Future climate change and insights into the implication for energy, communities and economies




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CSIRO Project Leader of the future climate and hazard activity in the Australian Climate Service

Outline:

- Greenhouse Gas Emissions
- Global warming Levels
- Climate Modelling
- Projected Change in Hazards
- Accelerated Warming

References:

USA National Climate Assessment 2023: nca2023.globalchange.gov

State of the Climate (Australia) 2022: http://bom.gov.au/state-of-the-climate

Australian Climate Risk Assessment (in progress)

CMIP6

SSPs – Shared Socioeconomic Pathways

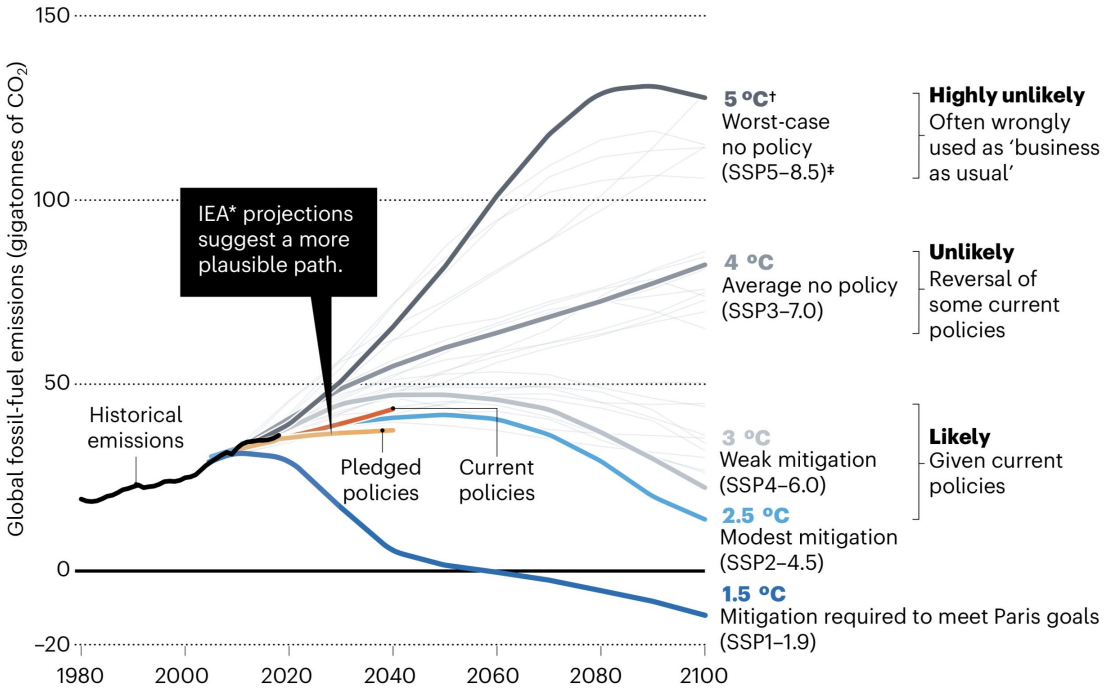
Range in possible scenarios

SSP3-7.0

SSP1-2.6

Comms challenge

People expect we are on the highest scenario and the low option is impossible



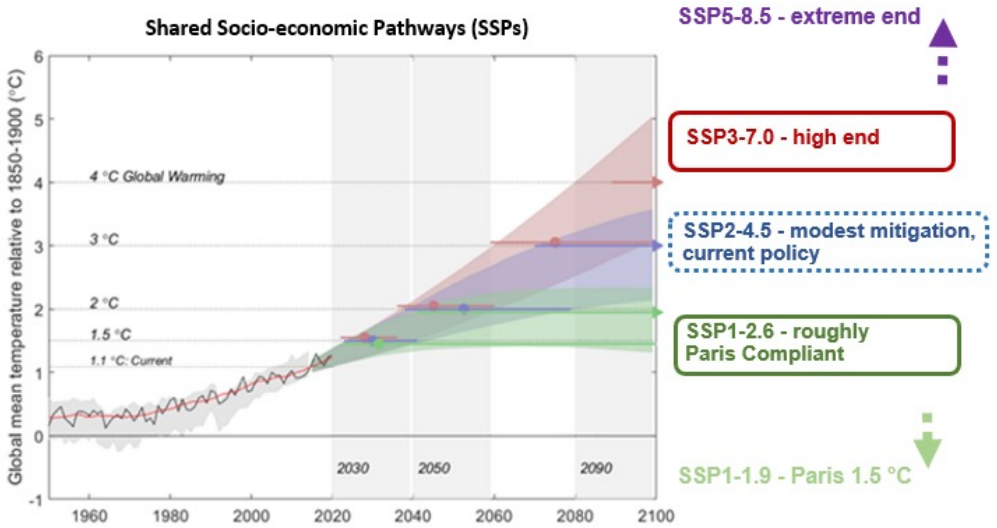
Hausfather and Peters 2020

Our Future Climate

Climate Scenarios

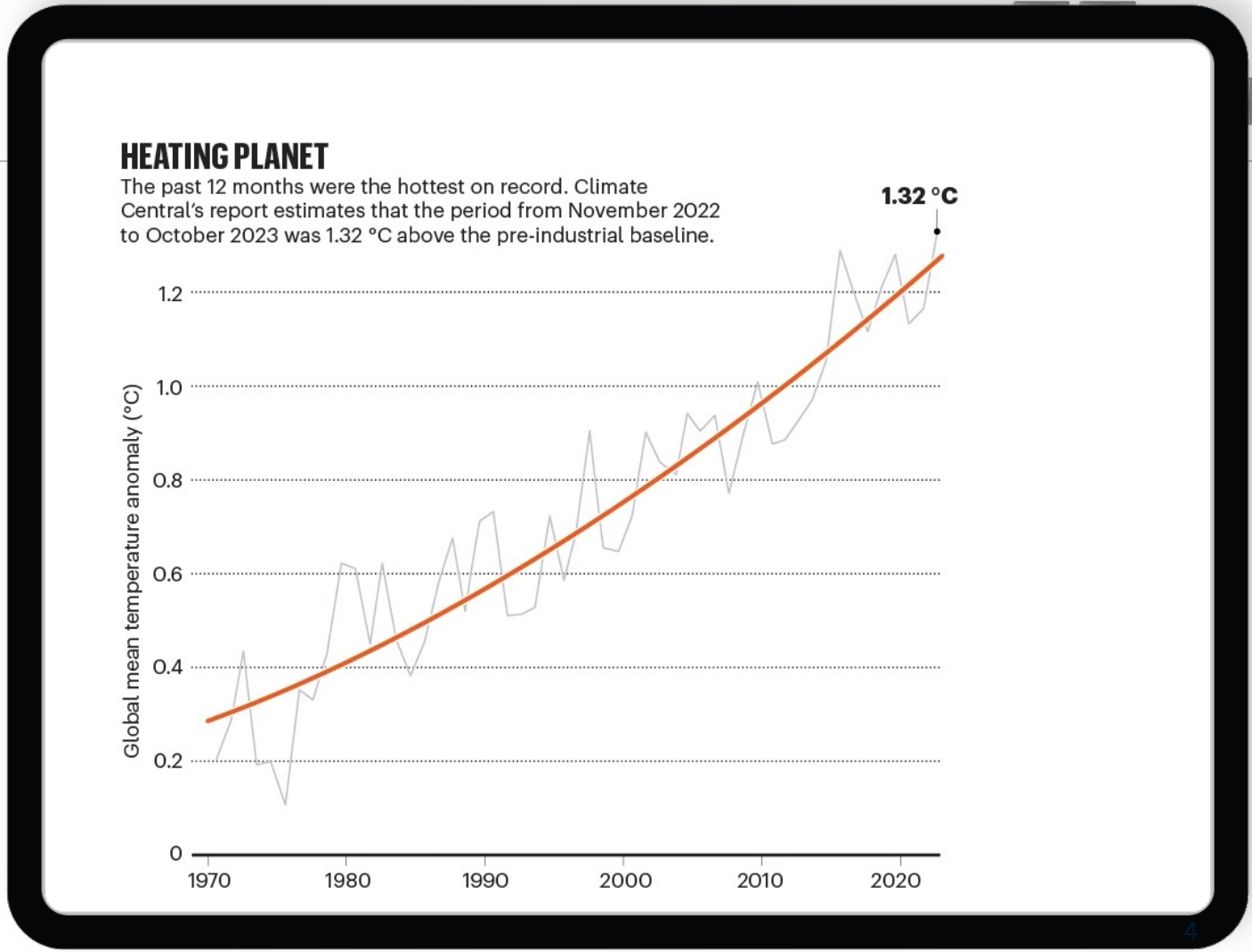
How to use the Climate Projections (CMIP)

Moving away for Shared Socio-economic Pathways (SSPs) to Global Warming Levels to characterise our future climate



Time horizon	Global Warming Level (GWL)
2050	GWL 1.5 (low emissions) GWL 2 (high emissions)
2090	GWL 2 (low emissions) GWL 3 (high emissions)

Global mean temperature anomaly



Future Weather Hazard: Record-breaking climate events of the past decade

Millennium Drought
1996-2009

Black Saturday
Feb 2009

Victorian and
Queensland Floods
2010-2011

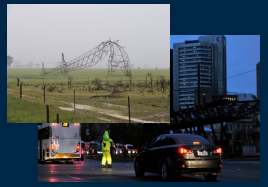
Record Hot
Summer
January
2013

Tasmanian
Fires October
2015

Tasmanian
Floods June
2016

NSW June 2016

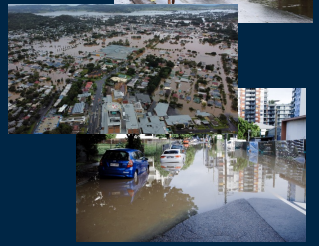
Eastern
Australian
Drought
2017-2019



SA System Black
Sept 2016

Victorian and NSW
Black Summer 2019

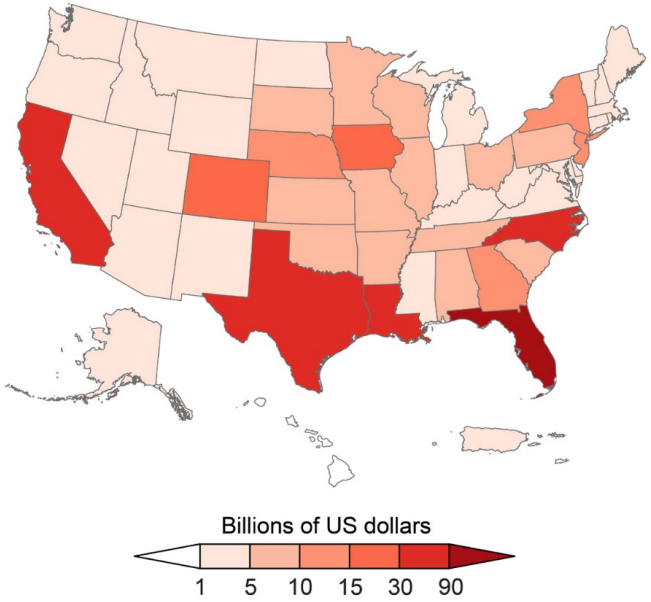
Queensland
and NSW
floods 2022



Australian Government
Bureau of Meteorology

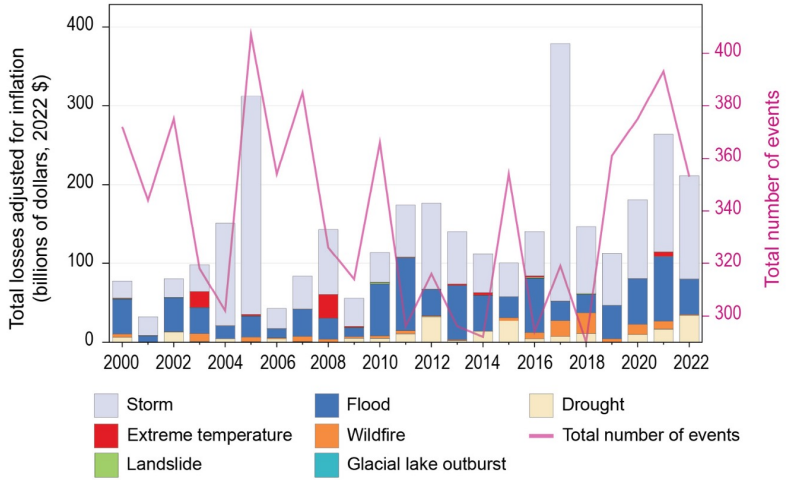
Economic Cost of Weather and Climate Disasters

Damages by State from Billion-Dollar Disasters (2018–2022)



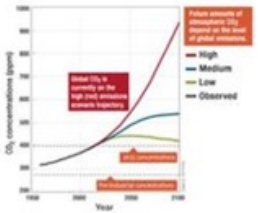
The US now experiences, on average, a billion-dollar weather or climate disaster every three weeks.

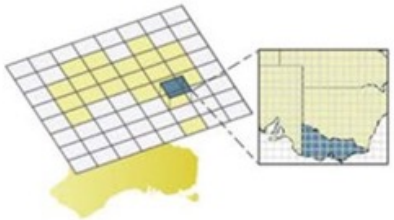
Climate-related disaster and economic losses

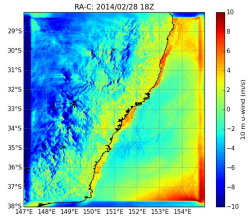


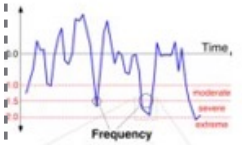
Global number and diversity of climate-related disasters since 2000

Workflow of climate modelling









Climate services

Emission Scenarios → Global Models (CMIP) → Regional Models → Calibrated output → Climate & Hazard intelligence → Users Products Services

Other lines of evidence: Obs, Paleo and more

Theory, process understanding

Other models (EMICs, emulators etc.)

Changes outside model range:
- Not modelled well in CMIP
- Non-linear changes
- Tipping points

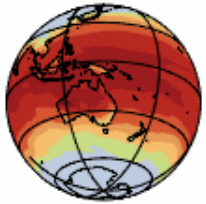
Global to Regional Modelling

100km -> 10 km

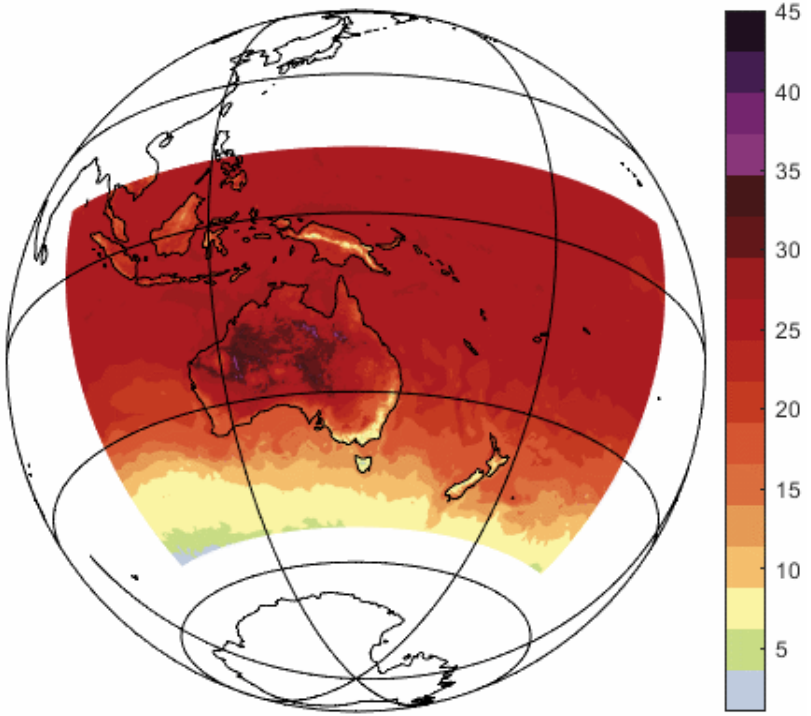
Like the Climate Model Intercomparison Project (CMIP) there is an International coordinate effort regional climate modelling (CORDEX)

Many regional domains (e.g. North America, Australian)

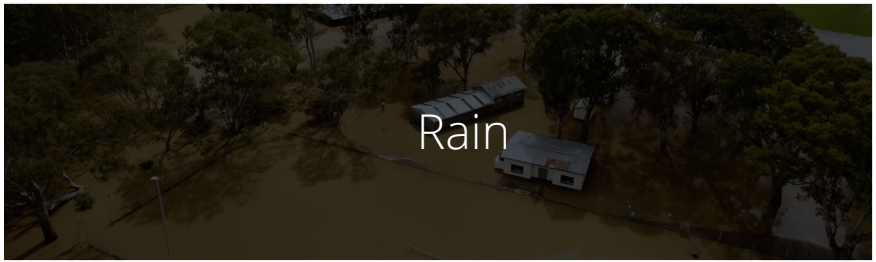
Focused on the Atmosphere and Land but can be coupled to Marine models to do coastal hazards too – e.g., waves and coastal erosion



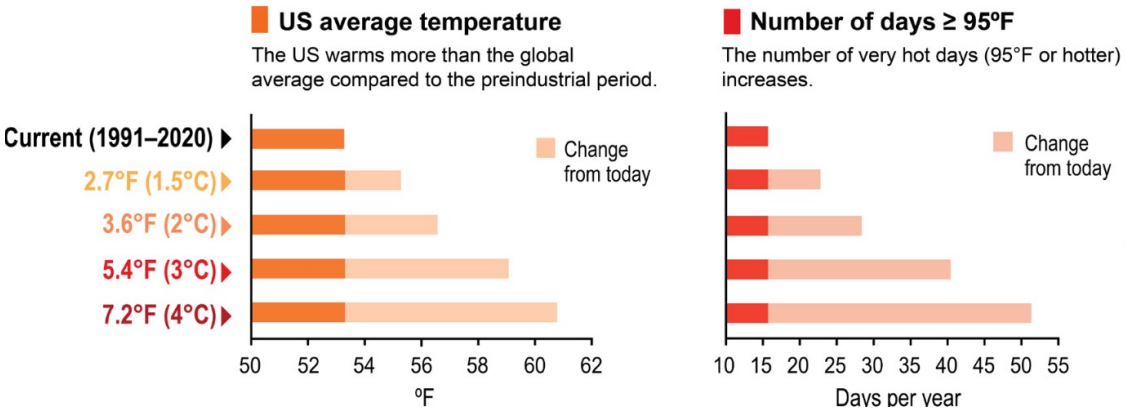
GCM versus CORDEX simulation
Surface temperature



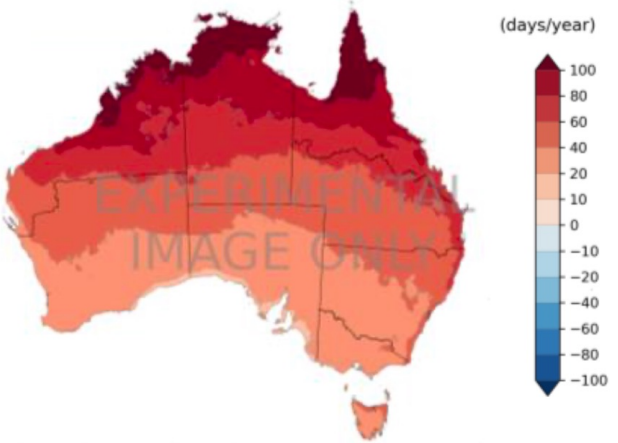
Weather hazards
Future outlook



Heatwaves

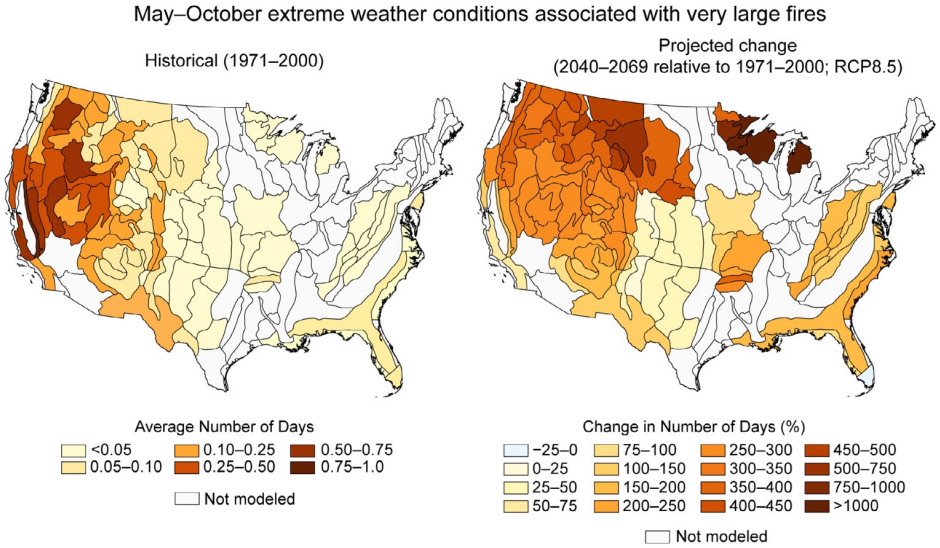


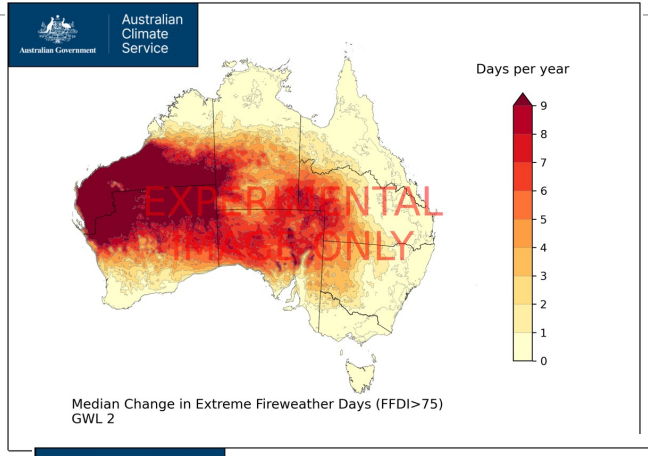
Change in number of days experiencing heatwave conditions

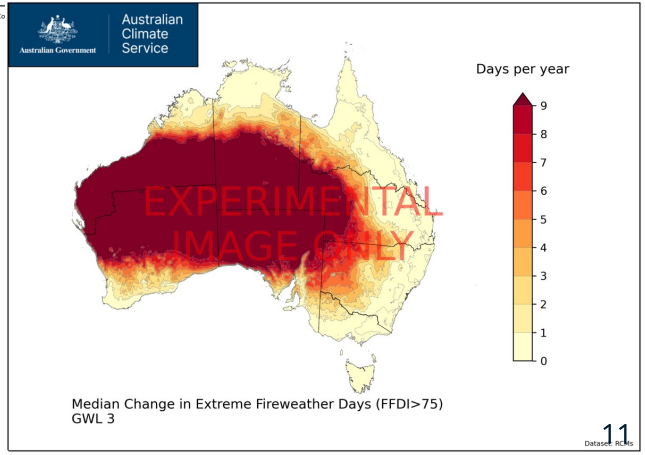


Change in number of days experiencing heatwave conditions
GWL 3.0 °C - GWL 1.2 °C

Extreme Fire Weather: conditions primed for large fires



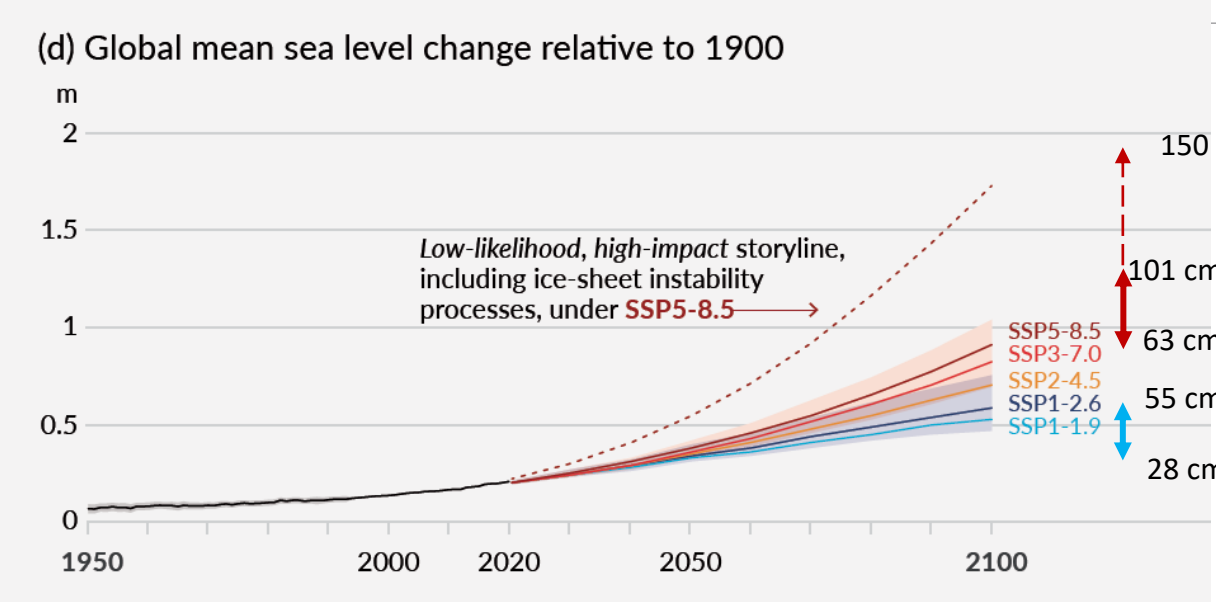




Sea Level Rise projected change by the end of the century

Various different outcomes! Must be acknowledge and deal with it using a risk management framework

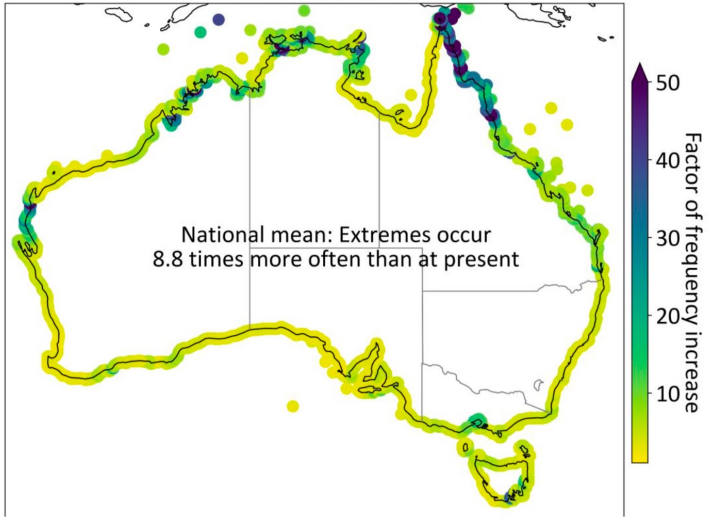
Likely range of 28 to 101 cm without considering tipping points likely the melting of ice sheets this century.



IPCC AR6 (2021)

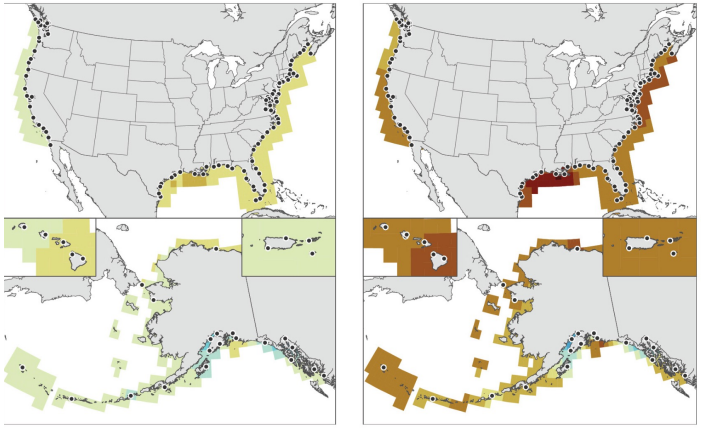
Sea Level Rise

Increase in extreme total water level frequency with 0.32 m additional SLR



Hazard metric	GWL 1.5	GWL 2	GWL 3
Mean Sea Level change from today	**Additional 0.14m Global Sea Level rise**	**Additional 0.32m Global Sea Level rise**	**Additional 0.54m Global Sea Level rise**
Frequency of present-day extreme total water levels	Increase in frequency of present-day extreme total water levels	Increase in frequency of present-day extreme total water levels. National mean increase of coastal extremes 8.8 times present (high confidence)	Increase in frequency of present-day extreme total water levels. National mean increase of coastal extremes 68.8 times present (high confidence)

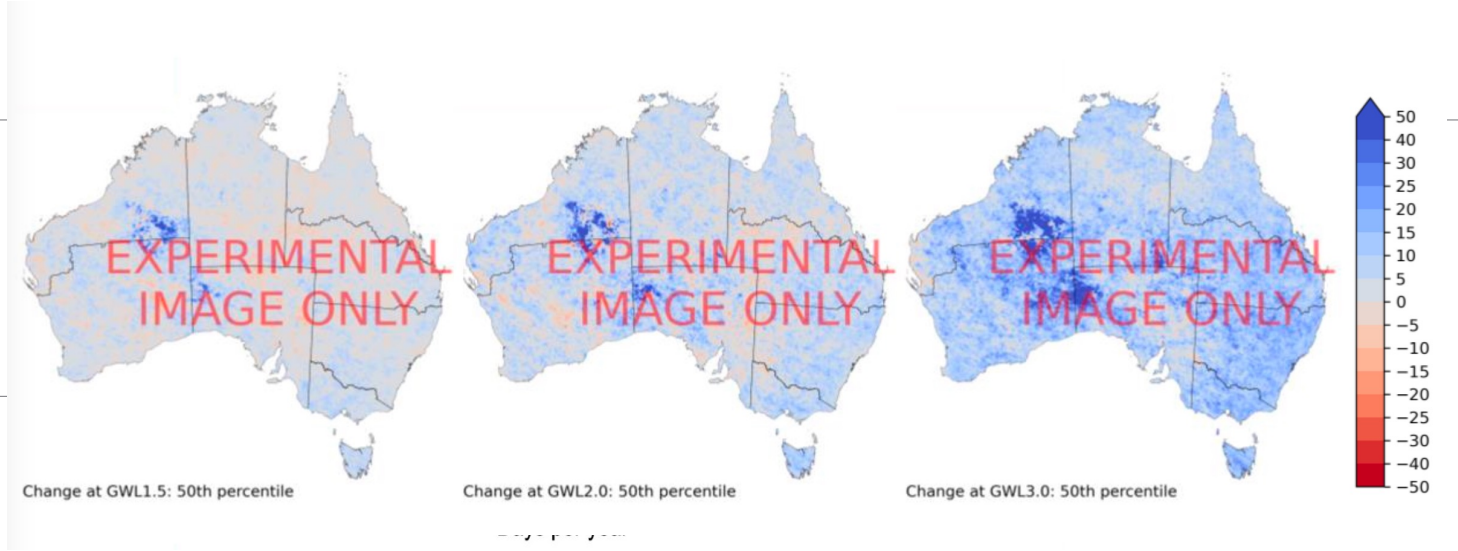
2050 2100

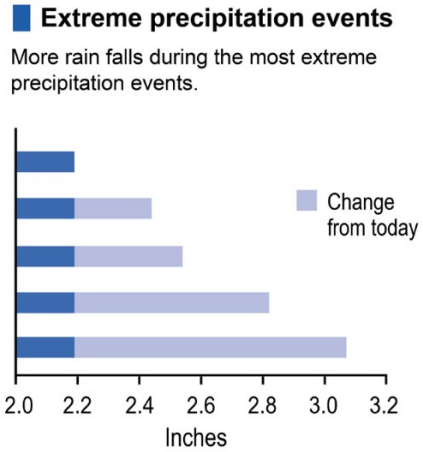


*Rise at the upper end of this range cannot be ruled out due to the possibility of rapid ice sheet loss. The amount of warming required to trigger such loss is not currently known but is assessed to be above 3.6°F (2°C).

Extreme Rainfall

More intense short-duration heavy rainfall events throughout the country.

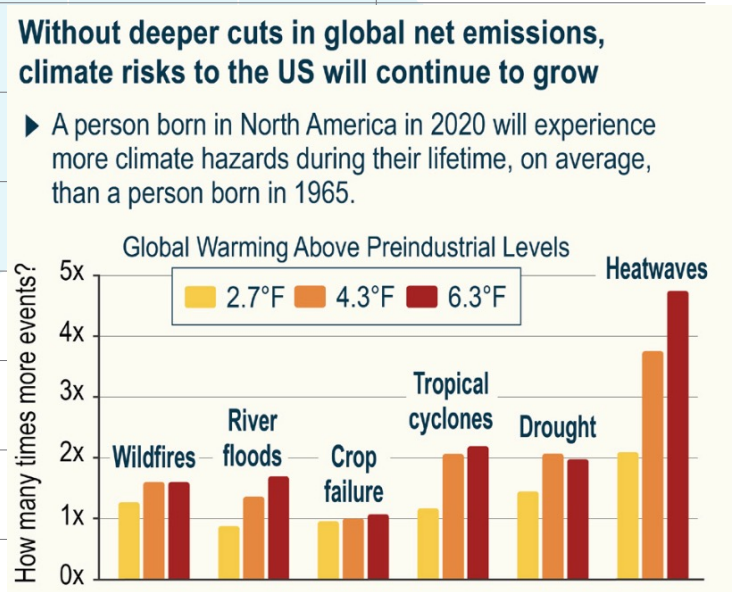




Weather hazards projected changes

Climate Measurement Standards Initiative Task Force on Climate-Related Financial Disclosures

	Cat 4 – 5 Tropical Cyclone frequency: **Increase**	Low – Medium
	Tropical cyclone latitude: **Poleward extension more likely than not**	Low
	Extreme hourly to daily rainfall: **Increase**	
	Flood risk factor: **Increase more likely than decrease**	
	Tropical Cyclone frequency: **Decrease**	
	Large hail (>2.5cm): **Unclear**	
L	East coast low frequency: **Decrease**	
	Extreme fire weather: **Increase**	



2023 Temperature Extremes

Source: Climate Central

WORLD VIEW | 19 March 2024

Climate models can't explain 2023's huge heat anomaly — we could be in uncharted territory

Taking into account all known factors, the planet warmed 0.2 °C more last year than climate scientists expected. More and better data are urgently needed.

By Gavin Schmidt

NEWS | 10 November 2023

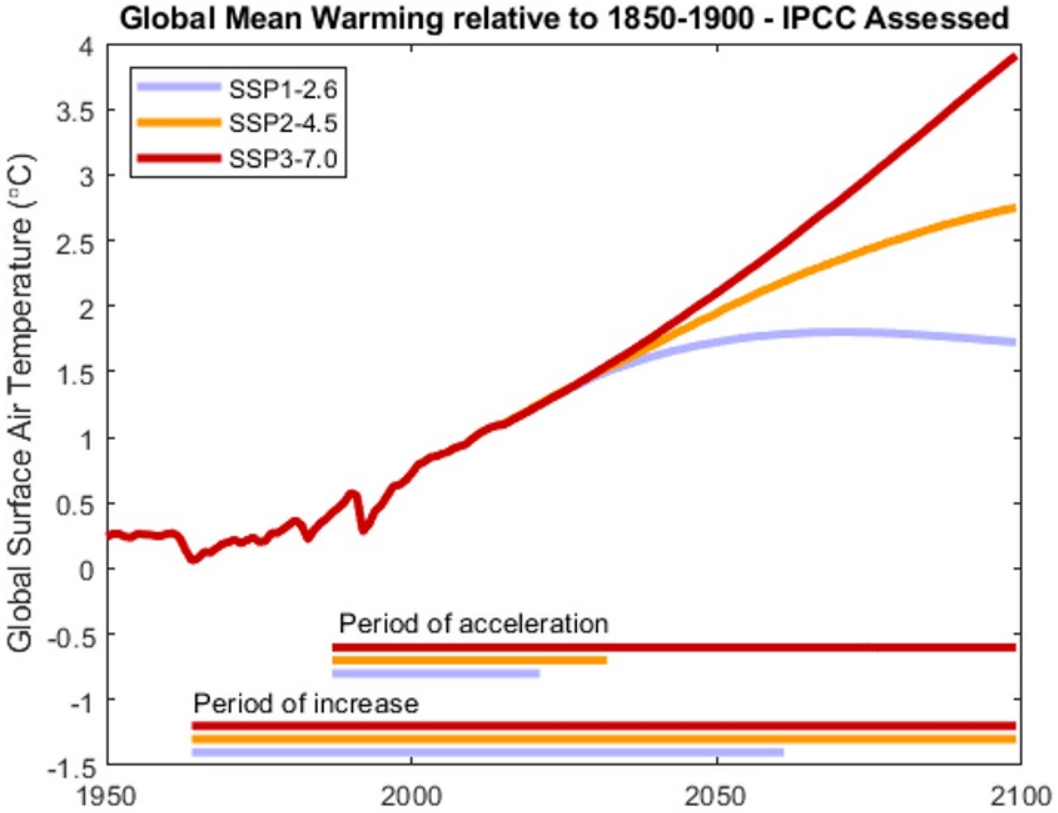
Earth just had its hottest year on record — climate change is to blame

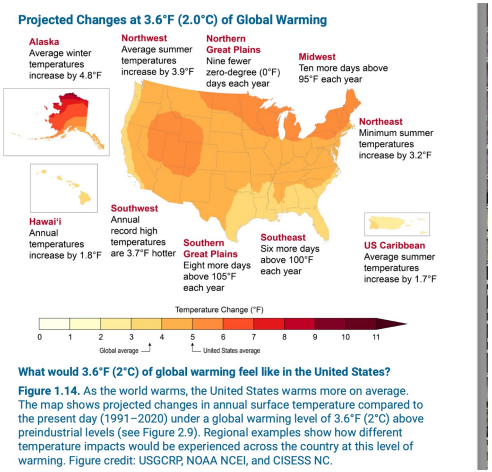
Around 7.3 billion people faced temperatures strongly influenced by global warming over the past year.

By Carissa Wong

Commentrary on 2023

Global mean temperature anomaly: CMIP6 Acceleration





Commentrary on 2023

17

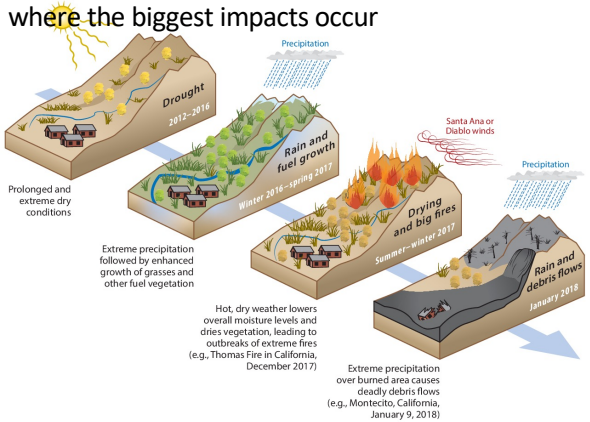
Key Messages

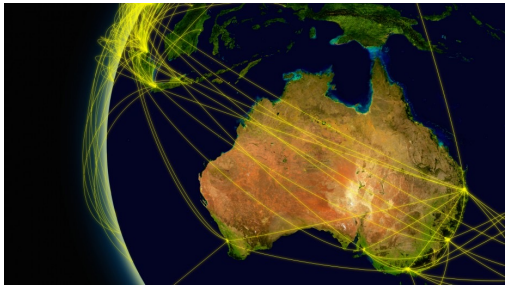
- Climate Is Changing, and Scientists Understand Why
- Extreme Events Are Becoming More Frequent and Severe
- Humans Are Changing Weather and Climate Extremes and How Much the Climate Changes Depends on the Choices Made Now
- Climate Change will Continue to Cause Profound Changes on people, communities, economies, and natural systems
- Move to renewal energy to reduce or Greenhouse Gas Emissions will require a more flexible systems

USA National Climate Assessment 2023: nca2023.globalchange.gov
State of the Climate (Australia) 2022: http://bom.gov.au/state-of-the-climate
Australian Climate Risk Assessment (in progress)

Some additional points : complex risk, global impacts and tipping points

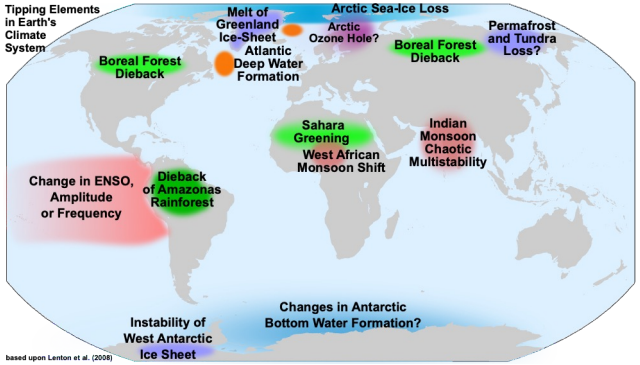
Increased Variability: Compound and consecutive extremes, cascading impacts can be where the biggest impacts occur





Connected: climate change cross borders and impacts Trade, Migration, Food Security, Conflict, …

Known Unknowns: Reaching global climate 'Tipping Points' may mean abrupt change, effects on Australia beyond projections shown here



Also consider regional 'regime shifts' with local abrupt change 'tipping points' within systems

Sequence of extremes California 2018 (AghaKouchak et al. 2020 Climate Extremes and Compound Hazards in a Warming World. *Annual Review of Earth and Planetary Sciences*)

Australian Government | Australian Climate Service

Seamless Climate and Hazard Downscaled Modelling

David Jones
Section Manager, Seamless Prediction Science

Richard Matear
Research Scientist, CSIRO