Future Australian climate scenarios

By Penny Whetton

Key messages

- Important advances in climate science in recent years, both at the global and the Australian scales, enable us to use computer simulations to explore with increasing confidence the consequences for our climate of various levels of emissions of greenhouse gases from human activities.
- The best estimate of annual average warming by 2030 (above 1990 temperatures) is around 1.0°C across Australia, with warming of 0.7–0.9°C in coastal areas and 1–1.2°C inland.
- Drying is likely in southern areas of Australia, especially in winter, and in southern and eastern areas in spring, due to a contraction in the rainfall belt towards the higher latitudes of the southern hemisphere. Changes in summer tropical rainfall in northern Australia remain highly uncertain.
- Intense rainfall events in most locations will become more extreme, driven by a warmer, wetter atmosphere. The combination of drying and increased evaporation means soil moisture is likely to decline over much of southern Australia. An increase in fire-weather risk is likely with warmer and drier conditions.

Climate models are mathematical representations of the Earth's climate system that are based on the laws of physics and are used to project the future climate. Climate models remain the best tools we have for exploring the climate of the future, even though they have some well-recognised limitations, such as the degree to which they capture the complexity of climate processes. The projections from climate models also depend on the extent of greenhouse gas emissions assumed to occur in the future.

Climate projections for Australia

A number of important advances in climate science have been made in recent years, both at the global and the Australian scales, which enable us to explore with increasing confidence the consequences for our climate of various levels of emissions of greenhouse gases from human activities. Two main uncertainties continue to qualify the projections of future climate, however: the level of humanity's future greenhouse gas emissions; and the precise response of the Earth's climate system to those emissions. These uncertain factors will affect the speed and extent of expected climate change.

As described in Chapter 2, it is already clear that greenhouse gas emissions are growing strongly, with observed emissions from 2000 to 2007 exceeding almost all assumed emission scenarios generated in the late 1990s. Much will depend on whether emissions continue to rise steeply or whether the world's emitters manage to control and reduce emissions.

Climate projections for Australia are based on combining results from the best available of the global climate models (GCMs). These models produce projections for factors such as temperature and rainfall both globally and in individual regions, which is why most projections are usually stated as a range. The range of projections will narrow as the models improve and uncertainty in emissions scenarios and climate dynamics diminishes.

Rainfall is one of the most difficult phenomena to predict, but climate projections suggest increased rainfall in the Earth's mid-to-high latitudes, decreased rainfall in the mid-latitudes around 25–30° north or south of the Equator (where southern Australia sits), and increases near the Equator. All the GCMs generally agree on this, although some draw the boundaries at slightly different latitudes.[1]

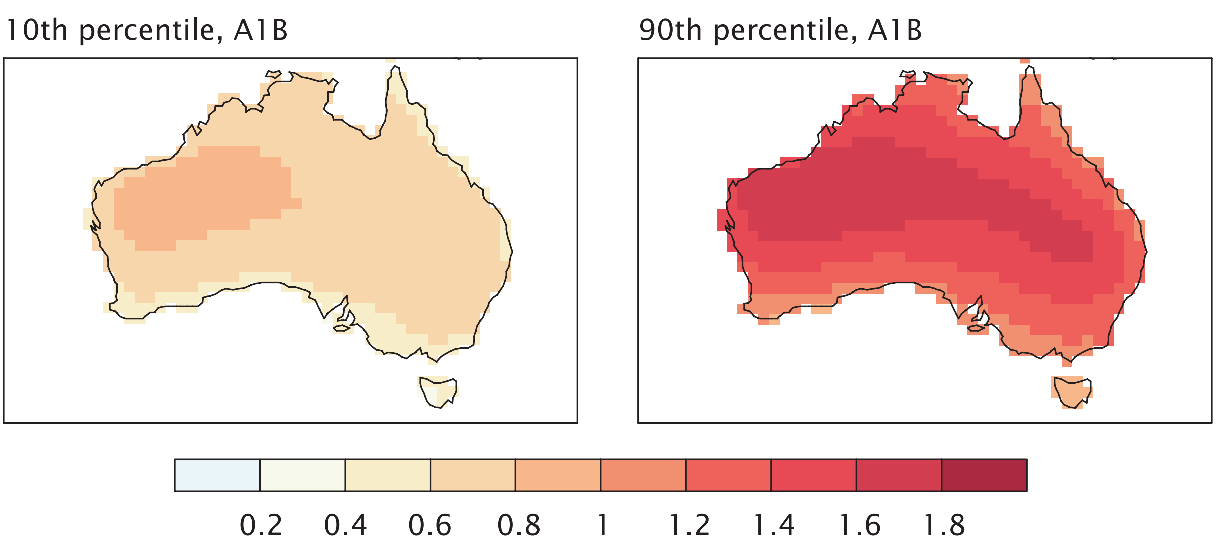
Temperature predictions have a higher degree of confidence than rainfall predictions. The main uncertainty in temperature projections relates to how much CO_2 and other greenhouse gases will be emitted between now and the latter part of this century. All of the GCMs point to global warming, but the pace and extent depend on the level of human emissions and on feedback mechanisms in the Earth's climate system captured in the models. There is a general tendency for warming to be stronger over land than over sea.[1]

Projections for Australia

The Earth already is committed to further warming and climate change due to existing greenhouse gas concentrations in the atmosphere, irrespective of any future increases. The general expectations are described below and are drawn from the *Climate change in Australia* technical report from CSIRO and the Bureau of Meteorology in 2007.[2]

Temperature

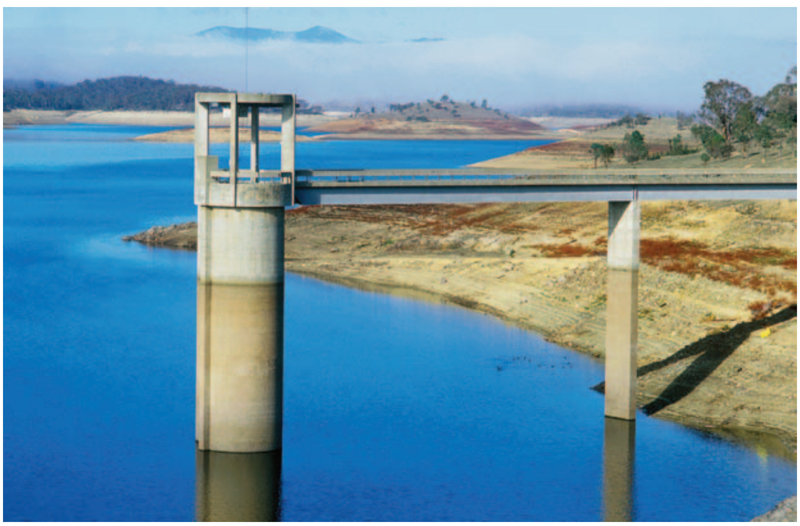
The best estimate of annual average warming by 2030 (above 1990 temperatures) is around 1.0ºC across Australia, with warming of 0.7–0.9ºC in coastal areas and 1–1.2ºC inland. The range of uncertainty is about 0.6–1.5ºC in each season for most of Australia. Projected warming by 2050 ranges from 0.8 to 1.8ºC (low greenhouse gas emission scenario) and 1.5 to 2.8ºC (high greenhouse gas emission scenario). By 2070 warming is expected to be between 2.2ºC (low greenhouse gas emissions scenario) and 5ºC (high emissions). Figure 3.1 illustrates the spatial distribution of high and low warming estimates for 2030.



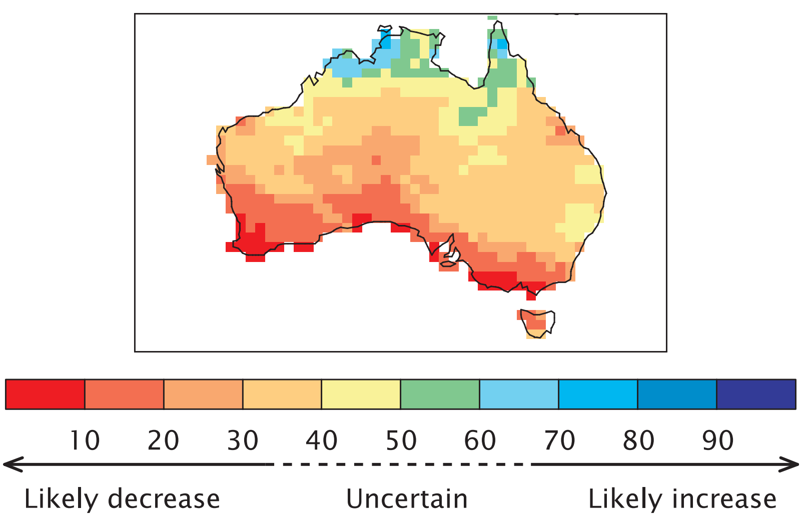
▲ ***Figure 3.1***: *Projected changes in annual average temperatures across Australia in 2030 (compared with 1990). Image at left shows the warming very likely to be exceeded (10% of model results show less warming) and the image at right shows the warming that is very unlikely to be exceeded (90% of model results show less warming).*

Rainfall

Climate models indicate that there is likely to be less rainfall in southern areas of Australia, especially in winter, and in southern and eastern areas in spring, caused by the contraction in the rainfall belt towards the higher (more southern) latitudes (Figure 3.2). Future changes in summer tropical rainfall in northern Australia remain highly uncertain. It is also likely that the most intense rainfall events in most locations will become more extreme, driven by a warmer, wetter atmosphere.



Gregory Heath/CSIRO



◂ ***Figure 3.2***: *Percentage of climate modelling experiments showing future increases in annual precipitation. In general, this gives an indication of the likely direction of precipitation change (but not magnitude of change). Widespread likely decreases are shown for southern Australia.*

Regional climate changes

The following regional snapshots[2] exemplify how these general projections of broad scale trends in climate are most likely to play out as changes in particular parts of the continent. The range of values depicting likely changes is due to an allowance for uncertainty in future emissions of greenhouse gases and the response of the climate system. The examples of potential impacts that may affect these regions have been drawn from various studies.

New South Wales and ACT

- Average stream flow decreases across the Murray–Darling Basin by 2030.
- 10–40% increase in the number of extreme fire danger days in Canberra by 2020.
- Annual heat-related deaths in Sydney rise from 176 (1990s) to 364–417 by 2020.

Sydney	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	18.3	19.2 (18.9–19.6)	19.9 (19.4–20.5)	21.3 (20.5–22.6)
No. days over 35ºC	3.5	4.4 (4.1–5.1)	5.3 (4.5–6.6)	8.2 (6–12)
Annual rainfall (mm)	1277	1238 (1162–1315)	1225 (1098–1340)	1174 (957–1404

Victoria

- Area inundated by a 1-in-100-year storm surge in Gippsland may increase 15–30% by 2070.
- Area with at least one day of snow cover per year on average shrinks 10–40% by 2020 and 20–85% by 2050.
- 20–65% increase in the number of extreme fire danger days in the Bendigo region by 2020.
- Potential doubling in the number of days over 35ºC in Melbourne by 2070.

Melbourne	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	15.7	16.6 (16.3–16.9)	17.1 (16.7–17.7)	18.5 (17.6–19.5)
No. days over 35ºC	9.1	11.4 (11–13)	14 (12–17)	20 (15–26)
Annual rainfall (mm)	654	628 (596–661)	615 (563–668)	582 (491–674)

South-East Queensland

* Less water for cities, industries, agriculture, and natural ecosystems.
* Less frost damage to crops, higher wheat yields but lower wheat quality, increased pest and disease risk.
* 20% increase in intensity of a 1-in-100-year rainstorm could, for example, inundate 7000 properties in the Nerang catchment in southern Queensland.

Bruce Miller/CSIRO

Brisbane	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	20.5	21.5 (21.2–21.9)	22.1 (21.6–22.8)	23.6 (22.6–24.9)
No. days over 35ºC	1.0	2.0 (1.5–2.5)	3.0 (2.1–4.6)	7.6 (4–21)
Annual rainfall (mm)	1192	1109 (978–1230)	1133 (978–1300)	1085 (799–1395)

Southern South Australia

* Sea-level rise may increase the cost of sand replenishment on Adelaide beaches.
* Farming of land at the drier fringe likely to be increasingly marginal if rainfall declines substantially.
* Grape quality in the Barossa Valley likely to decline due to higher temperatures.
* Potential doubling in the number of days over 35ºC in Adelaide by 2070.

Adelaide	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	16.5	17.4 (17.1–17.8)	18.0 (17.5–18.6)	19.3 (18.4–20.5)
No. days over 35ºC	17	23 (21–26)	26 (24–31)	36 (29–47)
Annual rainfall (mm)	463	444 (412–472)	430 (379–481)	403 (315–500)

South-west Western Australia

- Decline in annual stream flow.
- Wheat yield significantly reduced by 2070.
- Potential almost doubling of the number of days over 35ºC in Perth by 2070.

Perth	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	18.5	19.3 (19.1–19.7)	19.9 (19.5–20.5)	21.2 (20.4–22.3)
No. days over 35ºC	28	35 (33–39)	41 (36–46)	54 (44–67)
Annual rainfall (mm)	747	702 (650–754)	665 (590–754)	605 (471–762)

Northern coastal Queensland

- Sea-level rise likely to cause salt-water intrusion and inundation in some Torres Strait Islands.
- Significant loss of biodiversity in the Great Barrier Reef and Queensland Wet Tropics by 2020.
- Risk of inundation by a 1-in-100-year storm surge in Cairns area may more than double by 2050.

Cairns	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	24.9	25.8 (25.5–26.1)	26.4 (26.0–26.9)	27.8 (26.9–28.8)
No. days over 35ºC	3.8	6.6 (5.4–9.1)	12 (8–22)	44 (19–96)
Annual rainfall (mm)	2112	2112 (1943–2281)	2091 (1816–2387)	2091 (1584–2640)

Tasmania

- 21% of the Tasmanian coast is at risk of erosion and recession from sea-level rise.
- Strengthening of the East Australian Current may result in subtropical marine species moving into temperate waters, altering the habitat of many species.
- Changes in climate will favour a shift to warm-season grape varieties.

Hobart	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	13.0	13.6 (13.4–13.9)	14.1 (13.7–14.5)	15.1 (14.5–15.9)
No. days over 35ºC	1.4	1.7 (1.6–1.8)	1.8 (1.7–2.0)	2.4 (2.0–3.4)
Annual rainfall (mm)	576	571 (542–594)	559 (519–600)	542 (467–623)

Top End

- Remote area communities to face increased exposure to heat stress, fire, diseases, extreme rainfall events, and flooding.
- 80% loss of biodiversity in Kakadu wetlands for a 30 cm sea-level rise.

Darwin	Present average (1971–2000)	2030 average (mid emissions)	2070 average (low emissions)	2070 average (high emissions)
Annual temperature (ºC)	27.8	28.8 (28.5–29.2)	29.5 (29.0–30.1)	31.0 (30.1–32.2)
No. days over 35ºC	11	44 (28–69)	89 (49–153)	227 (141–308)
Annual rainfall (mm)	1847	1847 (1718–1960)	1829 (1644–2032)	1829 (1459–2217)

Extreme events

The combination of drying and increased evaporation means that soil moisture is likely to decline over much of southern Australia. The frequency of very dry conditions is expected to increase in Victoria and Tasmania and south-west Western Australia, based on 13 climate model simulations over the period 2010–2040.[3]

An increase in fire-weather risk is likely with warmer and drier conditions. Simulations show that the number of days with very high fire danger ratings increases by 2% to 30% by 2020 and by 5% to 100% by 2050. The number of days with extreme fire danger ratings increases between 5% and 65% by 2020 and between 10% and 300% by 2050. For example, Canberra may have an annual average of 19 to 25 very high or extreme fire danger days by 2020 and 22 to 38 days by 2050, compared with the present average of 17 days. It is also likely that the fire season will lengthen over and above this likely increase in frequency of fire-weather days.[4]

CSIRO

There is potential for significant increases in flooding due to higher mean sea level and more intense weather systems. Studies in the Australian region point to a likely increase in the proportion of tropical cyclones in the more intense categories (category 4 or 5), but a possible decrease in the total number of cyclones per year.

Abrupt changes and tipping points

Climate change does not proceed smoothly for a given change in radiative forcing from changing greenhouse gas levels. There is a risk of abrupt changes as the climate shifts from one state to another as a result of feedbacks in the climate system. This raises the possibility of events such as major changes in the ocean's thermohaline circulation: the global ocean current that distributes heat around the planet, leading to step-changes in warming or in extreme events. These are known as tipping points. Their hazard lies in the fact that, once they have occurred, it may be hard for the planet to return to its previous steady state. For example, once Greenland's ice cap is committed to melting it is unlikely to reform for thousands of years, leading eventually to sea-level rises of several metres.

Conclusion

Australia's climate projections have been under development for more than 20 years. They are achieved by combining the output from global climate models from around the world with those developed specifically in Australia, to produce projections with a range of most likely outcomes, as described above.

These projections can then be used to assess the possible impacts of climate change on our society, economy, and the environment by examining the implications of a changing climate on agricultural production, water availability, health-care issues, bushfire danger, and vulnerability to storms or flood damage at national and regional level.

Understanding the likely future changes to climate makes it possible to start drawing up action plans at national, state, regional, and local levels to adapt to the most likely changes. The difficulty of projecting changes in local climate conditions with accuracy should not be underestimated, however, which would make it sensible to prepare for a range of possible eventualities. Considerations of climate impacts and how to adapt to these are covered in the ensuing chapters.

Further reading

CSIRO (2008). A summary of probable climate change impacts around Australia. http://www.climatechangeinaustralia.gov.au/documents/resources/Climate_change_poster.pdf.

CSIRO (2008) *Water availability in the Murray-Darling Basin. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project*. CSIRO, Australia. http://www.csiro.au/partnerships/MDBSY.html.

CSIRO and Bureau of Meteorology (2007) *Climate change in Australia*. Technical Report. www.climatechangeinaustralia.gov.au.

Hennessy KJ, Fawcett R, Kirono DGC, Mpelasoka FS, Jones D *et al*. (2008) *An assessment of the impact of climate change on the nature and frequency of exceptional climatic events.* CSIRO Marine and Atmospheric Research, Aspendale. http://www.daff.gov.au/__data/assets/pdf_file/0007/721285/csiro-bom-report-future-droughts.pdf.

Lucas C, Hennessy KJ and Bathols JM (2007) *Bushfire weather in Southeast Australia: recent trends and projected climate change impacts*. Bushfire CRC, Melbourne.