SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis

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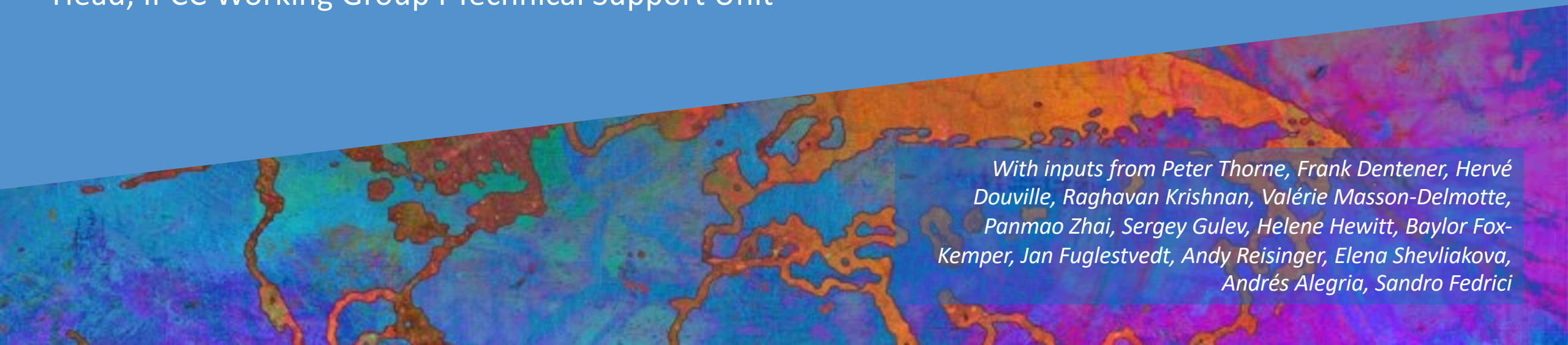
INTERGOVERNMENTAL PANEL ON Climate change

WMO UNEP

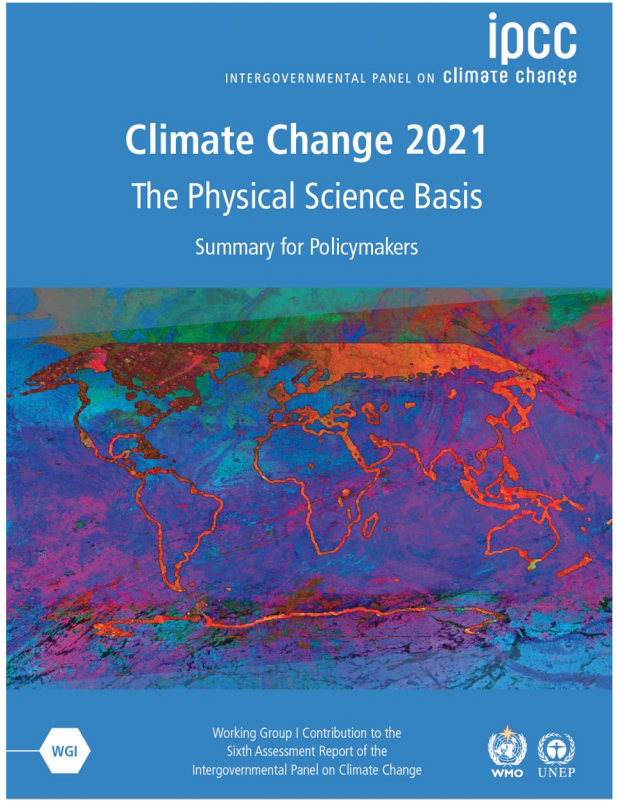
# Observations in the IPCC Climate Assessments

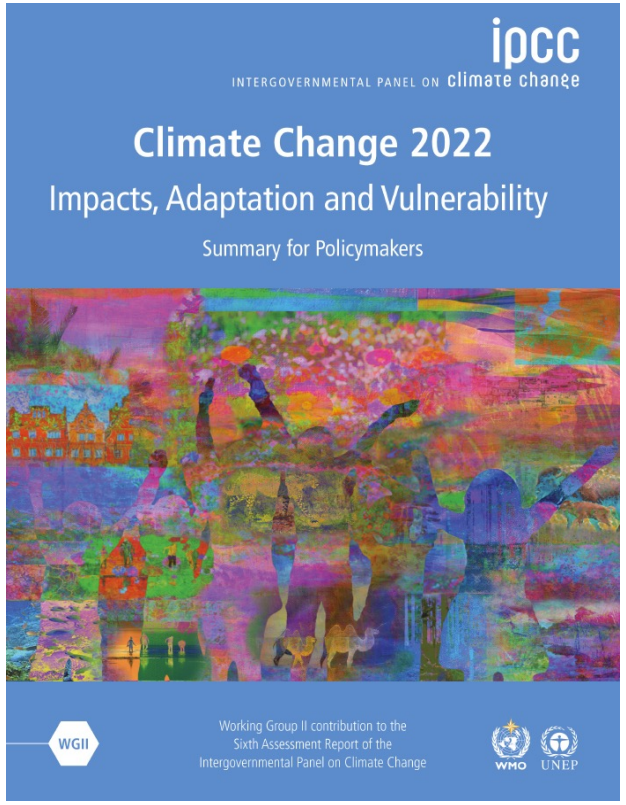
## Highlights of uses and needs based on the IPCC AR6 reports

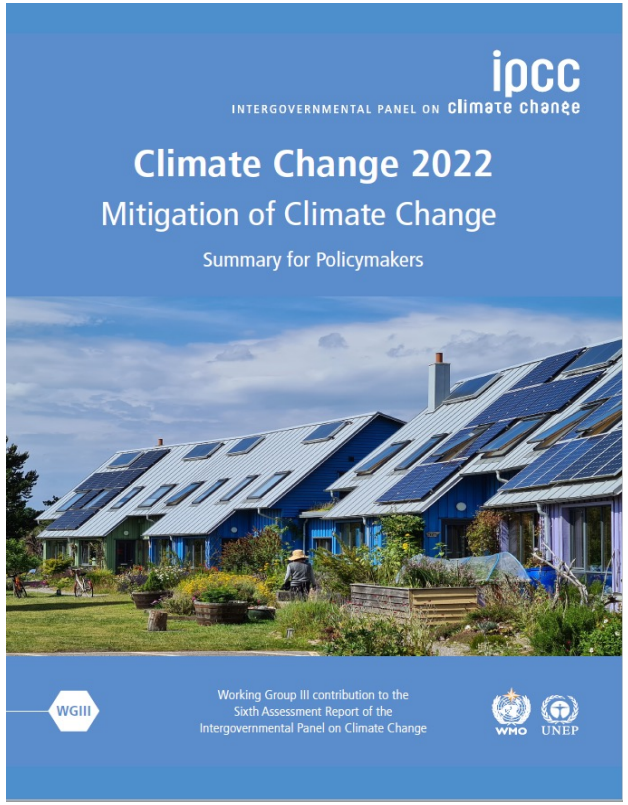
Anna Pirani
Head, IPCC Working Group I Technical Support Unit



*With inputs from Peter Thorne, Frank Dentener, Hervé Douville, Raghavan Krishnan, Valérie Masson-Delmotte, Panmao Zhai, Sergey Gulev, Helene Hewitt, Baylor Fox-Kemper, Jan Fuglestvedt, Andy Reisinger, Elena Shevliakova, Andrés Alegria, Sandro Fedrici*




**234** authors, **65** countries
**14,000+** scientific papers
**78,000+** review comments

**270** authors, **67** countries
**34,000+** scientific papers
**62,000+** review comments

**278** authors, **65** countries
**18,000+** scientific papers
**59,000+** review comments

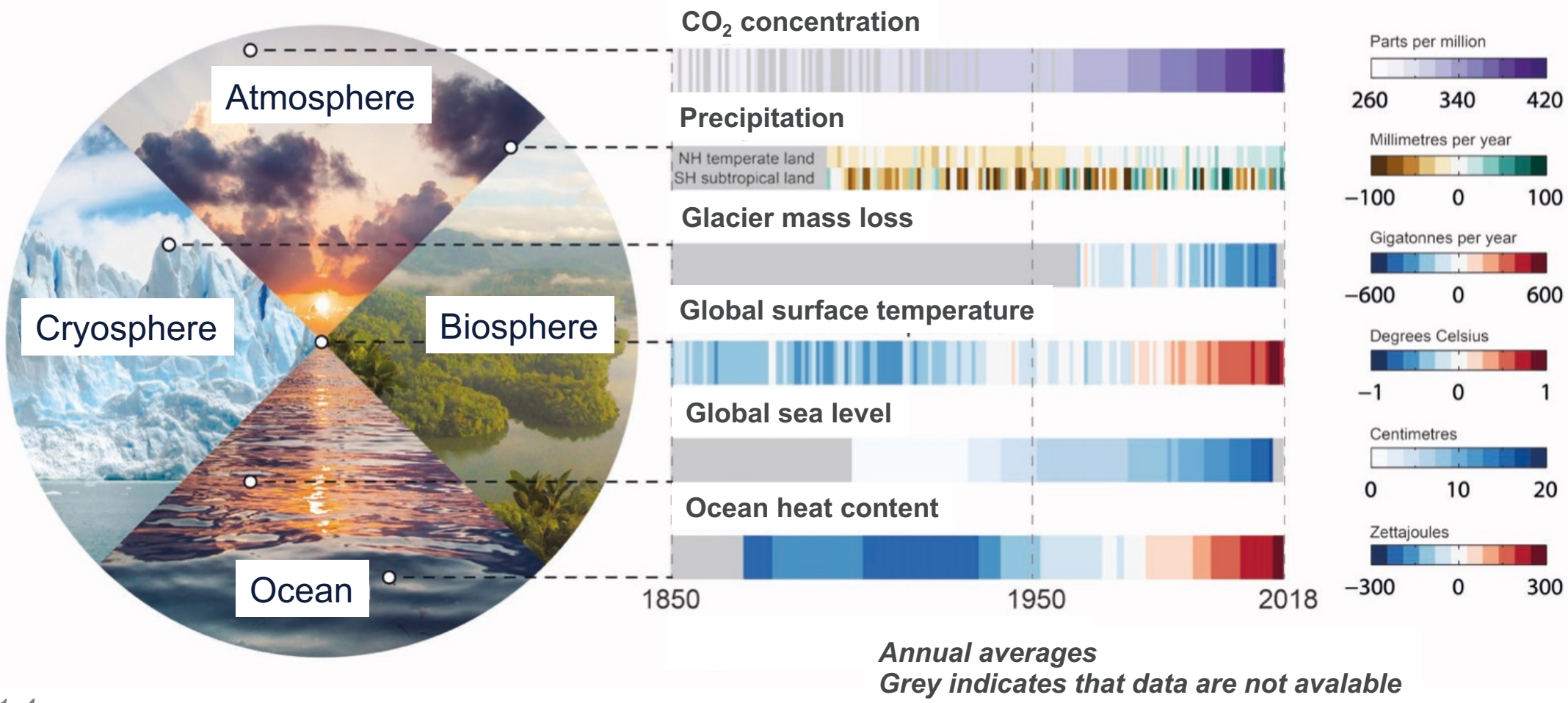
# Towards the 7th IPCC Assessment cycle

| | |
|---|---|
| 2023 | Completion of the AR6 Synthesis Report (March 2023)<br>AR6 Technical Support Units spinning down<br>Start of the AR7: Elections of AR7 Bureau (July 2023)<br>AR7 Technical Support Units start being constituted<br>Hand over from AR6 to AR7, lessons learned (Fall 2023) |
| 2024 – | Special Report on cities and climate change<br>Establishing the AR7 workplan (Working Groups, Special Reports)<br>Scoping of the AR7 reports<br>Authors selected<br>Renewal of Task Group on Data Support for Climate Change Assessments |
| 2028 | Global stocktake |

[Credit: NASA]

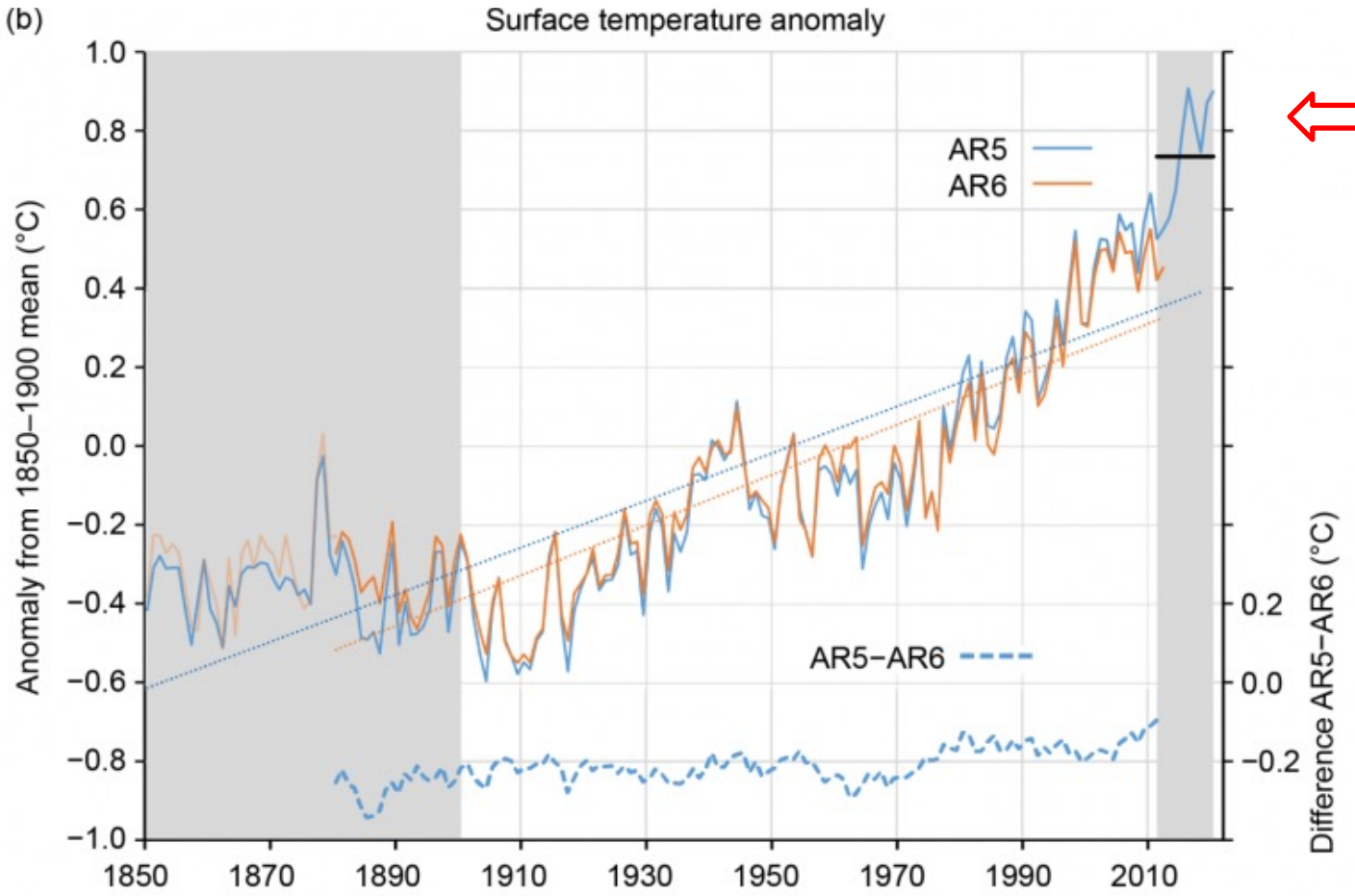
> Earth system observations are an essential driver of progress in our understanding of climate change and of informing our responses

# Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred




*WGI Figure 1.4*

# Updated global surface temperature estimates



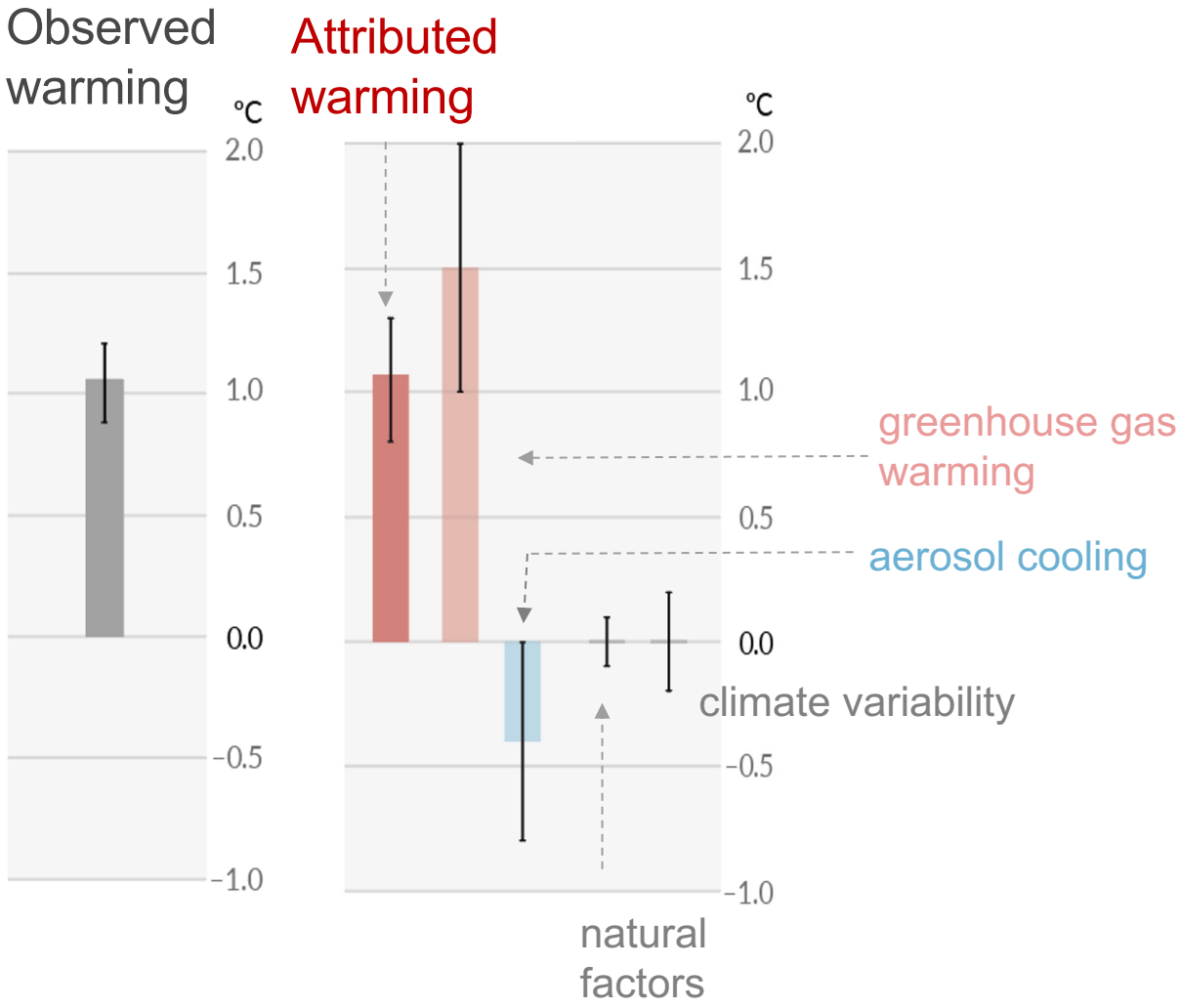

⇦ Last decade warmer than all prior decades on record

*Challenges (data voids) in polar regions, tropical forests, deserts, developing countries*

*Opportunities of data rescue, centennial reanalyses, coupled reanalyses*

*Air-sea fluxes to understand marine lower boundary layer fluxes*

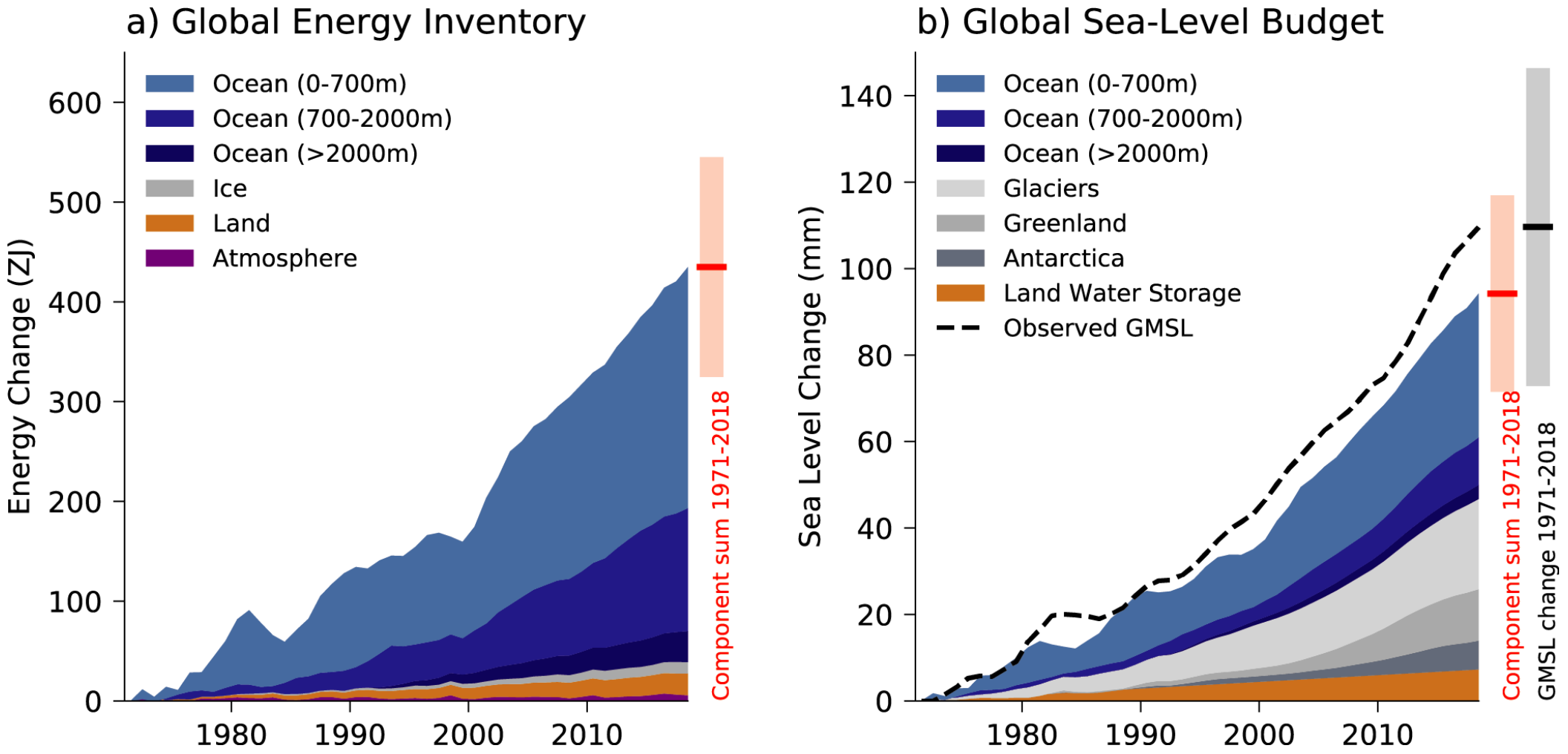
# Observed warming is driven by emissions from human activities




- *Global greenhouse gas monitoring system*
- *Regional distribution, timeseries, high resolution monitoring of aerosols and short-lived climate forcers*
- *Observational constraints on emissions with large uncertainty*
  - *fugitive methane emissions*
  - *natural / anthropogenic sources and sinks (land)*

*Adapted from WGI Figure SPM.2*

# The Earth's energy imbalance causes increased heating of the climate system

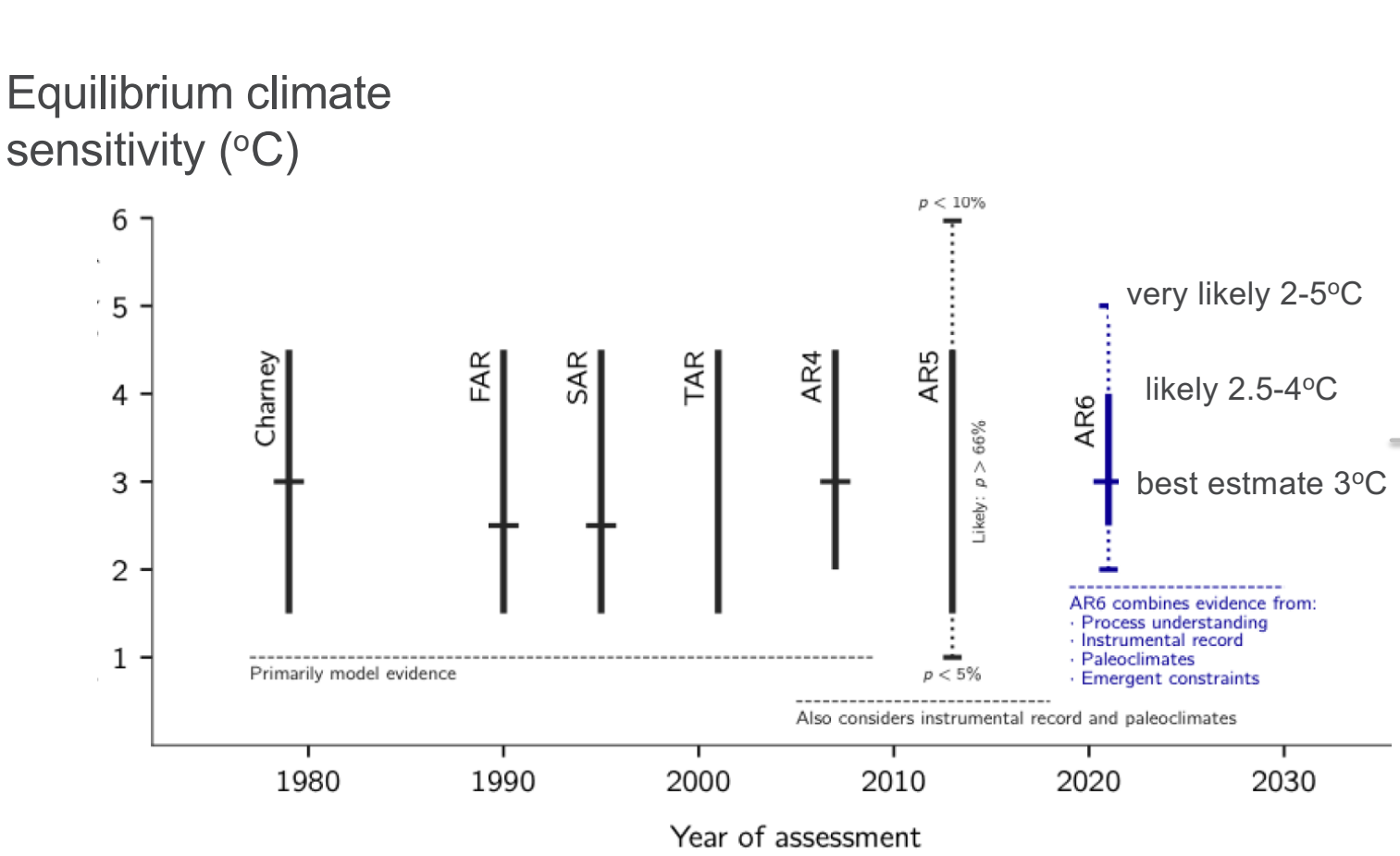


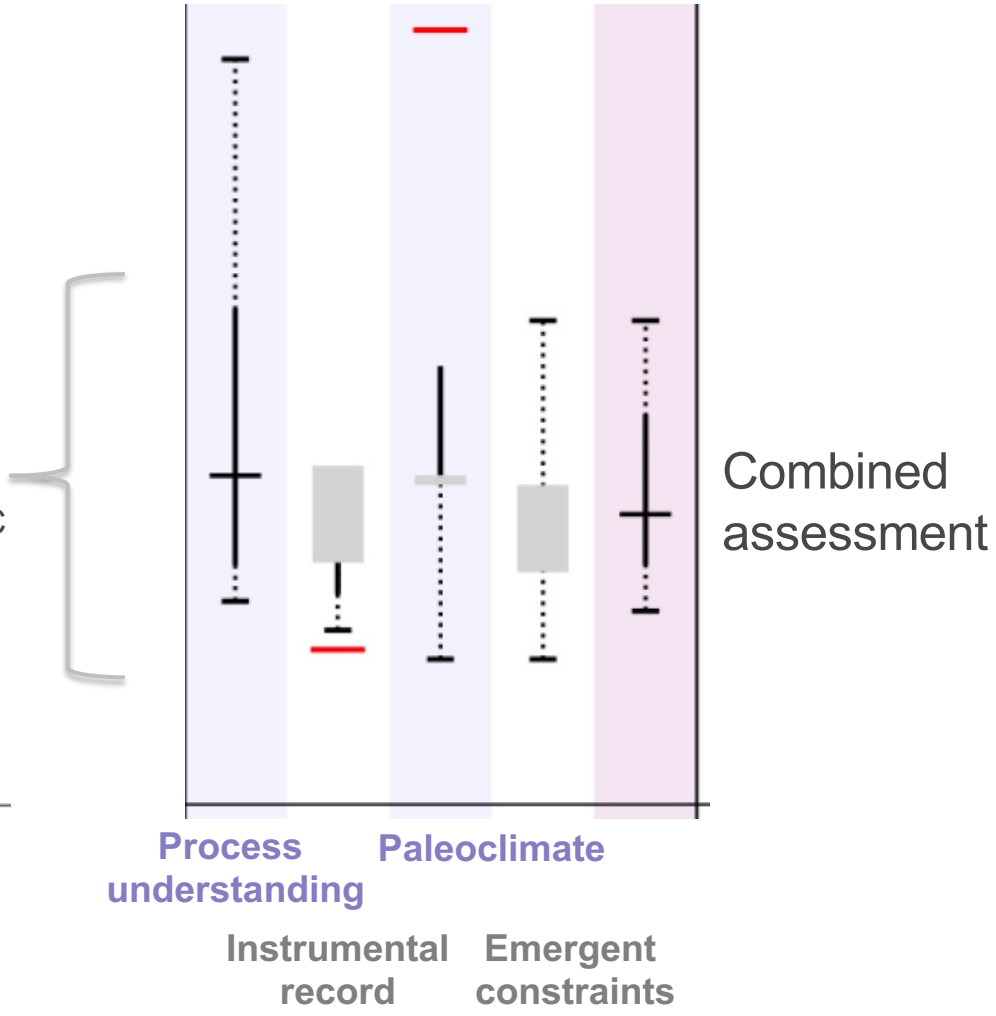

*WGI CCB 9.1, Figure 1*

[Credit: Hong Nguyen | Unsplash]

> The changes we experience today will increase with further warming

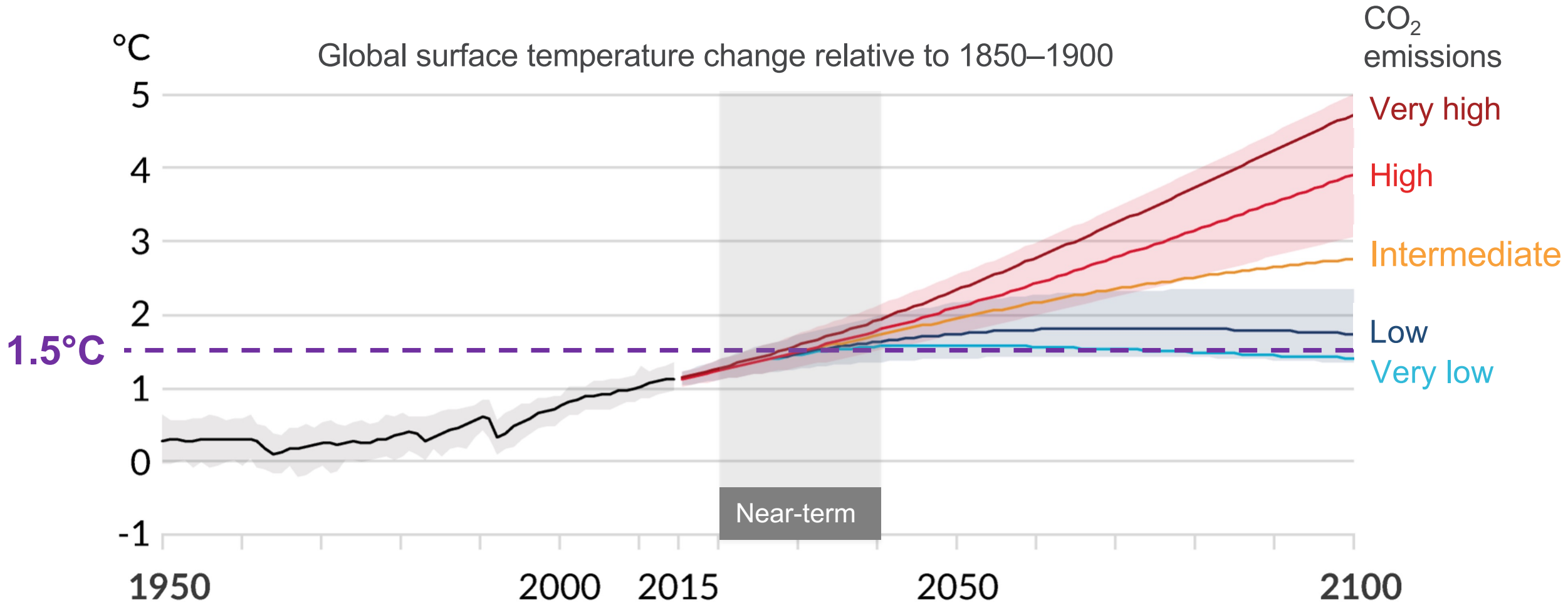
# Broad agreement across multiple lines of evidence, supporting a best estimate of equilibrium climate sensitivity of 3°C, with a *likely* range of 2.5°C to 4°C



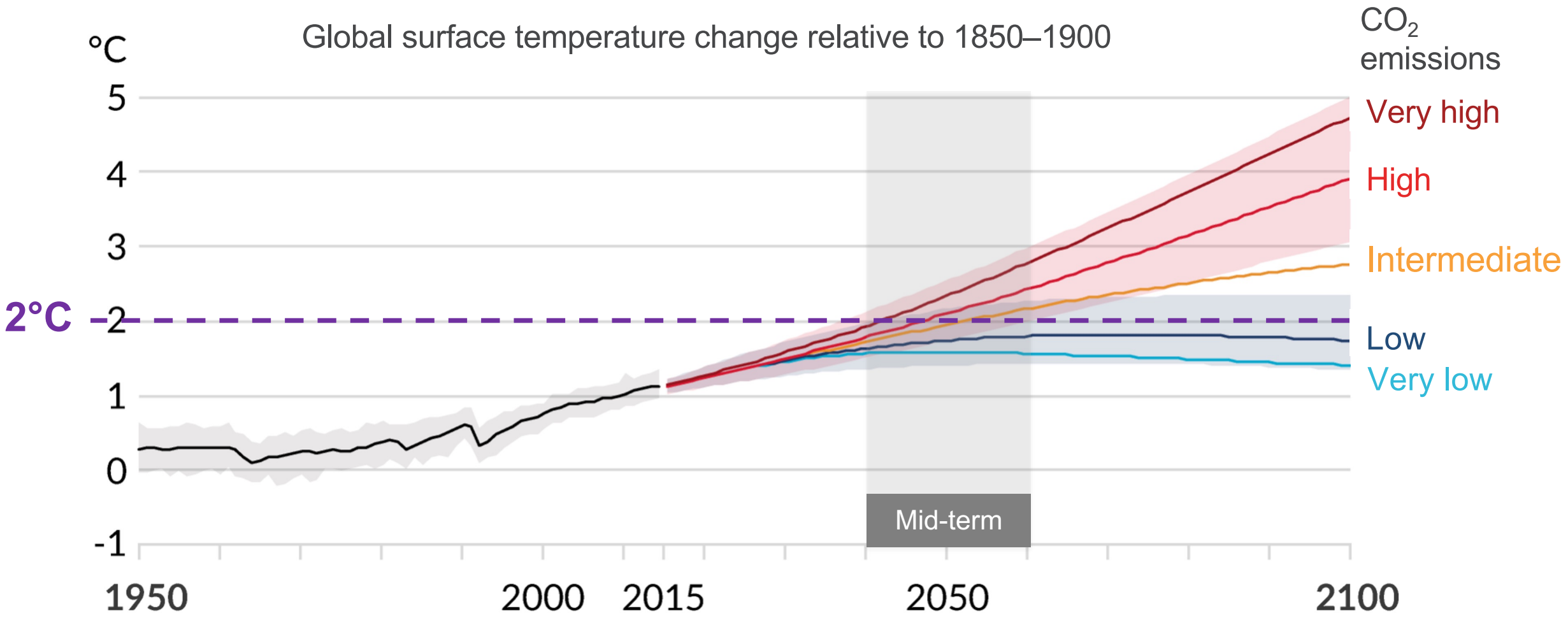

*WGI Figure TS.16*

# Future global warming depends on future emissions of $CO_2$ and other greenhouse gases




*WGI Figure SPM.8*

# Future global warming depends on future emissions of $CO_2$ and other greenhouse gases

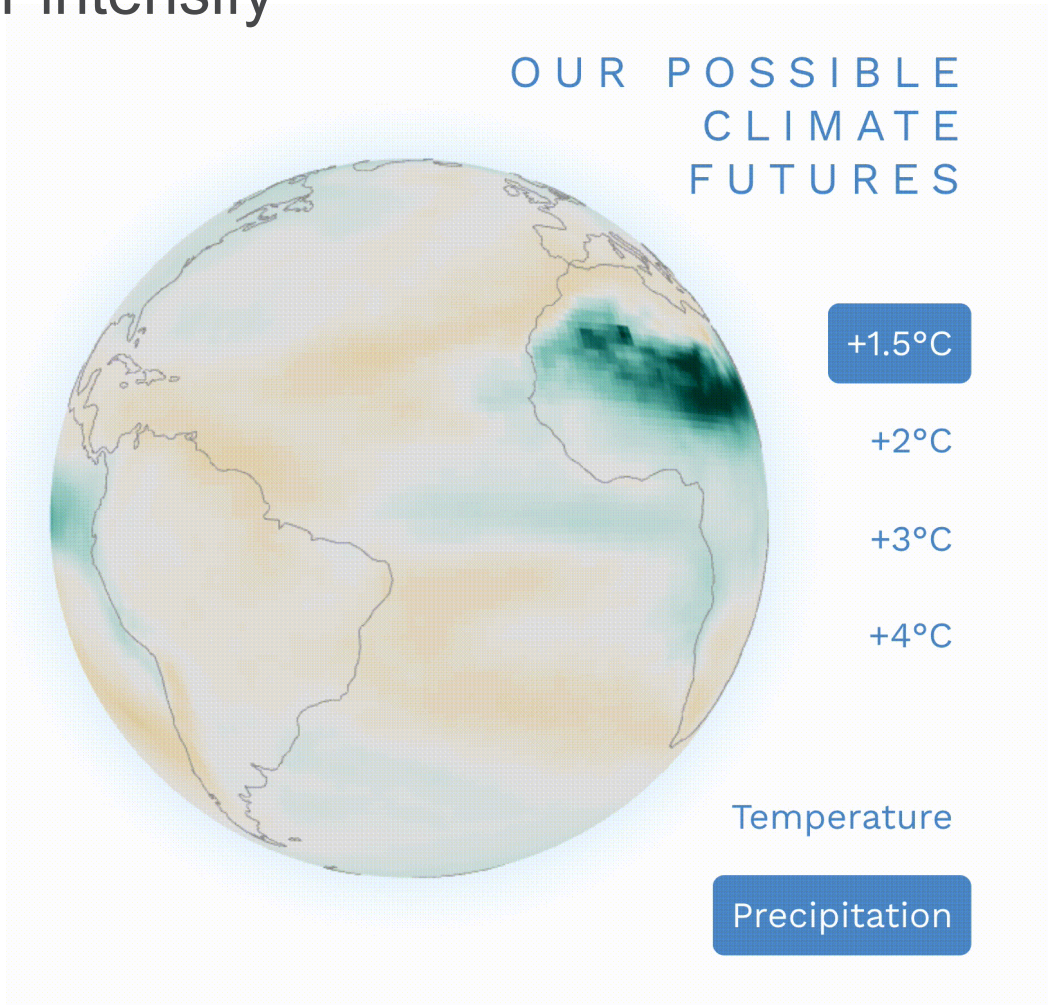



*WGI Figure SPM.8*

# Continued global warming is projected to further intensify the global water cycle

including its variability, global monsoon precipitation and the severity of wet and dry events

- *Longer observational time series*
- *Further analysis of past and current climate variability alongside future climate change projections*
- *Projected water cycle changes have not been constrained with observations in the AR6. Progress expected:*
  - *Direct relation to global warming*
  - *Other observations to constrain the water cycle response (e.g., global land surface relative humidity).*

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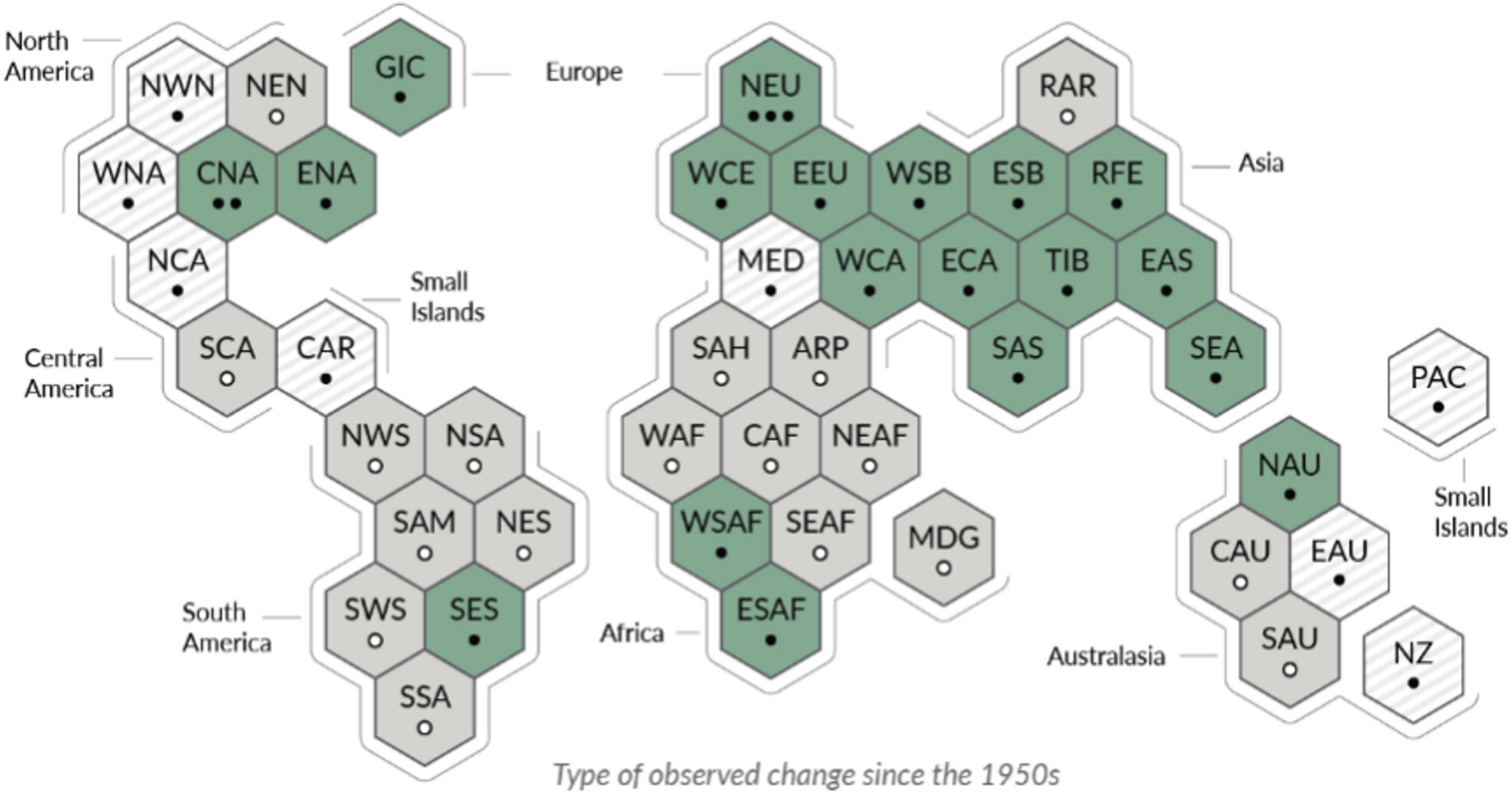
# Climate change is already affecting every region on Earth

## Heavy precipitation




*Type of observed change since the 1950s*

**Type of observed change**

Colour = Increase/decrease

Low agreement in the type of change

Limited data and/or literature

**Confidence in human contribution** to the observed change

●●● High

●● Medium

● Low due to limited agreement

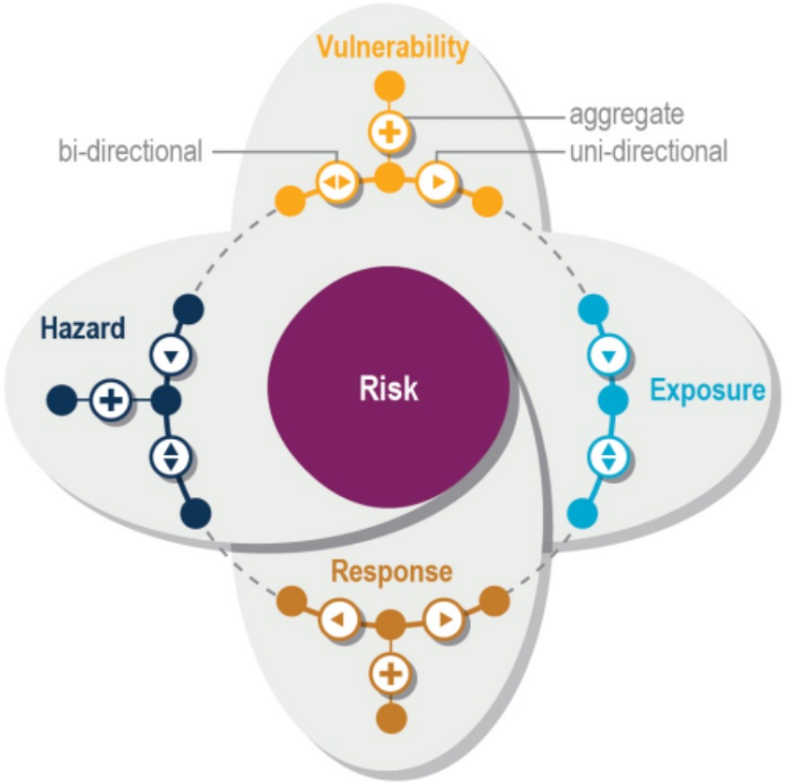
○ Low due to limited evidence

*WGI Figure SPM.3*


Every increment in global warming will result in increased risks

Photo Credits: Arek Socha, Pixabay

# Linking climatic impact-drivers with societal and ecosystem vulnerabilities and exposure, and consequences of responses to climate change


*3.3-3.6 billion people in highly vulnerable contexts*

*Ecosystems*

*1 billion people exposed to sea level rise by 2050*

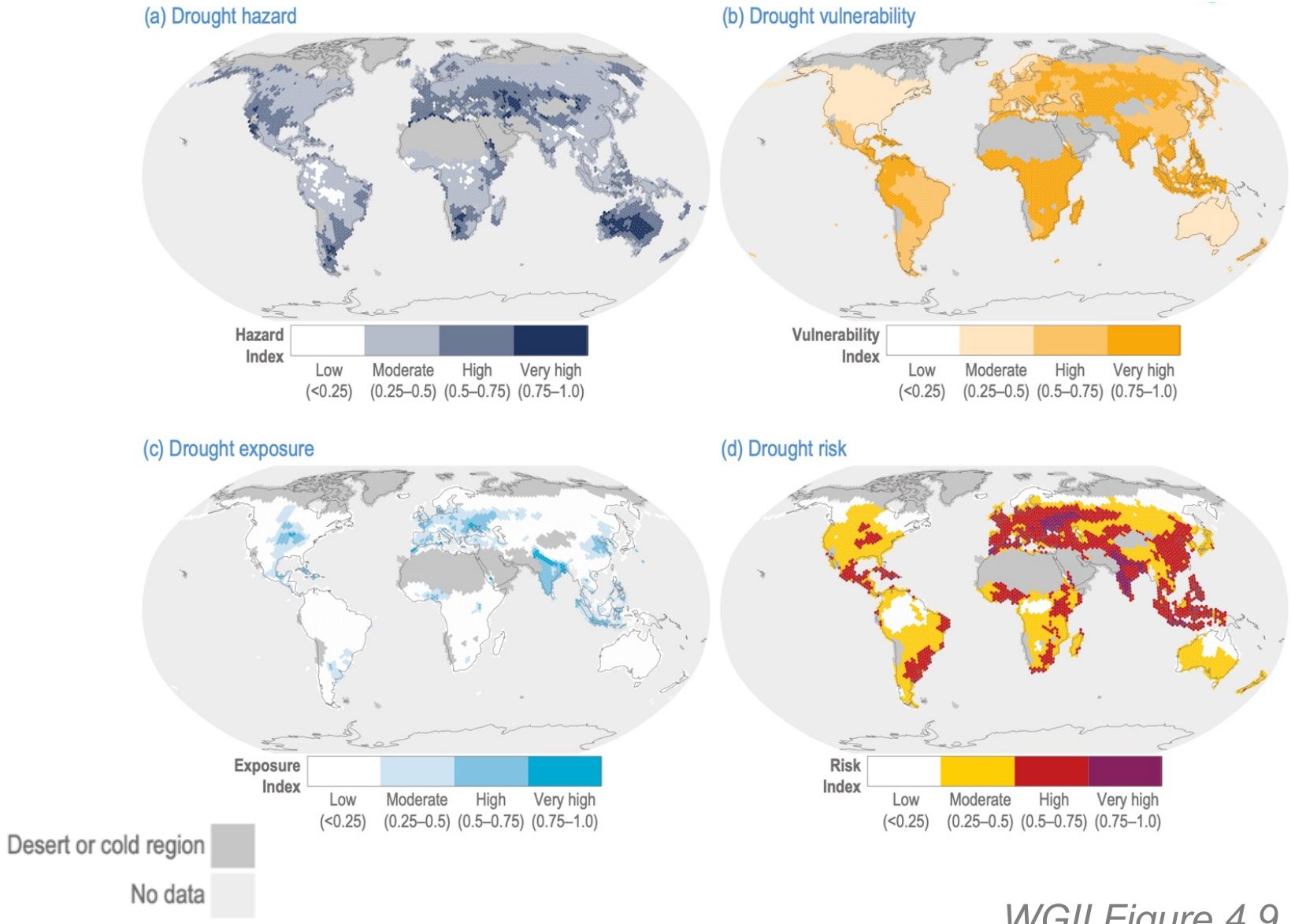
*Responses*

- *Maladaptation*
- *Pressures on land use*

*WGII Figure 1.5*

# Current global drought risk and its components in 1901-2010

- *Potential to develop EO applications based on info from multiple ECVs and combined with other types of data (e.g., socio-economics, demographics…).*

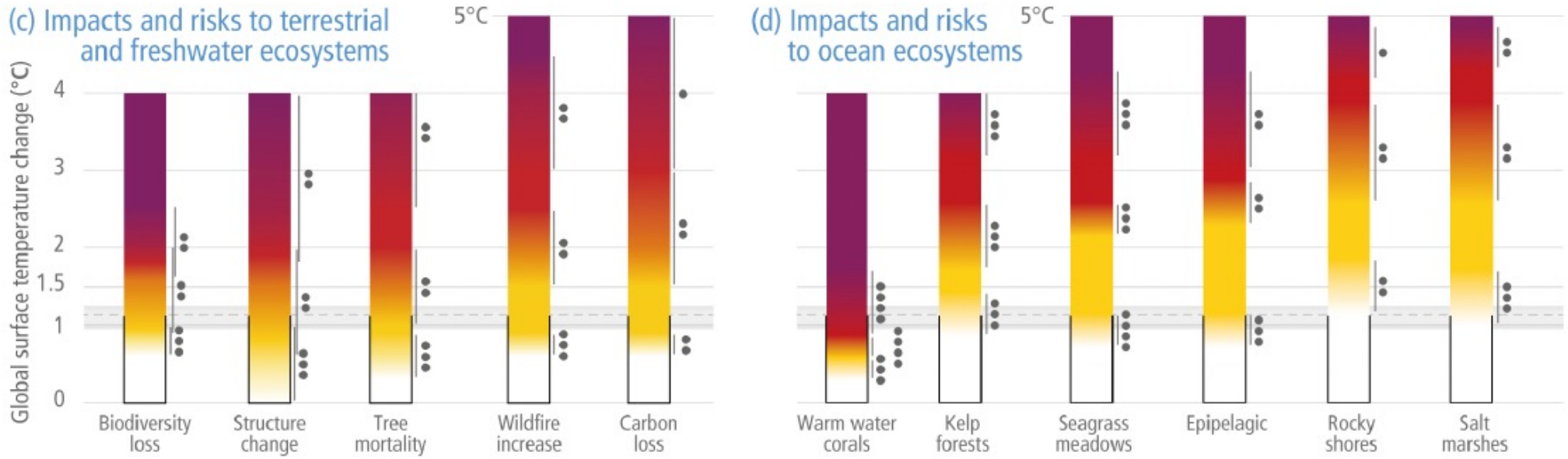



*WGII Figure 4.9*

# Adverse impacts and related losses and damages escalate with every increment of global warming

*Observations for ecosystem adaptive management*

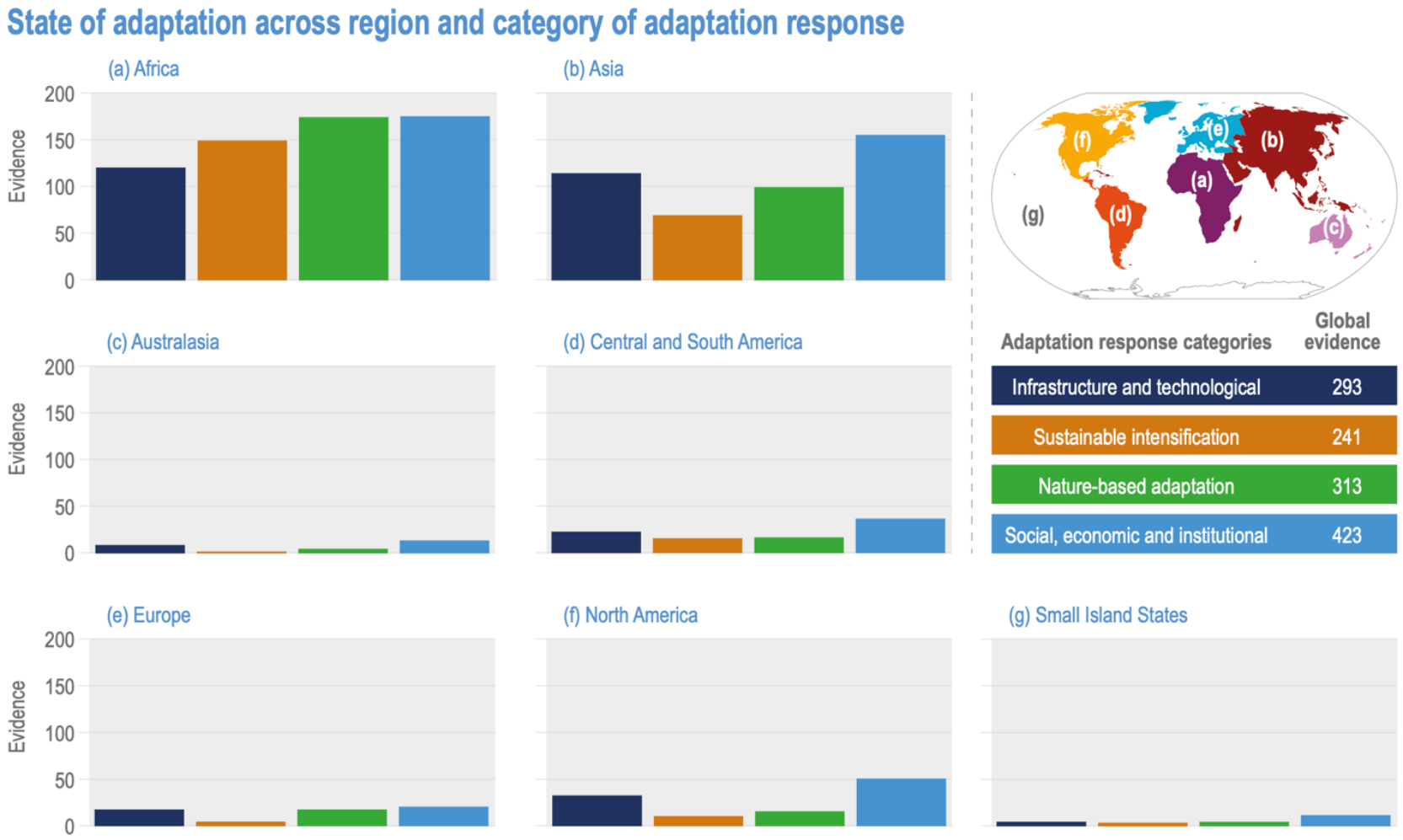
- *Enhancing the coastal monitoring network*
- *Early warning, cascading interactions, recovery, management interventions*
- *Habitat forming species, keystone species, ecosystem thresholds / tipping points*
- *Restoring carbon- and species-rich ecosystems*




*WGII Figure SPM.3*

# Evidence of constraints and limits to adaptation by region and sector

- *Existing comparative data for adaptive capacity worldwide is at a rather coarse level.*
- *Spatially more resolved (sub-national) data needed*




*WGII Figure 5.19*

To limit global warming, strong, rapid, and sustained reductions in $CO_2$, methane, and other greenhouse gases are necessary.

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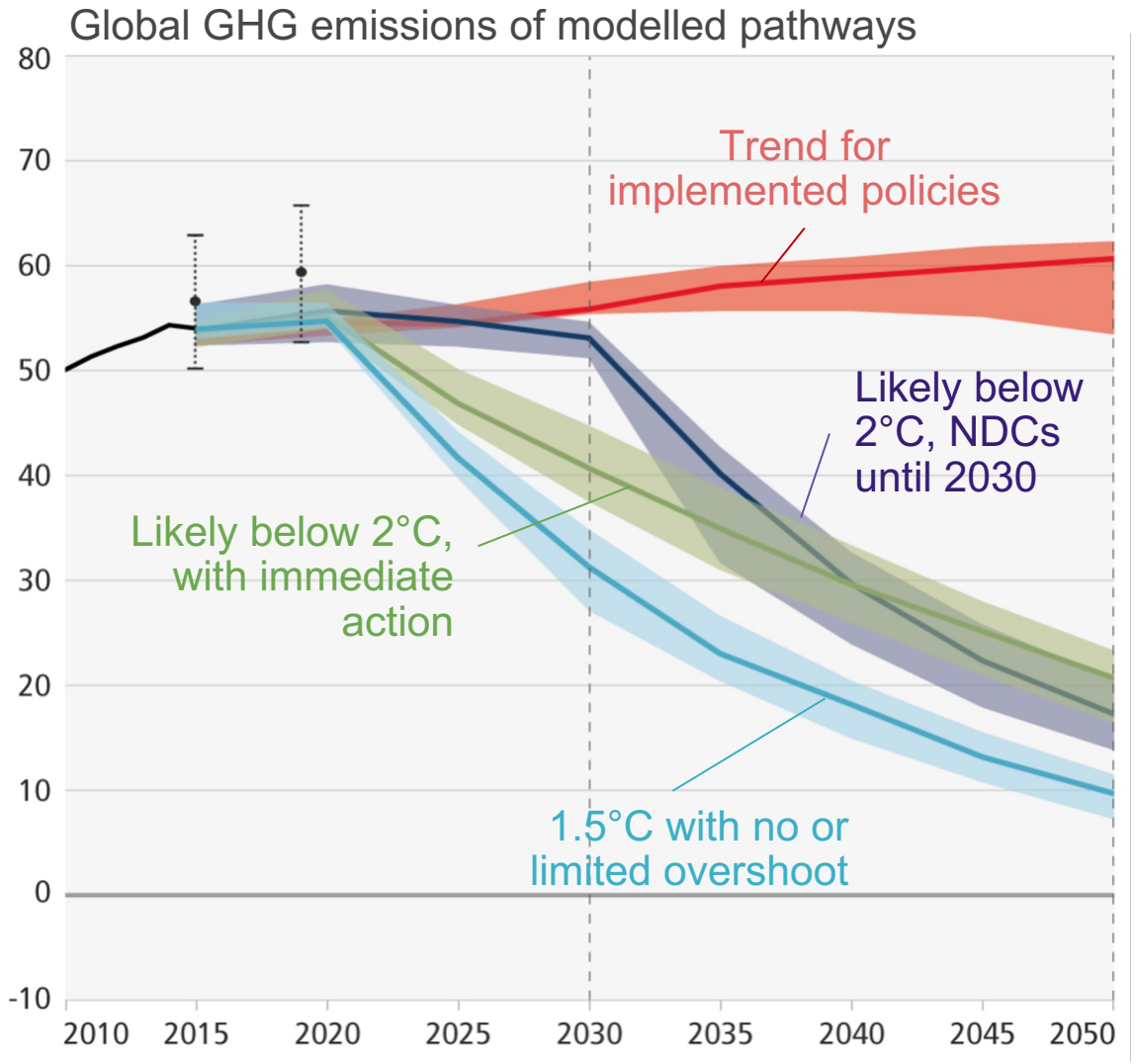
[Peter Nguyen / Unsplash]

# Assessing collective progress in emissions reductions

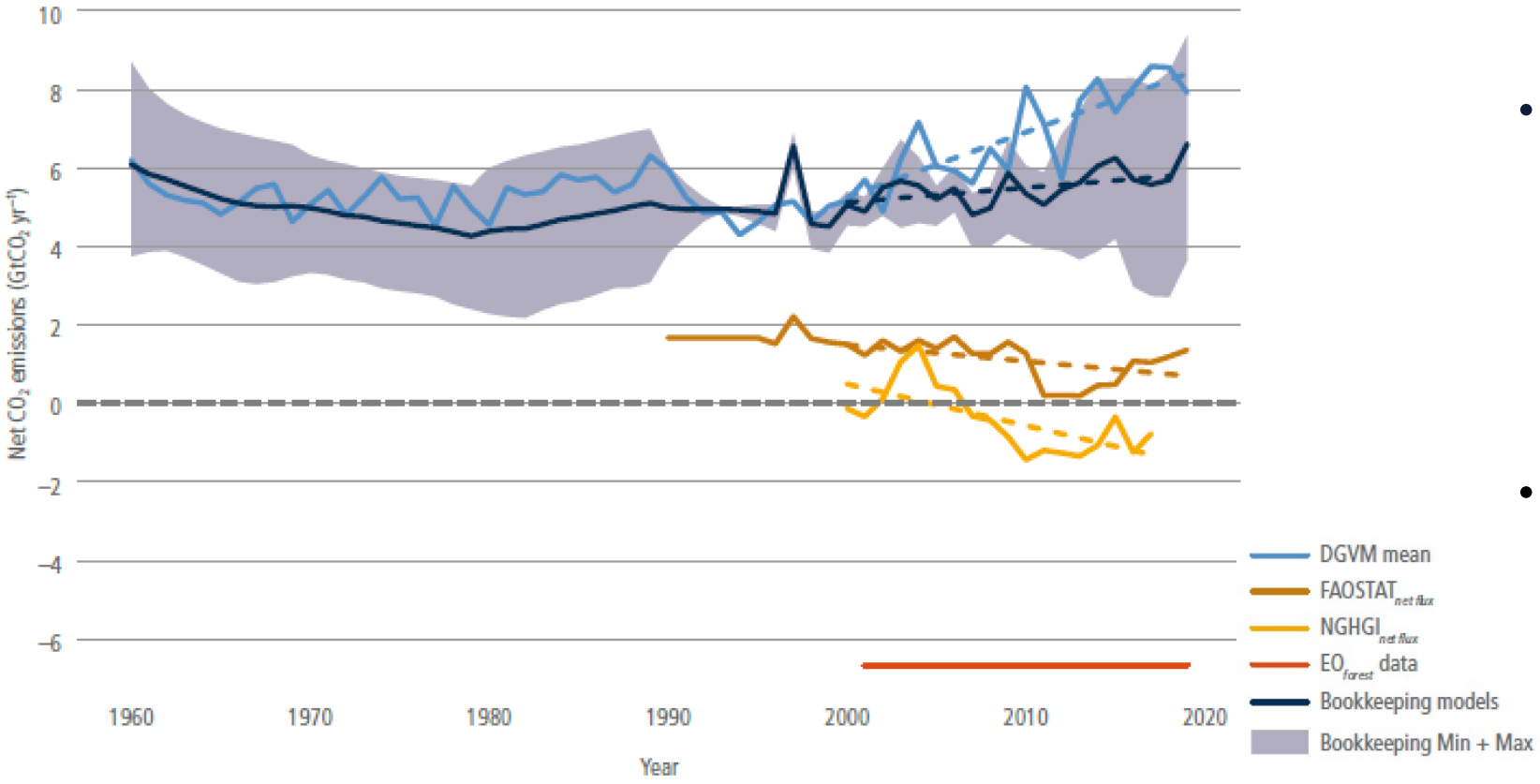



- *global obs of concentrations are important to constrain regional emissions databases.*
- *observing the state of biospheric C sinks, land, and the ocean to assess whether natural sinks are taking up human-caused emissions.*
- *regional/national emission estimates of non-$CO_2$ emissions by observations (satellite and regional flux networks)*

*WGIII Figure SPM.4*

# Reconciling estimates of greenhouse gas sources and sinks

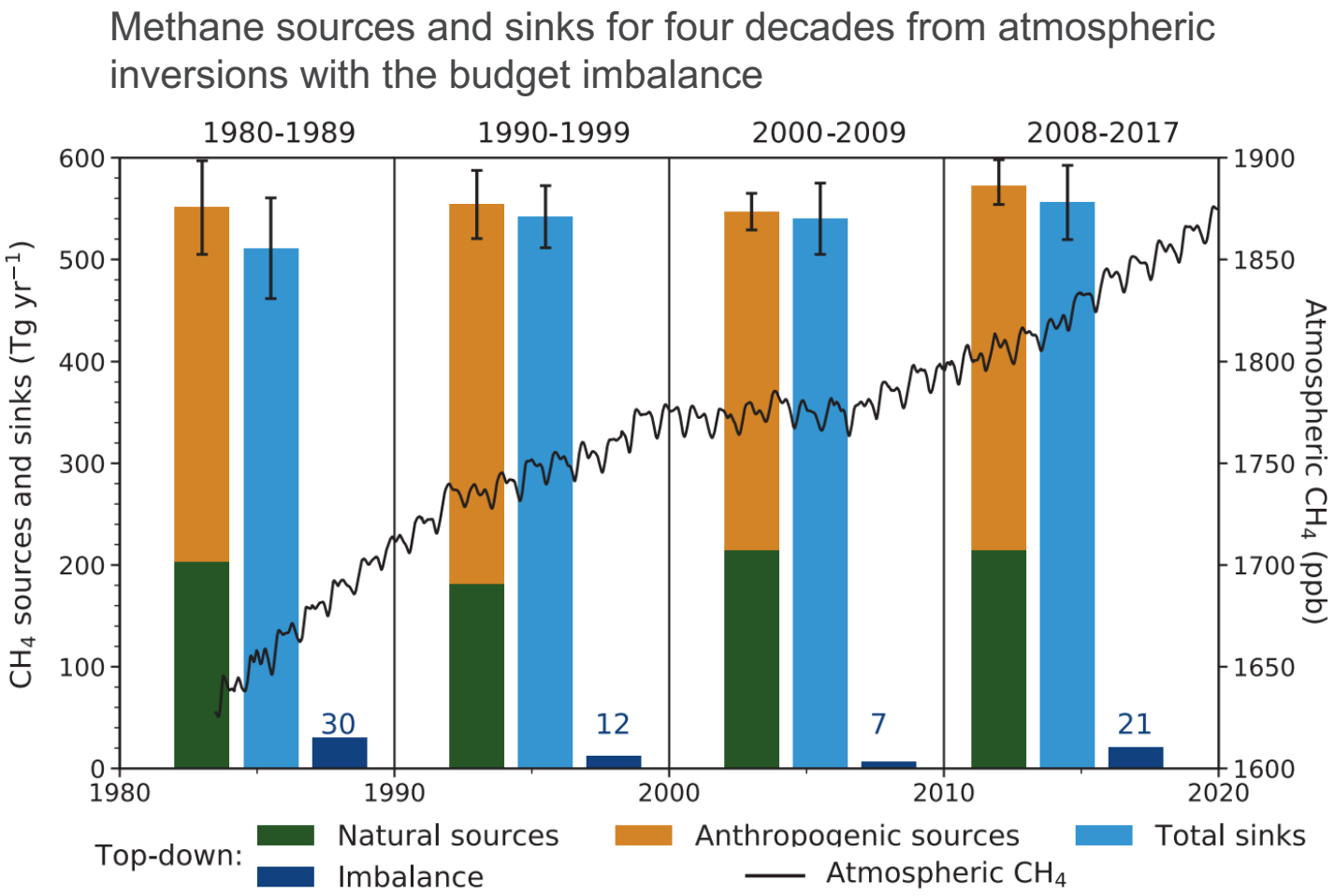
Global net $CO_2$ flux due to AFOLU estimated using different methods for the period 1960 to 2019 ($GtCO_2\ yr^{-1}$)




- *Regional $CO_2$ emissions from land-use/land-use change*
- *Remote-sensing products*
  - *spatial and temporal land-use and biomass data*
  - *attribute changes to human causes or natural variability*
- *High resolution observations, incl. fire, regrowth, repeated deforestation*

*WGIII Figure 7.4*

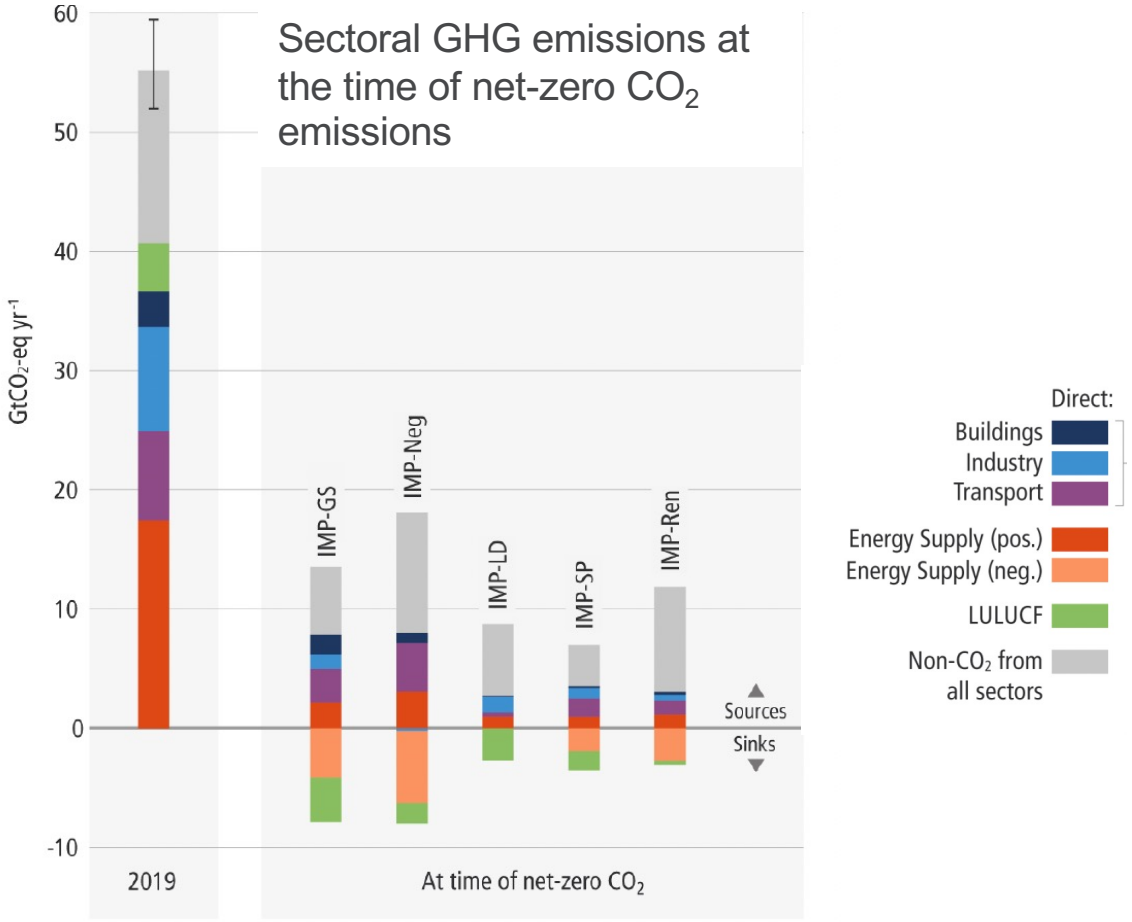
# Reporting of national greenhouse gas emissions and removals




*WGI CCB 5.2 Figure 1*

- *GHG fluxes - direct measurements for verification (and potential refinement) of inventory estimates*
- *Timeseries of land cover/land use area data across time*
- *Consistency in terminology and classifications of sources/sinks and associated natural and anthropogenic GHG fluxes*
- *Assessing the use of atmospheric observational data and inversion models for verification of national inventory estimates*

# There are options available now in every sector that can at least halve emissions by 2030




- *Improved quantification of anthropogenic and natural greenhouse gas fluxes and emissions modelling*
- *better understanding of the impacts of climate change on the mitigation potential and permanence*
- *improved (real time and cheap) measurement, reporting and verification*
- *monitoring in light of net zero*

*WGIII Figure SPM.5*

[Credit: NASA]

> While the quantity, quality and diversity of climate system observations have grown since AR5, the loss or potential loss of several critical components of the observational network is also evident.

# Building an integrated global observing system long-term to inform decision making

- *Use of multiple observational products*
- *Validation for climate models, use of community standards and tools*
- *Long-term consistent datasets*
- *Regional information, high resolution, urban-scale*
- *Constrainting estimates from multiple sources of evidence*
- *Rates of change and emergence*
- *Early warning and monitoring*
- *Verification of emissions*
- *Importance of free and open data, facilitate use of latest products*
- *Engagement in, and support of, the assessment process*

[Credit: NASA]

> The IPCC Climate Report shows how taking action now can move us towards a fairer, more liveable world.

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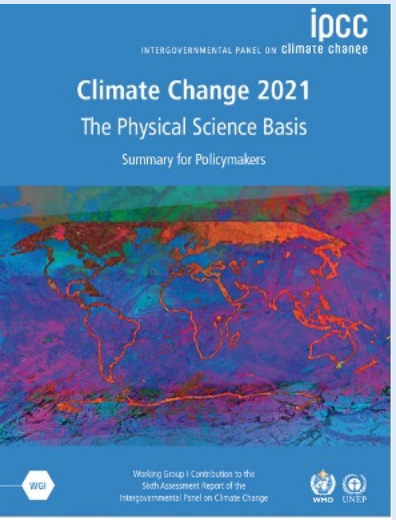
# Summary for Policymakers
# Technical Summary
# Interactive Atlas
# Report Chapters

www.ipcc.ch/report/ar6/wg1/




IPCC Sixth Assessment Report
Working Group 1: The Physical Science Basis

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CHAPTER 1

**Framing, Context and Methods**

Chapter 1 introduces the WGI contribution to AR6, its framing and context, and the methods used in the report.

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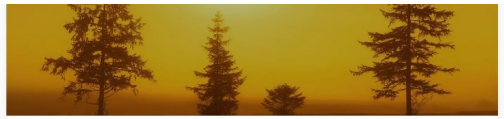

CHAPTER 2

**Changing State of the Climate System**

Chapter 2 provides evidence for large-scale past changes in selected components of the climate system.

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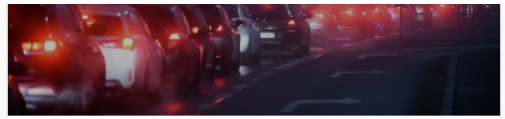

CHAPTER 3

**Human Influence on the Climate System**

Chapter 3 assesses human influence on the climate system and evaluates climate models on large scales.

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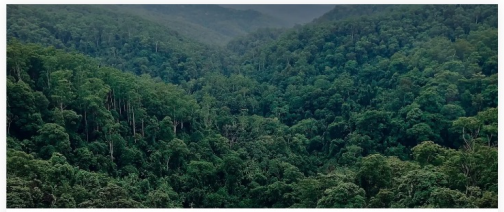
CHAPTER 4

**Future Global Climate: Scenario-based Projections and Near-term Information**



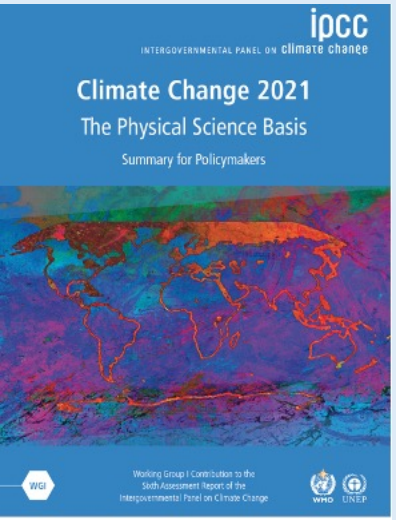
CHAPTER 5

**Global Carbon and other Biogeochemical Cycles and Feedbacks**

CHAPTER 6

**Short-lived Climate Forcers**

Chapter 6 discusses the evolution of reactive compounds and their effects on climate and global




**Summary for Policymakers**
**Technical Summary**
**Interactive Atlas**

**Report Chapters**
**1** Framing, context, methods

Data, Tools and Methods Used across the WGI Report

Major Developments and Their Implications

- Observational Data and Observing Systems
- Major Expansions of Observational Capacity
- Threats to Observational Capacity or Continuity
- New Developments in Reanalyses

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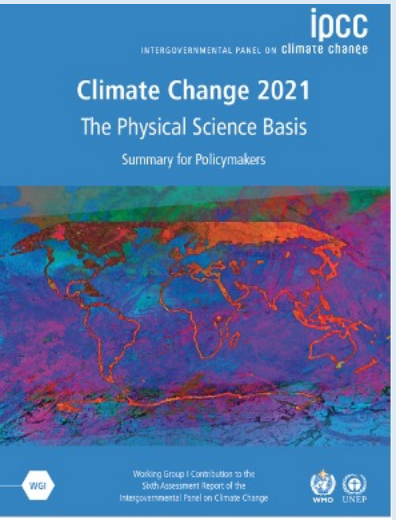


# AI Annex I: Observational Products

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**Lead Authors:**
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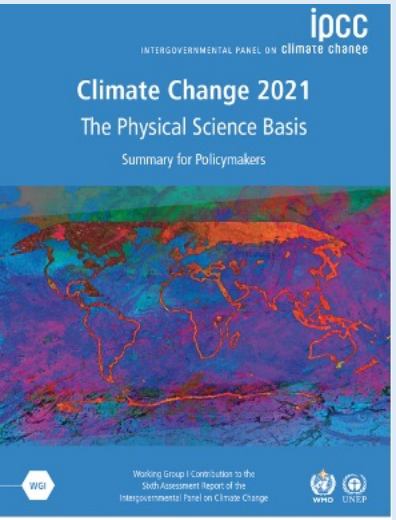
**Table AI.1 | Observational products used by Working Group I in the Sixth Assessment Report.**

| Name | Version | Type | Resolution (Time and Space) | Section(s) | Time Period | Citation, Link and DOI (Where Available) |
|---|---|---|---|---|---|---|
| NOAA-CIRES 20th Century Reanalysis (20CR) | 2c | Reanalysis | 3-hourly<br>2° × 2°, 24 vertical levels | 2.4.1 | 1851–2014 | Compo et al. (2011)<br>www.esrl.noaa.gov/psd/data/20thC_Rean/ |
| NOAA-CIRES 20th Century Reanalysis (20CR) | 3 | Reanalysis | 3-hourly<br>0.5° × 0.5° | 2.3.1<br>3.3.3<br>3.7.1 | 1851–2020 | Slivinski et al. (2019)<br>www.esrl.noaa.gov/psd/data/20thC_Rean/ |
| Finland Climate (Aalto) | | In situ | Daily<br>0.1° × 0.1° | 10.2.1 | 1961–2010 | Aalto et al. (2016)<br>www.csc.fi/-/paituli |
| ACORN-SAT Australian temperature data | 2.1 | In situ | Daily<br>Point-based | Atlas 6.2 | 1910–2020 | Trewin et al. (2020)<br>www.bom.gov.au/climate/data/acorn-sat/ |
| AERONET AOD Level 2.0 | 3 | Remote sensing | Monthly<br>Point-based | 2.2.6 | 1995–2020 | Giles et al. (2019)<br>https://aeronet.gsfc.nasa.gov/data_push/AOT_Level2_Monthly.tar.gz |
| Advanced Global Atmospheric Gases Experiment (AGAGE) | | In situ | Up to 36 times per day<br>Point-based | 2.2.3<br>2.2.4<br>5.2.2<br>5.2.3 | 1978–2020 | Prinn et al. (2018)<br>http://agage.mit.edu/data |

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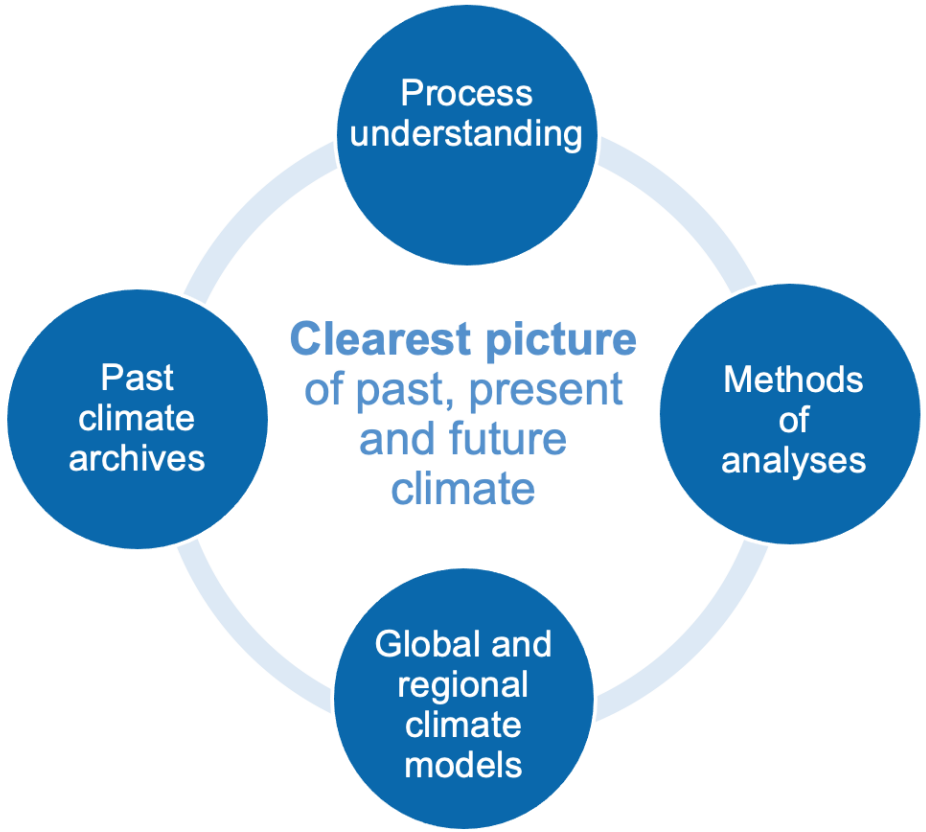
**3** Human influence on the climate system
**4** Future global climate

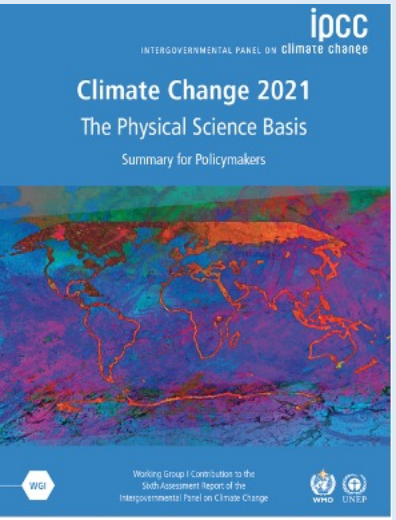
## Climate processes

**5** Global carbon and other biogeochemical cycles
**6** Short-lived climate forcers
**7** The Earth's energy budget
**8** Water cycle changes
**9** Oceans, cryosphere, sea change

## Regional climate information

**10** Linking global to regional climate
**11** Weather and extreme events
**12** Climate information for regional impact & risk assessment
**13** Regional climate change Atlas



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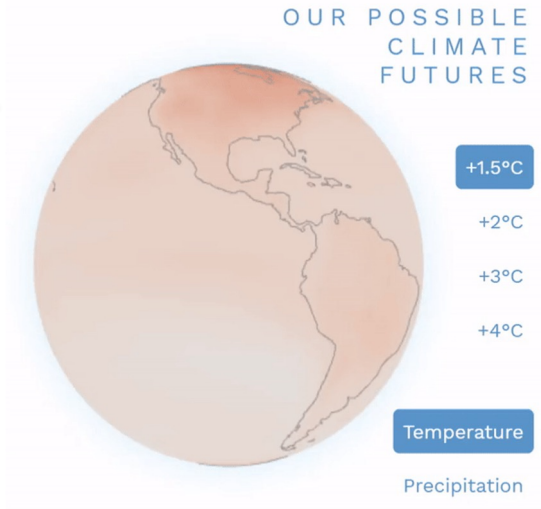


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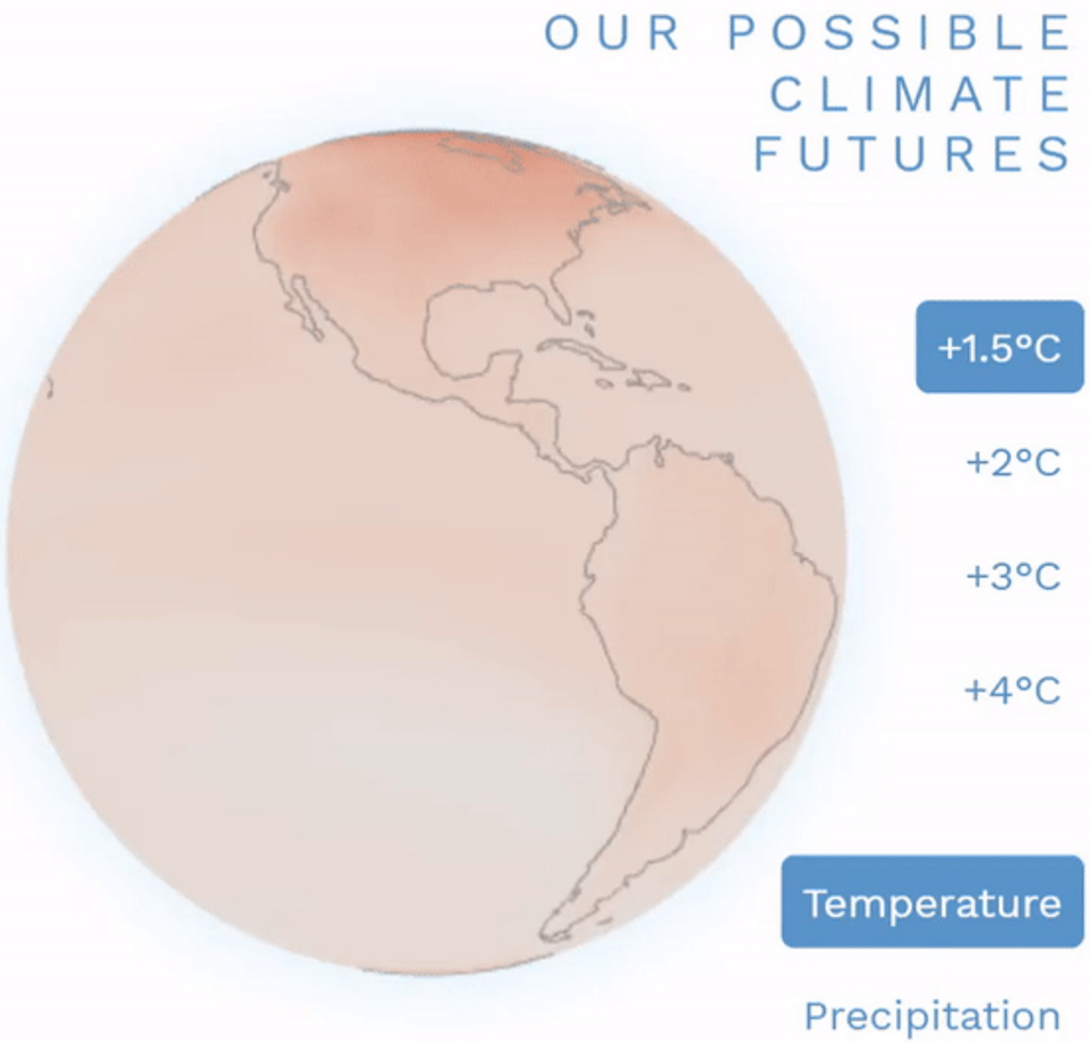
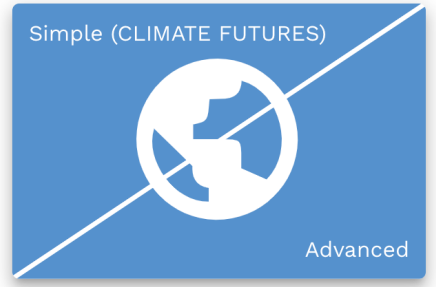
| |
|---|
| Africa |
| Asia |
| Australasia |
| Central and South America |
| Europe |
| Mountains |
| North and Central America |
| Ocean |
| Polar regions |
| Small Islands |
| Urban areas |

# https://interactive-atlas.ipcc.ch/




A novel tool for flexible spatial and temporal analyses of much o the observed and projected climate change information underpinning the Working Group I contribution to the Sixth Assessment Report, including regional synthesis for Climatic Impact-Drivers (CIDs).




REGIONAL INFORMATION

REGIONAL SYNTHESIS

OBSERVATIONS

- CRU TS
- HadCRUT5
- Berkeley Earth
- GPCC
- GPCP
- ERA5
- W5E5 (ERA5 adjusted)
- Daymet (North America)
- E-OBS (Europe)
- APHRODITE (Asia)
- AGCD (Australia)

# FAIR Data and Code – Figure Data Tables

- Figure traceability (which input datasets were used and giving the data creators credit)
- The data tables can also include links to code
- License type

| Figure number / Table number / Chapter section | Dataset / Code name | Type | Filename / Specificities | License type | Dataset / Code citation | Dataset / Code URL | Related publications |
|---|---|---|---|---|---|---|---|
| Figure 1.1 | Hadley Centre Sea Surface Temperature v3 (HadSST3) | Input dataset | HadSST.3.1.1.0_annual_globe_ts.txt | | | https://www.metoffice.gov.uk/hadobs/hadsst3 | Kennedy et al. (2011a, 2011b) |
| | BCC-CSM2-MR: hist-aer, hist-ghg, historical | Input dataset | | CC BY-SA 4.0 | Wu et al. (2018a, 2018b, 2019) | | |
| | Figure 1.1 Code | Code | | | Bloggs et al. (2021) | https://github.com/IPCC-WG1/Figure | |

*Observational dataset*

*Model dataset*

*Figure code*

# FAIR Data and Code

**Long term data archival via IPCC Data Distribution Centre** - www.ipcc-data.org

- CMIP6 snapshot
- Assessed 'constrained' datasets
- Figure data
- WGI Interactive Atlas full provenance and reusability

**Code**

- WGI Github Repository - github.com/IPCC-WG1

**Citations**

- Data and code are published via the DDC catalogue or with Zenodo
- Please also cite the full relevant (e.g. chapter) citation.

# Lessons learned for AR7

- *Ease of integration of multiple lines of evidence e.g. with community data standards and documentation, analysis tools, facilitated data access*
- *Documentation and curation of data assessed in the report for transparency and FAIR principles for open science*
- *Cataloguing datasets and literature assessed in the report*
- *Greater integration of data products, including links to other WGs by means of interactive tools to support user access and exploration*
- *Coordinated community support of the assessment and small author teams*

**SIXTH ASSESSMENT REPORT**
Working Group I – The Physical Science Basis

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

# Thank you

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