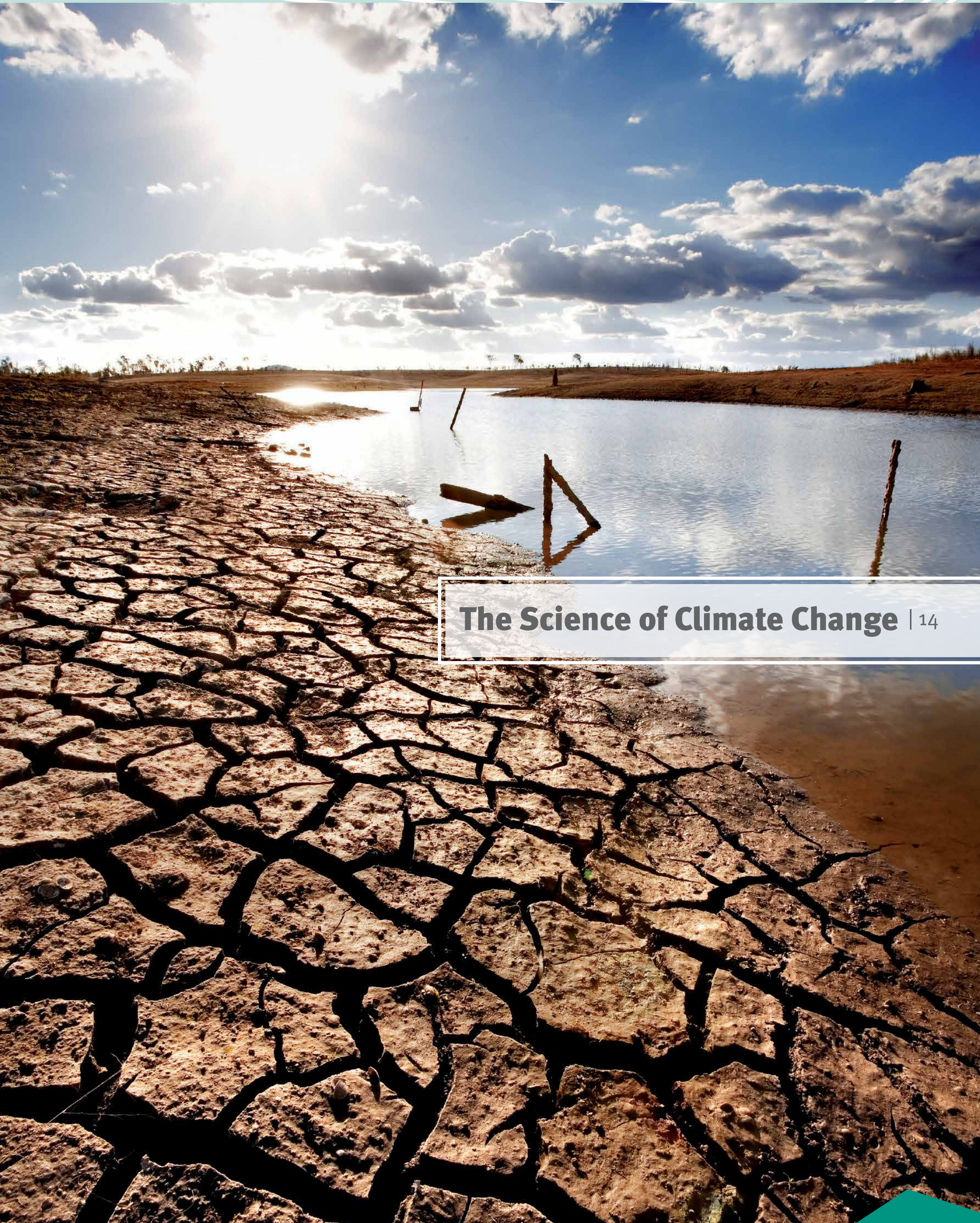


The Science of Climate Change | 14

Queensland Government

The science of climate change

This section summarises the basic science of climate change using published scientific literature, in particular the most recent Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report [8] and Climate Change in Australia – Information for Australia's Natural Resource Management Regions: Technical Report by CSIRO and the Bureau of Meteorology (BoM) [9]. While the IPCC synthesises global scientific knowledge on climate change periodically and informs climate change actions and polices worldwide, the CSIRO and BoM technical report specifically focuses on climate change around Australia, so underpinning Australia's climate change planning and actions.

What is climate change and sea-level rise?

Climate and sea levels change over time scales from decades to millions of years, in response to solar variations, changes in the Earth's orbit around the sun, volcanic eruptions, movement of the continents, and natural variability such as the El Niño-Southern Oscillation, Indian Ocean Dipole and the longer term Interdecadal Pacific Oscillation. However, since the start of the Industrial Revolution, humans have had increased influence because their activities add significantly to greenhouse gases (e.g. carbon dioxide, methane, nitrous oxide, and synthetic gases etc.) in the atmosphere (Figure 3). Greenhouse gases are transparent to much of the radiation from the sun, and allow it to pass through the atmosphere to warm the Earth. As outgoing radiation from the Earth is mainly in wavelengths that are absorbed by the greenhouse gases, some of that energy is captured and re-radiated back, warming the atmosphere and the Earth's surface. This is known as the greenhouse effect, and contributes towards global warming and other effects on our climate, such as changes in rainfall distribution and storm intensity.

Around 93 per cent of the additional heat created by global warming has so far been absorbed into the oceans. As water warms, it expands. This expansion has been the major cause of sea-level rise, with a smaller contribution from land-based glacier and ice sheet melt. In the 20th century, global average sea levels increased by 19 cm, and are currently rising by 3.2 mm/year. Over time, the contribution from ice melting is expected to increase substantially.

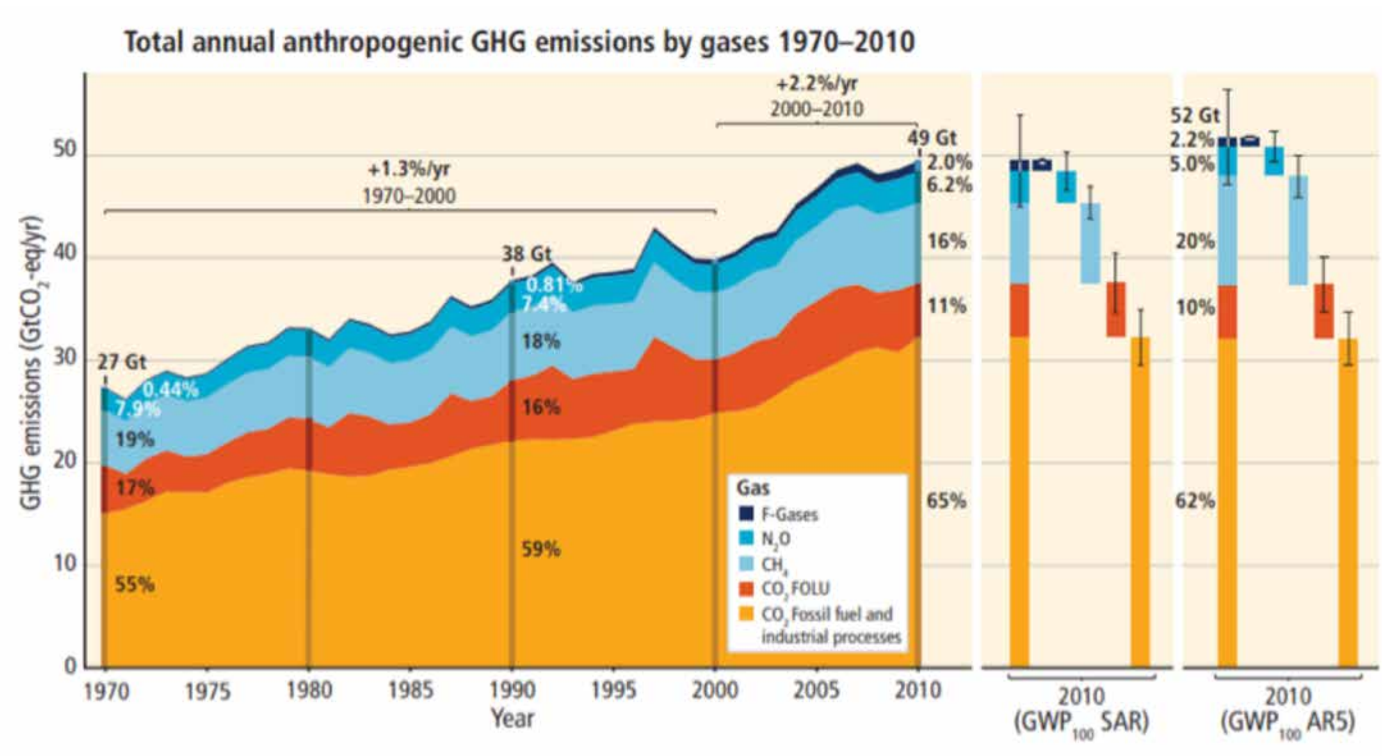


Figure 5: Total annual anthropogenic GHG emissions. Explanatory note (Gas types) - CO2 from forestry and other land use (FOLU); methane (CH4); nitrous oxide (N2O); fluorinated gases covered under the Kyoto Protocol (F-gases). Right side of the figure shows the associated uncertainties (90% confidence interval) indicated by the error bars [8].

Some of the additional carbon dioxide in the atmosphere (around 30–40 per cent) dissolves into the oceans, where it decreases the alkalinity of the water (an effect known as ocean acidification). This has the potential to make it more difficult for some organisms such as shellfish and plankton to form calcium carbonate, the material used for making shells and coral reefs. There are potentially knock-on effects for marine food chains, and for tourism and fishing industries [10].The effect is at present slight, but will increase in the future unless action is taken to reduce carbon dioxide emissions.

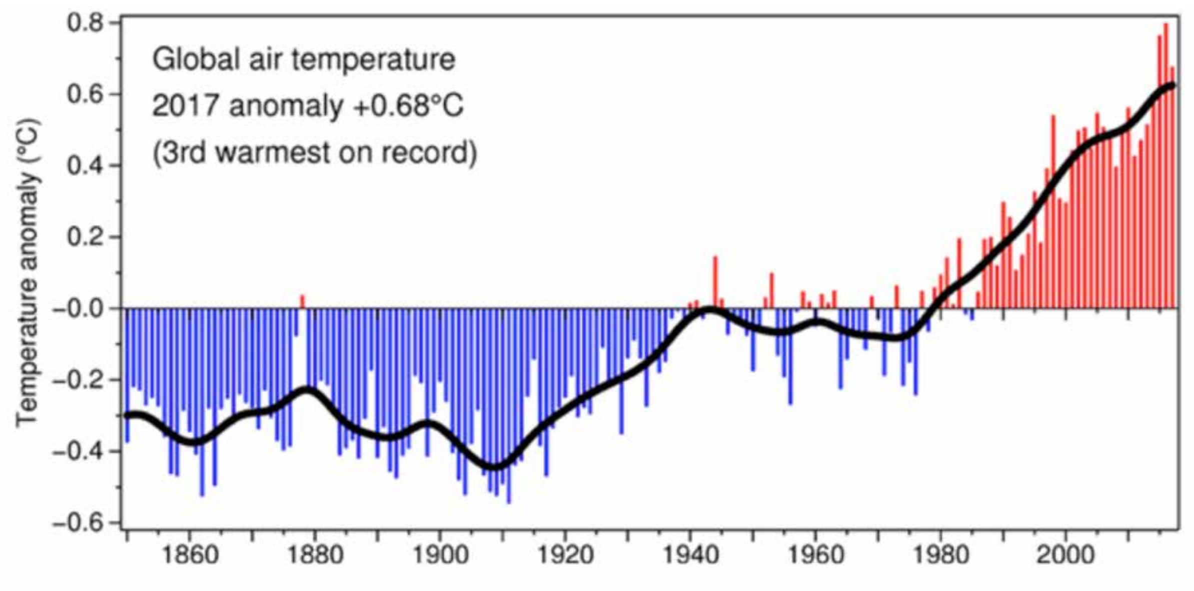


Figure 6: Global land and sea surface temperature record from 1850 to 2017,© Climatic Research Unit 2018: http://www.cru.uea.ac.uk (accessed 14 March 2018).

Recent climate change

Temperature observations from around the world, including satellite observations, can be used to understand how global warming is affecting temperatures. Figure 4 shows the global long-term trend, constructed by averaging from all records over the land and sea (sea surface temperatures are measured by ships and, more recently, by satellite). The temperature has risen by about 1°C since the start of records in 1850.

Future climate change projections

To understand what the changes are likely to be in our climate as a result of increased greenhouse gas concentrations, three-dimensional climate models, or General Circulation Models (GCMs) are used. GCMs are computer-based simulations of the Earth-Ocean-Atmosphere System. The laws of physics and chemistry that explain how the climate functions have been well understood for a very long time, and in GCMs, these are represented mathematically. By changing the greenhouse gas concentrations in these GCMs, future climate change scenarios can be constructed. However, it is important to recognise that these scenarios are not predictions—they are simply ‘plausible futures’. Some climate variables are better simulated by GCMs than others, so we can be more confident about some variables, such as sea-level rise and temperature, and less confident about others, such as wind and rainfall [11].

Climate change projections and scenarios

Uncertainties exist in GCM outputs due to factors such as natural variability, how we will live in the future, and the future energy mix of global and local economies (e.g. fossil fuels vs renewables). Therefore, scientists use 'scenarios' to describe future climate, and these underpin impacts analysis, adaptation planning and community engagement. A climate change scenario is a coherent, internally consistent and plausible description of a possible future climate state. It is a quantitative representation constructed from climate model data.

In its Fifth Assessment Report [8] in 2014, the IPCC used Representative Concentration Pathways (RCP) as a basis for building future climate scenarios. RCPs are future greenhouse gas concentration trajectories that are used for running GCMs. There are four RCPs, each designated by a number indicating how much we expect the Earth's energy balance will increase (in watts per square metre of the Earth's surface), with consequential increases in the average global temperature. By the end of the century, the most severe is RCP8.5, and the least severe is RCP2.6. Only in the RCP8.5 pathway do emissions of greenhouse gases continue to rise until 2100 (Figure 5). To achieve the other three pathways, emissions must be reduced, and to achieve the 2.6 pathway, emissions must start to reduce now. Over the past 15–20 years, global emissions have most closely tracked the RCP8.5 pathway [8, 12, 13].

The choice of scenario for understanding future risks to the emergency management sector will depend on a number of factors, such as the timeframe of the risk assessment (e.g. short, medium and long term) and the criticality of the asset / system under consideration. As an example, for understanding short- to medium-term risks to a hospital (high criticality) at the early stage of planning, a risk-averse approach might be used by selecting a high greenhouse gas concentration scenario (RCP8.5) [14]. In addition, changes to the climate out to years 2030–2040 are driven almost entirely by greenhouse gases that have already been emitted. Thus, choice of RCP makes little or no difference in the short term.

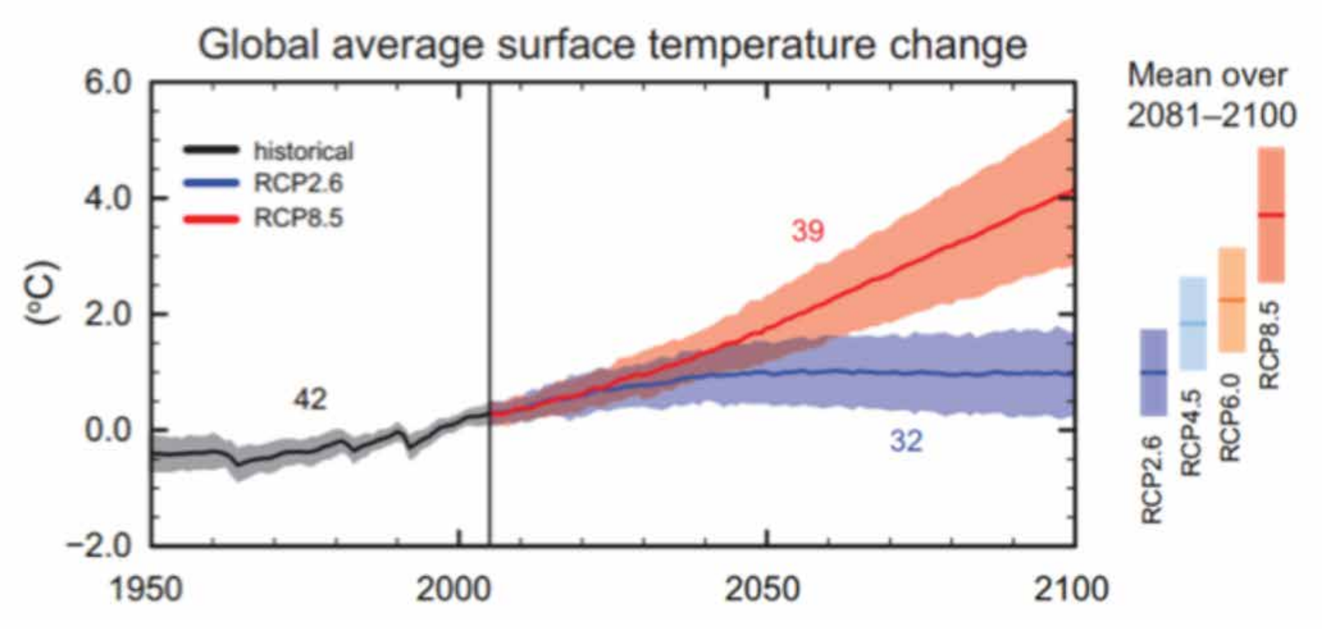
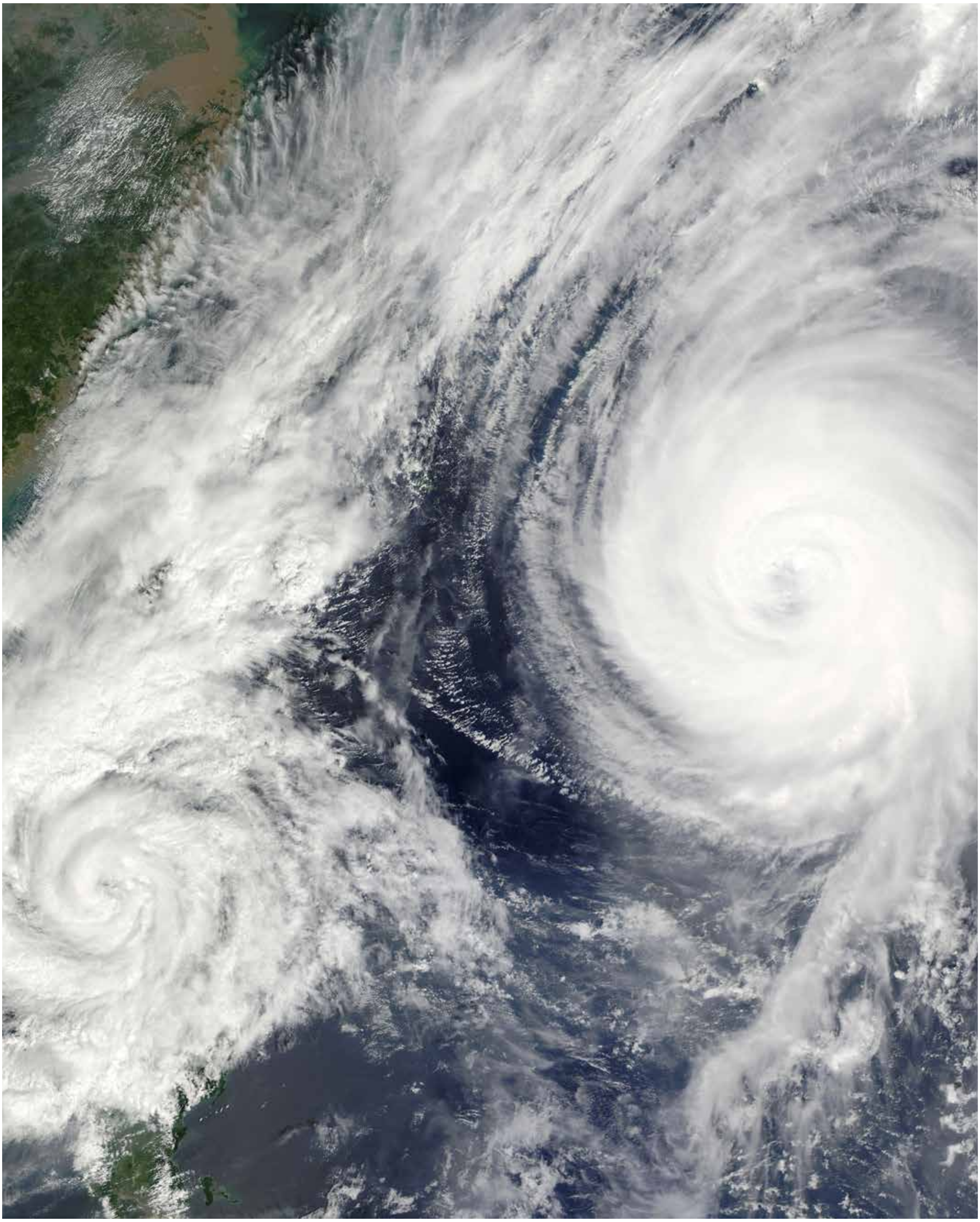


Figure 7: Change in global annual mean surface temperature relative to 1986–2005. The mean and associated uncertainties averaged over 2081–2100 are given for all RCP scenarios as coloured vertical bars [8].

The implications for emergency management of the variation in climate projections include that risk management strategies must be developed for dealing with events with potentially high impacts on the delivery of sector services, even if their probability of occurrence is low [15]. This approach is the most suitable in attempting to increase the capacity of the emergency management sector and increase the resilience of communities when faced with uncertain and complex circumstances.



Summary of current knowledge on climate change in Queensland

Overview of potential future climate change in Queensland

Increased temperature and heatwaves

The annual median temperature of Queensland is projected to increase by 1.4°C under lower emissions and 1.9°C under high emissions by 2050. There is high level of certainty of increased frequency and intensity of heatwaves, with more extremely hot days and fewer extremely cool days [9, 16, 17] (Figure 6).

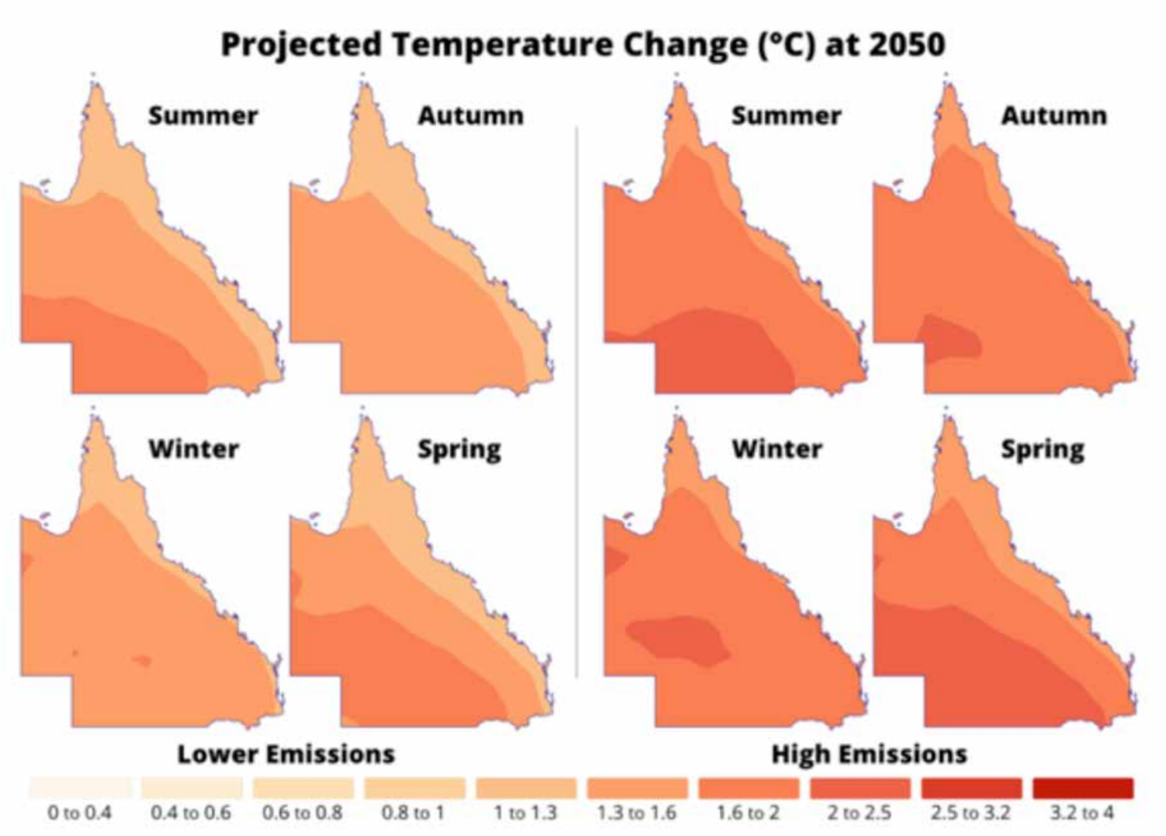


Figure 8: Temperature projection for Queensland for 2050 under lower emission (RCP 4.5) and higher emission (RCP8.5) scenarios.

Source: The Climate Change in Queensland map application tool (http://qgsp.maps.arcgis.com/apps/MapJournal/index.html?appid=1f3c05235c6a44dcb1a6faebad4683fc)

Fire danger

There is strong evidence that Queensland will experience an increased frequency of high fire risk days, with uncertainty about the magnitude of change [17–21].

Rainfall events

In general, Queensland can expect longer dry periods interrupted by more intense rainfall events (Figure 7). Some research suggests extreme El Nino and La Nina events may become more frequent [22, 23]. There is high level of agreement that some areas of Queensland will become drier (especially in winter and spring), and some areas will be likely to experience intensified rainfall events. These intense rainfall events will increase the risk of flooding, but uncertainty remains over which areas will be affected and the impact extent [9, 24, 25].

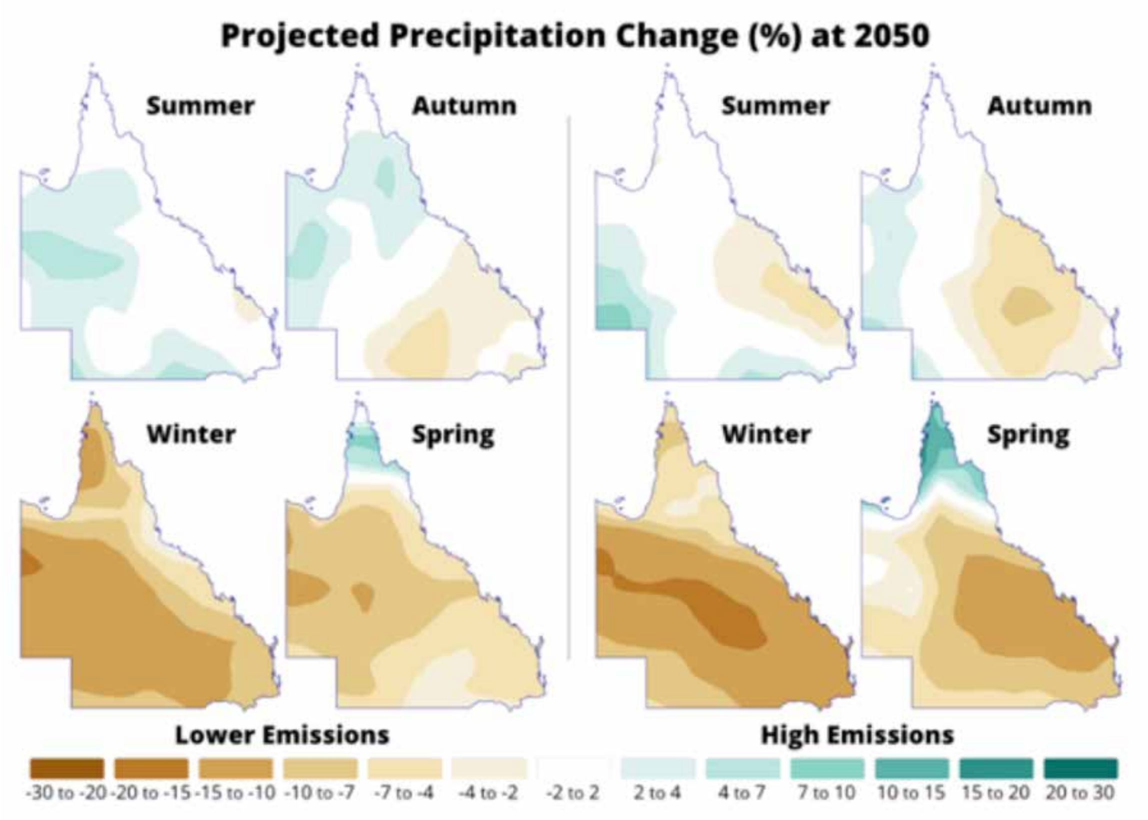


Figure 9: Rainfall projections for Queensland for 2050 under lower emission (RCP 4.5) and higher emission (RCP8.5) scenarios. Source The Climate Change in Queensland map application tool (http://qgsp.maps.arcgis.com/apps/MapJournal/index.html?appid=1f3c05235c6a44dcb1a6faebad4683fc)

Rising sea levels and increased storm surge events

There is a high level of certainty of sea-level rise resulting from thermal expansion of the ocean, but the rate and extent of additional sea-level rise caused by ice melt remains uncertain [16, 26]. Along the Queensland coast, sea level is expected to rise 13cm by 2030 (the model range is 8–18cm), and 65cm by 2090 (the model range is 45–87cm) under the high emission scenario [9, 26, 27]. The upper limit could be higher if rates of ice sheet melt are higher than currently modelled. A rise in sea level is likely to increase inundation of low-lying areas and erosion of soft shores.

Tropical cyclones

Uncertainty remains over the influence of climate change on the location, frequency and severity of tropical cyclones in Queensland. However, model projections show a future decrease in the number of tropical cyclones globally, but with an increase in the proportion of high intensity tropical cyclones.[21, 37-39].

Available scientific information to assess climate change risks

Climate change and sea-level rise projections play a crucial role in understanding future risks to Queensland communities. These projections are developed by climate scientists and available in different formats and variable levels of detail. A number of governments and scientific organisations deliver future hazard information at a high level, suitable for using in policy-making and strategic management decisions. Table 1 shows a list of the key scientific and government bodies providing knowledge and data of future hazards for Queensland, including climate change and sea-level rise projections.

Table 1: Sources of future hazard information for Queensland

Type of hazard/ climate variable	Source of information	Type of information that is available	Climate change scenarios and time frame of data	Potential application in emergency management
Mean Climate, Heatwaves, Extreme Indices, Droughts and Floods	Queensland Future Climate Dashboard https://www.longpaddock.qld.gov.au/ (to be updated in the near future)	Provides regional climate change summaries for a range of different regions and metrics	RCP 8.5 for year 2030, 2050, 2070 and 2090 across seasons with 10 km of spatial resolution	Suitable for getting detailed future climate change information at regional levels e.g. disaster management districts and Local Government areas of Queensland.
Heat wave, excessive rainfall, drought, coastal inundation	Climate Change in Australia website http://www.climatechangeinaustralia.gov.au/climatechangeinaustralia.gov.au/	Provides general information about climate change as well as regional summaries for 5 climate sub clusters roughly aligned with NRM regions for 14 climate variables based on global coarse resolution climate models (~200 km). It also provides comprehensive technical data and information to provide projections or inform decision-making.	4 RCP and 3 SRES scenarios at 5-year intervals from 2025 to 2090; monthly, 3-monthly, 6-monthly and annual changes	Can be used for obtaining an overview of future climate at a broad scale (Natural Resource Management Regions).
Information on impacts and adaptation in for coastal areas.	CoastAdapt (NCCARF) https://coastadapt.com.au/	The program provides a number of technical and adaptation guidelines for the coastal context.	Summary of mean climate based on Climate Change in Australia website http://www.climatechangeinaustralia.gov.au/	Suitable for getting an overview of impacts and adaptation in for coastal areas.
Coastal erosion and inundation	Department of Environment and Science https://www.ehp.qld.gov.au/coastalplan/coastalhazards.html#erosion_prone_area_maps	Coastal hazard area maps indicate the footprint of the inundation from a defined storm event or storm tide event with a 1% (or one-in-100 year) annual return probability and declared erosion prone areas	It considers state wide 0.8m rise of sea level by 2100	Suitable for identifying hazard prone coastal areas

*SRES (special report on emissions scenarios) are emission scenarios developed by Nakicenovic and Swart (2000) [31] and used as a basis for some of the climate projections in earlier IPCC assessment reports (up to AR4 in 2010). SRES start with socioeconomic circumstances from which emissions trajectories and climate impacts are projected into the future.