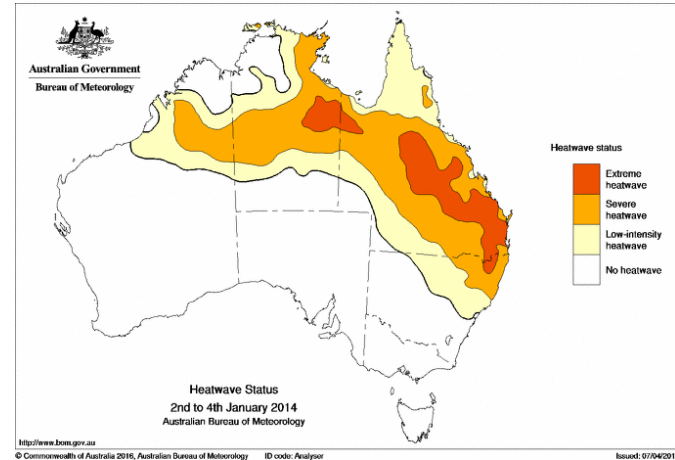


Climate Change Impacts

mapping increasing severity

35th Annual Scientific Meeting of the Australasian College for Emergency Medicine (ACEM), Perth November 2018

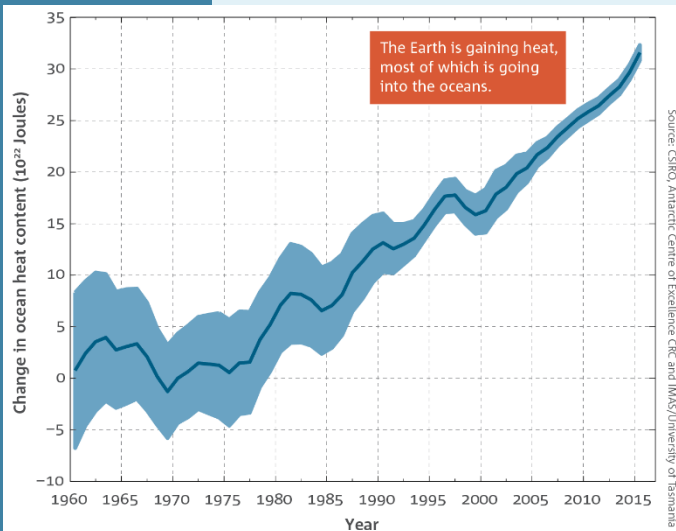
John Nairn
Australian Bureau of Meteorology
University of Adelaide



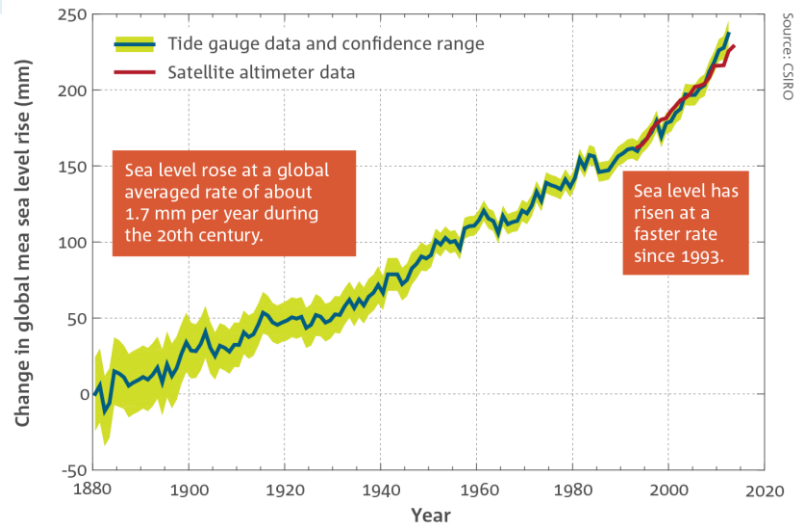
Global climate



Ocean heat content and sea level



Oceanic heat content



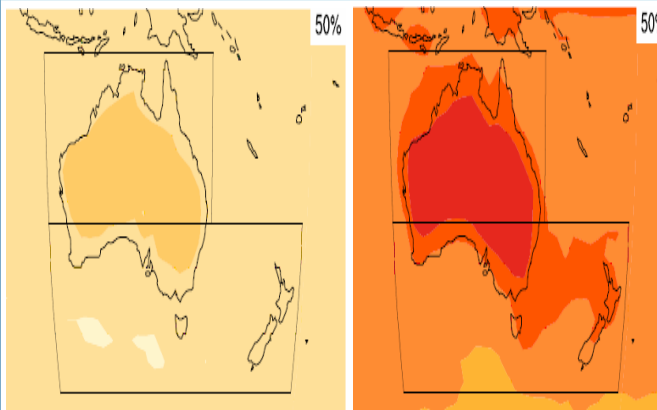
Global sea level

Australia's future climate

Australian climate projections for 2100

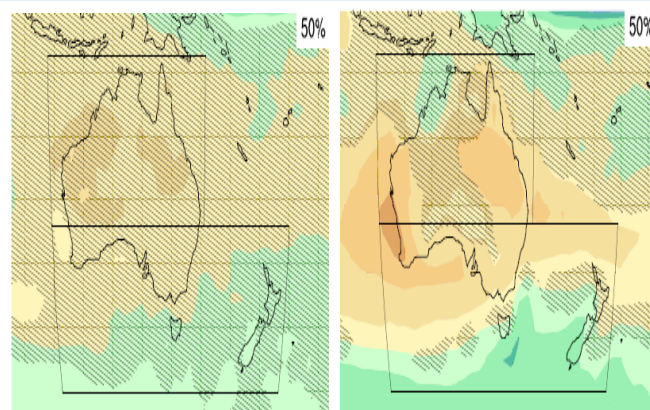
Annual temperature

Annual rainfall



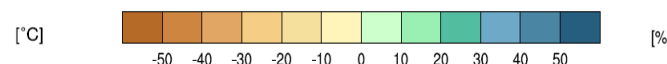
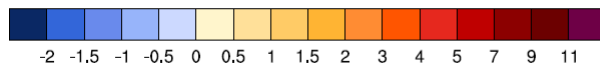
'Negative'
emissions

Business as usual
emissions



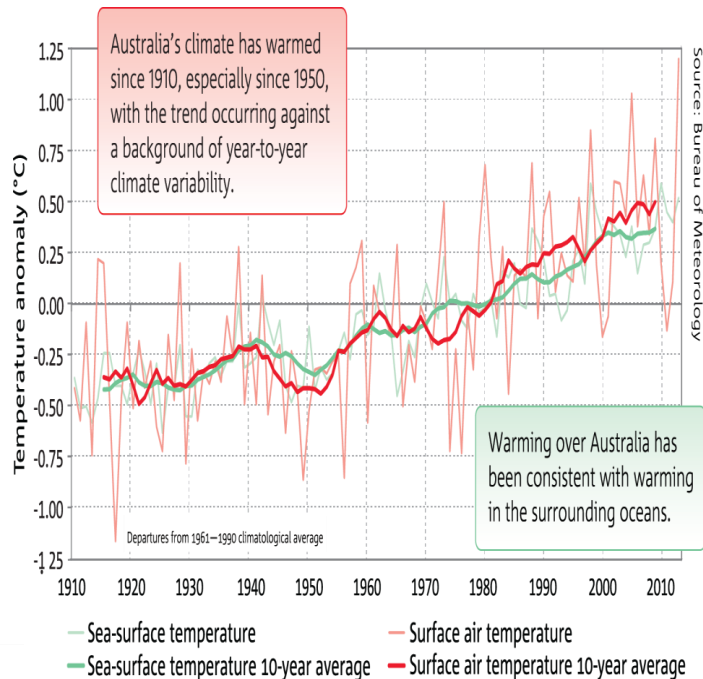
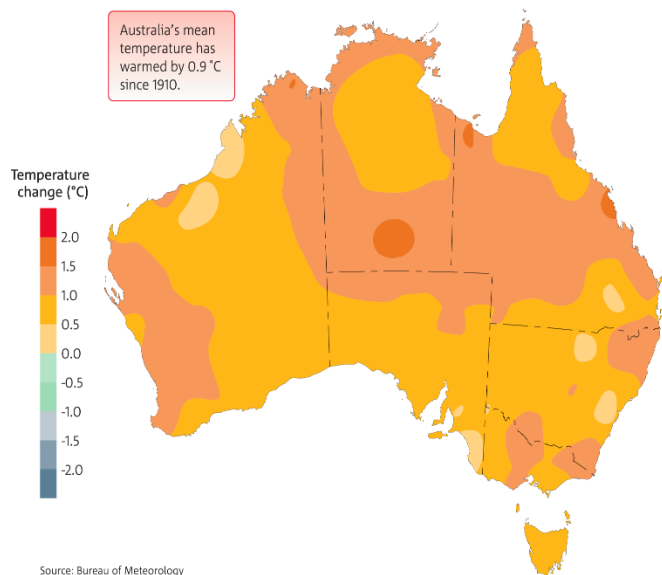
'Negative'
emissions

Business as usual
emissions





Warming from climate change

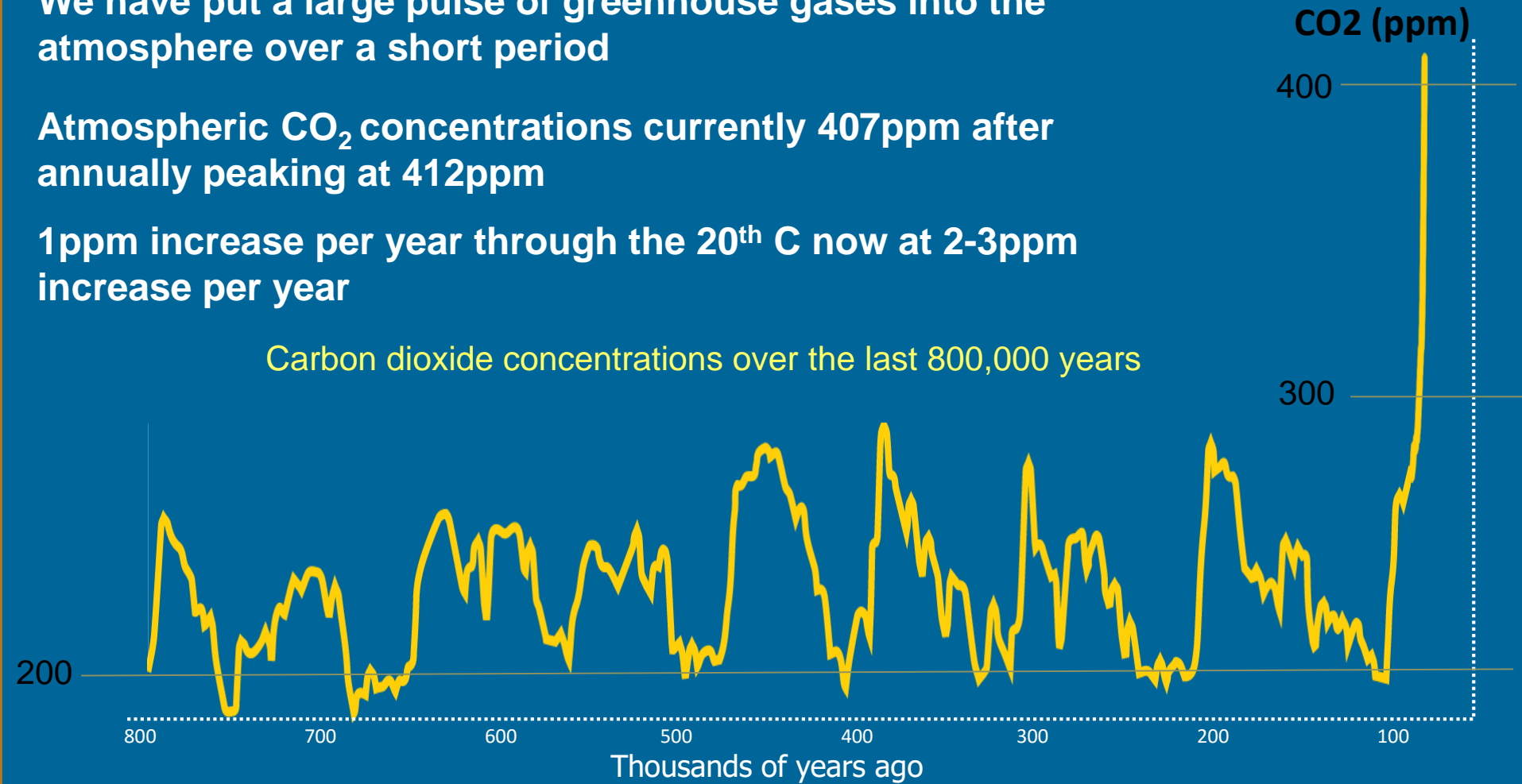


We have put a large pulse of greenhouse gases into the atmosphere over a short period

Atmospheric CO₂ concentrations currently 407ppm after annually peaking at 412ppm

1ppm increase per year through the 20th C now at 2-3ppm increase per year

Carbon dioxide concentrations over the last 800,000 years





Patterns of change

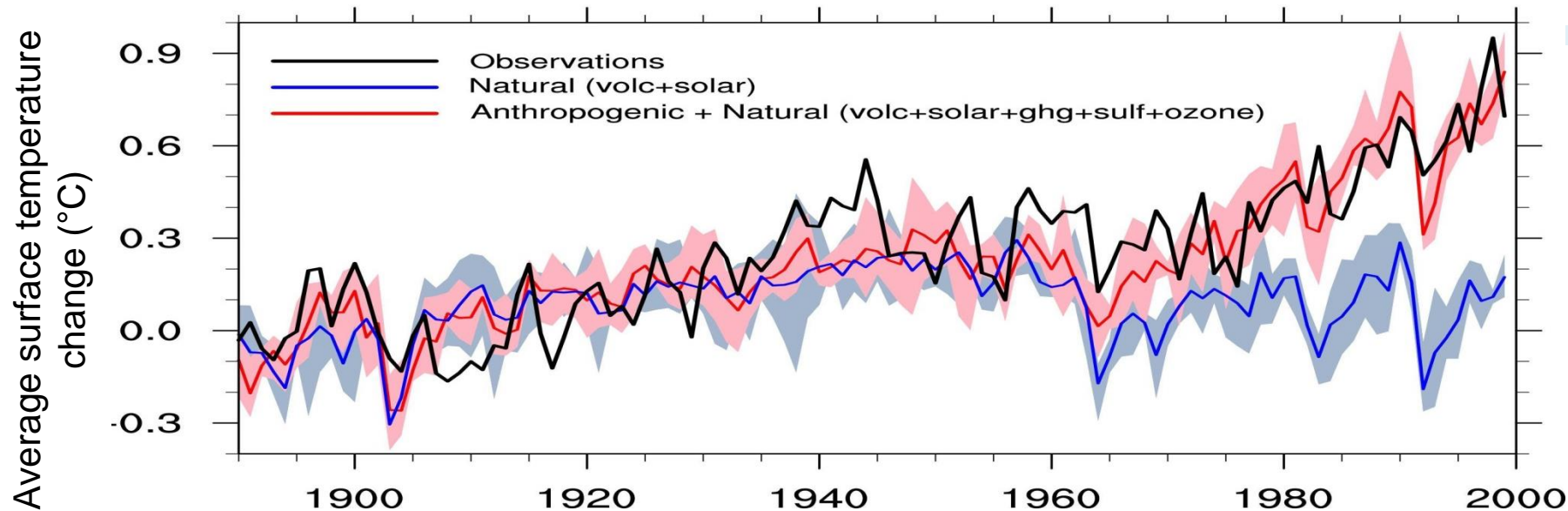
		Climate Drivers			
		Greenhouse Gases	Sun	Volcanoes	Internal Variability
Climate Patterns	Cooling upper atmosphere	✓	✗	✗	✗
	Less heat to space	✓	✗	✗	✗
	Rising tropopause	✓	✓	✓	✗
	Annual cycle	✓	✗	✗	✗
	Daily cycle	✓	✗	✗	✗
	Ocean warming	✓	✗	✗	✗
	More heat back to Earth	✓	✗	✗	✗
	Land warming faster than oceans	✓	✓	✗	✗
		✓ Consistent with Climate Driver	✗ Rules out Climate Driver		

There are a range of changes being observed, all of which can only be explained by what is expected from increased greenhouse gases. No other influence explains all of these patterns of change

Models can perform the “control experiment” not possible in the real world



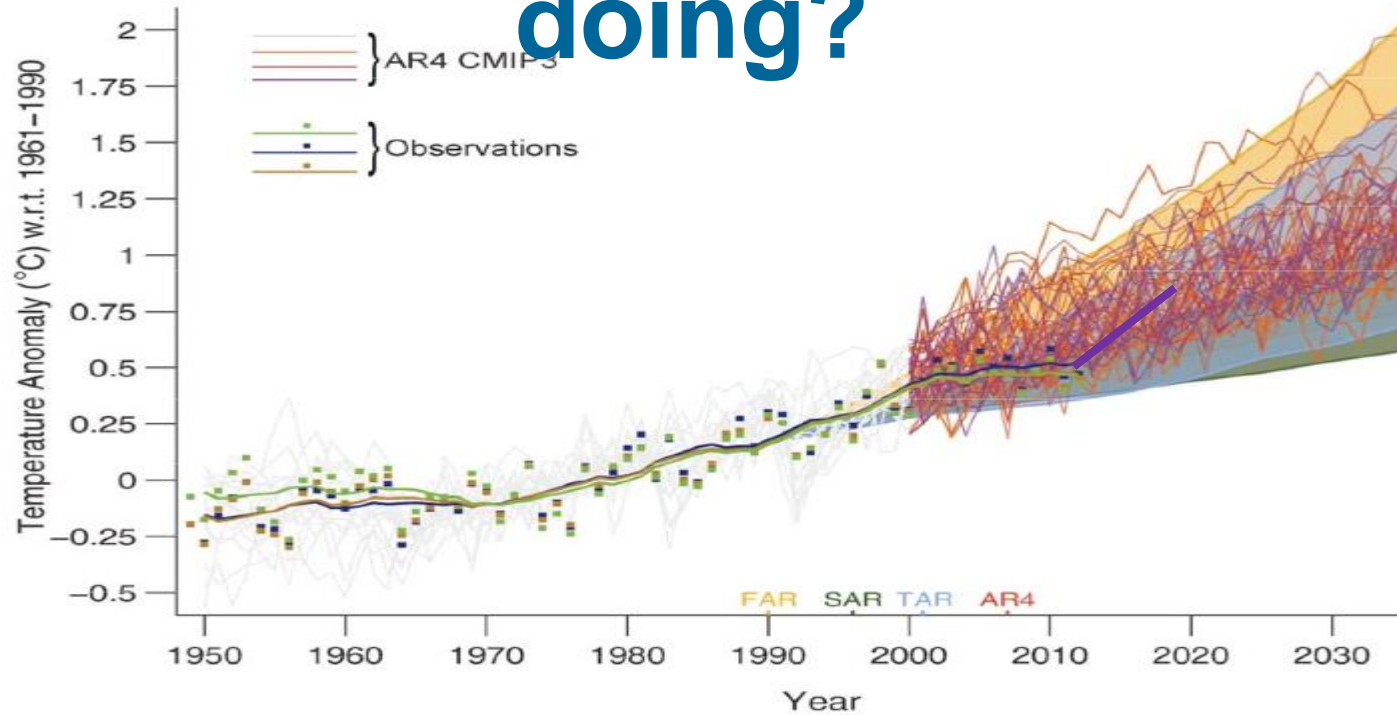
Australian Government
Bureau of Meteorology



Global climate models run without increasing greenhouse gases (blue line) fail to represent actual observed temperature (black line) from the 1960's on – when greenhouse emissions strongly increased

Models run with the observed greenhouse gas increase much better recreate the observed (black line) warming from 1960 on

How are the projections doing?

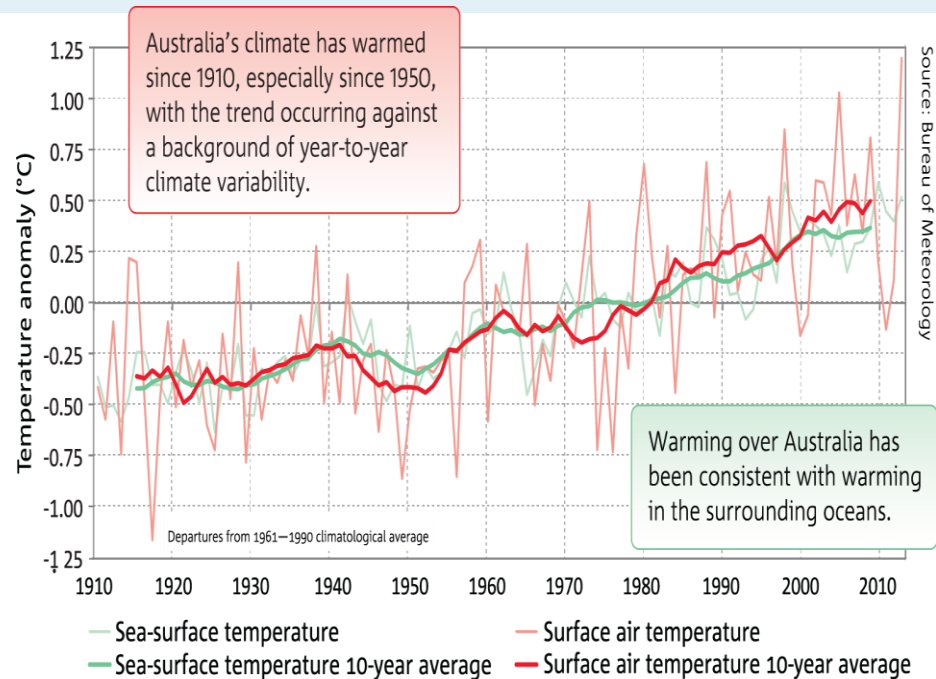
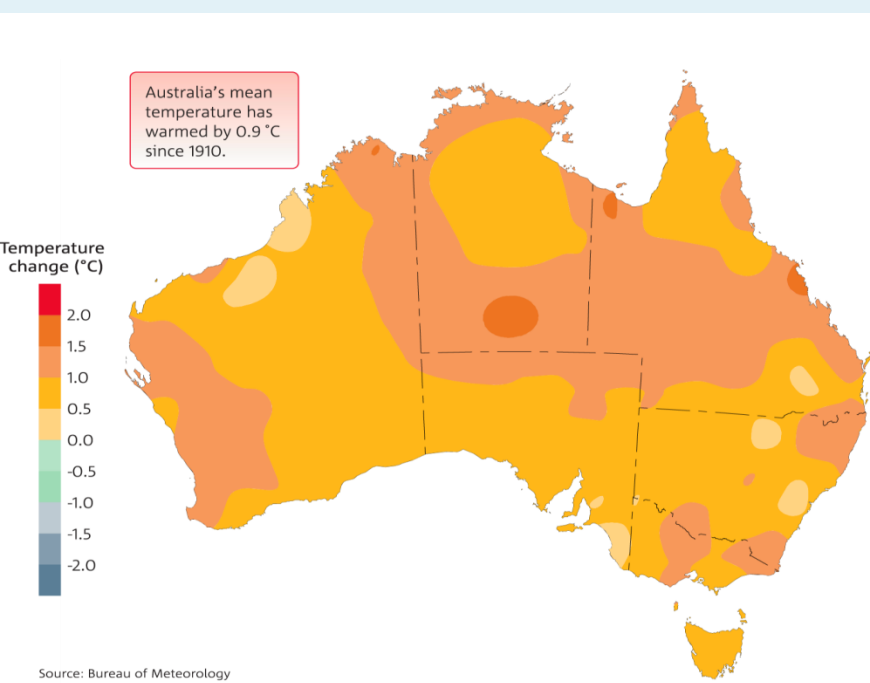


Earlier projections of warming from earlier IPCC reports (First Assessment Report – FAR and the Second and Third reports (SAR, TAR) are being seen in warming to date, after some slowdown in temperature rise through the period 2000-2013



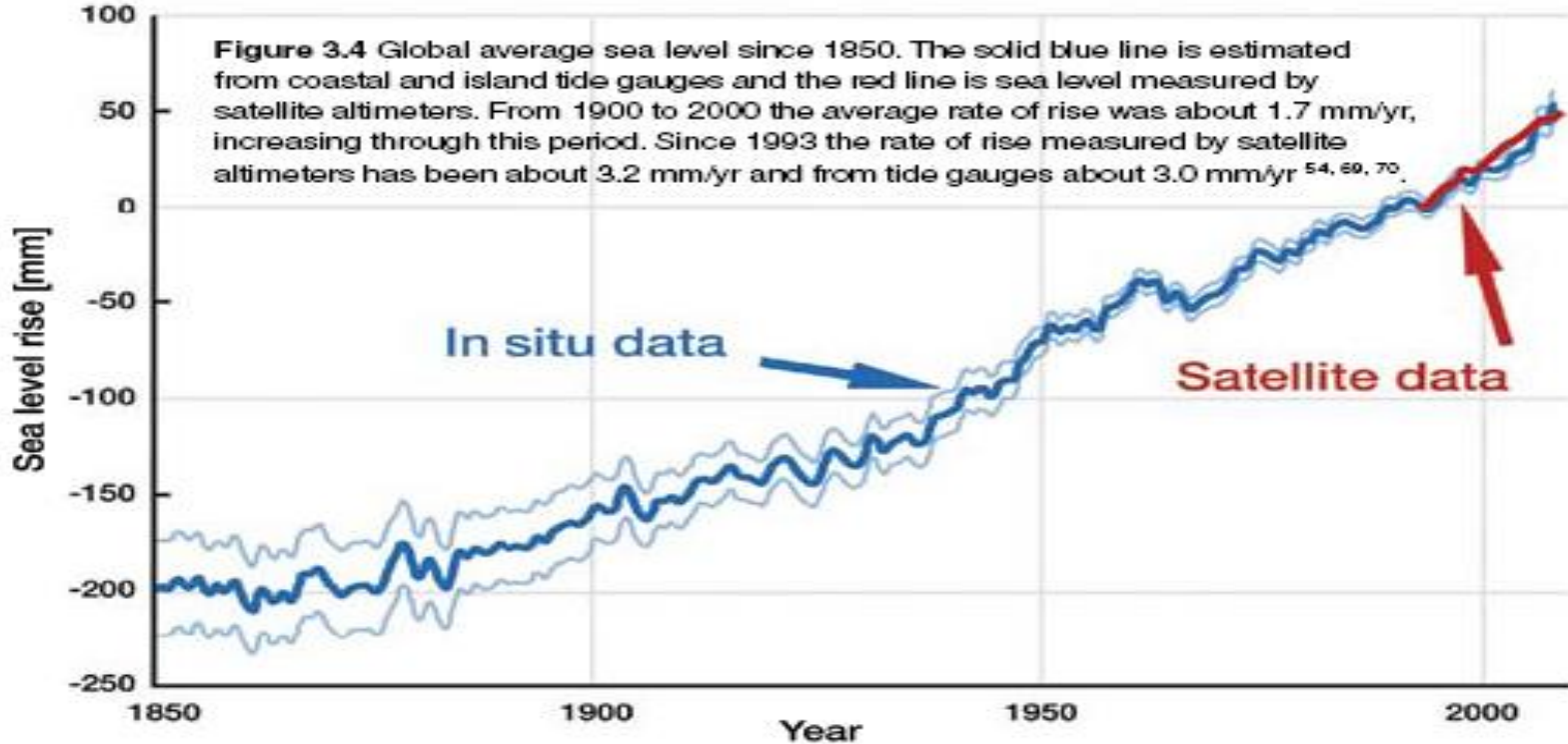
Australian Government
Bureau of Meteorology

Australia is warming - on land and in the oceans





Sea level has risen ~20cm since 1850



Both tide gauge and satellite sea level data show sea level rise in excess of 3mm per year

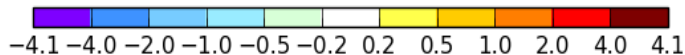
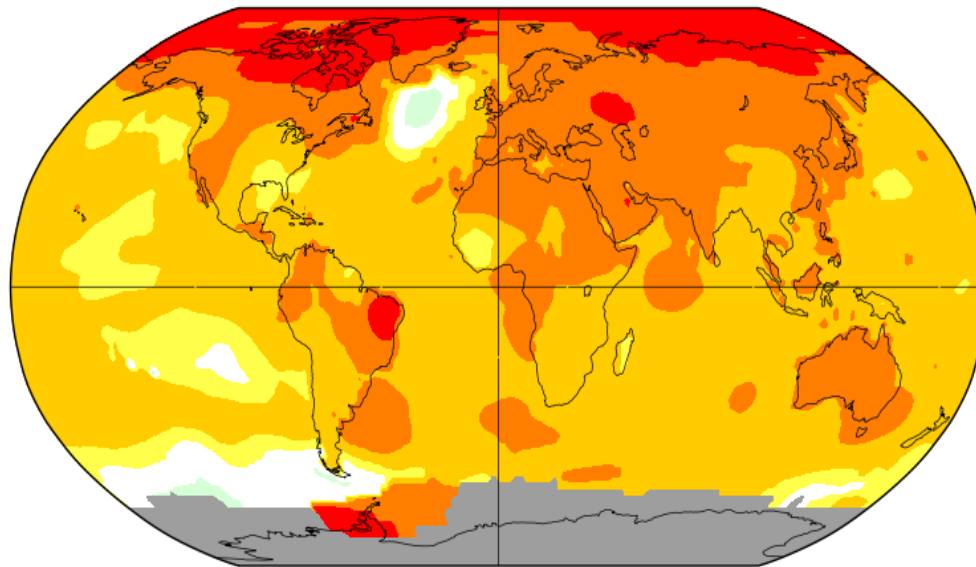


Warming around the globe

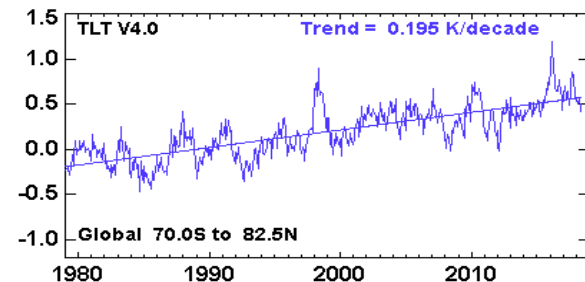
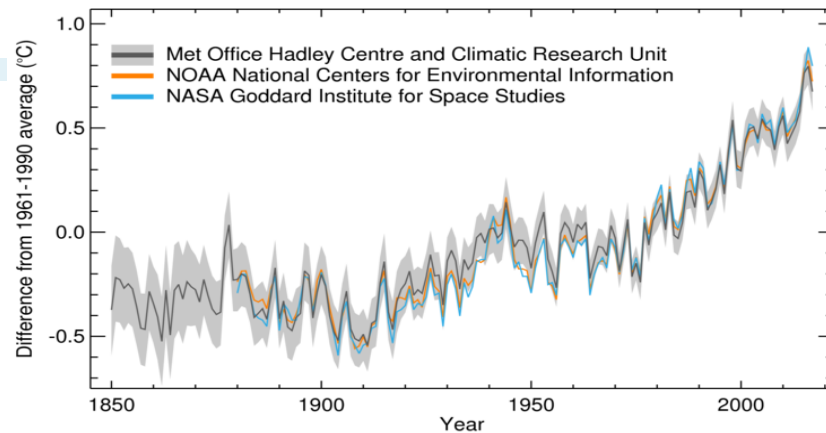
Annual J-D 2008-2017

L-OTI(°C) Anomaly vs 1880-1950

0.92



Global average temperature anomaly
(1850-2017)



Lower tropospheric temperature from satellite data

2016 was the hottest year on record globally. 2017 2nd hottest

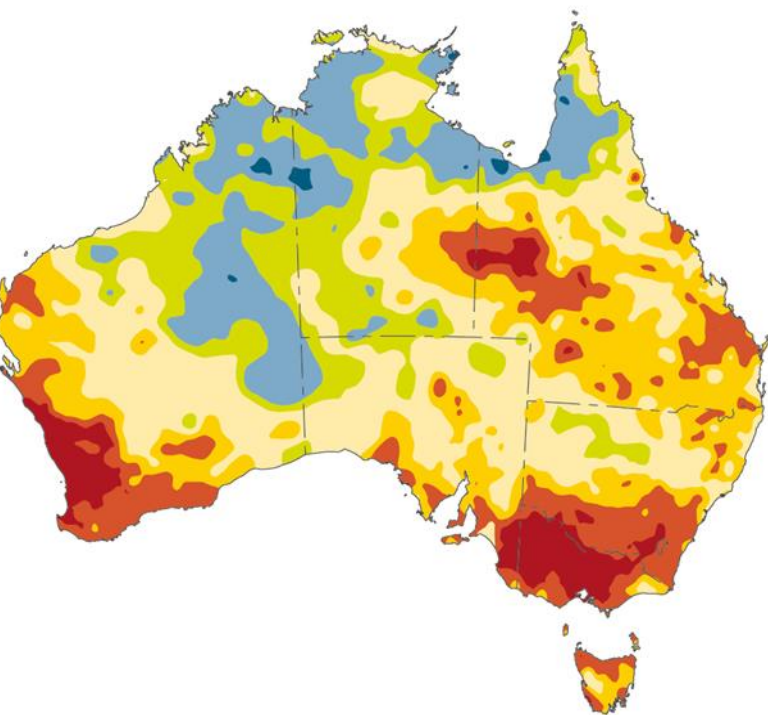
https://data.giss.nasa.gov/gistemp/graphs_v3/

http://images.remss.com/msu/msu_time_series.html



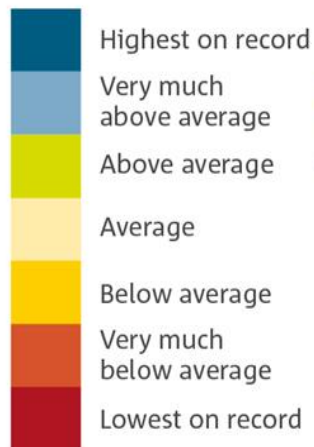
Australian Government
Bureau of Meteorology

Rainfall trends

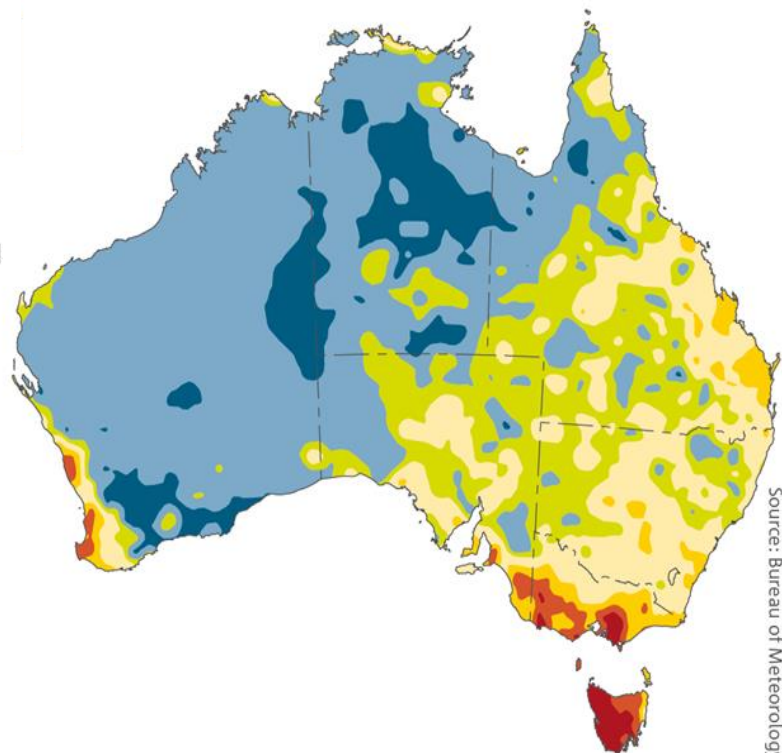


April – October

Rainfall decile ranges



Source: Bureau of Meteorology



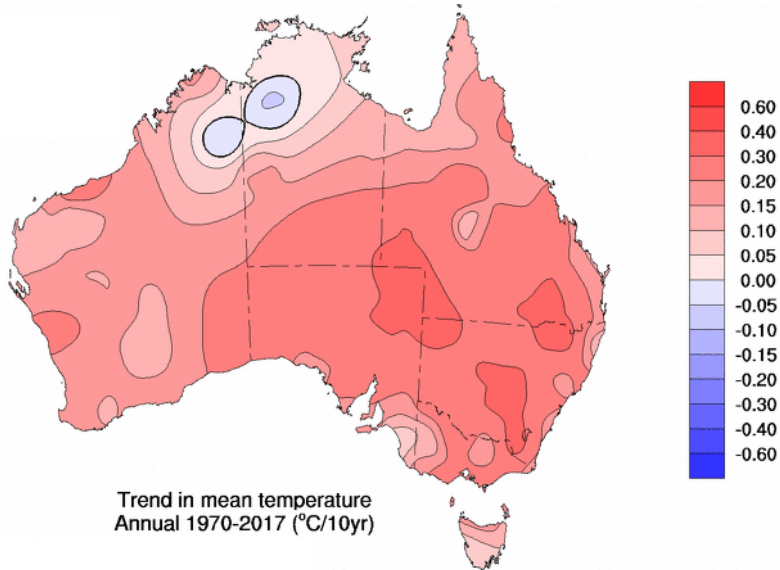
November-March

Source: Bureau of Meteorology



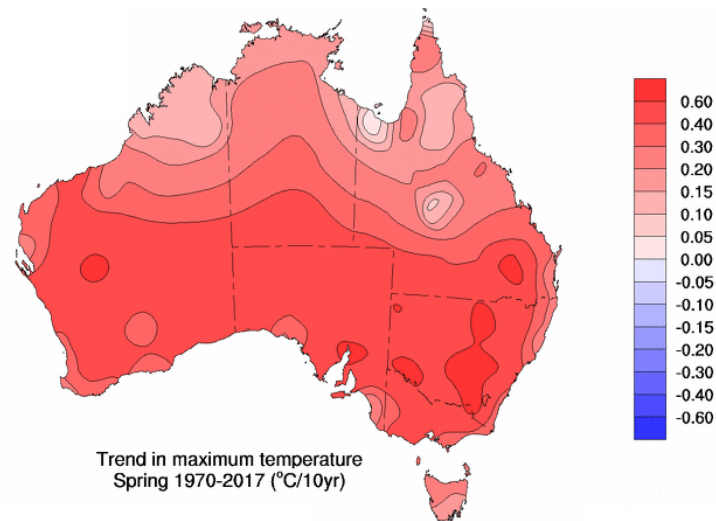
Seasonal temperatures

Significant seasonal and regional variability exists in trends



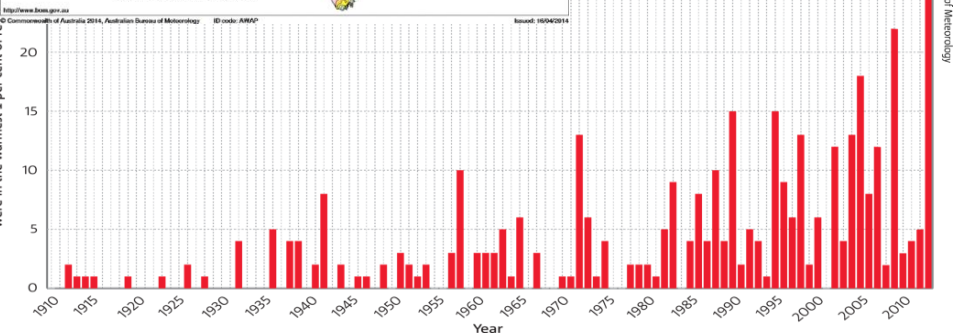
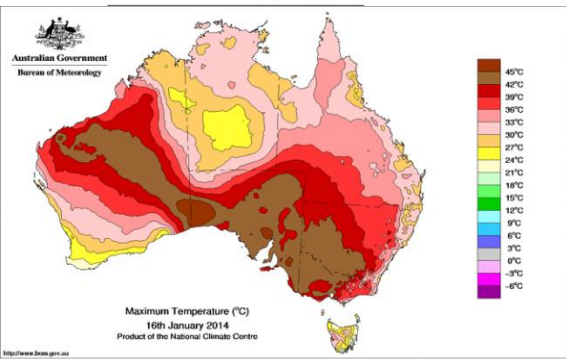
Spring maximums are strongly warming

<http://www.bom.gov.au/climate/change/>

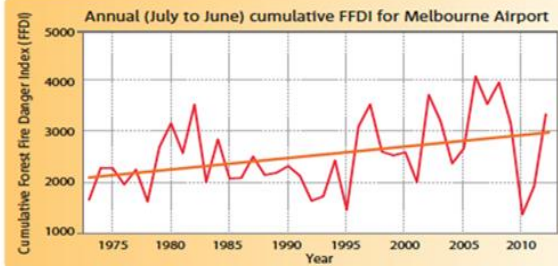
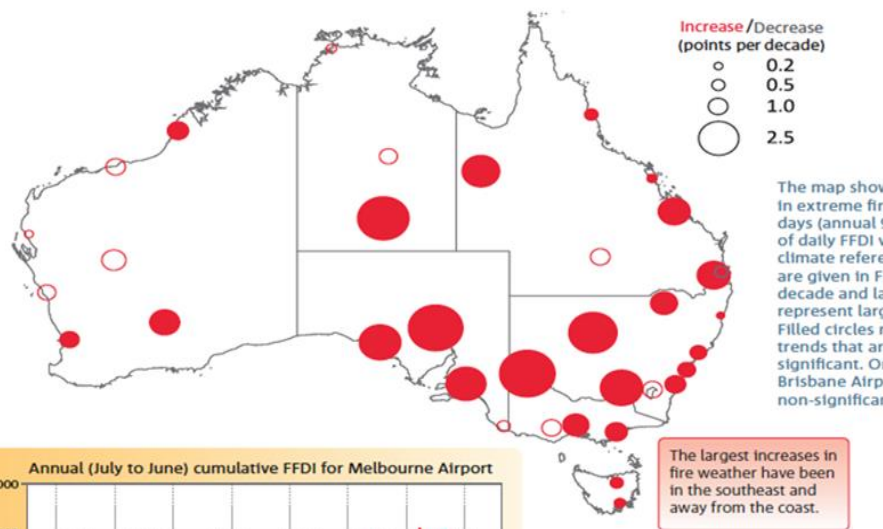


Increased heatwave intensity and increased bushfire risk

Australian Government



Source: Bureau of Meteorology, CSIRO and Office of Environment and Heritage (NSW)



Time series showing the increasing trend in the annual cumulative Forest Fire Danger Index (FFDI) at Melbourne Airport. A long-term trend is discernible despite significant annual variability.

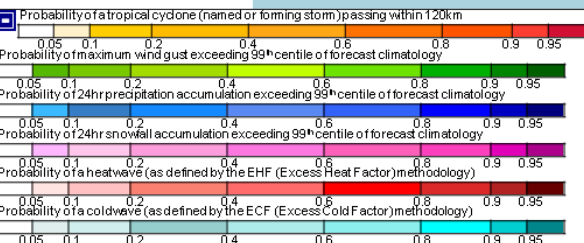
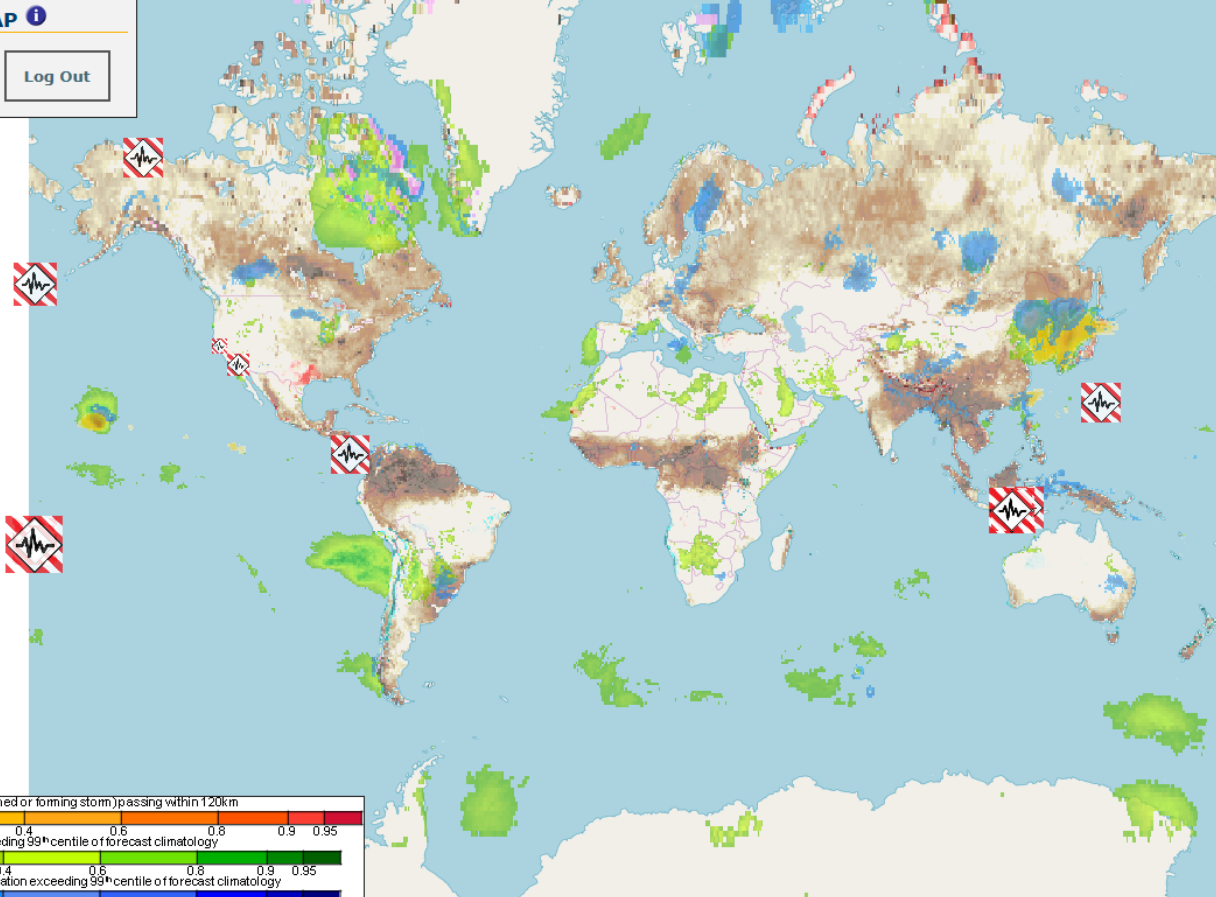
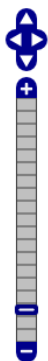
GLOBAL HAZARD MAP

Prototype Environment

Non-operational

DT 12UTC 20/08/2018

Log Out



Summary map

☐ Day 1 Tue 21/08/2018

☐ Day 2 Wed 22/08/2018

☐ Day 3 Thu 23/08/2018

☒ Day 4 Fri 24/08/2018

TC: MM ☒ EC ☐ MOG ☐

Wind gust: MM ☒ EC ☐ MOG ☐ c.c. ☐

Precip: MM ☒ EC ☐ MOG ☐ c.c. ☐

Snow: MM ☒ EC ☐ MOG ☐ c.c. ☐

Heatwave: EC ☒

Coldwave: EC ☒

☐ Day 5 Sat 25/08/2018

☐ Day 6 Sun 26/08/2018

☐ Day 7 Mon 27/08/2018

Abbreviations

s.p. = Summary Polygons

c.c. = Climatology contours

Det = Deterministic

MM = Multi-model

EC = ECMWF

MOG = MOGREPS-G

(m/s for wind gust, mm for precip & snow)

Monitoring and recent geohazards

☐ 7-day antecedent rainfall (GPM)

☐ 30-day antecedent rainfall (GPM)

☒ Soil moisture

☐ Earthquakes >4.5 mag in last 24hrs

☒ Significant earthquakes in last month

Vulnerability and exposure fields

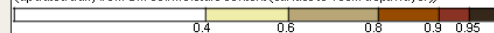
☐ Population density

☐ Fragile States (2014 Ranking)

Static environmental data

☐ Major river basins

Percentage of soil saturation
(updated daily from UM soil moisture content (surface to 10cm depth layer))

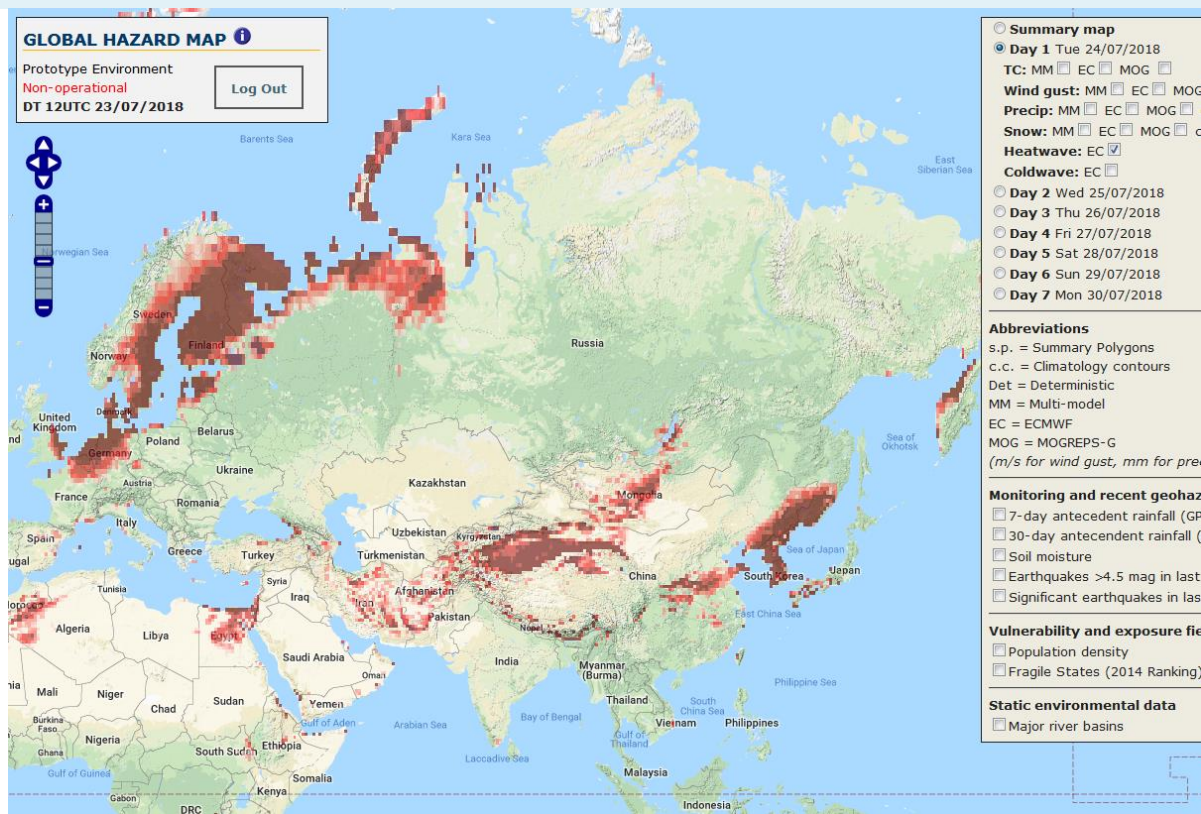


Recent Earthquakes (updated every 10 minutes, sized according to magnitude)





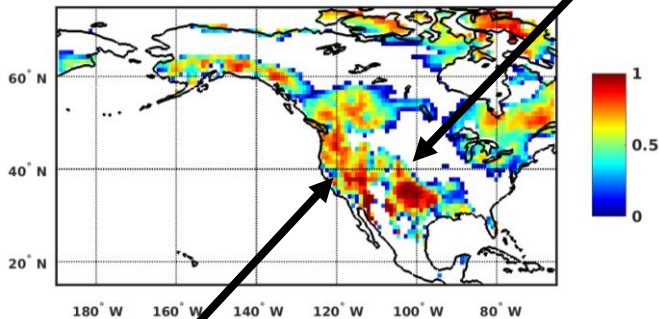
Australian Government
Bureau of Meteorology



Energy usage skyrockets as
heat wave hovers over Texas

Australian Government
Bureau of Meteorology

Quant. of obs. dry EHF (ECDF) for: 16-Jul-2018 to 22-Jul-2018

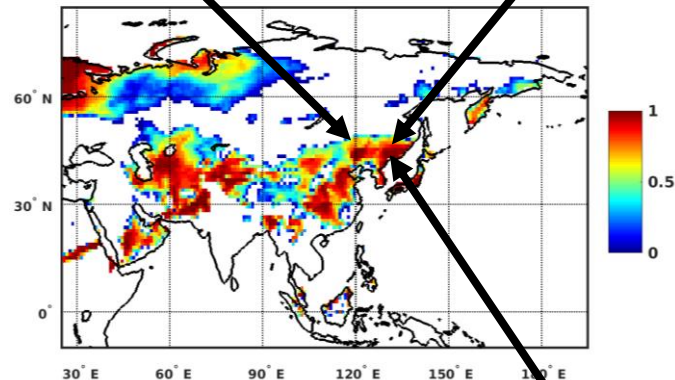


L.A. County issues heat
wave warning for the
week ahead

Heat wave continues in
South Korea with record
temperature

Record high in Japan as
heat wave grips the
region

Quant. of obs. dry EHF (ECDF) for: 16-Jul-2018 to 22-Jul-2018



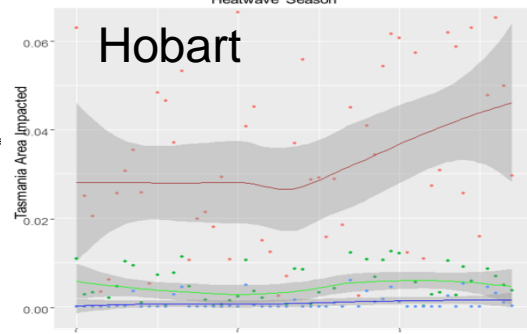
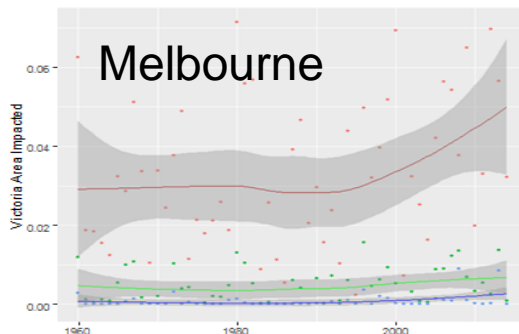
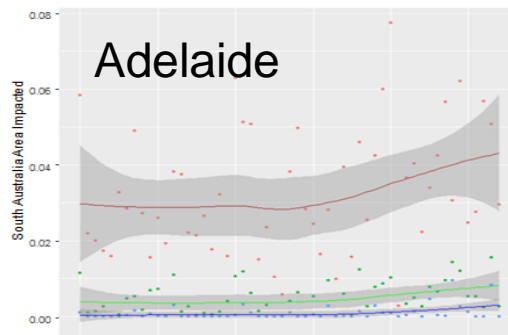
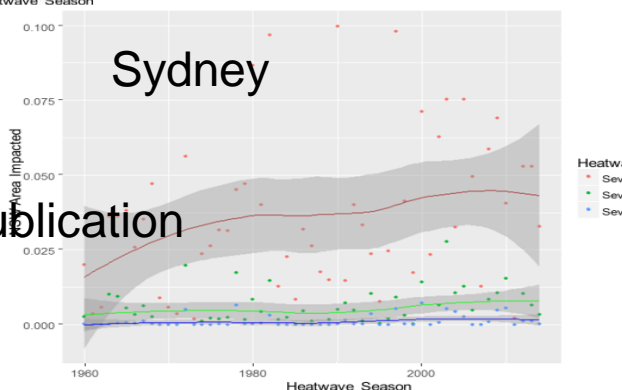
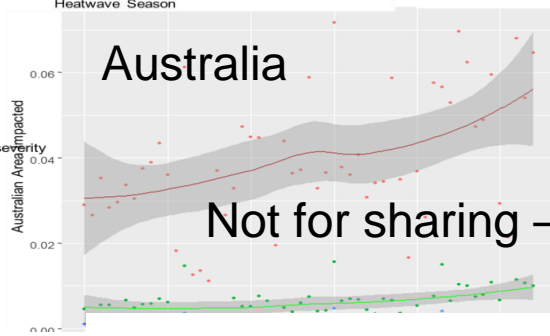
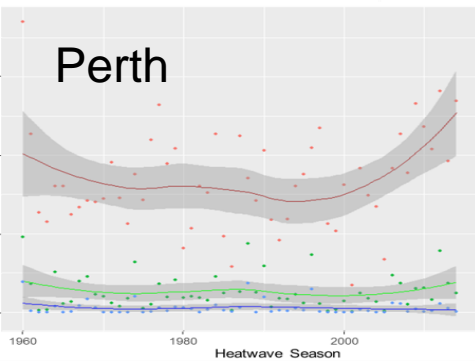
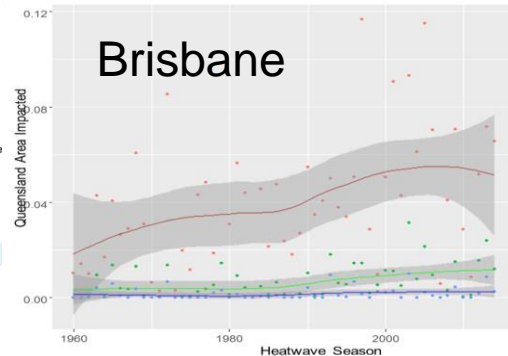
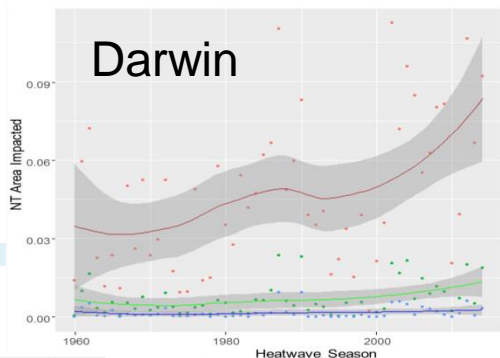
Heat wave grips Japan,
killing more than 30
people, sending
thousands in hospital

NEED



Australian Government
Bureau of Meteorology

proportion of region
per year
for severity 0, 1 & 2



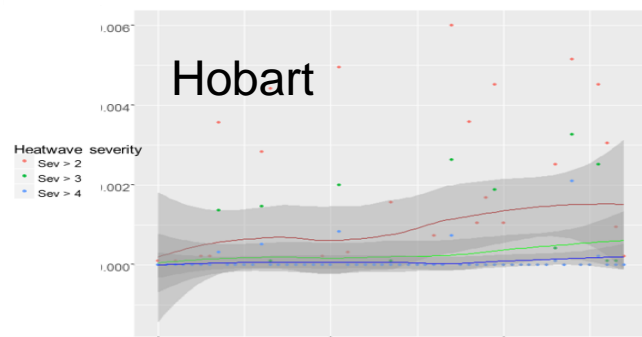
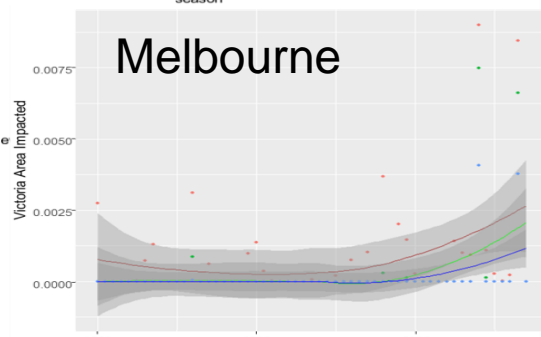
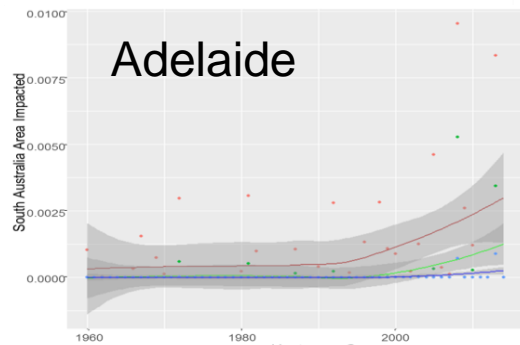
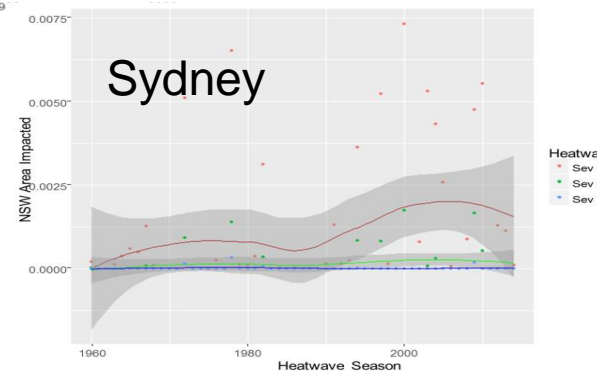
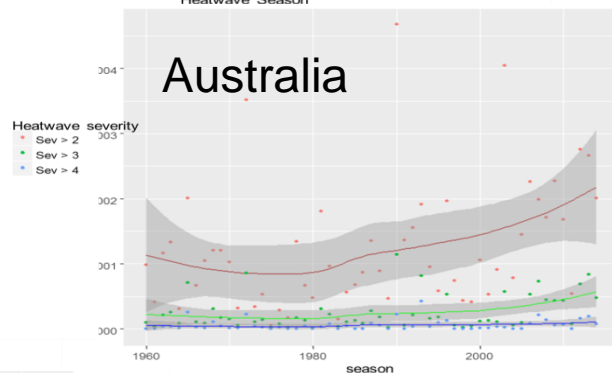
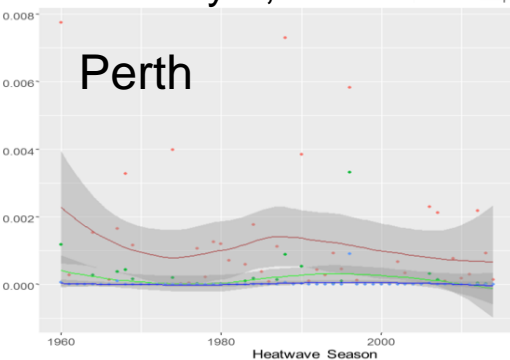
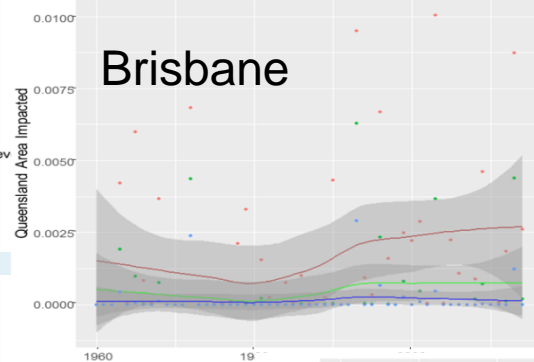
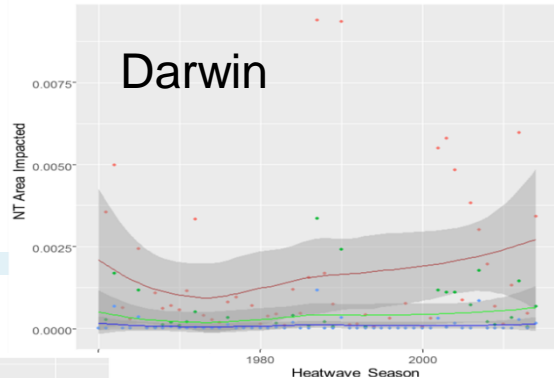
Not for sharing – pre-publication

NEED



Australian Government
Bureau of Meteorology

proportion of region
per year
for severity 2, 3 & 4



service demand to a heatwave intensity and severity definition

Heatwave severity trend across all Australian capital cities

Low-intensity heatwaves have increased across all of Australia, including capital cities, although Perth has increased markedly

Severe and extreme heatwaves have plateaued (Brisbane & Sydney) or decreased (Perth) whilst others (Adelaide, Melbourne and Darwin) have increased markedly

Excess Heat Factor

STEP 1: Heatwave intensity

local climatology driven

STEP 2: Heatwave severity

normalise intensity; impact scales to local intensity climatology

METHOD



Heatwave Intensity: STEP 1



Excessive Heat Factor

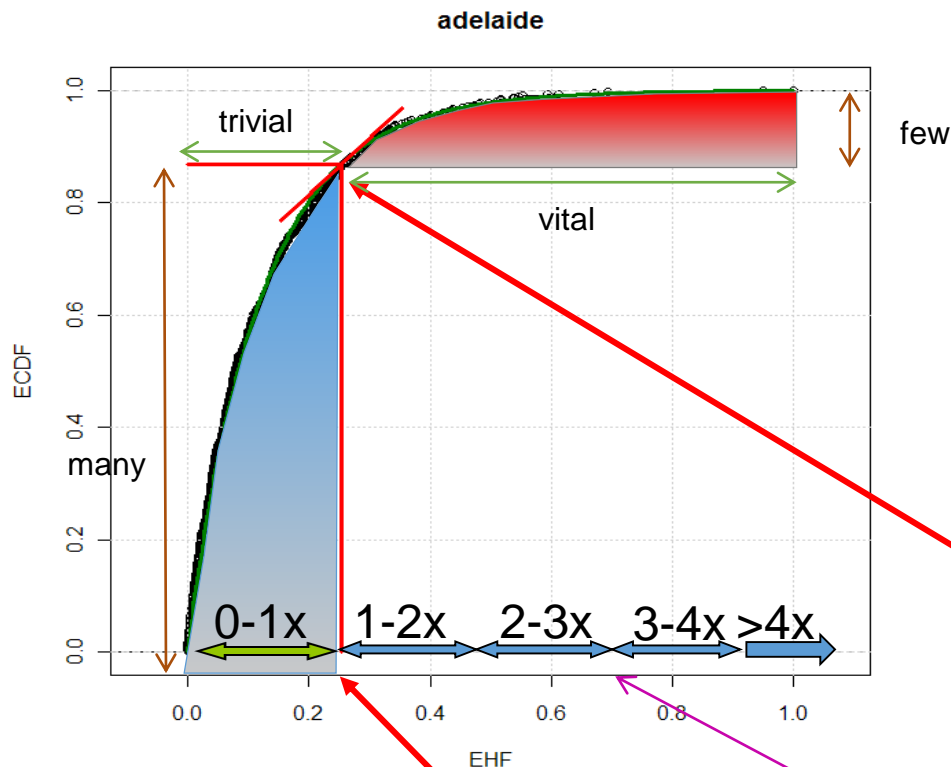
$$EHF = EHI_{sig} \times \text{Max}(1, EHI_{accl})$$

Long term temperature anomaly \times (+ve Short term temperature anomaly)

Heatwave detection

Amplifying term

Heatwave Severity: STEP 2



Generalized Extreme Value theory
utilizing Peaks over Threshold

Generalized Pareto distribution function
– suited to fat tail distributions

85:15

~~80:20~~ rule for rareness or severity of
heatwave intensity

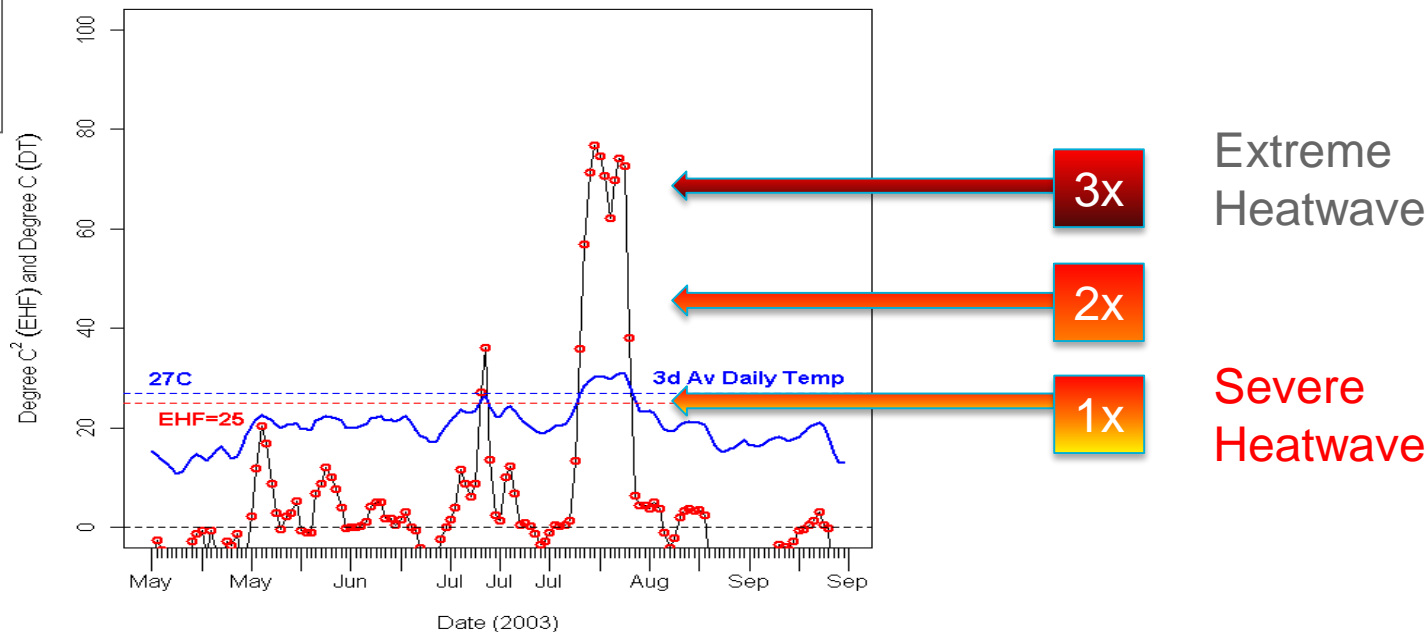


International case studies

France experienced ~15,000 excess deaths in 2003

Peak amplitude of
>3 x sev threshold

Paris Excessive Heat Factor





Requirement for a national heatwave warning framework which incorporates partner agencies warning requirements

Service alignment within an all hazards warning framework

- Heatwave
- Bushfire
- Pollens
- Severe winds
- Flood
- & more



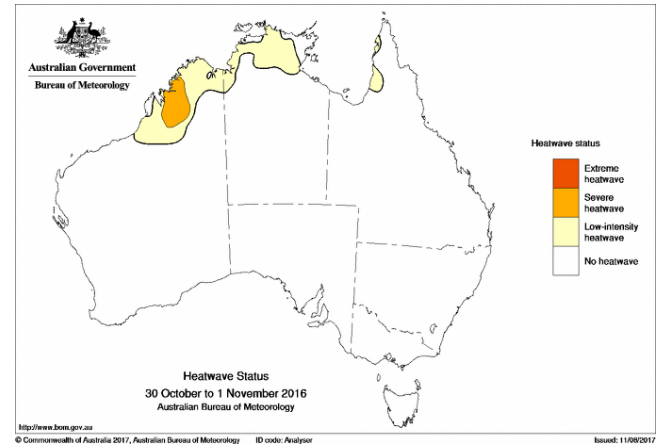
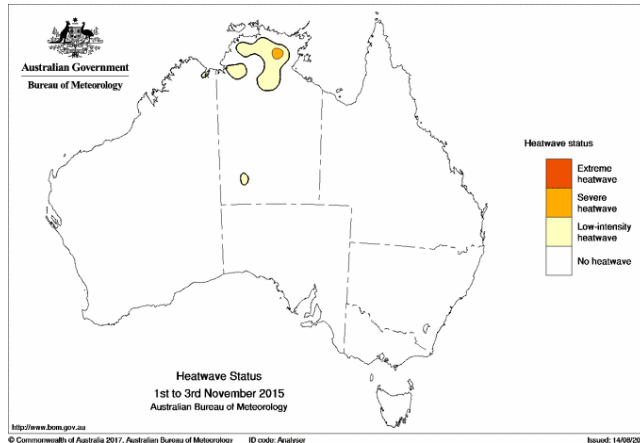
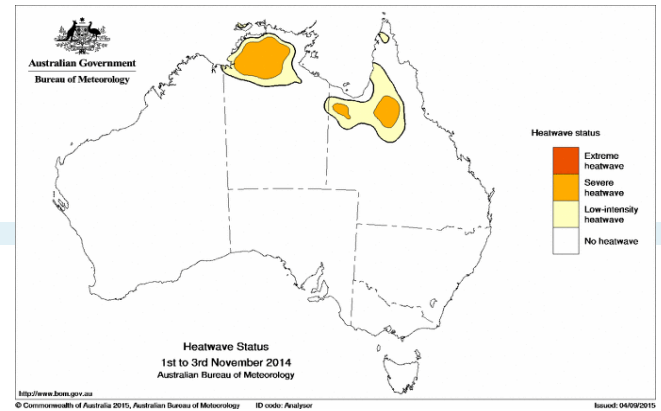
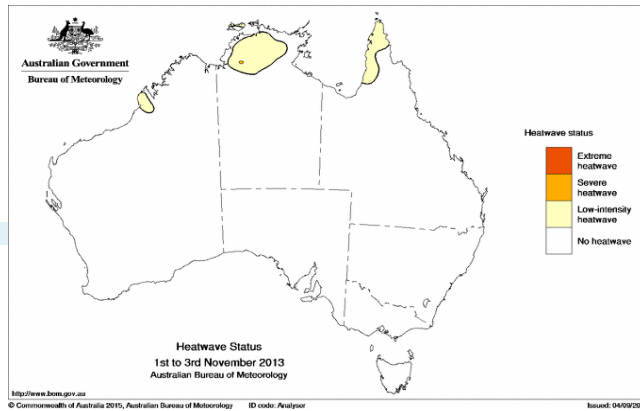
Australian Government
Bureau of Meteorology

Austral summers

2013-14, 2014-15

2015-16, 2016-17

John Nairn
Bureau of Meteorology
State Director South Australia
National Heatwave Project Director
Churchill Fellow (Heatwaves)



Thank you...