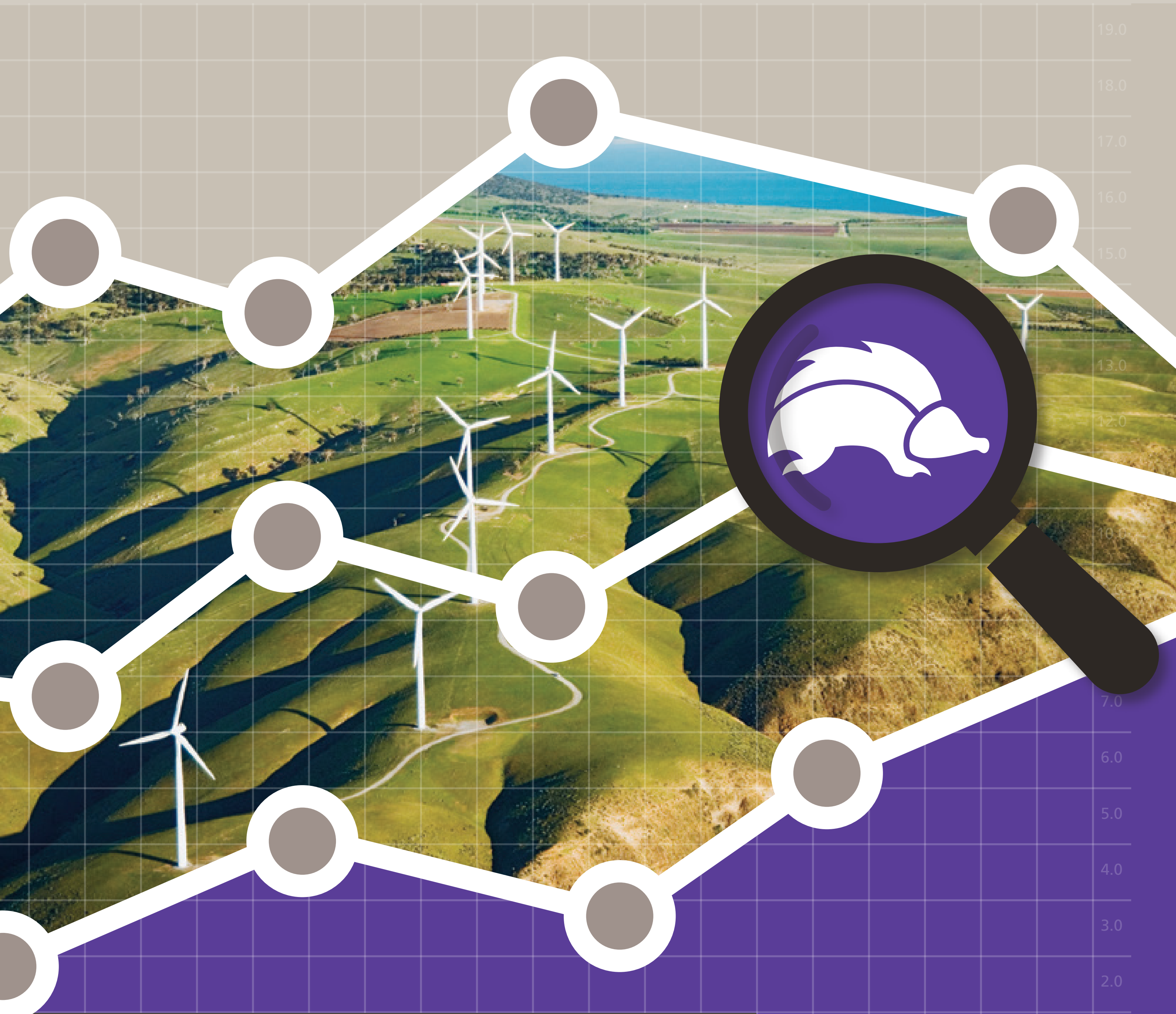
Climate change AND climate variability

Understanding and effectively communicating the basics



Government of South Australia
Adelaide and Mount Lofty Ranges
Natural Resources Management Board

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Contents

Cover image: Established in 2003, the Starfish Hill windfarm is located near Cape Jervis (within the Adelaide and Mount Lofty Ranges region) and is South Australia's first ever windfarm.

Key points

Climate science

- Life as we know it depends on the presence of greenhouse gases (GHG) such as carbon dioxide – without them the Earth's average climate would be around 33°C cooler.
- Since the industrial revolution human activities such as burning fossil fuels, agriculture and land clearing have dramatically increased atmospheric GHG concentrations, creating the enhanced greenhouse effect and its associated climatic changes.
- 97% of climate scientists believe that human activities are causing climate change (the long-term change to global or regional climate patterns due to increased atmospheric GHG levels).
- 'Climate inertia' refers to the lag between GHGs being emitted and the resulting warming-related climatic impacts. This means that atmospheric carbon dioxide concentrations will remain high for many years to come, even if emissions were to cease right now.
- 2°C above pre-industrial average global temperatures is the widely agreed upon dangerous climate change threshold, beyond which the risks of impacts are deemed unacceptable.
- Atmospheric carbon dioxide concentration of 450 parts per million (ppm) is consistent with about a 50% chance of limiting warming to 2°C or less.
- While the global atmospheric carbon dioxide concentration remained relatively consistent at 280 ppm throughout human history, by mid-2017 it reached 402 ppm (as measured at Mauna Loa Observatory in Hawaii).
- Known as Representative Concentration Pathways (RCPs), four distinct scenarios are used by the Intergovernmental Panel on Climate Change (IPCC) to define specific emission trajectories and their related warming consequences to 2100. Named RCP8.5, RCP6, RCP4.5 and RCP2.6, they respectively range from a high emission scenario to one with substantial GHG reduction measures. Each scenario leads to a significantly different future climate by 2100.

Climate change observations

- 2016 was the Earth's warmest year on record since reliable global surface air temperature records began in 1880, and the 15 years leading up to 2016 were among the 16 warmest on record.
- Globally-averaged ocean temperatures are increasing, with warming extending to at least 2,000 m below the surface.
- Globally-averaged sea levels have risen by over 20 cm since the late 19th century.
- Since the beginning of the industrial revolution, the acidity of surface ocean waters has increased by approximately 30% due to the absorption of anthropogenic carbon dioxide.
- Australia's mean surface air temperature and surrounding sea surface temperature have both warmed by approximately 1°C since 1910.
- Average yearly temperatures in South Australia have risen by almost 1°C over the past century.
- More severe fire weather conditions and longer fire seasons have been observed across large parts of Australia since the 1970s.

Climate change impacts

- Australia's susceptibility to mosquito-borne diseases such as dengue fever is likely to increase with changing temperatures. Increased temperatures and changes to water availability may also increase the prevalence of water-borne diseases such as cholera.
- Extreme rainfall events are projected to intensify throughout most of Australia, increasing the risk of flooding and erosion events.
- Australian sea levels are projected to rise throughout the 21st century at a faster rate than over the past four decades, driven mainly by ocean thermal expansion and the melting of glaciers and ice caps.
- In 2016 the Great Barrier Reef experienced its worst coral bleaching event on record due to rising sea surface temperatures.
- Adelaide's average temperature is expected to increase by 0.6°C–1.3°C by 2030 as compared to 1990. A doubling of the number of days over 35°C compared to its long-term average may be experienced by 2070.
- South Australia is projected to experience increases in time spent in drought, with associated adverse impacts on crop and food production. Notably, drier conditions in eastern Australia could result in significant water flow reductions throughout the Murray Darling Basin.
- With sea levels predicted to rise by 1.1 m by 2100, between 25,200 and 43,000 residential buildings in South Australia (with an estimated replacement value of AUD $4.4–$7.4 billion) may be at risk of inundation.

Climate change responses

- Climate change mitigation involves actions that reduce greenhouse gas emissions from a wide range of industrial and agricultural activities, as well as actions that increase the amount of carbon dioxide absorbed in natural carbon sinks.
- Climate change adaptation involves actions to prepare for and respond to climate change impacts.
- Both mitigation and adaptation actions are vital – the former to slow down climate change globally, and the latter to prepare for some of its unavoidable local consequences.

Climate policy

- Australia is one of the top 10 Organisation for Economic Co-operation and Development (OECD) country GHG emitters per capita, responsible for around 1.5% of all global GHG emissions.
- In 2015, 196 countries committed to the international Paris Agreement aiming to limit global warming to 1.5°C–2°C above pre-industrial temperatures.
- Australia's current commitment is to reduce its GHG emissions by 26%–28% below 2005 levels by 2030.
- Current global climate policies would not be sufficient to limit global warming to no more than 2°C above pre-industrial temperatures.
- South Australia currently generates 39% of its electricity from renewable energy and aims to reach 50% by 2025. It also aims to achieve carbon neutrality by 2050.
- South Australia has 11 regional climate change adaptation plans across the state.
- The AMLR NRM board has identified climate change as one of the four key drivers of change in the region, and has in recent years been active in researching and communicating its implications in key areas such as water availability, biodiversity conservation, primary production and bushfire risk.

Climate change communication

- Effective climate change communication involves adapting to the values and worldviews of the receiving audience, and using engaging language and clear examples and images.
- Climate change communication that clearly leads from problems to solutions and the benefits of action is likely to promote positive emotional responses and more effectively motivate engagement.
- While it is useful to relate climate change to tangible, locally felt impacts, it is important not to casually attribute single weather events to climate change without the appropriate scientific evidence.

1 | Introduction

This document is a useful resource for anyone who, in their work or personal lives, encounters climate change related questions, or would like to communicate climate change concepts more accurately and effectively. This document aims to:

- clarify key climate related concepts as a starting point for discussing climate change issues
- enable users to more confidently and consistently discuss and deliver climate change content
- provide users with easy access to useful climate change information sources for further learning and exploration.

This document is designed so that users can easily access relevant information and is structured as follows:

- **Chapter 2** defines key climate change concepts and includes useful diagrams and analogies.
- **Chapter 3** outlines Australia's contribution to global greenhouse gas emissions and summarises the relative contribution of each state and territory.
- **Chapter 4** provides key relevant climate change observations and impacts in a global, national and local context.
- **Chapter 5** explains the Intergovernmental Panel on Climate Change's emission scenarios used for forecasting future emissions based on differing sets of societal choices.
- **Chapter 6** explains the two main climate change response categories, being adaptation and mitigation, and the importance of implementing an integrated response.
- **Chapter 7** outlines key climate change mitigation and adaptation policies in a national and local context and includes specific examples.
- **Chapter 8** explains the issue of extreme weather event attribution to climate change, incorporating examples of how such attribution has been performed in a scientifically accurate manner.
- **Chapter 9** summarises climate change communication and framing strategies, featuring examples of more and less effective engagement tactics.
- **Chapter 10** discusses key psychological factors relevant to communicating climate change to young people.
- **Chapter 11** lists useful climate change resources, including informative websites and useful videos for educators, engagement professionals and school students.
- The **glossary** provides clear and concise definitions of key climate-related terms used in this document.

2 | Key scientific concepts explained

2.1 Weather vs climate

'Weather' is the short-term, rapidly changing condition of the atmosphere at a given place and time, influenced by the movement of air masses and experienced through conditions such as rainfall and high and low temperatures, humidity and wind.

By contrast, 'climate' is the long-term pattern of weather conditions at a particular location and requires scientific analysis of average precipitation, temperature, humidity, sunshine and other such measures.

All humans experience weather directly, while a location's climate can only be described and understood through the averaging of documented weather conditions throughout long periods of time. For a useful illustration of the difference between weather and climate refer to weather versus climate video in Chapter 11.

2.2 Natural climate variability

As shown in Figure 1, Earth's climate has always been variable due to a number of factors, including:

- processes such as the El Niño Southern Oscillation[1]
- the cumulative effect of chaotic and random aspects of the weather
- the Earth's natural orbital variations (affecting the shape of the Earth's orbit around the sun) and its axial variations (affecting the tilt of the Earth vis-a-vis the sun).

[1] El Niño Southern Oscillation (sometimes known as ENSO) is the natural fluctuation (occurring every 2–7 years) of sea surface temperatures and atmospheric air pressure across the equatorial Pacific Ocean. El Niño conditions are caused by relatively weak trade winds, resulting in cooler than normal sea surface temperatures around northern Australia and hence in reduced rainfall over eastern Australia, while La Niña conditions are caused by the reverse pattern and therefore tend to result in increasing humidity and rainfall over eastern, northern and central Australia.

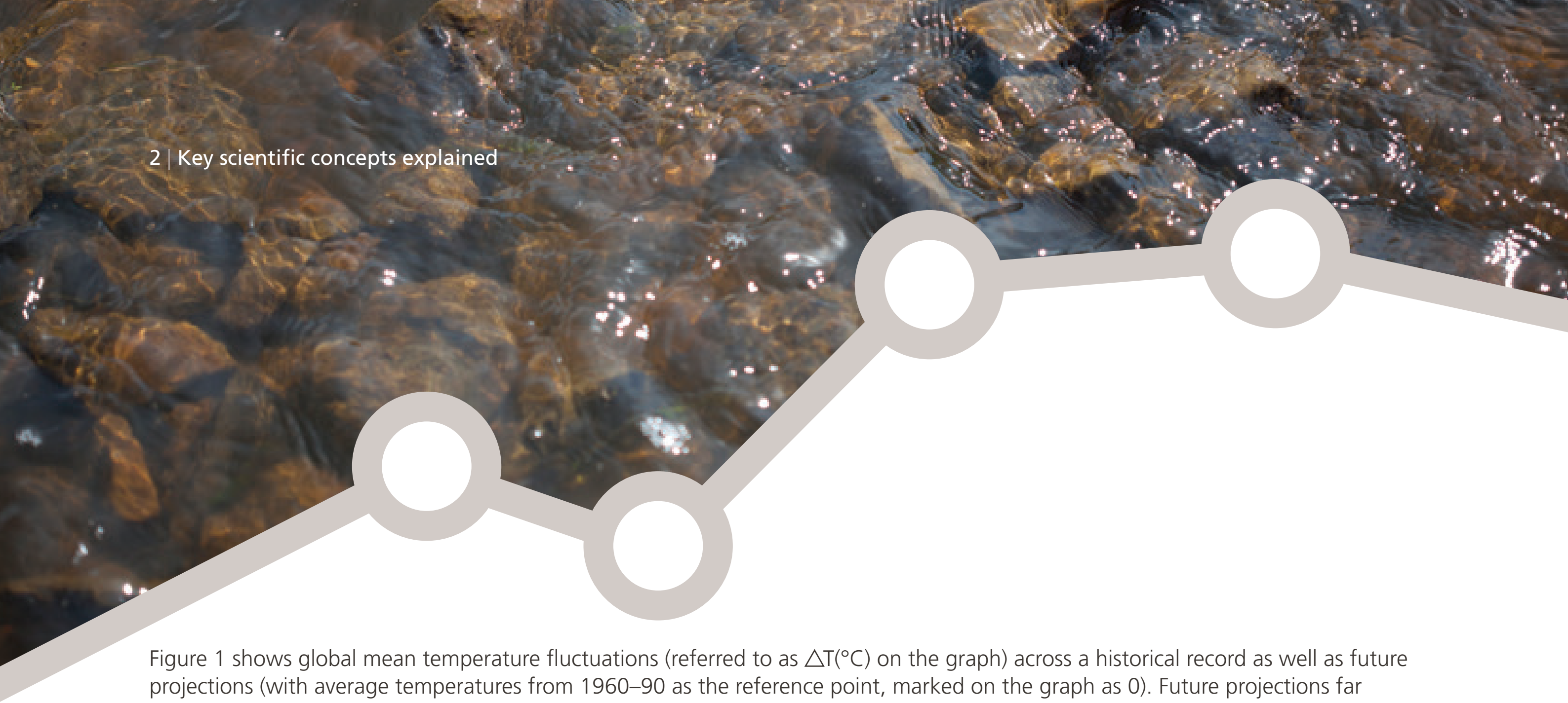


Figure 1 shows global mean temperature fluctuations (referred to as △T(°C) on the graph) across a historical record as well as future projections (with average temperatures from 1960–90 as the reference point, marked on the graph as 0). Future projections far exceed the natural variability observed in the last five million years before present (Yrs BP).

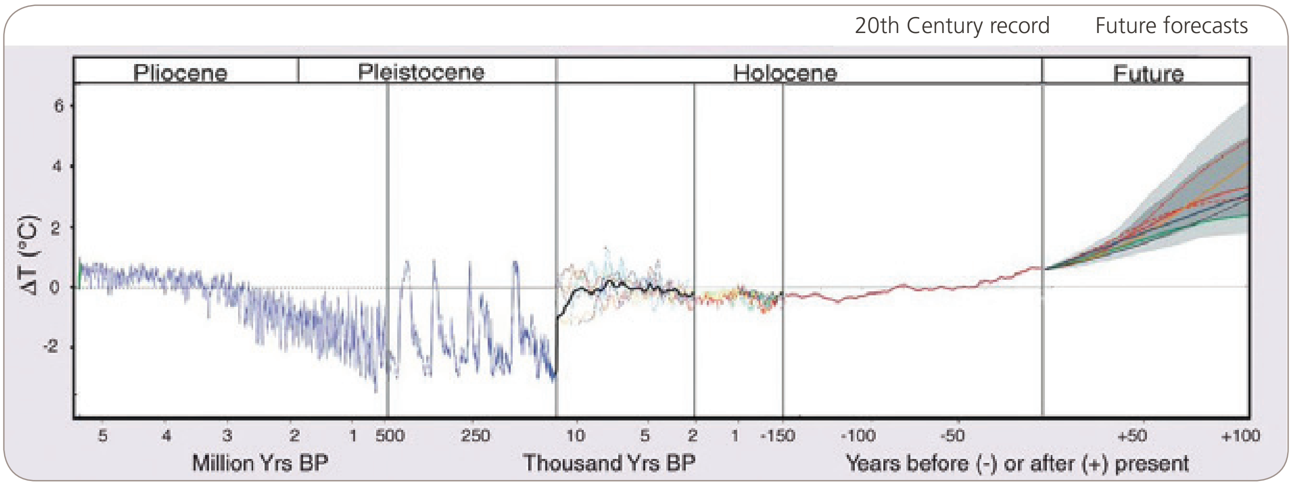


FIGURE 1: Global mean temperature anomalies across a historical record and future projections

Source: The future of species under climate change: resilience or decline? 2013 report available: science.sciencemag.org

These variations, commonly known as the Milankovitch cycles, are responsible for the Earth's cyclical shifts between glacial periods (also known as ice ages) and warmer, interglacial periods (such as the present era).

The Milankovitch cycles, each of which takes approximately 100,000 years to complete, are linked to global atmospheric carbon dioxide levels and temperatures. Both factors have remained relatively stable over the past 800,000 years, with a difference of around 8°C local temperature and 100 ppm[2] of carbon dioxide between glacial and interglacial periods. As shown in Figure 2, ice core data[3] show that current carbon dioxide levels are over 100 ppm higher than at their peak around 320,000 years ago.

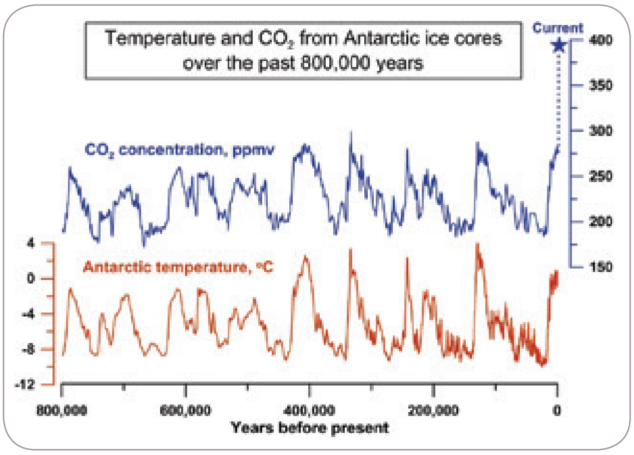


FIGURE 2: Temperature and carbon dioxide levels from Antarctic ice core data over the past 800,000 years (2014)

Source: Simple Climate available: simpleclimate.wordpress.com

[2] Parts per million – the level of global atmospheric carbon dioxide is measured in terms of concentration, expressed as parts per million (ppm), or sometimes as parts per billion (ppb).

[3] Ice core data: An ice core is a cylinder-shaped sample of ice drilled from a glacier or ice sheet to provide well-preserved and detailed climate records. Analysis of the physical and chemical properties of these samples indicate historical greenhouse gas concentrations and temperatures.

CLIMATE VARIABILITY – A BIT LIKE 'SIGNAL' AND 'NOISE'…

To understand the relationship between climate variability and climate change, it is useful to think of audio engineers who attempt to hear specific sounds (referred to as 'signals') above other unwanted sounds (referred to as 'noise'), a situation referred to as high signal-to-noise ratio.

In reference to climate, climate change can be thought of as the 'signal', with natural variability being the 'noise'. In some cases the signal is strong and the background variability is low, while in other cases the variability dominates and the climate change signal is hard to detect. For example, the signal-to-noise ratio is higher over larger areas (for example a whole continent), and longer time scales (for example 200 years). Conversely, at regional spatial scales and at shorter (e.g. 5–20 year) time scales the signal becomes more obscured by the 'noise' of natural variability.

2.3 The greenhouse effect

As shown in Figure 3, some of the sun's energy is absorbed by the Earth's surface while some is reflected back towards the atmosphere in the form of infrared radiation. Greenhouse gases (GHGs) prevent a portion of the sun's energy from escaping back into space and hence keep the Earth's surface warmer than it would otherwise be. This natural phenomenon is known as the greenhouse effect.

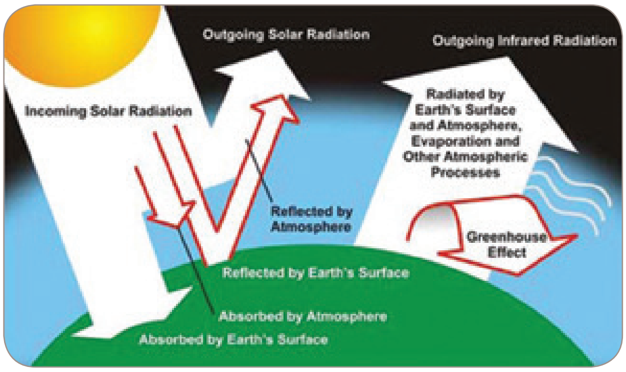


FIGURE 3: An illustration of the Earth's solar radiation balance and the greenhouse effect

Source: Environment and Climate Change Canada available: canada.ca/en/environment-climate-change

2.4 The enhanced greenhouse effect

The enhanced greenhouse effect is the phenomenon by which the greenhouse effect is magnified due to human activities which increase GHG emissions (such as extensive agriculture and the burning of fossil fuels), and activities which reduce the removal and storage of carbon dioxide (such as deforestation). This human-induced (anthropogenic) enhanced greenhouse effect is believed by 97% of climate scientists to cause the gradual warming of the Earth and its associated impacts, a phenomenon commonly referred to as 'climate change'.

THE ENHANCED GREENHOUSE EFFECT – A BIT LIKE AN OVER-STUFFED DOONA…

The atmosphere is like a doona around the Earth's surface. When you are in bed the stuffing inside the doona traps the heat and keeps you warm. GHGs act as the stuffing in the atmosphere's doona and hence if there were no GHGs to trap the heat, the Earth would be much colder. As more stuffing is added to the Earth's doona, it gets thicker and better at trapping heat. Similarly, human activities such as burning fossil fuels, agriculture and land clearing emit large amounts of GHGs thereby adding stuffing to the Earth's doona and causing it to overheat.

The level of global atmospheric carbon dioxide is measured in terms of concentration, expressed as parts per million (ppm) or parts per million volume (ppmv). While throughout history carbon dioxide levels have remained relatively consistent at 280 ppm, the current level is over 400 ppm as a result of the enhanced greenhouse effect.

CLIMATE CHANGE AND PROBABILITIES – A BIT LIKE ROLLING A DIE…

While under a relatively stable climate a given location has certain odds of experiencing hotter years and cooler years (or wetter winters and drier winters for example), human induced GHG emissions are now changing the underlying climate and hence the corresponding probability distributions, in the same way that changing a die numbered 1–6 to instead read 2–7 would reduce the odds of a lower number being rolled (while increasing the odds of rolling a higher one).

2.5 Greenhouse gases

There are some 30 heat absorbing gases in the Earth's atmosphere referred to as 'greenhouse gases', of which some are human induced (anthropogenic) and some occur naturally, but have increased significantly in atmospheric concentration due to human activities.

While water vapor is the most abundant greenhouse gas in the atmosphere, human activities have only a small direct influence on its atmospheric concentration, primarily through irrigation and deforestation. The surface warming caused by human production of other GHGs, however, leads to an increase in atmospheric water vapor because warmer temperatures make it easier for water to evaporate and stay in the air in vapor form. This creates a positive feedback loop, in which warming leads to more evaporation which in turn leads to more warming (discussed in Section 2.7).

Long-lived greenhouse gases such as carbon dioxide, methane and nitrous oxide are chemically stable and persist in the atmosphere over decades or centuries, meaning they have a long-term influence on the climate. To enable the emissions of different GHGs to be expressed as a common unit, all emission amounts are expressed in 'carbon dioxide equivalent' (or 'CO_2e') terms. For example, as methane is 25 times more potent than carbon dioxide as a heat trapping gas, one tonne of methane emissions is referred to as 25 tonnes CO_2e.

Figure 4 shows the relative contributions of the main GHGs (expressed as gigatonnes of carbon dioxide equivalent or '$GtCO_2e$') for the period 1970–2010, comprising methane, nitrous oxide, fluorinated gases, and carbon dioxide both from fossil fuel combustion and industrial processes, and from forestry and other land use (known as FOLU). As shown in the graph, the period 2000–10 saw a greater average annual increase in emissions than that of the 1970–2000 period.

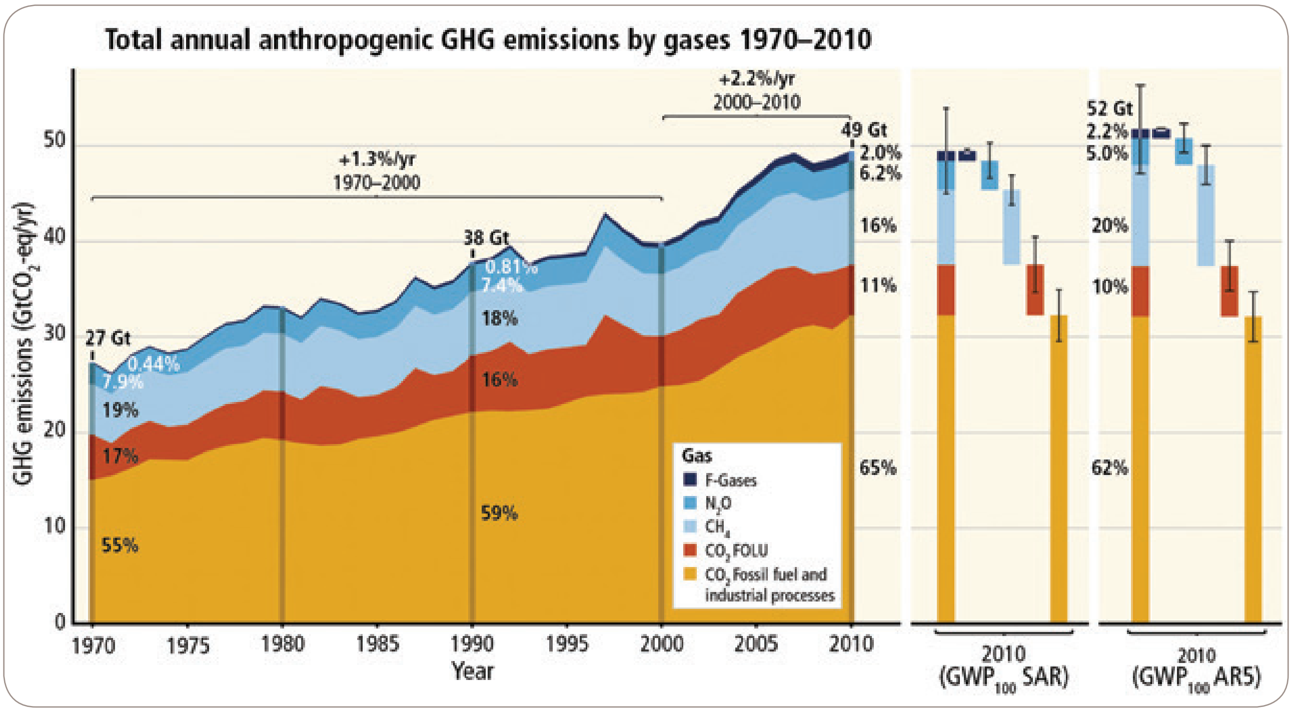


FIGURE 4: Total annual anthropogenic GHG emissions from 1970 to 2010
Source: IPCC AR5 Synthesis Report available: ipcc.ch/report/ar5

Carbon dioxide (CO_2) is present throughout the natural environment (as explained in Section 2.4), but is also the most abundant anthropogenic GHG, produced in large amounts through human activities such as land clearing and the burning of fossil fuels (e.g. coal, oil and natural gas). Carbon dioxide is removed from the atmosphere when absorbed and stored by oceans and wetlands, or captured and used by plants in the process of photosynthesis.

Methane (CH_4) is emitted through natural sources such as wetlands, termites and the oceans. It is also emitted through human activities such as the production and transportation of coal, oil and natural gas, as well as through waste decomposition in landfill and livestock farming. 1 tonne CH_4 = 25 tonnes CO_2e.

Nitrous oxide (N_2O) occurs naturally as one of the many forms of nitrogen, however, it is released in large amounts through industrial and agricultural activities such as the use of synthetic fertilisers and the combustion of fossil fuels and solid waste. 1 tonne N_2O = 298 tonnes CO_2e.

Fluorinated gases (F-gases) are a group of anthropogenic gases including for example sulphur hexafluoride (SF_6), primarily used in magnesium and aluminium production. 1 tonne SF_6 = 22,800 tonnes CO_2e.

Other GHGs include Ozone, which occurs naturally by chemical reactions involving ultraviolet radiation and oxygen molecules, and Halocarbons, compounds containing carbon and at least one halogen, primarily from anthropogenic sources such as air conditioners and aerosols.

2.6 The carbon cycle

Carbon is present throughout the natural environment in a fixed amount and in many forms. The carbon cycle involves the continuous movement of carbon through the oceans, land, atmosphere and life on Earth, as demonstrated in Figure 5. As a result of human activities (such as the burning of fossil fuels), carbon is being emitted much faster than would naturally be the case, resulting in a 40% increase in its atmospheric concentration since the beginning of the industrial revolution (around 1760).

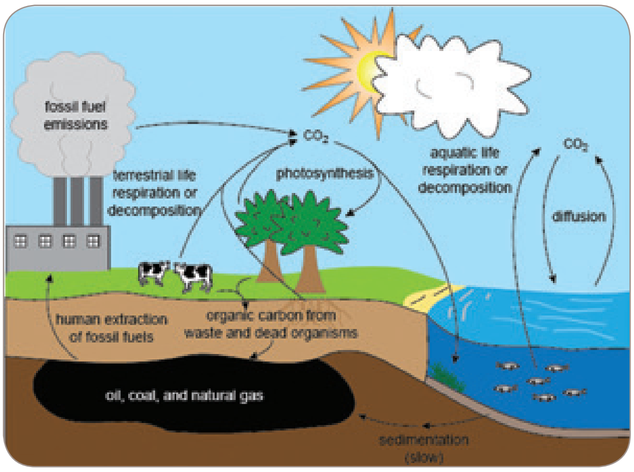


FIGURE 5: An illustration of the Earth's carbon cycle
Source: Class Notes, class 9 natural resources available: classnotes.org.in

2.7 Climate inertia

'Climate inertia' refers to the lag between GHGs being emitted and the resulting warming-related climatic impacts being felt or observed. Caused by the thermal inertia of the oceans (which take much longer to warm up than the atmosphere), this lag would result in atmospheric carbon dioxide concentrations remaining elevated for many years to come, even if GHG emissions were to cease right now. As a result, it is virtually certain for example, that thermal expansion related sea level rise will continue for many centuries to come.

2.8 Climate tipping points and dangerous climate change

A climate tipping point is a critical threshold beyond which a climatic system shifts to a new state. It is difficult to predict exactly when a tipping point will be reached, however at such points a small change can trigger self-reinforcing positive feedback mechanisms and ultimately lead to large, widespread and long-term systemic changes, collectively referred to as 'runaway climate change'.

Two degrees Celsius above pre-industrial average global temperatures is the widely agreed upon dangerous climate change threshold. Limiting the warming caused by anthropogenic carbon dioxide emissions to less than 2°C (since the period 1861–80) will require total cumulative anthropogenic carbon dioxide emissions (since that period) to not exceed 3670 $GtCO_2$ (gigatonne of carbon dioxide). Retaining about a 50% chance of limiting global warming to 2°C or less would require atmospheric CO_2 concentrations to remain below 450 ppm. Sustained increased emissions will cause further warming and long-lasting changes to all components of the climate system, increasing the likelihood of severe, pervasive and sometimes irreversible impacts, as discussed in Chapter 4.

3 | Australia's GHG emissions in the global context

The global mean carbon dioxide level in 2015 was 399 ppm and the carbon equivalent level of GHG was 487 ppm (as shown in Figure 6) — a 44% increase from the concentration of 278 ppm around the year 1750, and likely the highest level in at least the past two million years. As of June 2017, the global atmospheric carbon dioxide concentration was 402 ppm, as measured at Mauna Loa Observatory in Hawaii.

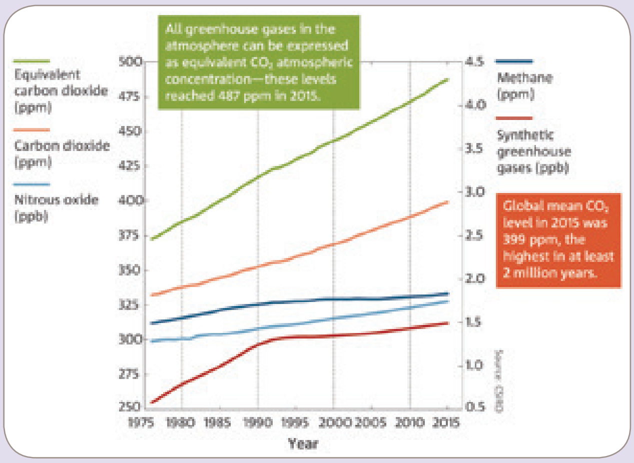


FIGURE 6: Global atmospheric greenhouse gas concentrations between 1975 and 2015

Source: Bureau of Meteorology, State of the Climate 2016 report available: www.bom.gov.au

Australia is one of the top 10 OECD country GHG emitters per capita[4], with electricity generation, direct fuel combustion, transport and agriculture being its largest emission sources. According to the Department of Climate Change and Energy Efficiency, Australia represents approximately 1.5% of all global anthropogenic GHG emissions (as shown in Figure 7) while South Australia contributes 5.6% of Australia's emissions (as shown in Figure 8), equating to approximately 0.075% of total global anthropogenic emissions.

As explained in Section 6.1, no amount of national mitigation measures would prevent Australia from experiencing climate change impacts well into the future, hence the need for strong adaptation measures to be planned and implemented.

[4] Gross direct emissions divided by the country's population, excluding emissions or removals from land-use, land-use change and forestry

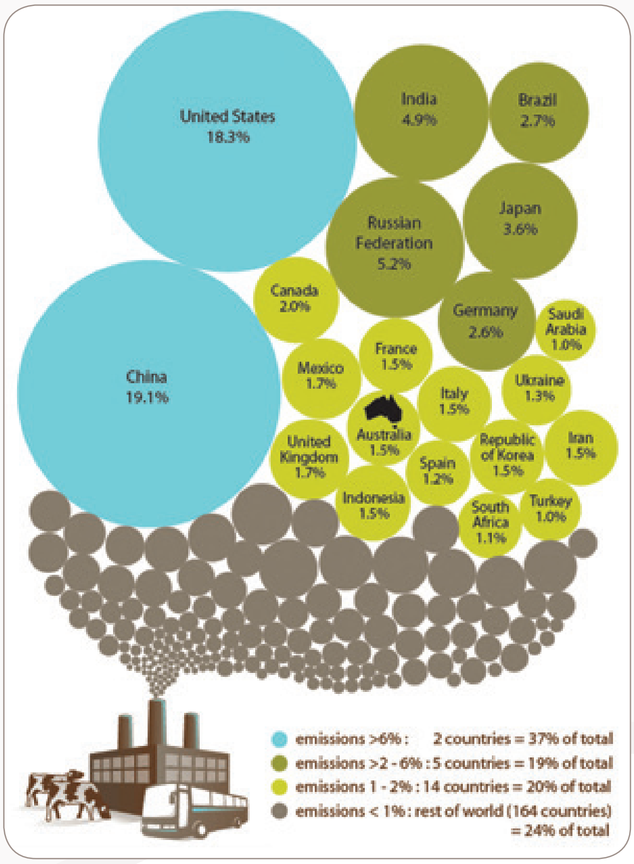


FIGURE 7: The relative contribution (in percentage figures) of Australia and other selected countries to global anthropogenic greenhouse gas emissions (2005)

Source: Young Carbon Farmers, Australian agriculture's contribution available: futurefarmers.com.au

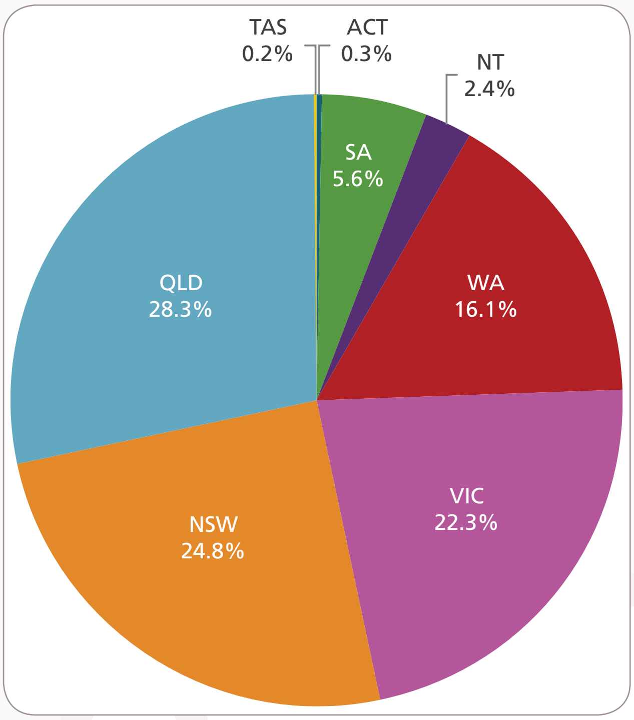


FIGURE 8: The relative contribution (in percentage figures) of Australia's states to its total anthropogenic greenhouse gas emissions (2015)

Data source: Australian Greenhouse Emissions Information Systems available: ageis.climatechange.gov.au

4 | Climate change observations and impacts

4.1 Climate change observations

The following are examples of key global and regional climate change observations (references provided in end notes p 36).

Global

The year 2016 was the warmest on record since reliable global surface **air temperature** records began in 1880 (as shown in Figure 9), with the last 15 years being among the 16 warmest years on record.[i]

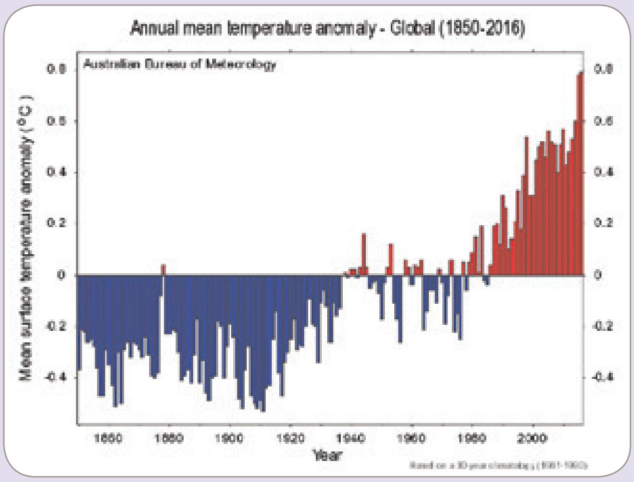


FIGURE 9: Annual global mean temperature anomalies between 1850 and 2014

Source: Bureau of Meteorology, climate change and variability available: bom.gov.au

Globally-averaged **ocean temperatures** are increasing, and this warming extends to at least 2,000 m below the surface.[i]

Globally-averaged **sea levels** have risen by over 20 cm since the late 19th century (as shown in Figure 10), with approximately one third of this rise attributed to thermal expansion due to ocean warming, and the rest attributed to melting land ice.[i]

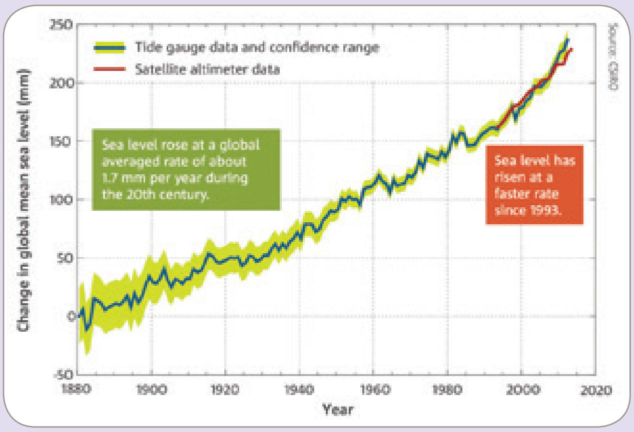


FIGURE 10: Global mean sea levels between 1880 and 2014

Source: Bureau of Meteorology, State of the Climate 2016 report available: bom.gov.au

Australia

Australia's climate has warmed by around 1°C in mean **surface air temperature** and surrounding **sea surface temperature** since 1910, as shown in Figure 11.[i]

Except in parts of northern Australia, the annual number of **35°C and above days** has increased in Australia in recent decades.[i]

The duration, frequency and intensity of **extreme heat events** have increased across large parts of Australia.[i]

The number of **extreme fire weather** days has increased across large parts of Australia since the 1970s, and a longer fire season has been observed in some areas.[i]

May – July **rainfall** has decreased by approximately 19% since 1970 in the southwest of Western Australia.[i]

Oceans around Australia have warmed and **ocean acidity** levels have increased.[i]

Mean sea levels have risen around Australia, and this rise amplifies the effects of **high tides and storm surges**.[i]

The Australian region's 2016 **sea surface temperature** anomaly (0.73°C above the 1961–1990 average) was the highest since records began in 1900.[ii]

The average pH of surface waters around Australia is estimated to have decreased between 1880–89 and 2000–09 by approximately 0.1, with southern seas experiencing slightly greater **acidification** than northern ones.[i]

In 2016 the Great Barrier Reef experienced its worst **coral bleaching** event on record due to rising sea surface temperatures.[iii]

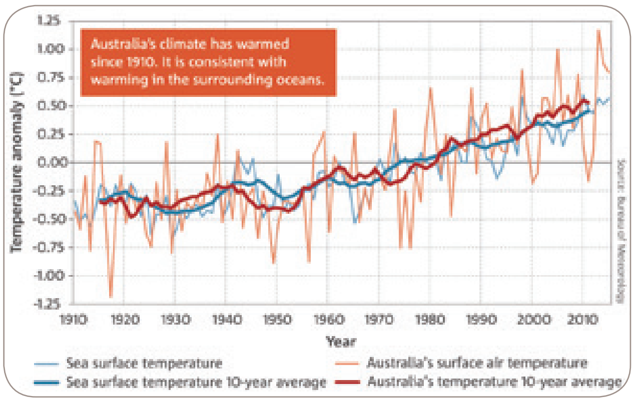


FIGURE 11: Australia's air and sea surface temperature anomalies between 1910 and 2015

Source: Australian Bureau of Meteorology, State of the Climate 2016 report available: bom.gov.au

South Australia

Average yearly temperature in South Australia has risen by almost 1°C over the past century.[iv]

During the 2009 Adelaide heatwave, direct **heat-related hospital admissions** increased 14-fold and there was a 16% increase in ambulance call-outs.[vii]

The 1997–2009 **drought** over south-eastern Australia resulted in Murray Darling Basin flows falling to less than 50% of their long-term average.[v]

The drying across southern Australia in 2016 was the strongest recorded large scale **rainfall** change since national records began in 1900.[i]

Sea levels in South Australia have been rising at an average rate of approximately 4.6 mm per year since the early 1990s (as compared to the annual global average of 3.2 mm).[iv]

4.2 Climate change impacts in Australia

Related to the above observations, the following are examples of key climate change impacts anticipated for Australia (references provided in end notes).

Australia

Regardless of the emissions scenario, Australian **annual average temperature** is projected to increase by about 0.6°C–1.3°C by 2030 (compared to the baseline period 1986–2005).[vi]

Serious risks for **human health**, such as additional heat-related deaths due to increased frequency and duration of heat waves.[vii]

It has been estimated that by 2030 the number of professional firefighters in Australia will need to approximately double (as compared to 2010) to keep pace with increased population, asset value and **fire danger weather**.[viii]

Australia's susceptibility to **mosquito-borne diseases** such as dengue fever is likely to increase with changing temperatures and seasonal patterns, while increased temperatures and changes to water availability may increase the prevalence of **water-borne diseases** such as cholera.[ix]

As the atmosphere warms, its capacity to hold moisture increases. **Extreme rainfall events** are consequently projected to increase in intensity throughout most of Australia, resulting in enhanced risk of flooding and erosion events.[i]

In line with global mean sea level rise, Australian **sea levels** are projected to rise throughout the 21st century at a faster rate than over the past four decades, driven mainly by ocean thermal expansion and melting from glaciers and ice caps.[vi]

South Australia

South Australia is projected to experience increases in time spent in drought, with associated adverse impacts on **crop and food production**. Notably, drier conditions in eastern Australia could result in significant water flow reductions throughout the Murray Darling Basin.[x]

Increasing temperatures are likely to influence both **wine grape production** and quality across Australian wine regions, including McLaren Vale and the Barossa Valley.[xi]

Cool season rainfall is projected to decline in southern Australia, driven by a southward movement of winter storm systems.[vi]

South Australia's coastline is particularly vulnerable to the impacts of **sea level rise**, which has been rising at an average rate of approximately 5 mm per year since 1992.[xii]

With sea levels predicted to rise by 1.1 m by 2100, between 25,200 and 43,000 **residential buildings** in South Australia (with an estimated replacement value of AUD $4.4–$7.4 billion) may be at risk of inundation.[iv]

Adelaide and Mount Lofty Ranges region

Under an intermediate emissions scenario, the median number of **extreme heat days** (days over 35°C) in Adelaide is expected to increase from 20 (for the baseline period 1981–2010) to 26 by 2030 and to 32 by 2090.[xiii]

Under an intermediate emissions scenario, the region's **average maximum temperatures** could increase by 0.9°C by 2030 and by 1.8°C by 2090, while **average minimum temperatures** could increase by 0.6°C by 2030 and by 1.4°C by 2090 (compared to the baseline period 1986–2005).[xiv]

Under a high emissions scenario, the region's **average maximum temperatures** could increase by 1.1°C by 2030 and by 3.4°C by 2090, while **average minimum temperatures** could increase by 0.8°C by 2030 and by 2.9°C by 2090 (compared to the baseline period 1986–2005).[xiv]

As shown in Figure 12, by 2030 projected annual **rainfall reductions** are similar under both the intermediate and high emission scenarios (explained in Section 5.1), however by 2090 rainfall is projected to decline more than twice as much under the high emissions scenarios (for the baseline period 1986–2005).[xiv]

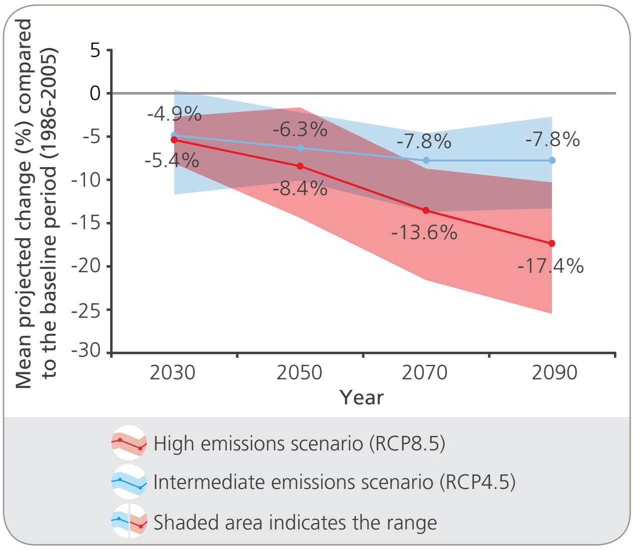


FIGURE 12: Projected percent change in the Adelaide and Mount Lofty Ranges region's average seasonal rainfall from 2030 to 2090

Source: Goyder Institute, SA Climate Ready report available: goyderinstitute.org

The most drastic **rainfall reductions** are expected to occur in spring, with 17% and 25.2% reductions projected by 2070 under the intermediate and the high emissions scenarios respectively.[xiv]

Availability of irrigation water for agriculture around Adelaide and the Mount Lofty Ranges is expected to decline.[xv]

5 | Emission scenarios and trajectories

5.1 Representative concentration pathways (RCPs)

When investigating how the Earth's climate will respond to future conditions, scientists take into consideration factors such as GHG emissions, developments in technology, changes in energy generation and land use, global and regional economic circumstances and population growth.

To provide a consistent set of starting conditions, historical data and possible future emissions, the following four distinct scenarios named 'representative concentration pathways' (RCPs) are used by the IPCC, each defining a specific emissions trajectory and its related warming consequences to 2100:

- RCP8.5 – a high energy use characterised by increasing GHG emissions over time as a result of population growth, a low rate of low emissions technology development and no implementation of climate policies.
- RCP6 – a scenario assuming heavy reliance on fossil fuels, intermediate energy intensity, an increasing use of croplands and a declining use of grasslands. Radiative forcing[5] is stabilised shortly after 2100 through the application of a range of GHG emission reduction strategies.
- RCP4.5 – a future of relatively ambitious GHG emission reductions including reduced energy intensity, implementation of strong reforestation programs, yield increases and dietary changes to reduce the use of croplands and grasslands. As in RCP6, radiative forcing is stabilised shortly after 2100.
- RCP2.6 – a scenario with substantial GHG reductions sustained over time, low energy intensity, cropland use for bio-energy production, a declining use of oil and a peak of carbon dioxide concentration occurring in the year 2050.

Figure 13 demonstrates the projected atmospheric carbon dioxide concentrations for the four RCPs, with the grey area indicating the range of emission trajectories found in published literature.

While the RCP scenarios in Figure 13 make it clear that societal choices and circumstances will have a very large impact on the resulting GHG concentrations by the end of the century, it is useful to note that the four scenarios only start diverging significantly from each other around the year 2030.

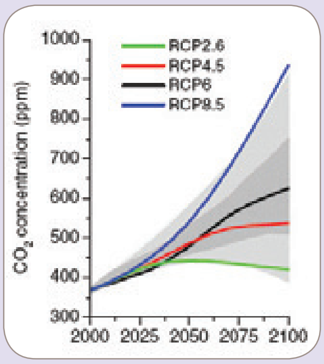


FIGURE 13: Projected atmospheric carbon dioxide concentrations for the RCPs between the years 2000 and 2100

Source: The representative concentration pathways: an overview, 2011 report available: link.springer.com

[5] Radiative forcing, expressed as Watts per square metre, is the capacity of gases or other forcing agents to affect the Earth's energy balance (the subtotal of incoming solar radiation and outgoing infrared radiation), thereby contributing to the enhanced greenhouse effect.

5.2 Emission trajectories

As of November 2017, the pledges made by many of the world's governments would at best limit warming to 3.2°C above pre-industrial levels, while national policies currently in place are projected to result in about 3.7°C warming. A substantial gap therefore remains between the mitigation actions governments have committed to and their existing policies, with both projected to result in emissions pathways well above the Paris Agreement's long-term warming goal of no more than 2°C (discussed in Section 7.1).

Figure 14 demonstrates that in the absence of relevant targeted policies, global warming is expected to reach 4.1°C–4.8°C above pre-industrial mean temperatures by 2100.

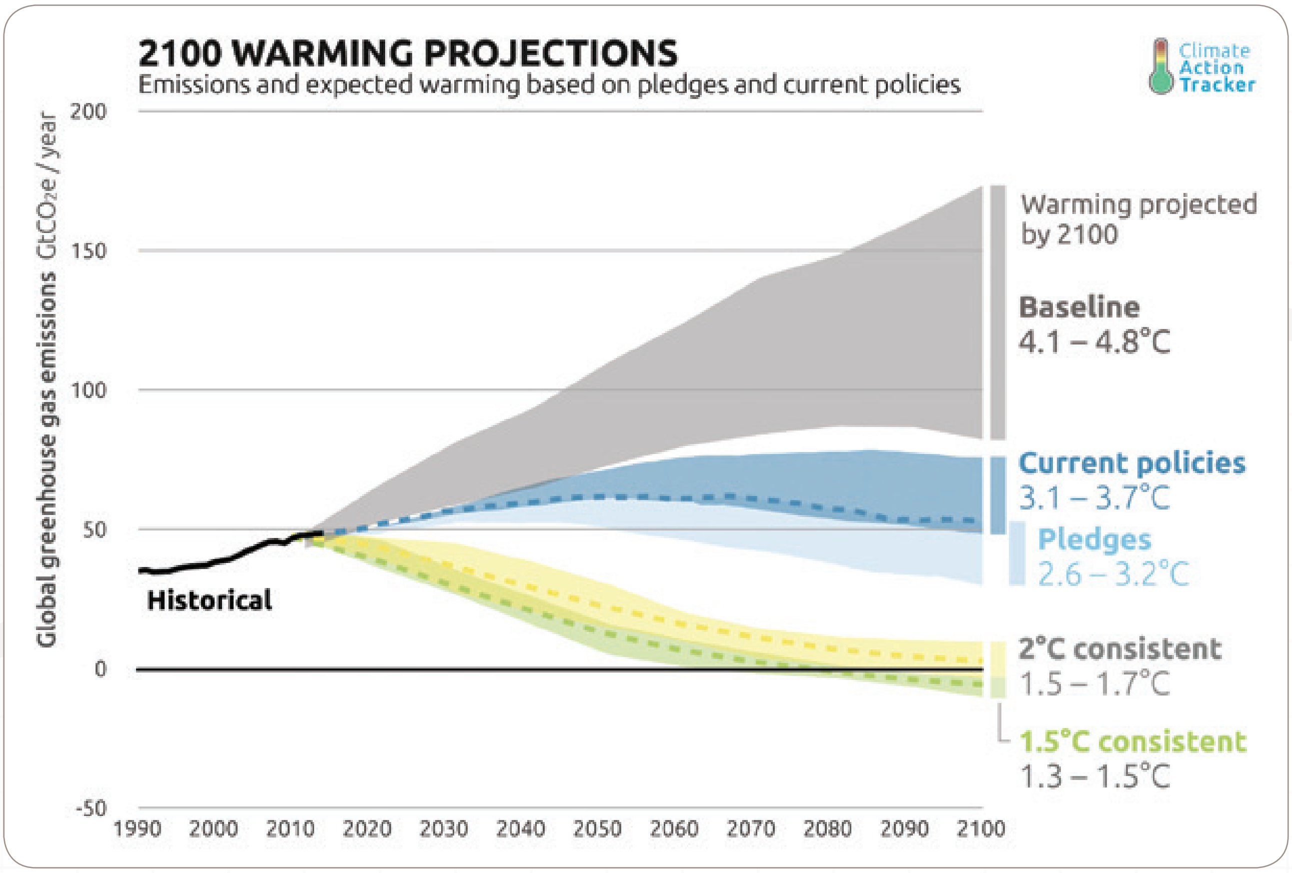


FIGURE 14: The projected effect of current policies and pledges on global temperatures (2018)
Source: Climate Action Tracker available: climateactiontracker.org/global

6 | Climate change responses

There are two main responses to climate change, namely mitigation (reducing GHG emissions) and adaptation (managing climate change impacts and reducing their risks). As shown in Figure 12, some activities have both mitigation and adaptation aspects.

These two response types are not however always compatible, a clear example being the drought proofing strategy of large scale water desalination, which while often seen as an effective adaptation measure is nonetheless a highly emission intensive activity.

Failure to reduce emissions fast enough would increase humanity's adaptation load into the future, as well as increasing the likelihood of having to resort to alternative geoengineering strategies[6].

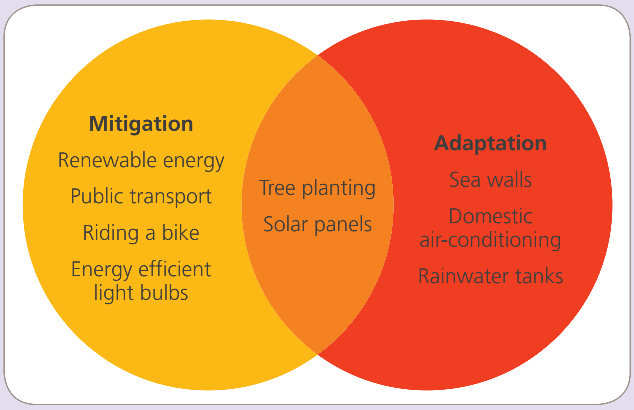


FIGURE 15: Examples of climate change mitigation and adaptation responses

6.1 Climate change mitigation

Mitigation includes actions that **reduce emissions** in a wide range of industrial and agricultural activities, as well as actions that permanently remove carbon dioxide from the atmosphere into carbon sinks, in a process referred to as **carbon sequestration**. Carbon sequestration can occur at the point of emission (e.g. from power plants) or through natural processes (such as photosynthesis), and includes increasing the storage of carbon in soil, vegetation, the oceans or underground geological formations.

While mitigation actions can be undertaken by individuals, households and organisations, they are only meaningful as a part of a global effort. The climate risk reduction benefits of mitigation are diffused in space and time and are not distributed proportionally to effort. As denoted by the term 'climate justice', climate change risks are unevenly distributed and are generally greater for disadvantaged communities, despite those communities' relatively small per capita emissions.

6.2 Climate change adaptation

As delayed climate change impacts will occur due to past, current and future GHG emissions (as discussed in Section 2.7), climate change adaptation activities are necessary to prepare for, and reduce the severity of key climate-related risks. Many adaptation actions can occur at the individual or household level, and as distinct from mitigation actions, they aim to address local impacts and are therefore often planned and implemented by local or regional bodies (such as local councils and NRM Boards).

[6] Geoengineering involves deliberate, large-scale modification of the climate. One solar geoengineering strategy would see tiny particles called sulphate aerosols injected into the stratosphere to reflect back some of the sun's radiation in order to offset the warming effects of ongoing greenhouse gas emissions.

6.3 An integrated response to climate change

Australia is one of the world's largest per capita GHG emitters (as outlined in Chapter 3) and hence has a moral, global responsibility to mitigate climate change as a matter of urgency.

The longer substantial emission reductions are postponed, the more drastic and costly those reductions would need to be in order to have the same mitigating effect.

However, due to climate inertia (discussed in Section 2.7) and Australia's relatively small contribution to global GHG emissions (outlined in Chapter 3), no amount of national mitigation measures would prevent Australia from experiencing climate change impacts well into the future, hence the need for strong adaptation measures.

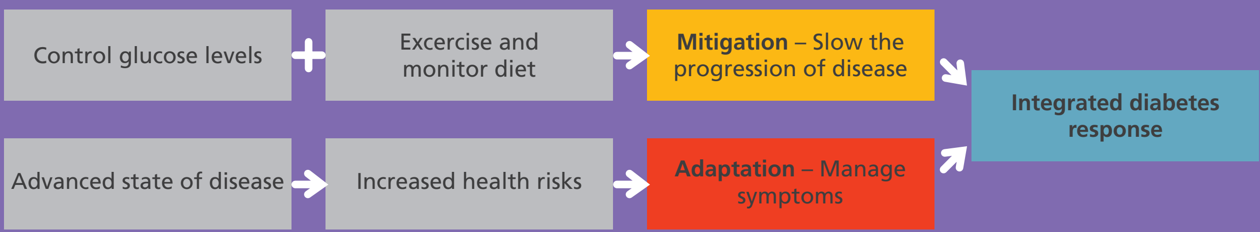
CLIMATE CHANGE MITIGATION AND ADAPTATION – A BIT LIKE MANAGING DIABETES…

Slow the illness

Type II diabetes is a progressive condition which can be slowed by pursuing a healthy lifestyle and by maintaining blood glucose levels within a target range. These actions can be likened to climate change ***mitigation***, as mitigation actions are necessary to reduce climate change risks.

Manage the illness

However, once diabetes has reached an advanced state, it is necessary to manage its unavoidable risks with medication. This can be likened to climate change ***adaptation***, as some climate change impacts are currently occurring and will unavoidably continue to occur into the future.



7 | Policy context

7.1 Australia

In 2015 Australia signed the international Paris Agreement under the United Nations Framework Convention on Climate Change, in which each party submitted its nationally determined contribution with the objective of limiting global average warming to 1.5°C–2°C above pre-industrial temperatures. Australia's Paris commitment is to reduce its GHG emissions by 26%–28% below 2005 levels by 2030.

A 2017 report by The Australia Institute, 'Meeting our Paris Commitment' (see References, p 34) found that the most efficient path for Australia to meet its Paris commitment would require the electricity sector, which accounts for 35% of the country's total emissions, to reduce its 2005 emission levels by 40%–55% and to comprise 66%–75% of renewable sources by 2030.

7.2 South Australia

South Australia has reduced levels of GHG emissions while maximising economic opportunities, and includes both climate change mitigation and adaptation features. There is also an aspiration for the City of Adelaide to become the world's first carbon neutral city.

Climate change mitigation

South Australia currently generates 48.9% of electricity from renewable energy (more than any other mainland state). GHG emissions – reduction focus areas include energy efficiency, renewable energy sources, transport, waste management and buildings. Collaboration with other states and regions to encourage global climate action and contribute to Australia's delivery of the Paris Climate Agreement is important. Businesses and the community also have a role to play in reducing their emissions.

Climate change adaptation

South Australia is building resilience to climate change. There are 11 regional climate change adaptation plans, including the planned actions in Table 1. The South Australian Government is working with regions on climate risks and adaptation across the state.

TABLE 1: EXAMPLES OF SOUTH AUSTRALIA'S REGIONAL CLIMATE CHANGE ADAPTATION PRIOIRITIES

Adaptation Theme	Action
Biodiversity	• Protect vulnerable natural habitats. • Implement appropriate bushfire management strategies. • Enable flora and fauna species migration.
Business/economy	• Establish adaptation programs, frameworks and measures to assist businesses. • Relocate and build away from high risk areas.
Coastal	• Construct or upgrade sea walls, hard structural walls and barriers. • Educate the community about the impacts of coastal erosion. • Relocate or repurpose assets in risk areas.
Emergency	• Improve community climate hazard preparedness. • Develop climate resilient infrastructure. • Utilise community centres and facilities as natural disaster shelters.
Infrastructure	• Protect and back up essential services. • Update infrastructure design standards to reflect the changing climate.
Public spaces	• Design and construct climate sensitive infrastructure. • Implement water sensitive urban design and develop alternative water sources. • Promote wider use of climate ready guidelines.
Primary industries	• Make appropriate changes to farming and land management including planting cover crops. • Implement more efficient irrigation practices.
Urban living	• Update building codes, development plans and management policies to be 'climate ready'. • Educate the community on climate risks and on the benefits of climate resilient infrastructure. • Increase urban green space.
Vulnerable people	• Build community connectivity and support. • Raise awareness about climate risks. • Implement appropriate residential energy management strategies.
Water management	• Implement water reuse strategies, including desalination and stormwater harvest and reuse. • Re-calibrate and update water management plans.

7.3 The Adelaide and Mount Lofty Ranges region

The AMLR NRM Board's Strategic Plan identifies climate change as one of the four key drivers of change in the region, to be addressed through the following strategic directions:

- Participate in opportunities for low carbon futures.
- Build the adaptive capacity of communities.
- Build the understanding and knowledge of future climate change impacts.
- Provide opportunities for landscapes to adapt to climate change.
- Provide opportunities for production systems to adapt to climate change.

In order to better understand the likely impacts of climate change on managing natural resources and to strategically address them, the Adelaide and Mount Lofty Ranges Natural Resources Management Board ('the AMLR NRM board') has undertaken or participated in the following recent investigations:

- A primary industry climate vulnerability assessment covering the viticulture, perennial and annual horticulture, annual cropping, extensive livestock and dairy sectors.
- A landscape-scale assessment of climate change impacts on terrestrial biodiversity and the corresponding broad adaptation strategies, with further investigations currently in train to identify the region's terrestrial biodiversity adaptation priorities at a finer geographical scale.
- A climate change impact assessment of the region's surface water resources.
- A review of fire weather trends in the region.

To support mitigation and adaptation efforts in the urban context, the AMLR NRM board is also:

- the core funder and driving force behind Water Sensitive SA, South Australia's water sensitive urban design capacity-building program, and in the financial year 2017–18 has invested more than $640,000 in water sensitive urban design interventions, partly in recognition of their urban cooling benefits
- partnering with local councils to deliver Living Smart, a community sustainability and well-being course that helps participants reduce their environmental impact and improve their quality of life
- partnering with the Carbon Neutral Adelaide program to deliver a 9 month trial of South Australia's first carbon neutral schools program, assisting Adelaide schools to monitor and reduce their carbon emissions.

Many of the AMLR region's 26 local councils have for many years been actively planning and implementing climate change mitigation activities in their respective municipalities, with some examples provided here.

Implemented actions

City of Unley

- In 2015, 10 kW solar panels were installed at the Unley Swimming Centre.

City of Charles Sturt

- A partnership with the non-government organisation Canopy has been established to plant trees at Morella Station, Salt Creek, to offset the council's future carbon emissions.

City of Tea Tree Gully

- In 2016, 600 trees were planted with the help of 60 Fairview Park Primary School students.
- In 2010, the council endorsed a Climate Action Plan aiming to reduce corporate GHG emissions by 40% of 2006–07 levels by 2020.

Planned actions

The City of Onkaparinga

- Source more than 50% of energy use from renewable sources by 2028.
- Purchase 100% green power for all large council buildings.
- Improve fleet fuel efficiency.

City of Mitcham

- Purchase accredited green power to offset 20% of electricity use.
- Complete an energy audit of the civic centre to identify efficiency improvements.
- Reduce the number of printers and reduce paper waste.

City of Unley

- By 2020, reduce grid energy use by 5%.
- Improve the energy efficiency of buildings through insulation, management systems, and upgrades to heating and cooling systems.

City of Alexandrina

- Increase green power purchase.
- Introduce smaller, more fuel efficient and hybrid fleet cars.
- Undertake a carbon emissions reduction study to develop a GHG emissions reduction strategy.
- Work with the Local Government Association, other councils, SA Power Networks and the State Government to identify opportunities to improve the energy efficiency of public lighting.

City of Charles Sturt

- Encourage the community to use public transport to reduce household GHG emissions.
- Provide the community with a carbon footprint calculator to help identify ways individuals can reduce their emissions.

8 | Attributing weather events to climate change

As individual extreme weather events (such as severe storms, bushfires or heatwaves) can be a result of natural climate variation (explained in Section 2.2), it is not easy to attribute them to anthropogenic climate change. Scientists do however use advanced climate models to determine how much more likely a certain event was made due to the addition of anthropogenic GHG emissions. This process is similar to that of epidemiologists investigating how smoking increases the likelihood of lung cancer developing within an individual patient.

Successful attribution depends on how well we can observe and model an individual extreme event. The rarer the event, the more difficult it is to identify the causes of changes in its frequency or severity, as there are fewer cases to evaluate. Similarly, small-scale, localised and shorter-duration events are more difficult to attribute as they are harder to observe and to model clearly, and are more strongly affected by natural variability. Figure 16 shows the level of confidence climate scientists have in attributing different sorts of extreme events to climate change.

While it's useful to relate the global phenomenon of anthropogenic climate change to tangible, locally felt impacts, it is important not to casually attribute single weather events to it without the appropriate scientific modelling to support such attribution, keeping in mind that even when scientists are quite confident about their attribution, they typically express it in terms of an increased probability, not as a certainty.

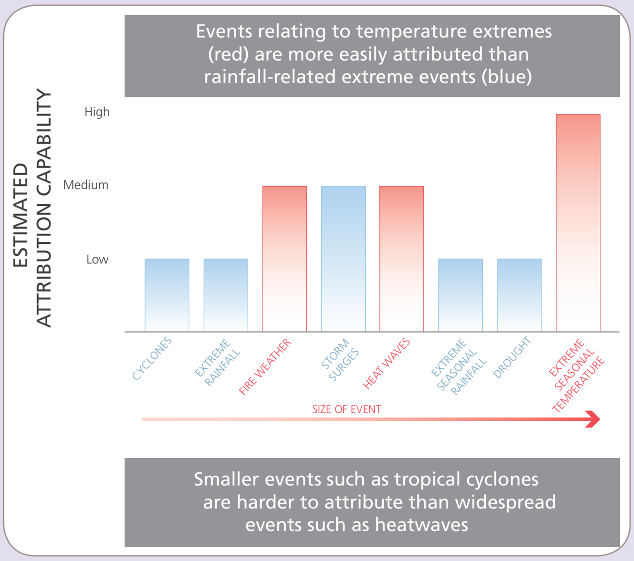


FIGURE 16: Estimated attribution capability for different extreme weather events

Source: Weather extremes and climate change – the science behind the attribution of climatic events (2015) available: climatescience.org.au

Recent examples of weather events attributed to climate change:

- In 2017 New South Wales experienced its hottest summer on record, which was made at least 50 times more likely to occur due to climate change.
- The extreme ocean temperatures that caused the longest global coral bleaching event at the Great Barrier Reef in 2016 were made at least 175 times more likely due to climate change.
- Human-induced climate change increased the likelihood of above 34°C and above 38°C days occurring in Brisbane in November 2014 by at least 25% and 44%, respectively.
- The 2013 Australian heatwaves were made more than 2,000 times more likely to occur due to climate change.

9 | Effective communication and framing

Do:	Don't:
Demonstrate agreement on climate science, as this helps shift the conversation to solutions. For example: '97% of climate scientists agree that climate change is happening and that human activities are the cause' or 'the most trusted scientific authorities, including the CSIRO, the Bureau of Meteorology and NASA, all agree that climate change is already in train'.	Engage in 'belief' and 'debate' framing – creating the impression that the science is questionable or debatable provides a justification for inaction.
Relate climate change to everyday issues set in familiar locations, referring to extreme weather events, human health concerns, agricultural challenges, or property and infrastructure impacts, and using first person language when appropriate. Be sensitive to people impacted. Examples can backfire if you are viewed as exploiting recent tragic events.	Attribute individual events to climate change without scientific proof (as explained in Chapter 8).
Focus on the issues your audience most cares about. Be conscious that people's values and worldviews influence how they view climate change.	Focus on impacts far in the future, physically distant or irrelevant to your audience.
Connect science with solutions – people are more likely to accept the science and less likely to experience dread and apathy if they understand the available solutions and the benefits of taking action. Cite well-known occasions in history on which society has successfully overcome seemingly intractable challenges (such as eradicating polio or implementing the internationally agreed Montreal Protocol to protect the ozone layer), as this inspires people and demonstrates that transformative change is possible.	'Preach' on climate science and impacts without offering hopeful solutions.
Be honest and open. If you do not have the answers admit it, source the correct information or direct your audience towards the relevant resources.	Get bogged down in scientific detail or in protracted public arguments about the accuracy of specific figures.
Use clear examples, appropriate analogies (such as the blanket analogy pg.7) and engaging stories (which most people find more memorable than statistics) to connect climate change issues to core human values.	Overwhelm your audience with statistics and complex science, as you risk 'losing' many of your listeners.
Use age appropriate messaging, providing your audience with clear, accurate information at a level you know they can understand and relate to.	Use concepts and references too obscure, advanced or intimidating for your audience.
Ensure charts and graphs used are clear, easily understandable and appropriate for the age of your audience. Incorporate images of people, as these are often engaging and memorable.	Rely solely on complex charts and graphs, as these often assume prior knowledge and may be less engaging (particularly for young audiences).

10 | Key psychological factors in communicating climate change to young people

These days, children's learning about nature is frequently linked to learning about climate change and other environmental issues. Climate change is often a subject of much concern and discussion amongst adults and in the media. These problems are large, complex to understand and have the potential to bring up strong feelings like fear, anxiety, frustration, anger and despair. It is likely that children are aware of climate change but confused about the impacts they will personally experience. Learning about such issues can cause worries and anxiety. However, children can also quickly understand new problems and can be enthusiastic about putting solutions in place.

10.1 Fear and guilt based messages

Fear and guilt are not useful emotions for encouraging engagement and they often repress people's sense of being able to make any positive impact. This is particularly true for young people, as learning about huge problems like climate change can already be distressing.

10.2 Solutions-focused engagement

Young people's pro-environmental behaviours are directly related to having a sense of duty of care for the environment and to believing their actions will make a difference. While young people need to understand how and why climate change occurs, teaching this topic should incorporate a strong focus on action and solutions. Clearly leading from problems to potential solutions and benefits of action is likely to promote positive emotional responses, motivate engagement and minimise the counterproductive feelings of dread and apathy. It is helpful to make young people aware of opportunities to take action and of the importance of making small as well as big changes.

10.3 Critical thinking

Adolescence is a time when young people are developing their abilities to use abstract and logical thinking. Adolescents have a greater interest in the world and a need to question and digest information in terms of cause and effect. Young people should be taught to critically analyse the information they are consuming, and it is important that their questions are heard, understood and answered sensitively. It is useful to explore their thoughts and ideas with them and to provide them with actions to pursue and resources they can access at home.

10.4 Talking about climate change

Young people are likely to find emotions more motivating than scientific facts, graphs and statistics, and so when these are used they should remain clear and simple. Young people are more likely to connect to the topic if they feel that climate change is important, relevant to them, and that they can do something real about it. Relevant stories, examples and activities are useful in motivating young people to engage in the issue.

10.5 Age appropriate messaging

Environmental messages should be made appropriate to the children's age and learning stage. Most young children are not at a sufficient level of scientific literacy to understand complex issues such as climate change, nor do they have the emotional or psychological maturity to deal with these concepts. Children will often consider how new information will specifically affect them. For example, a child may respond to information about climate change by asking: "will a cyclone come and destroy our house next?" With young children the focus should therefore be on incorporating positive environmental messages into everyday activities, and promoting a general appreciation for nature.

11 | Useful resources

For educators/engagement professionals

Australian Youth Climate Coalition: Youth organisation that provides school talks, workshops and support for student action via their schools program. http://www.aycc.org.au/

Camel Climate: A website for accessing and sharing educational resources to teach climate change. Includes lesson plans, videos and resources on a range of topics. http://camelclimatechange.org/index.html

Climate Change Live: Provides educational resources for teachers and students. https://climatechangelive.org/

Climate Outreach: A series of guides and resources with academic references, but written with practical outcomes in mind. http://climateoutreach.org/resources/communicating-climate-change-adaptation-a-practical-guide-to-values-based-communication/

Climate Reality glossary: An extensive list of climate definitions. http://educators.climatereality.org.au/uploads/1/2/9/4/12943361/primaryresource1.1.pdf

Red Cross – Climate Ready Communities: A South Australian guide for preparing for climate change impacts http://www.redcross.org.au/files/climate-ready-communities-a-guide-to-getting-started.pdf

The Climate Reality Project: Provides lesson plans, videos and resources to teach primary and secondary school students. http://educators.climatereality.org.au/step-by-step-guide1.html

The Guardian newspaper: Has a useful section on its website dedicated to providing clear and concise answers to the most frequently asked questions about climate science. https://www.theguardian.com/environment/climate-change

The Story Group: A collection of climate change stories from around the world, includes useful videos and images. http://thestorygroup.org/category/nationalclimateassessment/

NASA's Climate Kids: Provides activity ideas that can be related to climate change and sustainability. https://climatekids.nasa.gov/menu/teach/

New Scientist magazine: Has a guide to what is known and unknown about climate change science. https://www.newscientist.com/article-topic/climate-change/

For school students

Australian Youth Climate Coalition: Youth climate action network. Opportunities for students to be involved in local action groups and campaigns. http://www.aycc.org.au/

ACT Government Act Smart: Although ACT specific, provides resources for students to learn about climate change and how to take action. http://www.actsmart.act.gov.au/

Climate Change Live: Provides educational resources and games for students. https://climatechangelive.org/

Kids' Crossing – Living in the Greenhouse: Educates students on key climate change concepts. https://eo.ucar.edu/kids/green/warming6.htm

NASA's Climate Kids: Guides kids through a series of climate change and sustainability concepts and questions. Included activities, games and videos. https://climatekids.nasa.gov/greenhouse-effect/

Our changing climate – using climate change information to 2030: Provides a clear explanation of climate variability. http://nespclimate.com.au/wp-content/uploads/2017/10/Using-climate-change-information-to-2030.pdf

Videos

Do the math: Bill McKibben's 3 numbers concerning dangerous climate change. https://www.youtube.com/watch?v=5KtGg-Lvxso

The carbon cycle: https://sustainabilityhub.com/climate/

The Climatedogs: A series of animated dog videos representing different climate processes that drive rainfall variability across Australia. http://www.climatekelpie.com.au/understand-climate/climatedogs

The Story Group – climate change: A collection of powerful stories about Americans experiencing climate change impacts. http://thestorygroup.org/category/videos/nationalclimateassessment/

Weather versus climate change: A useful explanation of the difference. https://www.youtube.com/watch?v=cBdxDFpDp_k

Why 2 degrees Celsius is climate change's magic number: An explanation of the importance of limiting warming to two degrees Celsius above pre-industrial levels to avoiding dangerous climate change (2015). http://www.pbs.org/newshour/bb/why-2-degrees-celsius-is-climate-changes-magic-number/

Glossary

Note: **bolded** terms are defined in the glossary.

Anthropogenic	Resulting from or produced by humans.
Carbon dioxide (CO_2)	A colourless odourless gas formed by the burning of carbon compounds or breathed out by humans and animals in respiration. The burning of fossil fuels to create electricity and produce fuel for transport is increasing the amount of carbon dioxide in the atmosphere.
Carbon footprint	The total amount of **greenhouse gases** added to the atmosphere as a result of an activity, as measured in the equivalent amount of carbon dioxide.
Carbon neutrality	A state of producing no net **greenhouse gas** emissions.
Carbon sinks	Natural systems that absorb **carbon dioxide** from the atmosphere and store it. For example, forests, soils and the oceans.
Climate	The long-term pattern of weather conditions in a particular location.
Climate change	A long-term change to global or regional climate patterns due to increased atmospheric levels of **greenhouse gases**.
Climate change adaptation	Actions that prepare for or respond to the impacts of climate change.
Climate change mitigation	Reducing emissions of **greenhouse gases**, including actions that reduce emissions from a wide range of industrial and agricultural activities, as well as actions that increase the amount of carbon dioxide absorbed and stored in natural **carbon sinks**.
Climate justice	The notion that people experiencing the worst impacts of climate change are often not those contributing the most to it, for example, countries struggling most with the effects of sea level rise are often relatively low per capita **greenhouse gas** emitters.
Dangerous climate change	A degree of climate change in which the risk of impacts is beyond an acceptable level. This level is often associated with the widely agreed upon target of **two degrees** Celsius above average pre-industrial global temperatures.
Enhanced greenhouse effect	The phenomenon by which the **greenhouse effect** is magnified due to human induced increase of **greenhouse gas** emissions, relating to activities such as deforestation and the burning of **fossil fuels**.
Feedback mechanism	When the result of an initial process triggers changes in a second process, which in turn influences the initial one. A positive feedback mechanism intensifies the original process, and a negative feedback mechanism reduces it.
Fossil fuels	Natural sources of energy, including coal, oil and gas, formed from the decayed remains of plants and animals over millions of years.
Global warming	The concept now commonly referred to as **climate change**.
Greenhouse effect	The natural phenomenon whereby **greenhouse gases** prevent some solar radiation from escaping back into the atmosphere and hence warm the Earth.
Greenhouse gases (GHG)	Gases that absorb heat in the Earth's atmosphere. There are around 30 greenhouse gases, of which the primary ones are CO_2, methane and water vapour.
IPCC	Intergovernmental Panel on Climate Change, the most authoritative international body on climate science.
Thermal expansion	The increase in a material's volume as a result of an increase in it's temperature.
Tipping points	Thresholds beyond which climatic systems shift to a new state.
Two degrees warming (2°C)	An internationally agreed threshold for average **global warming** over which **climate change** is likely to become unacceptably dangerous.
Weather	The brief, rapidly changing condition of the atmosphere at a given place and time, influenced by the movement of air masses.

References

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https://www.sei-international.org/mediamanager/documents/A-guide-to-RCPs.pdf

Alliance for Climate https://acespace.org/

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City of Unley – preparing for climate change http://yoursay.unley.sa.gov.au/5815/documents/14106

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Climate change – Department of Environment, Water and Natural Resources
https://www.environment.sa.gov.au/Science/Science_research/climate-change

Climate change definitions http://cwcb.state.co.us/environment/climate-change/Documents/ClimateChangeDefinitions.pdf

Climate change detection and attribution https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch9s9-1-2.html

Climate change impacts in South Australia http://www.environment.gov.au/climate-change/climate-science/impacts/sa

Climate change in Australia https://www.climatechangeinaustralia.gov.au/en/

Climate Change Live https://climatechangelive.org/index.php?pid=180

Climate change: what you can do http://www.psychology.org.au/publications/tip_sheets/climate/

Climate Classroom Kids http://climateclassroomkids.org/educators/climate-101/

Climate Literacy and Energy Awareness Network http://cleanet.org/clean/literacy/climate/index.html

Climate Reality Project Glossary http://educators.climatereality.org.au/uploads/1/2/9/4/12943361/primaryresource1.1.pdf

Climate Reality Project http://www.climatereality.org.au/climate-educators-skillshare.html

Communicating climate change Adaptation: a Practical Guide to Value-based communication
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