Department of Meteorology

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OBSERVING EARTH TO MONITOR, UNDERSTAND AND PREDICT CLIMATE CHANGE

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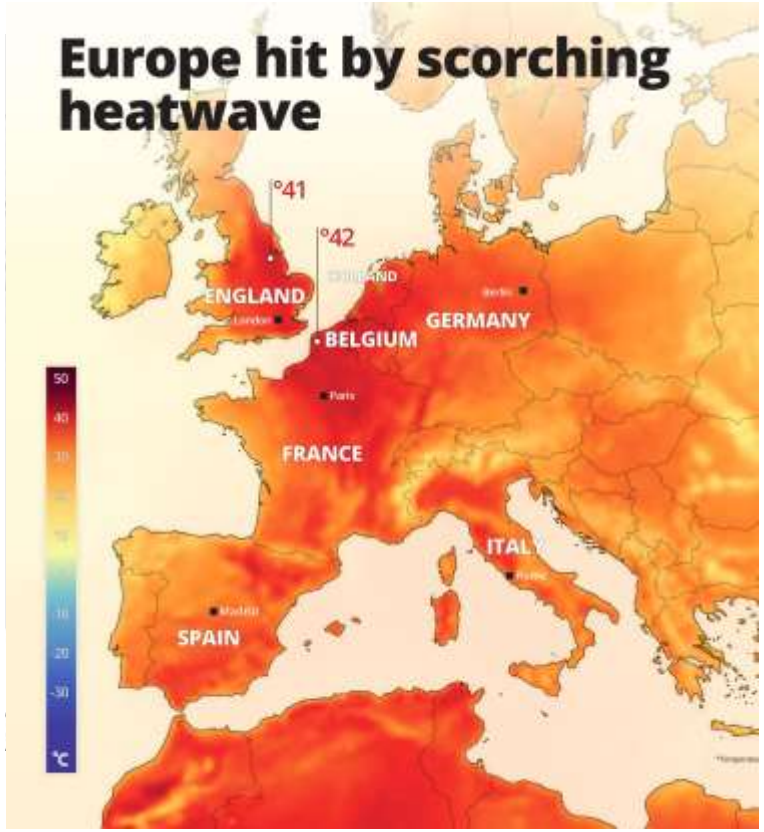
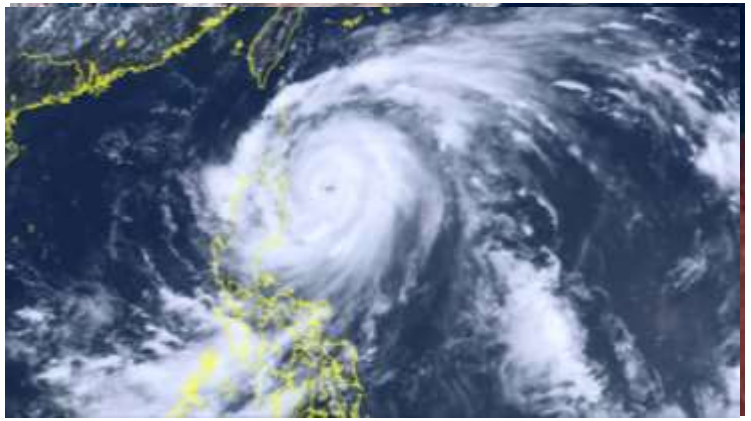
ONGOING CLIMATE CHANGE





www.met.reading.ac.uk/~sgs02rpa/extreme.html

Climate change over last 800,000 years

420 ppm

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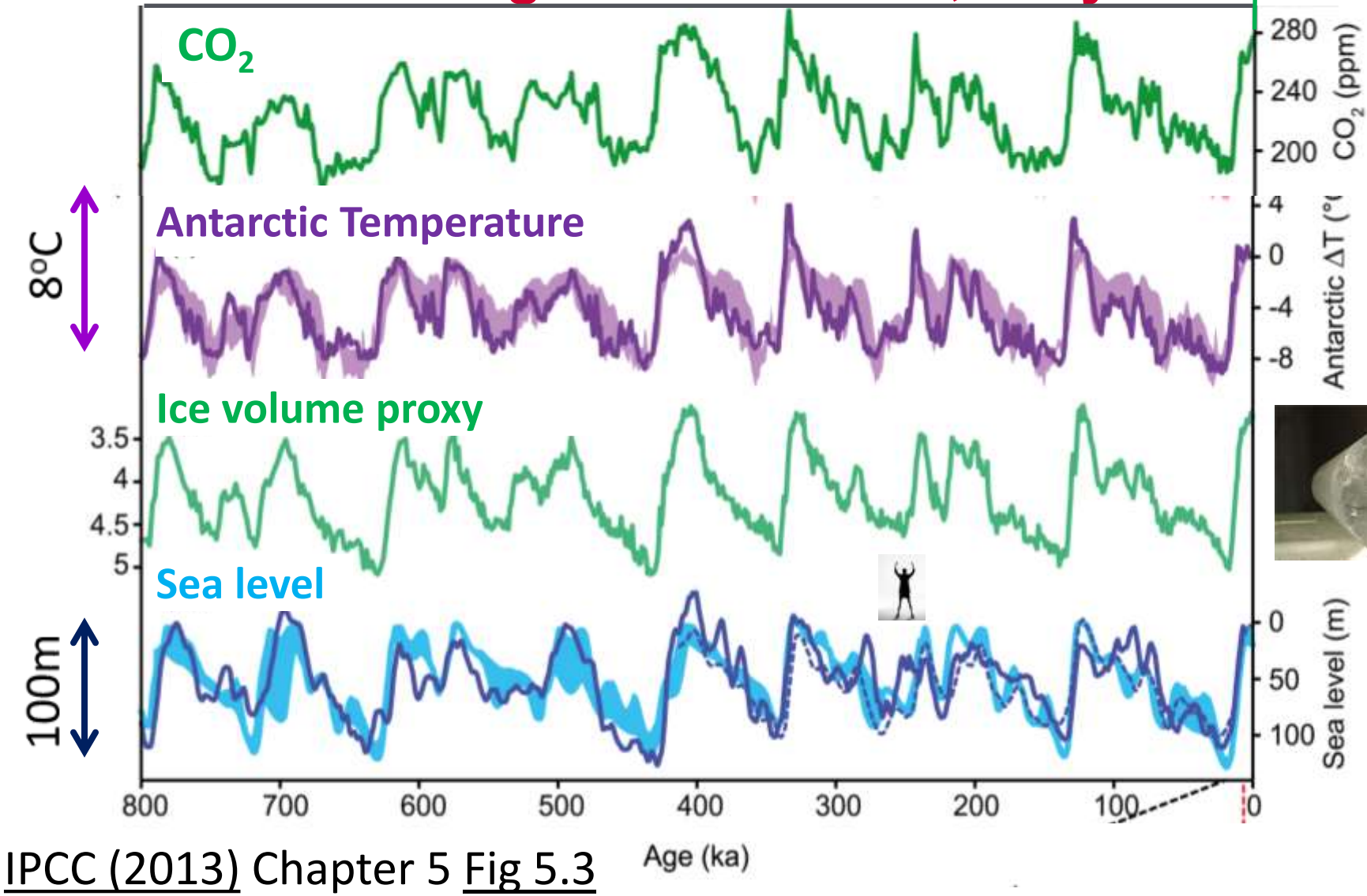
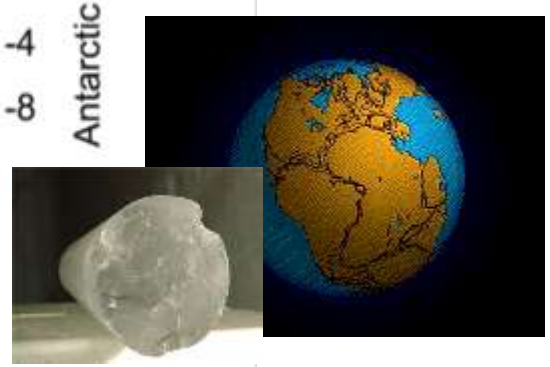
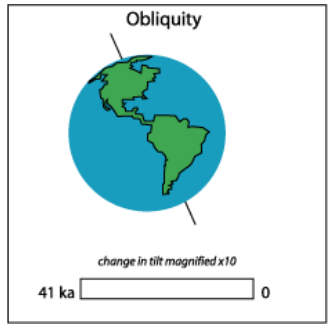


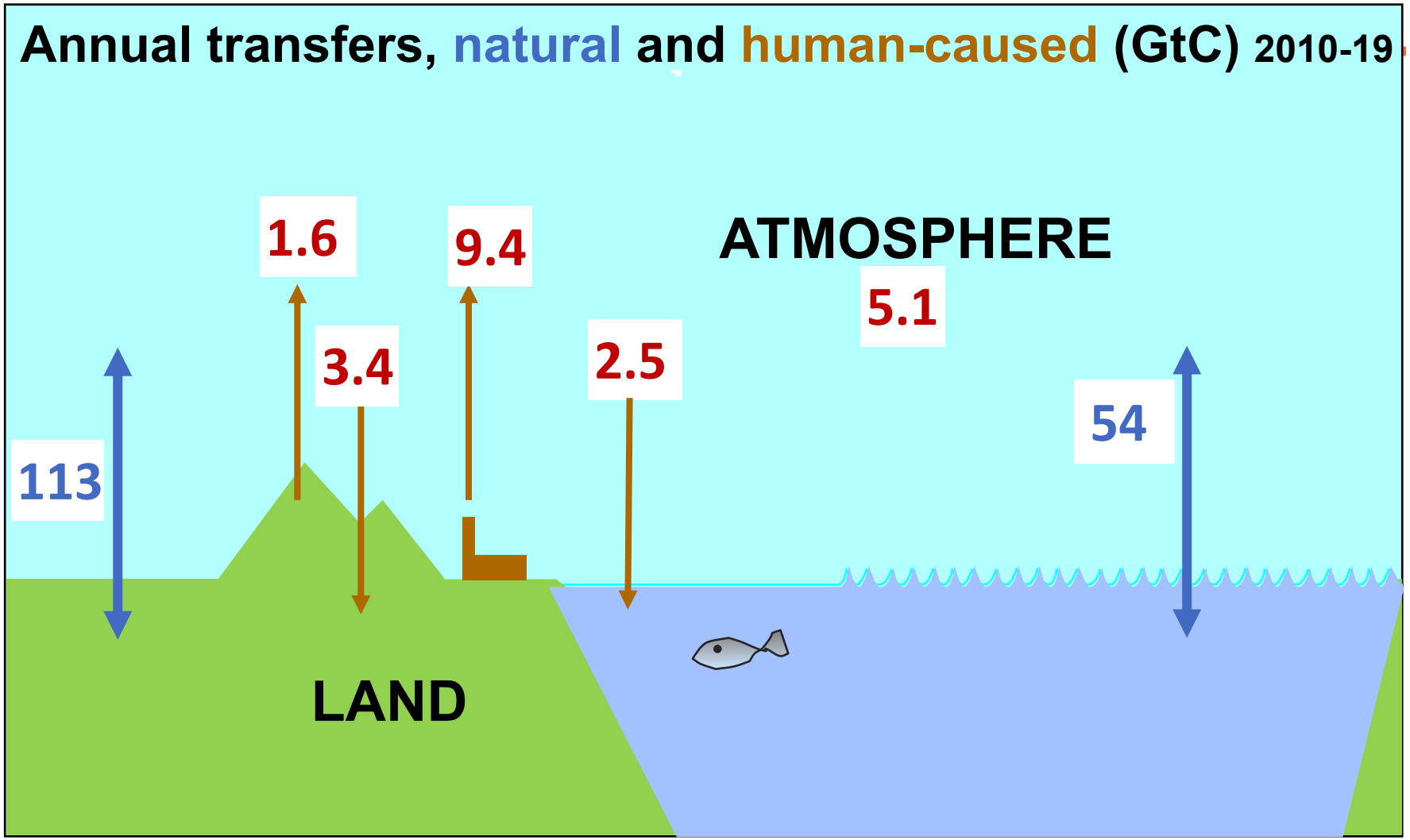
IPCC (2013) Chapter 5 Fig 5.3

The climate has always changed. But…





Natural & human-influenced carbon cycle



- Human activities have tipped natural carbon cycle out of balance
- This is driving increases in atmospheric CO_2 concentrations
- CO_2 concentrations highest in at least 2 million years

Values in billions of tonnes of Carbon per year from IPCC (2021) Ch5

It is indisputable that human activities are causing climate change

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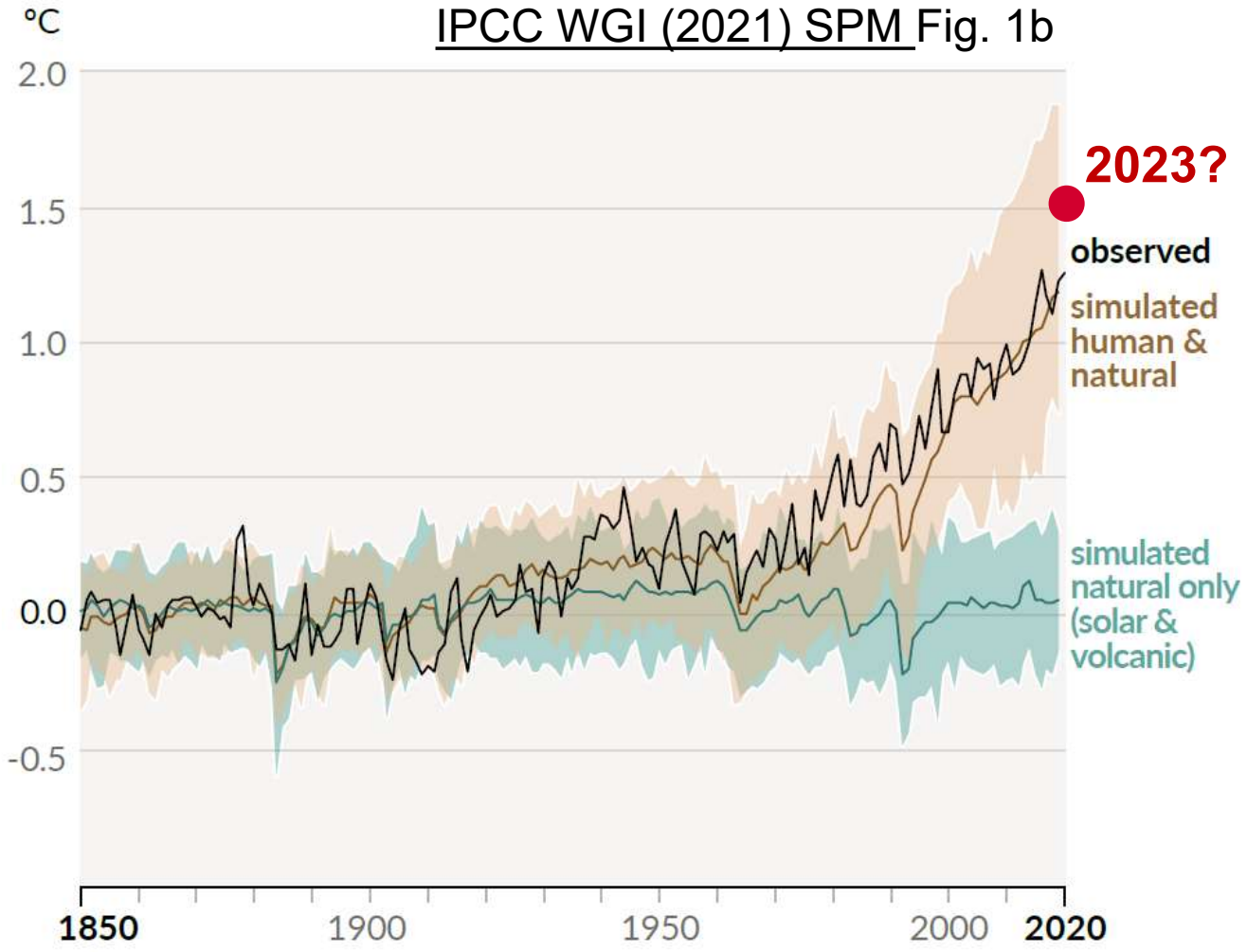
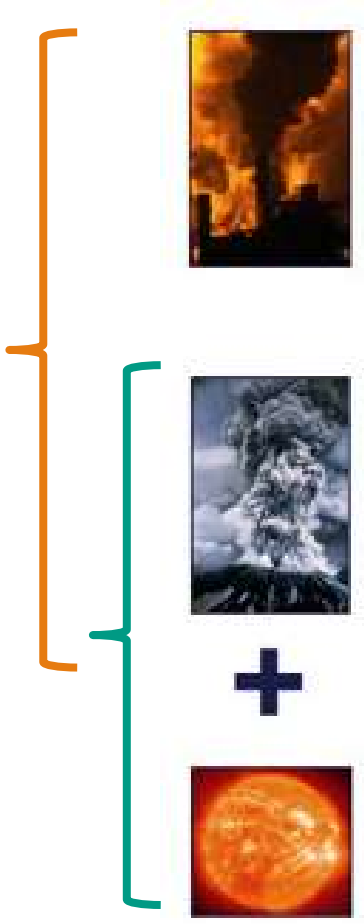
IPCC WGI (2021) SPM Fig. 1b





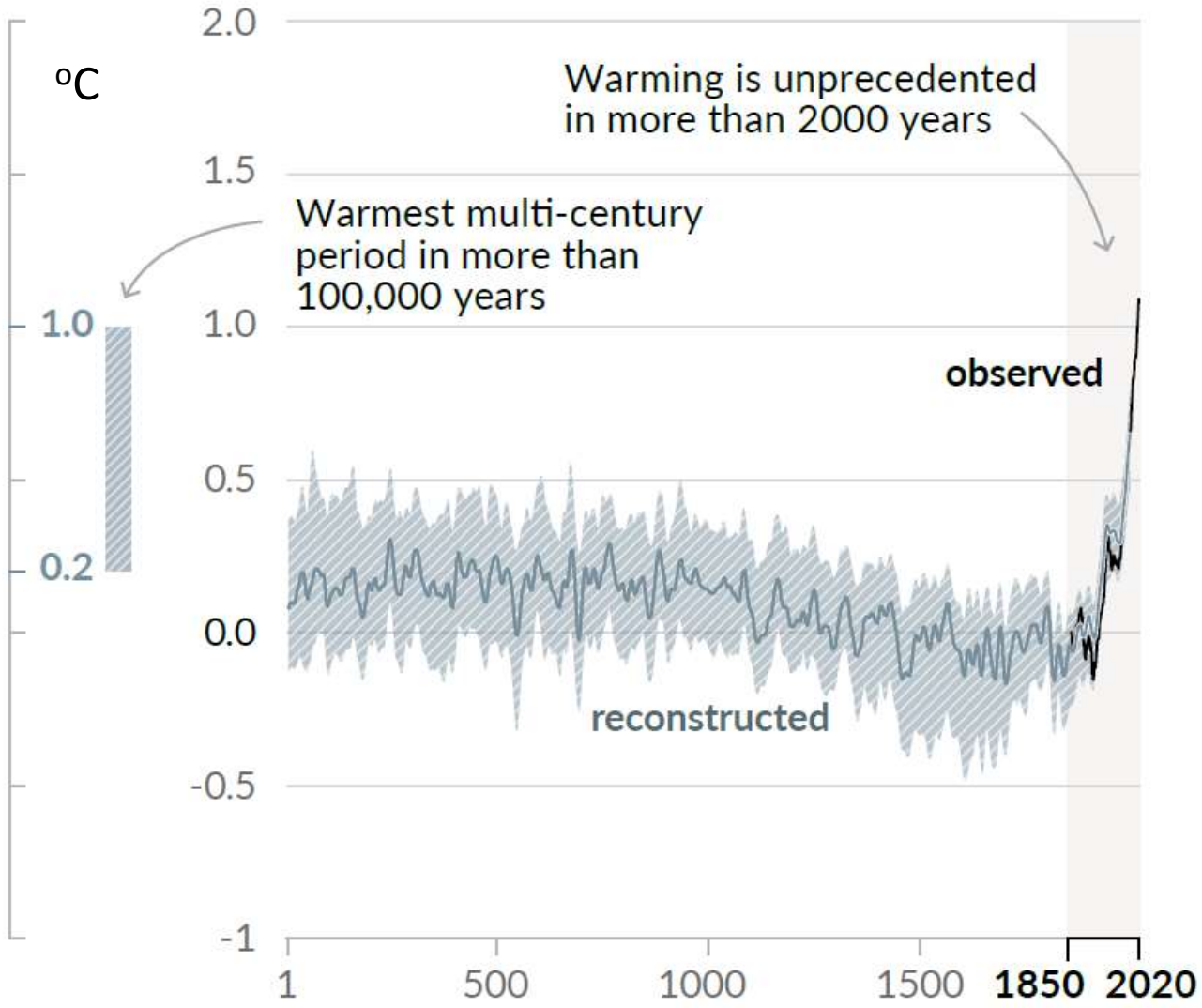
► Observed warming is driven by emissions from human activities

► 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

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Figure SPM.3

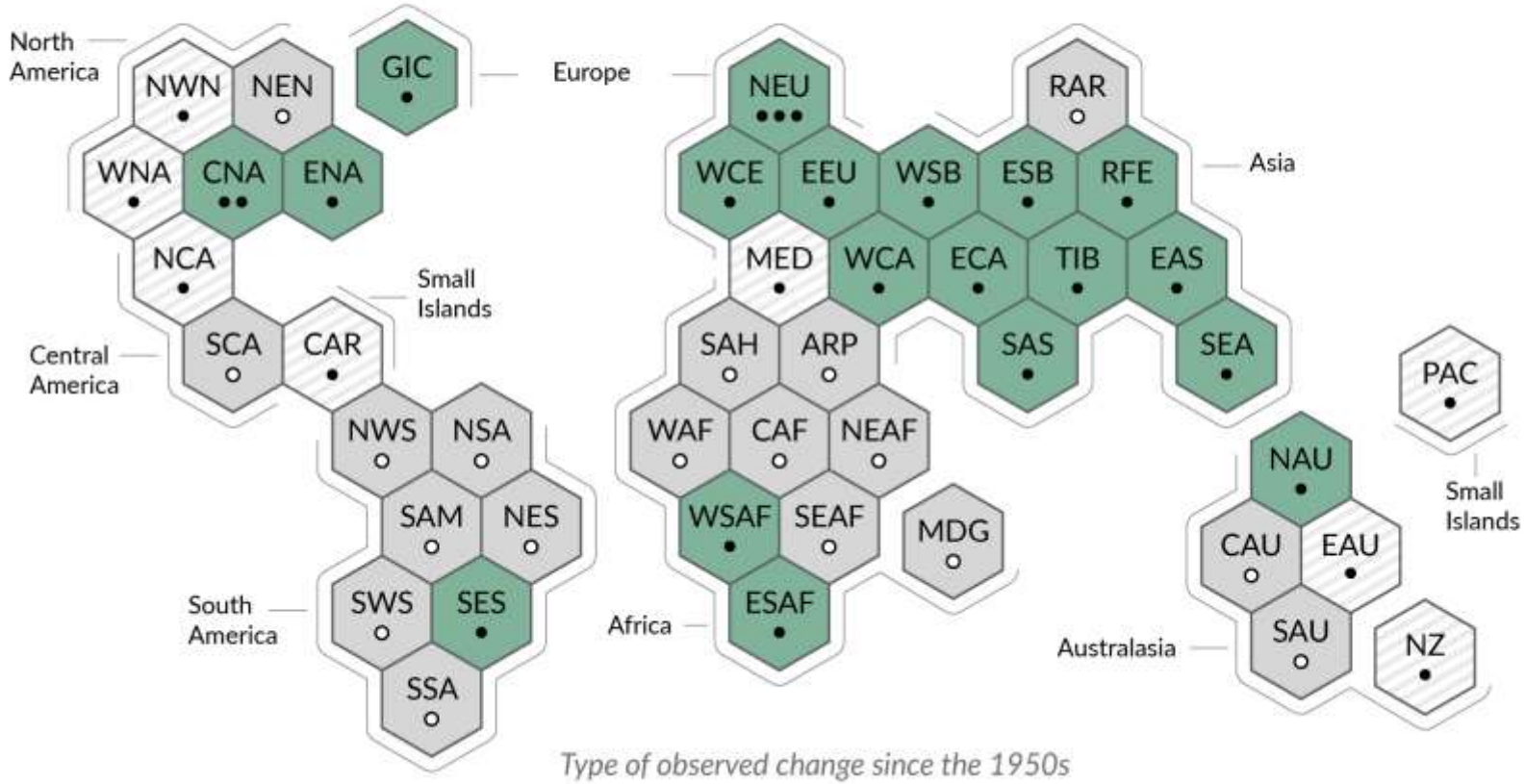
b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in heavy precipitation

- Increase (19)
- Decrease (0)
- Low agreement in the type of change (8)
- Limited data and/or literature (18)

Confidence in human contribution
to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence



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

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Figure SPM.3

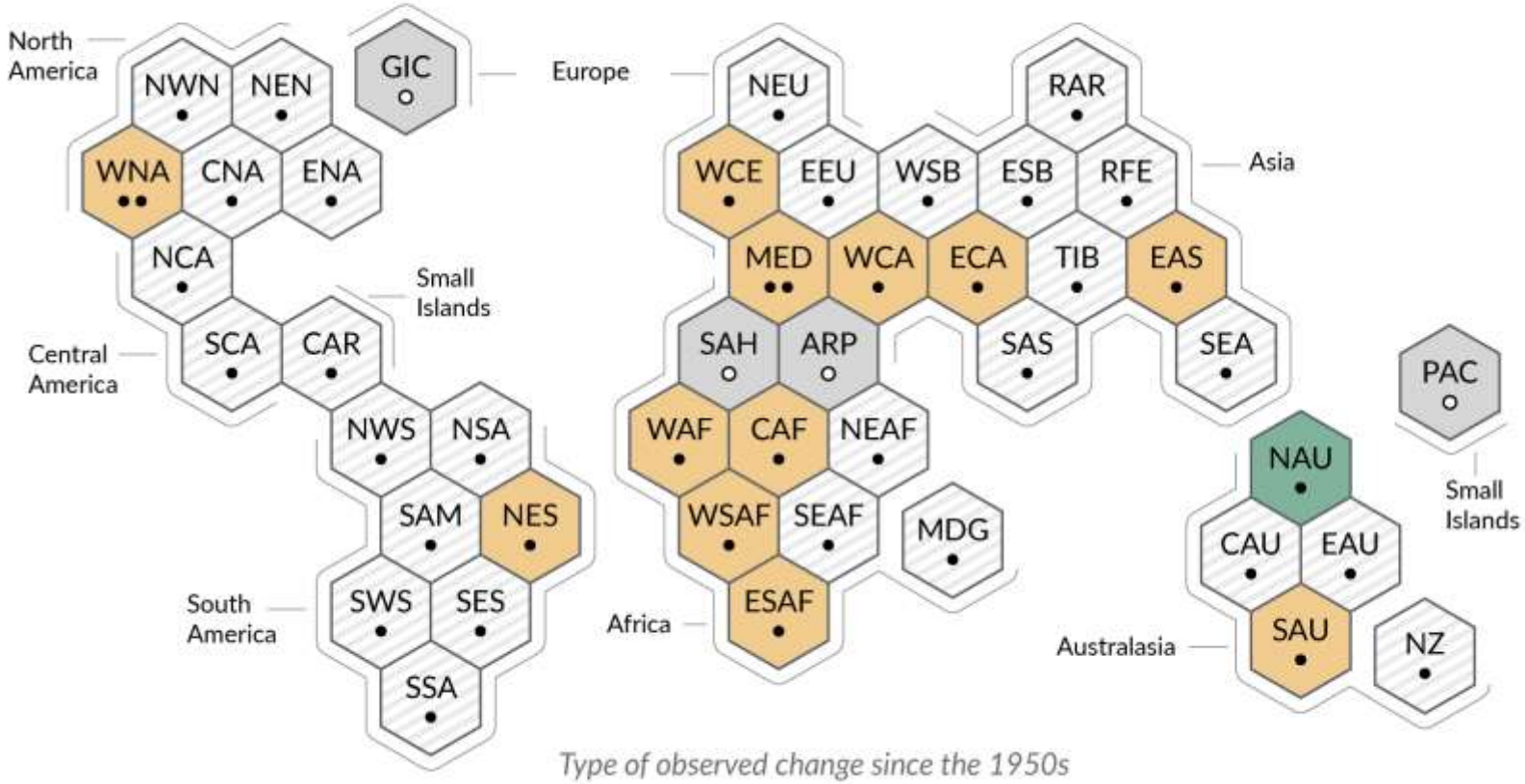
c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in agricultural and ecological drought

- Increase (12)
- Decrease (1)
- Low agreement in the type of change (28)
- Limited data and/or literature (4)

Confidence in human contribution
to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence

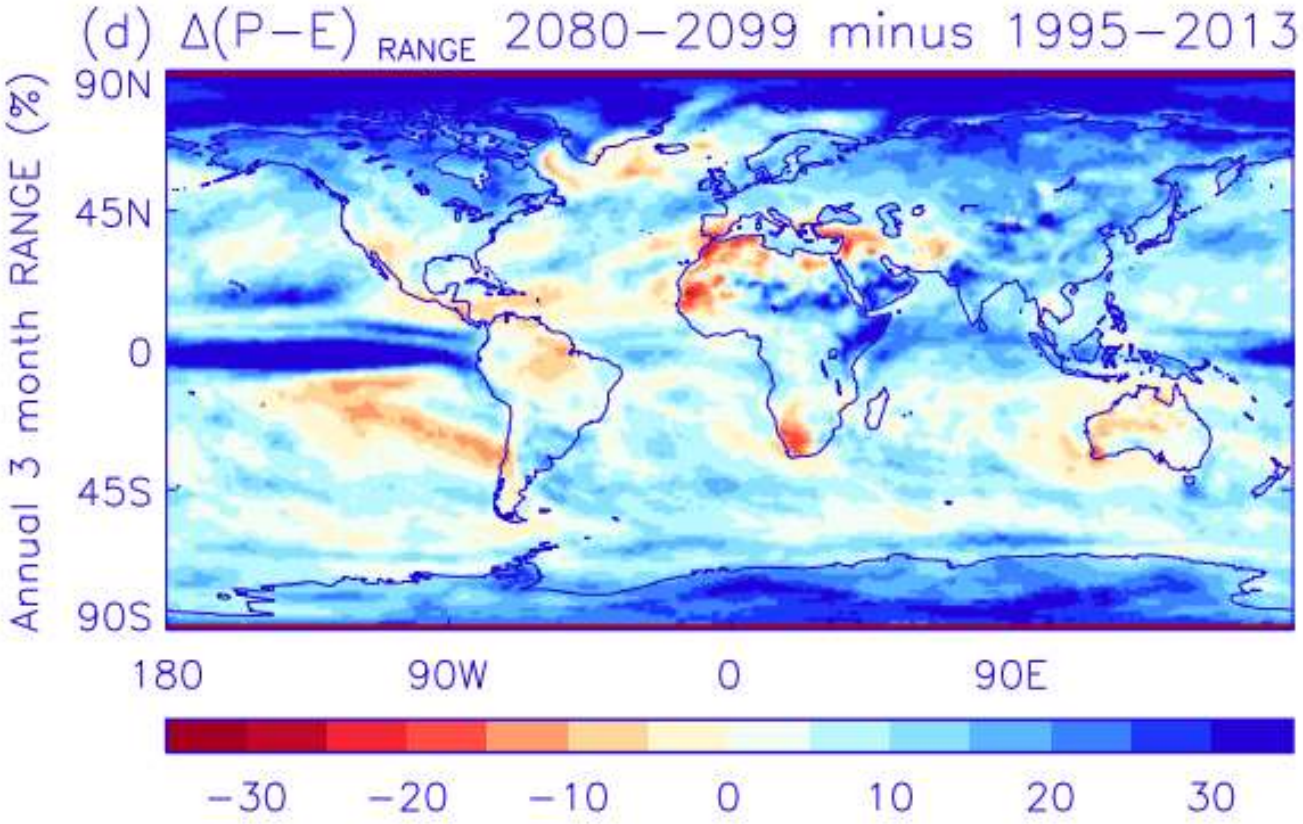


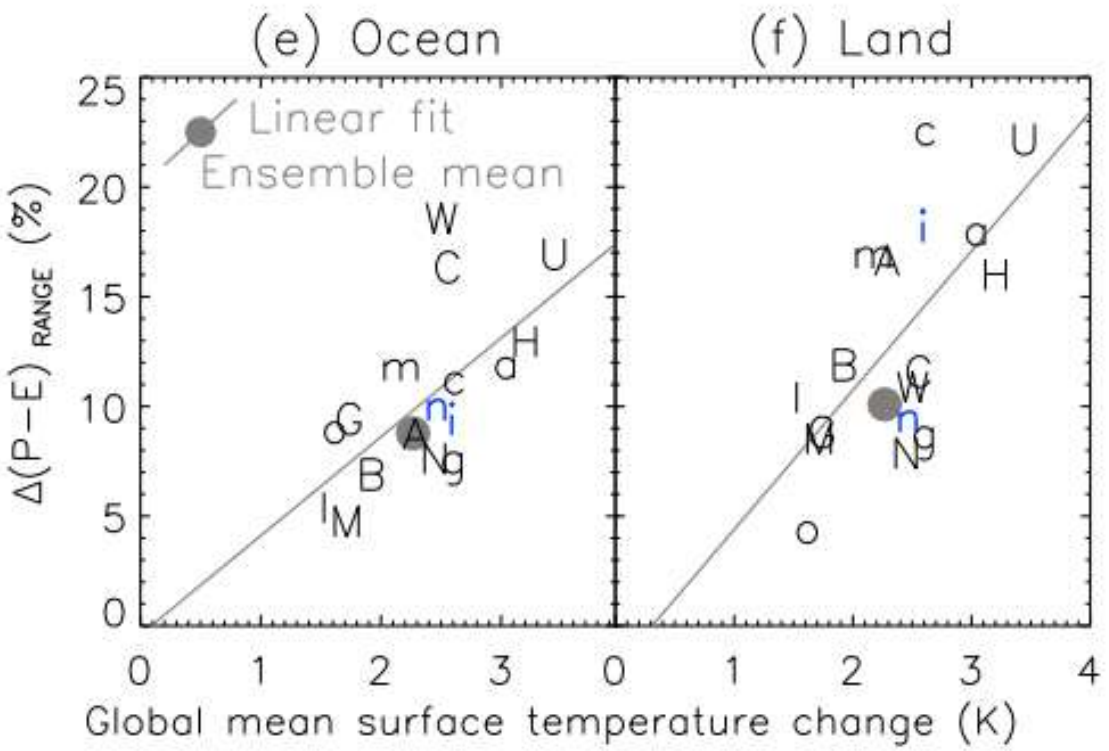
Type of observed change since the 1950s

> 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.

See Douville et al.(2021) IPCC chapter 8.

Increasing range between wet & dry



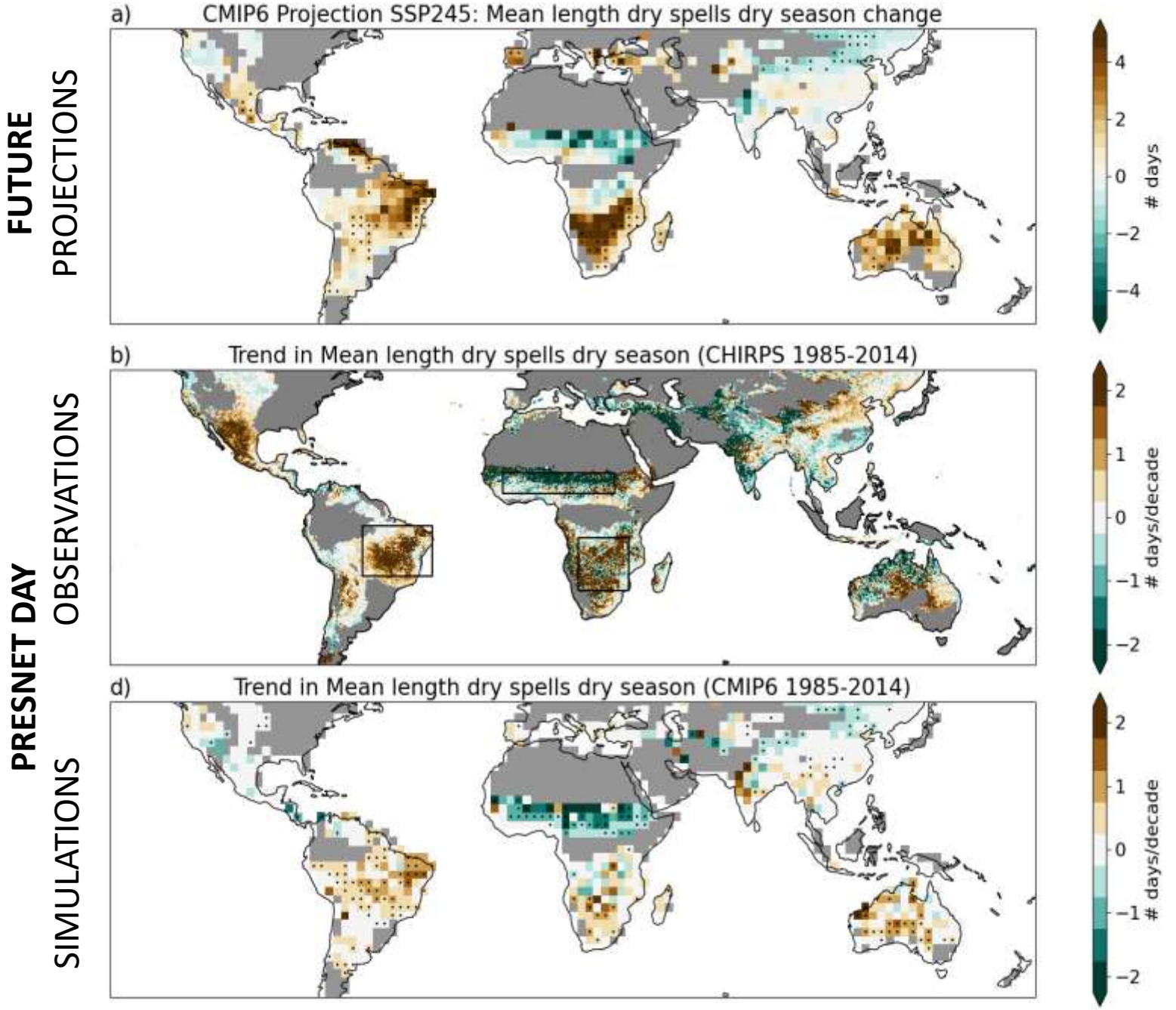


Allan (2023) Environmental Research Letters
Supplementary Fig. S17

Can we detect emerging signals of water cycle change?

- Emerging signals of more intense dry seasons over eastern Brazil, southern Africa and Australia (opposite in Sahel)

Wainwright et al. (2022) GRL →



IS CONTINENTAL DRYING UNDERESTIMATED BY CLIMATE MODELS?

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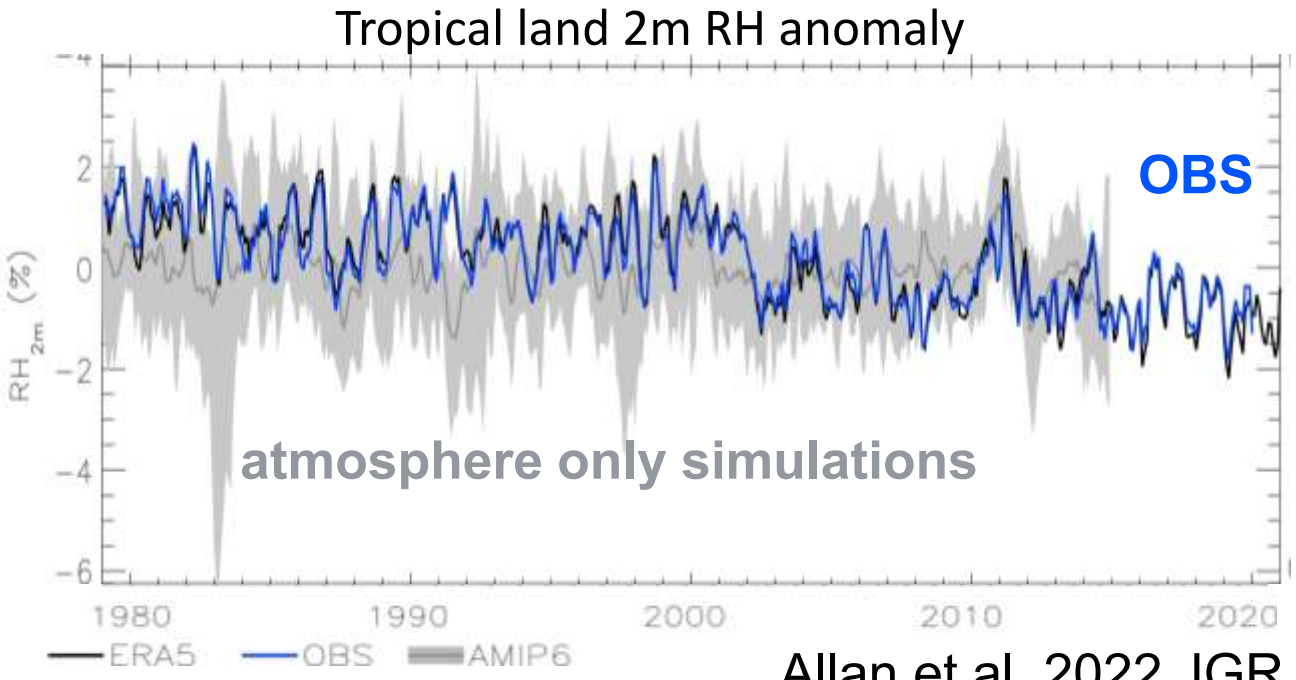
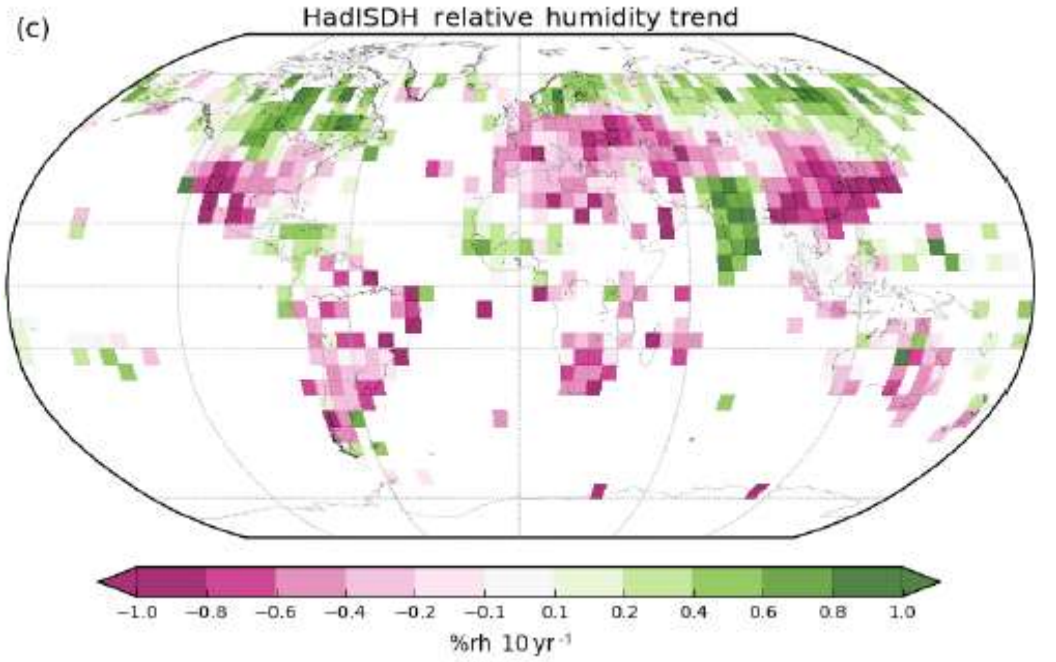
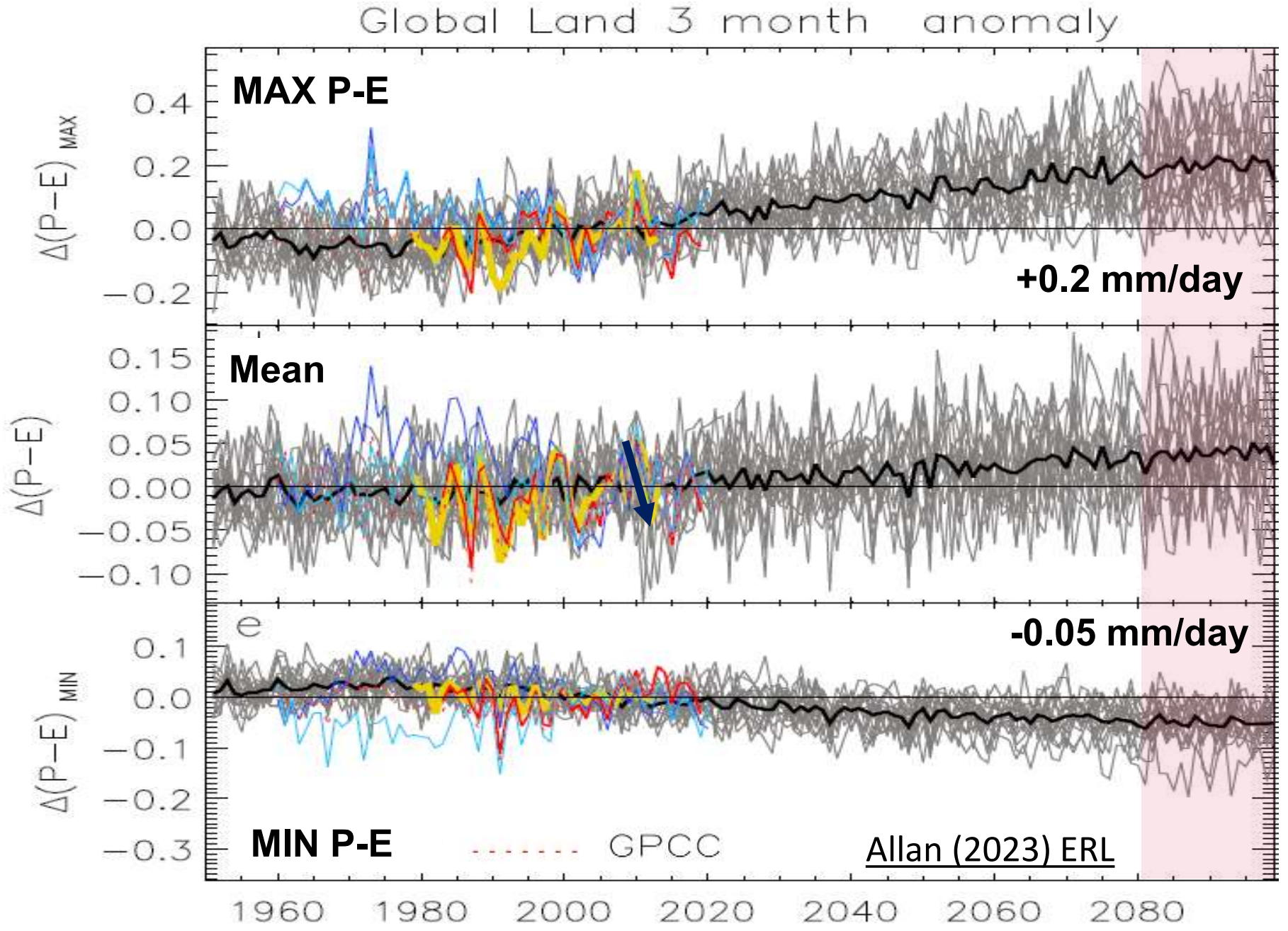
- Declining Relative Humidity over land
- Consistent with larger warming over land than sea e.g. O'Gorman & Byrne (2018) PNAS
- Not fully captured by CMIP5/6 simulations even when forced with observed SST
  e.g. Allan et al. 2022 JGR, Dunn et al. 2017 ESD



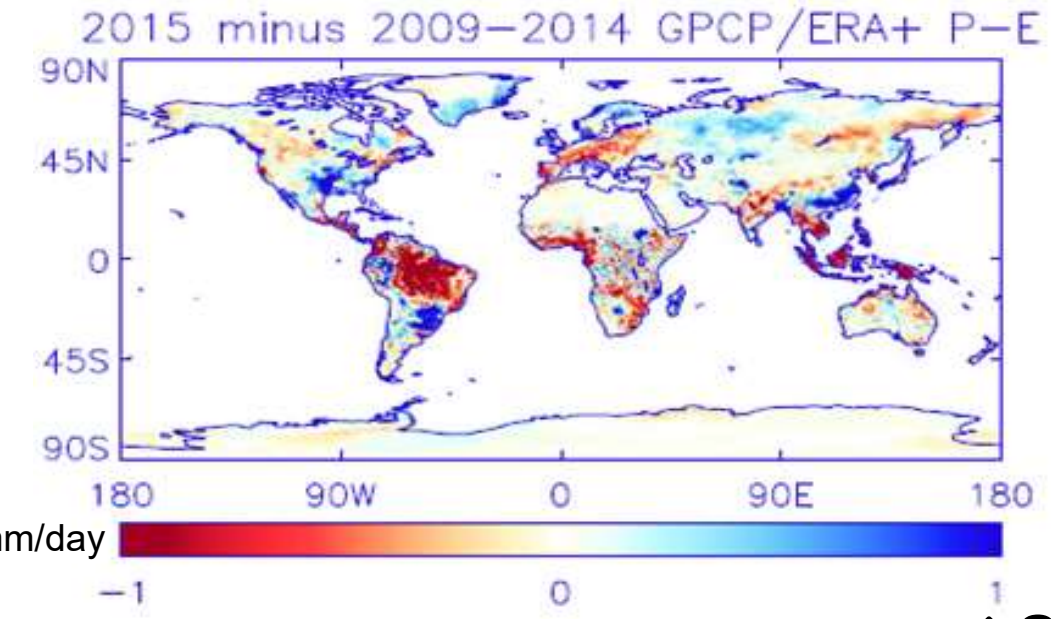
Allan et al. 2022 JGR

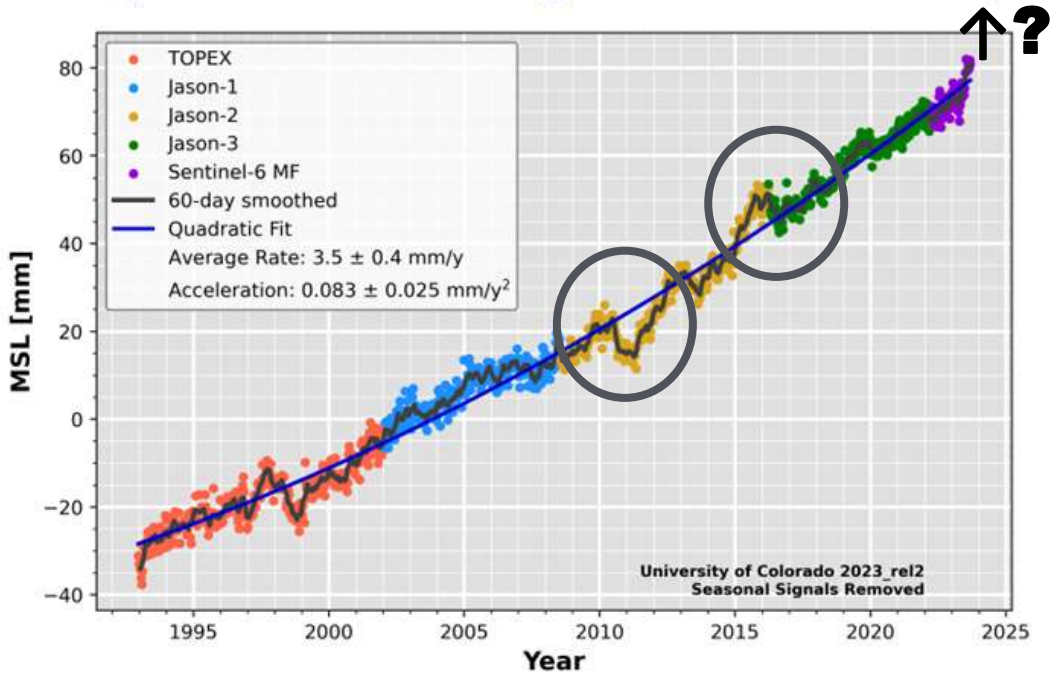


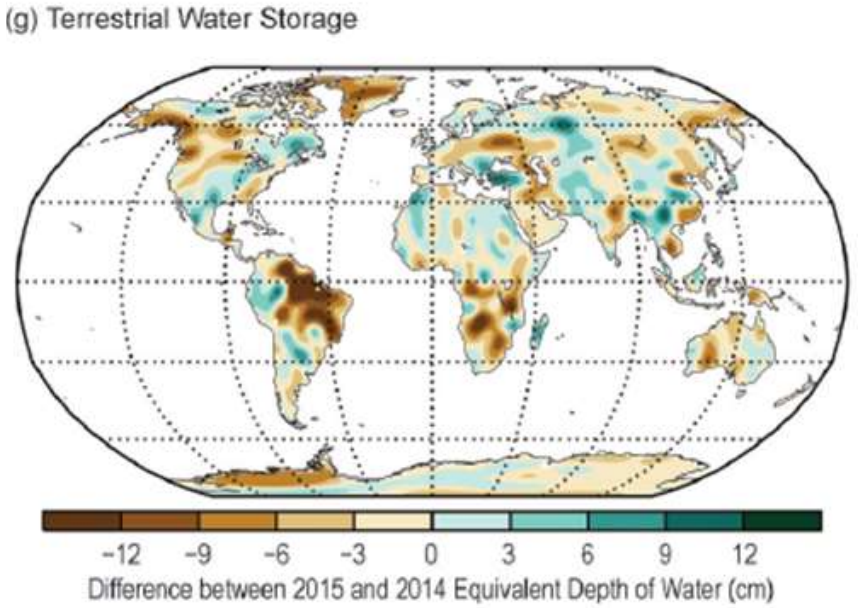
Dunn et al. 2017 ESD



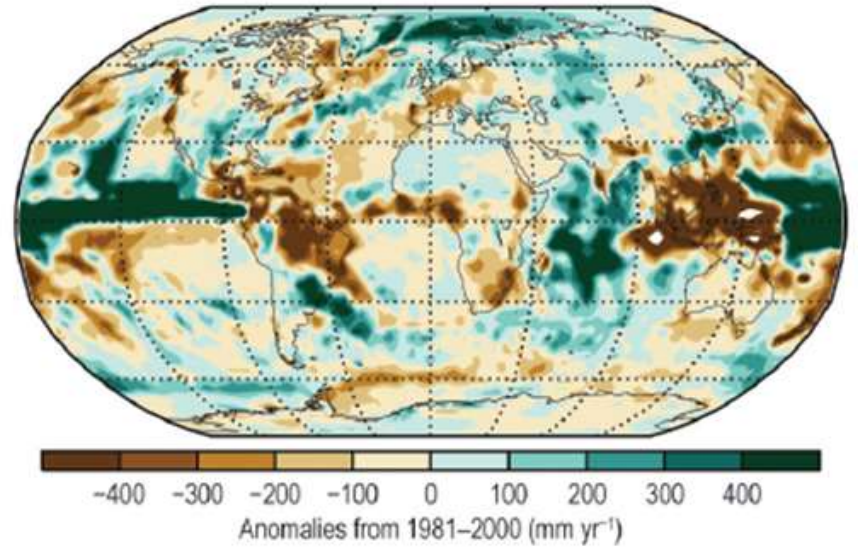
GPCP/ERA5
ERA5
ERA5 MDiv
AMIP6
CMIP6







(h) Precipitation **state of the climate 2015**



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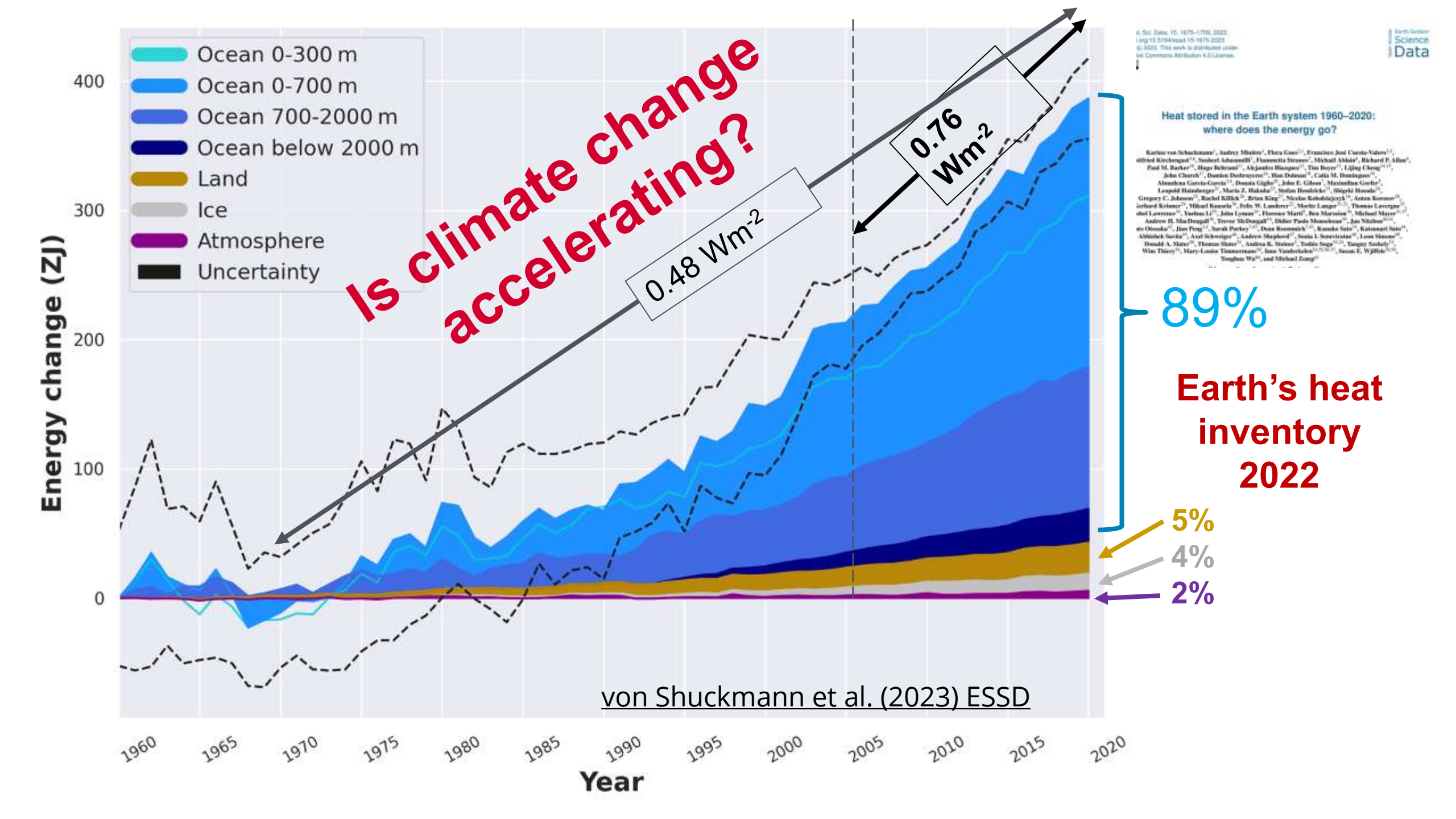
Chasing water through 2015/16 El Niño

Boening et al. (2012) GRL: The 2011 La Niña so strong, the oceans fell


Ocean 0-300 m
Ocean 0-700 m
Ocean 700-2000 m
Ocean below 2000 m
Land
Ice
Atmosphere
Uncertainty
Is climate change accelerating?
0.48 Wm-2
0.76 Wm-2
89%
Earth's heat inventory 2022
5%
4%
2%
von Shuckmann et al. (2023) ESSD
Heat stored in the Earth system 1960–2020: where does the energy go?
Energy change (ZJ)
Year
400
300
200
100
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

Unexpected pattern of global warming?

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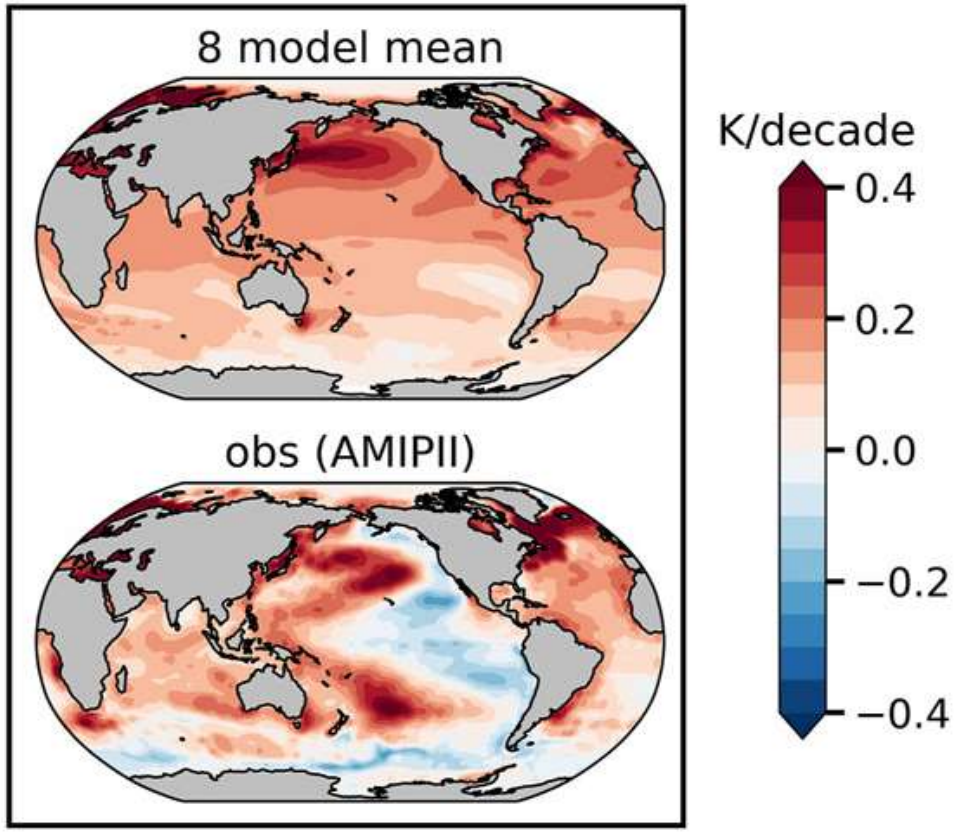
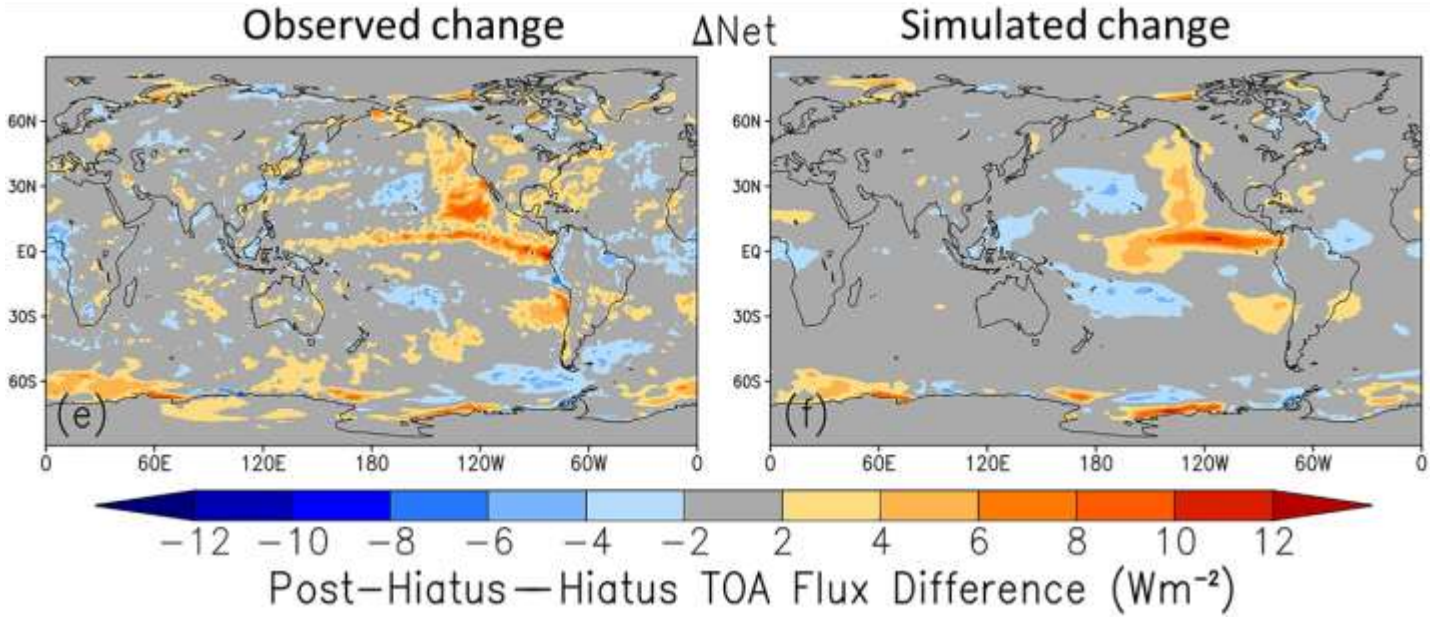


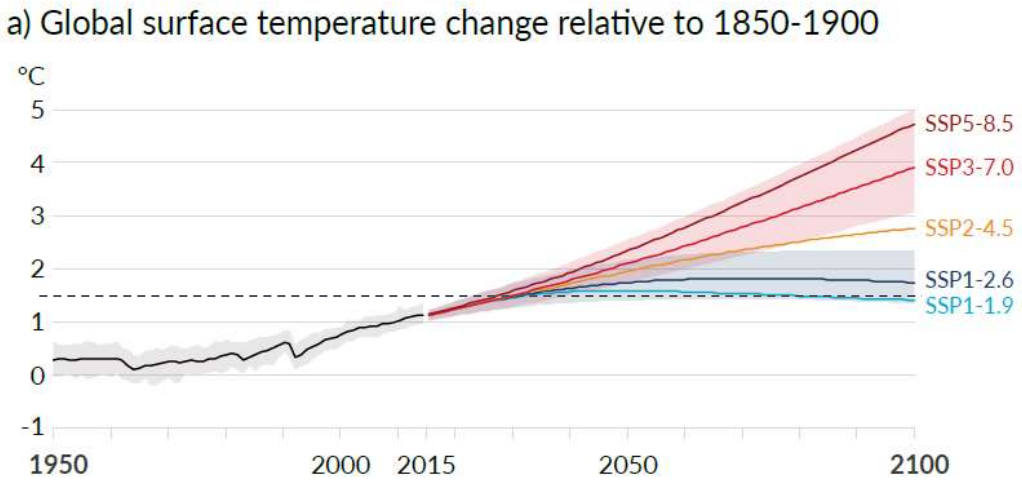
Pattern of observed warming (1979-2014) is unexpected!
Dong et al. (2021) GRL

This has weakened amplifying climate feedbacks relative to coupled models (Andrews et al. 2022 JGR)

…but new Earth radiation budget measurements and simulations suggest clouds are now awakening and causing more sunlight to be absorbed (Loeb et al. 2020 GRL)

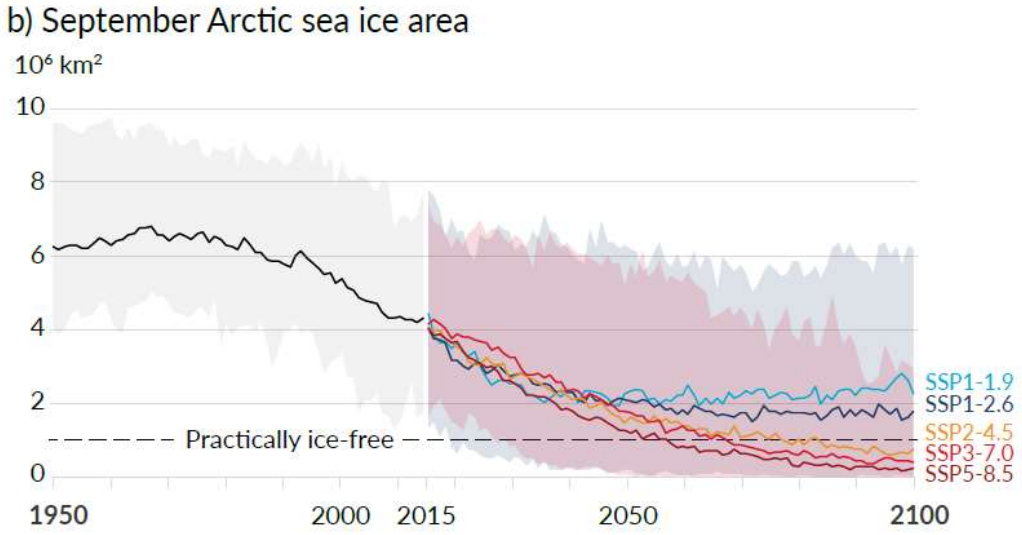


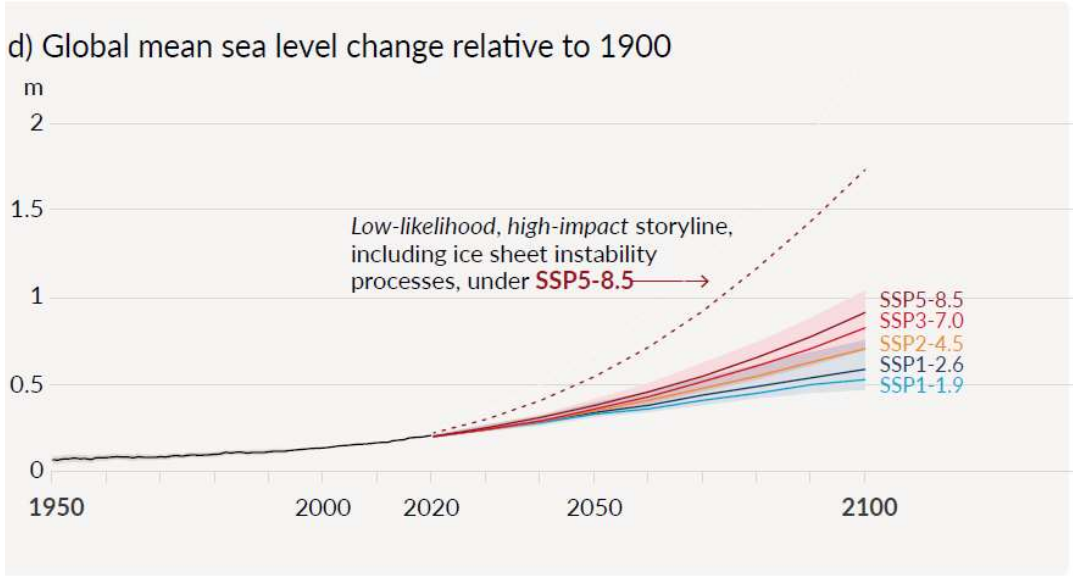
Some changes in the climate system are irreversible but many changes can be slowed or stopped by limiting warming

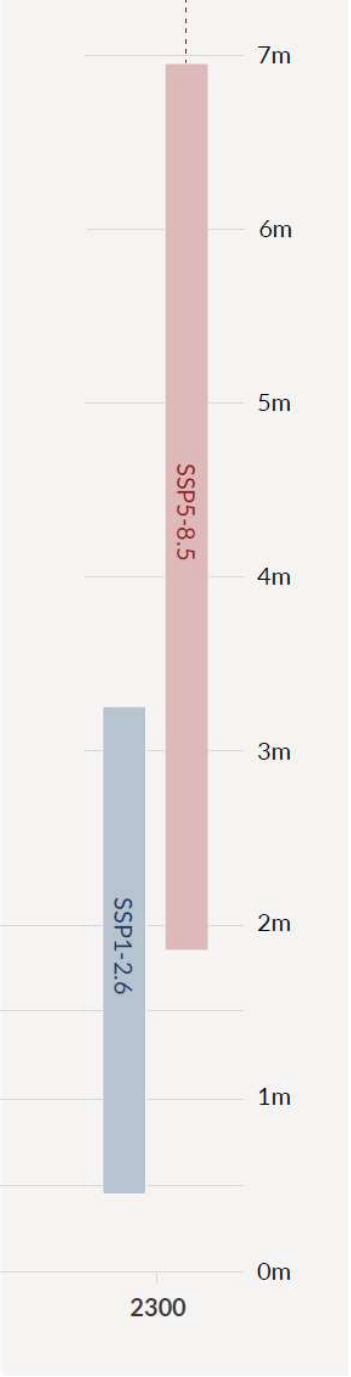


Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades
[IPCC (2021) WG1 SPM]

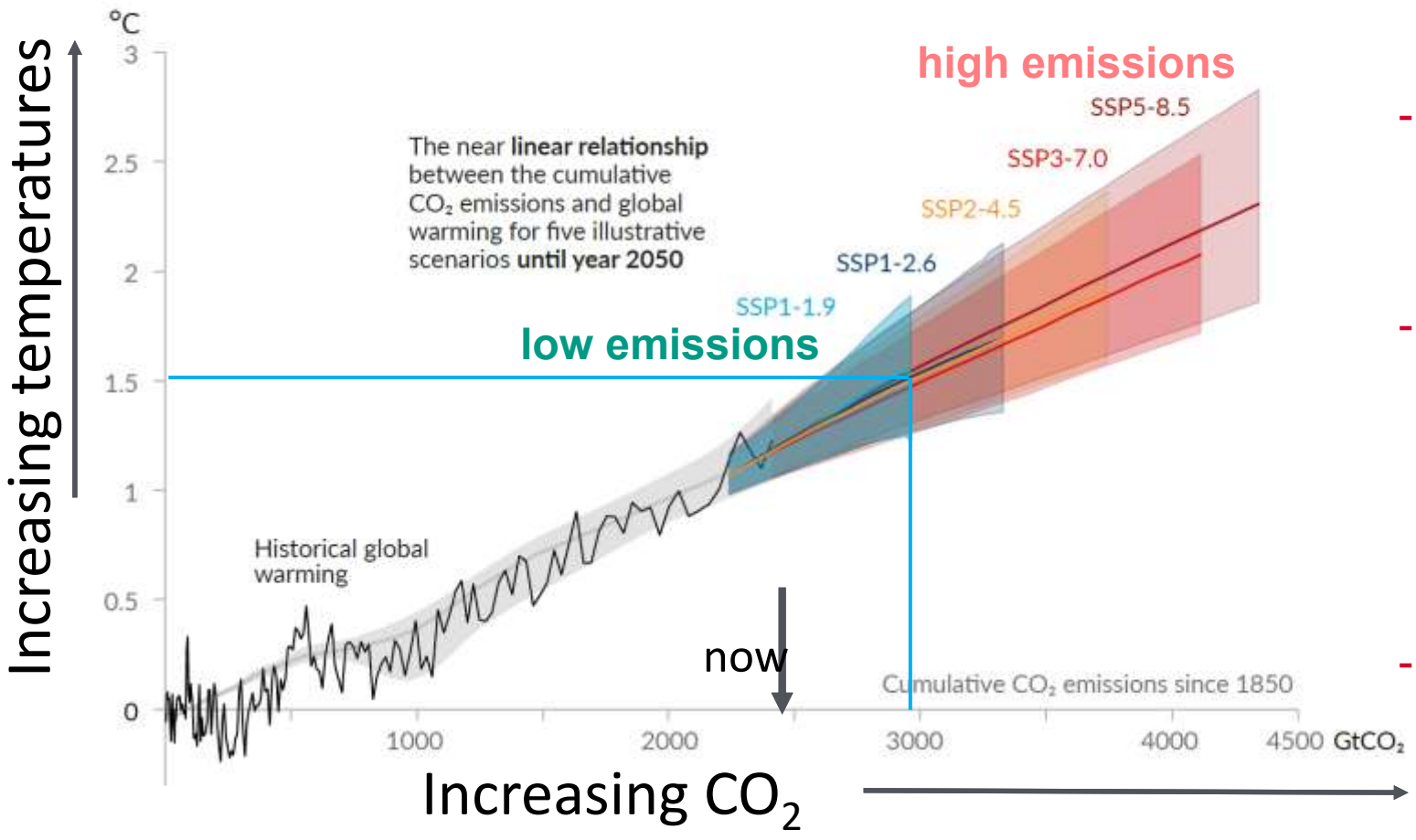
High emissions
Low emissions







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 CO_2 emissions

- Act thoughtfully

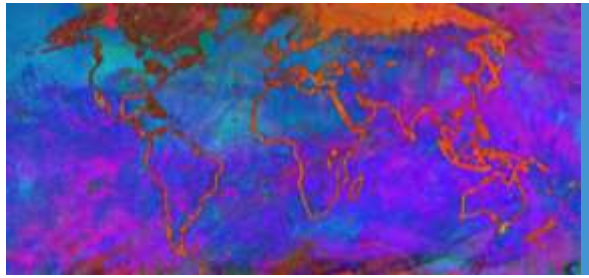
  Develop strategies maximising synergies and taking into account the local context, use a wide array of measures and actions

- 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



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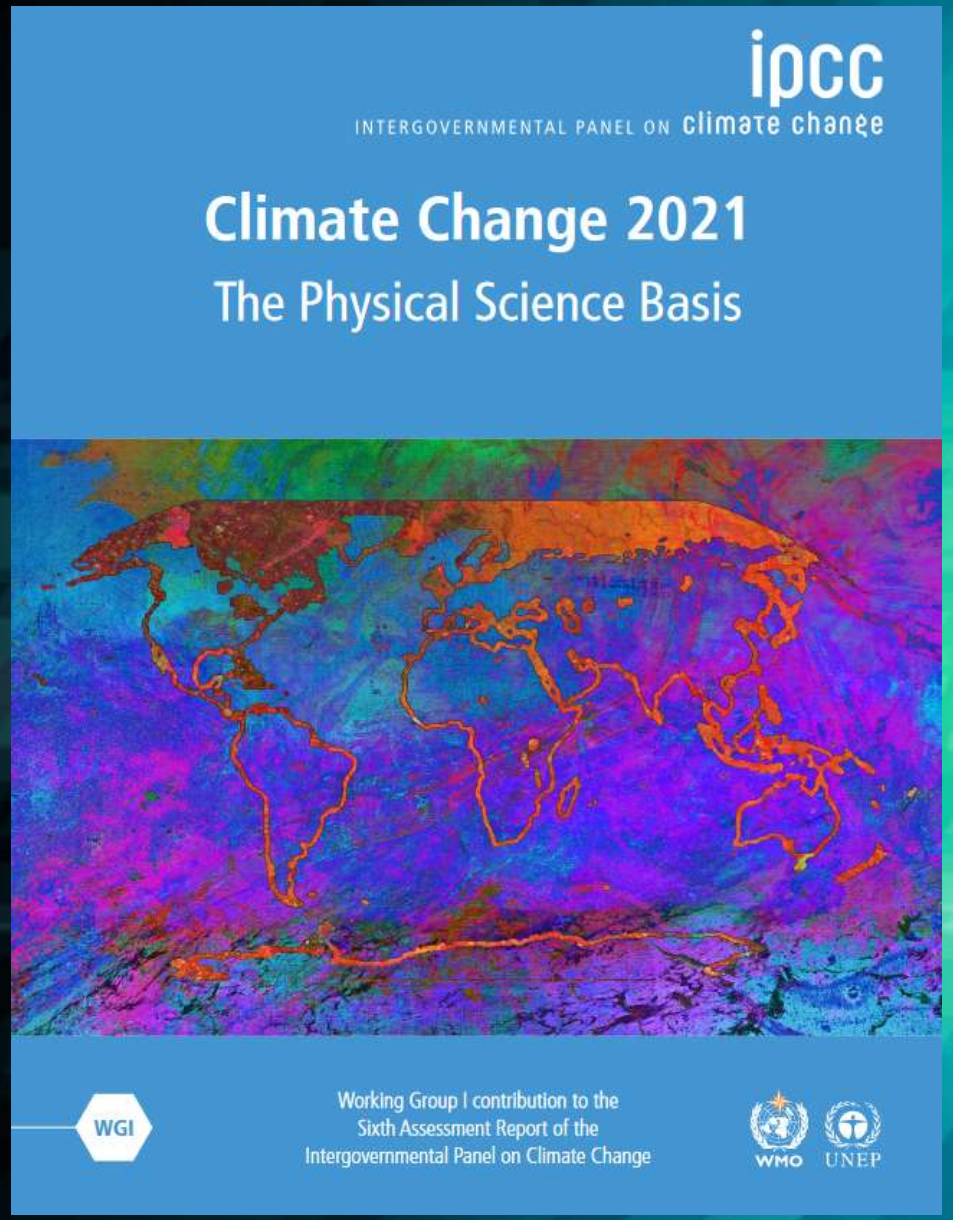
- Earth's climate has always varied but it is an established fact that human activities are now driving climate change
- Recent changes in climate are widespread, rapid and unprecedented in thousands of years.
- Human activities are intensifying extreme climate events, including heat waves, heavy rainfall, 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



IPCC (2023) Synthesis Report published Monday 20th March

www.ipcc.ch/report/ar6/wg1