ELECTRICITY SECTOR CLIMATE INFORMATION PROJECT

Climate Change Science and Data Overview

Electricity Sector Climate Information (ESCI) Project

Data visualisation consultation
February 7th Feb, 2020 2:30-4:30pm

Australian Government
Department of the Environment and Energy

CSIRO

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Australian Government
Bureau of Meteorology

CSIRO

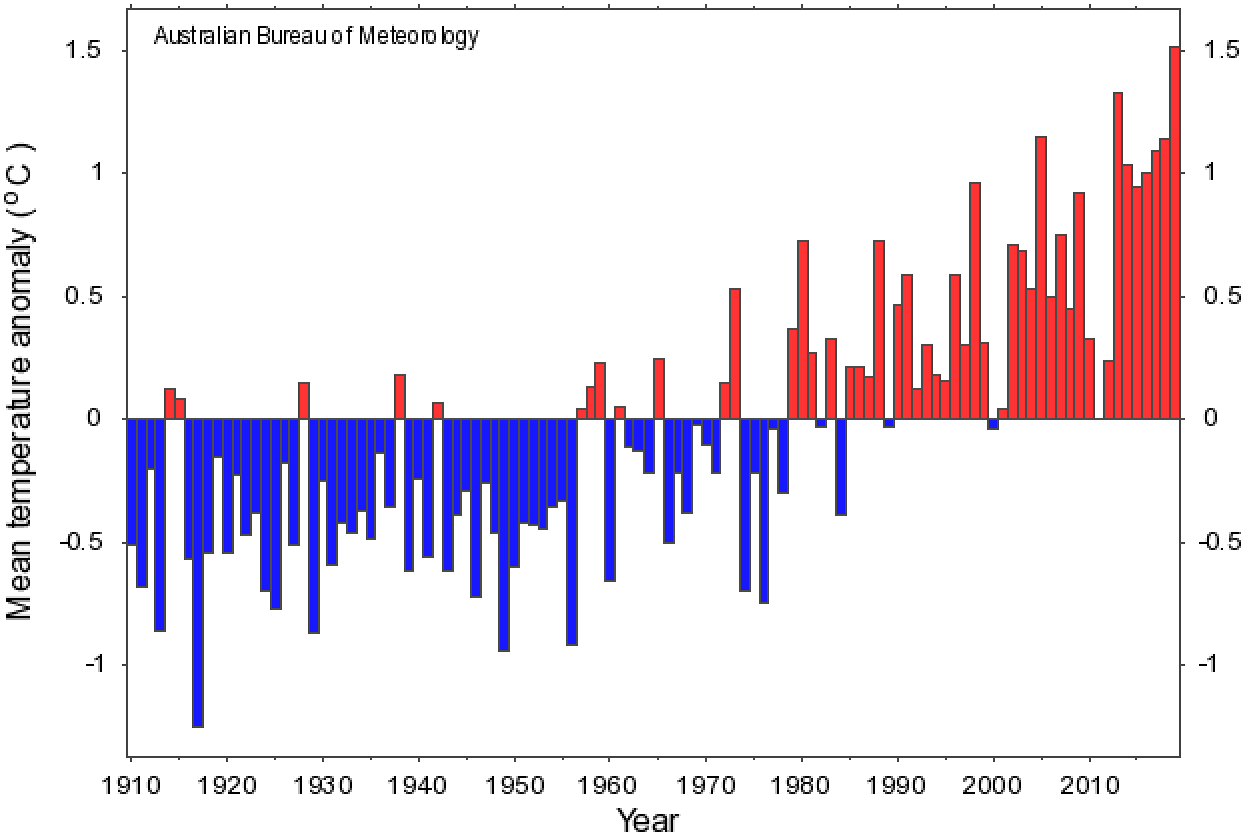
Purpose

This consultation is targeted at technical users of climate information who are involved in asset planning decisions. The ESCI team is looking for input into the design of data visualisations that will support risk analysis on extreme heat (noting that extreme heat has been identified as a priority electricity sector climate hazard).

Structure of the consultation

- State of the Australian Climate: review of the science and major trends of interest to the electricity sector
- Fundamentals of climate projection, limits of the science and sources of uncertainty
- Sample data products: consultation on preliminary output from the ESCI project

Australia has seen a consistent warming trend in the past 3 decades



- Warming of 1.1 °C since 1910
- Nine of the ten warmest years have occurred since 2004
- 2019 was the warmest, followed by 2013, 2005 and 2018

BoM (2020)

Ocean warming and melting glaciers have resulted in accelerating sea level rise

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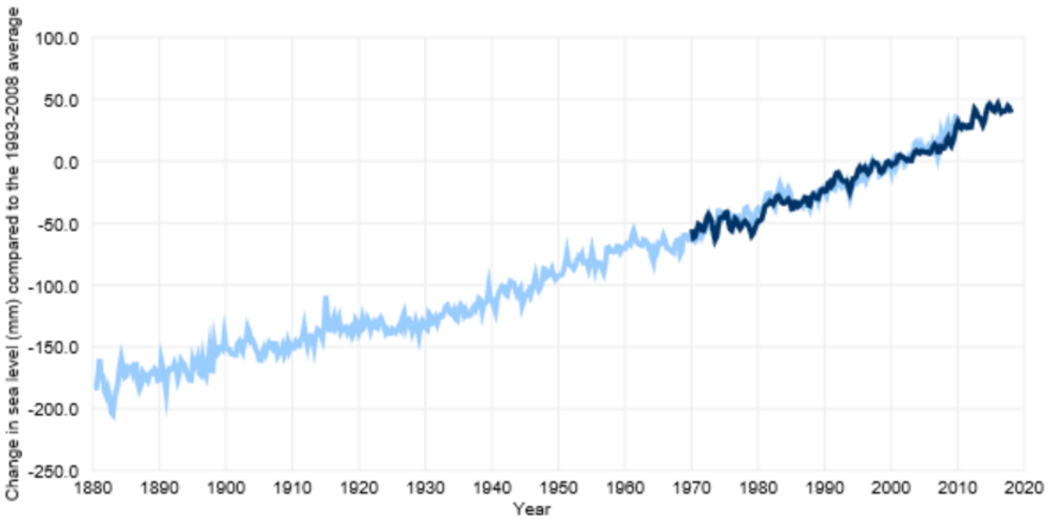
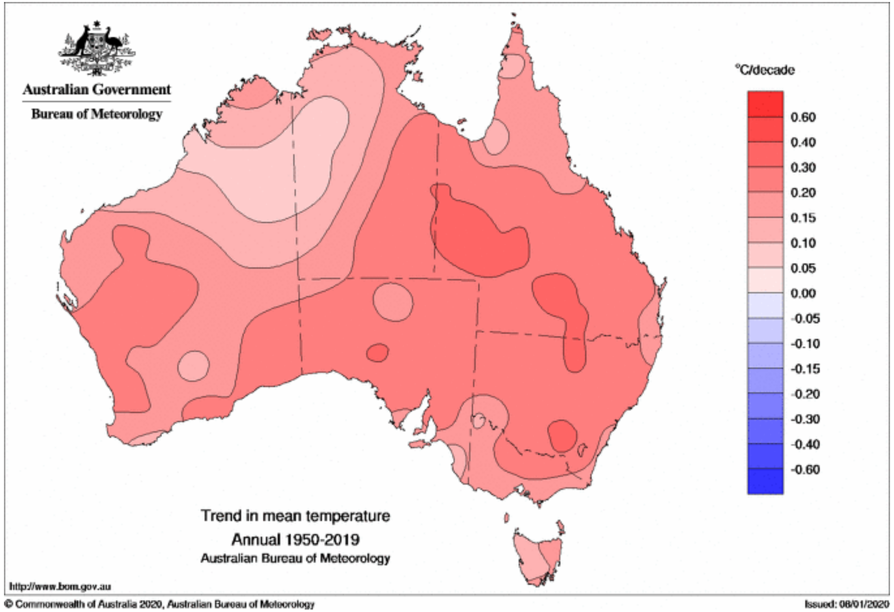
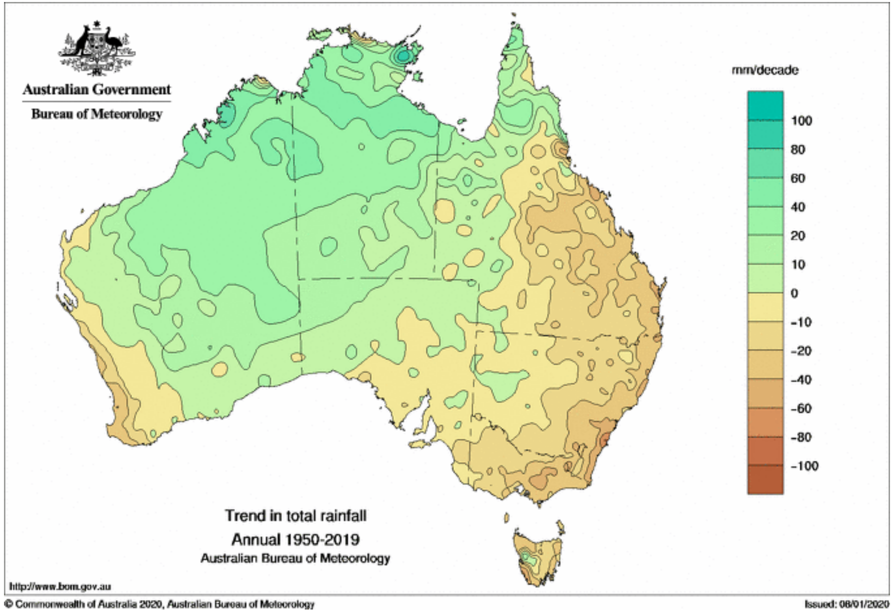


- Global average sea level rose:
  - 1902-2015, by 1.4 mm/year
  - 1971-2010, by 2.0 mm/year
  - 1993-2010, by 3.2 mm/year
  - 2006-2015, by 3.6 mm/year
- Since the early 1970s, glacier mass loss and ocean thermal expansion together explain about 75% of the observed sea level rise
- Ocean warming accounts for more than 90% of the energy accumulated in the climate system

Light blue line (Church and White, 2011).
Dark blue line, University of Hawaii Fast Delivery sea level data (NOAA, 2018).
Statistics: IPCC 2013 and 2019

Climate change in Australia differs by region





Greatest warming in the south and east, with more heat waves and fewer frosts

Less rain in the south and east, more rain in the north-west

BoM – Issued 08/01/2020

Extreme temperature and rainfall events are more common

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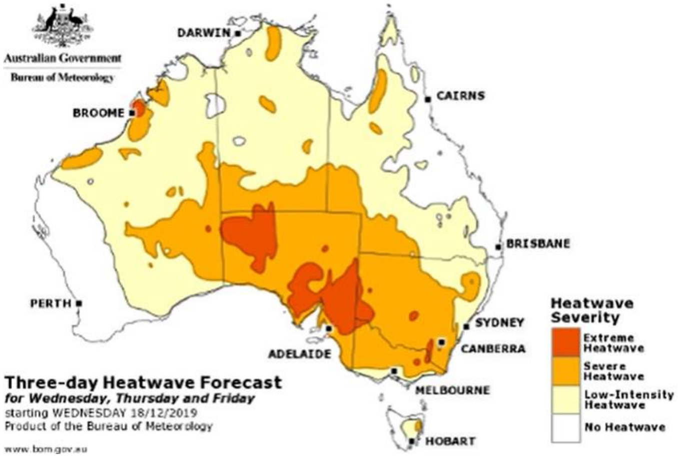
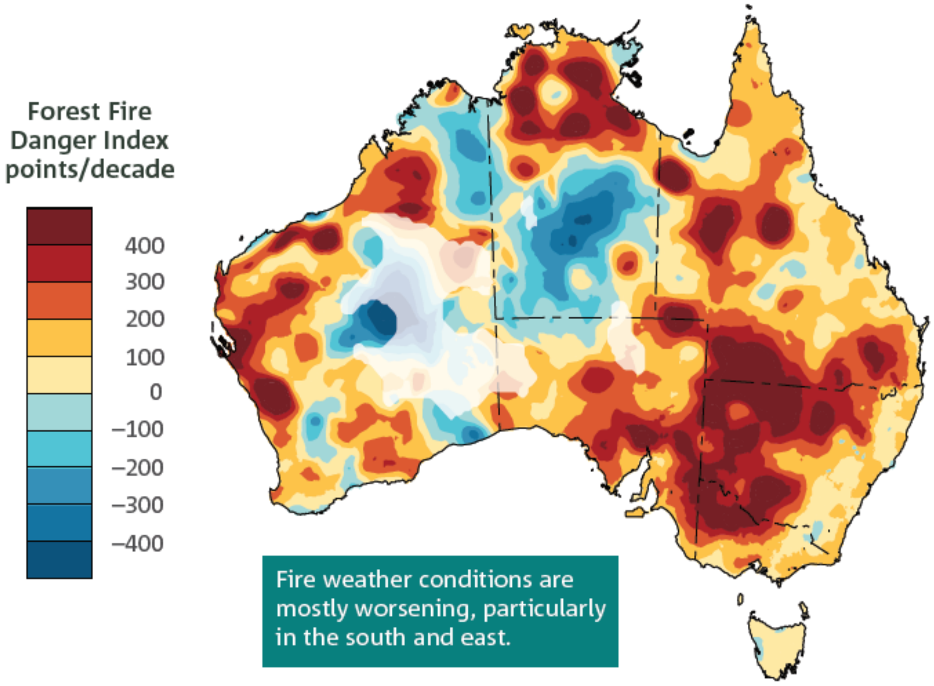


- Heatwaves have increased in duration, frequency and intensity in many regions.
- Very high monthly maximum or minimum temperatures now occur around 12 % of the time (2003–2017) compared with around 2 % of the time in the past (1951–1980)
- Decreases in heavy daily rainfall have tended to occur in southern and eastern Australia, with increases in the north.
- Heavy daily rainfall has accounted for an increased proportion of total annual rainfall since the 1970s

BoM & CSIRO (2018)

Fire season is becoming longer and more intense

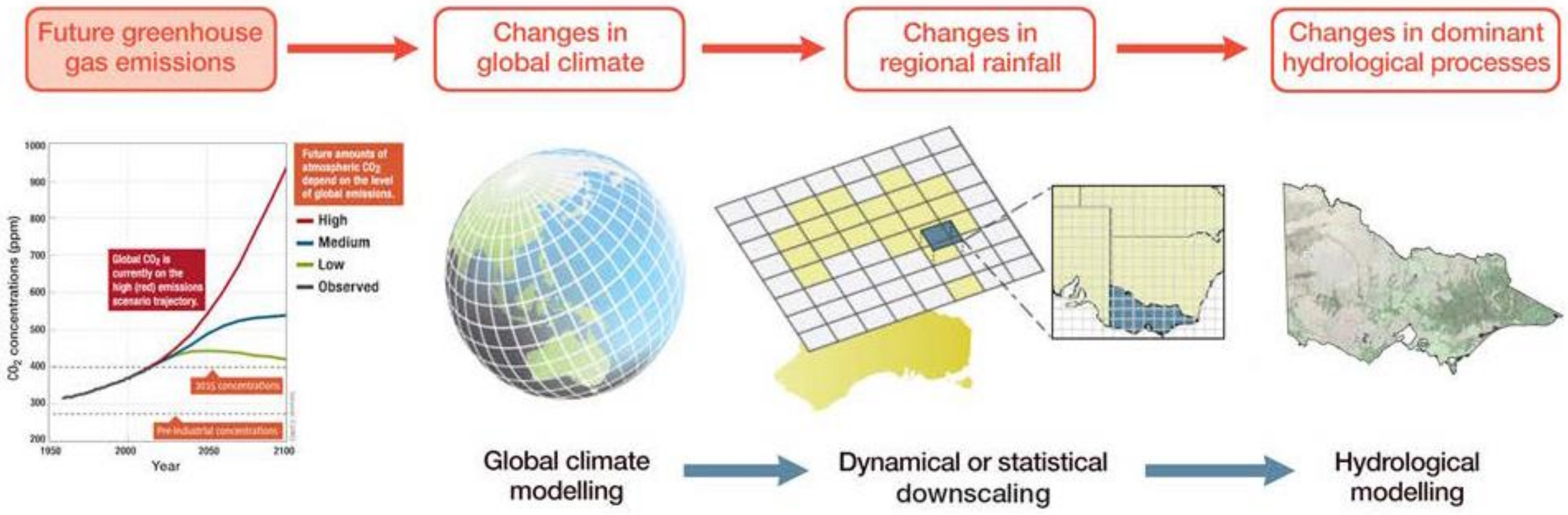


Trend from 1978 to 2017 in the annual sum of daily Forest Fire Danger Index – an indicator of the severity of fire weather conditions.

- Warmer and drier conditions have increased fire-weather risk
- Annual fire danger index increased across most of Australia since 1978
- Largest increases in spring and autumn
  - Longer fire season and greater overlap with Northern Hemisphere fire seasons
  - Shorter period for fuel-reduction burning
  - More resources needed for fire management

BoM and CSIRO (2018)

Fundamentals of climate projection – hydrology example



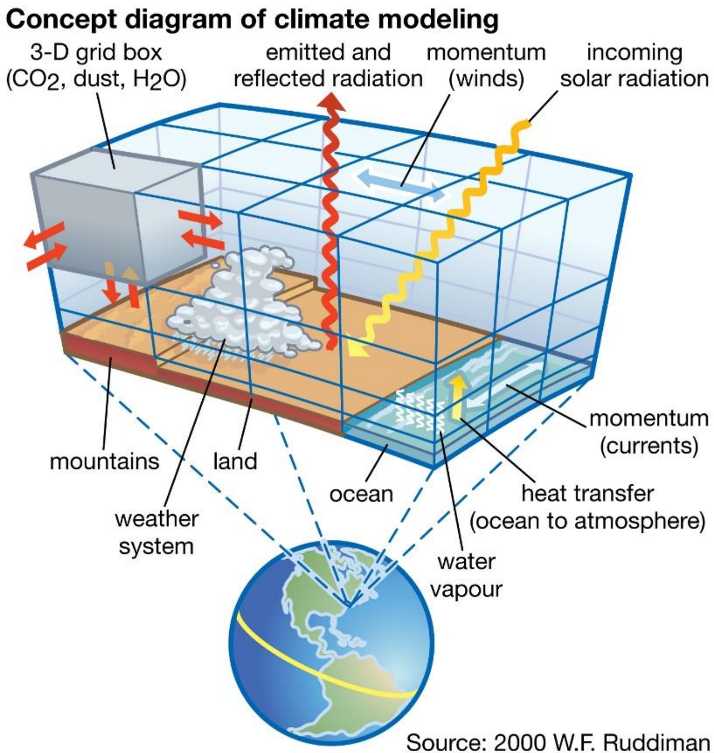
Climate projections require an assessment of future greenhouse gas emissions scenarios, defined by the IPCC, and are derived from global climate models using knowledge of the physical processes at work

Chiew et al, 2016

Global Climate Models have been highly successful at representing past and future weather

Projections of the future climate use up to 40 General Circulation Models (GCMs) to provide high time resolution information about the future climate. 8 GCMs have been identified which are particularly accurate in representing Australia.

- Mathematically represent physical processes over a three-dimensional grid of points across the globe, including the surface, oceans and atmosphere
- Calculations are made for hundreds of climate variables over thousands of grid-points, over hundreds of years
- The computer-intensive nature of this activity limits the horizontal resolution of most global climate models (GCMs) to about 100 km.
- Results match well with historical observations

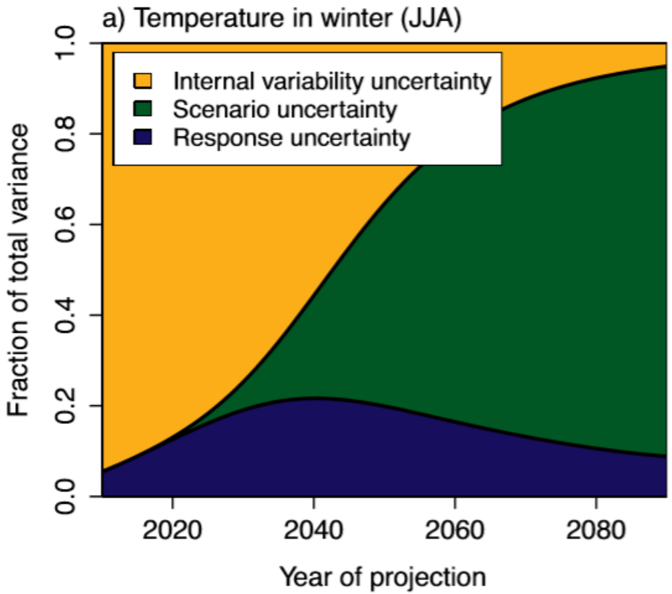


Source: 2000 W.F. Ruddiman

There are three main sources of uncertainty in regional climate projections

Three main sources of uncertainty

1. Natural climate variability
   - This includes short- and medium-term trends like weather and ENSO/IOD cycles.
2. Assumptions about future greenhouse gas and aerosol scenarios.
3. Regional climate responses to each scenario due to limitations in climate models.
   - Some variables, temperature for example have low response uncertainty, where models typically agree.
   - Other variables, including wind and precipitation have higher response uncertainty.



In the short-term, natural climate variability contributes the largest proportion of uncertainty; in the longer-term uncertainty is dominated by policy and societal trends. Regional climate modelling contributes the smallest fraction of uncertainty.

CSIRO and BoM (2015)

Assumptions about future climate behaviour depend on political and societal responses

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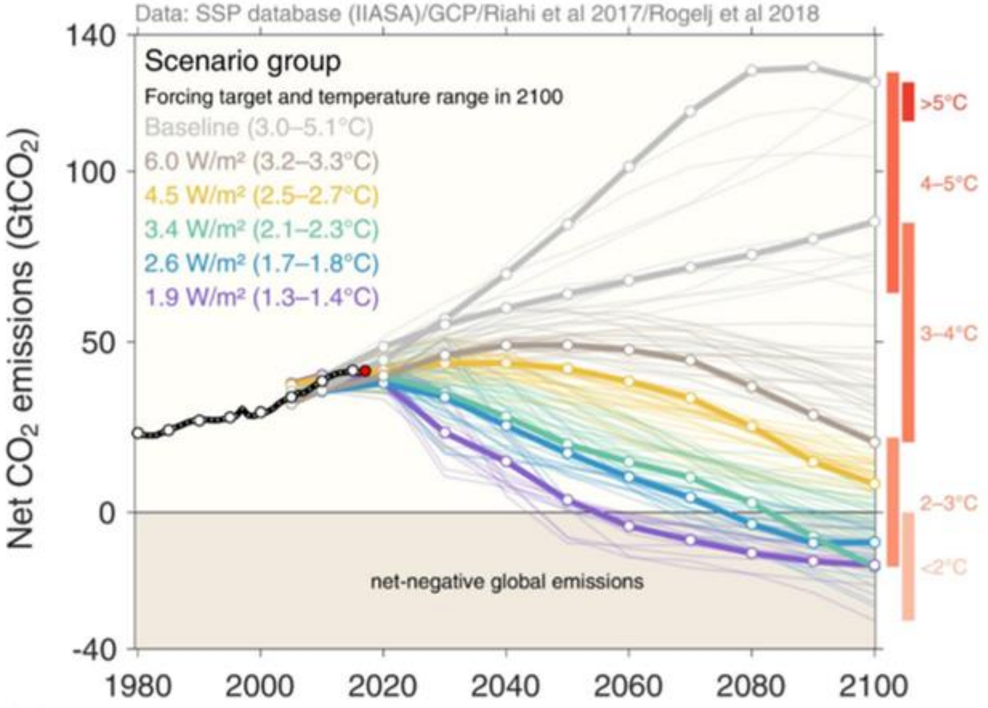
Estimates of greenhouse gas emissions for different scenarios

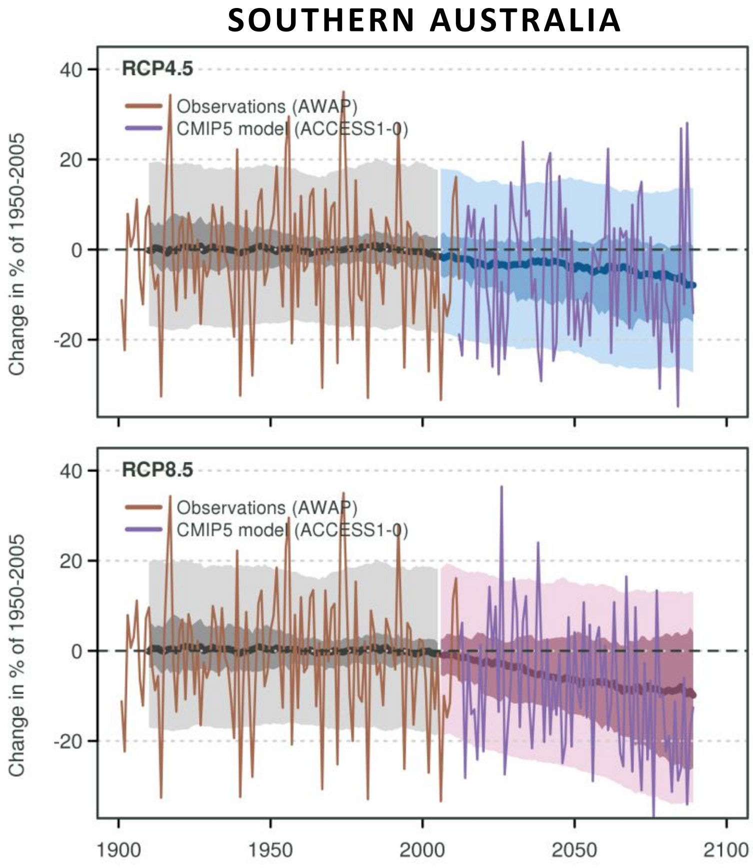


- RCP stands for 'Representative Concentration Pathway'
- The IPCC RCP scenarios range from very high (RCP8. 5) through to very low (RCP1.9) future concentrations
- Scenarios that avoid 2°C warming by 2100 need global CO_2 emissions to decline rapidly towards net negative global emissions after 2050
- **Data in the consultation uses RCP 8.5 as a basis for modelling, this is the IPCC recommended baseline**

The relative impact of natural climate variability can be seen in time series data

South Australian example of rainfall variability from year to year, superimposed on a climate change trend.

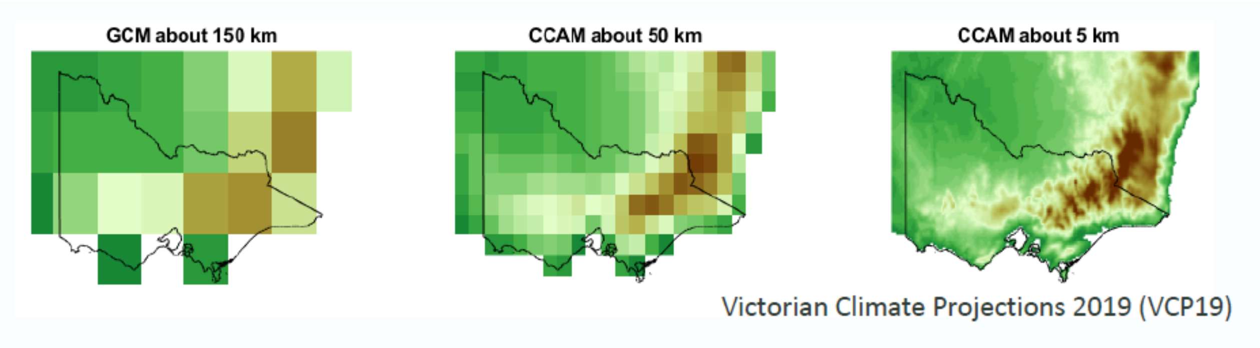
Two different future greenhouse gas scenarios have been selected to show the impact on the trend: RCP 8.5 is the IPCC baseline and best represents current trends.



CSIRO and BoM (2015)

Regional Climate modelling is relatively accurate, and provides additional information

Dynamical downscaling example



Higher resolution projections can be obtained from the GCMs through downscaling

- Statistical interpolation of boundary conditions can quickly provide localised data
- Running specialised models at high resolution can add value in complex areas of particular interest, e.g. mountains, coastal areas.

The ESCI Project will provide a framework for using tailored climate information for risk-based decision-making in the electricity sector

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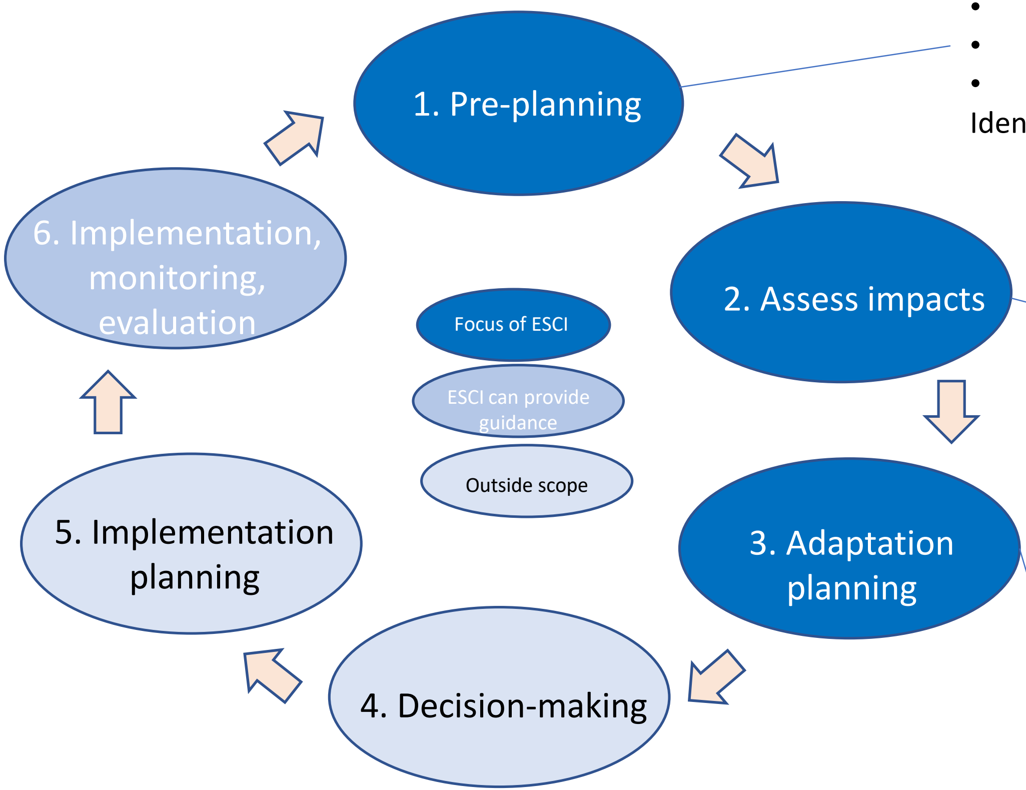
Draft Climate-Risk Assessment Framework



Understand decision-making processes:

- Operating risk
- Reliability
- Investment risk

Identify vulnerabilities

Focus of today's consultation

Use tailored climate information to scan for and quantify physical impact:

1. Time series of key climate variables driving supply and demand
2. Compound/ extreme weather scenarios to stress test the system
3. Changes in the probability of exceedance of key variables by region over time

- Generate adaptation pathways
- Quantify and evaluate against objectives
- Identify system changes needed

Previous ESCI work has identified priority electricity sector vulnerabilities

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Focus of today's consultation

- Temperature (average, maximum & heatwave)
  - Generator and network capacities, rates of deterioration and failure rates
  - Customer demand for cooling load
- Bushfire
  - Threat to all assets, with particular smoke impacts on transmission lines
  - Design specifications
- Wind (average and gust)
  - Wind generation output and design
  - Network capacity, design specifications and failure rates

Risk frameworks will also provide guidance on risk assessment for other vulnerabilities.
E.g. coastal inundation, extreme precipitation events & flooding.

Sample spatial visualisations of climate information. Days over threshold for history & 4 climate models.

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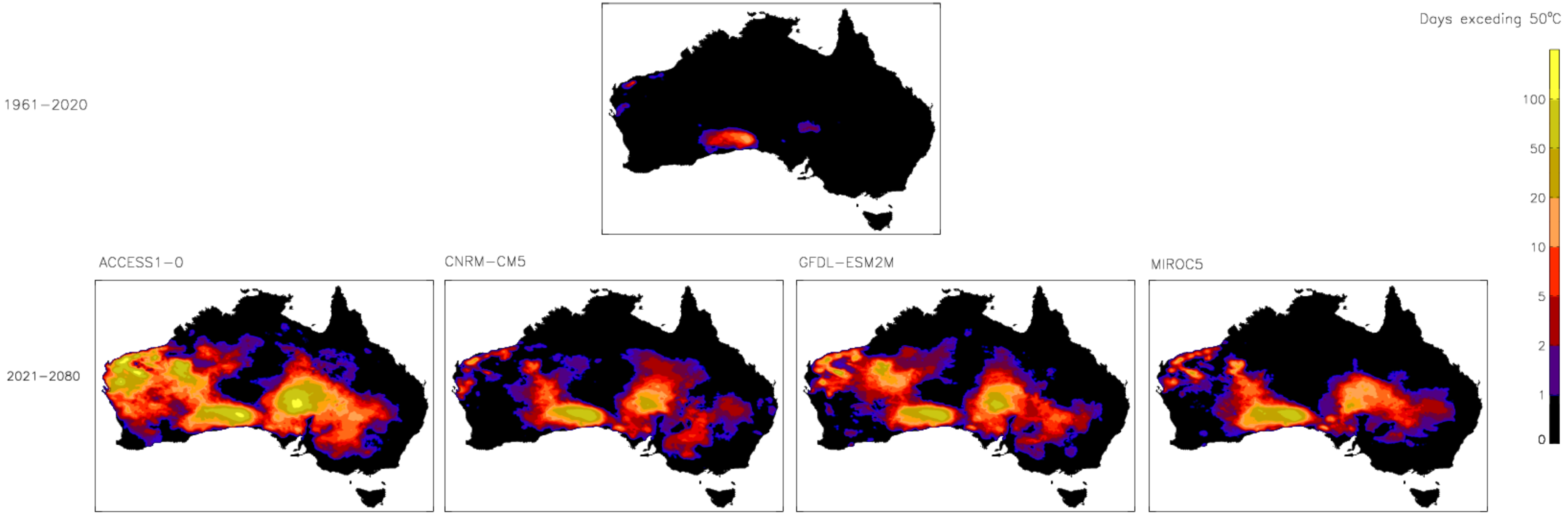

Climate models represent response uncertainty

Sample spatial visualisations of climate information.
1 in 10 year return temperature for history and 4 climate models

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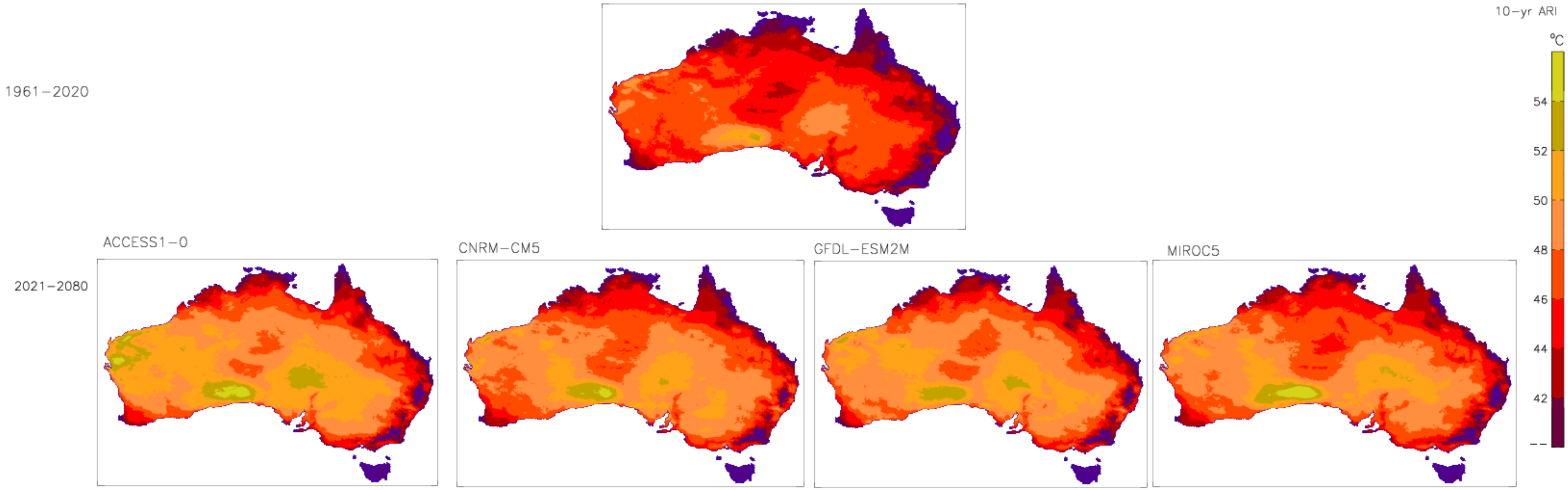

Climate models represent response uncertainty

Sample spatial visualisations of climate information. Temperature over thresholds – single climate model

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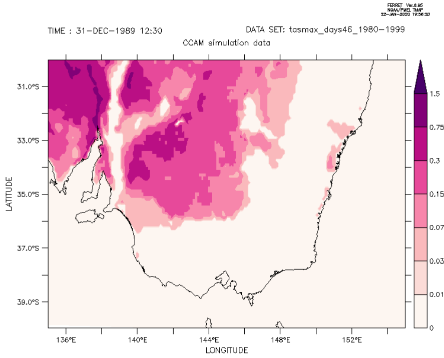
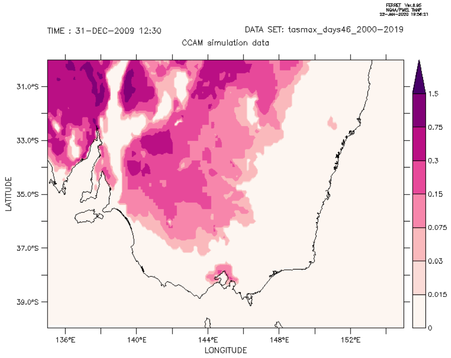
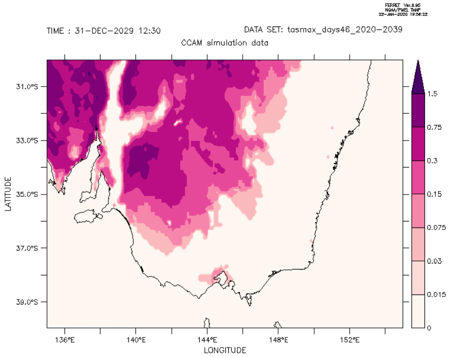


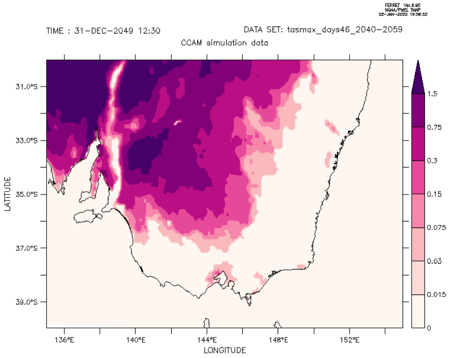
Days per year exceeding 46 C for 1980 to 1999



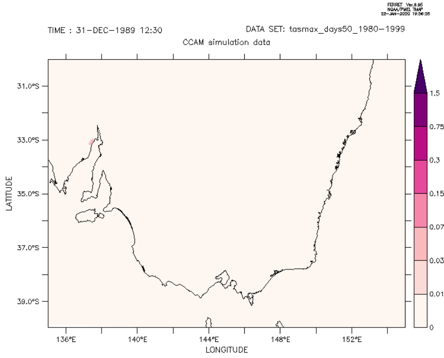
Days per year exceeding 46 C for 2000 to 2019



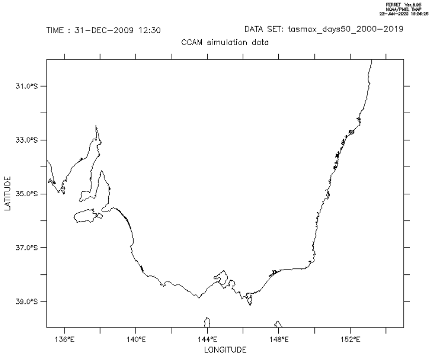
Days per year exceeding 46 C for 2020 to 2039



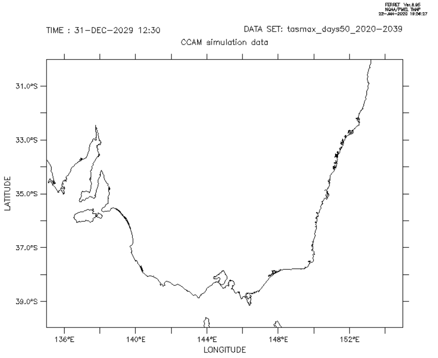
Days per year exceeding 46 C for 2040 to 2059



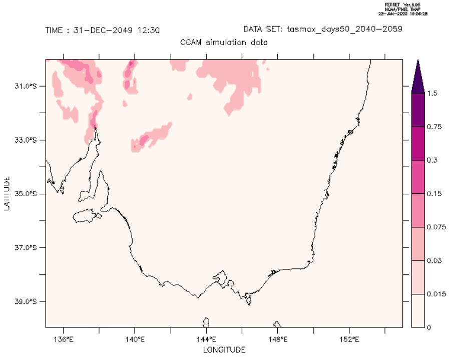
Days per year exceeding 50 C for 1980 to 1999



Days per year exceeding 50 C for 2000 to 2019



Days per year exceeding 50 C for 2020 to 2039



Days per year exceeding 50 C for 2040 to 2059

Sample spatial visualisations of climate information.
1 in 20 year return temperature – single climate model

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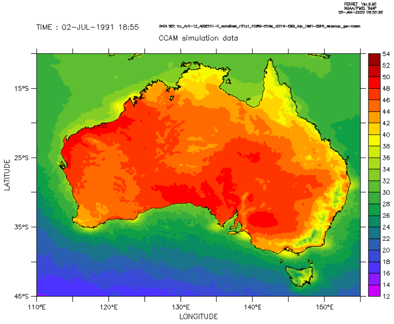
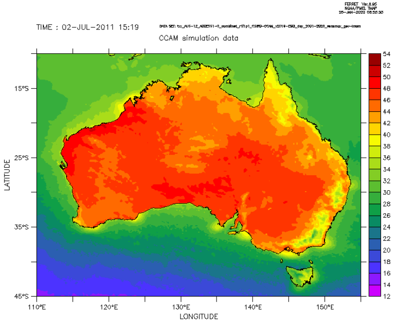
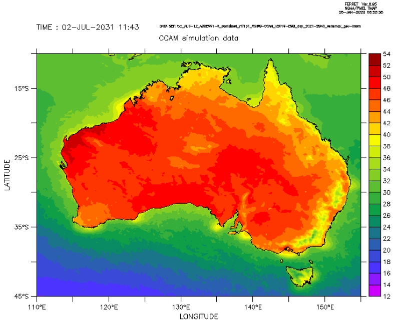


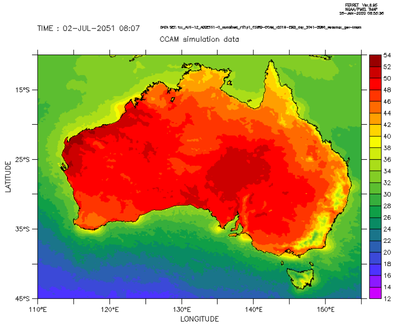
1-in-20 ARI for 1981 to 2000



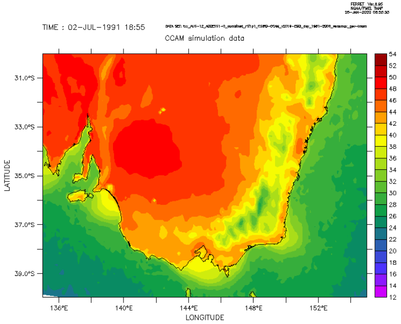
1-in-20 ARI for 2001 to 2020



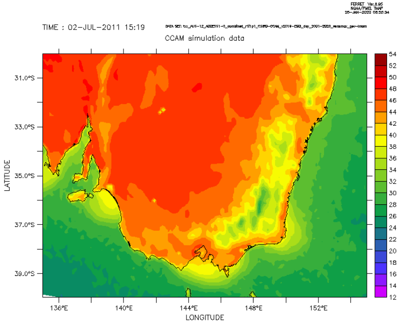
1-in-20 ARI for 2021 to 2040



1-in-20 ARI for 2041 to 2060



1-in-20 ARI for 1981 to 2000



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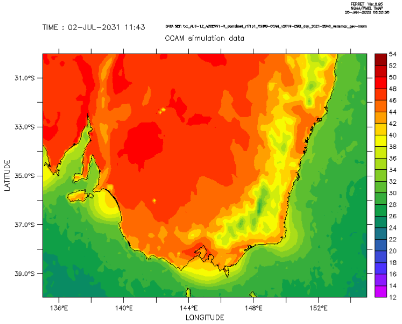
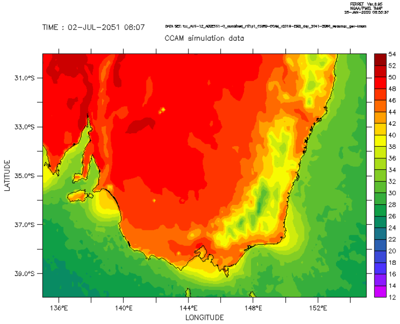


1-in-20 ARI for 2021 to 2040



1-in-20 ARI for 2041 to 2060

Sample temporal visualisations of climate information for a single location

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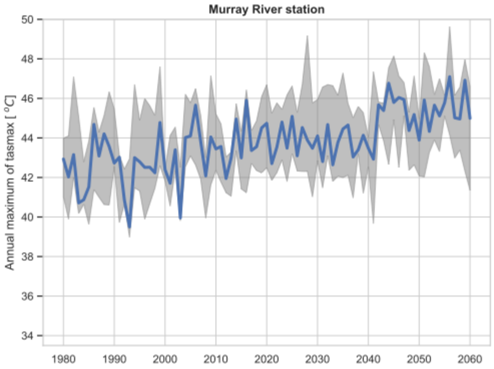
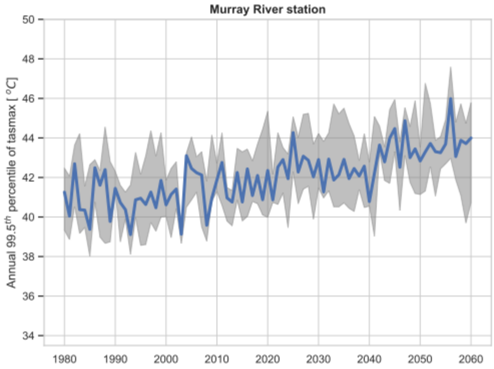
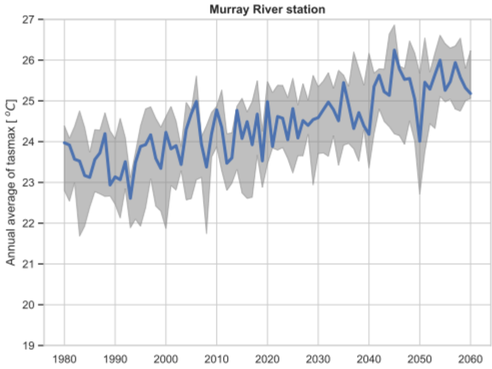


Annual maximum temperature

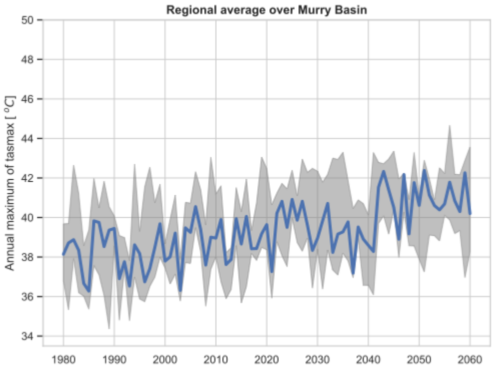


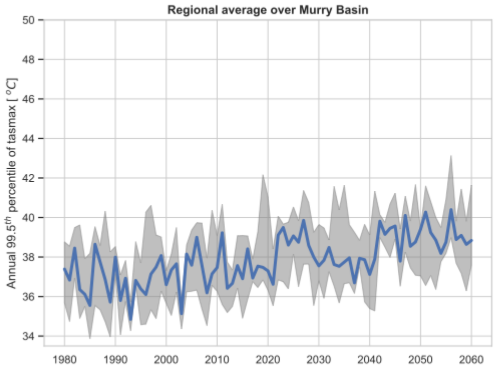
Annual 99.5th pctl daily max

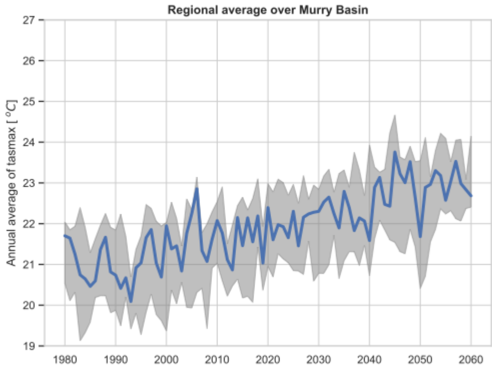


Annual average daily max

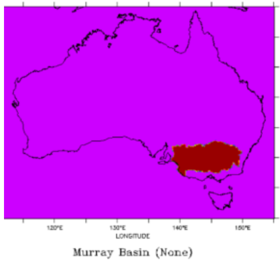
Murray River
(Red Cliffs Substation)







Murray Basin
Region



Sample temporal visualisations of climate information for a single location

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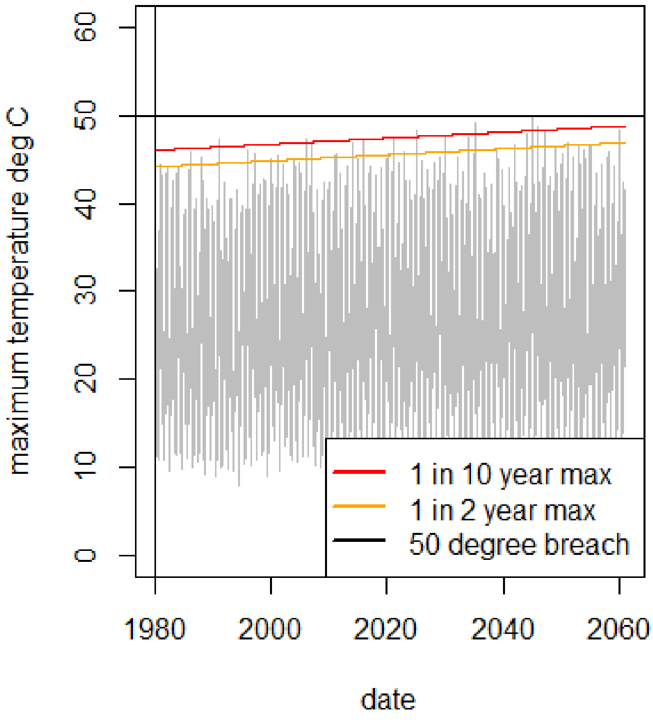

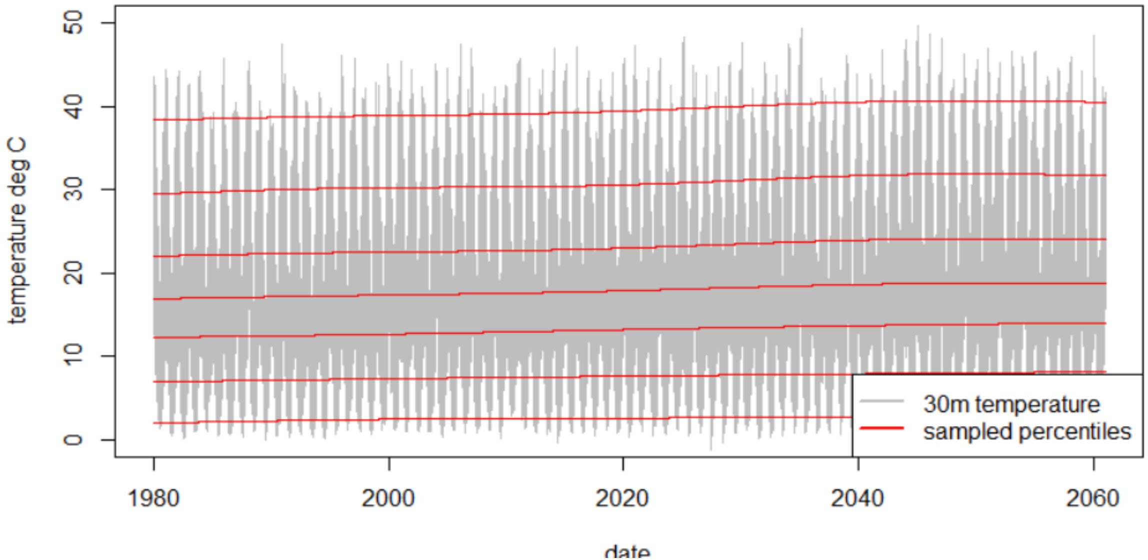

Consultation questions

- What applications could you/ would you use this information for?
- What specifications would be more useful?
    - Are spatial and/or time-series formats more useful?
    - Which locations are most of interest?
    - Are there thresholds or return periods that are particularly relevant?
- How would you prefer to access the data, and which formats would be most desirable?
- What guidance and support would your organisation require to effectively use this information?