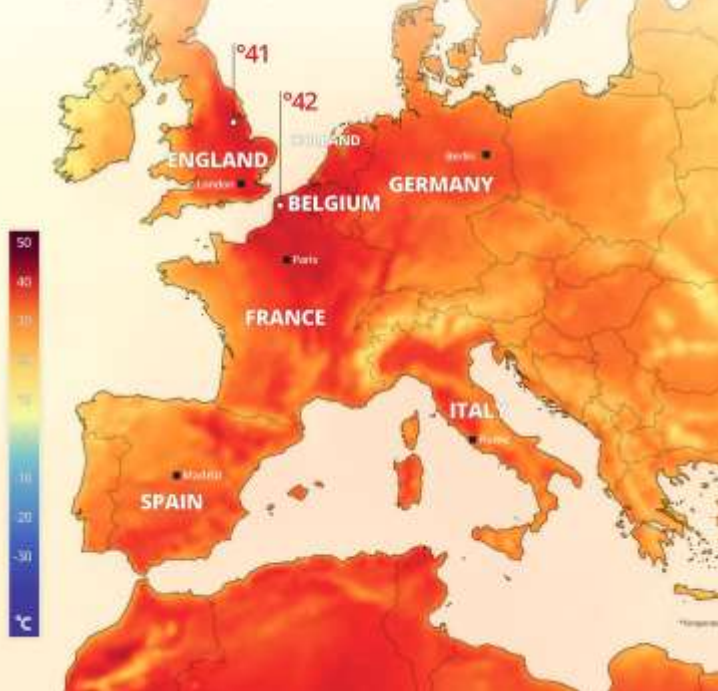


THE PHYSICAL SCIENCE BASIS FOR CLIMATE CHANGE: CAUSES & CONSEQUENCES

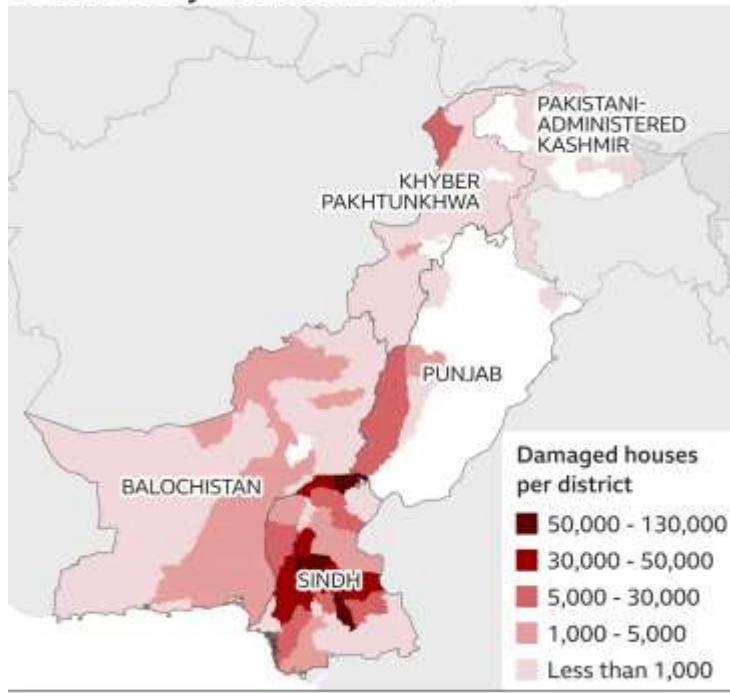
Professor Richard Allan [@rpallanuk](#) r.p.allan@reading.ac.uk
GRIDSERVE conference, Wokefield Park, 14th March 2023



Europe hit by scorching heatwave



Areas hit by monsoon rains



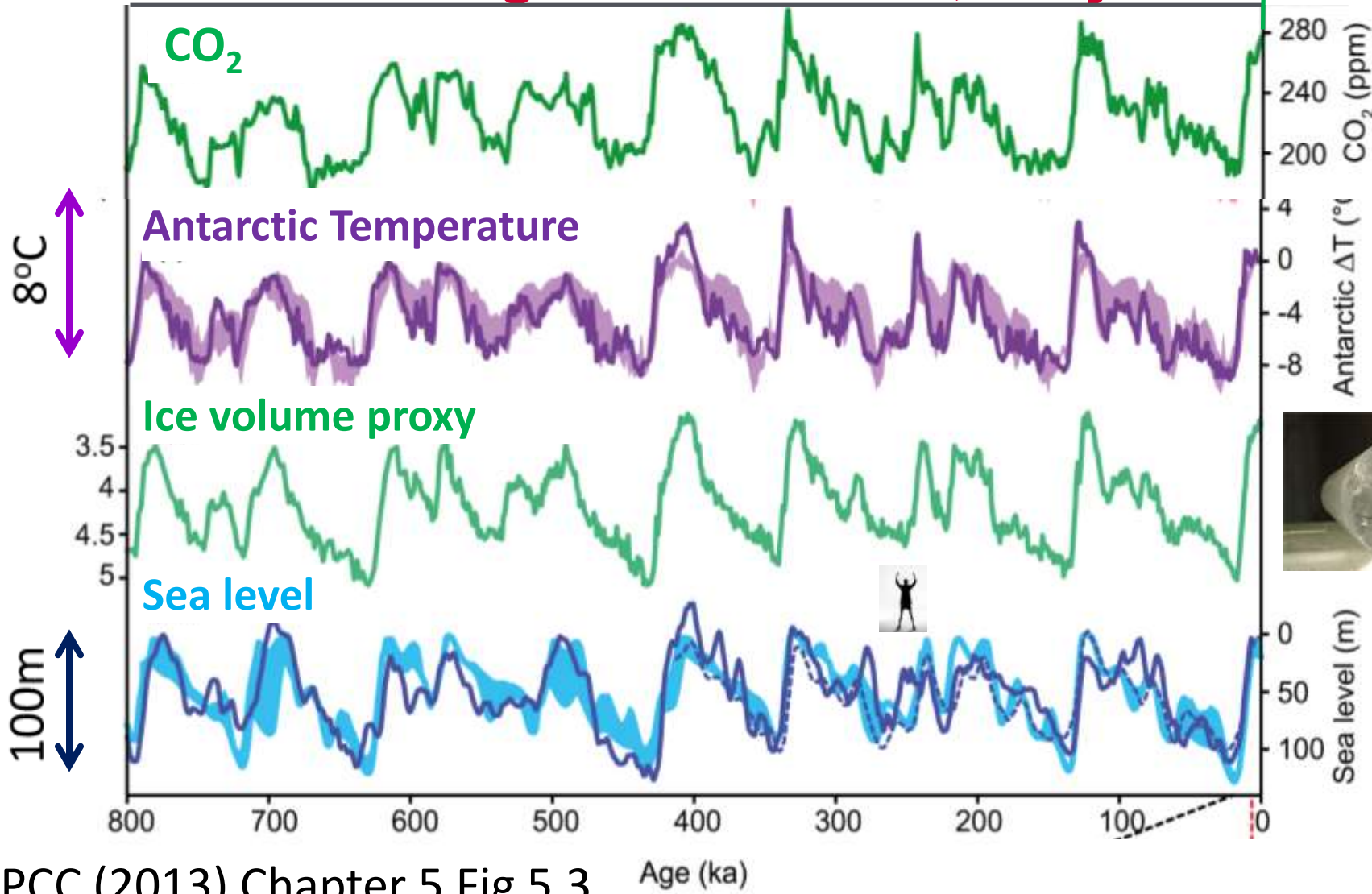
Source: UN OCHA

BBC

ONGOING CLIMATE CHANGE

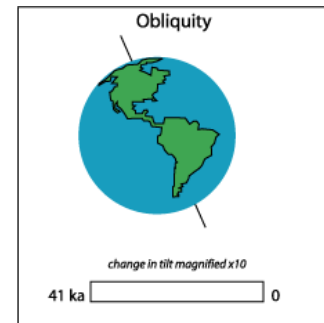
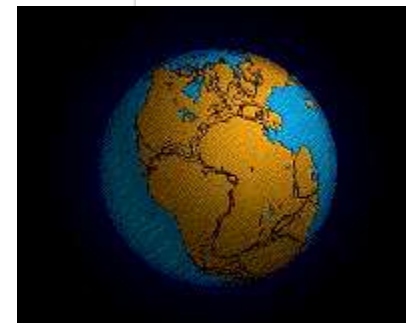


Climate change over last 800,000 years



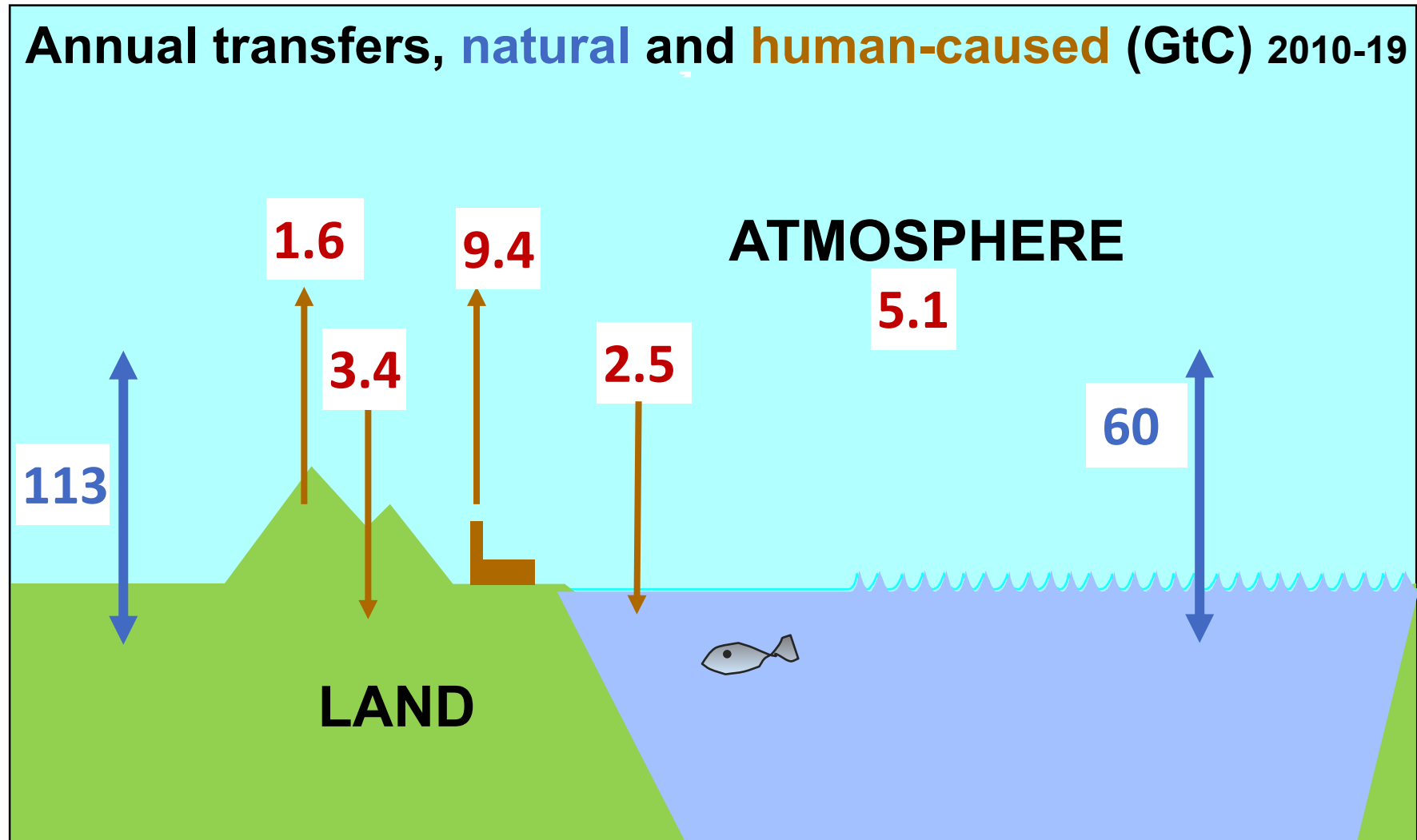
418 ppm

The climate has always changed. But...



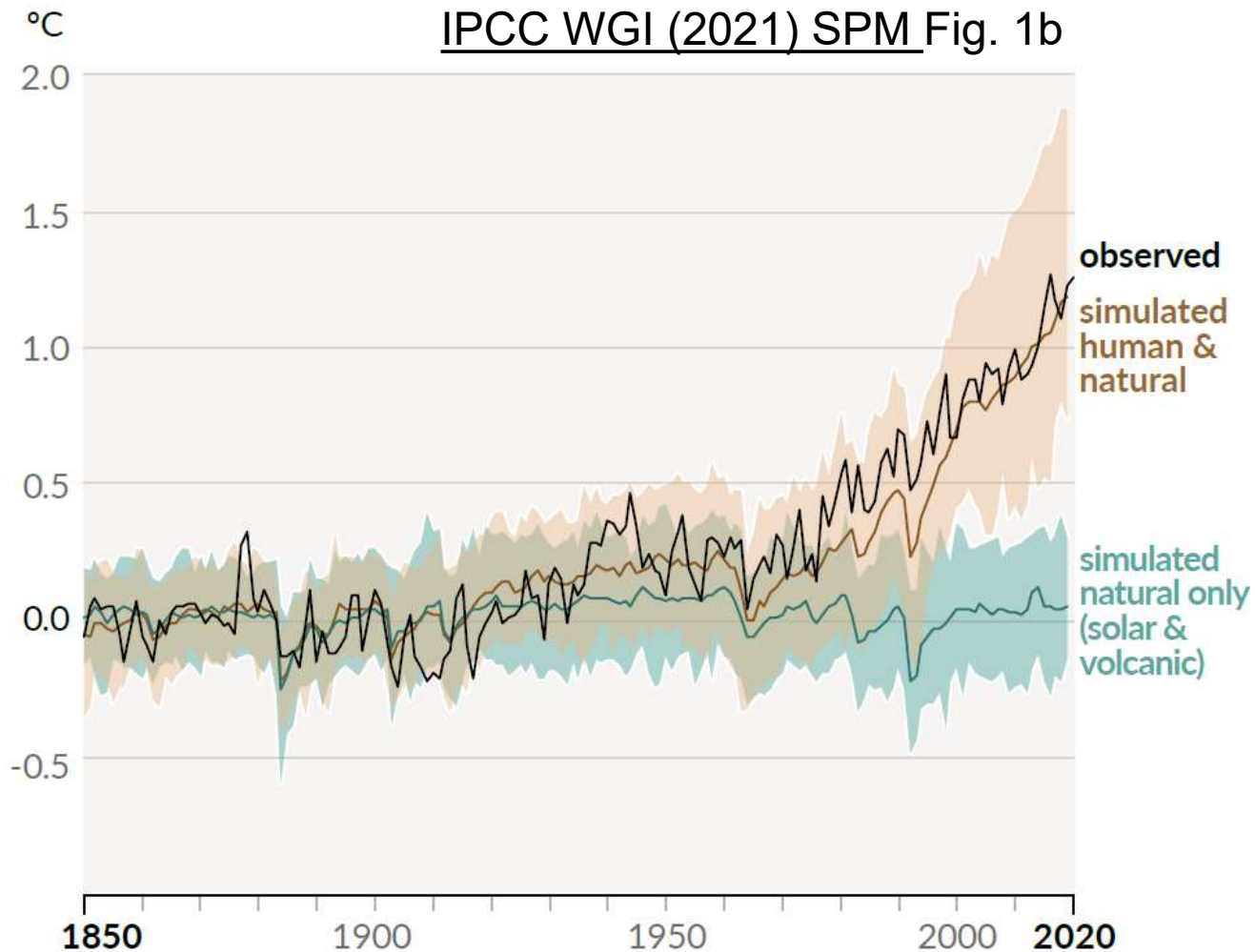
IPCC (2013) Chapter 5 Fig 5.3

Natural & human-influenced carbon cycle



- Human activities have tipped the natural carbon cycle out of balance
- This is driving increases in atmospheric CO₂ concentrations
- CO₂ concentrations highest in at least 2 million years

It is indisputable that human activities are causing climate change



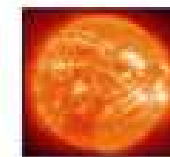
► Observed warming is driven by emissions from human activities



► Natural factors do not contribute to rapid warming over past 5 decades

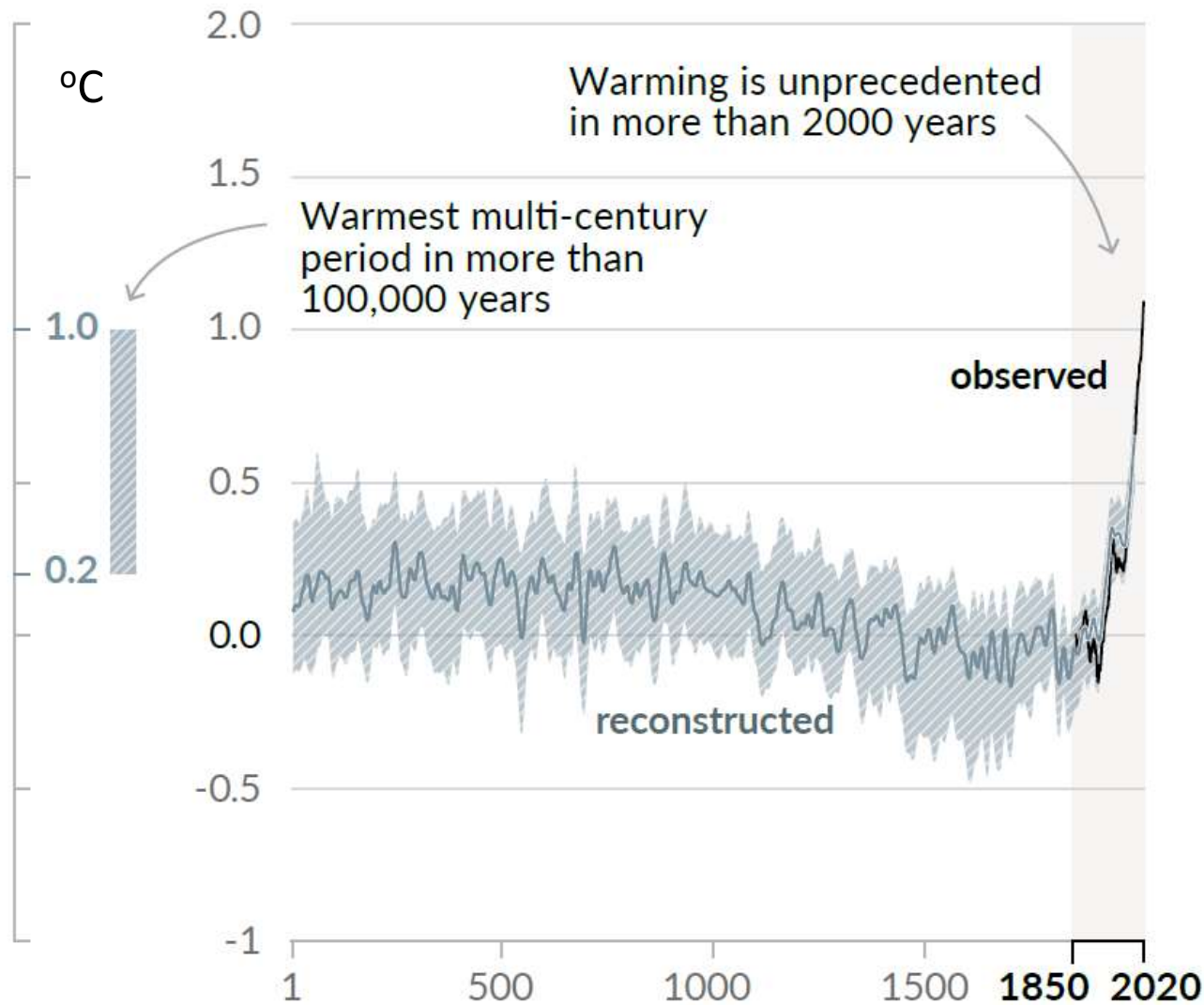


► Greenhouse gas warming has been partly masked by aerosol cooling



► Warming is amplified by feedback loops involving water vapour, ice & clouds

Recent changes in the climate are widespread, rapid and unprecedented in thousands of years



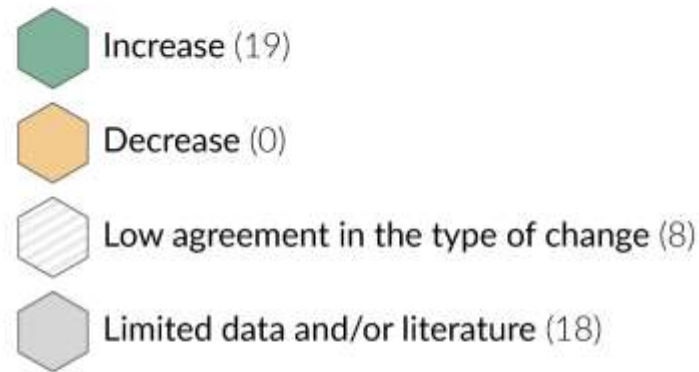
- Global mean surface temperature increased faster since 1970 than in any other 50 year period over at least the last 2000 years
- Warmth of past decade comparable to last interglacial 125,000 years ago [*when peak sea level was 5-10m higher than today*]

[IPCC WGI 2021 SPM]

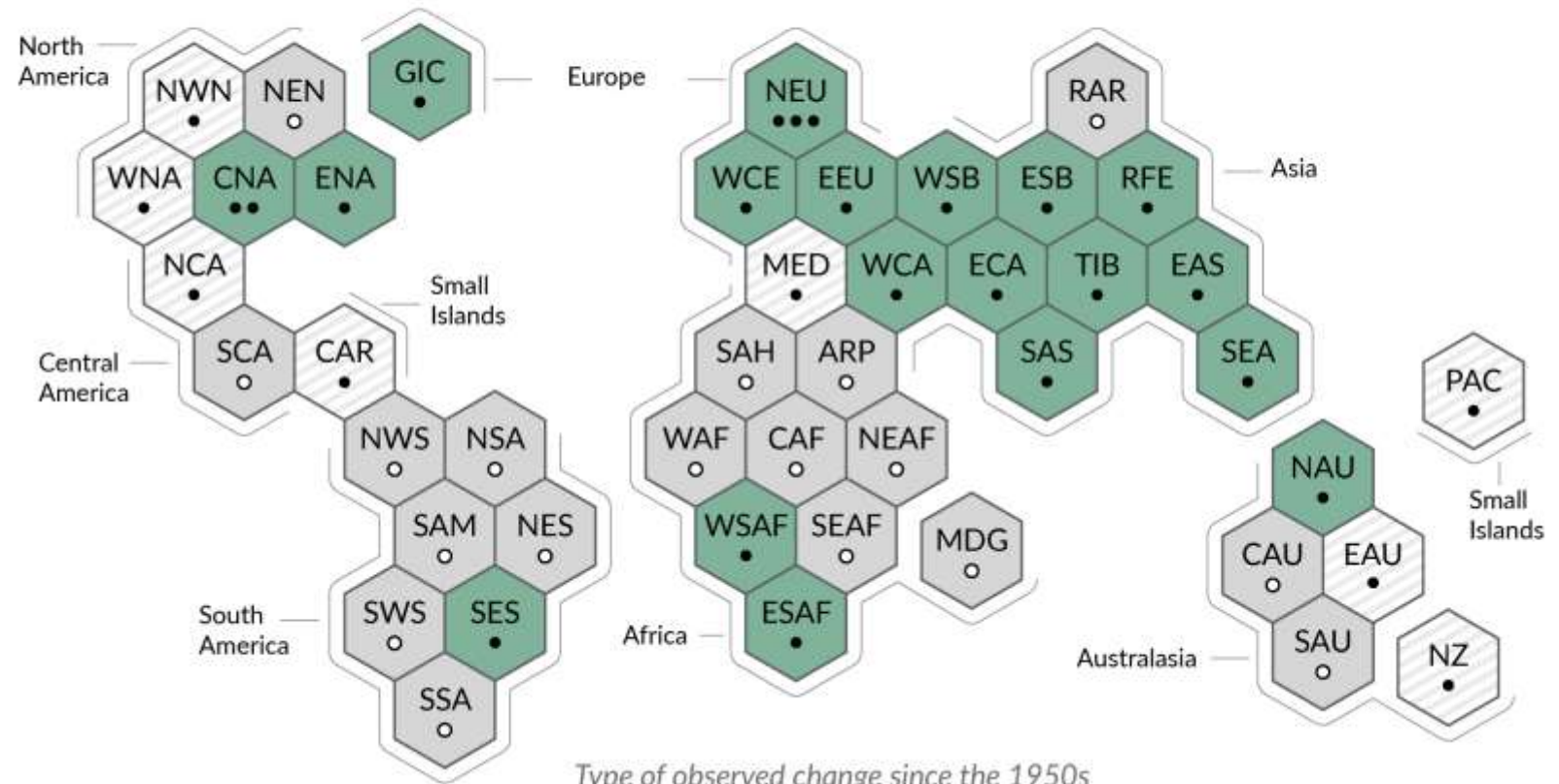
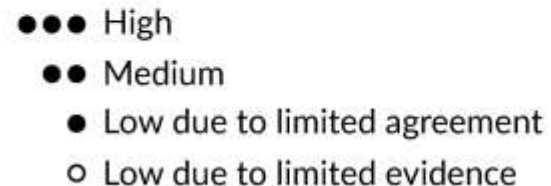
Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

b) Synthesis of assessment of observed change in heavy precipitation and confidence in human contribution to the observed changes in the world's regions

Type of observed change in heavy precipitation



Confidence in human contribution to the observed change

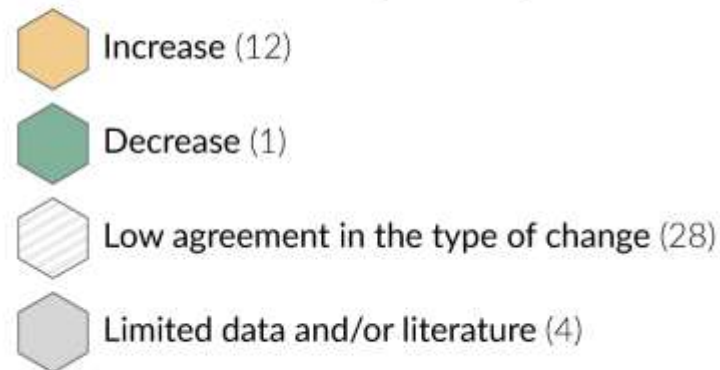


Type of observed change since the 1950s

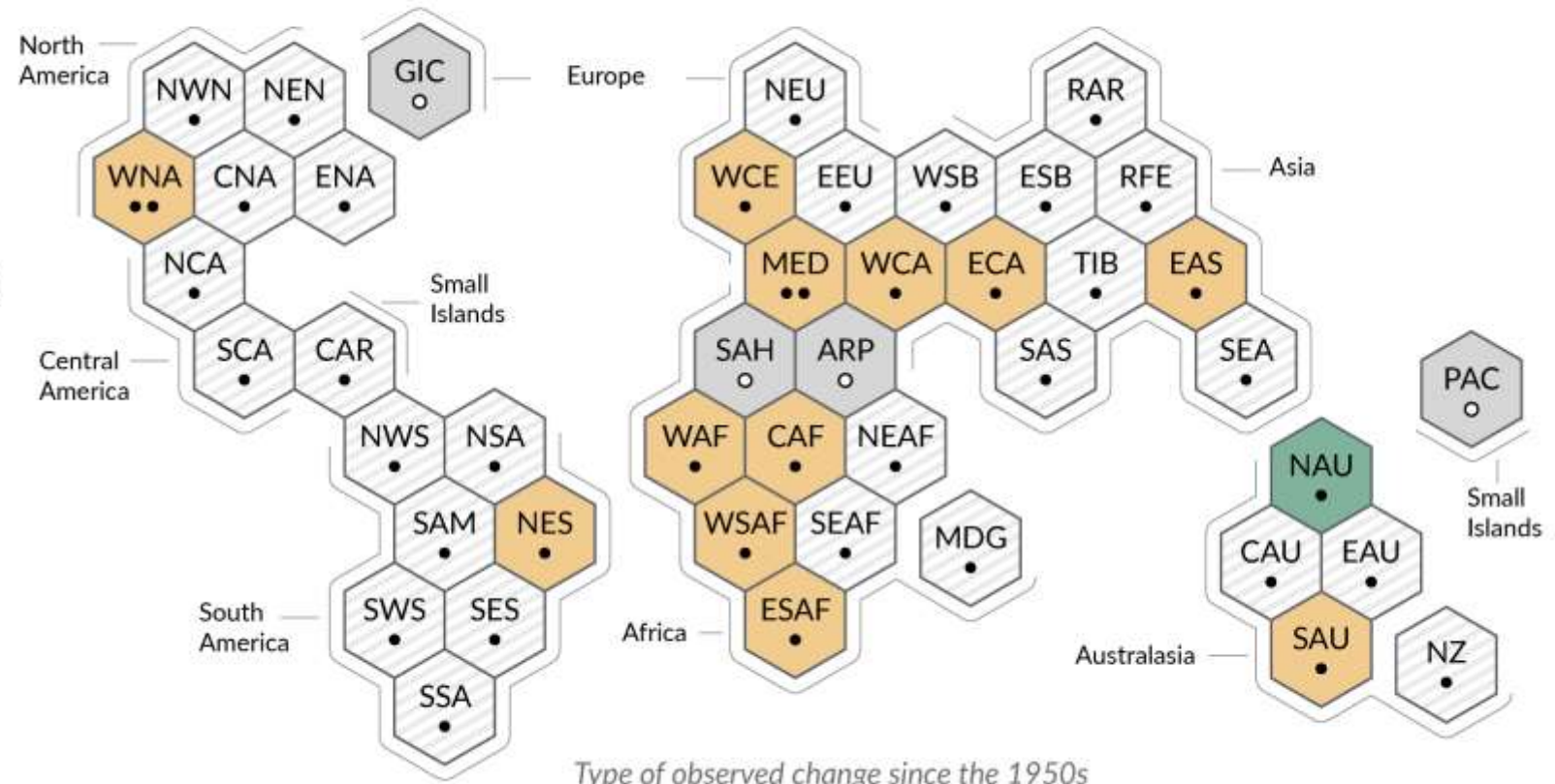
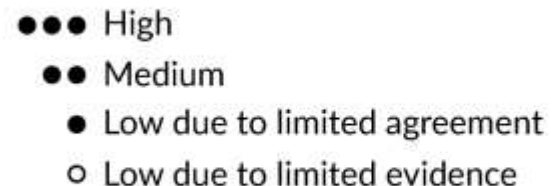
Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions

Type of observed change in agricultural and ecological drought



Confidence in human contribution to the observed change



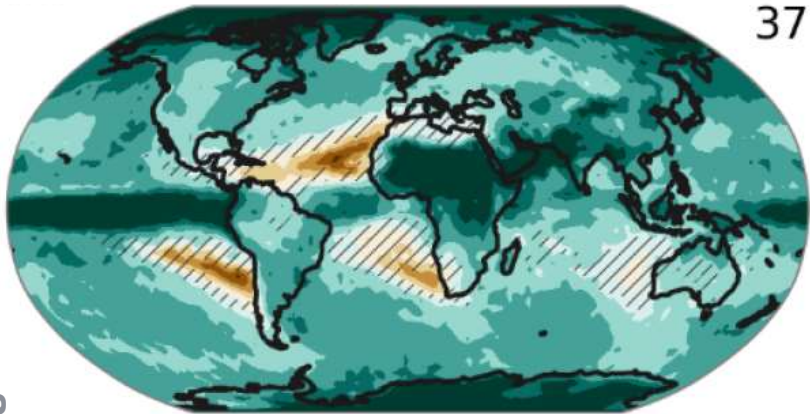


“ Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events.

Water cycle changes at 4°C warming...

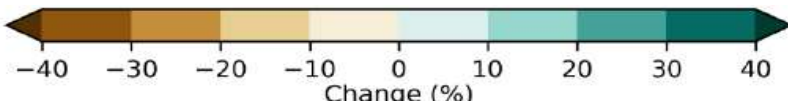
Precipitation intensity (Rx1day)

37

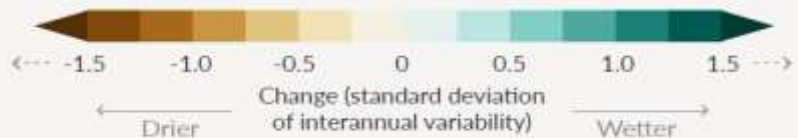
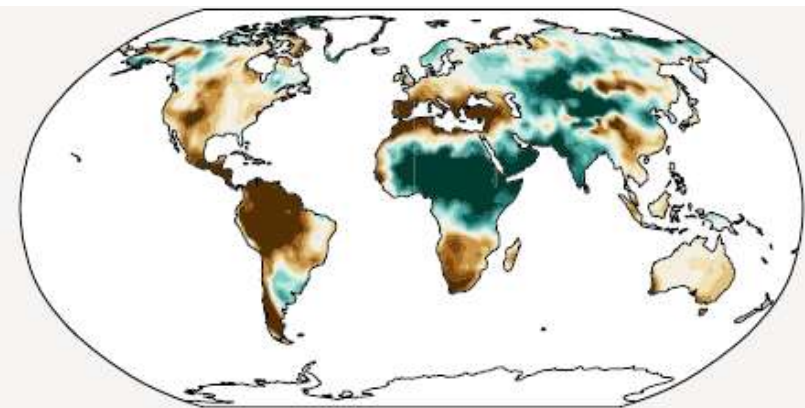


- More intense rainfall
- More severe droughts (and hot/dry extremes)
- Wet events wetter, dry events drier
- Increased variability (day to day, year to year)
- Tipping points?

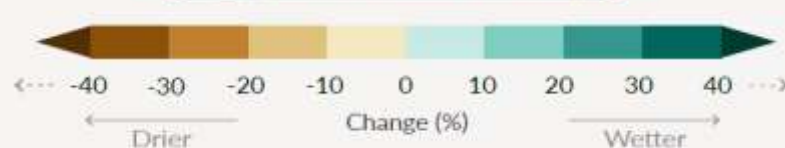
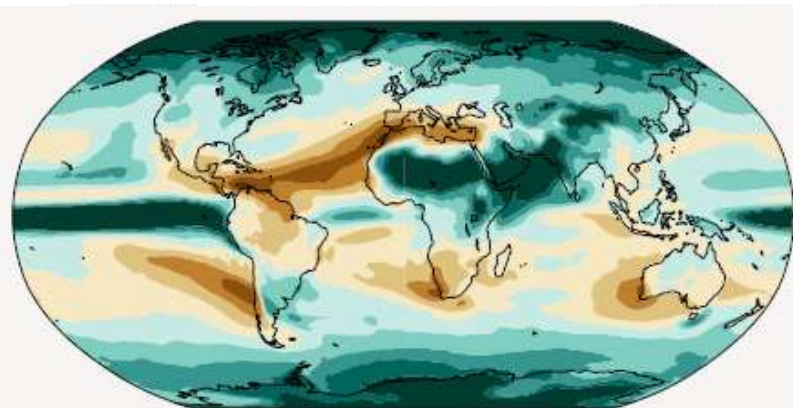
% change



Total Column Soil Moisture



Mean Precipitation



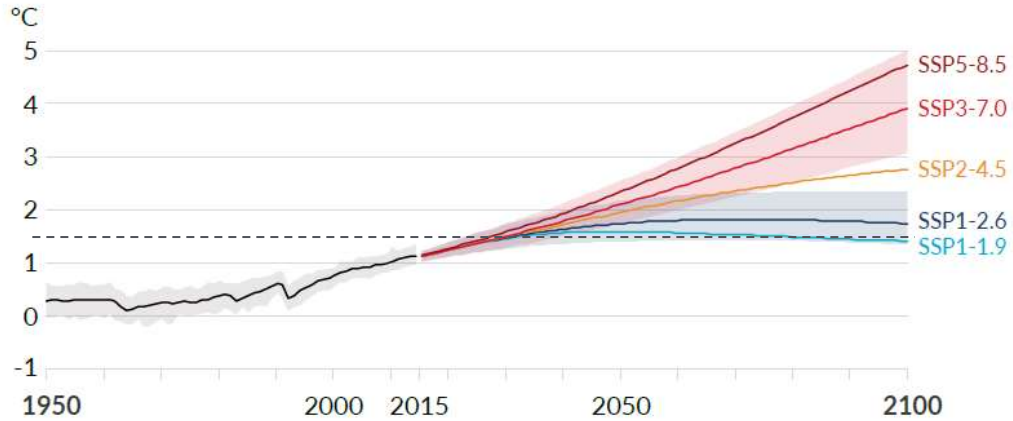
- But large effect of circulation change on regional water cycle

IPCC WG1 (2021) Chapters 11, 4, 8 and SPM; see also Technical Summary BoxTS.6

Some changes in the climate system are irreversible but many changes can be slowed or stopped by limiting warming



a) Global surface temperature change relative to 1850-1900

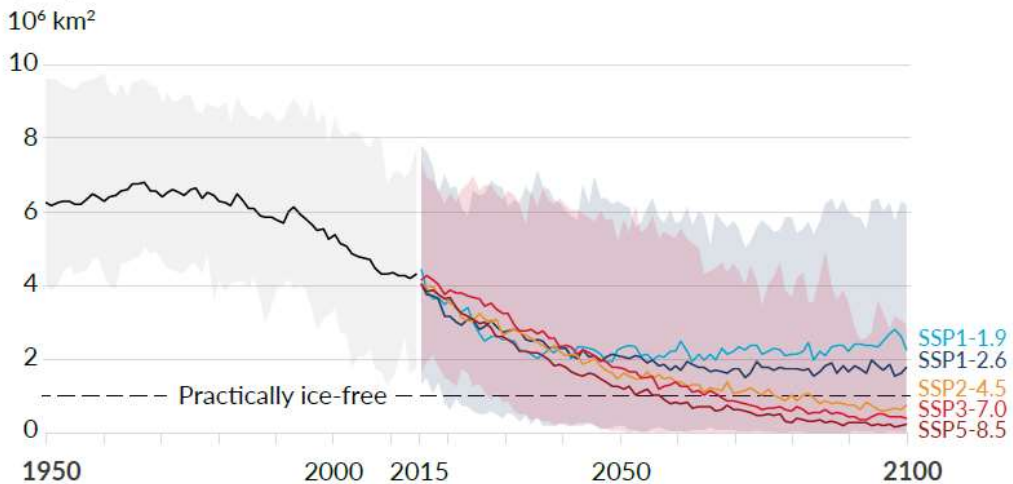


Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO₂ and other greenhouse gas emissions occur in the coming decades

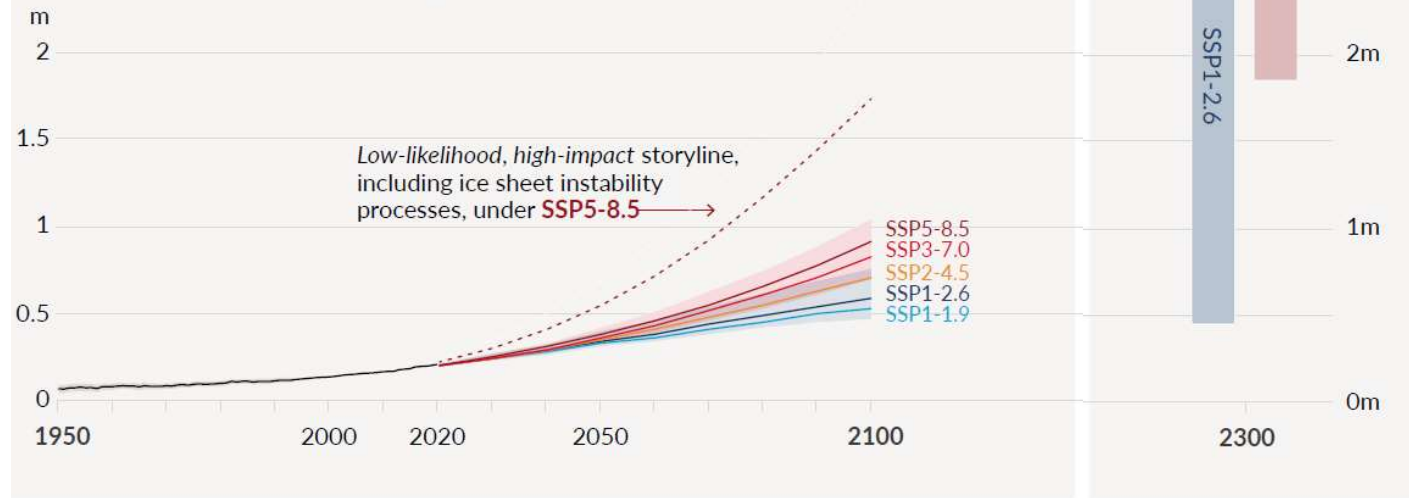
[IPCC (2021) WG1 SPM]

High emissions
Low emissions

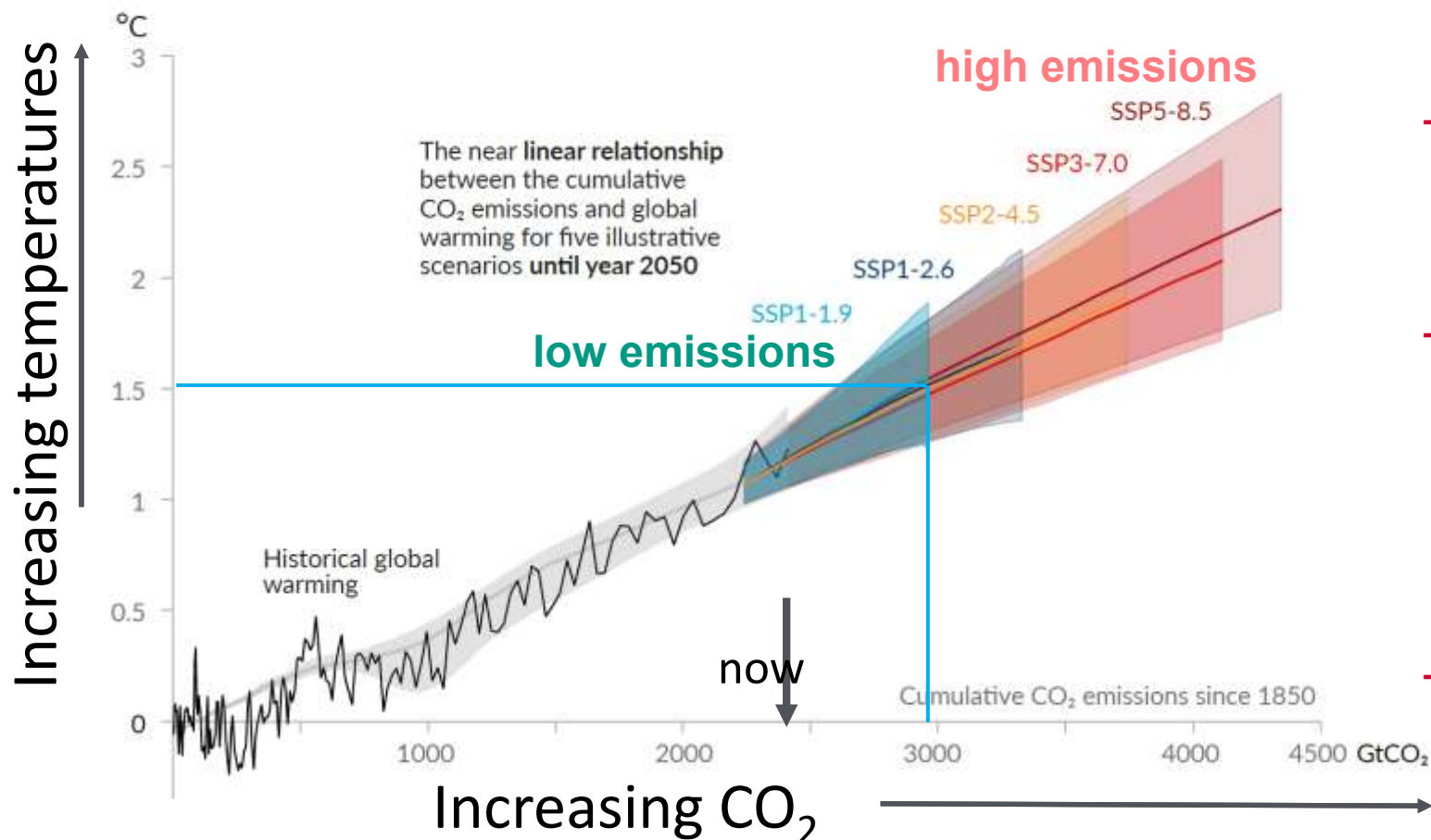
b) September Arctic sea ice area



d) Global mean sea level change relative to 1900



Limit Carbon Emissions to Avoid Dangerous Climate Change

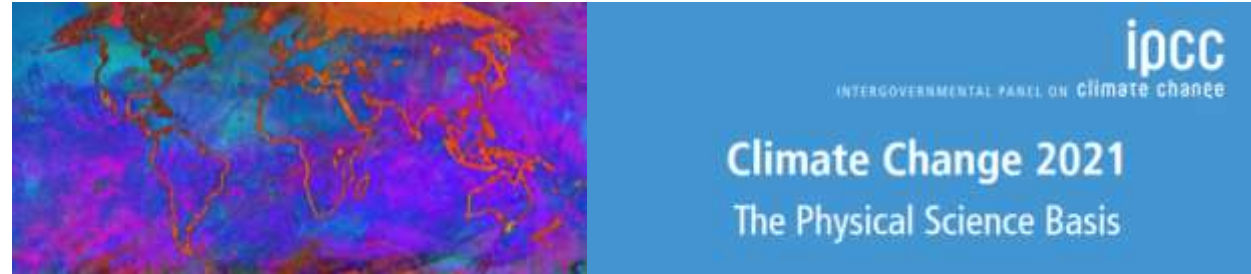


[IPCC WGI 2021 SPM]

- Act now
 - To keep future options open
- Act everywhere
 - Efforts in all sectors are needed to reach global zero CO₂ emissions
- Act thoughtfully
 - Develop strategies maximising synergies and taking into account the local context, use a wide array of measures and actions
- Act jointly
 - Collaboratively and including national and sub-national authorities, civil society, the private sector and local communities

Joeri Rogelj (*IPCC AR6 & SR1.5 author*)

Key Messages

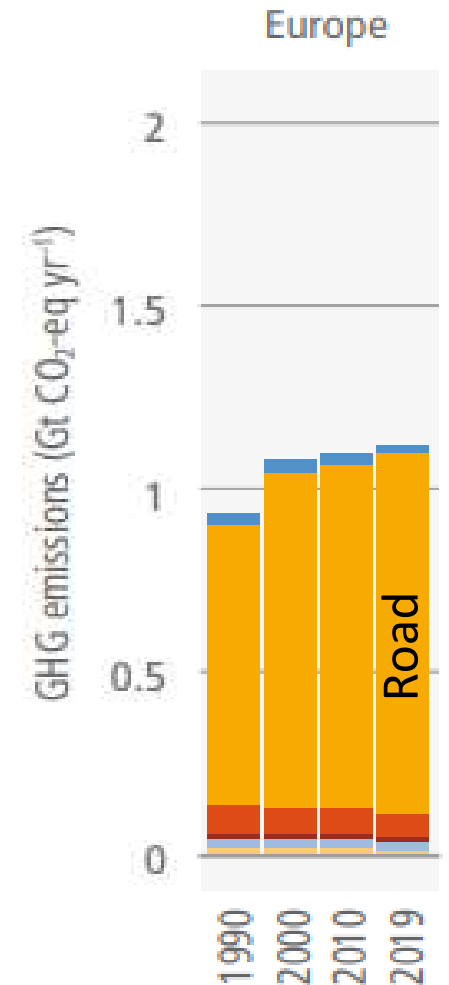


- Earth's climate has always varied but it is an established fact that human activities are now driving climate change
- Recent changes in climate are widespread, rapid and unprecedented in thousands of years.
- Human activities are intensifying extreme climate events, including heat waves, heavy rainfall, and droughts
- Every bit of global warming increases the magnitude of climate change including the severity of climate extremes
- Limiting warming to 1.5°C requires immediate, rapid, and large-scale reductions in greenhouse gas emissions



Mitigation of Transport emissions

- IPCC (2022) WG3, Chapter 10 Transport, Jaramillo et al.
- Transport 23% of global energy-related CO₂ emissions
- 70% of direct transport emissions came from road vehicles
- Growing need for systemic infrastructure changes that enable behavioural modifications
- Battery electric vehicles have lower lifecycle greenhouse gas emissions (~87 gCO₂-eq per vehicle-km) than internal combustion engine vehicles (~203 gCO₂-eq per vehicle-km) when charged with low-carbon electricity
- Limiting warming to 1.5°C with no overshoot requires 42-68% reduction in transport-related CO₂ emissions by 2050
- growing concerns about resource availability, labour rights, non-climate environmental impacts, and costs of critical minerals needed for lithium-ion batteries

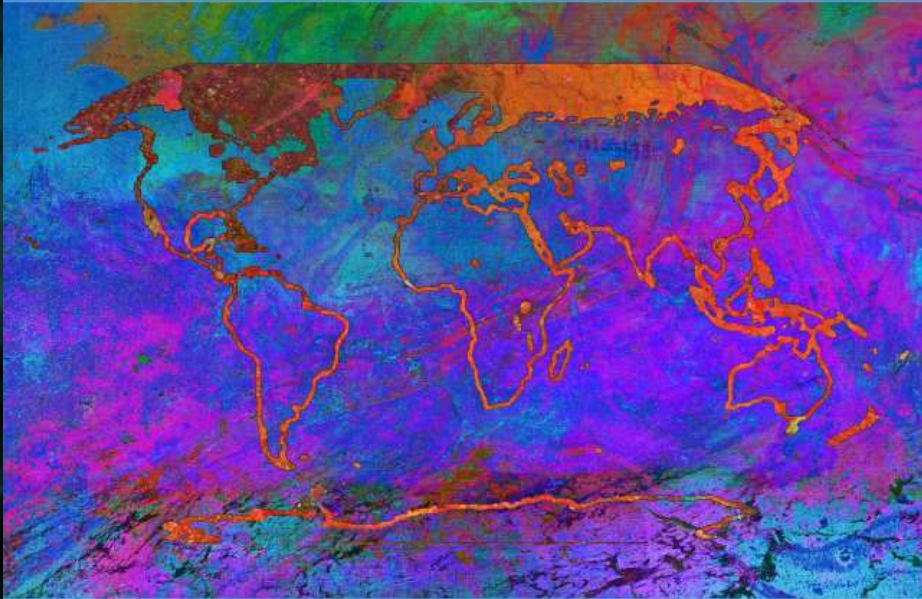


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INTERGOVERNMENTAL PANEL ON climate change

Climate Change 2021

The Physical Science Basis



WGI

Working Group I contribution to the
Sixth Assessment Report of the
Intergovernmental Panel on Climate Change



IPCC (2023)
Synthesis Report
published Monday
20th March

www.ipcc.ch/report/ar6/wg1

