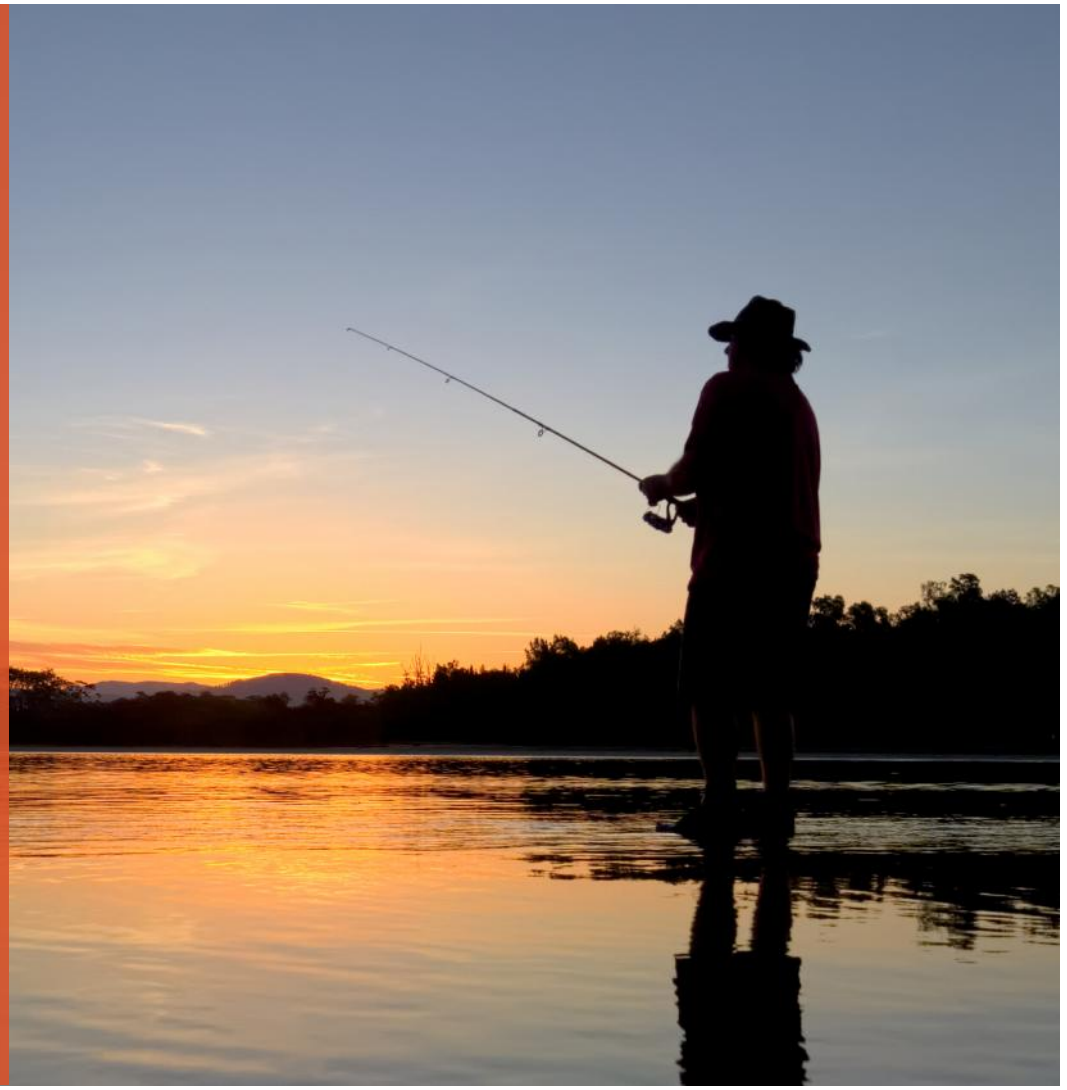
Climate change and natural hazards in Australia

Blair Trewin
Bureau of Meteorology

Australian Government
Bureau of Meteorology

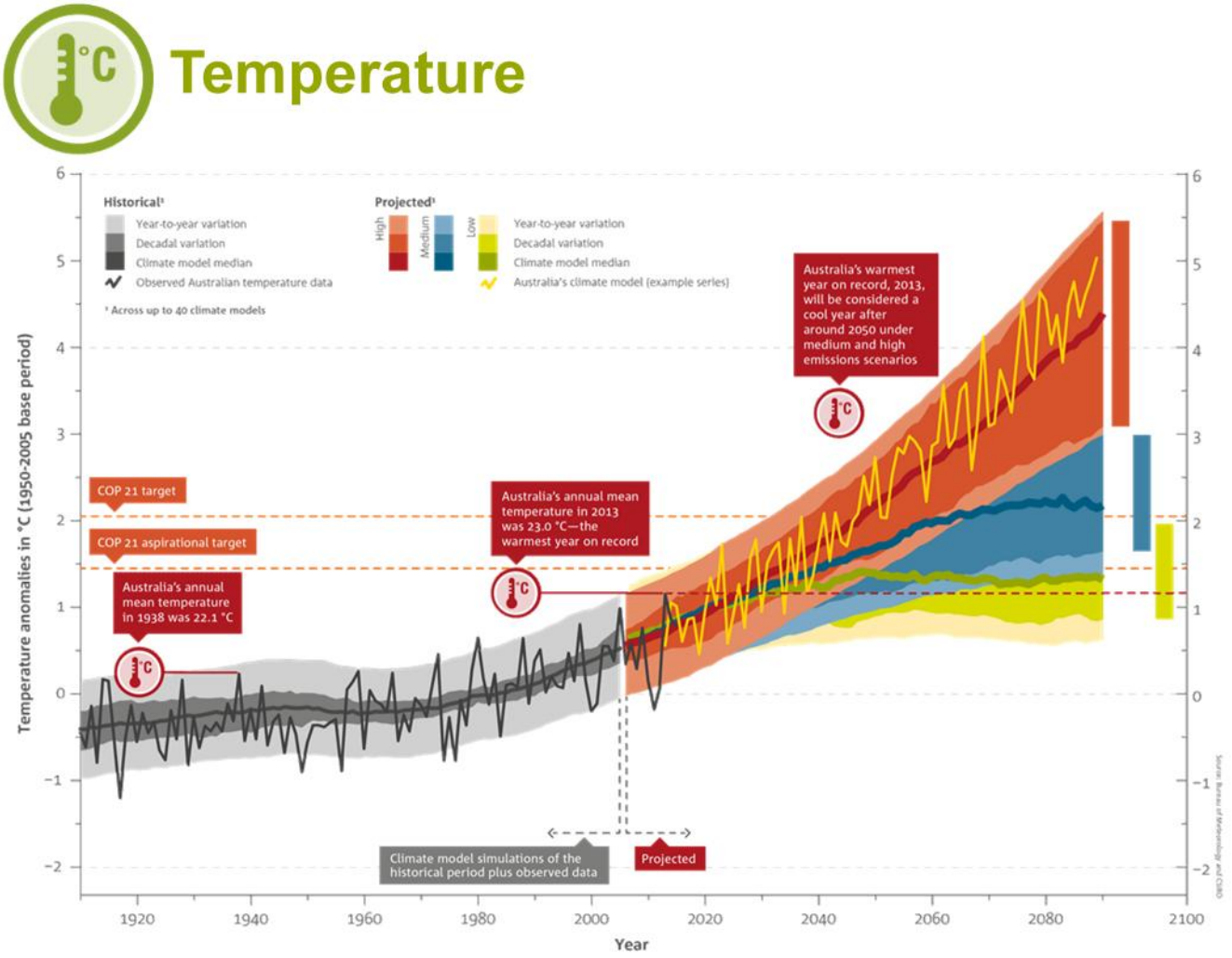


Contents

- Introduction to climate change scenarios
- How climate change affects (or doesn't affect) different hazards
- Compound extremes – when lots of things happen at once
- The most extreme extremes – what's the worst-case scenario?
- Seasonal climate influences on hazards, and the role of climate prediction in planning

Australian Government
Bureau of Meteorology

Warming under all scenarios



Australian Government
Bureau of Meteorology

Not all hazard profiles show a climate change signal

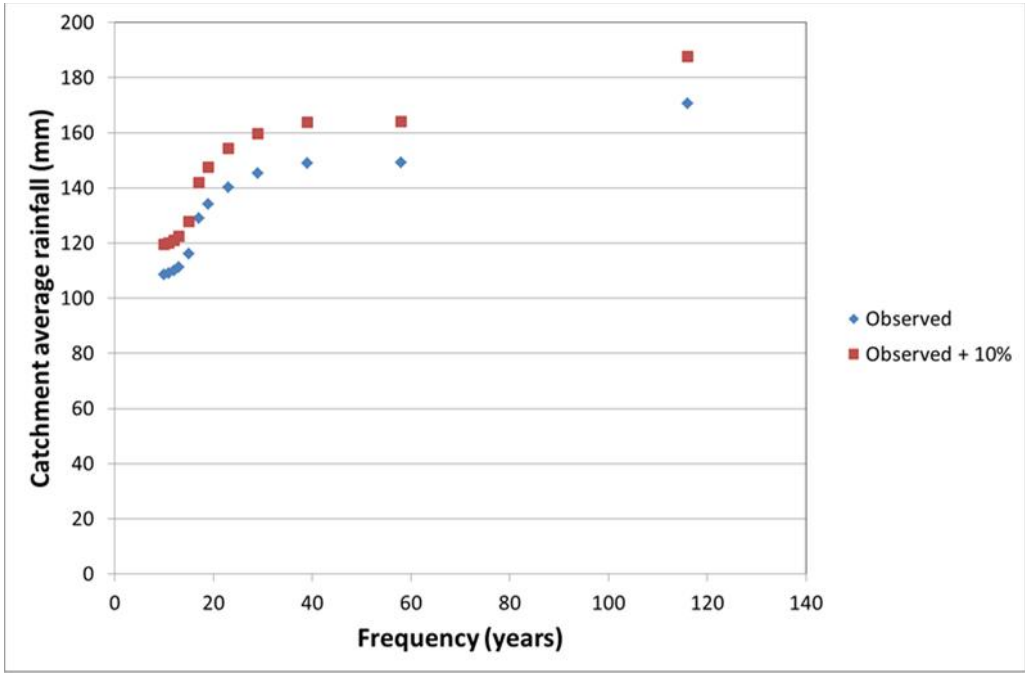
Changes observed, further changes projected	• Extreme temperatures/heatwave • Sea levels/storm surge/coastal flooding • Fire weather
Changes likely but no clear signal yet observed	• Extreme rainfall • Tropical cyclone frequency and intensity
No clear indication of observed or projected changes	• Severe local storms (hail, tornadoes etc.) • Strong winds (non-cyclonic)

Australian Government
Bureau of Meteorology

A small change in a variable can have a large effect on return periods

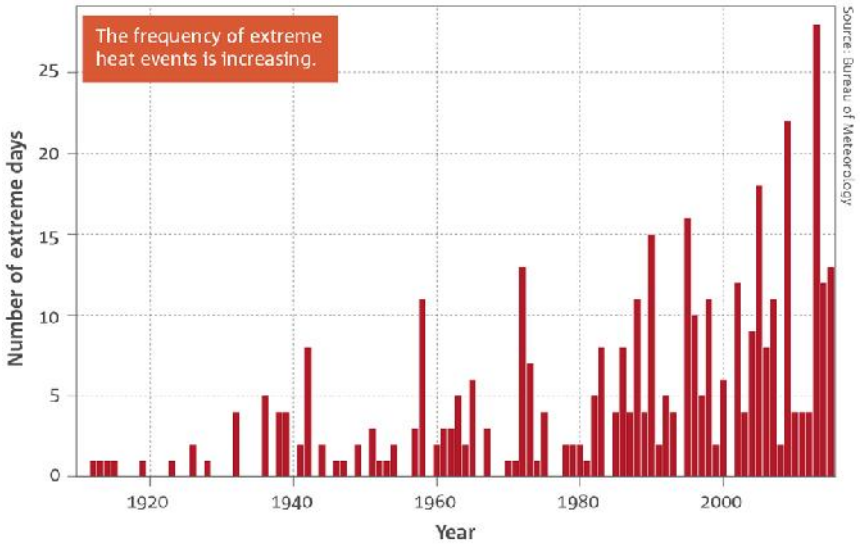
Australian Government
Bureau of Meteorology

1-day catchment average rainfall for Brisbane River



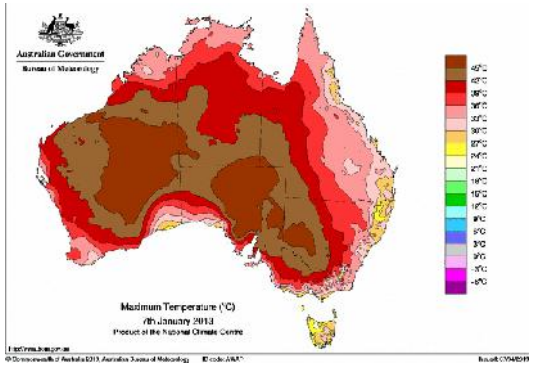
A 10% increase in extreme 1-day rainfall can reduce expected recurrence interval by 50% or more

Extreme heat events are already increasing



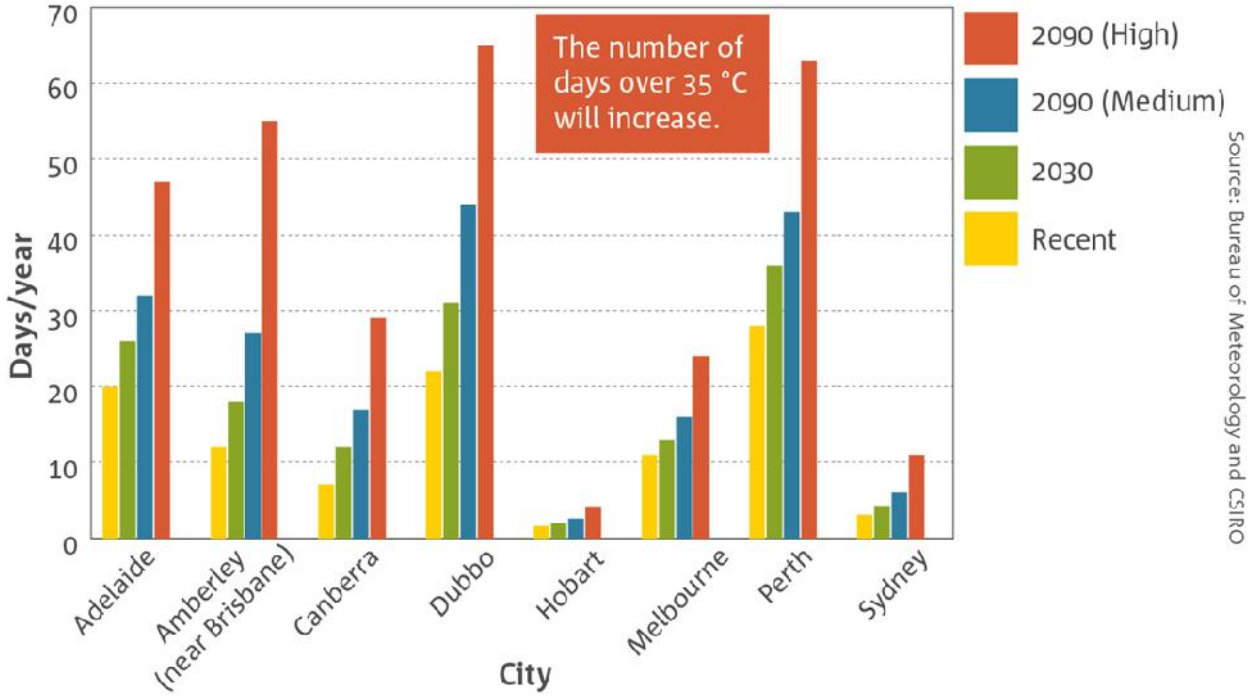
Days with Australian area-averaged mean temperature above 99th percentile

7 January 2013 – Australia's hottest area-averaged day on record



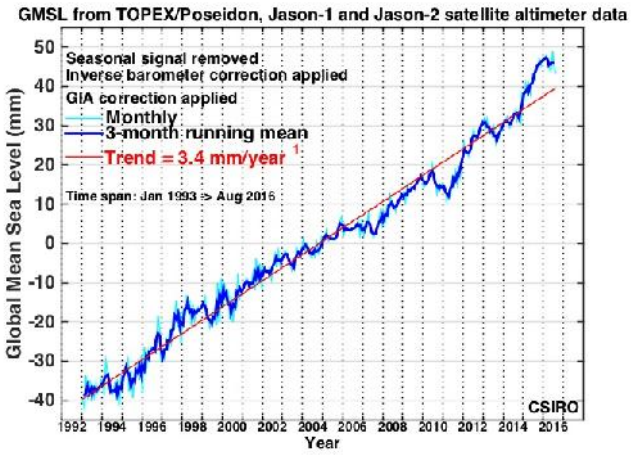
Australian Government
Bureau of Meteorology

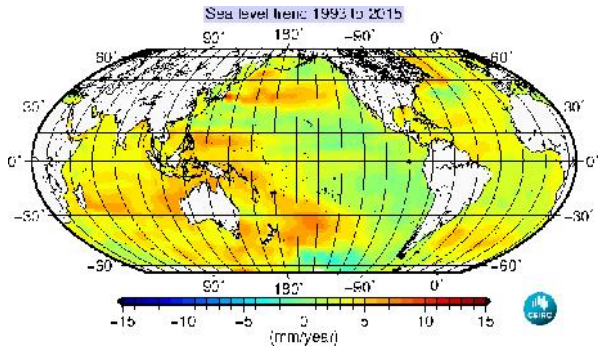
Number of extreme heat days expected to rise under all scenarios



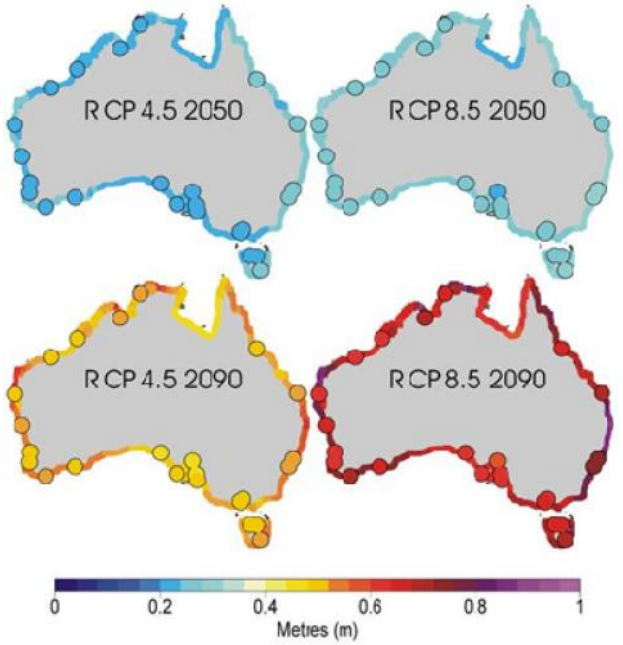
Australian Government
Bureau of Meteorology

Global sea levels are rising, and further rises are projected





Sea level allowance required

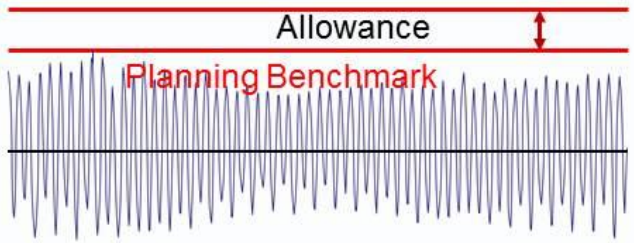


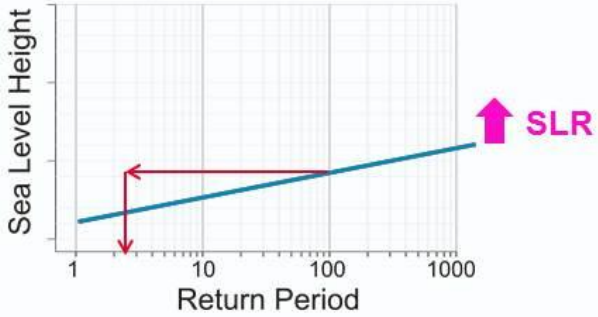
Australian Government
Bureau of Meteorology

A small rise in sea level can greatly increase the frequency of flooding

Australian Government
Bureau of Meteorology

Sea level rise will increase the frequency of extreme sea levels

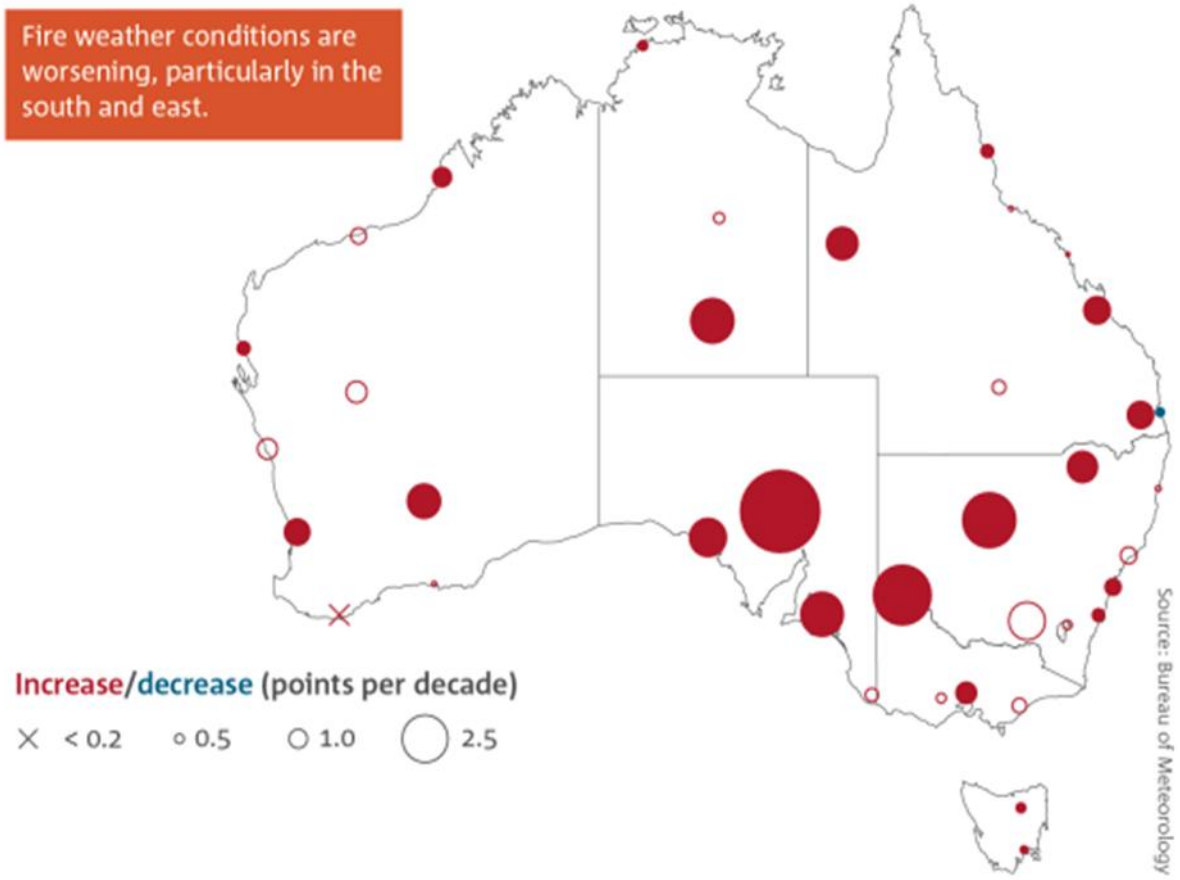




Source: McInnes et al, AMOJ (2015)

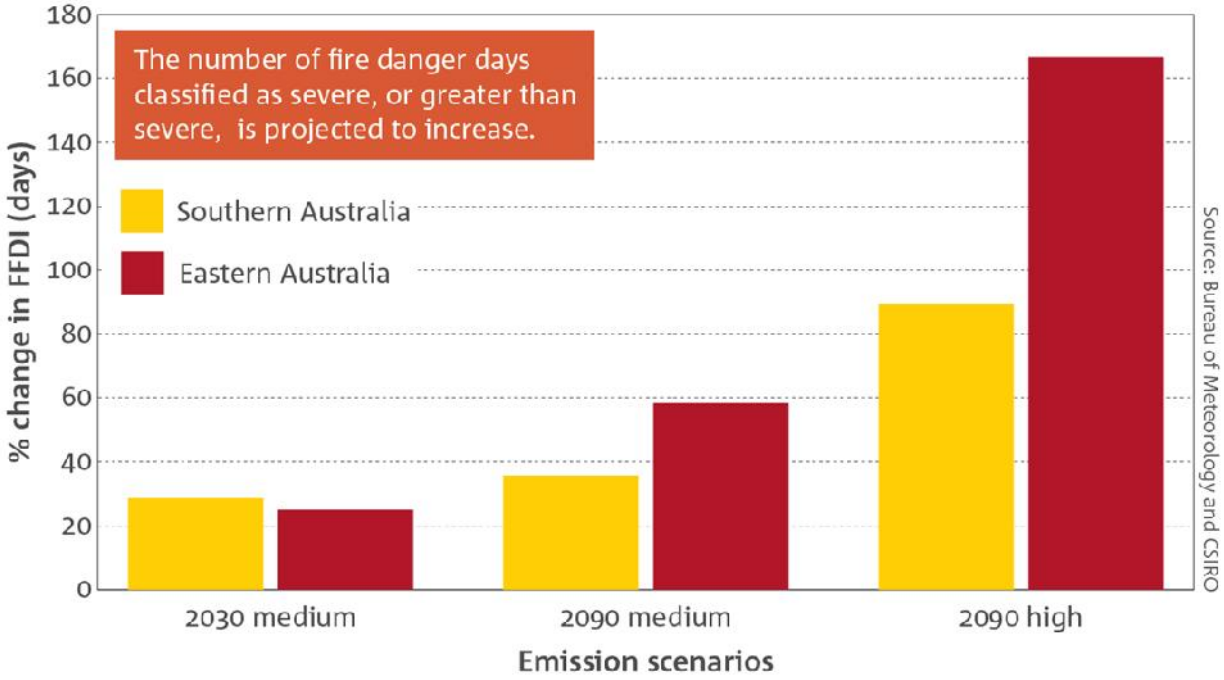
CSIRO

Observed increases in FFDI in many areas



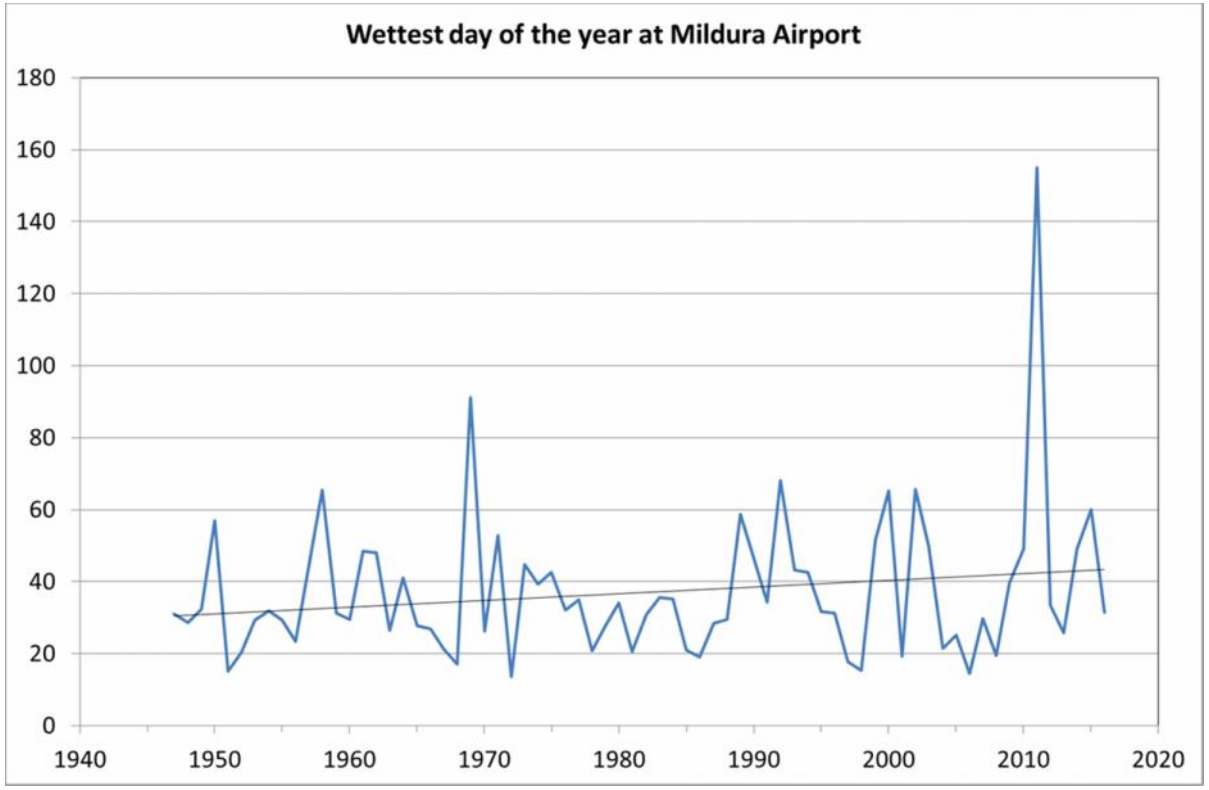
Australian Government
Bureau of Meteorology

Projected change in severe fire weather days



Australian Government
Bureau of Meteorology

Extreme rainfall is highly variable

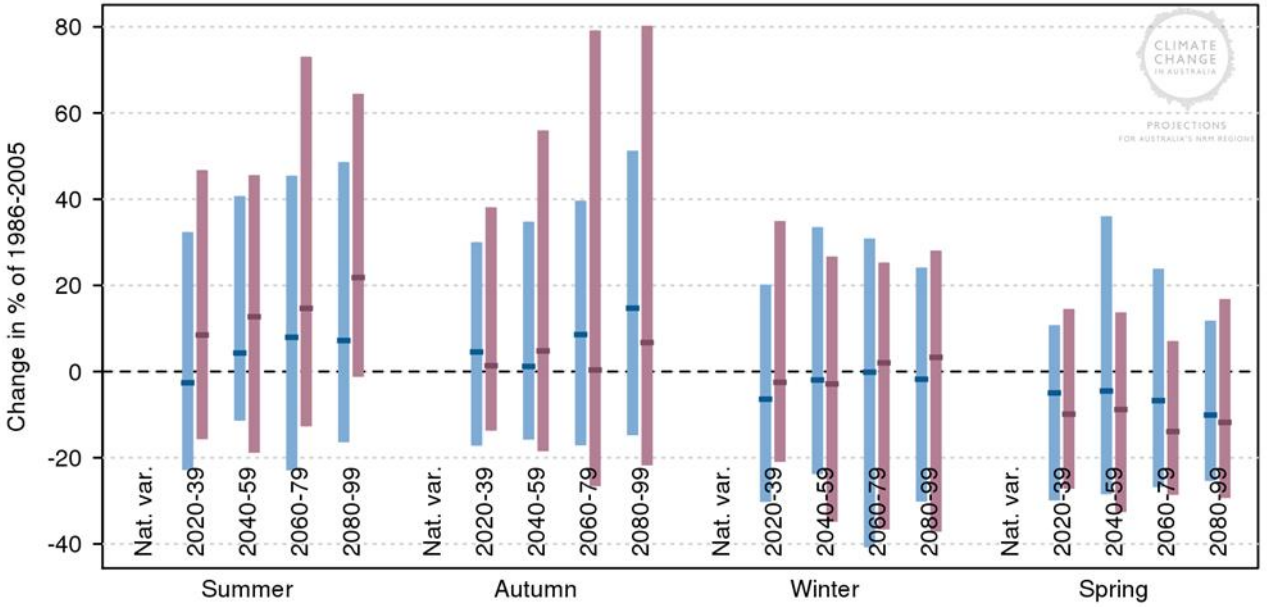


1947-2016 trend is 1.9 mm/decade (but drops to 0.4 if 2011 is omitted)

Australian Government
Bureau of Meteorology

Projected changes in extreme rainfalls

1 in 20 year wettest day, East Coast North region

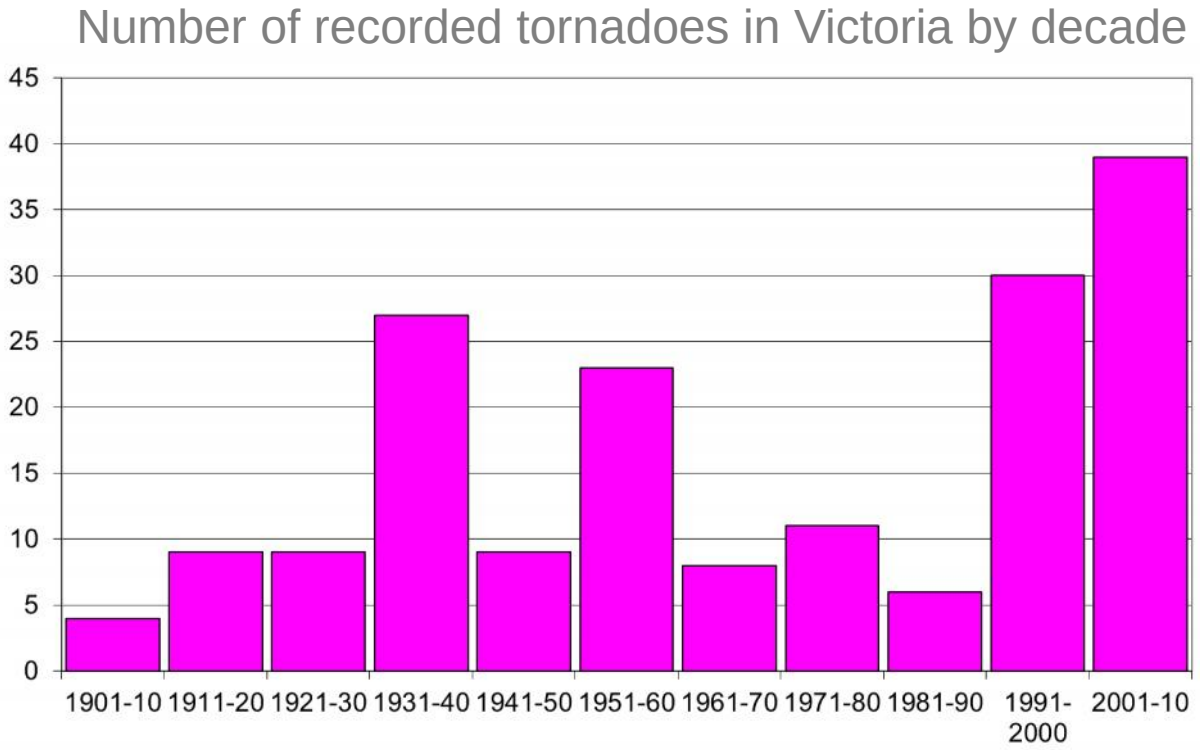


Increases in extreme rainfall likely, even in regions where mean rainfall decreasing

Blue – medium emissions; red – high emissions

Australian Government
Bureau of Meteorology

Low confidence in severe local storm changes



- IPCC found low confidence in observed trends of severe local storms
- Observations often incomplete, especially historical

Australian Government
Bureau of Meteorology

Assessing how climate change affects a hazard can be complex – example of Hurricane Harvey

Australian Government
Bureau of Meteorology

What factors do we need to consider?

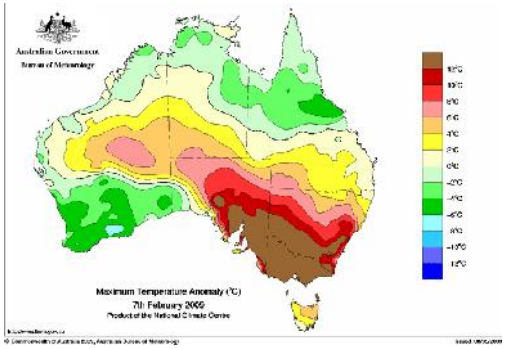
- Are tropical cyclones becoming more frequent?
- Are tropical cyclones becoming more intense?
- Are tracks of tropical cyclones changing?
- Is the movement speed of a tropical cyclone changing?
- Is the amount of rain that a cyclone of given intensity is capable of producing changing?
- How much local sea level rise is the result of climate change, and how much is local subsidence?
- How does sea level rise affect the risk of storm surge flooding?
- How does sea level rise affect river flooding (through inhibiting drainage)?

Some potential scenarios for compound extremes

- An extreme event affecting a large number of places simultaneously
- Extreme events affecting multiple parts of a broad region, close in time
- Multiple extreme events of the same type in close succession in the same area
- Multiple extreme events of different types in close succession in the same area

Australian Government
Bureau of Meteorology

What's the risk of extreme heatwaves affecting multiple cities at once?

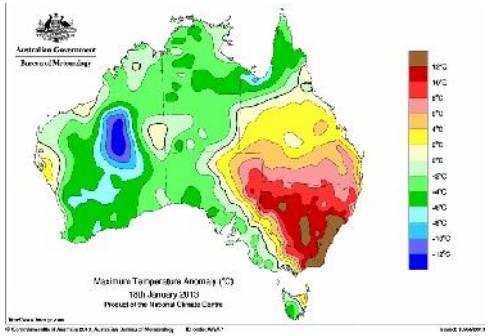


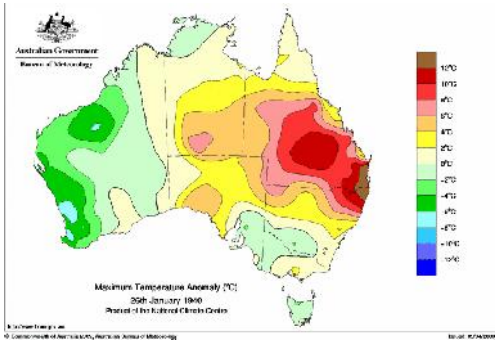
7 February 2009

Melbourne 46.4 (record)
Sydney 33.5 (Richmond 41.9)
Brisbane 30.8

18 January 2013

Sydney 45.8 (record)
Brisbane 32.6
Melbourne 25.9



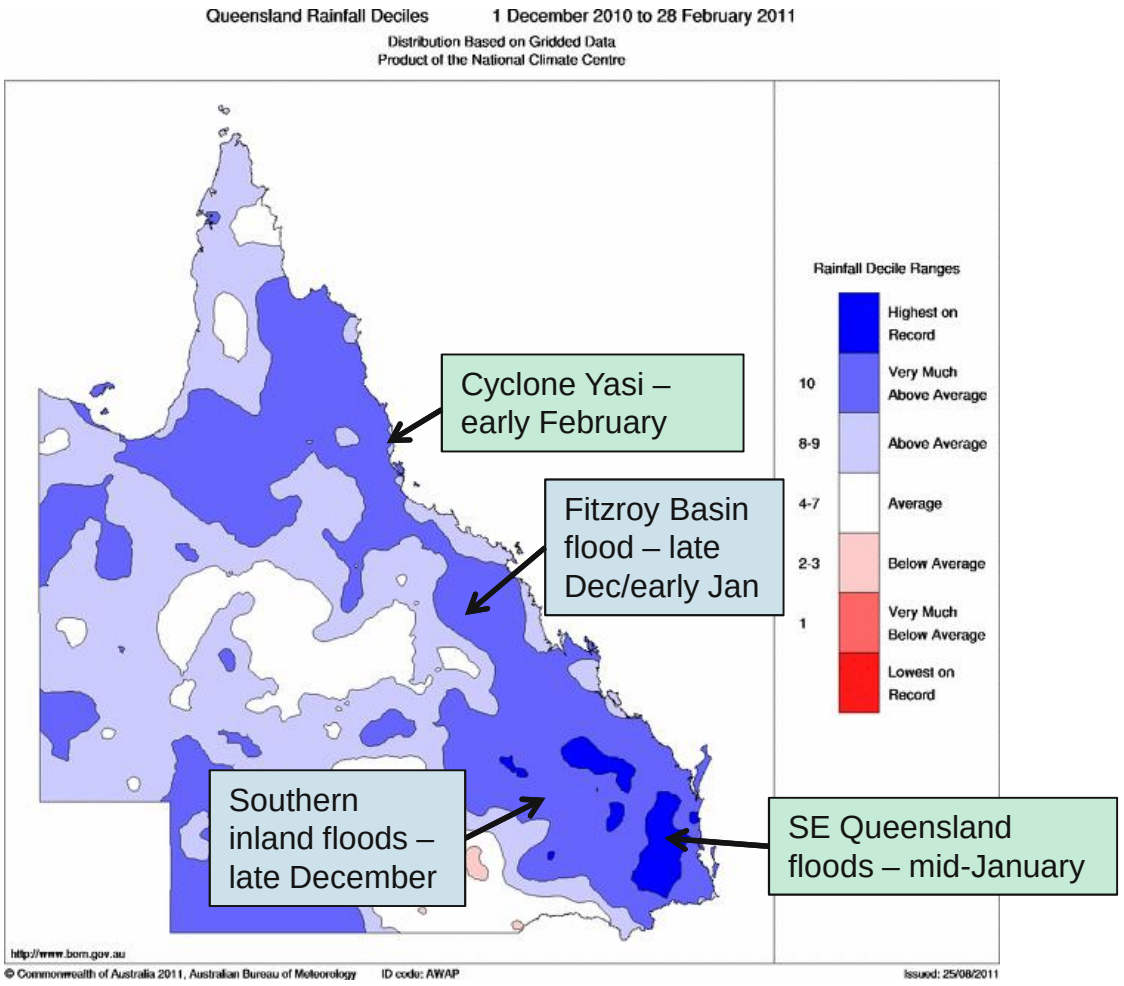


26 January 1940

Brisbane 43.2 (record)
Sydney 25.3
Melbourne 27.7

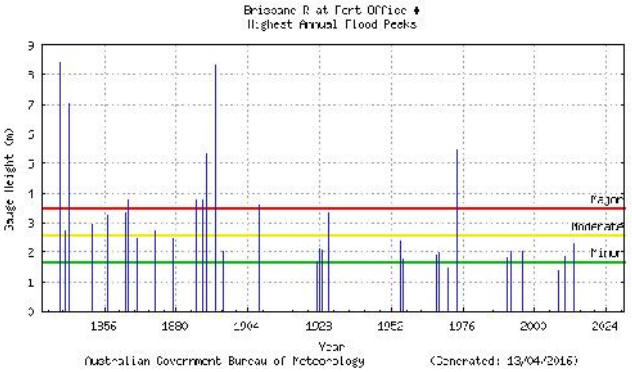
Australian Government
Bureau of Meteorology

Multiple impacts in a region in rapid succession



Australian Government
Bureau of Meteorology

Multiple incidents of the same type – Brisbane floods 1893



Two separate floods, peaking on 6 and 19 February

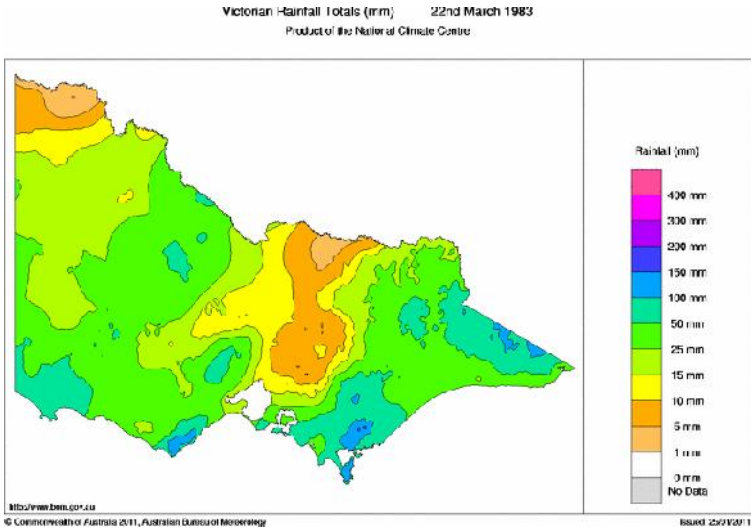
6 February flood peak 8.35 m, 19 February also above 8 m

Australian Government
Bureau of Meteorology

Multiple incidents of different types – Otway Ranges 1983

Ash Wednesday fires, 16 February 1983

Flash floods, 22 March 1983 (Tanybryn 375 mm – state daily record)

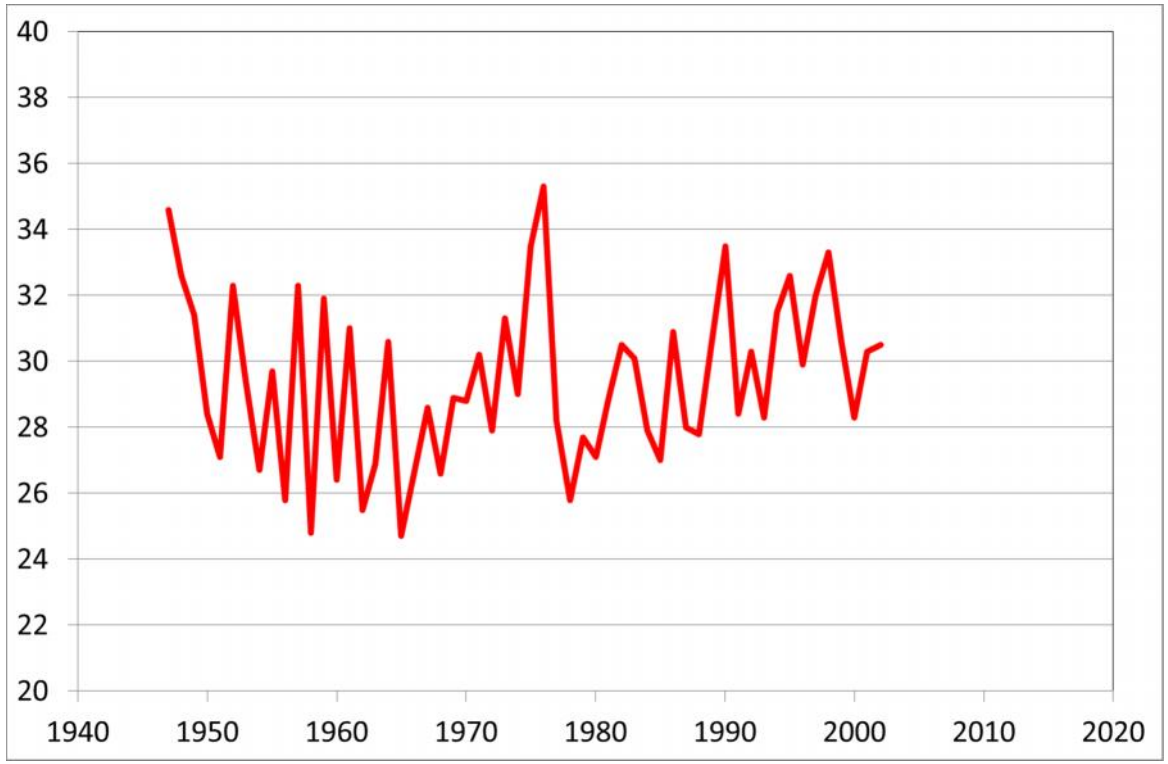


Australian Government
Bureau of Meteorology

What's the realistically possible range for a heatwave?

Australian Government
Bureau of Meteorology

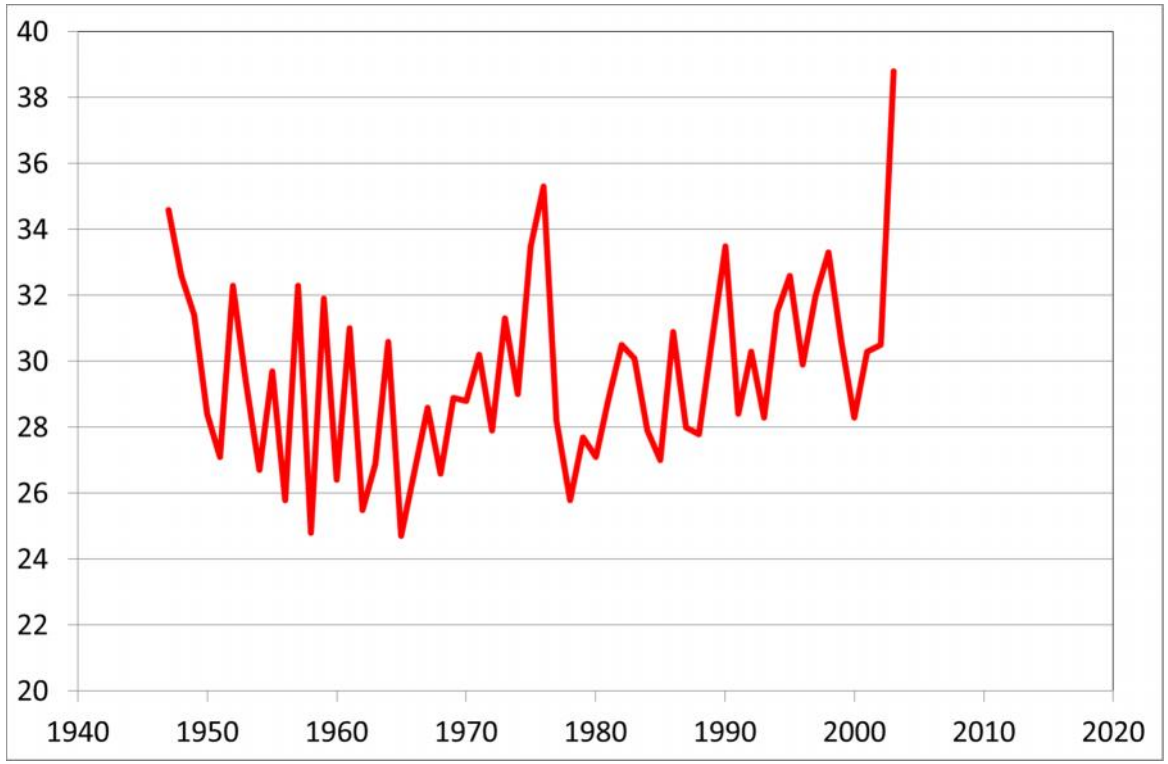
Average maximum temperature, hottest week of year



What's the realistically possible range for a heatwave?

Australian Government
Bureau of Meteorology

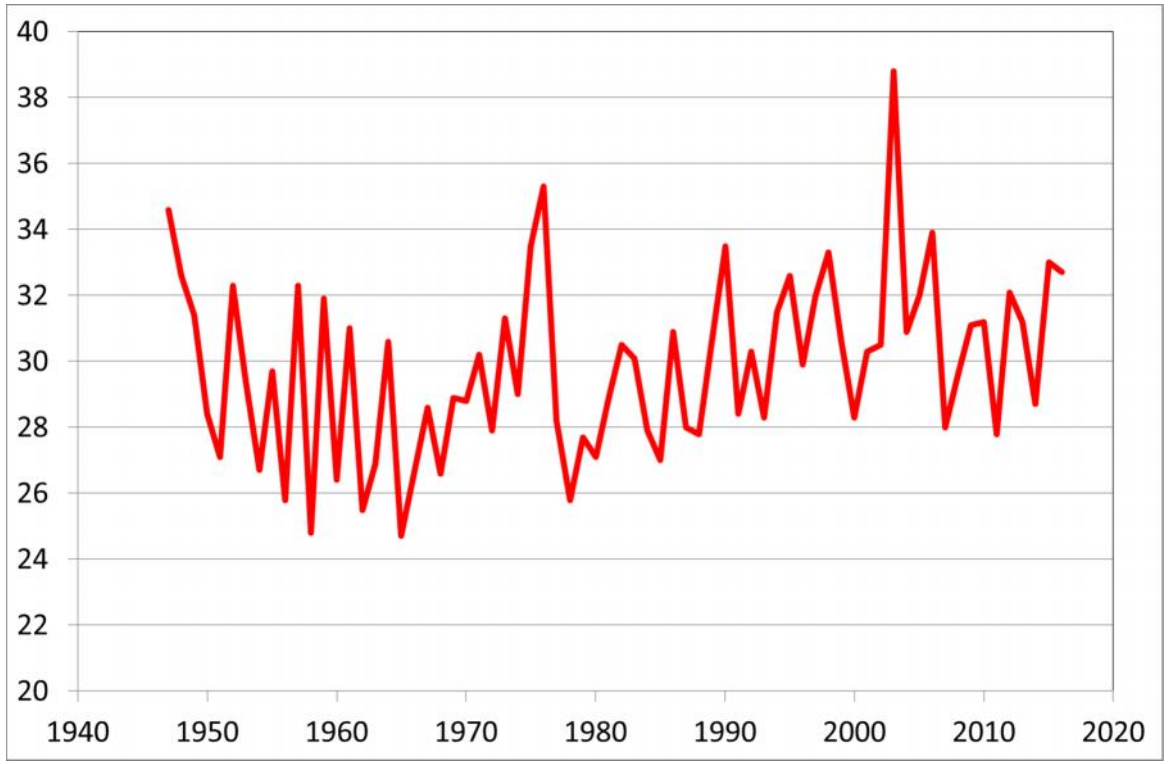
Average maximum temperature, hottest week of year



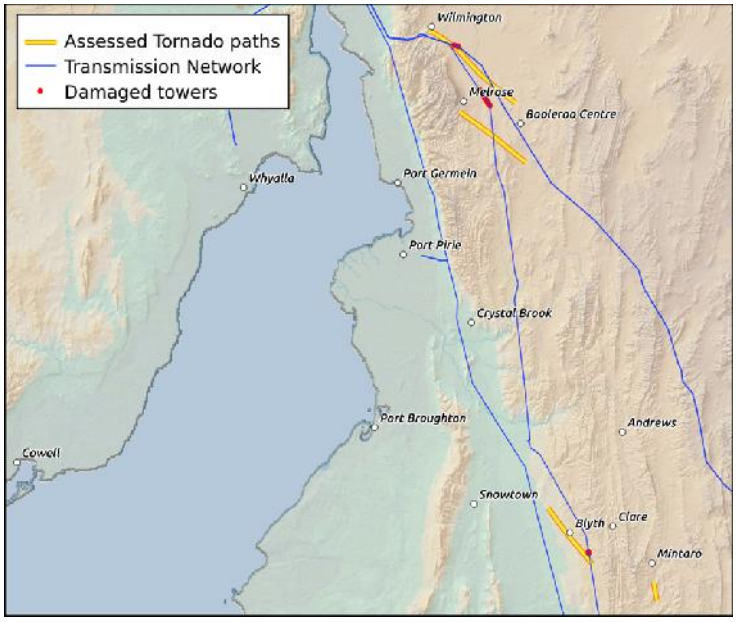
What's the realistically possible range for a heatwave?

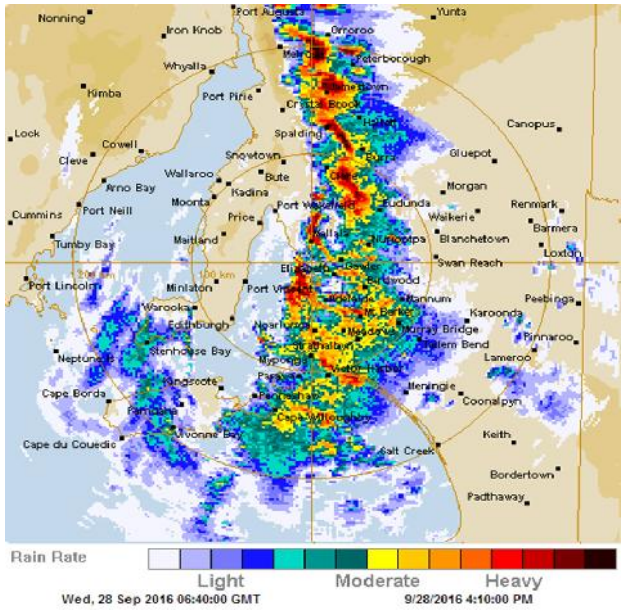
Australian Government
Bureau of Meteorology

Average maximum temperature, hottest week of year



September 2016 SA tornado outbreak





At least 7 documented tornadoes

Australian Government
Bureau of Meteorology

The 1897 Wimmera tornado outbreak

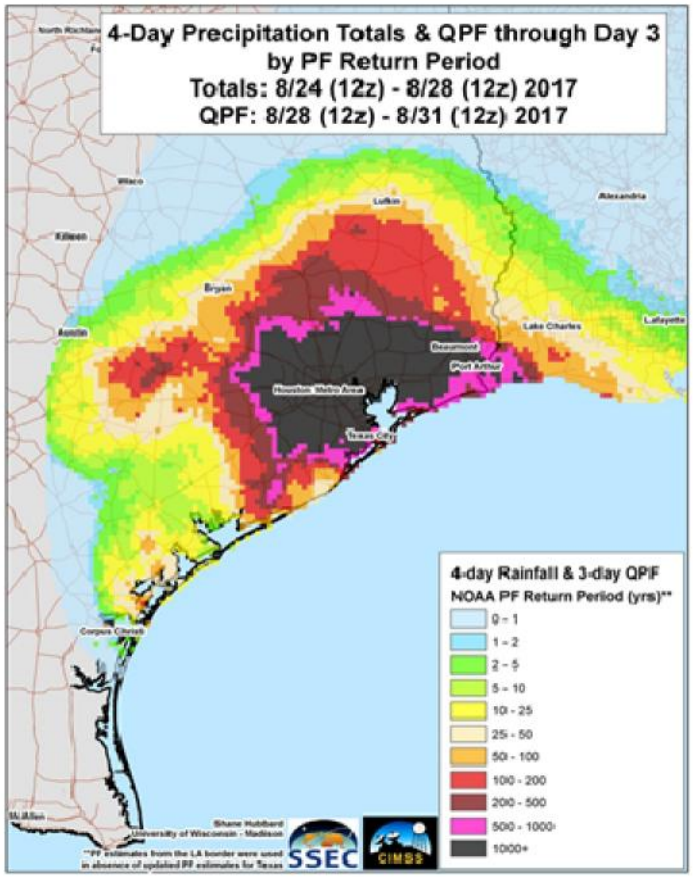
Nhill, 19 November 1897 (source: Wimmera Way Back When)

Historical research indicates up to 40 tornadoes

Some believed to be of F3 or higher intensity

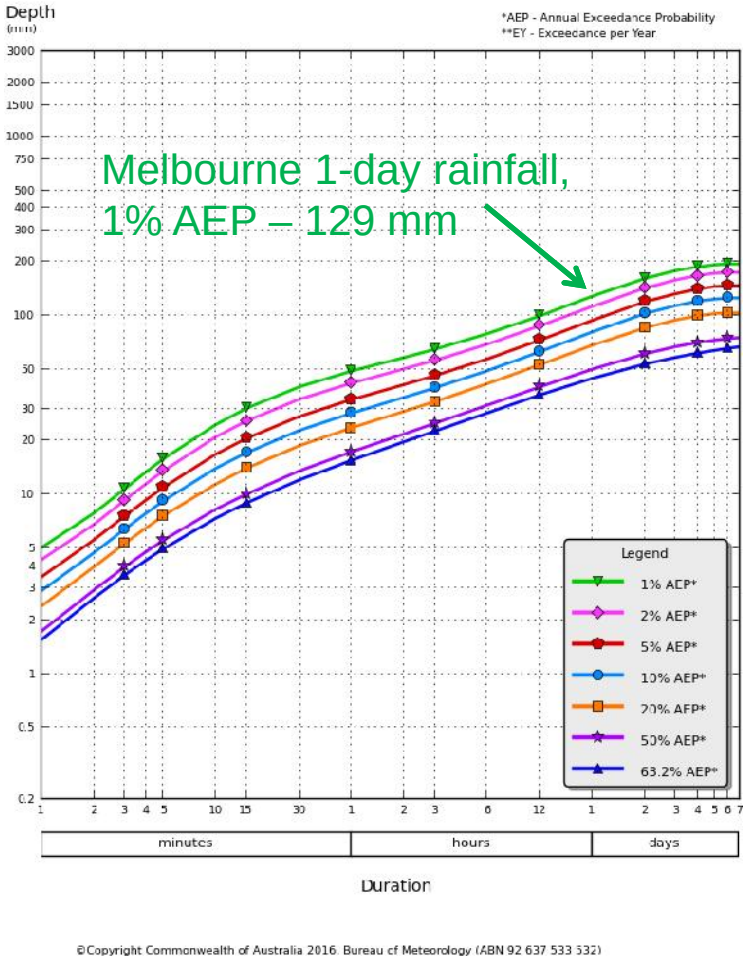
Australian Government
Bureau of Meteorology

How exceptional an event was Hurricane Harvey?



Australian Government
Bureau of Meteorology

Assessment of rainfall probabilities

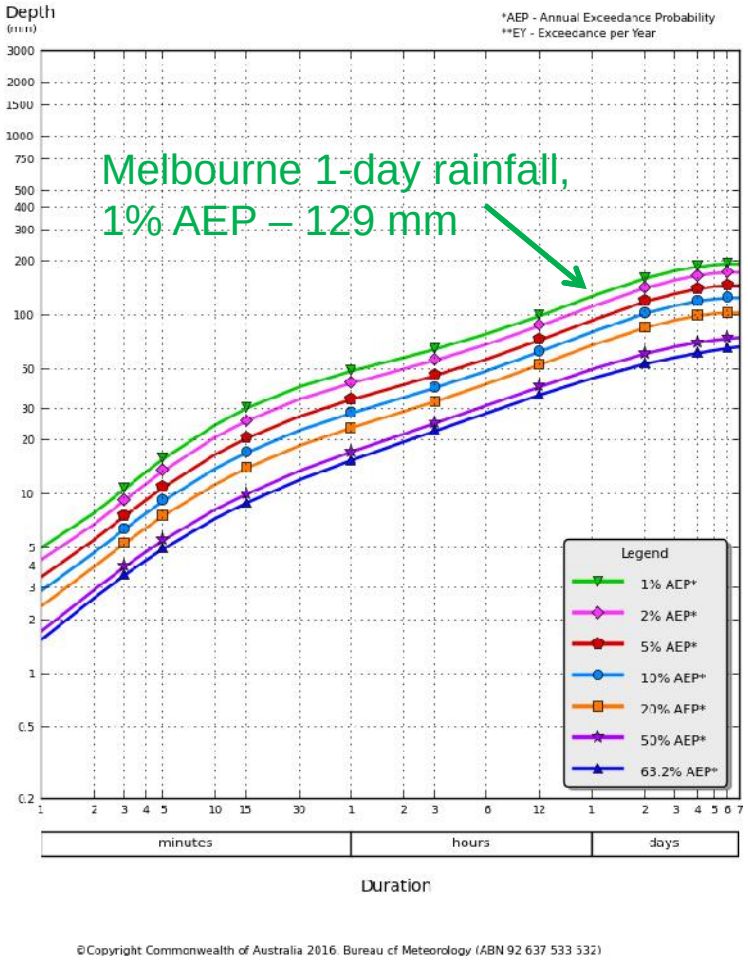


Australian Government
Bureau of Meteorology

Design rainfalls at Melbourne for 24 hours

- 1% AEP – 129 mm
- 0.2% AEP – 173 mm

Assessment of rainfall probabilities



Design rainfalls at Melbourne for 24 hours

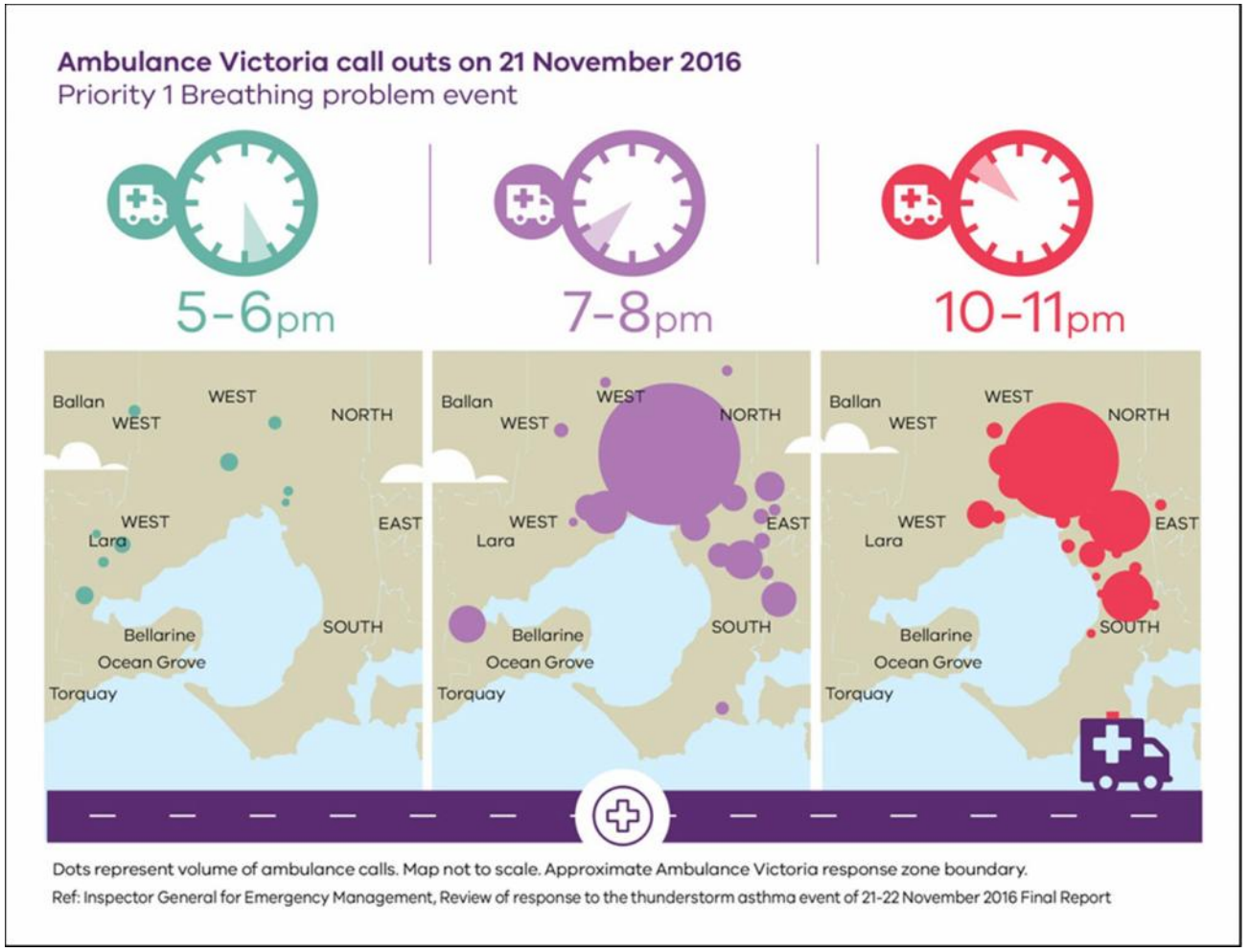
- 1% AEP – 129 mm
- 0.2% AEP – 173 mm

But – 129 mm has been exceeded somewhere in metropolitan Melbourne (excluding Dandenongs) on 17 different days since 1900 (~1 in 7 years)

2 events since 1900 have exceeded the 0.2% AEP threshold

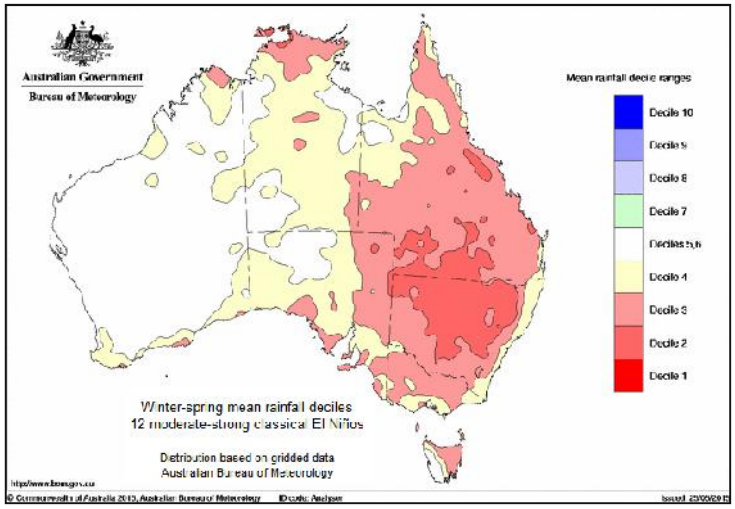
Australian Government
Bureau of Meteorology

Unexpected hazards can emerge – the Victorian thunderstorm asthma outbreak



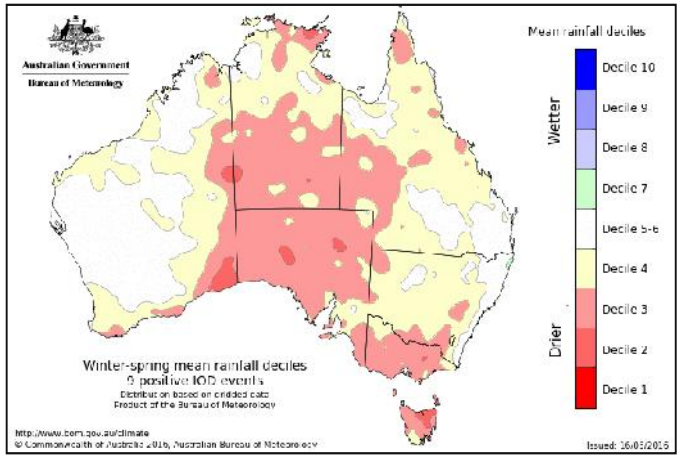
Australian Government
Bureau of Meteorology

Major climate drivers influence Australian seasonal climate



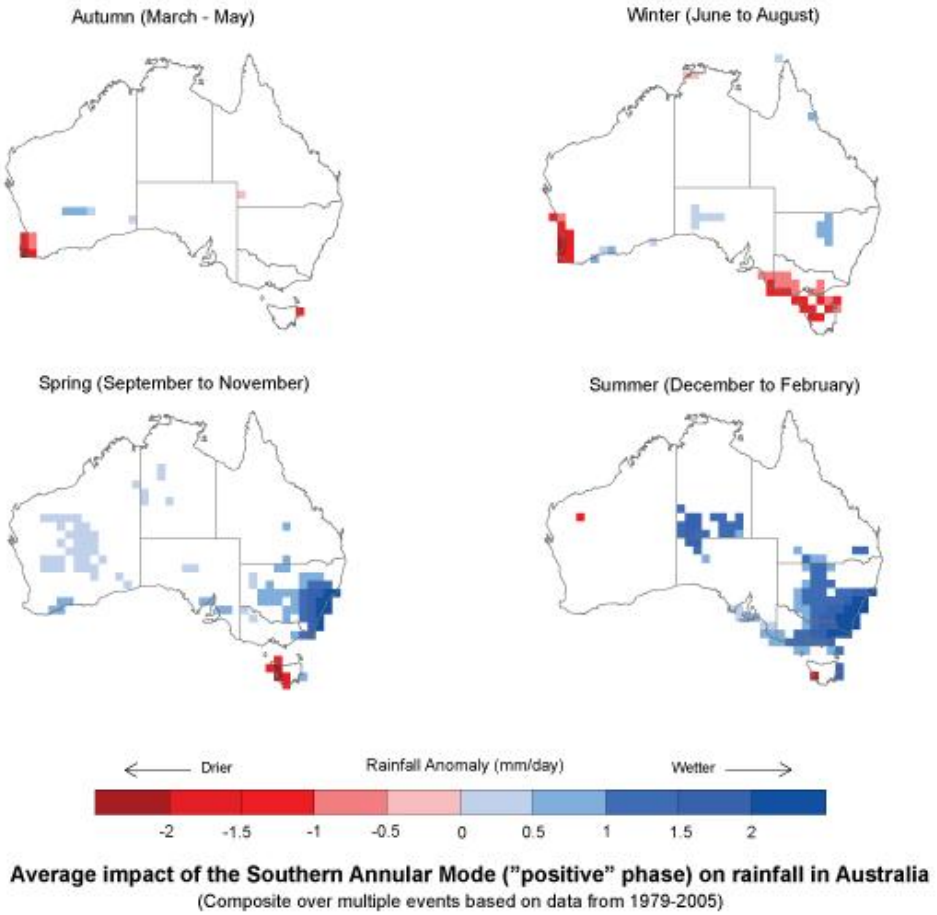
El Niño’s effect on rainfall

Positive Indian Ocean Dipole (IOD)’s effect on rainfall



Australian Government
Bureau of Meteorology

The Southern Annular Mode – a shorter-term climate driver



Average impact of the Southern Annular Mode ("positive" phase) on rainfall in Australia

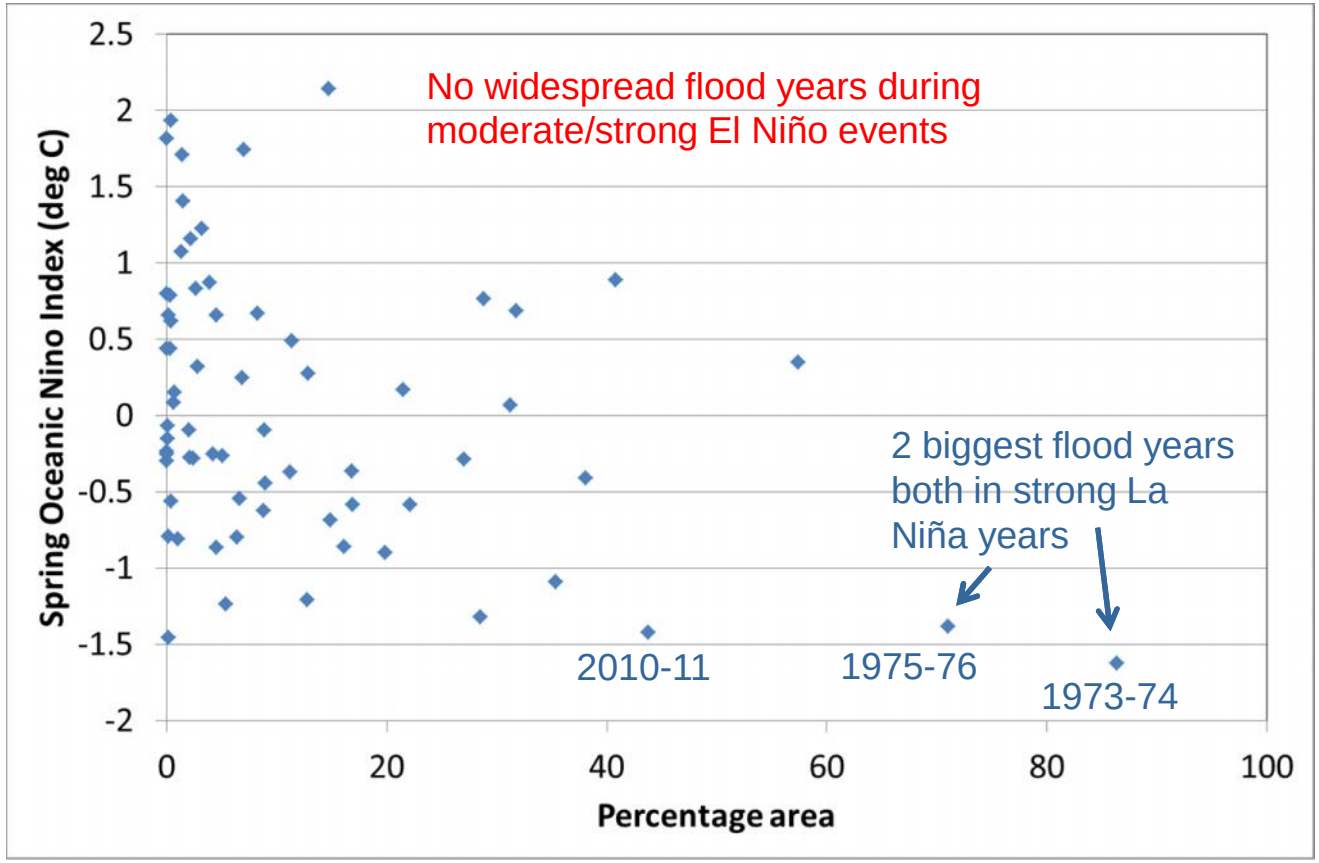
(Composite over multiple events based on data from 1979-2005)

Australian Government
Bureau of Meteorology

Seasonal climate drivers can affect extremes

Australian Government
Bureau of Meteorology

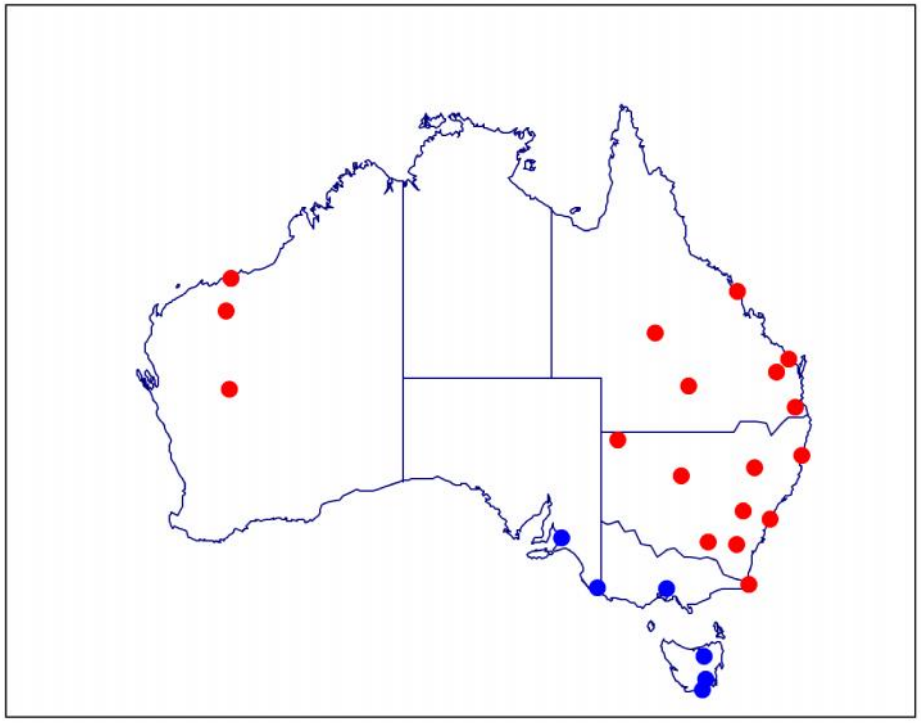
Area of Queensland with summer rainfall above 90th percentile



ENSO influence on heatwaves

Australian Government
Bureau of Meteorology

5-day heatwave index relationship with ENSO



Red – heatwaves more likely during El Niño
Blue – heatwaves more likely during La Niña

Single-day extremes do not always match this!

New weekly forecasts – filling the gap