Extreme Weather Events

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2025

South Australia

Figure : Where in the world is South Australia?

Climate

- Adelaide is at latitude 35.9^o south and longitude 138.6^o east.
- It has a Mediterranean climate with cool wet winters and hot dry summers.
- Even in winter, there are numerous sunny or partly sunny days.

Kaurna Country

- Ninna marni. Greetings
- Ngaityo Kaurna yartangka tapanaprinthi. I come from the land of the Kaurna People.
- Ninna puru kauwi, yertaitya. We walk together into the future.

Global Surface Temperature Anomaly

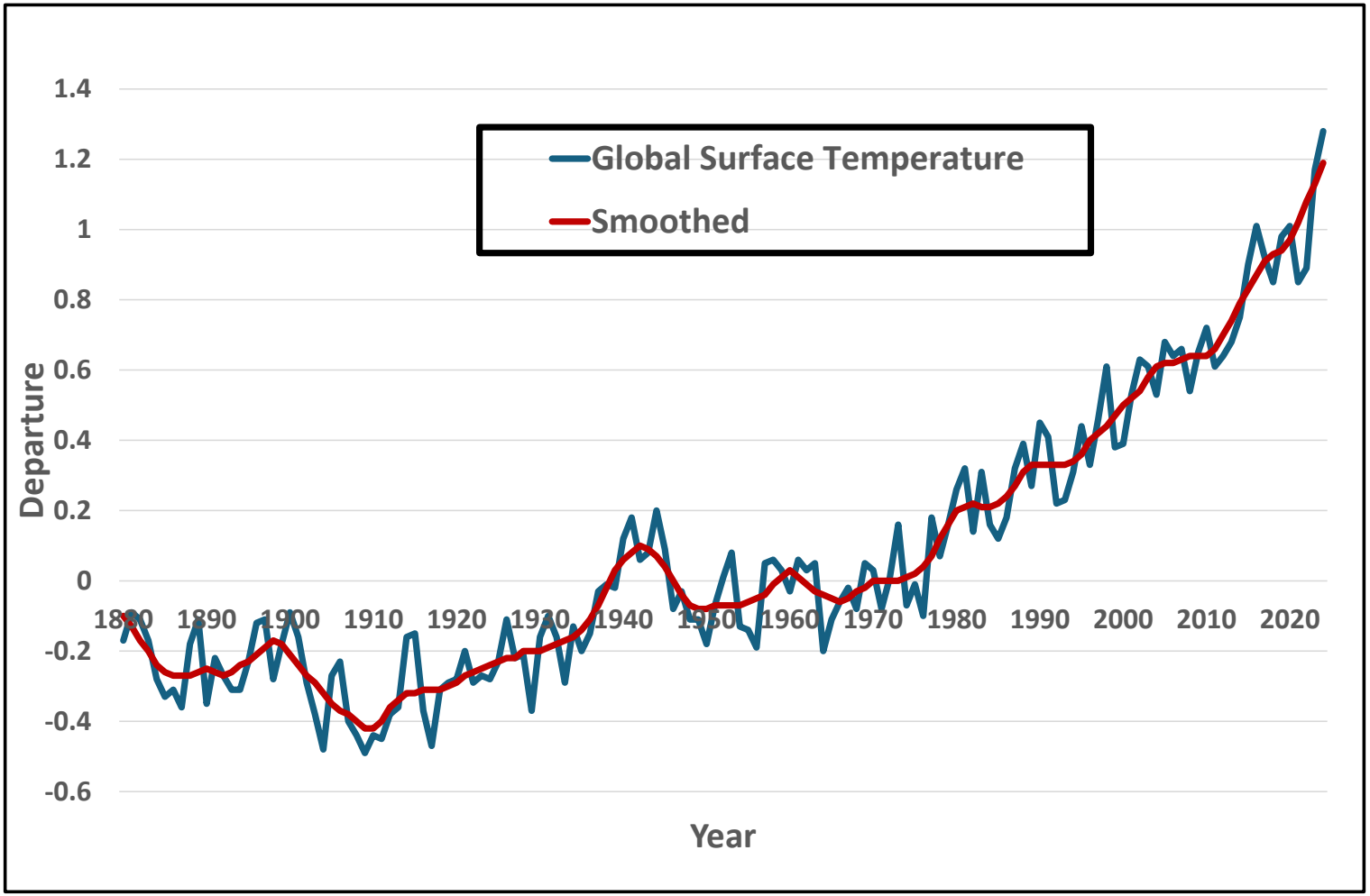


Figure : Difference in global surface temperature compared to the long-term average from 1951 to 1980

Adelaide Maximum Temperature

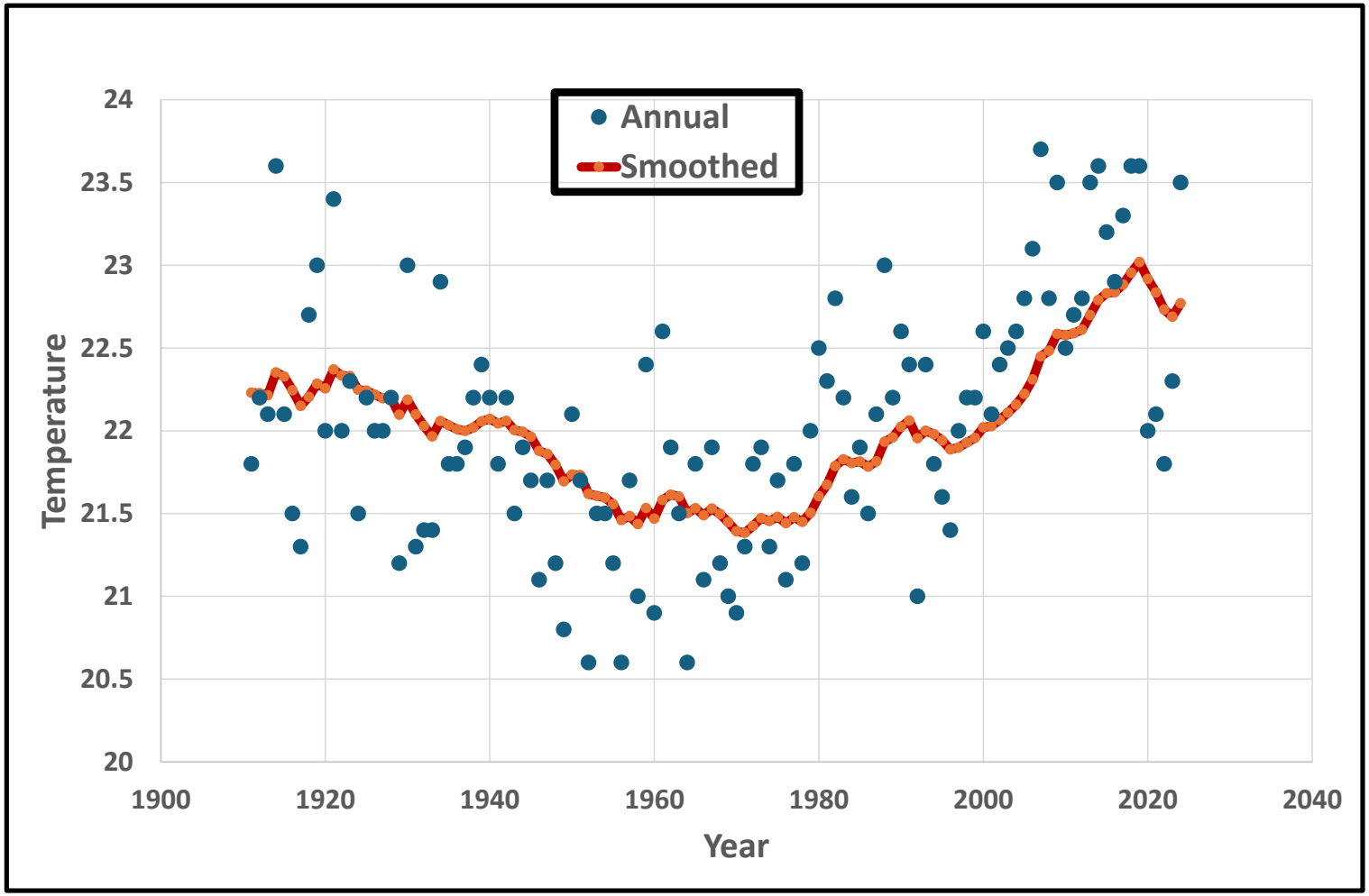
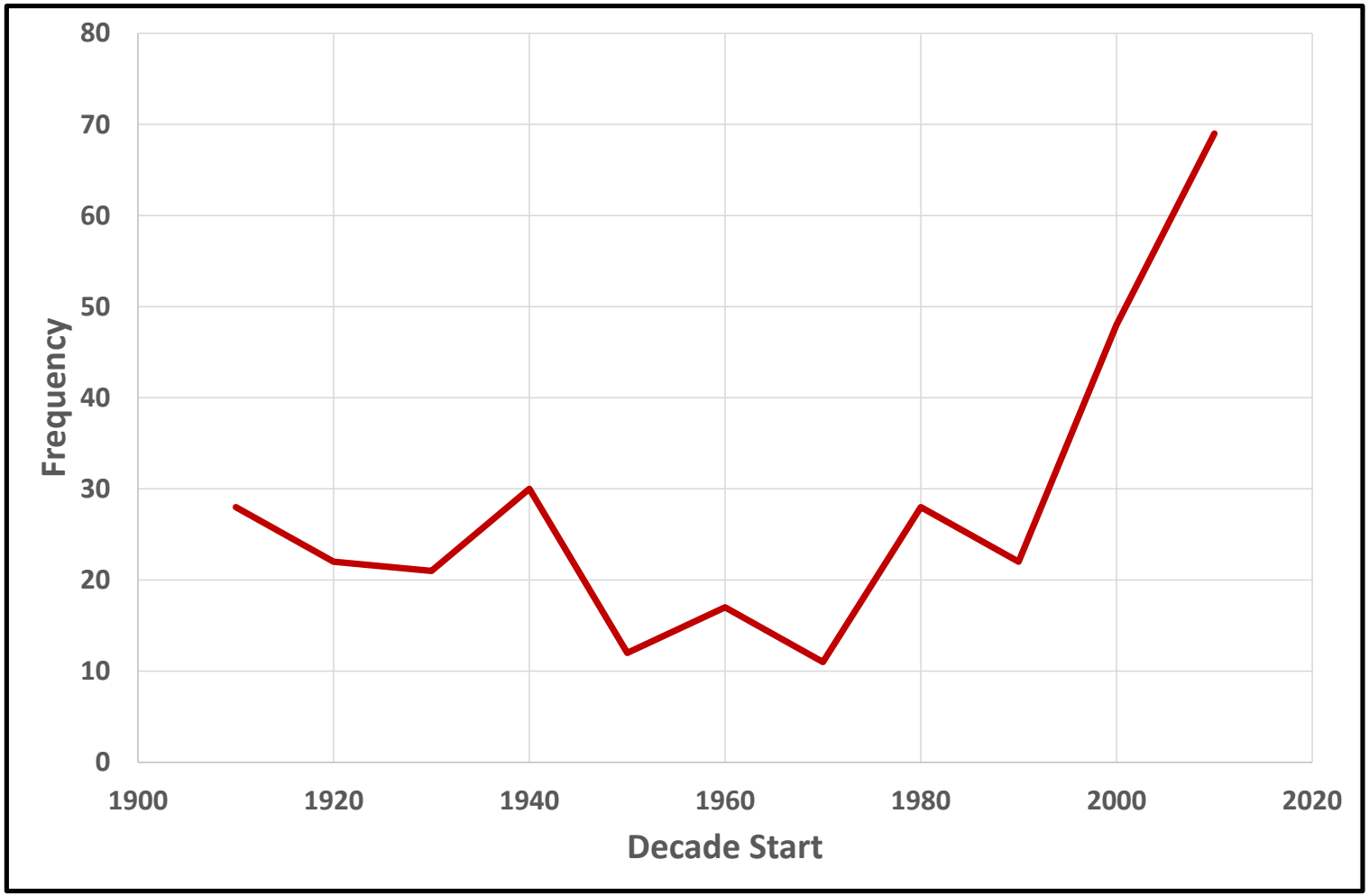


Figure : Difference in global surface temperature compared to the long-term average from 1951 to 1980

Number of Days over 40 Degrees per Decade



Effects of Heatwaves

- A recent study (Xu et al. (2025) $https://doi.org/10.1016/j.envint.2025.109747$) examined groups of older people in medium-sized communities that interact together socially and economically.
- They reported 1.08 deaths per 100,000 directly attributable to heatwaves in Australia in the period 2016 to 2019.
- In that period the number of heatwave days steadily increased.
- It is more difficult to gather statistics on morbidity, but some studies have examined extra hospitalisations, including those from injuries from extra fire fighting and so on.
- There is also the pressure on the electricity grid stability from peak air conditioning demand.

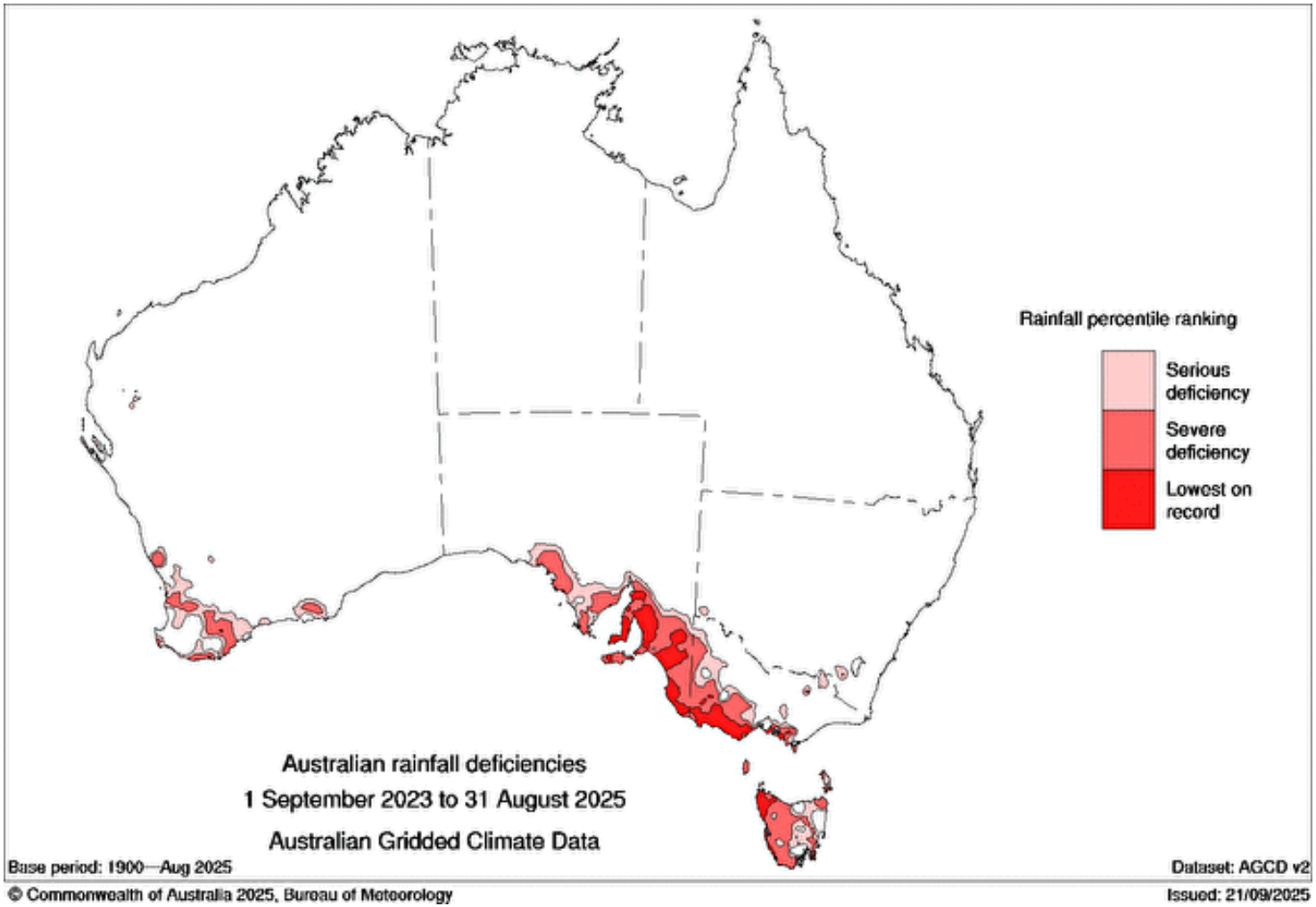
IPCC Sixth Assessment Report

- Human induced greenhouse gas emissions have led to an increased frequency and possibly intensity of some weather and climate extremes.
- Changes in extremes and their attribution to human influence has strengthened since AR5, in particular for extreme precipitation, droughts, tropical cyclones.
- Some recent hot extreme events would have been *extremely unlikely* to occur without human influence on the climate system.

Extreme Weather Events 2025

Deadliest meteorological events during 2025			
Rank	**Event**	**Date(s)**	**Deaths**
1	2025 European heatwaves	May 2025–present	1,884+
2	2025 Tarasin landslide	Aug-31	375–1,573
3	2025 Pakistan floods	June 2025–present	831
4	2025 Mokwa flood	May 28–29	500
5	July 2025 Central Texas floods	July 4–7	135
6	Tropical Storm Wipha	July 16-23	60
7	Typhoon Co-may	July 23-August 3	55
8	2025 Bolivia floods	March 2025–present	50
9	Tornado outbreak of March 13–16, 2	March 13–16	43
10	2025 Queensland floods	January 28 – April 20	33

Drought in South Australia



Effects of the Drought

- Most of Adelaide's water comes from the Murray-Darling river system, so many people in the city heard of effects but did not experience them since the upper reaches of the system had rain.
- Agricultural production was very limited in 2024, and in 2025 there was a lot of anxiety - would it be useful to plant the winter crops?
- Tremendous knock on effects in the regional centres as a lot of economic activity flows from the agricultural output.
- Many suffered mental health problems.

Queensland Floods

- The 2025 Queensland floods refer to significant flooding that impacted the northeast Australian state of Queensland in late January, early February, into March and April 2025.
- By 4 p.m. local time on 2 February, some areas received more than 1,000 millimetres of precipitation, with Paluma recording over 175 mm of rainfall within a three-hour period.

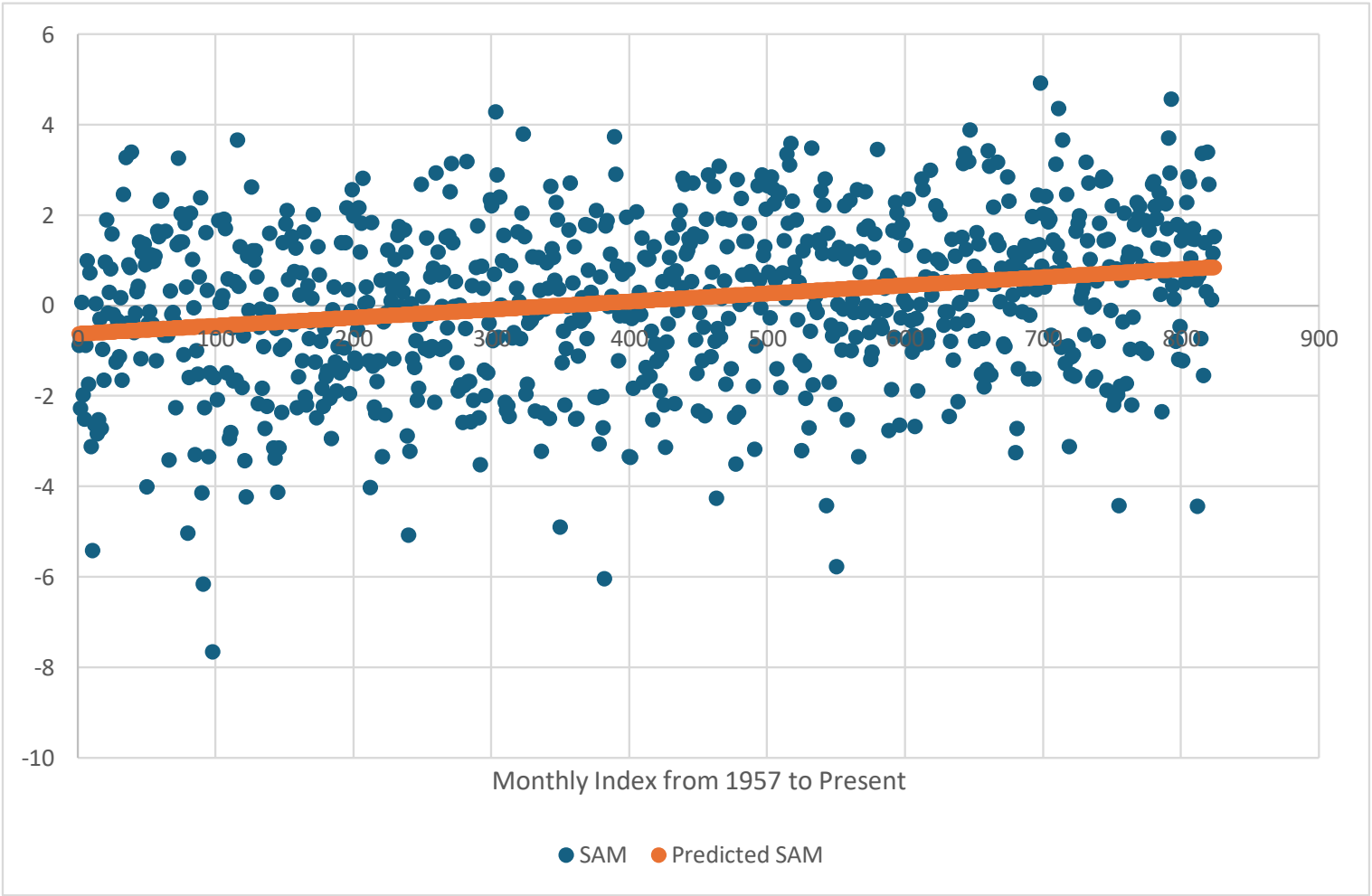
Effects of the flooding

- More than 8,000 homes lost power, with approximately 6,000 affected properties in Hinchinbrook, 2,000 in Townsville, and 600 in Mackay.
- There were deaths, hospitalisations, and people displaced from their homes.
- The clean up problems were huge, mud all through homes, sewage flowing in the streets, vegetation battered.
- Intense rainfall and flooding causes soil loss and hence agricultural loss, both short and long term.
- Soil, nutrients and fertilizers flowed off the land into the sea, causing immense damage to the Great Barrier Reef.

Southern Annular Mode

- The Southern Annular Mode, or SAM, also known as the Antarctic Oscillation (AAO), is a mode of variability which can affect rainfall in southern Australia.
- The SAM refers to the north/south movement of the strong westerly winds that dominate the middle to higher latitudes of the Southern Hemisphere.

Long Term Trend of SAM



What Does the Trend Mean?

- There are different influences for positive and negative SAM relative to winter or summer.
- The general pattern however is that the more positive SAM is, the more the belts of westerly winds will contract towards Antarctica.
- There are different scenarios for winter and summer, but the general impact for South Australia is a lowering of rainfall.
- In the two year period studied, almost all months had a positive SAM.
- In the same vein, a positive SAM generally means increased rainfall for Eastern Australia.
- Under a changing climate, SAM is predicted to spend more time in the positive phase, bringing drier weather to parts of southern Australia during winters, and wetter conditions during summer in south-eastern Australia and eastern Tasmania.

Attribution

- The organisation World Weather Attribution performs analysis to check links between climate change and specific weather events.
- This is a complicated issue and rather than say climate change caused an event, they will analyse whether the probability of an event happening or the intensity of an event is increased because of climate change.
- In June 2025 intense monsoon rainfall led to severe flooding in northern Pakistan.

The Pakistan Floods

- Observational datasets show the 30-day maximum rainfall over the study region is now approximately 22% more intense than it would have been in a climate that had not warmed by 1.3C.
- Trends in climate models show an increase in intensity of extreme rainfall of about 12%, which is smaller than the trend found in observations.
- The difference is due to the complex terrain which is easier to pick up in observations, rather than in large scale climate models.

AccuWeather study for United States

- A new AccuWeather study of more than 60 years of rainfall records shows U.S. precipitation totals are flat, but heavy downpours and hourly extremes are increasing.
- When it rains, it is falling harder, faster and in more extreme bursts.
- Flooding is not driven by how much rain falls in a year, its driven by how hard and how fast it comes down.
- The shift is toward event intensification.

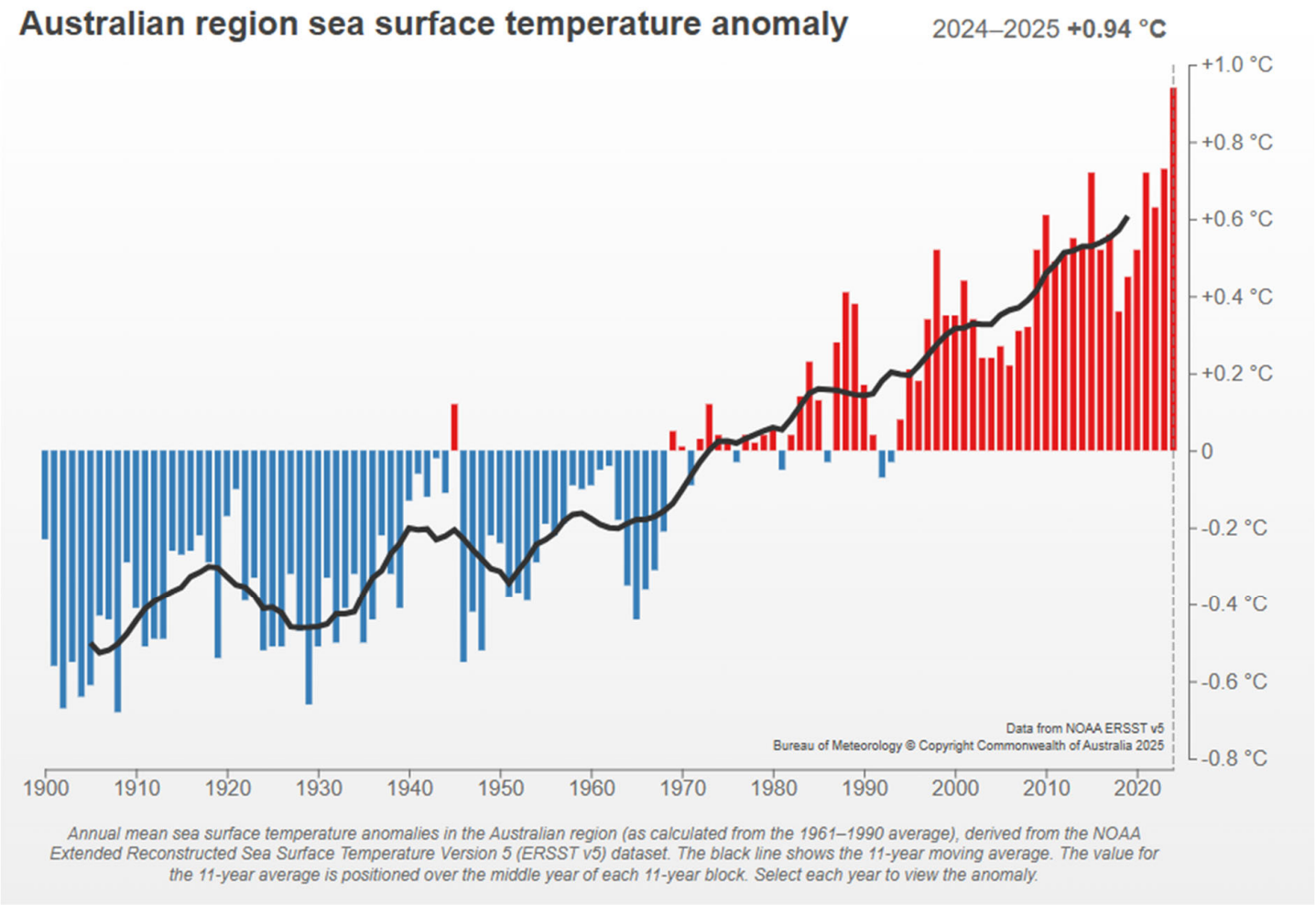
Rainfall In the Semi-arid Region 80 km East of Adelaide

- Total rainfall is increasing over time on the Monarto plateau, where we have a 52 hectare property.
- We have spent 40 years on biodiversity enhancement and saving endangered species from extinction.
- In January, 2024, there was 100 mm in one day at our place, with less than 25 mm nearby.
- Like many places it is increasing in intensity as well.

Flood in creek bed

South Australian Blue Gum

Marine Heatwaves

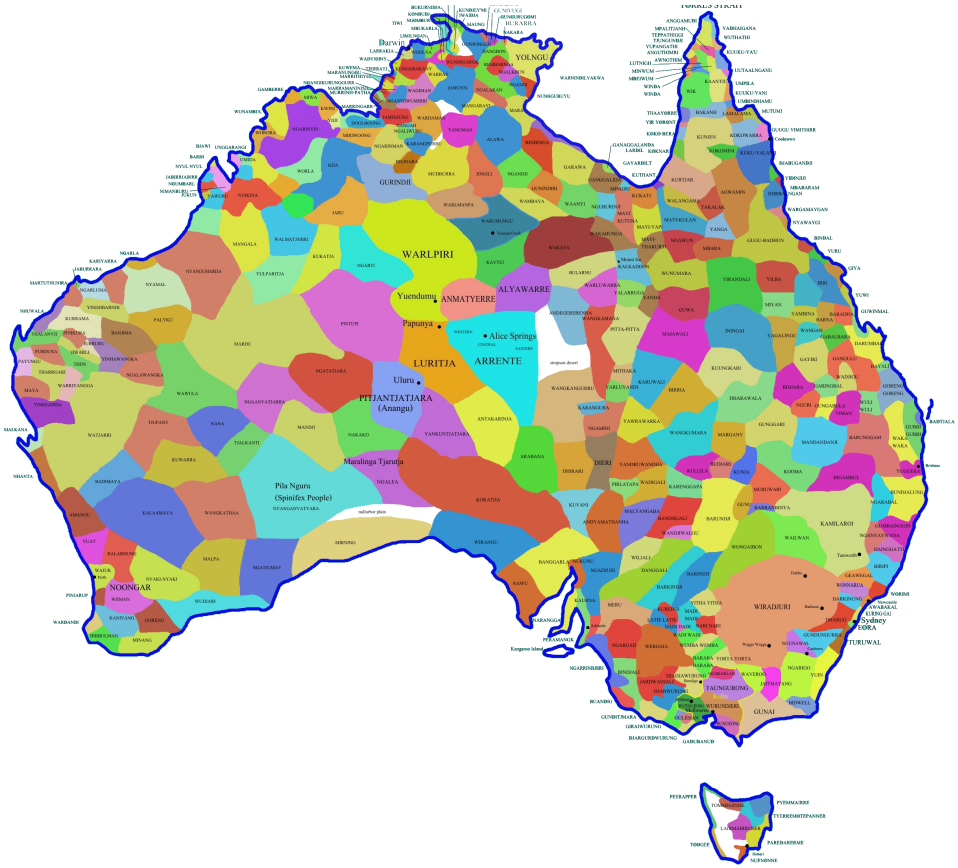


Algal Bloom in South Australia

- A marine heatwave began in South Australia in September 2024, causing ocean temperatures to rise approximately 2.5C above average, contributing to a large-scale microalgae bloom that has continued to affect the coast.
- This heatwave, along with nutrient-rich runoff from the $2022 - 23$ River Murray floods and a recent cold-water upwelling, created ideal conditions for the bloom.
- The ongoing bloom has resulted in significant impacts on marine life, including fish and abalone mortalities, and is associated with public health warnings due to potential skin and respiratory irritation.

Area of the Bloom

It has spread to an area covering 4500sq km since being identified off the Fleurieu Peninsula in March.



Effects of the Algal Bloom

- Thousands of marine creatures, including dolphins, sharks, rays, and a wide variety of fish, invertebrates, and sea life, have been killed by the bloom.
- The bloom has transformed vibrant underwater ecosystems into barren seascapes, impacting sea habitats.
- The bloom has had a significant impact on commercial fishing operations and other businesses dependent on the sea.
- The crisis has impacted coastal communities, with loss of tourism as well.

Other Marine Heatwaves

- Queensland authorities are investigating the deaths of thousands of fish that washed up on a popular Gold Coast beach in October this year.
- A spokesperson said water quality monitoring indicated high water temperature and low dissolved oxygen in the area, which can cause fish deaths.
- New Zealands oceans are warming 34% faster than the global average, with NZ180bn (US104bn) worth of housing at risk of flooding, a new report about the nations marine environment has revealed.

Adaptation

- We have to be mindful that adaptation to extreme weather events can depend on ones ability to make provisions, so read the suggestions with that in mind.
- Do not build on floodplains. Even if you do not get flooded, your house may be uninsurable.
- Surround your self with as much vegetation as possible, even if only on a balcony.
- Keep fit through nutrition and exercise so you are more resilient to extreme heat.

Walk the Talk

- We grow one third of our food in a suburban garden, using compost that we make.
- It also acts as climate control – through design – so we only use it and fans for air con.
- We do not own a car so we walk, cycle and take public transport.
- The garden also provides habitat for frogs, lizards, birds.
- We have a small solar system (because of low demand) plus battery.

The Entrance

South Australia - the World Leader in Electricity from Variable Renewable Energy (VRE)

- The International Energy Agency has identified six phases of variable renewable energy (VRE) integration.
- 1. VRE has no significant impact at the system level
  2. VRE has a minor to moderate impact on the system
  3. VRE determines the operation pattern of the power system
  4. VRE meets almost all demand at times
  5. Significant volumes of surplus VRE across the year
  6. Secure electricity supply almost exclusively from VRE

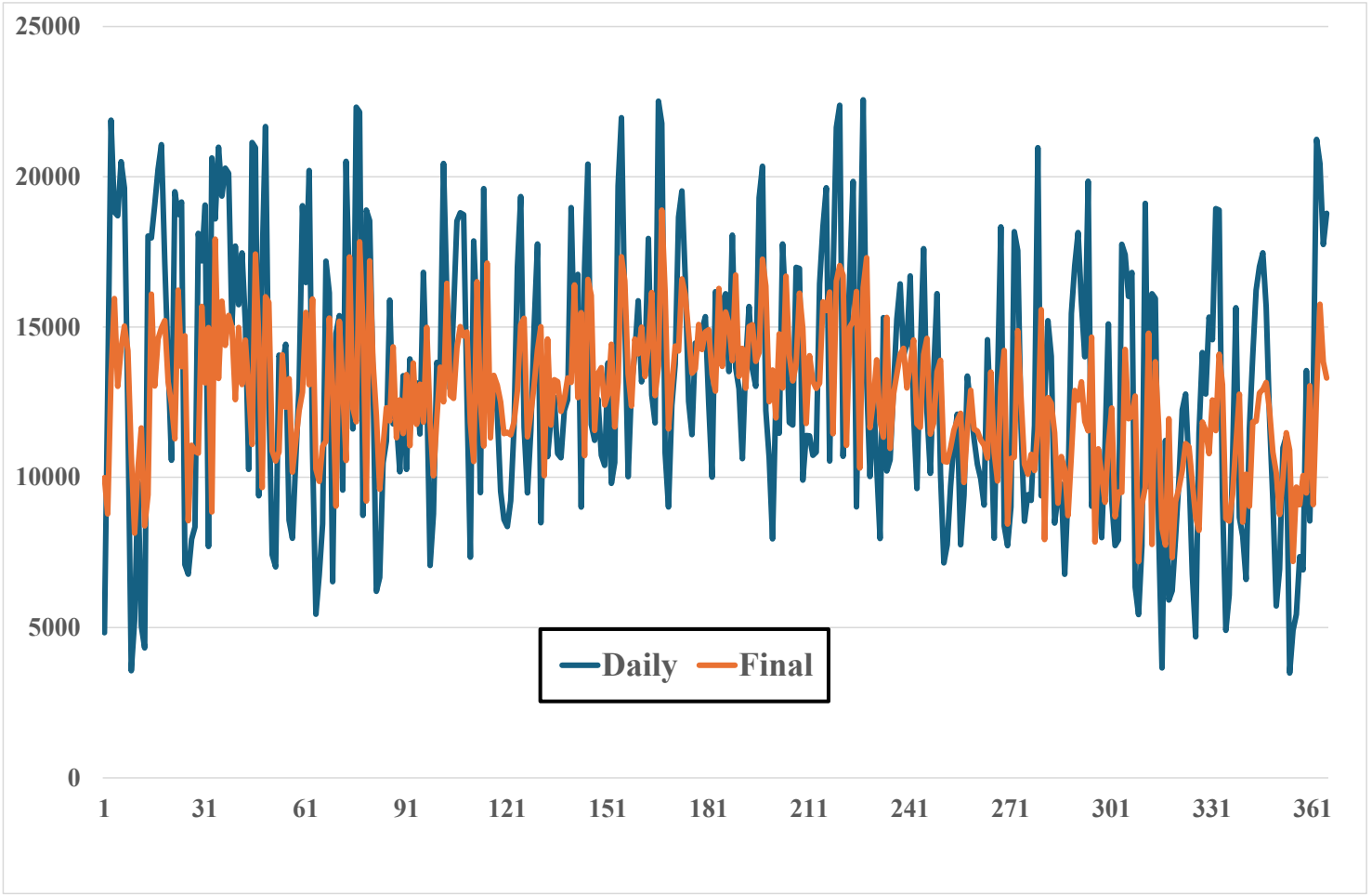
Why South Australia

- In 2024 South Australia became part of the elite group of two, along with Denmark, to achieve Phase 5.
- Denmark, however, is able to draw the equivalent of 100% of its maximum demand from connections to other grids, but for South Australia the maximum is 25%.
- A major contributor is rooftop solar, with 40% of domestic dwellings having PV systems.
- We are now living in a world where our largest customer, the local distribution network, is also our largest generator, says Simon Emms, Head of the SA transmission network.

Remaining Challenges - One is Dunkelflaute

- The major problem is how to cope with Dark Doldrums, or periods with low VRE.
- The first thing to do is to measure how probable they are, for periods of 2 up to 7 days for example.
- Construct a model for the six years of data, that includes output from solar and wind farms, plus rooftop solar.
- Then use an approach from stochastic modelling called non parametric bootstrapping to construct a few hundred years of synthetic data.
- This will have the same statistical properties but will contain short sequences not present in the original data - needed to understand what is possible to happen.

Model Fit


25000
20000
15000
10000
5000
0
1
31
61
91
121
151
181
211
241
271
301
331
361
Daily
Final

Results

Sequence	*Number*	*Return Period*
2	1136	0.17
3	380	0.52
4	141	1.4
5	36	5.6
6	9	22.2
7	9	22.2

Conclusion

- There have always been extreme weather events - the difference is the increasing frequency and intensity.
- These two characteristics can be linked to climate change.
- There is a growing movement to directly attribute aspects of specific events to climate change.
- Studying extremes is crucial since reporting changes in means is not raising peoples' consciousness.
- Google Mediterranean Mindset Gardening Australia to see an 8 minute segment on our garden.