Australian National University

Understanding changes in climate and extreme events

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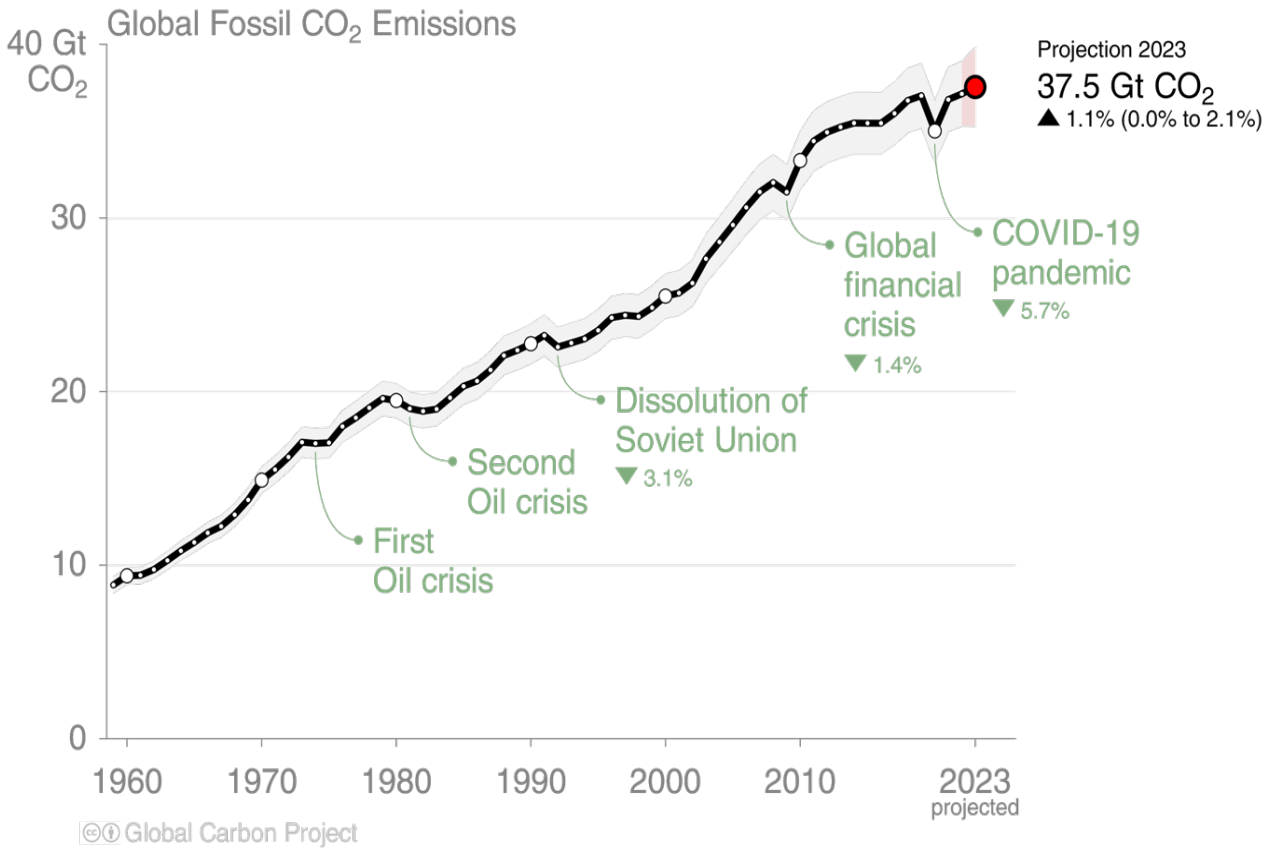
Vice Chair, IPCC Working Group II

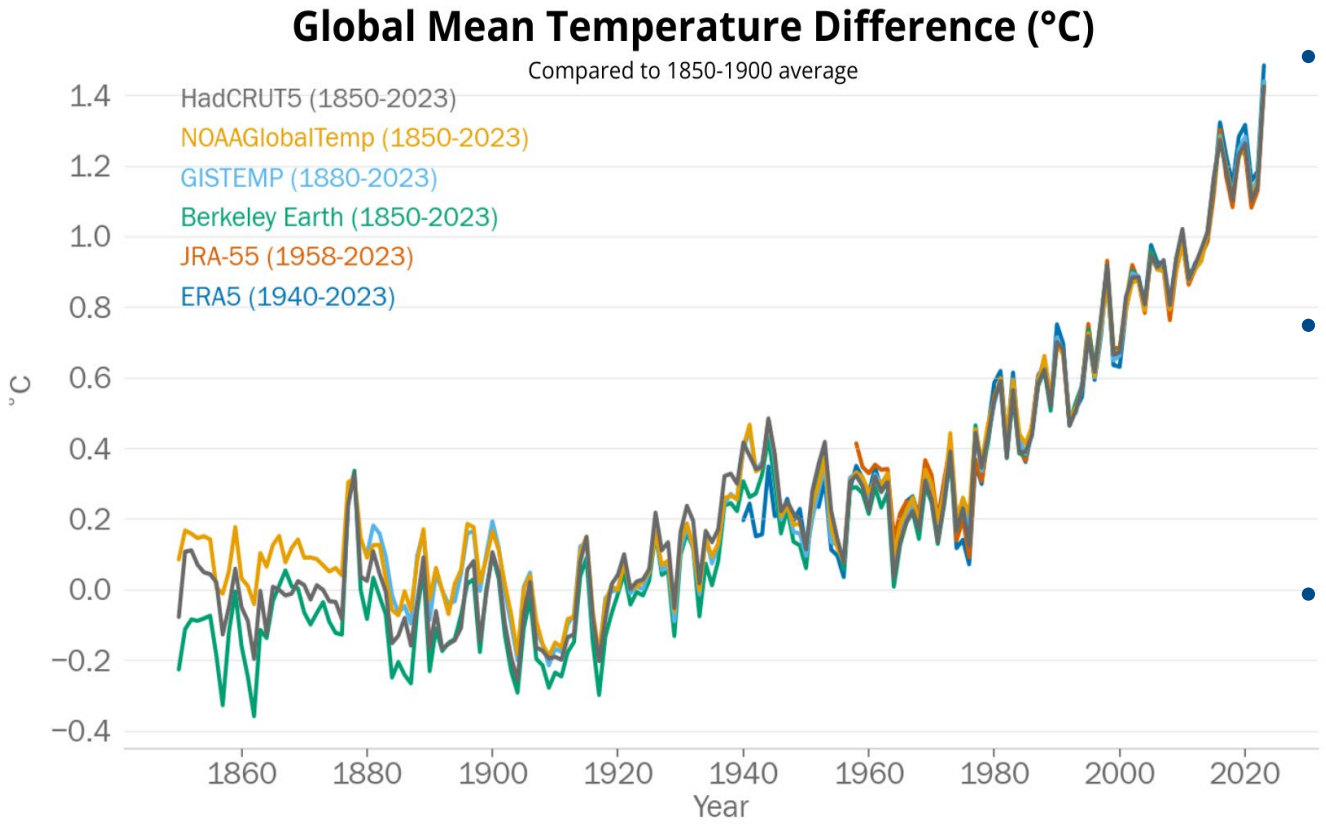
CO_2 emissions increasing (again)



- CO_2 last year 424ppm (pre-industrial levels were about 280ppm) highest in at least 2M (and maybe 14M) years
- Record levels of methane, nitrous oxide and other GHGs

Global Carbon Project 2022; Friedlingstein et al. 2022; IPCC 2021; CENCO2PIP 2023

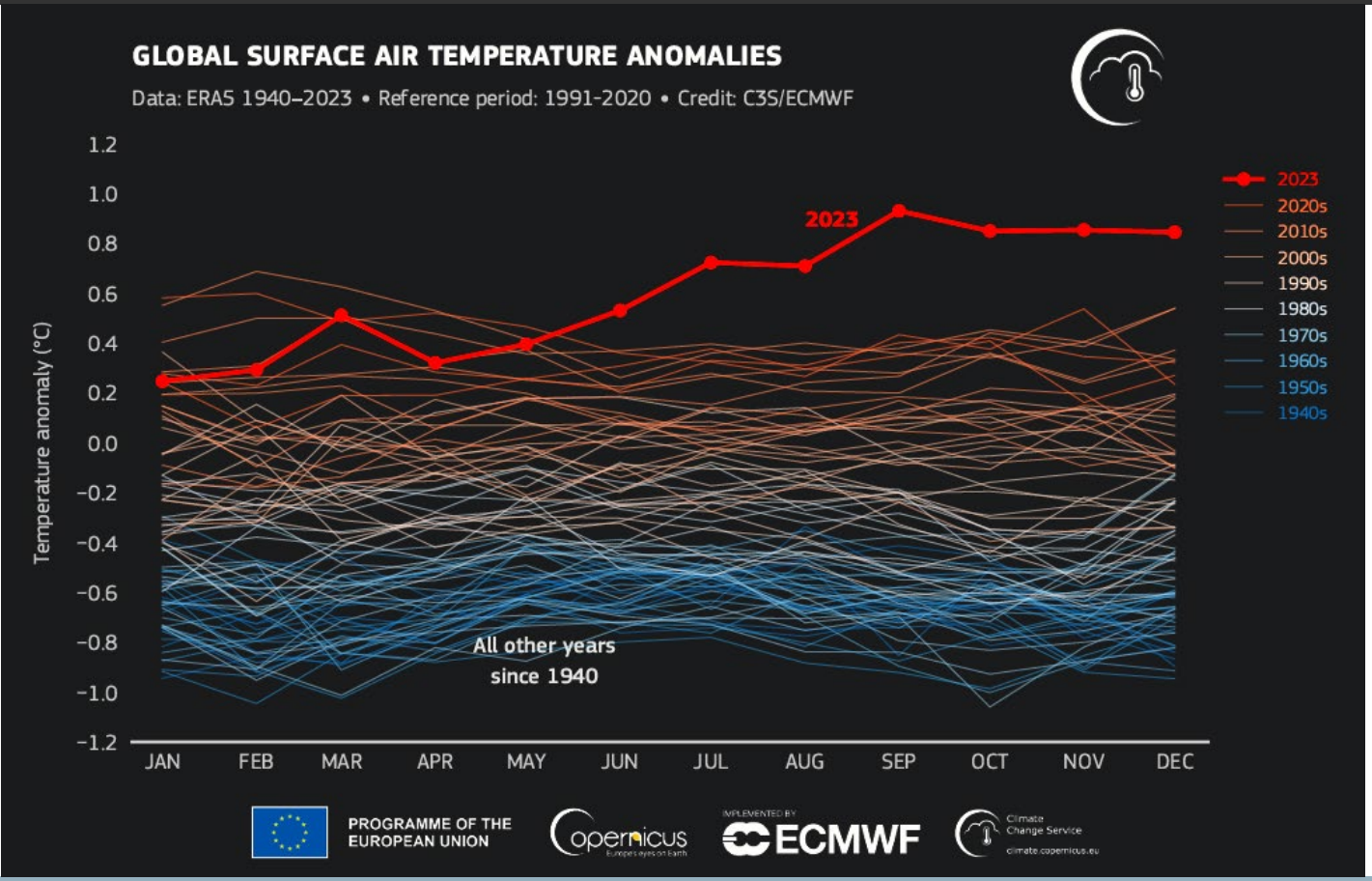
Globally – 2023 way hottest on record



- Hottest year on record, about 1.45°C above pre-industrial levels
- Every month from June to December had record temperatures
- 2 days exceeded 2°C globally for the first time

WMO 2024; Copernicus 2024; Rantanen and Laaksonen 2024

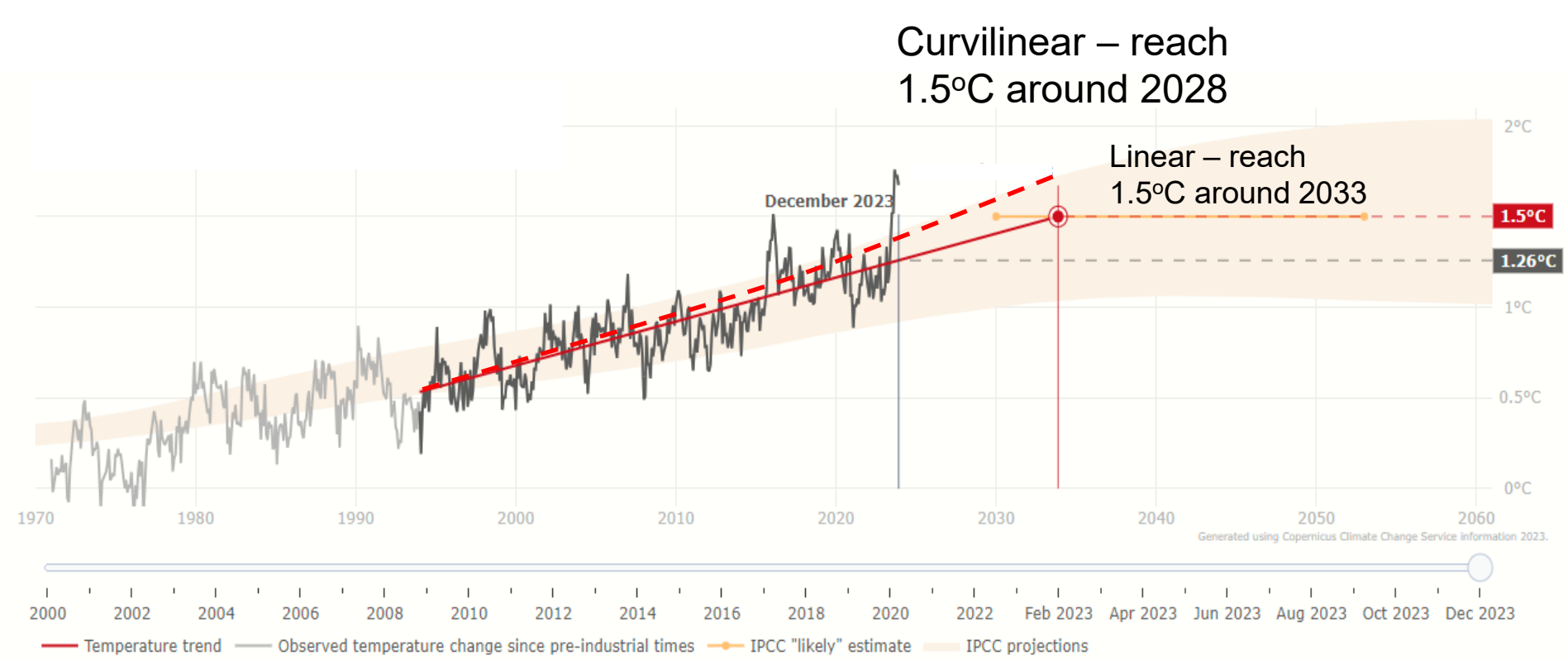
Extraordinarily hot globally



- Unlikely due to just GHG and El Niño
- Possible influence of reduced shipping emissions
- Tonga volcano

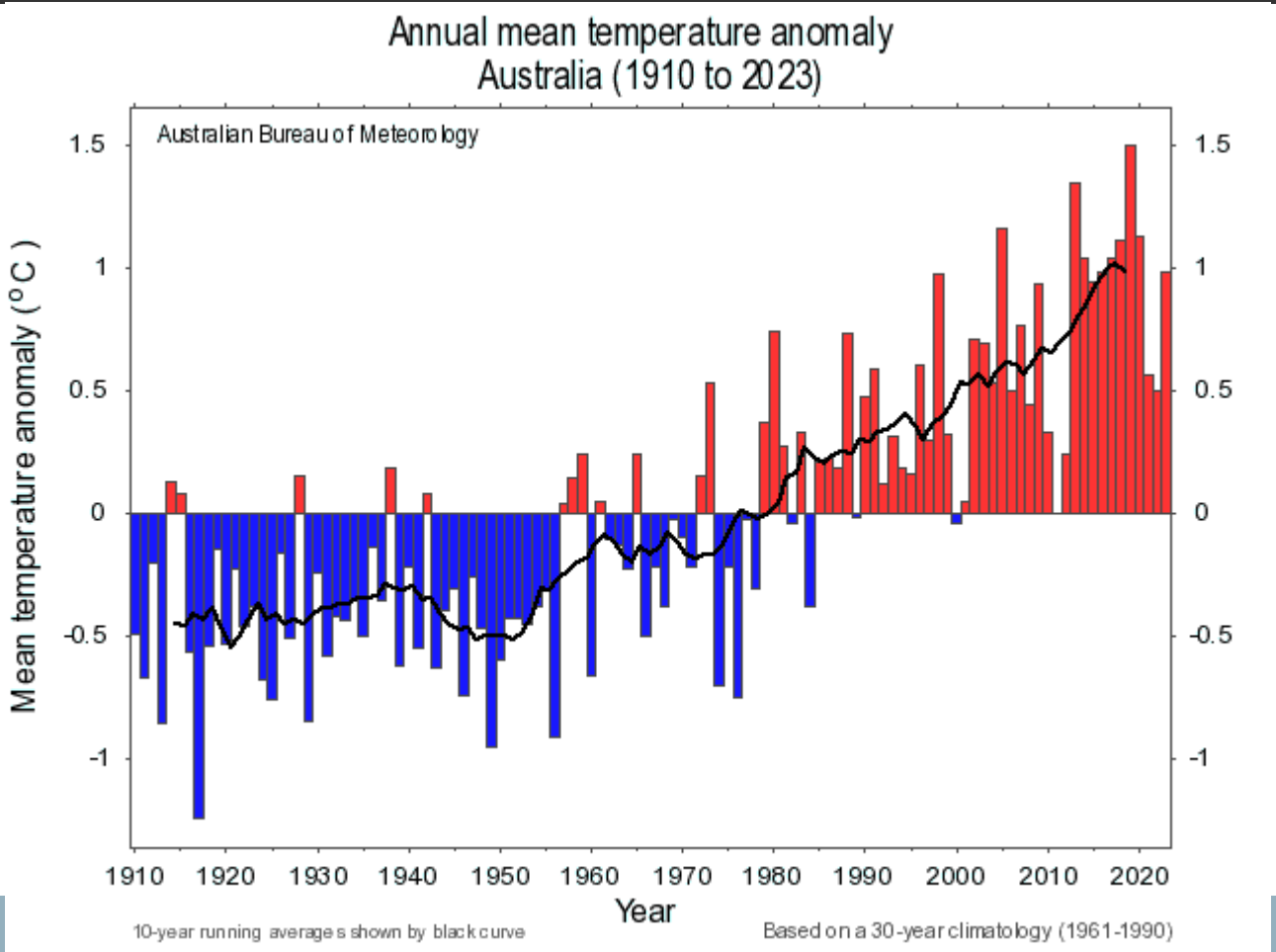
Copernicus 2024

Racing towards 1.5°C

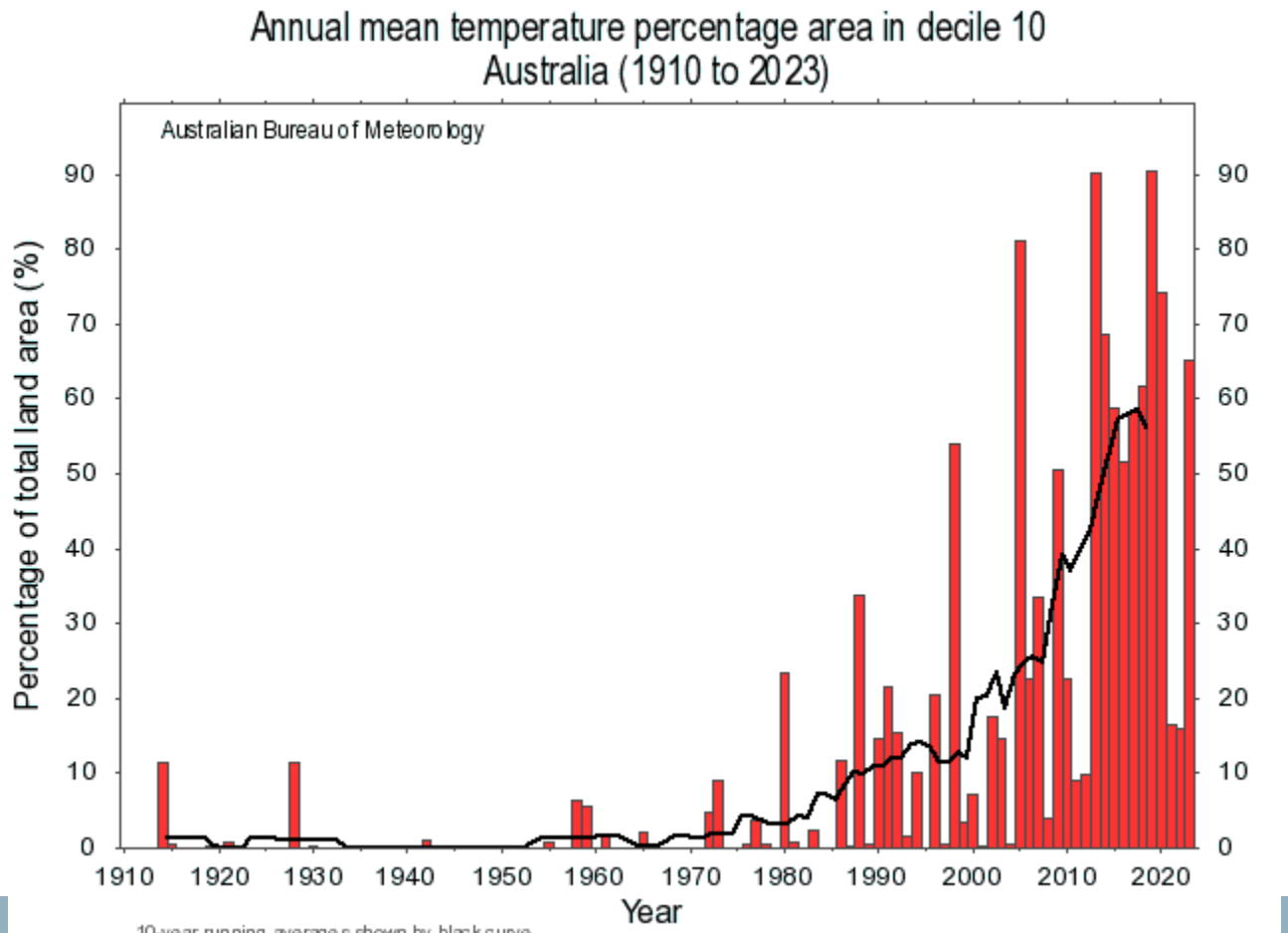


Copernicus 2024

Australia: record temperatures

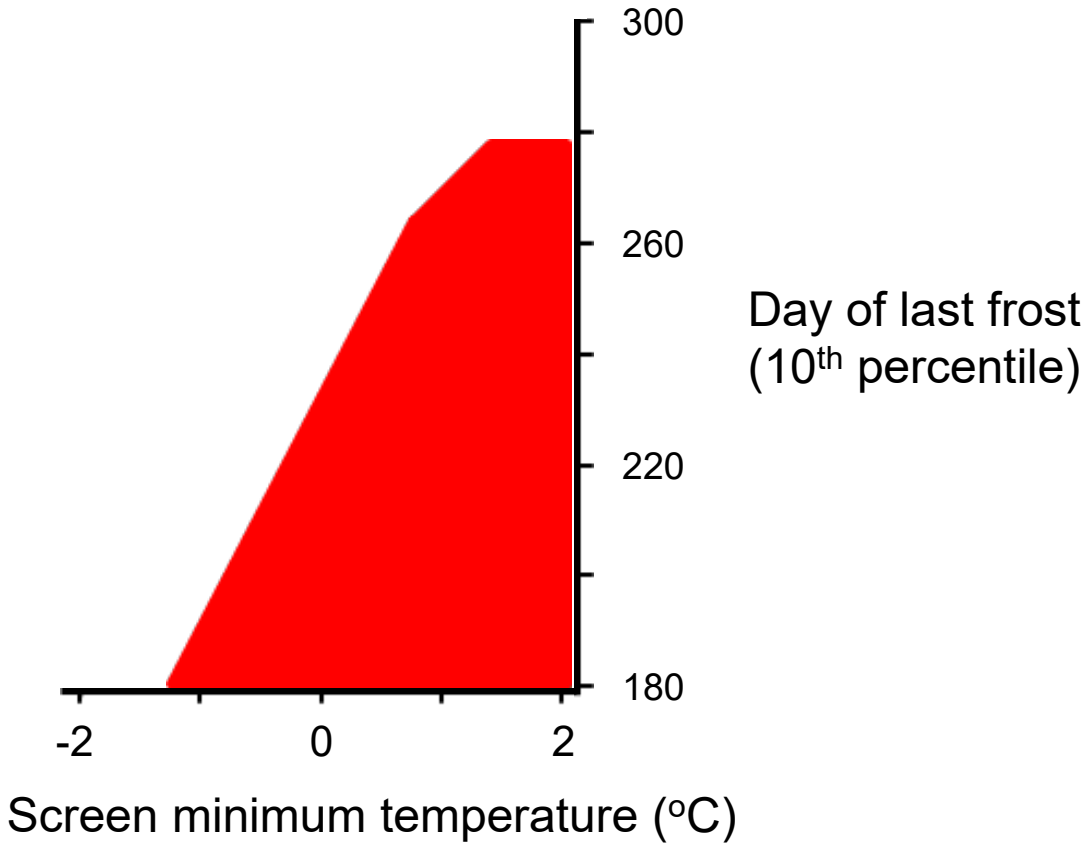


Extremes almost everywhere, all the time



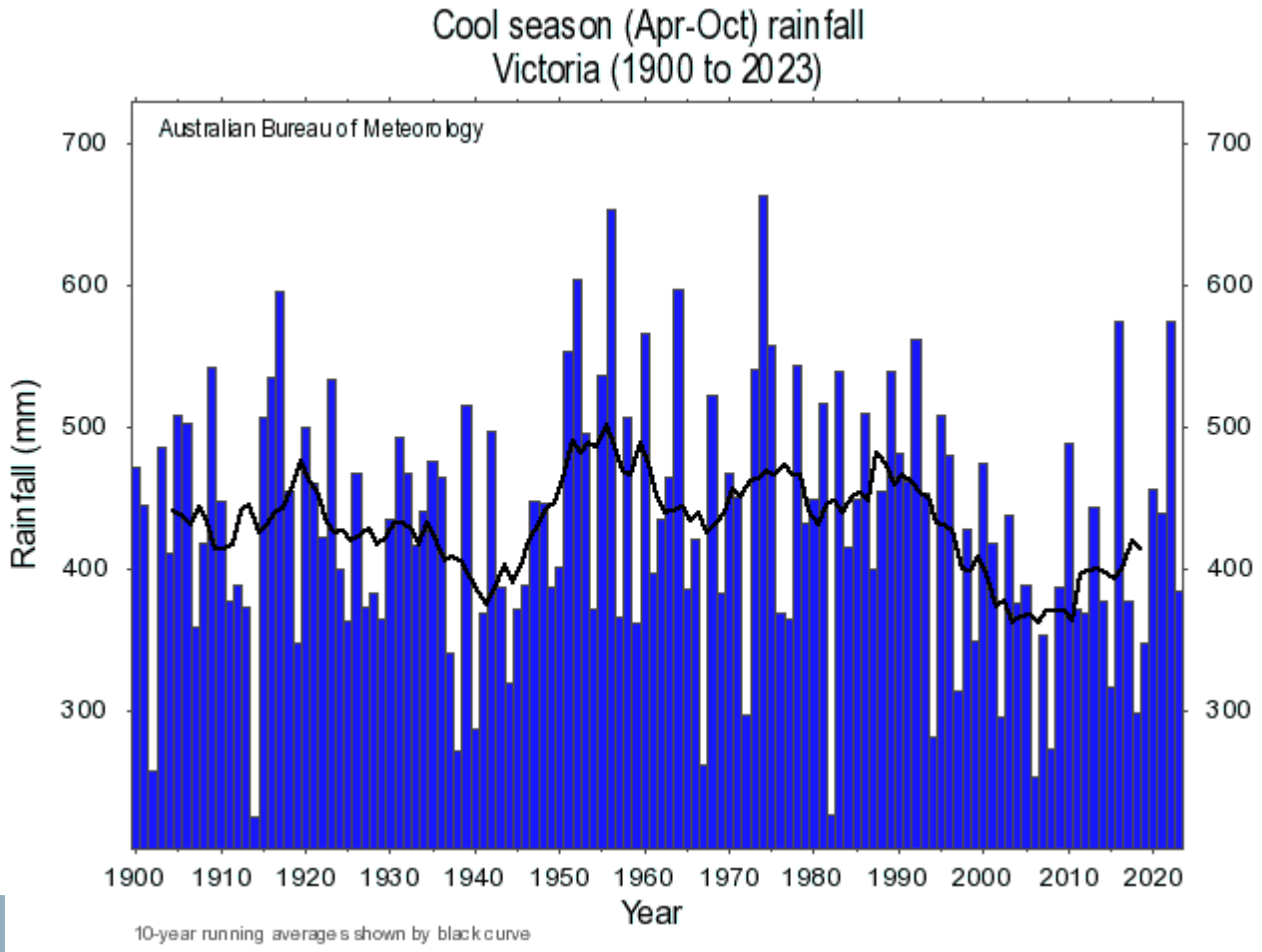
BoM 2024

Frost risk increasing in SE Australia



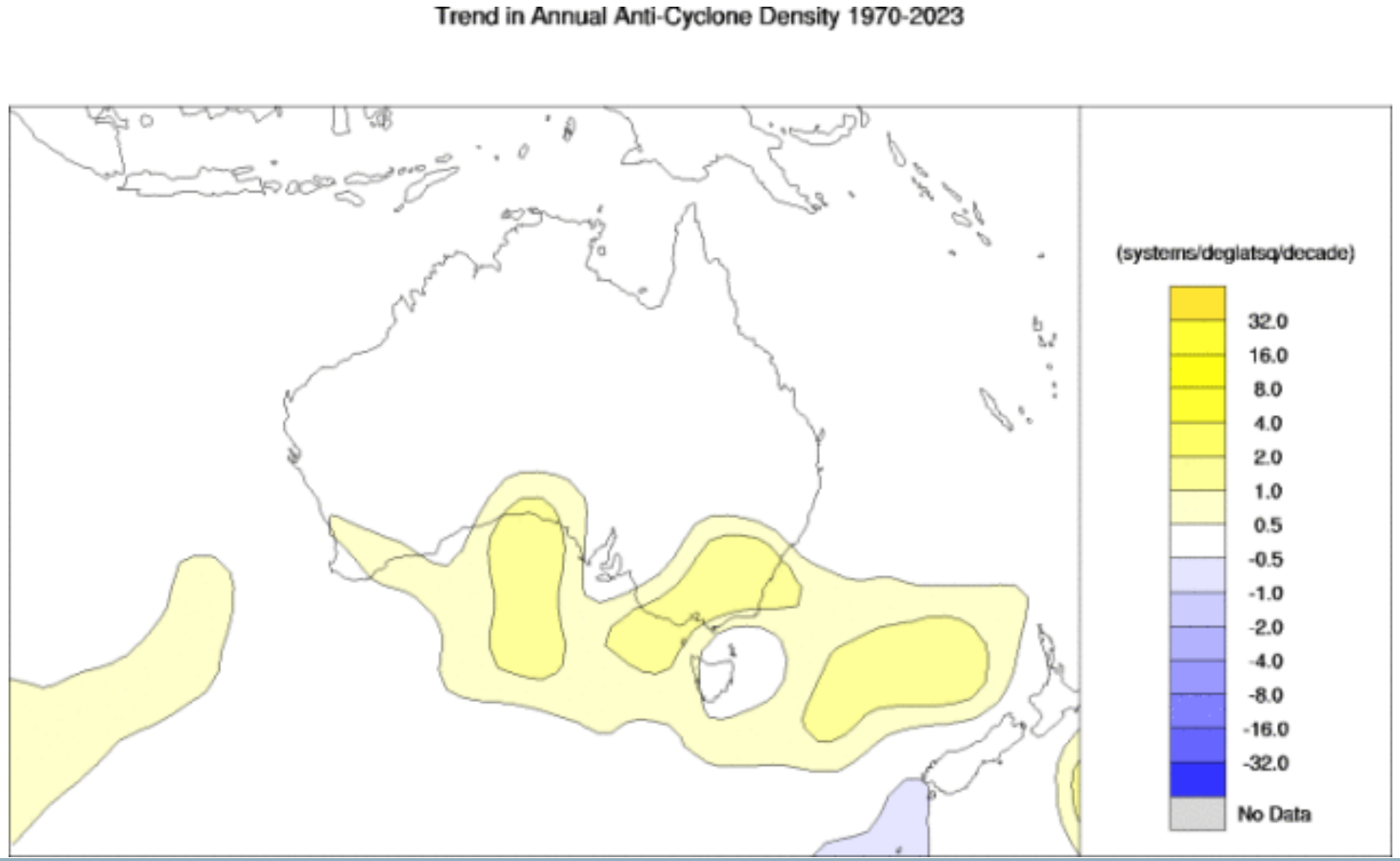
Crimp et al. 2016

Drying trends in the SW and SE



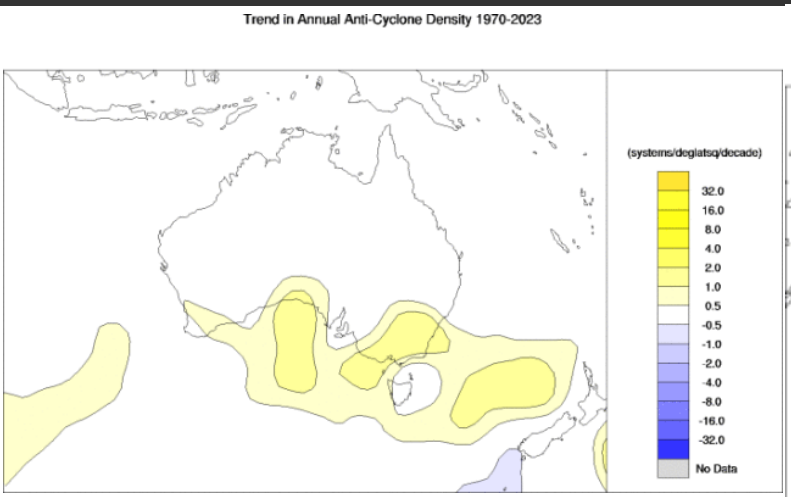
BoM 2024

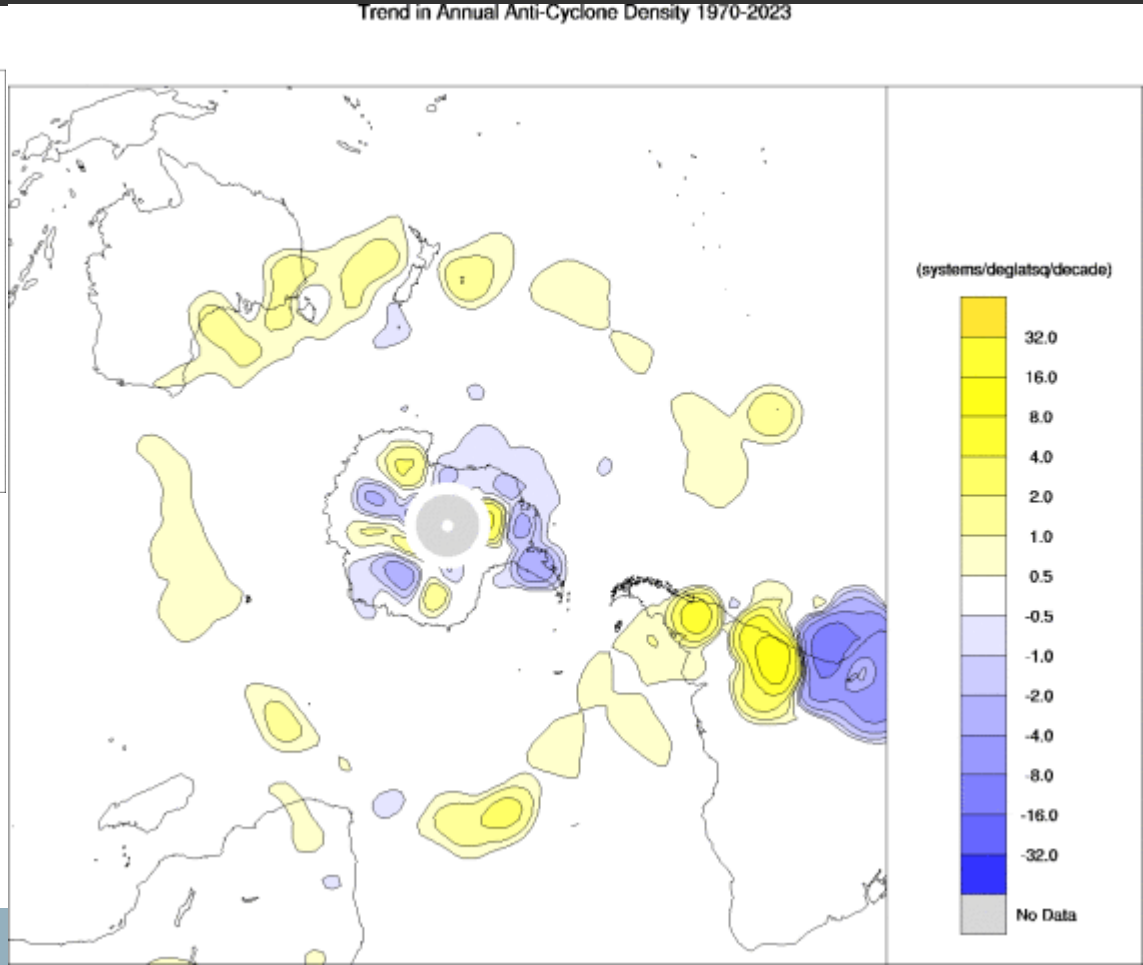
Change in pressure systems: Australia



BoM 2024

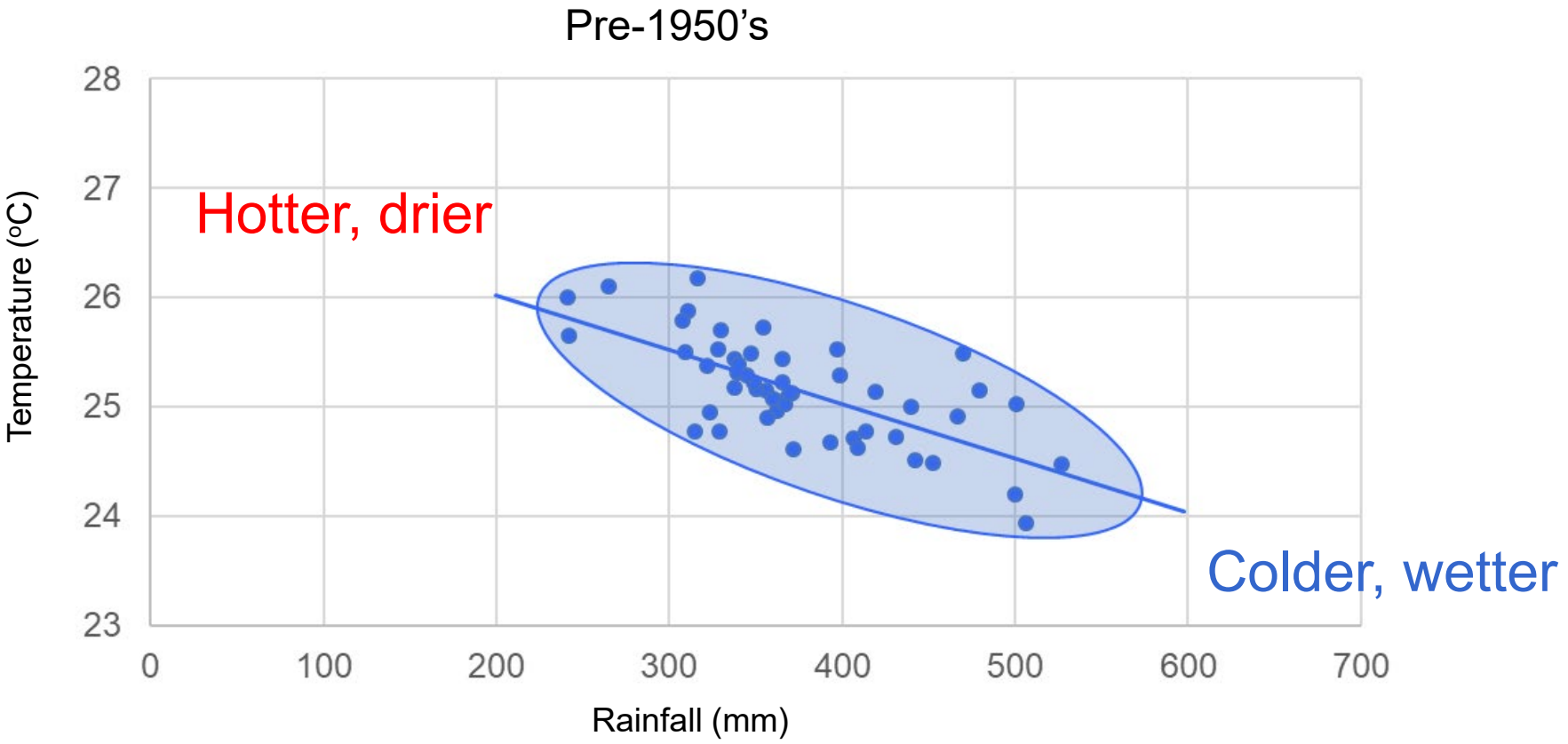
Change in pressure systems: Sthn Hemisphere





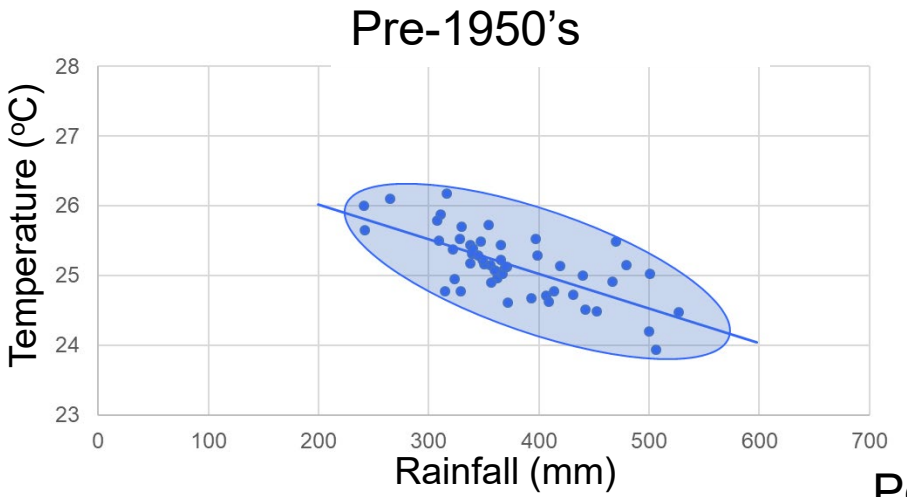
BoM 2024

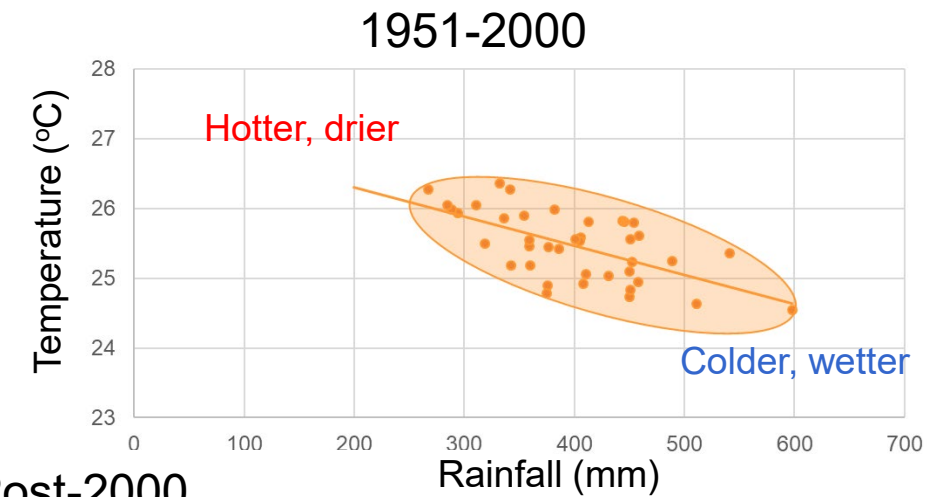
The rainfall-temperature operating envelope

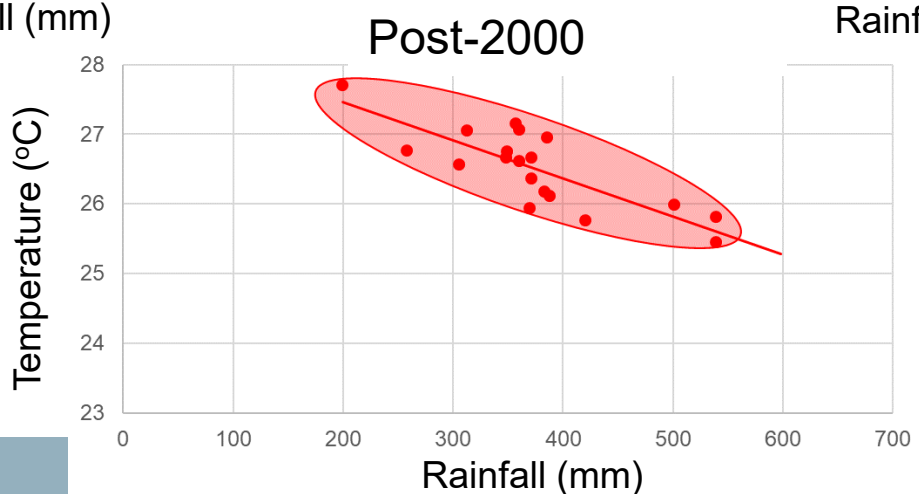


Analysis: Howden 2020. BoM data

Rainfall-temperature operating envelopes

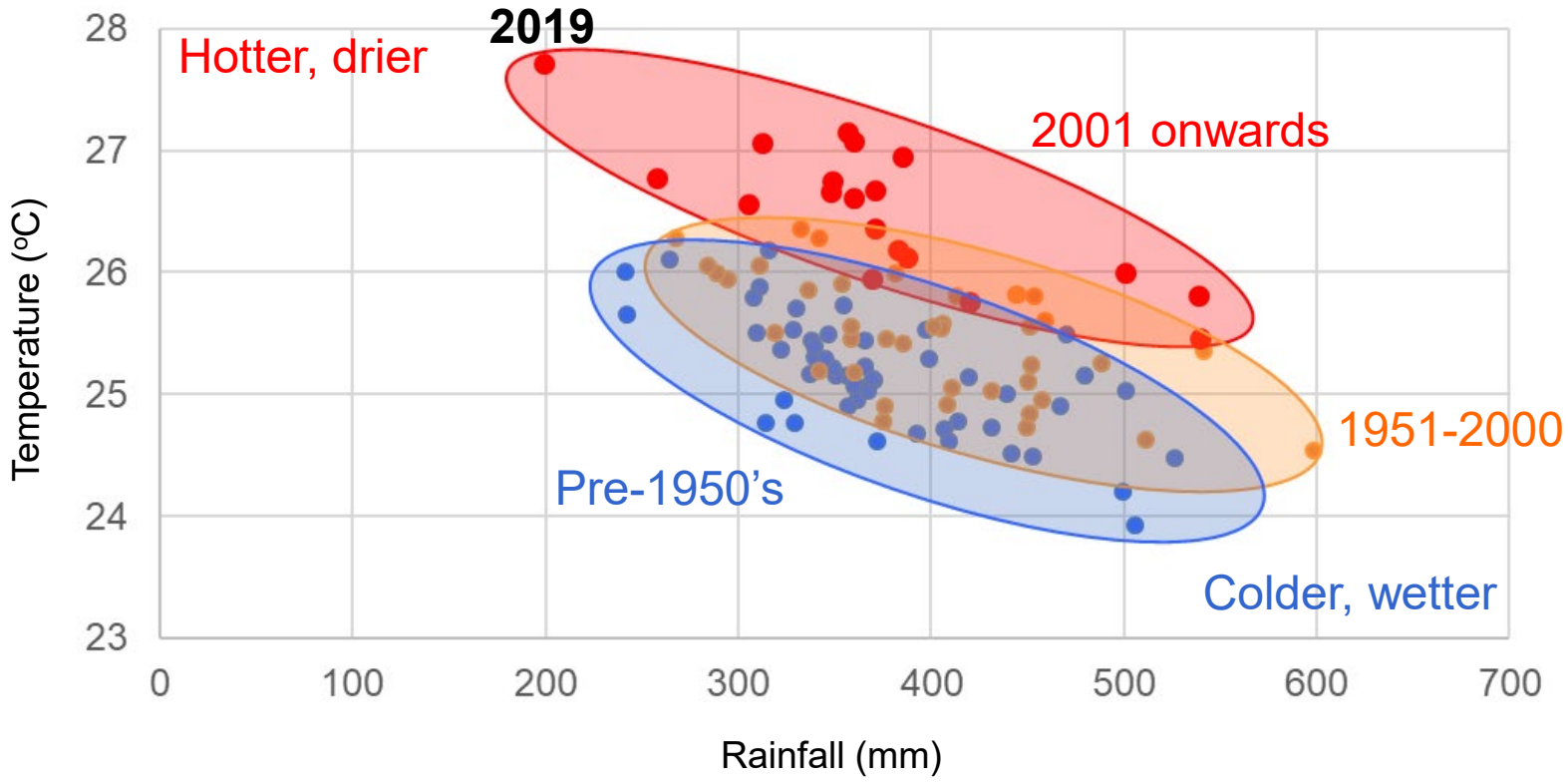






Howden 2020. BoM data

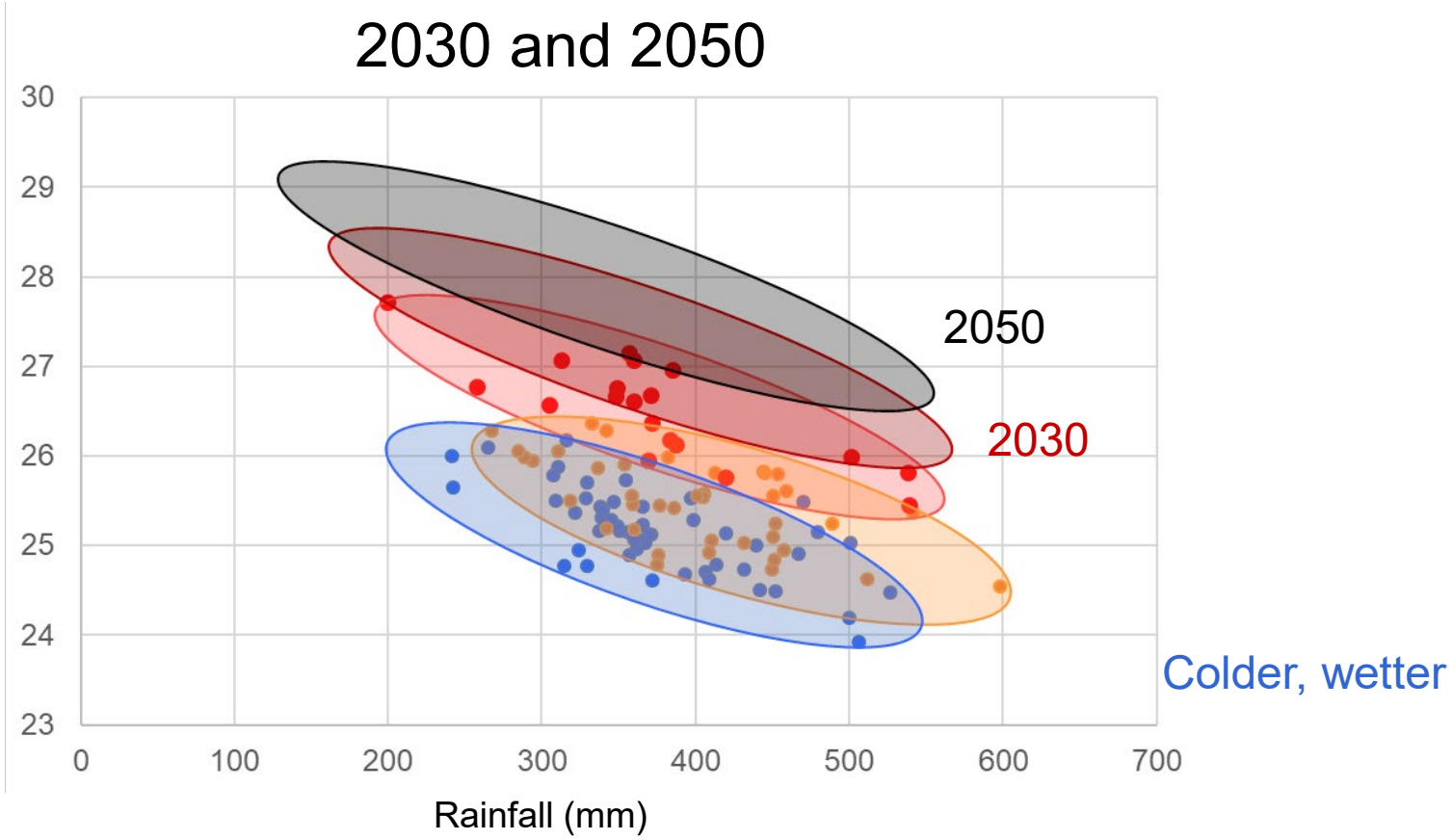
A changed operating environment



Analysis: Howden 2020. BoM data

Further changes in operating environments

Hotter, drier



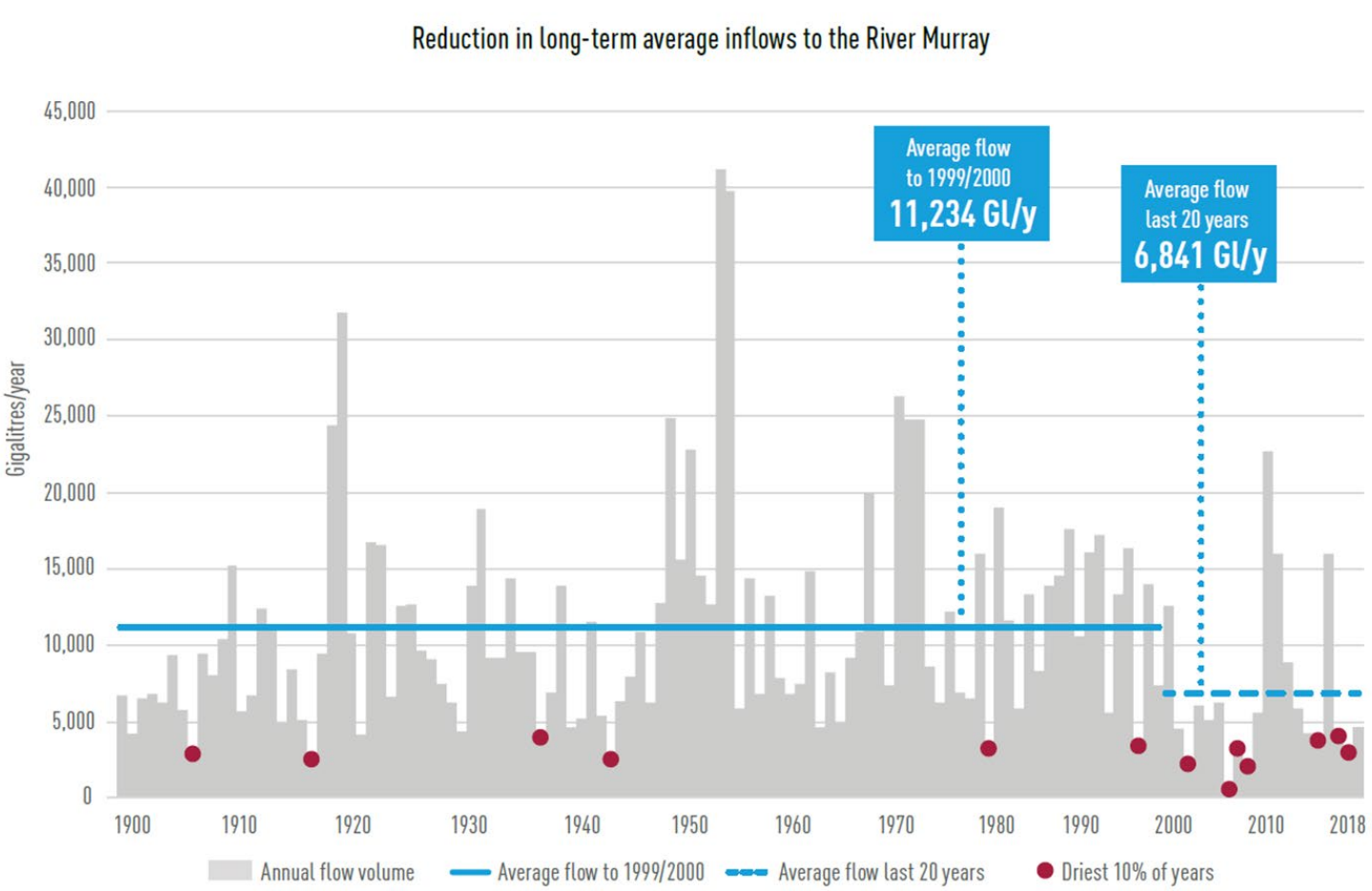
Analysis: Howden 2021. BoM data; IPCC 2018

Acceleration of the water cycle

- The global water cycle is accelerating at about twice the rate indicated by the global climate models
- Generating both increased drought risk and flood risk
  - increased soil moisture variability
- Rainfall intensity has increased
  - 40% increase in the Sydney basin for the critical sub-hourly time-scale
- Increased dryness of the air
- In SW and SE Australia, observed reductions in river flow are similar to those projected by models for 2050 or later

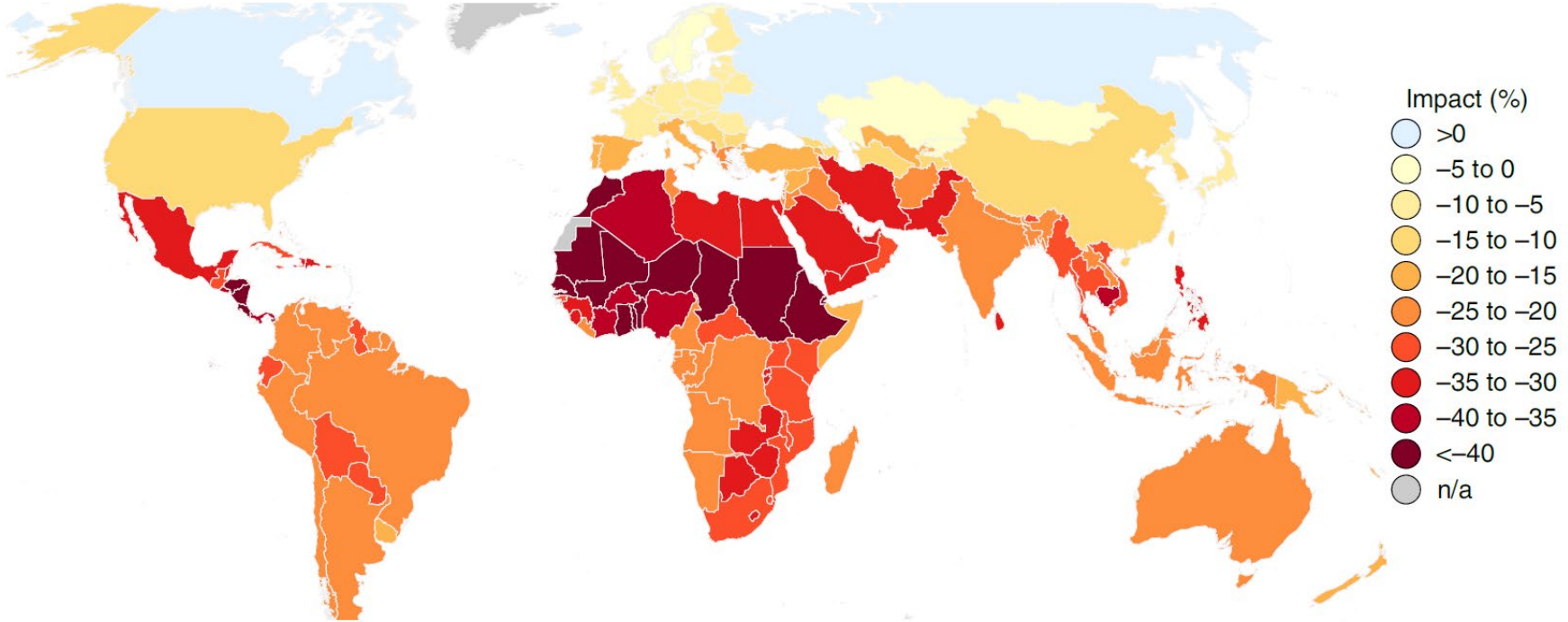
Sohail et al. 2022, Yu et al. 2020, van Dijk et al. 2023, Ayat et al. 2023, Yin et al. 2023, Hammond et al. 2022

MDB flows: historical



MDBA 2020

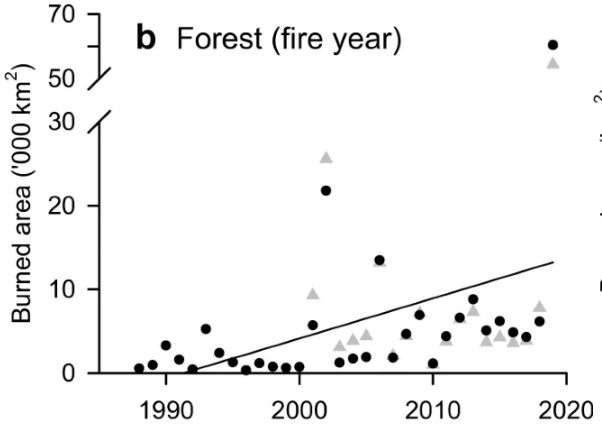
Climate changes drag back global ag productivity

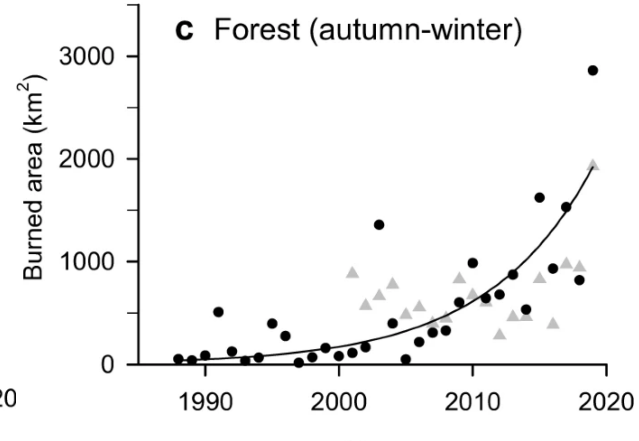


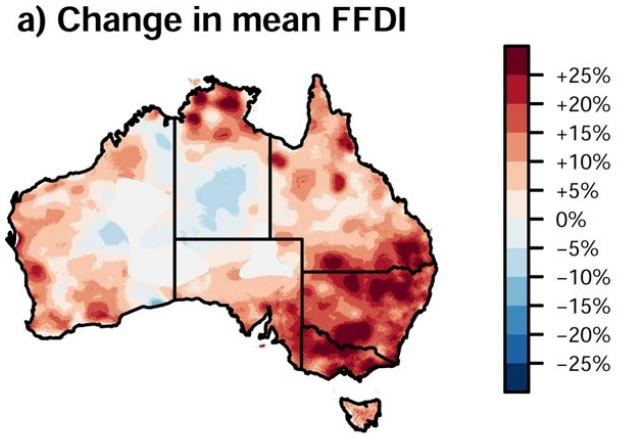
- Global average agricultural productivity reduced by 21%

Ortiz-Bobea et al. 2021

Fire risk is increasing



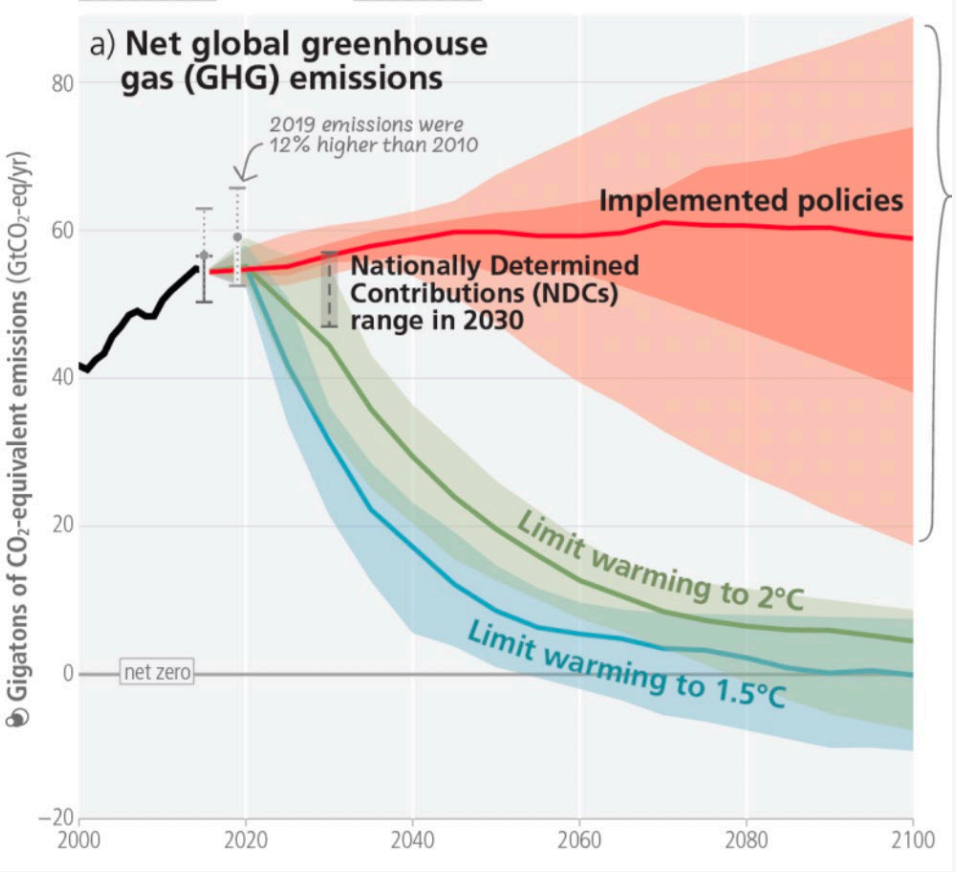




- Clear fingerprint of climate change
  - Fire season has extended
  - Fire intensity and frequency have increased
  - Days of high fire danger have increased
  - Affected area has increased

Canadell et al. 2021, Oldenborough et al. 2020

Emission trajectories: challenging



Limiting warming to 1.5 °C

- Global GHG emissions peak before 2025, reduced by 43% by 2030.
- Methane reduced by 34% by 2030
- Most pathways overshoot

Limiting warming to around 2°C

- Global GHG emissions peak before 2025, reduced by 27% by 2030.

IPCC 2023

Many emission-reduction options

Very large *potential* to cut emissions, globally

- options for 50% emissions reduction by 2030 identified costing <US$100/tCO$_2$-eq

Large potential at very low costs

- half of the total at cost <US$20/tCO$_2$-eq

Synergies with adaptation and sustainable development

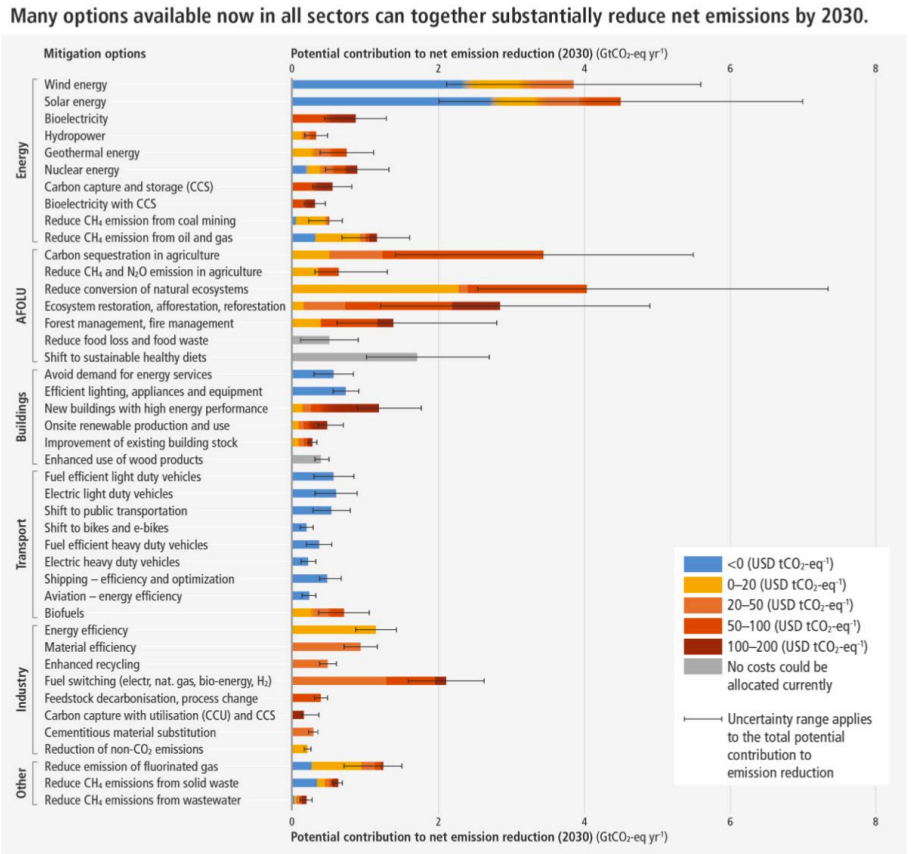
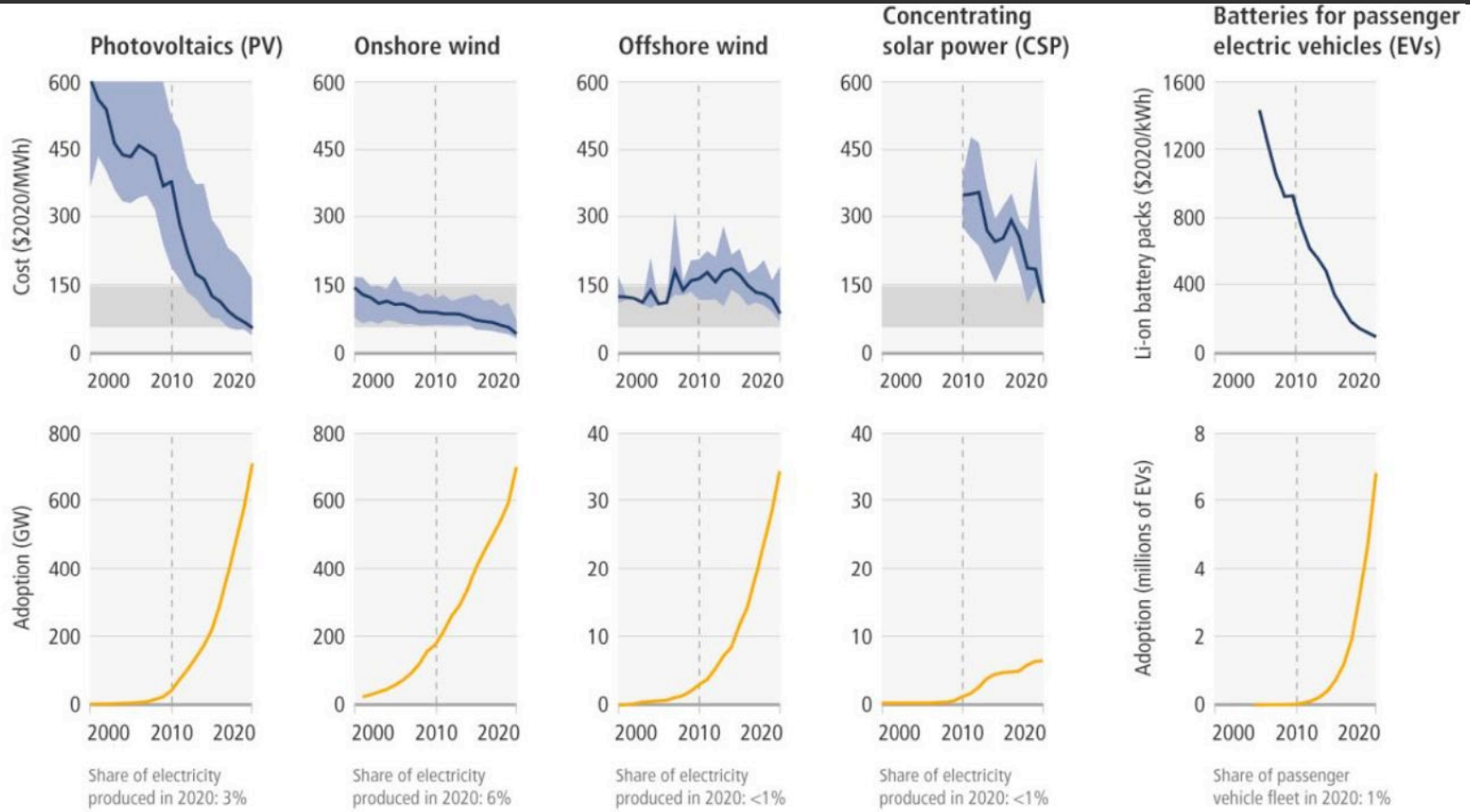


Figure SPM.7: Overview of mitigation options and their estimated ranges of costs and potentials in 2030

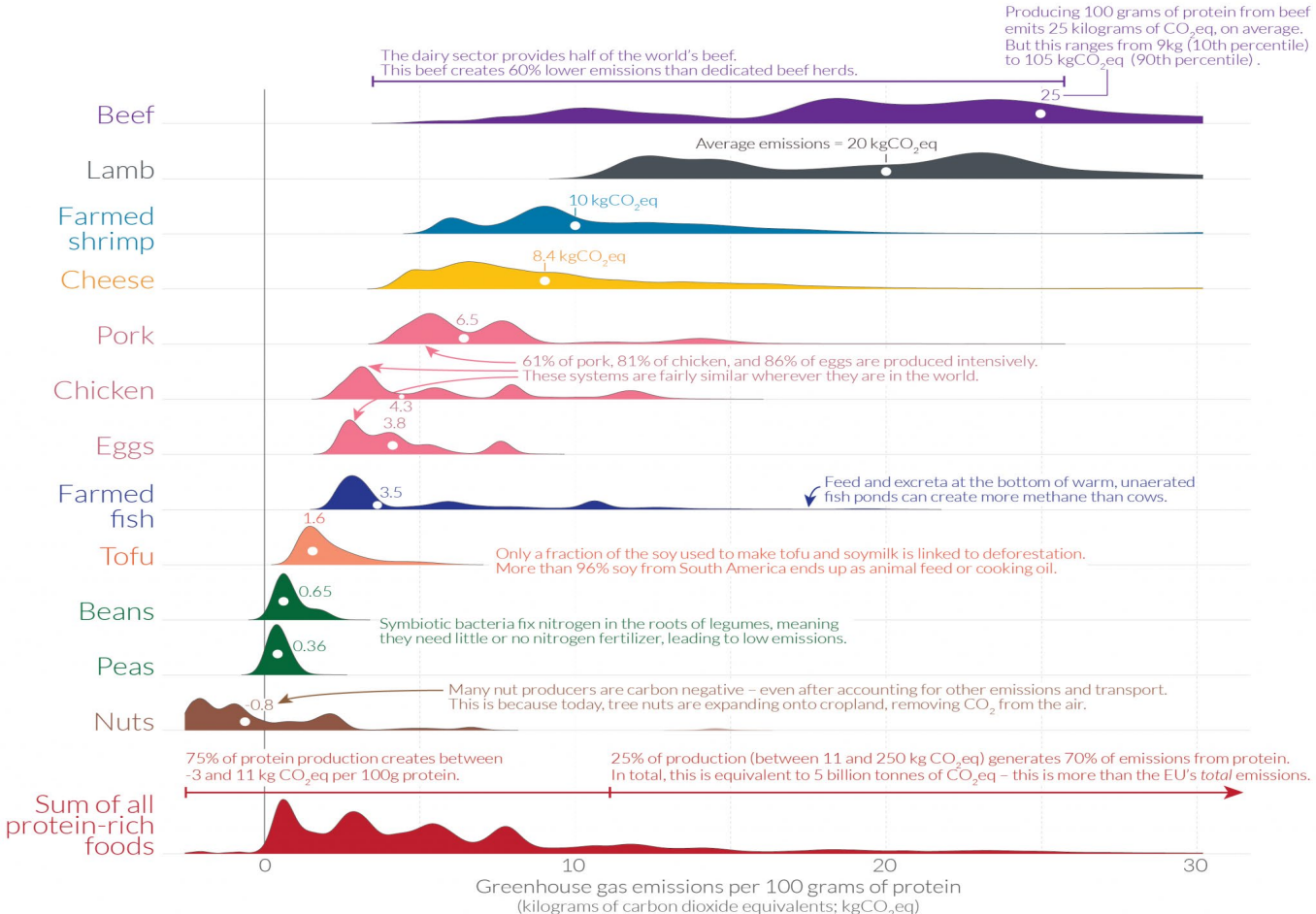
IPCC 2023

Costs of renewables/batteries and their use



IPCC 2023

Reducing GHG emissions: many options

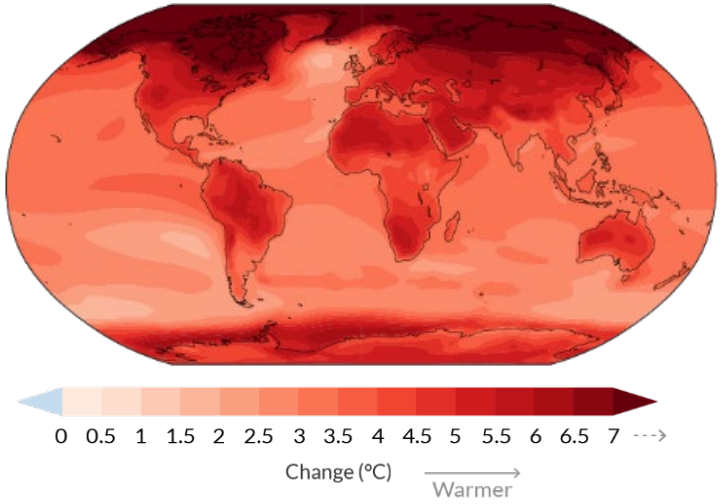


- There are many options to get the goods and services we want but with a much lower GHG footprint

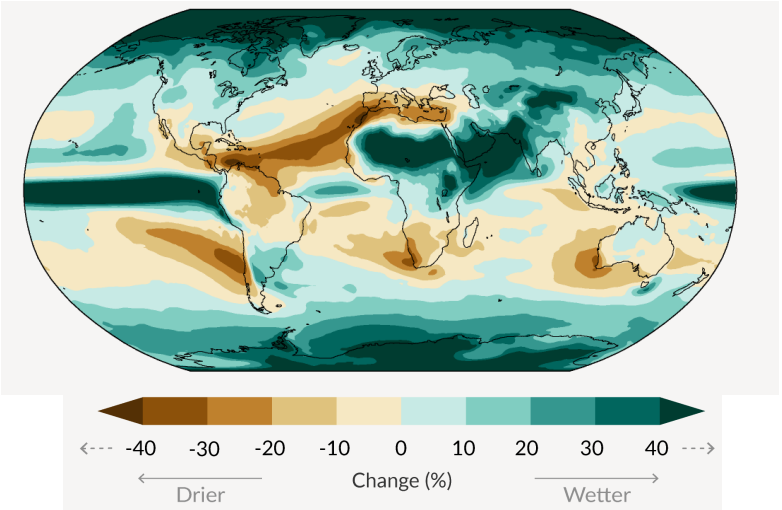
www.ourworldindata.org

Changed rainfall, temperature & water

Temperature (4°C scenario)



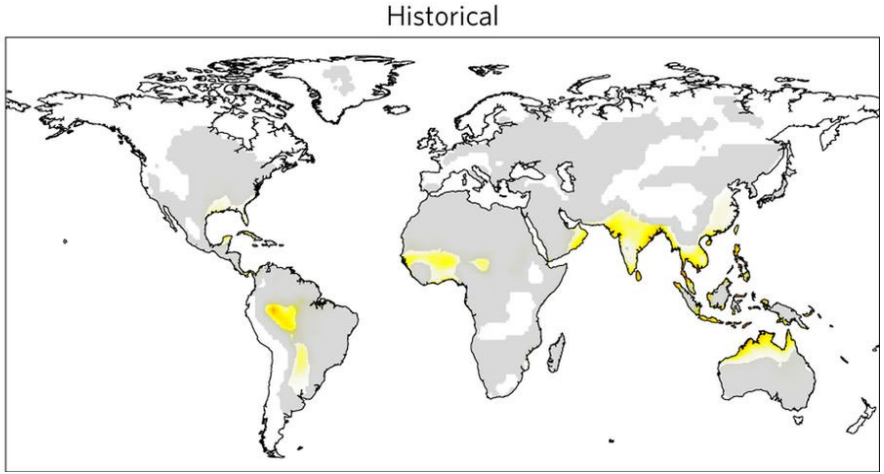
Rainfall at 4°C

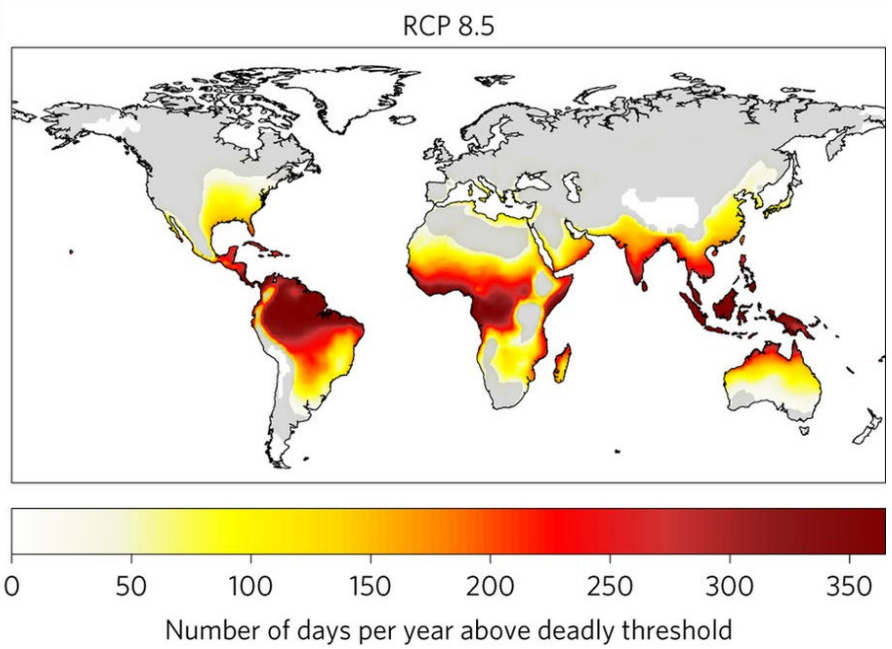


- Heat-related health issues (heat stress, vector- and food-borne disease, air pollution, mental health etc)
- Impacts on the food and energy systems (both supply and demand)
- Impacts on natural systems
- Sea level rise etc etc

IPCC 2021

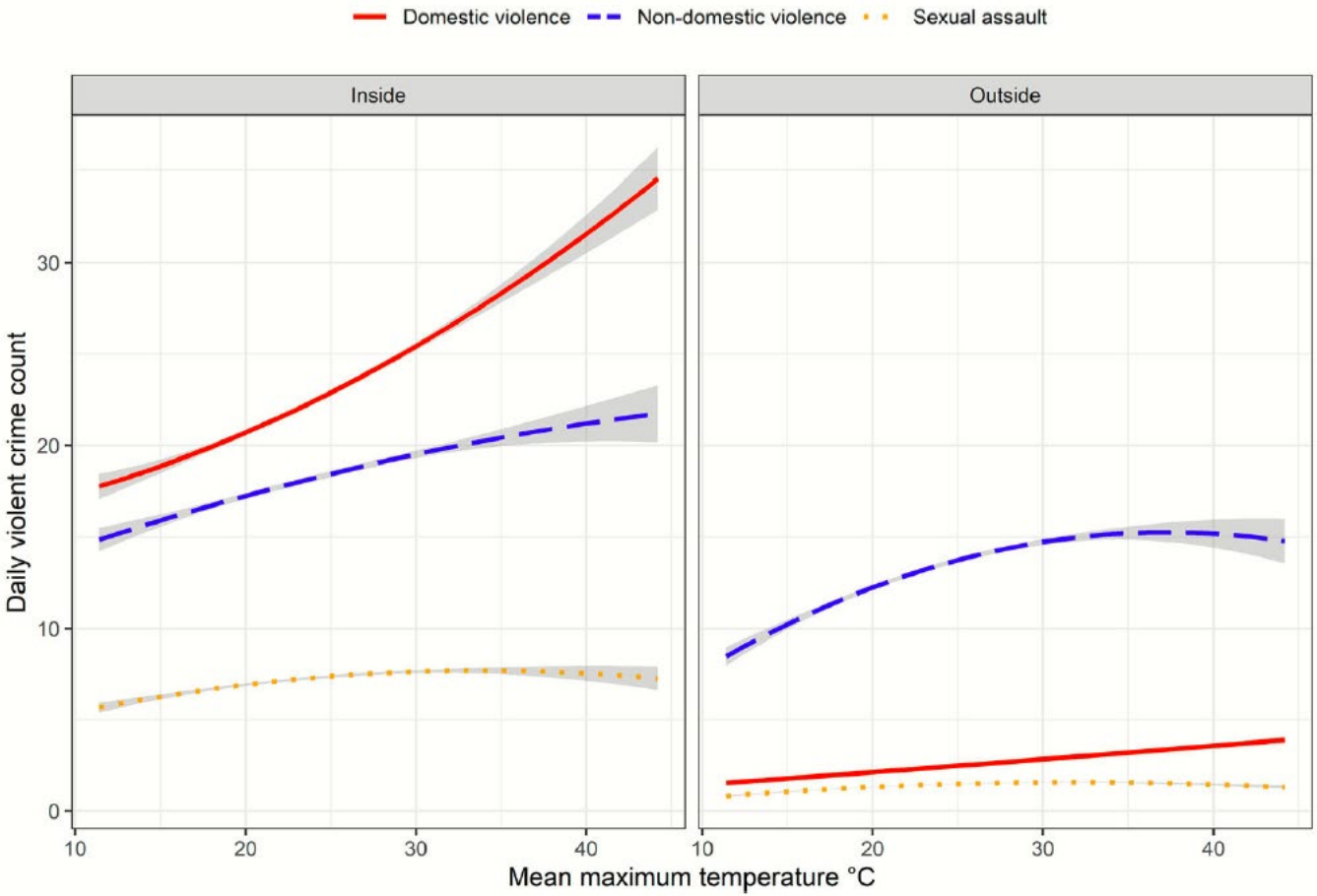
Heat stress frequency: global





Mora et al. 2017

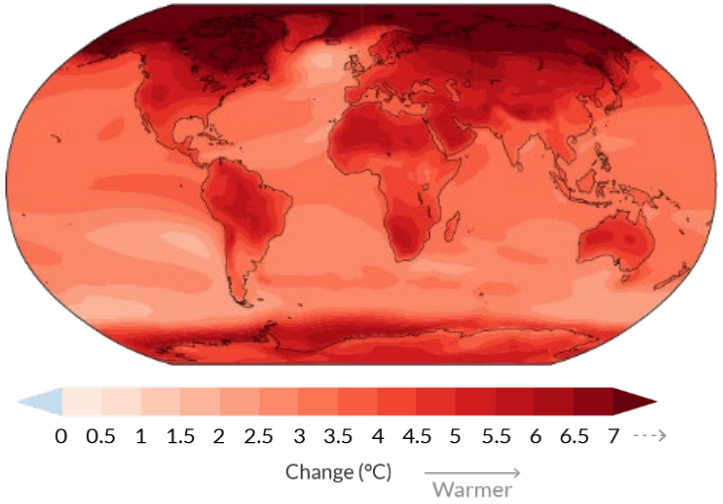
Violence increases with temperature



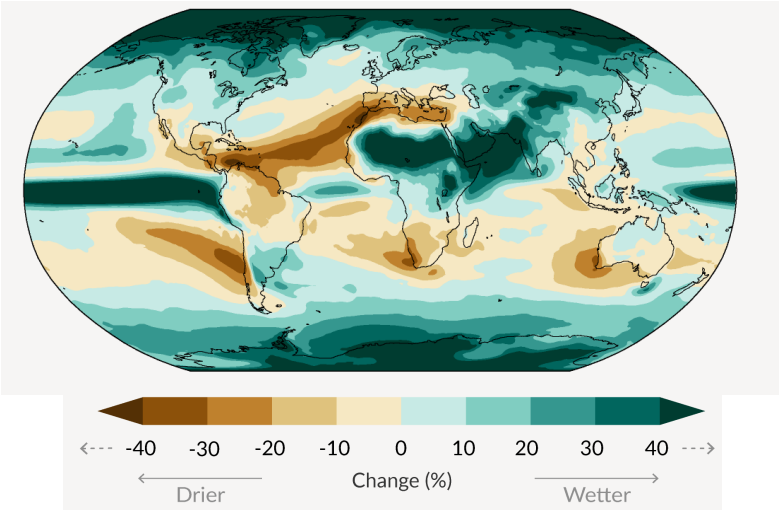
Stevens et al. 2023

Changed rainfall, temperature & water

Temperature (4°C scenario)



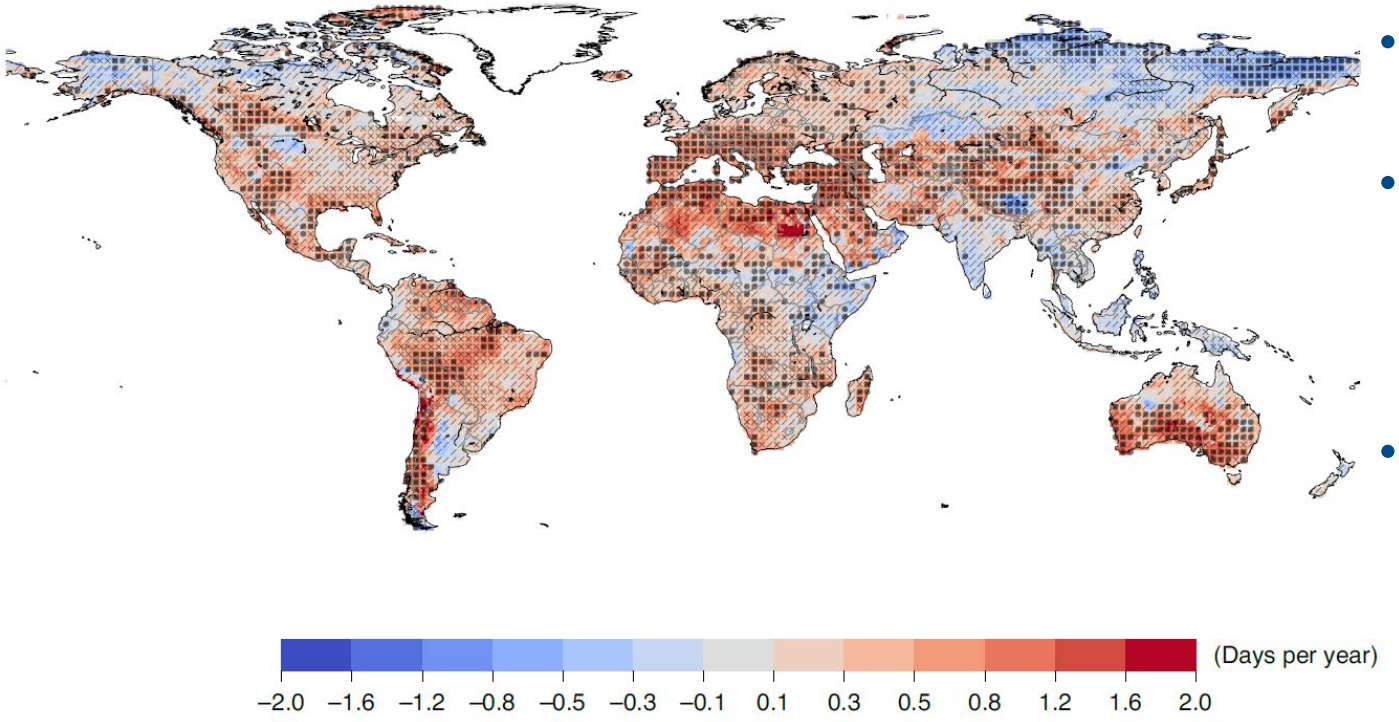
Rainfall at 4°C



- ENSO-based rainfall variability likely to increase
- Sub-tropical ridge intensification and storm track suppression
- Rainfall intensity increase with implications for flooding and erosion
- Increased variability of soil moisture

IPCC 2021

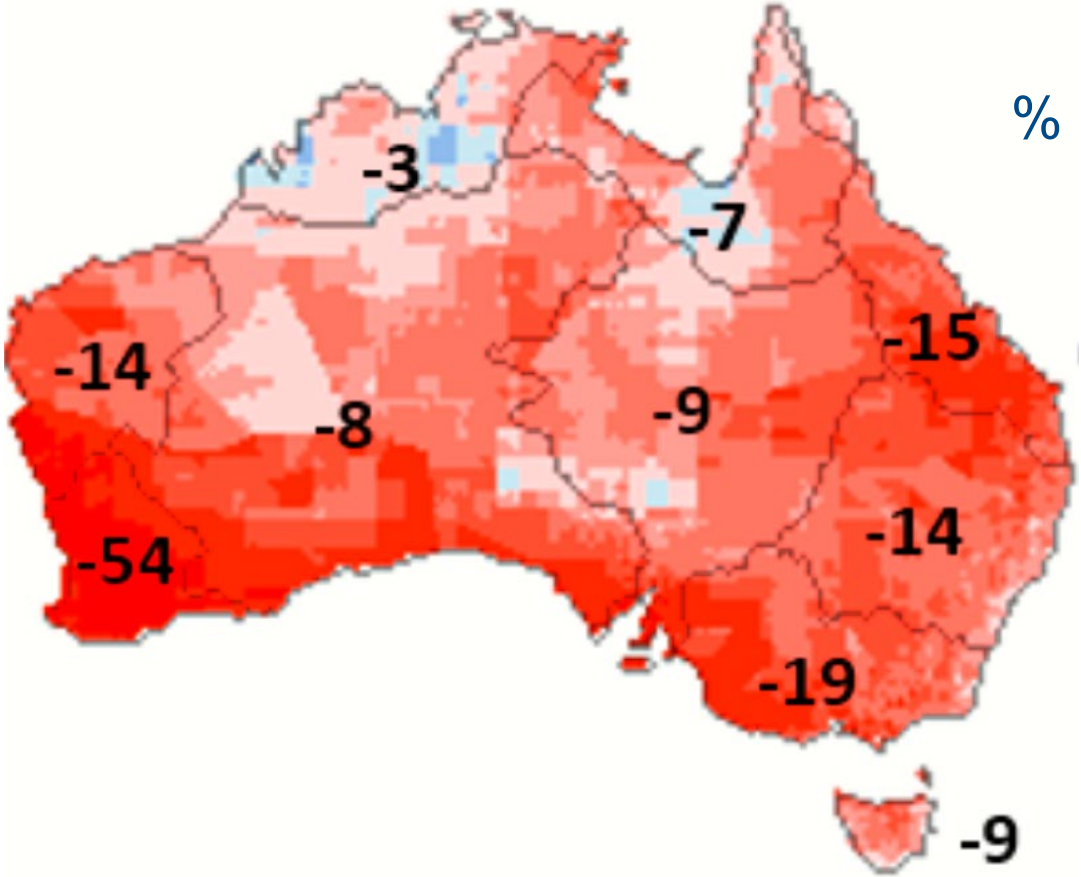
Drought becomes much worse: global



- Food prices likely to increase
- Food trade increase due to variability in supply
- Competitive advantage to those who adapt best

Pokhrel et al. 2021

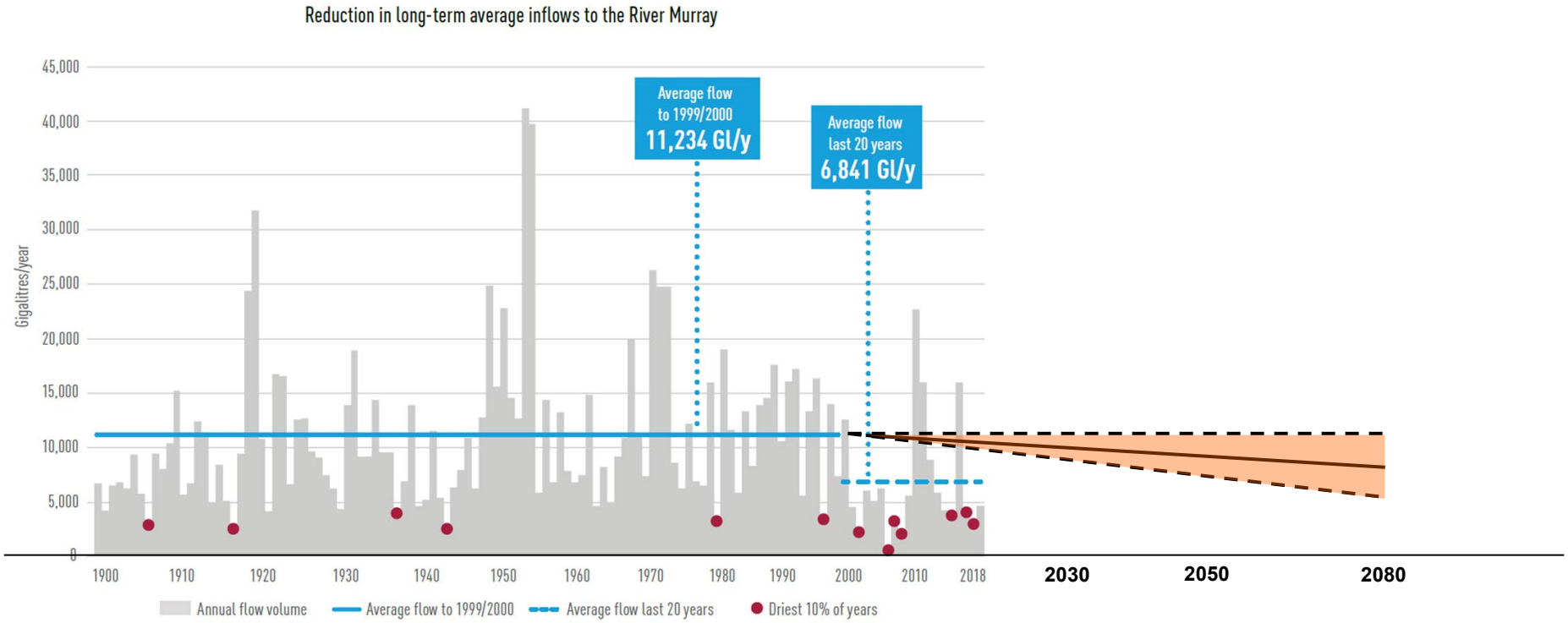
In the future, water resources more limited



% change in runoff per ^{o}C

IPCC 2022

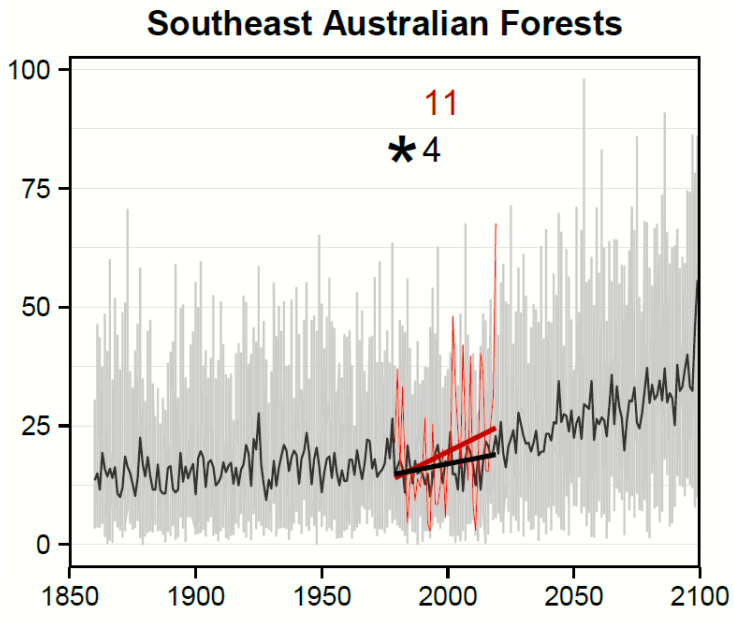
MDB flows: historical and projected



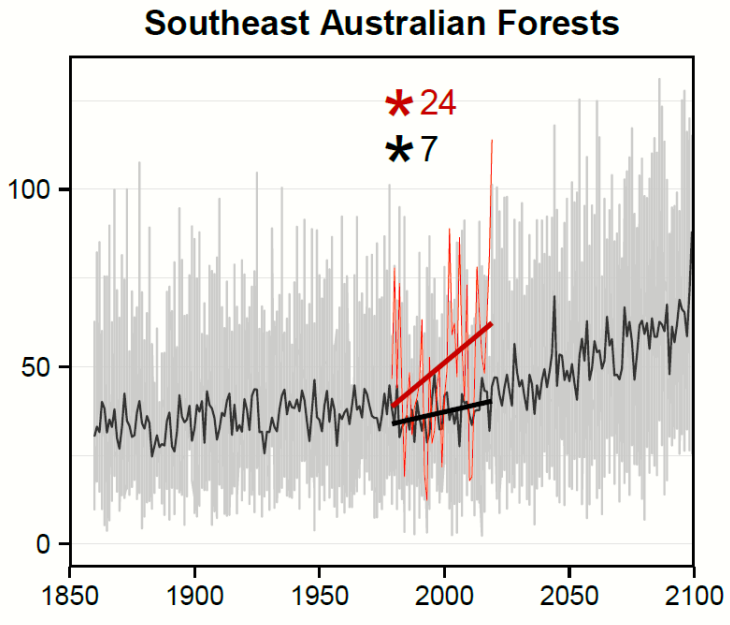
MDBA 2020; CSIRO 2021

Past and future fire changes

Fire Weather index



Fire Weather season length



Jones et al. 2022, Cai et al. 2022

Many potential adaptation responses

- Planning
- Infrastructure
- Pr
- To
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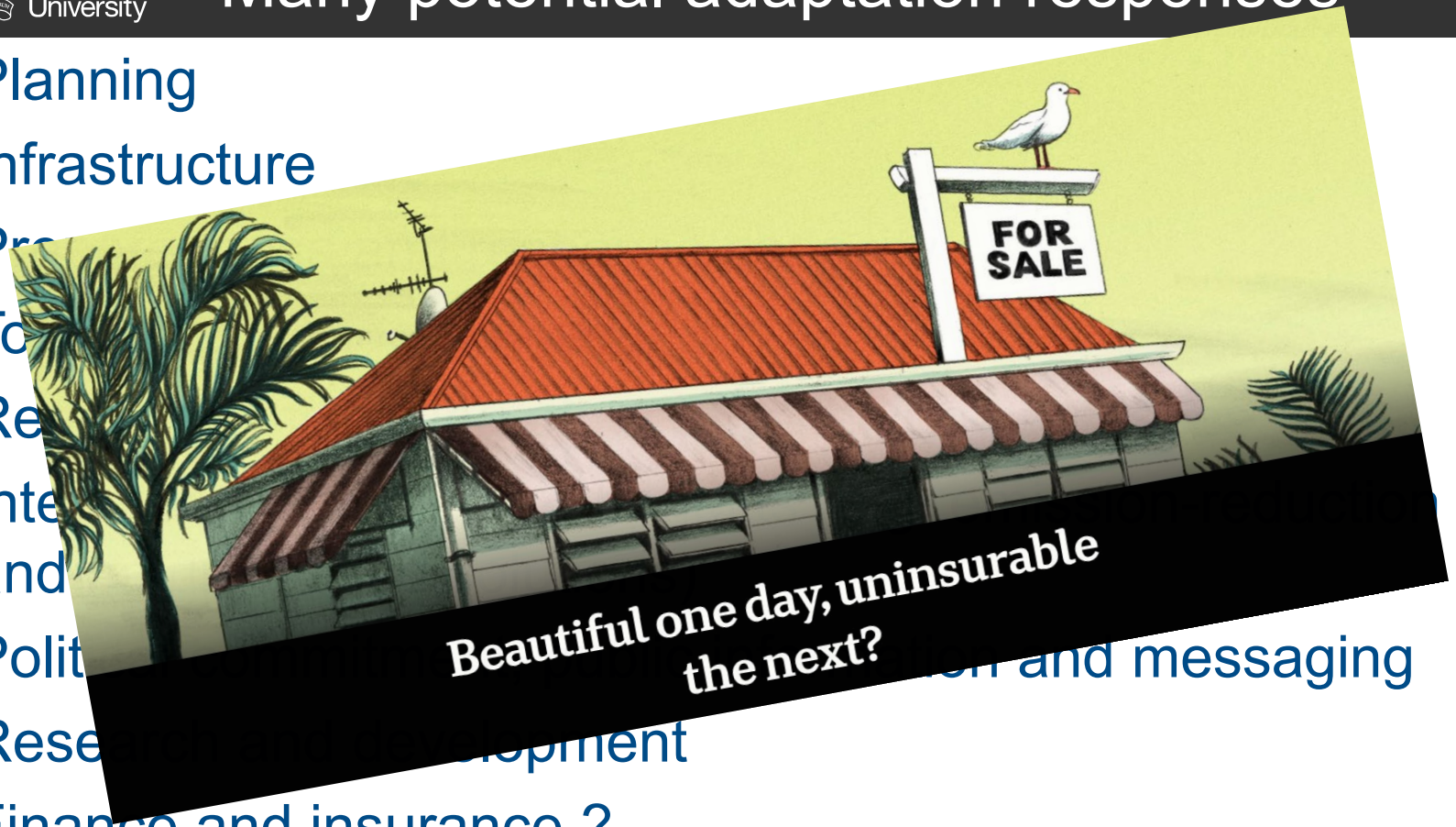
- Inte
  and
- Polit
- Rese
- Finance and insurance ?



Australian National University

Climate change is a bit like a train

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Every year matters
Every half a degree matters
Every choice matters

Howden and Colvin 2018

Things you can do

- Assess your own footprint and commit to others to change what makes sense for you
- Be influencers: talk with your heart and head to the people you know (especially those who are not engaged)
- Widen your audience: talk to people you don't know (yet)
- Emphasise urgency and integration. It is supported by the science
- Challenge the social licence of those who are a big part of the problem
- Take individual action but push expectations up to industry and government
- Be kind to allies – it needs many voices and perspectives. We are all in this together

Thanks to Helen Oakey