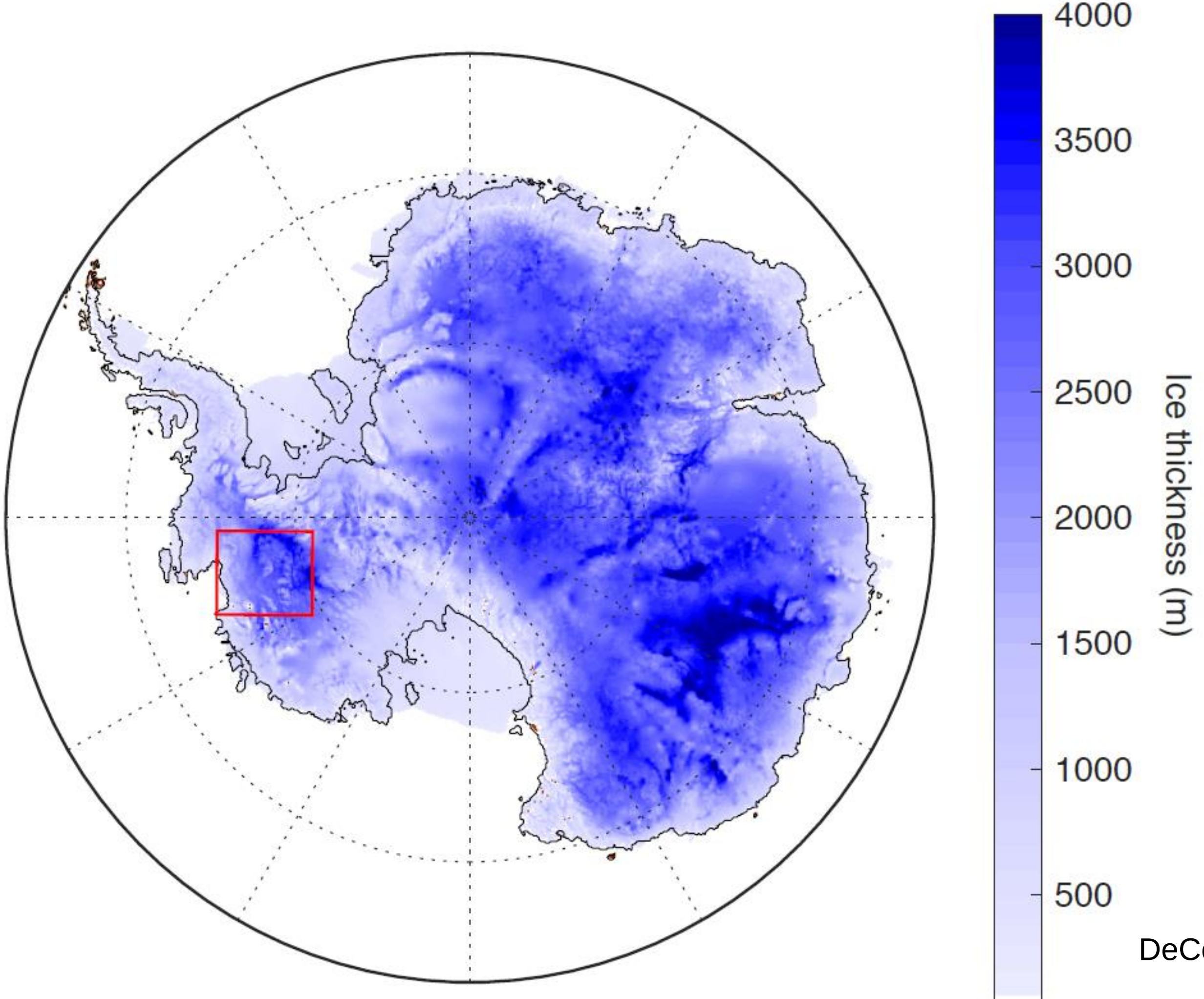
+ 1.5 ºC = 8 cm

+ 2.0 ºC = 9 cm

NDCs (+3 ºC) = 15 cm

DeConto et al., 2021

1950

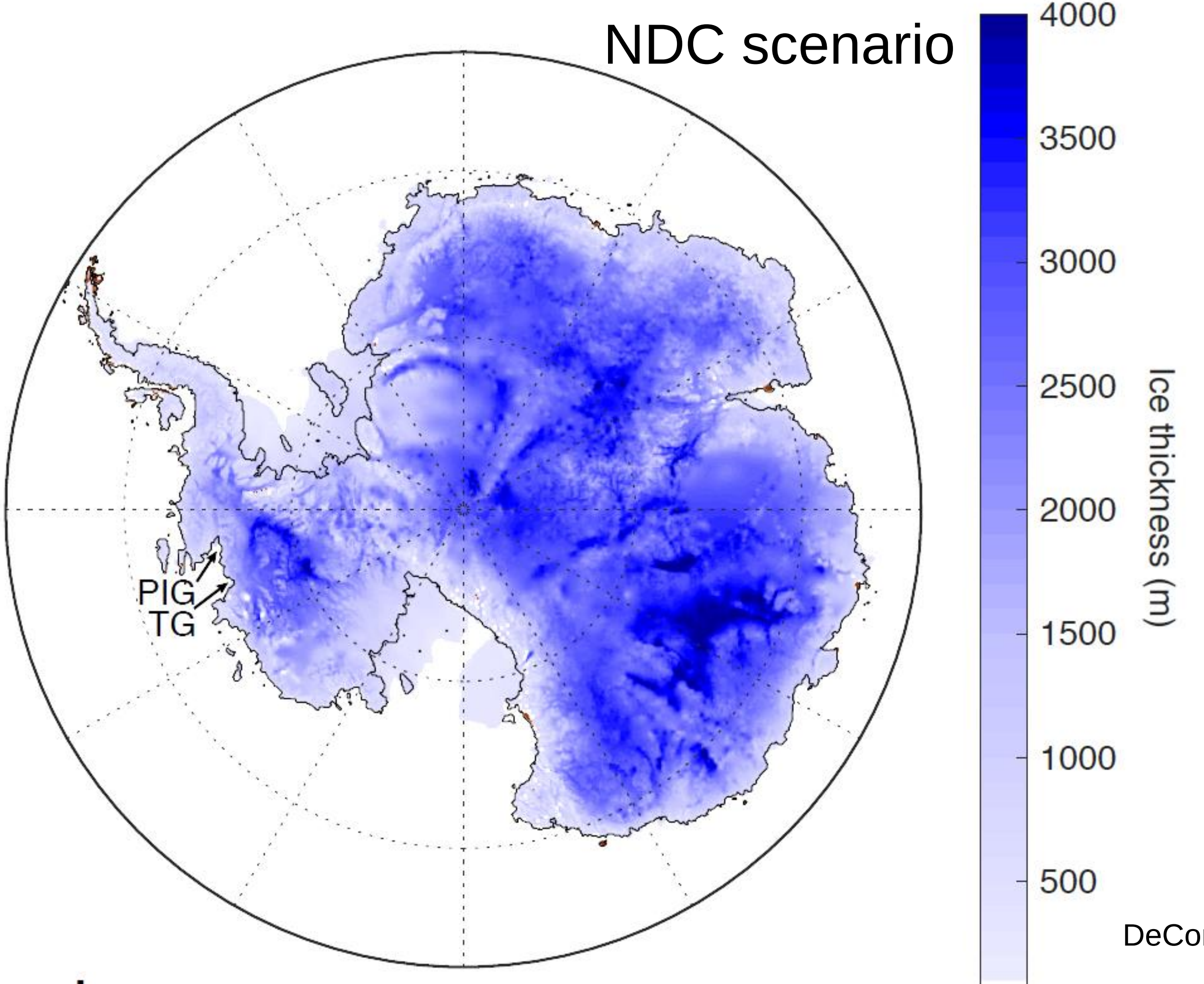


DeConto et al., 2021

2100

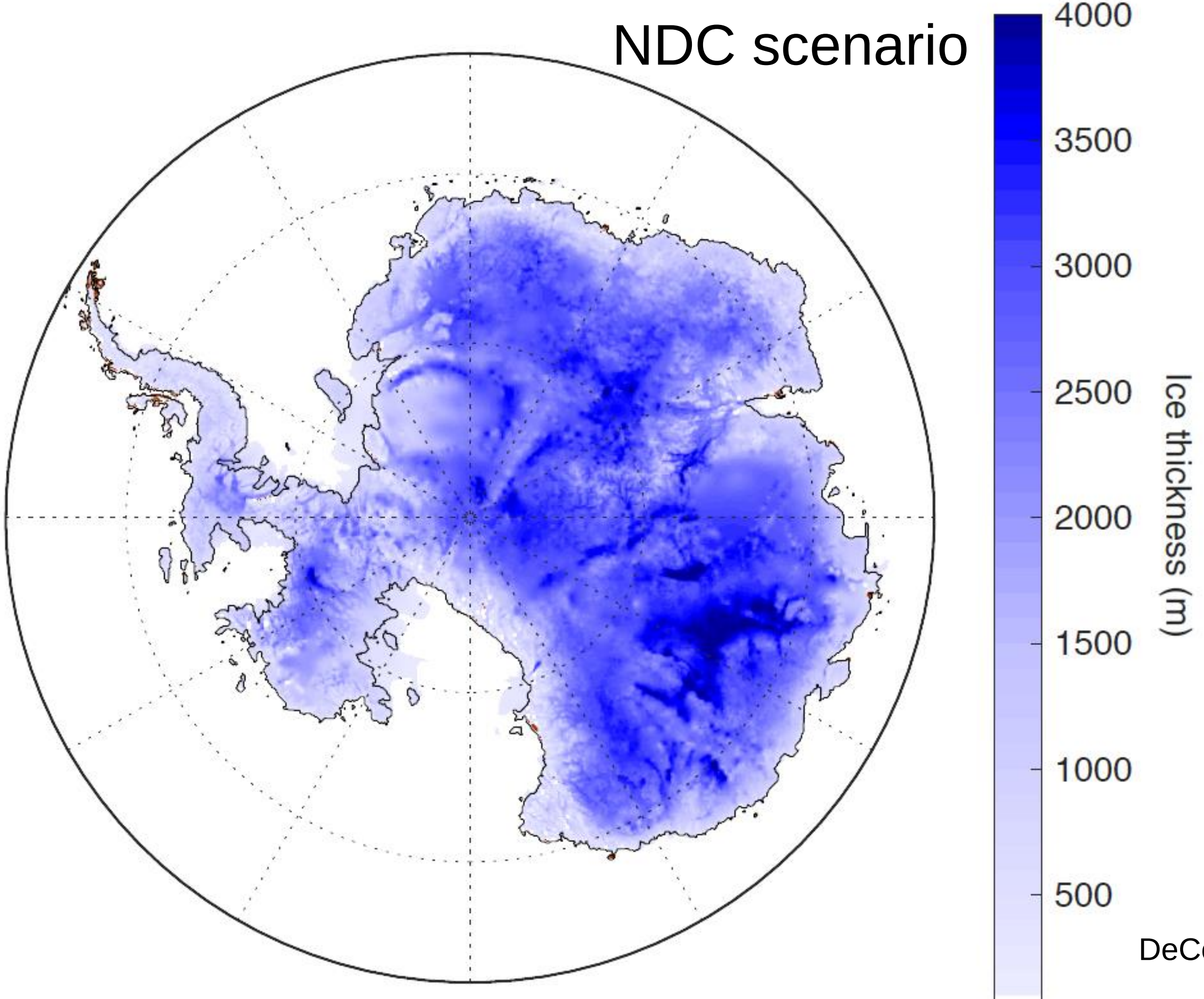
15 cm (8–27)

NDC scenario



DeConto et al., 2021

NDC scenario

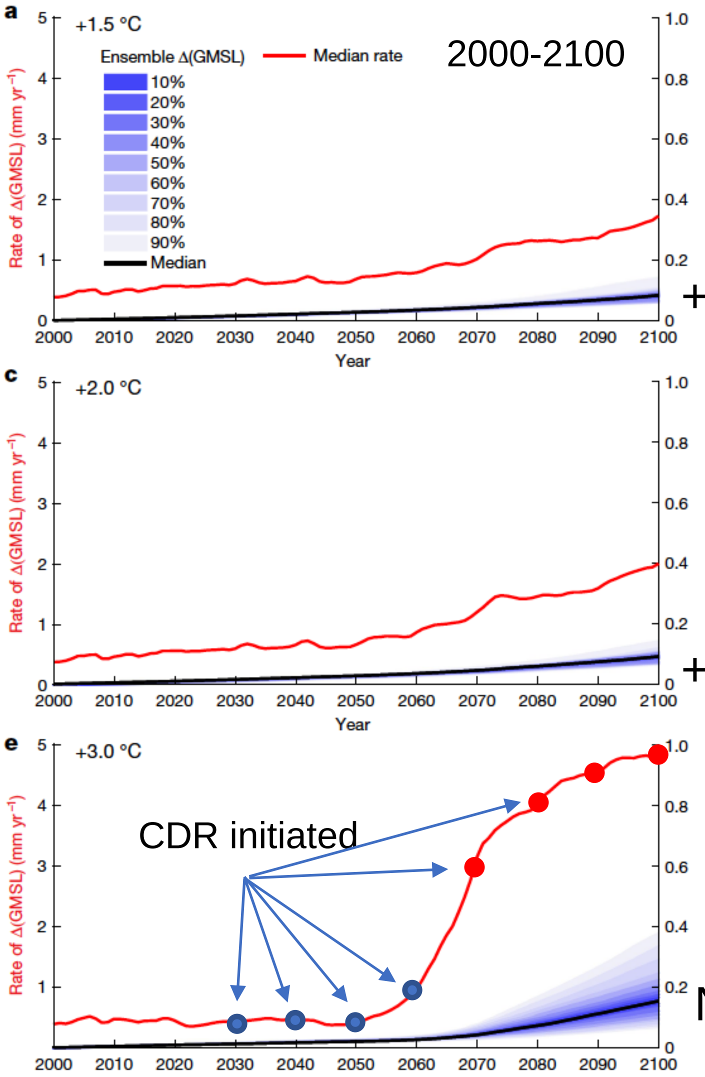


2300

154 cm (104–203)

DeConto et al., 2021

Can CDR stop Antarctic ice loss once initiated?



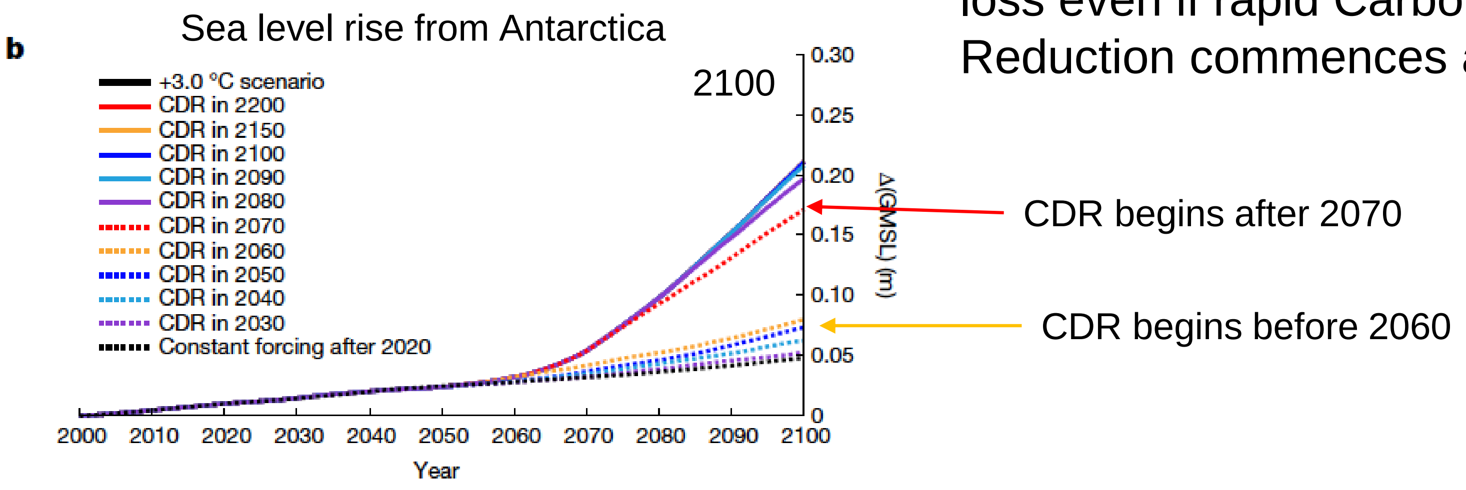
+ 1.5 ºC = 8 cm

+ 2.0 ºC = 9 cm

NDCs (+3 ºC) = 15 cm

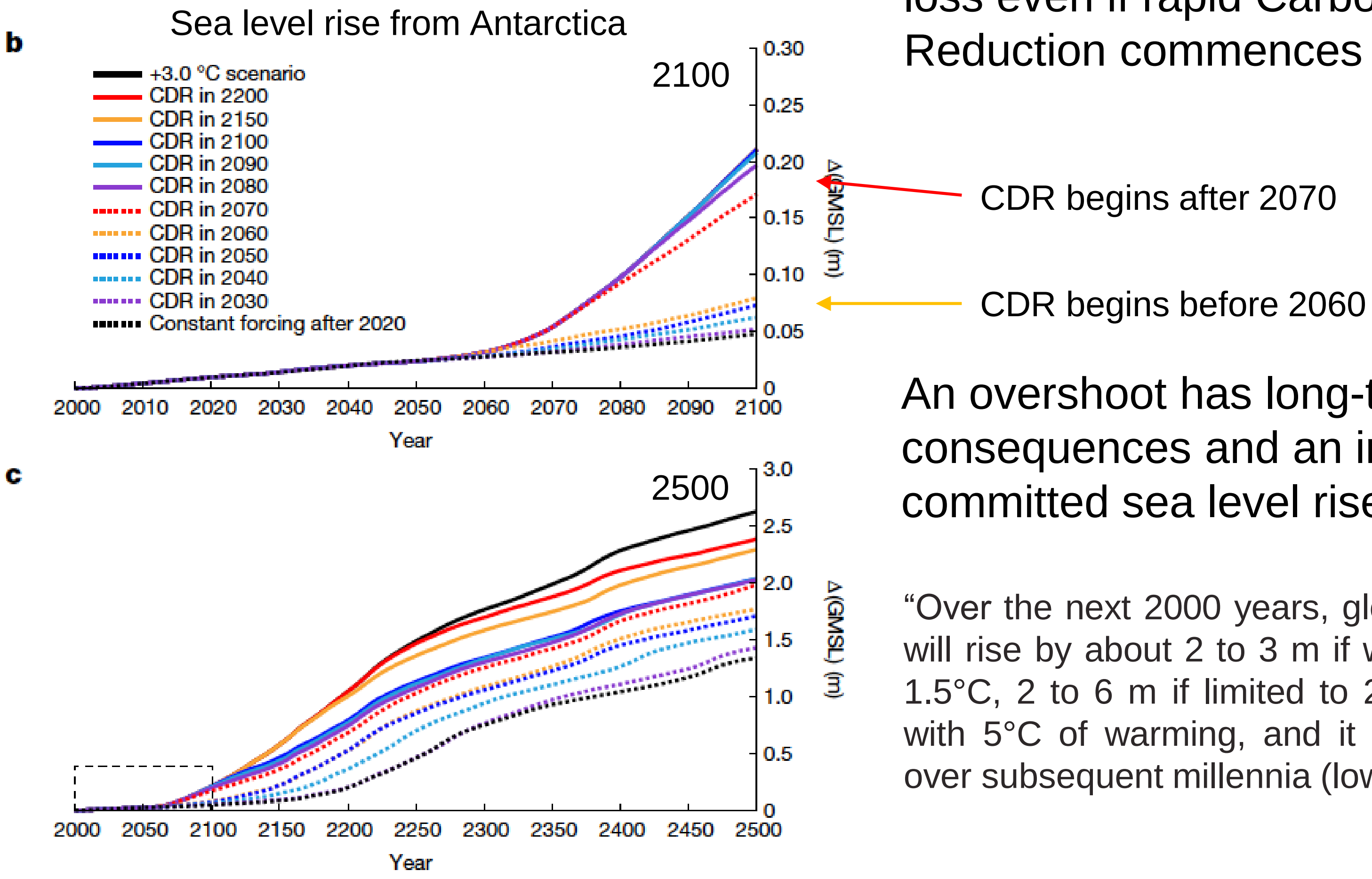
DeConto et al., 2021

Following the NDCs triggers rapid ice loss even if rapid Carbon Dioxide Reduction commences as soon as 2070



DeConto et al., 2021

Following the NDCs triggers rapid ice loss even if rapid Carbon Dioxide Reduction commences as soon as 2070

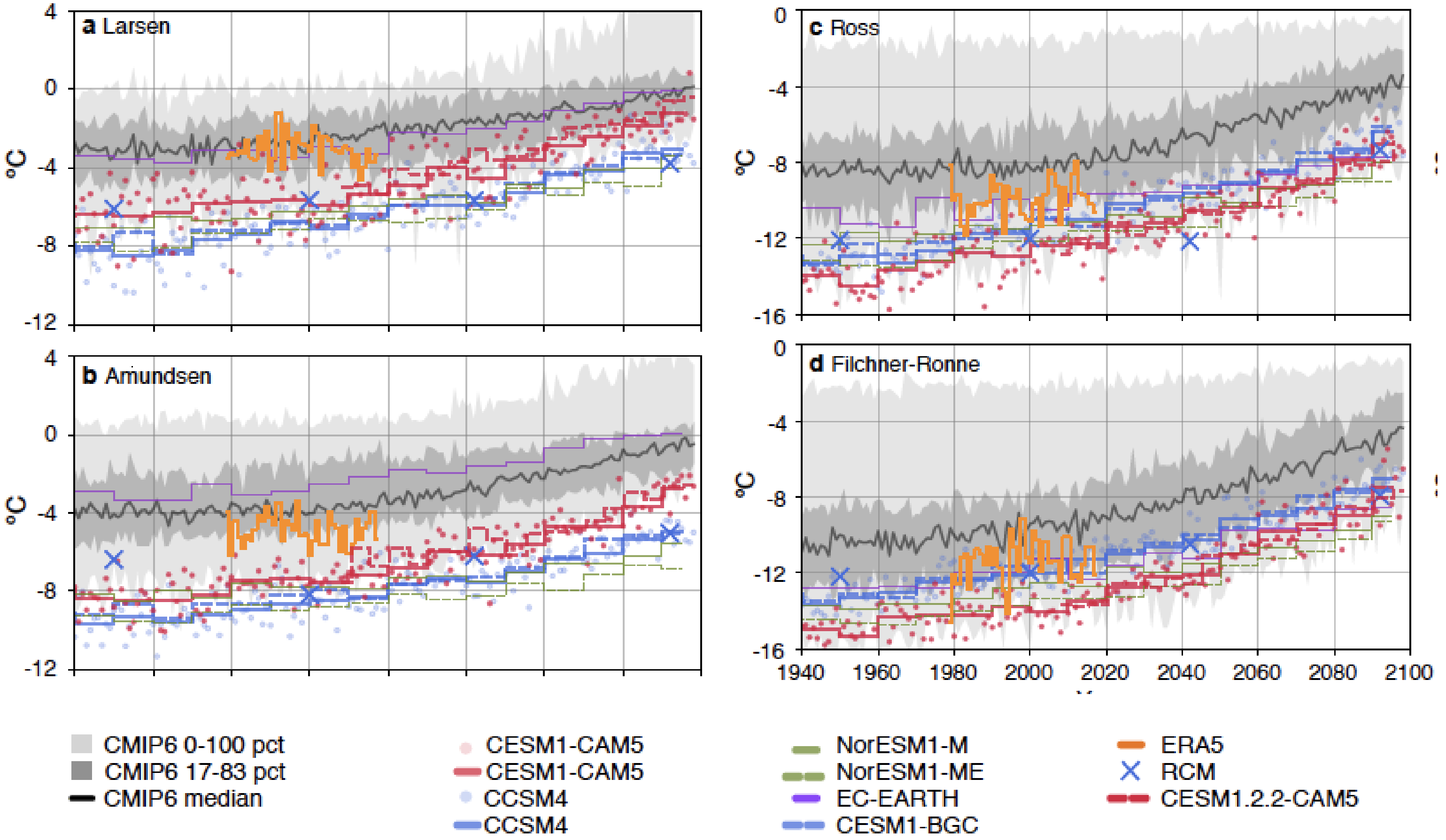


An overshoot has long-term consequences and an increase in committed sea level rise despite CDR

"Over the next 2000 years, global mean sea level will rise by about 2 to 3 m if warming is limited to 1.5°C, 2 to 6 m if limited to 2°C and 19 to 22 m with 5°C of warming, and it will continue to rise over subsequent millennia (low confidence)." AR6

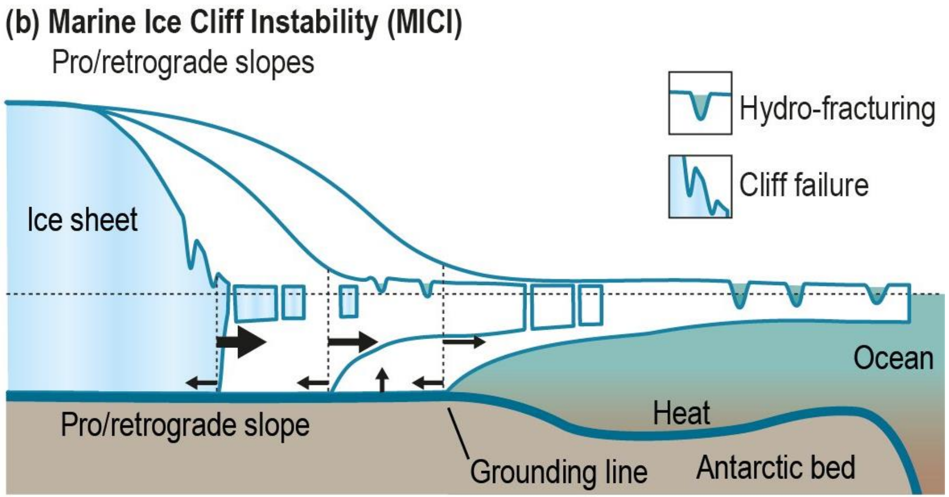
DeConto et al., 2021

RCP8.5/SSP5-85
DJF warming over key Ice shelves



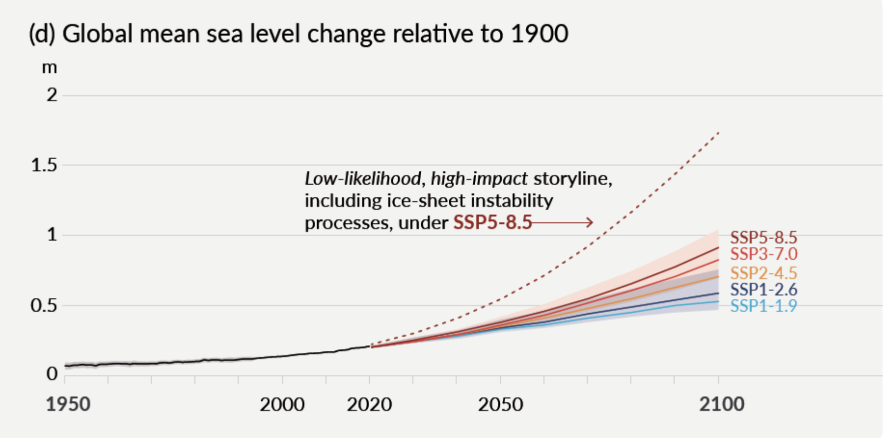
DeConto et al., 2021; Li et al., in review

Marine Ice Cliff Instability MICI



IPCC SROCC

“*Low confidence* is ascribed to projections incorporating MICI because there is *low confidence* in the current ability to quantify MICI”. IPCC AR6



IPCC AR6

PROCEEDINGS OF THE ROYAL SOCIETY A

Proc. R. Soc. A (2012) 468, 913–931
doi:10.1098/rspa.2011.0422
Published online 23 November 2011

Upper and lower limits on the stability of calving glaciers from the yield strength envelope of ice

By J. N. Bassis[1,2,*] and C. C. Walker[1]

“*Low confidence* is ascribed to projections incorporating MICI because there is *low confidence* in the current ability to quantify MICI”. IPCC AR6

Ice-cliff failure via retrogressive slumping

Byron R. Parizek[1,2*], Knut Christianson[3], Richard B. Alley[2], Denis Voytenko[4], Irena Vaňková[4], Timothy H. Dixon[5], Ryan T. Walker[6,7], and David M. Holland[4]

A simple stress-based cliff-calving law

Tanja Schlemm[1,2] and Anders Levermann[1,2,3]

[1]Potsdam Institute for Climate Impact Research, Potsdam, Germany
[2]Institute of Physics and Astronomy, University of Potsdam, Potsdam, Germany
[3]Lamont-Doherty Earth Observatory, Columbia University, New York, USA

ARTICLE

Check for updates

https://doi.org/10.1038/s41467-021-23070-7 OPEN

Marine ice-cliff instability modeling shows mixed-mode ice-cliff failure and yields calving rate parameterization

Anna J. Crawford[1✉], Douglas I. Benn[1], Joe Todd[2], Jan A. Åström[3], Jeremy N. Bassis[4] & Thomas Zwinger[3]

ICE SHEETS

Transition to marine ice cliff instability controlled by ice thickness gradients and velocity

J. N. Bassis[1*], B. Berg[1,2], A. J. Crawford[3], D. I. Benn[3]

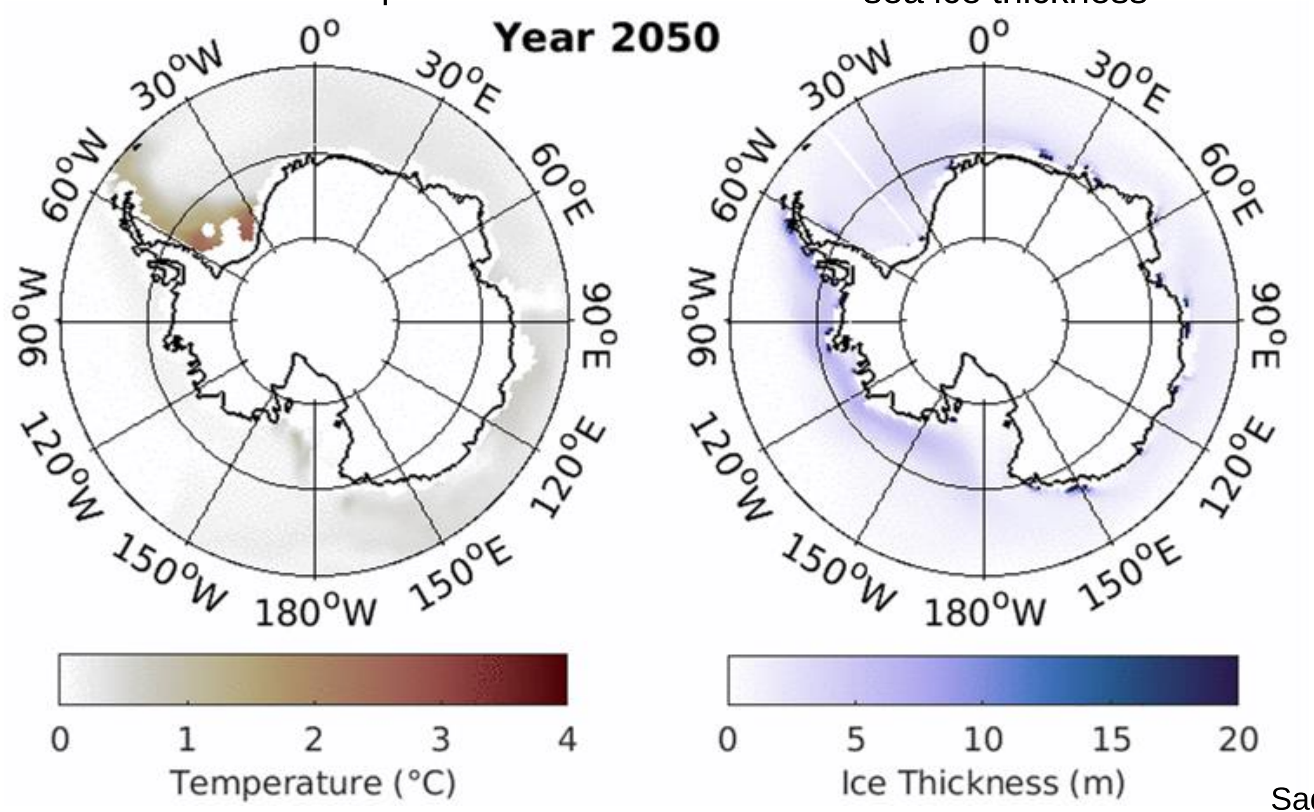
Portions of ice sheets grounded deep beneath sea level can disintegrate if tall ice cliffs at the ice-ocean boundary start to collapse under their own weight. This process, called marine ice cliff instability, could lead to catastrophic retreat of sections of West Antarctica on decadal-to-century time scales. Here we use a model that resolves flow and failure of ice to show that dynamic thinning can slow or stabilize cliff retreat, but when ice thickness increases rapidly upstream from the ice cliff, there is a transition to catastrophic collapse. However, even if vulnerable locations like Thwaites Glacier start to collapse, small resistive forces from sea-ice and calved debris can slow down or arrest retreat, reducing the potential for sustained ice sheet collapse.

NCAR CESM1 RCP8.5 with Antarctic meltwater input

RCP8.5
(high emissions)

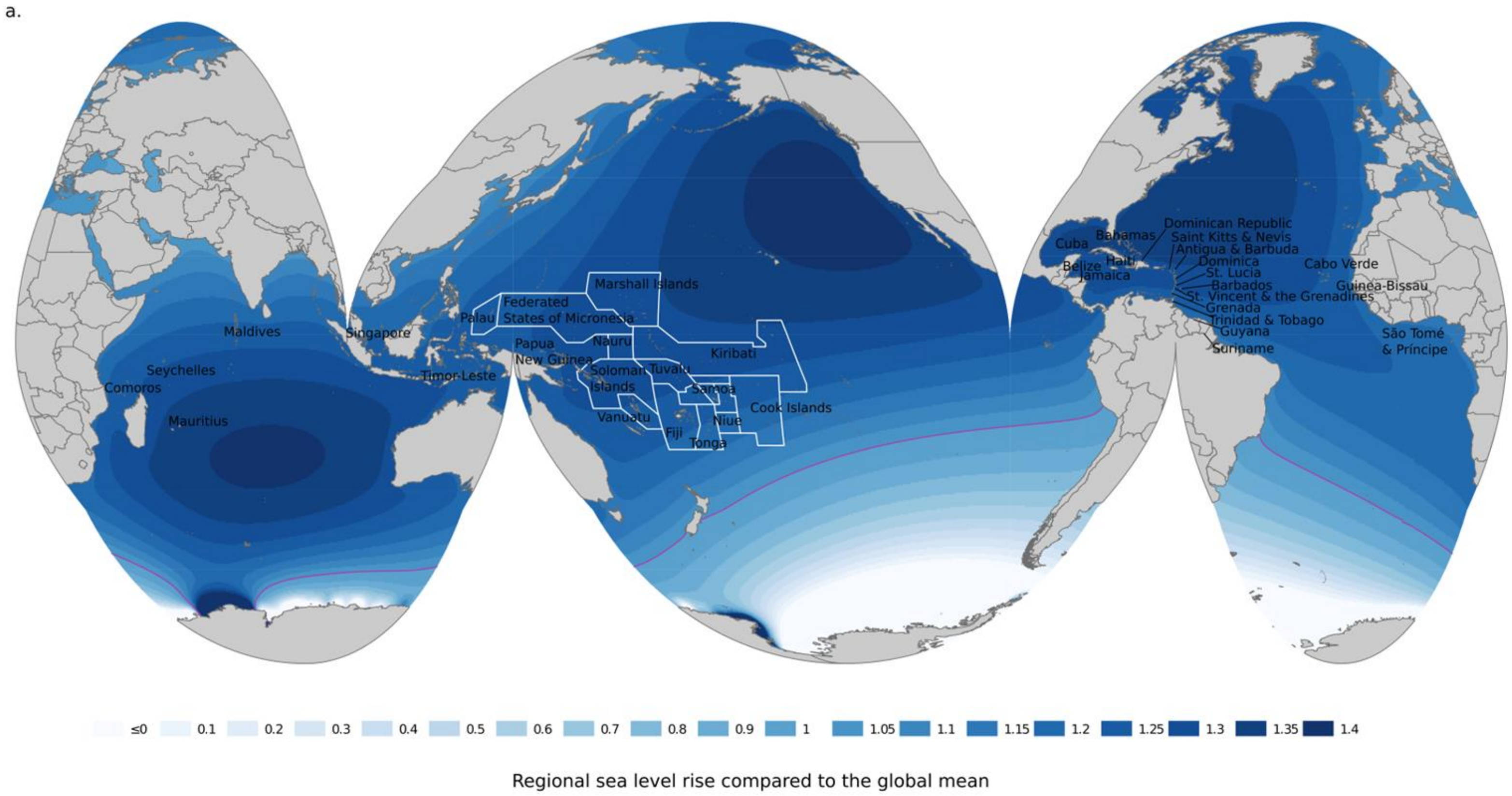
400 m ocean temperature

sea ice thickness



Sadai et al., 2020

Gravitational, rotational, dynamic sea level “fingerprint”

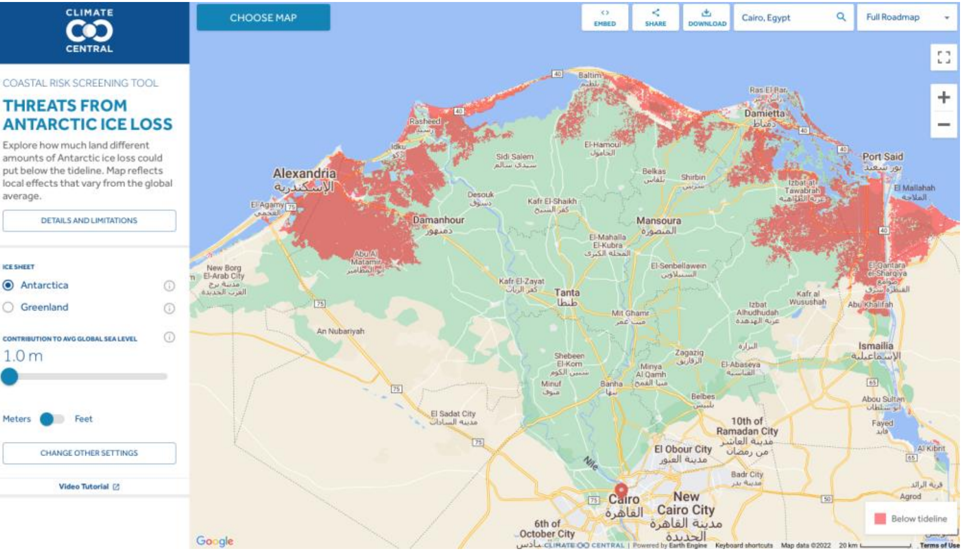


RCP4.5, no cliff collapse, 2100

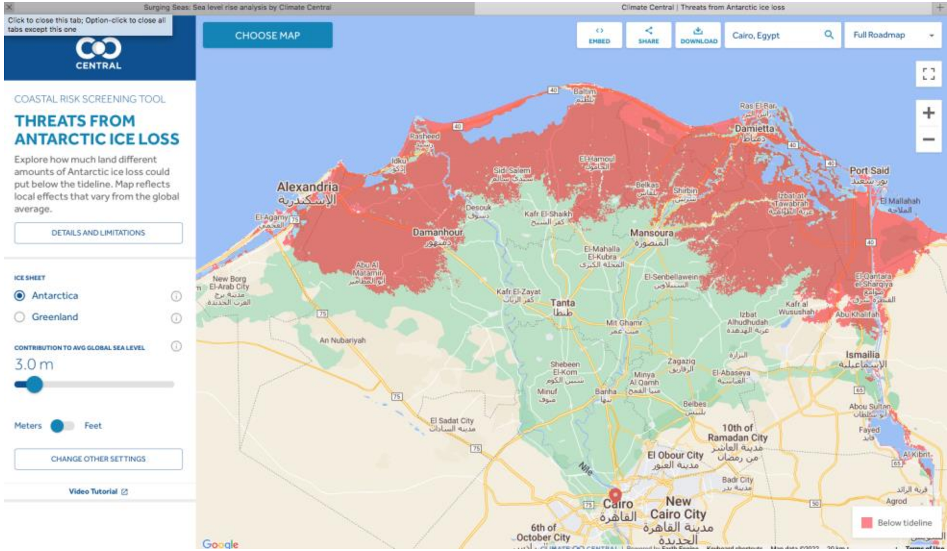
Fingerprint data: Dr. Natalya Gomez & Jeremy Roffman; Image: Sadai et al., in review

Nile Delta inundation from Antarctic-driven sea level

+1 m



+3 m



INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Key Characteristics and Multiple Roles of Carbon Dioxide Removal

Oliver Geden, Andy Reisinger, Jim Skea

14th Meeting of SBSTA Research Dialogue
Bonn, 9 June 2022

Definition of Carbon Dioxide Removal

Anthropogenic activities removing carbon dioxide (CO_2) from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products.

It includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and direct air carbon dioxide capture and storage (DACCS), but excludes natural CO_2 uptake not directly caused by human activities.

Summary for Policymakers

C.11 The deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO_2 or GHG emissions are to be achieved. The scale and timing of deployment will depend on the trajectories of gross emission reductions in different sectors. Upscaling the deployment of CDR depends on developing effective approaches to address feasibility and sustainability constraints especially at large scales. (*high confidence*)
{3.4, 7.4, 12.3, Cross-Chapter Box 8 in Chapter 12}

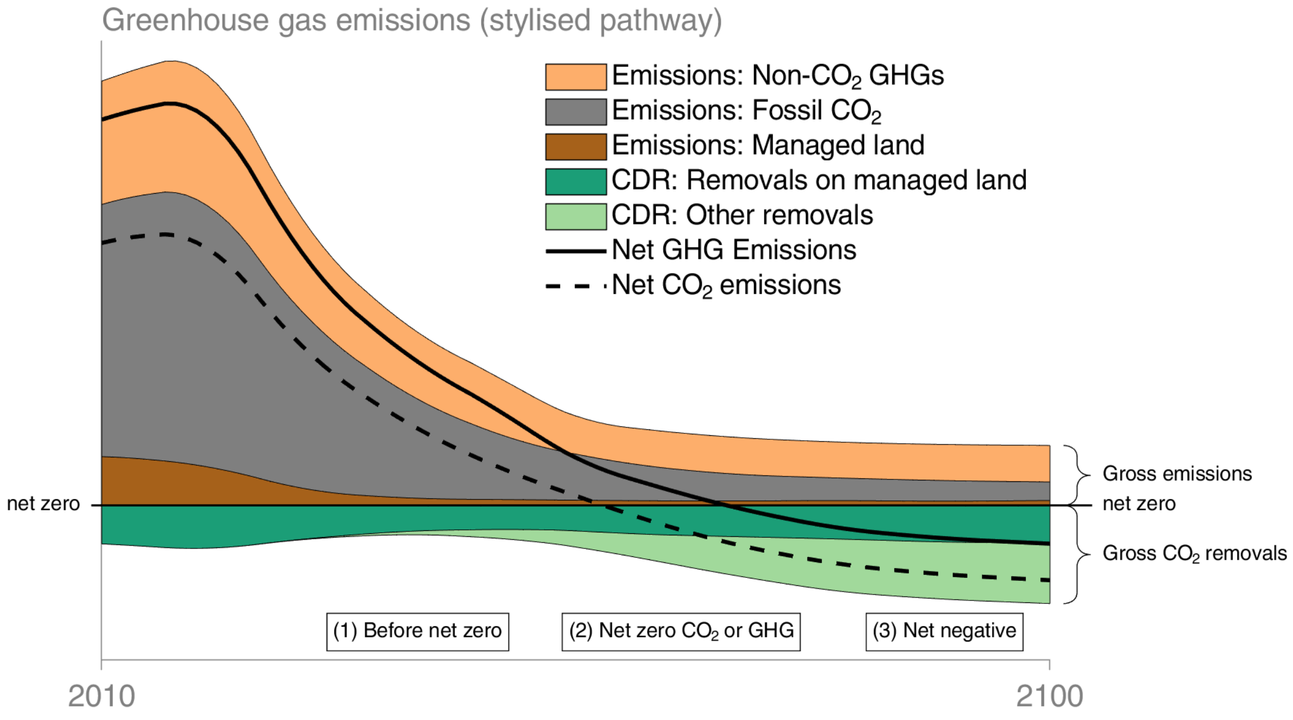
C.11.1 CDR refers to anthropogenic activities that remove CO_2 from the atmosphere and store it durably in geological, terrestrial, or ocean reservoirs, or in products. CDR methods vary in terms of their maturity, removal process, timescale of carbon storage, storage medium, mitigation potential, cost, co-benefits, impacts and risks, and governance requirements (*high confidence*). Specifically, maturity ranges from lower maturity (e.g., ocean alkalinisation) to higher maturity (e.g., reforestation); removal and storage potential ranges from lower potential (<1 Gt CO_2 yr^{-1}, e.g., blue carbon management) to higher potential (>3 Gt CO_2 yr^{-1}, e.g., agroforestry); costs range from lower cost (e.g., 45-100 USD/tCO_2 for soil carbon sequestration) to higher cost (e.g., 100-300 USD/tCO_2 for DACCS) (*medium confidence*). Estimated storage timescales vary from decades to centuries for methods that store carbon in vegetation and through soil carbon management, to ten thousand years or more for methods that store carbon in geological formations (*high confidence*). The processes by which CO_2 is removed from the atmosphere are categorised as biological, geochemical or chemical. Afforestation, reforestation, improved forest management, agroforestry and soil carbon sequestration are currently the only widely practiced CDR methods (*high confidence*). {7.4, 7.6, 12.3, Table 12.6, Table TS.7, Cross-Chapter Box 8 in Chapter 12, WG I 5.6}

C.11.2 The impacts, risks and co-benefits of CDR deployment for ecosystems, biodiversity and people will be highly variable depending on the method, site-specific context, implementation and scale (*high confidence*). Reforestation, improved forest management, soil carbon sequestration, peatland restoration and blue carbon management are examples of methods that can enhance biodiversity and ecosystem functions, employment and local livelihoods, depending on context (*high confidence*). In contrast, afforestation or production of biomass crops for BECCS or biochar, when poorly implemented, can have adverse socio-economic and environmental impacts, including on biodiversity, food and water security, local livelihoods and on the rights of Indigenous Peoples, especially if implemented at large scales and where land tenure is insecure (*high confidence*). Ocean fertilisation, if implemented, could lead to nutrient redistribution, restructuring of ecosystems, enhanced oxygen consumption and acidification in deeper waters (*medium confidence*). {7.4, 7.6, 12.3, 12.5}

C.11.3 The removal and storage of CO_2 through vegetation and soil management can be reversed by human or natural disturbances; it is also prone to climate change impacts. In comparison, CO_2 stored in geological and ocean reservoirs (via BECCS, DACCS, ocean alkalinisation) and as carbon in biochar is less prone to reversal. (*high confidence*) {6.4, 7.4, 12.3}

C11.4 In addition to deep, rapid, and sustained emission reductions CDR can fulfil three different complementary roles globally or at country level: lowering net CO_2 or net GHG emissions in the near-term; counterbalancing 'hard-to-abate' residual emissions (e.g., emissions from agriculture, aviation, shipping, industrial processes) in order to help reach net zero CO_2 or net zero GHG emissions in the mid-term; achieving net negative CO_2 or GHG emissions in the long-term if deployed at levels exceeding annual residual emissions (*high confidence*) {3.3, 7.4, 11.3, 12.3, Cross-Chapter Box 8 in Chapter 12}

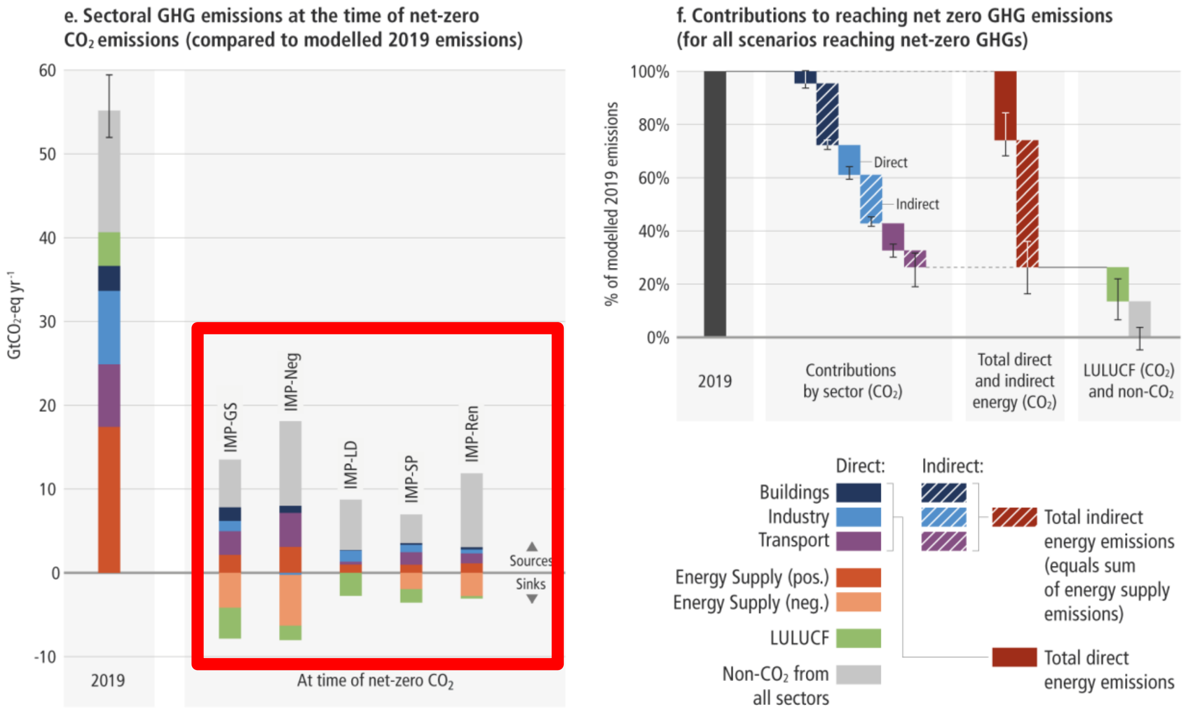
C.11.5 Rapid emission reductions in all sectors interact with future scale of deployment of CDR methods, and their associated risks, impacts and co-benefits. Upscaling the deployment of CDR methods depends on developing effective approaches to address sustainability and feasibility constraints, potential impacts, co-benefits and risks. Enablers of CDR include accelerated research, development and demonstration, improved tools for risk assessment and management, targeted incentives and development of agreed methods for measurement, reporting and verification of carbon flows. (*high confidence*) {3.4, 7.6, 12.3}



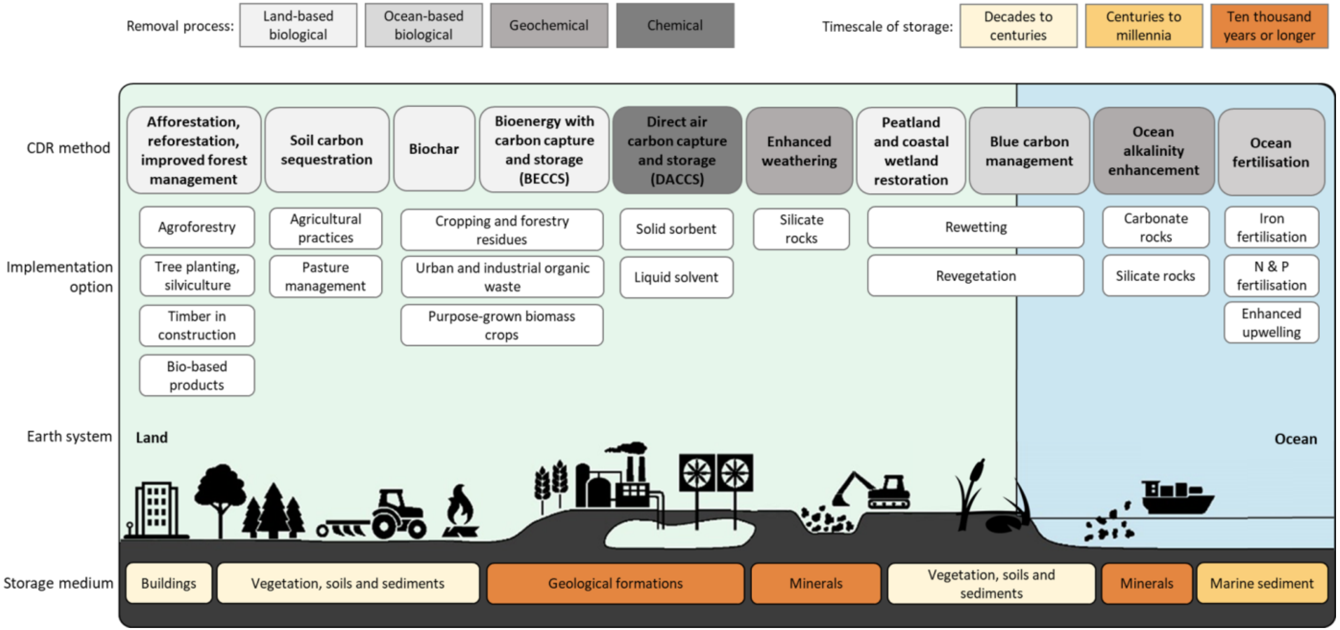
CHAPTER 12, CROSS-CHAPTER BOX 8, FIGURE 2

- Global and national mitigation pathways share basic components
- 3 complementary roles of CDR in ambitious mitigation parthways
- Net-zero GHG reached later than net-zero CO_2 emissions

Net zero CO_2 and net zero GHG emissionsare possible through different modelled mitigation pathways.



Summary for Policymakers, Figure SPM.5



- Taxonomy of methods based on AR6 WG I, highlighting *removal process & timescale of storage*
- Often several implementation options per CDR method
- Vulnerability to reversal as main concern for carbon stored in vegetation, soils and sediments
- CCS and CCU can be part of CDR methods, with durable storage of CO_2 from biomass or ambient air

CHAPTER 12, CROSS-CHAPTER BOX 8, FIGURE 1

Table 12.6 Summary of status, costs, potentials, risk and impacts, co-benefits, trade-offs and spill over effects and the role in mitigation pathways for CDR methods. TRL = Technology Readiness Level. Author judgement ranges (assessed by authors in the literature) are shown, with full literature ranges shown in brackets

CDR option	Status (TRL)	Cost (USD tCO₂⁻¹)	Mitigation Potential (GtCO₂ yr⁻¹)	Risk & Impacts	Co-benefits	Trade-offs and spill over effects	Role in modelled mitigation pathways	Section
DACCS	6	100–300 (84–386)	5–40	Increased energy and water use.	Water produced (solid sorbent DAC designs only).	Potentially increased emissions from water supply and energy	In a few IAMs; DACCS complements	{12.3.1.1}
Enhanced weathering	3–4	5((2						
Ocean alkalinity enhancement	1–2	4(						
Ocean fertilisation	1–2	5(						

Afforestation/Reforestation	8–9	0–240	0.5–10	Reversal of carbon removal through wildfire, disease, pests may occur. Reduced catchment water yield and lower groundwater level if species and biome are inappropriate.	Enhanced employment and local livelihoods, improved biodiversity, improved renewable wood products provision, soil carbon and nutrient cycling. Possibly less pressure on primary forest.	Inappropriate deployment at large scale can lead to competition for land with biodiversity conservation and food production.	Substantial contribution in IAMs and also in bottom-up sectoral studies.	Chapter 7, Section 7.4
Biochar	6–7	10–345						
Soil Carbon Sequestration in croplands and grasslands	8–9	45–100						
Peatland and coastal wetland restoration	8–9	Insuffici data						

				removed, risks of unintended side effects.		utilization in other regions, fundamental alteration of food webs, biodiversity		
Blue carbon management in coastal wetlands	2–3	Insufficient data, estimates range from ~100 to ~10000	<1	If degraded or lost, coastal blue carbon ecosystems are likely to release most of their carbon back to the atmosphere; potential for sediment contaminants, toxicity, bioaccumulation and biomagnification in organisms; issues related to altering degradability of coastal plants; use of subtidal areas for tidal wetland carbon removal; effect of shoreline	Provide many non-climatic benefits and can contribute to ecosystem-based adaptation, coastal protection, increased biodiversity, reduced upper ocean acidification; could potentially benefit human nutrition or produce fertiliser for terrestrial agriculture, anti-methanogenic feed additive, or as an	If degraded or lost, coastal blue carbon ecosystems are likely to release most of their carbon back to the atmosphere. The full delivery of the benefits at their maximum global capacity will require years to decades to be achieved	Not incorporated in IAMs, but in some bottom-up studies: small contribution.	{12.3.1.3}, Chapter 7, Section 7.4
BECCS	5–6	15–4(						

Agroforestry	8–9	Insufficient data	0.3–9.4	Risk that some land area lost from food production; requires high skills.	Enhanced employment and local livelihoods, variety of products improved soil quality, more resilient systems.	Some trade-off with agricultural crop production, but enhanced biodiversity, and resilience of system.	No data from IAMs, but in bottom-up sectoral studies with medium contribution.	Chapter 7, Section 7.4
Improved Forest management	8–9	Insufficient data	0.1–2.1	If improved management is understood as merely intensification involving increased fertiliser use and introduced species, then it could reduce biodiversity and increase eutrophication.	In case of sustainable forest management, it leads to enhanced employment and local livelihoods, enhanced biodiversity, improved productivity.	If it involves increased fertiliser use and introduced species it could reduce biodiversity and increase eutrophication and upstream GHG emissions.	No data from IAMs, but in bottom-up sectoral studies with medium contribution.	Chapter 7, Section 7.4

Chapter 12, Table 12.6

Research needs & knowledge gaps

Fundamentals

- Definition of *durability*
- Monitoring, reporting and verification of carbon flows

Characteristics of Methods & Pathways

- Effectiveness of methods (*costs & potentials*)
- Risks & co-benefits, incl. scale
- Residual emissions vs. CDR

Governance & Policy

- Feasibility & sustainability constraints, risks & co-benefits
- Certification & accounting
- Targeted incentives

Role of Carbon Dioxide Removal Technologies in Climate Change

SBSTA Research Dialogue

9th June 2022

By

Naif Alqahtani

Climate Change

- Long-term rise in temperatures and weather patterns.
- Natural, such as through variations in the solar cycle.
- Human activities have been the main driver of climate change.

Picture source: [Effects | Facts – Climate Change: Vital Signs of the Planet (nasa.gov)]

Climate Change

- Policy and economic shifts, R&D, and upscaling the technologies needed to meet the goals.
- Eliminate emissions and removing carbon is essential.
- CDR is very important to solve the climate crisis.

Picture source: Supporting Climate and Clean Energy Solutions - CZI News (chanzuckerberg.com)

What is CDR?

- Carbon dioxide removal (CDR) refers to all activities that remove CO_2 from the atmosphere and store it for long periods of time.
- It is also known as negative carbon emission.

Natural	Technological
Afforestation, reforestation, and forestry management	Direct air capture
Biochar	Enhanced mineralization
Biosequestration/ and other Land use	Carbon sequestration
Agricultural practices / soil sequestration	Bioenergy with carbon capture & storage
Wetland restoration / Mangrove planting	

What is CDR?

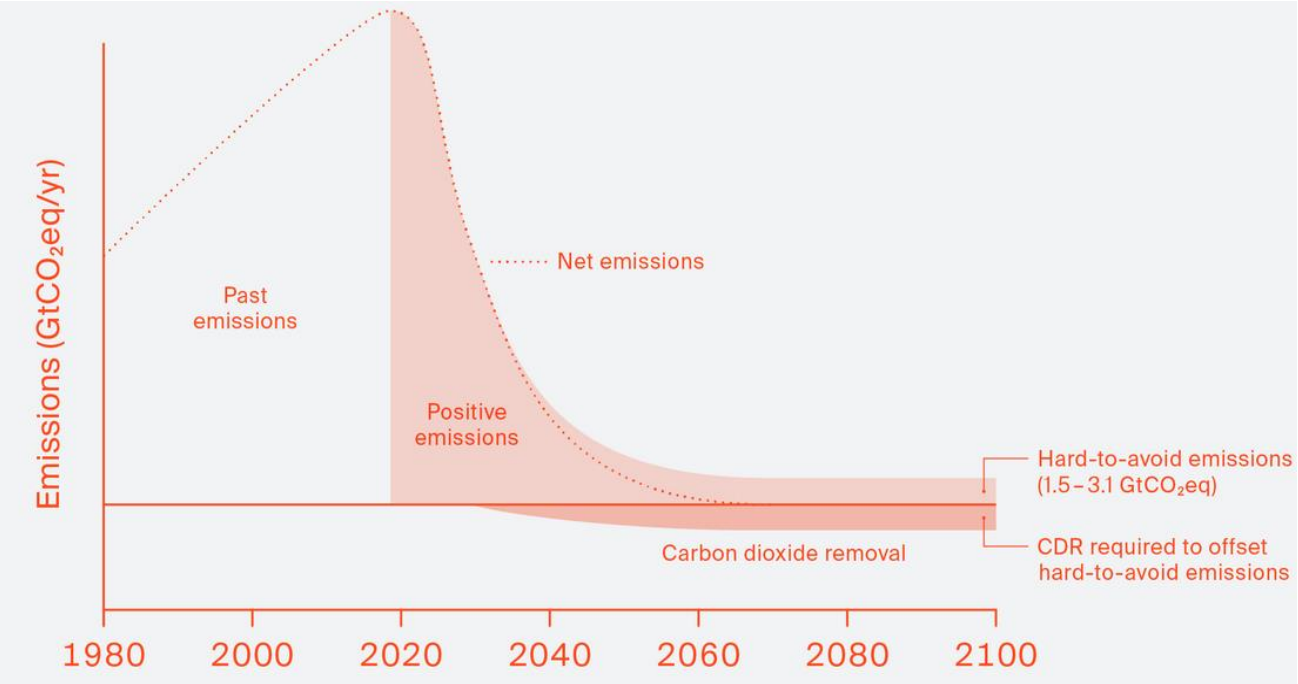


Figure Source: CDR Primer. J. Wilcox, B. Kolosz, & J. Freeman, 2021 (Carbon Dioxide Removal Primer (cdrprimer.org))

CDR Technologies

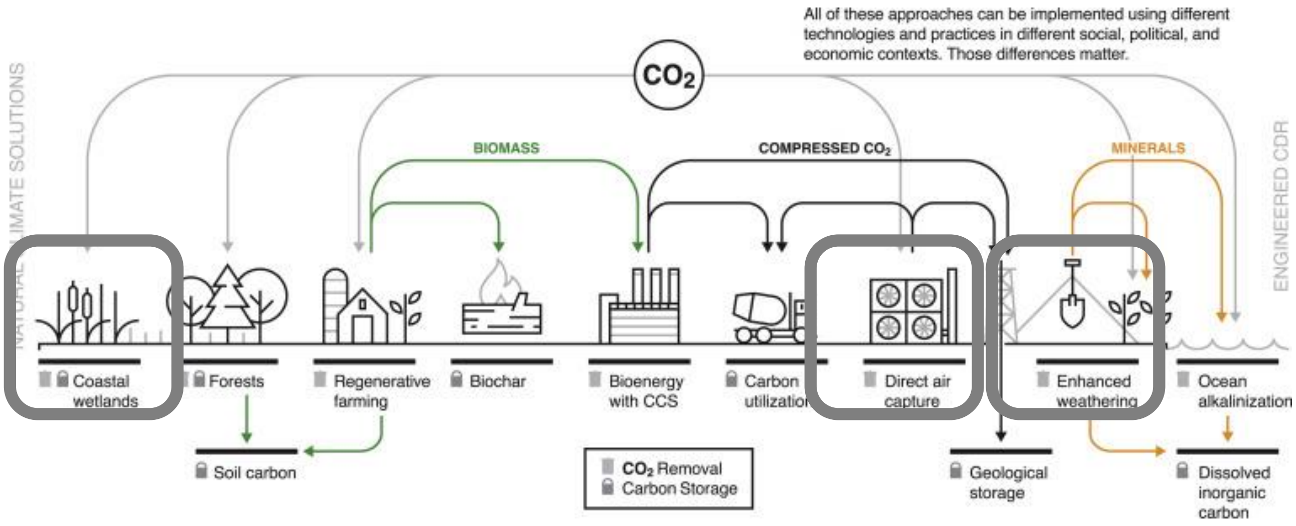


Figure Source: [Principles for Thinking about Carbon Dioxide Removal in Just Climate Policy (cell.com)]

Mangrove planting

- Wetland restoration / Mangrove planting.
- Absorb more carbon.
- Tolerance to saline water.
- Saudi Green Initiative.
- By 2030, plant 100 million mangrove trees

Mangrove Forest in Jazan, Saudi Arabia

Direct Air Capture (DAC)

- DAC technologies extract CO_2 directly from the atmosphere.
- The CO_2 can be permanently stored in deep geological formations (thereby achieving negative emissions or carbon removal).
- Current DAC capacity 9,000 tCO_2 per year.

Picture Source: [Direct air capture sucks carbon right out of the skies | WIRED UK]

Enhanced Mineralization

- Accelerating the natural CO_2 reaction process with minerals.
- Potential scale up to capture 2 – 4 $GtCO_2$ /yr by 2050.

Picture Source: [CO2 Mineralization: A Carbon Storage Technology for a Sustainable Future | Frontiers Research Topic (frontiersin.org)]


THANK YOU
THANK YOU
THANK YOU

IPCC AR6 Report on Impacts, Adaptation and Vulnerability

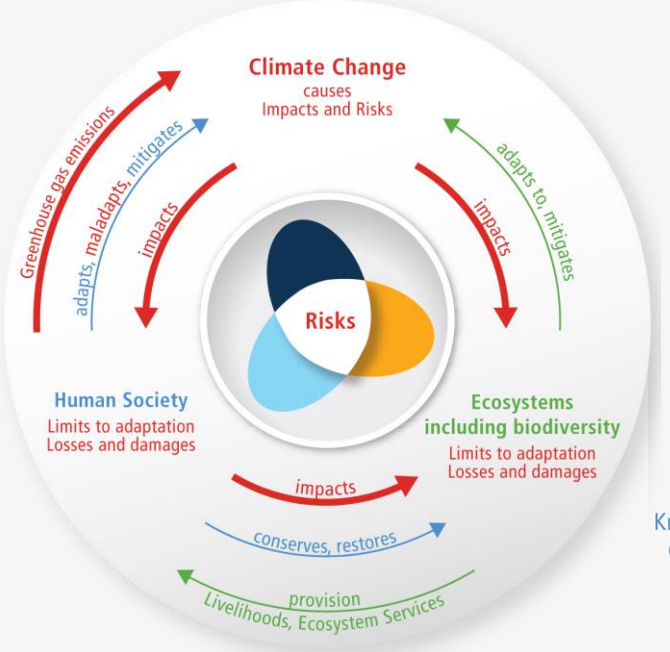
Research Requirements

….while taking urgent climate action

Hans-O. Pörtner, Co-Chair IPCC Working Group II, WG II authors and TSU

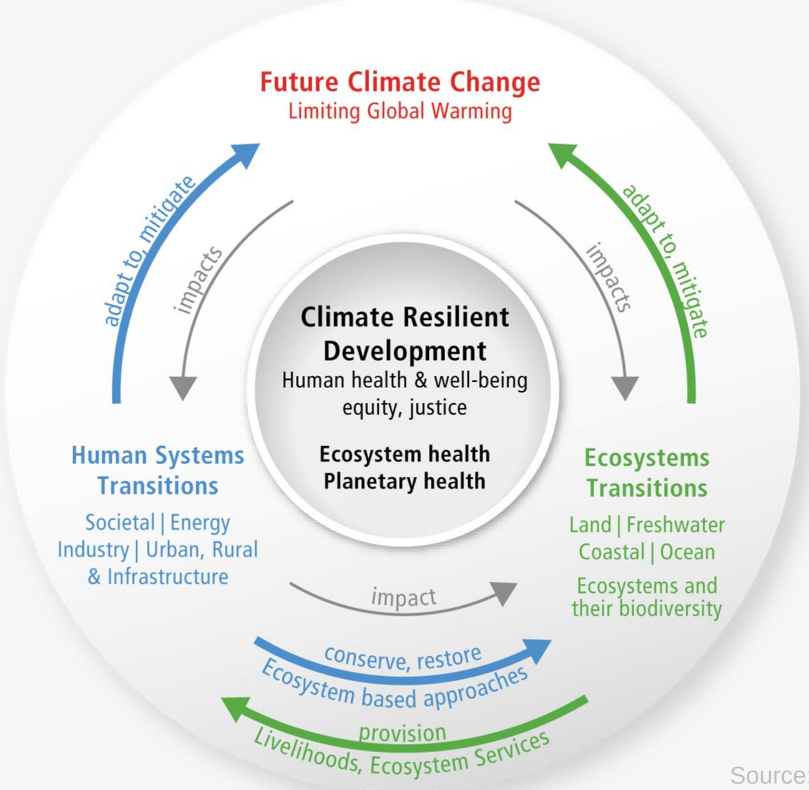


Current imbalance … …a sustainable future?



From urgent to timely action

Governance
Finance
Knowledge and capacity
Catalysing conditions
Technologies

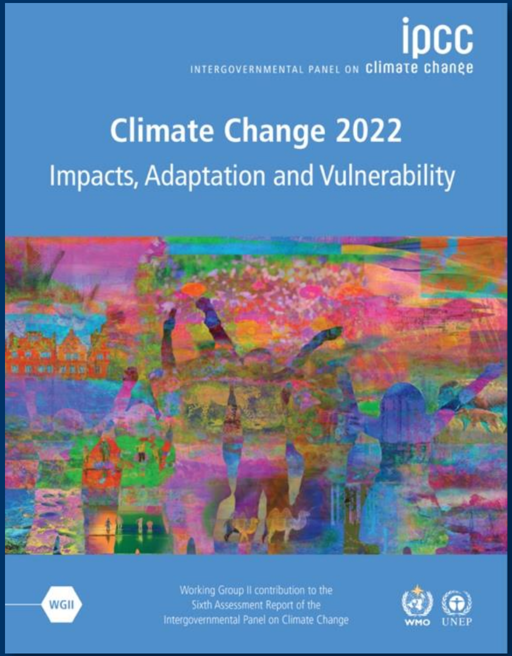


The risk propeller shows that risk emerges from the overlap of:

Climate hazard(s) | Vulnerability | Exposure

...of human systems, ecosystems and their biodiversity

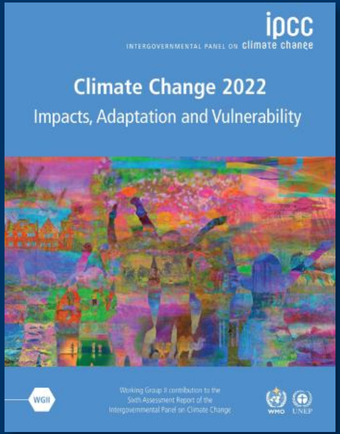
Source:
IPCC WGII AR6
SPM Figure 1



Improved system understanding, quantifications

We do not know enough about (mechanisms, cause and effect, **warming levels**) concerning…

- The **vulnerability** of species, biodiversity, ecosystems, humans, societies at regional scale, the when and why of biological and societal tipping points (ecosystems)
- **Scope for and Limits to adaptation** (evolutionary adaptation vs. human action, mechanisms constraining biodiversity and ecosystem services)

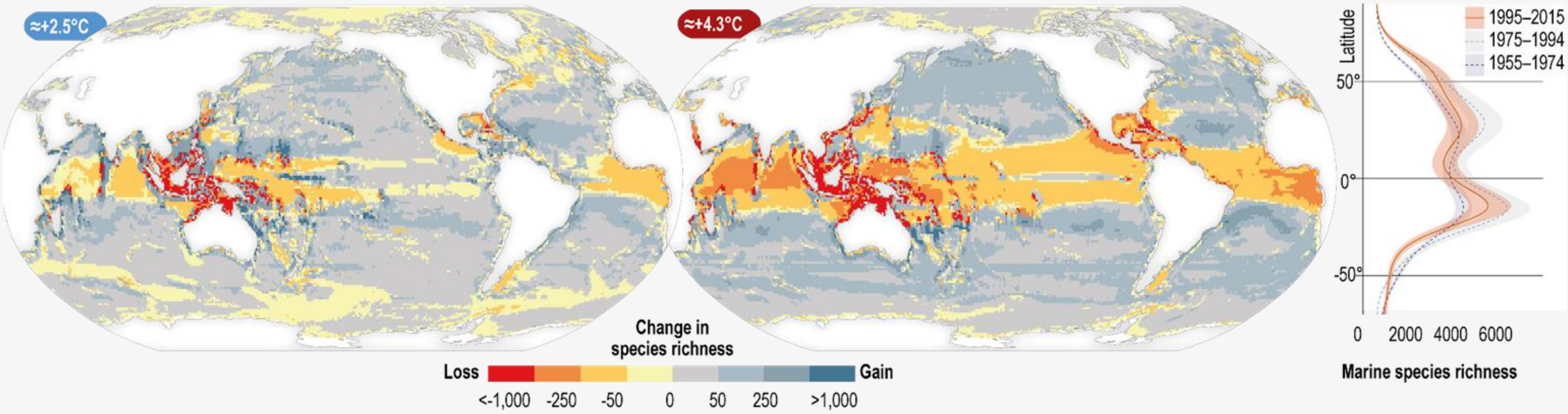


e.g. quantified societal and ecosystems risks, adaptation and (hard) limits:

- Interactions between heat stress, human thermal performance and levels of societal functioning
- The vulnerability of human society at regional scale
- Environmental (in relation to social) criteria for human well-being and health …
- Environmental criteria for ecosystem health and biodiversity ? … matching human health criteria?
- Integrating human, ecosystem and planetary health

e.g., Heat induced habitat change and loss

Mechanism-based understanding is insufficient how temperature underpins biodiversity distribution and defines species habitat and ecosystem functioning, considering species composition, adaptation capacities and limits

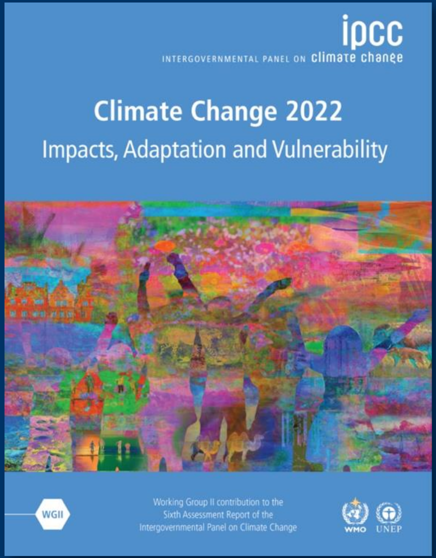


By analogy, similar or related mechanisms govern loss of mammalian / human / lifestock habitat and societal performance.

e.g. Quantified societal consequences

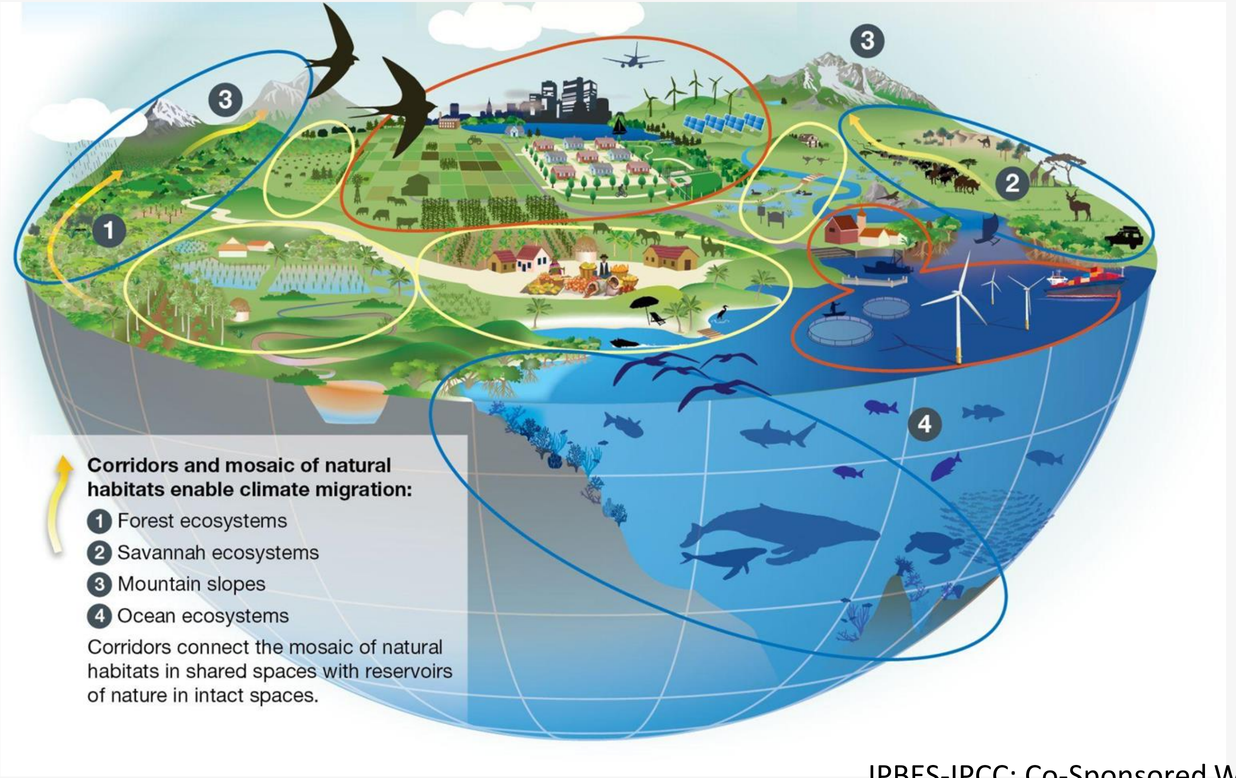
- Regional vulnerability due to overlapping challenges, effects of compound risks?
- To what extent are adaptation capacity and limits improved/shifted upward by poverty reduction, equity, justice and resource distributions?
- Integration of different knowledge systems towards Climate Resilient Development?
- How to avoid maladaption?

Implementing adaptation across systems, e.g. through spatial planning



- How to optimize the strengthening of the biosphere and human resilience together?
- Understanding the spatial needs of species and ecosystems for self-sustaining biodiversity, species compositions, ecosystem services
- Developing and implementing spatial planning of mosaic 'scapes for freshwater / marine / terrestrial and urban systems
- Optimized neighbouring of protected, shared and heavily used spaces with species migration corridors

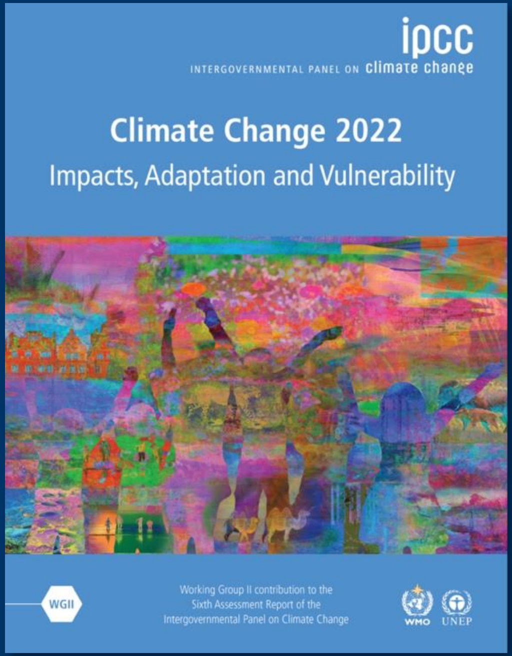
Integrating conservation, climate and societal actions for Climate Resilient Development



Quantifying effective and specific uses and conservation needs:

Setting up mosaic land-, sea- and freshwater-scapes: Effective and equitable conservation and restoration of approximately 30-50% of land, freshwater and ocean ecosystems can help ensure a healthy planet

Further quantified approaches

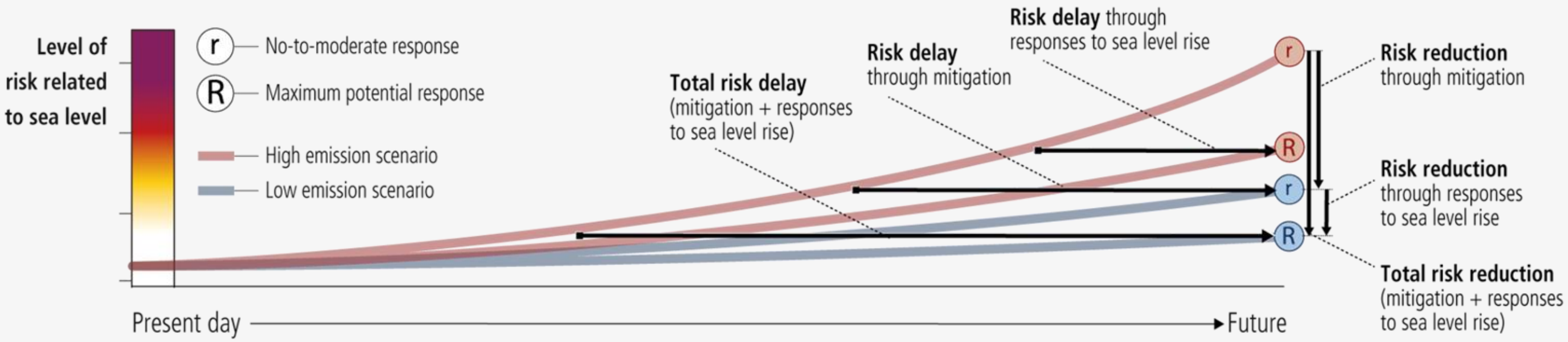


We do not know enough about

- The trajectory of risk over time for different scenarios
- Evaluation of adaptation and mitigation effectiveness using proper metrics for risk reduction
- Compound risks and adaptation challenges
- Societal implications, costs, barriers and tipping points

Risk and adaptation trajectories under sea level rise and in response to mitigation

- Schematic illustration of risk reduction and the delay of a given risk level through responses to sea level rise and/or mitigation. = **beyond a static approach**
- The amount of risk reduction and delay depends on sea level and response scenarios and varies between contexts and localities.



IPCC SROCC: SPM Figure 5b

ipcc

Climate change combines with unsustainable use of natural resources, habitat destruction, growing urbanization and inequity

… enhancing risks, reducing the capacity to adapt…

How and how much?

Youssef Abdelwahab / Unsplash

Overall:

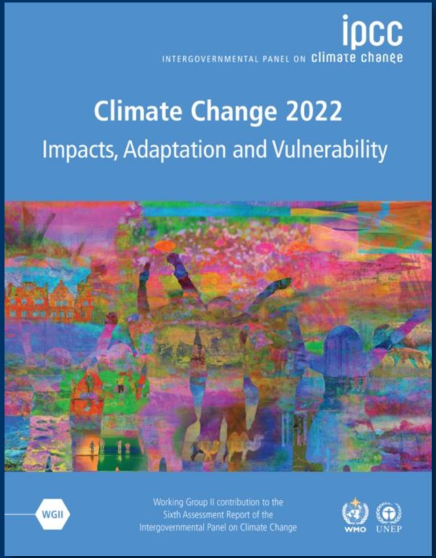
- Using a common language and metric to measure adaptation success within Climate Resilient Development:

  - e.g. risk levels and reduction following IPCC risk assessments?

- Do we have a uniform Common Goal on Adaptation considering equity and justice?:

  - e.g. keeping risk levels at moderate levels or below across regions and sectors?

  - e.g. indicators of Climate Resilient Development?

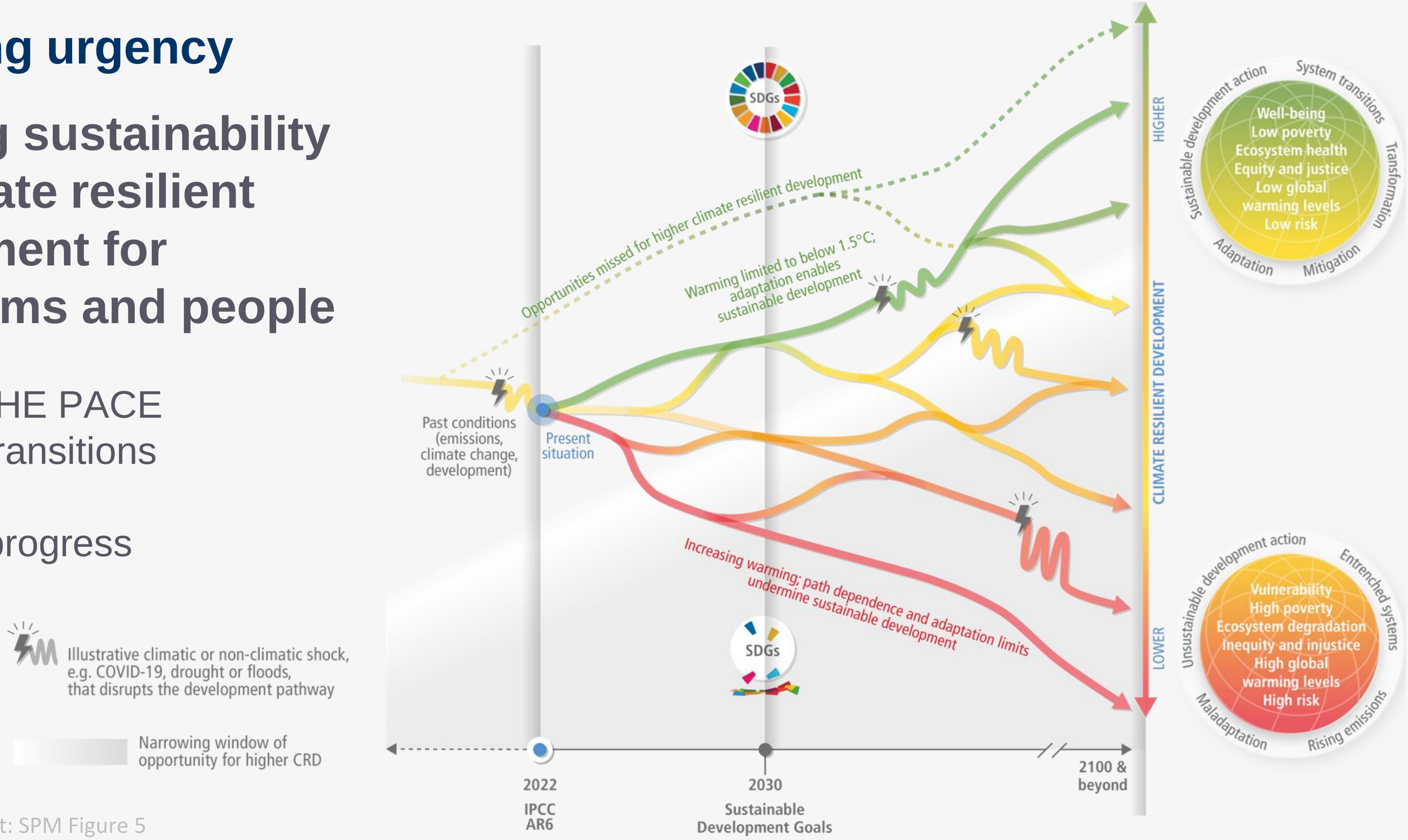


Increasing urgency

Reaching sustainability and climate resilient development for ecosystems and people

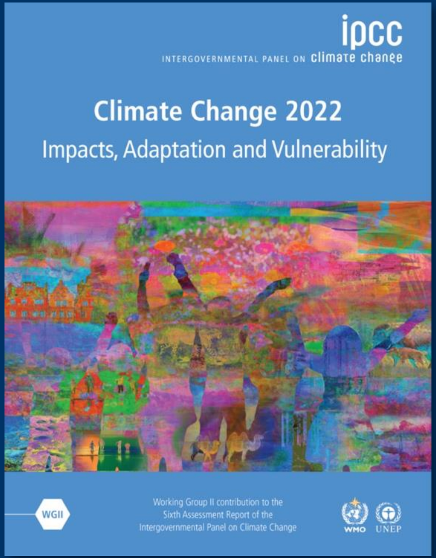
SETTING THE PACE
for system transitions

Monitoring progress



IPCC AR6 WGII Report: SPM Figure 5

Setting velocity in climate action



The psychology of systematically accelerating transformative adaptation and mitigation?

- How to rapidly change institutions?
- How to rapidly build political and societal will?
- How to set and trigger societal transitions?

Enhancing knowledge of impacts and risks for motivation and responses concerning:

- the role of closing immediate information gaps?
- the role of closing education gaps in curricula, reaching climate and biodiversity literacy?

Thank you!

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For more information: IPCC Secretariat: ipcc-sec@wmo.int IPCC Press Office: ipcc-media@wmo.int Visit ipcc.ch

WASP

WORLD ADAPTATION SCIENCE PROGRAMME

making science work for climate adaptation

The World Adaptation Science Programme (WASP)

Inputs for the Research Dialogue at SB 56

UN environment programme

WORLD METEOROLOGICAL ORGANIZATION

United Nations Climate Change

ipcc INTERGOVERNMENTAL PANEL ON climate change

GREEN CLIMATE FUND

gef

UNITED NATIONS UNIVERSITY

WASP portfolio

- Science for Adaptation Policy Briefs (SAPBs)
- Science to support action: Core Projects
- Community building: Adaptation Futures 2023

Montreal, October 2-6, 2023: The 7th Adaptation Futures International Conference will be organized by Ouranos, in partnership with the Government of Canada, and WASP

https://www.ouranos.ca/af2023/

Key insights from recent SAPBs

- **SAPB on Early Warning Systems for Adaptation**
  - **Learning how risks' exposure and vulnerability are shifting** with climate change is key to improving preparedness for future hazards.
  - Important **changes in extremes** are expected even for the **lowest warming scenarios.**
  - What worked in the past is no longer sufficient for **addressing today's and future risks.**
  - EWSA urgently **needs interdisciplinary and intersectoral collaboration** between policymakers and scientists, sectoral experts, humanitarian/disaster risk management actors and vulnerable communities.
- **SAPB on Cascading Shocks and Stressors**
  - Cascading impacts of climate change **amplify human vulnerabilities and risks**.
  - There are increasingly **small windows of time in which to build back** from each shock and stressor.
  - **Impacts are exacerbated for those most at risk** (e.g., women, children, the elderly, and marginalized groups).
  - Responding to cascading risks and impacts **requires transdisciplinary, cross-scale and cross-sector action.**
  - A focus on **equity and justice is essential for effective responses** in vulnerable developing countries.
- To learn more – poster session this afternoon

WASP Core Projects

Advance adaptation science in areas of high and immediate policy relevance

Mobilize and coordinate research community for knowledge generation and use

Key research gaps / needs: Global Goal on Adaptation

- **Operationalize the GGA** through the development and testing of metrics for adaptive capacity, vulnerability and resilience and applying them to track progress and evaluate actions.
- Consider **interactions of adaptation with critical UN SDG's** with a view identifying synergies and tradeoffs and designing strategies to delivery multiple benefits.
- Use the GGA and related metrics to identify and respond to **cross-scale and cross-sector collective governance** challenges.

Key research gaps / needs: Effectiveness of Adaptation

- Identified in the AR6 as a weakness in the current literature – and needed to **inform investments and scaling / replication** of adaptation interventions – especially by private actors.
- Improvement needed in the underlying **economics of adaptation** – and estimation of public and private costs and benefits
- Strengthening methods and approaches for **learning-by and while doing**

Adaptation Research Alliance

Catalyzing and scaling action oriented research

Inputs for the Research Dialogue at SB 56

The ARA is a **multistakeholder coalition** of 150 members from the **science, policy and practice communities** that is driving a paradigm shift towards **research that is demand-driven, user-centered and action oriented**. ARA members have endorsed the **Adaptation Research for Impact** principles

ARA portfolio

Advocacy	Research Planning and Cooperation	Resource Mobilization and Delivery
Adaptation Research for Impact Principles: Encouraging their adoption, tracking implementation and sharing learning	**Consultative processes to identify research needs and opportunities**	**Climate Adaptation and Resilience (CLARE) – a UK & Canada funded program to support action research in Asia-Pacific and Africa**
Submissions to the UNFCCC Global Stocktake and the GlaSS work program	**Microgrants to facilitate and mobilize local actors to figure out research needs and opportunities – and strengthen capacity in the process**	**Co-creation "sandboxes" for new program development in urban resilience, smallholder farmer resilience and LDC capacity strengthening**

ARA Consultative processes – what needs to happen for research to better support action?

- Breaking down silos
- Enhanced collaboration
- More effective communication
- Better Monitoring Evaluation and Learning Systems
- Integrating capacity-building into research
- More long term funding for adaptation

Food systems / small - holder agriculture (IDRC)	Climate risk assessments in LDC's (CSAG / UCT)	Global health: climate resilient health systems (RCRCCC & PHE)	Gender & social inclusion (IDRC)

ARA Micrograants

27 micrograants awarded for needs identification on burning issues

22 December 2021

Global workshop on co-producing burning issues

20 January 2022

Regional workshops share learning

12, 20 & 26 April 2022

Key insights

Biggest need is capacity-building and integrating / coordinating existing knowledge into governments and communities

Incorporating intersectionality of climate with other policy agendas is important – including combining currently separate policy instruments

Creating capacity for engaging design and facilitation on regional and local level.

More integrated and unconventional learning and reflection process that are interwoven with project activities

Proposals Received

77

Grants Approved

Africa

14

Asia & Pacific

7

Latin America & Caribbean

6

Countries

Kenya
India
Philippines
Argentina
Malawi
Sierra Leone
Panama
Tanzania
Bangladesh
Colombia
Ghana
India
Guatemala
Kenya
Ethiopia
Madagascar
Haiti
Nigeria
Rwanda
South Africa
Benin
Japan

AATF
actionaid
CABI
Climate Centre
FRIENDSHIP
SOAS University of London
Alternative Futures

All India Disaster Mitigation Institute
Alliance Bioversity International CIAT
CANSA South Asia
Climate System Analysis Group CSAG
GEAG
iihs Indian Institute for Human Settlements
CDKN Climate & Development Knowledge Network
UNDP

ICCCAD International Centre for Climate Change and Development
IPAM International Platform on Adaptation Metrics
iied International Institute for Environment and Development
IISD
ISET International
KOTA KITA A City for All
GSMA

Kenya Markets Trust Better Markets, Better Lives
Norwich Institute Sustainable Development
SSN Towards Climate Resilience
ODI
PlanAdapt Creating a Climate for Change
RESURGENCE.
SEI

START
Women's Climate Centers International
World Resources Institute
Oxford Policy Management
sdi.
NCDR National Science and Technology Center for Disaster Reduction
LANDROSA Land for Economic Emancipation

ARIN Africa Research & Impact Network
Science 4 Africa
bc3 Basque Centre for Climate Change Klima Aldaketa Ikergai Sustainability, that's it!
World Health Organization
Cw2 climate wise women
IDRC · CRDI Canada
IGES Institute for Global Environmental Strategies
Université Nationale d'Agriculture

enda
Royal University of Bhutan
Universidad Nacional de Rosario
The University of the West Indies
Save the Children
Institución Universitaria Colegio Mayor de Antioquia
NWO Netherlands Organisation for Scientific Research
AFD Agence Française de Développement

ICIMOD
HELVETAS
UK Centre for Ecology & Hydrology
Global Resilience Partnership
Global Innovation Fund
ECAS Environmental Capacities and Sustainability Institute

Caldas da Rainha Câmara Municipal
ISB Bharti Institute of Public Policy
IDDRI 20 ans
Oxfam
christian aid
ACDI African Climate & Development Initiative
GAYO Green Africa Youth Organization

University of Liberia
FARM AFRICA
eit Climate-KIC
W CHanGE Center for Health and the Global Environment
UEA University of East Anglia

Ground Truth Solutions
HSRC Human Sciences Research Council
Bill & Melinda Gates foundation
UN environment WCMC
UKADR United Kingdom Alliance for Disaster Research
University of Maryland

United Nations University UNU-EHS Institute for Environment and Human Security
IRI
ACIAR
SRUC
IPR / IFRA
UNESCO ETXEA
UKaid from the British people
Adaptation Without Borders

Echnoserve
University of Exeter
DRFN
MHT
KULIMA
Met Office
PRIA Knowledge. Voice. Democracy.

GEO Indigenous Alliance

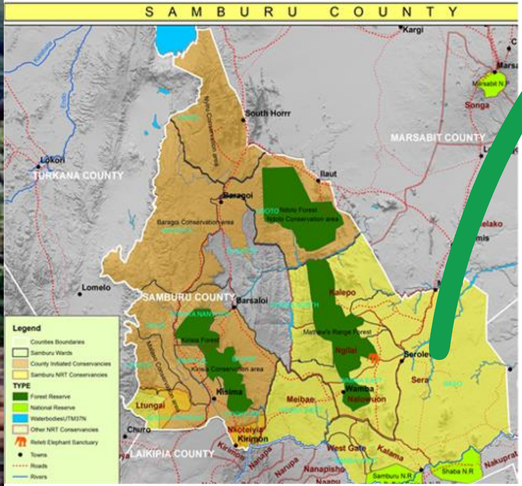
UNFCCC Research Dialogue 2022

SARARA

TITUS LETAAPO

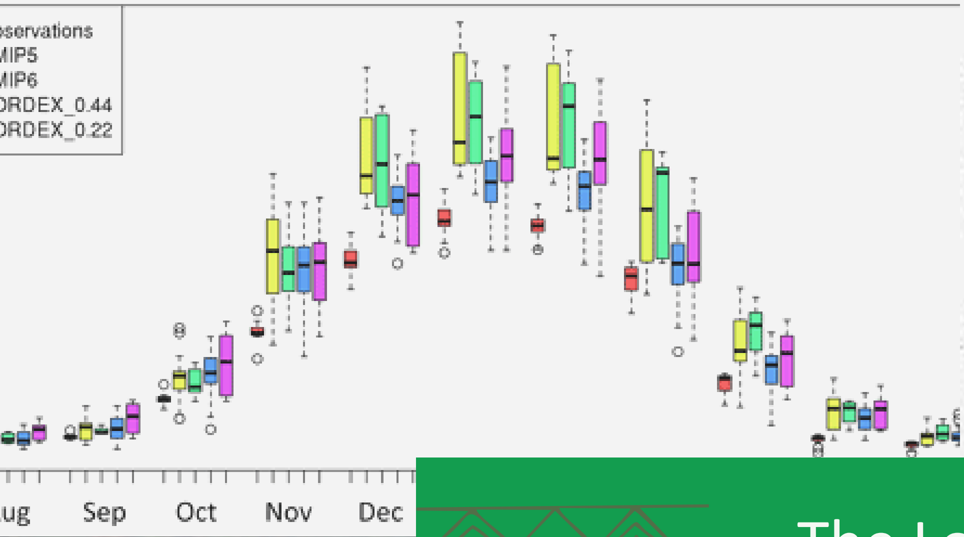
Co-founder of the GEO Indigenous Alliance, Sarara Foundation

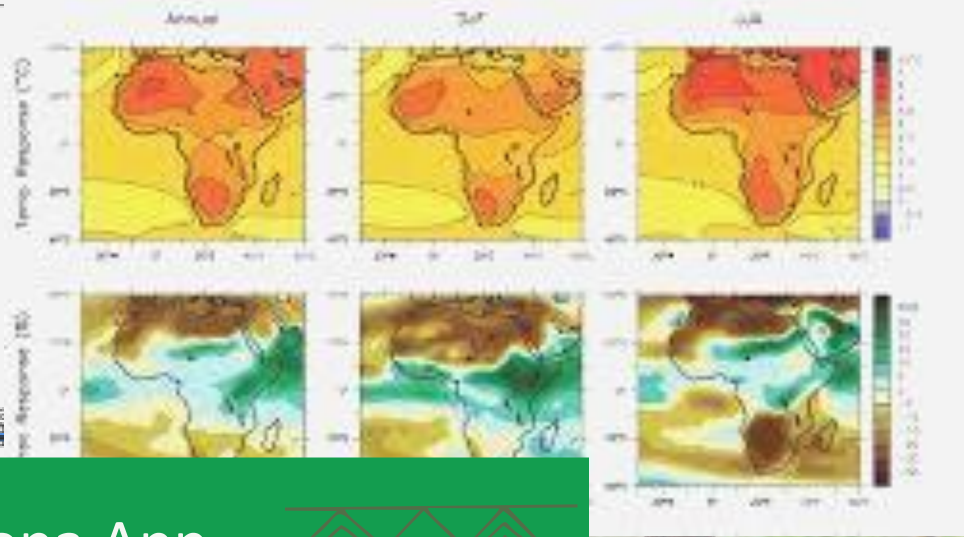
Samburu People, Northern Kenya



Semi-nomadic pastoralists who herd mainly cattle, but also keep sheep, goats and camels.

The Lopa App





INDIGENOUS DATA CHALLANGES

No internet connectivity & access to key climate data

Lack of funding for Indigenous-led projects

Limited or lack of relevant government services

Indigenous knowledge not taken seriously

OUR RECCOMENDATIONS

Invest in public services & communication infrastructure

Fund Indigenous-led projects and provide tailored training

Include Indigenous Knowledge in climate assessments

Advocate for Indigenous Data Sovereignty

Lets collaborate!

Ashe Oleng/Thank you

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