

# PROJECTING AUSTRALIAN CLIMATE CHANGE

# 5

## Key points

Australia's dry and variable climate has been a challenge for the continent's inhabitants since human settlement.

Temperatures in Australia rose slightly more than the global average in the second half of the 20th century. Streamflow has fallen significantly in the water catchment areas of the southern regions of Australia. Some of these changes are attributed by the mainstream science to human-induced global warming.

Effects of future warming on rainfall patterns are difficult to predict because of interactions with complex regional climate systems. Best-estimate projections show considerable drying in southern Australia, with risk of much greater drying. The mainstream Australian science estimates that there may be a 10 per cent chance of a small increase in average rainfall, accompanied by much higher temperatures and greater variability in weather patterns.

Australia is a vast continent characterised by high regional and seasonal climate variability. It has a wide range of ecosystems within its borders, from tropical to alpine and Mediterranean to arid desert. There are multiple influences on Australia's climate, ranging from the global, to the regional, such as the El Niño – Southern Oscillation, and the local, such as the Great Dividing Range.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (2007) have undertaken major work projecting Australia's future climate. The Review commissioned the CSIRO to extend its projections for a number of variables out to 2100 on the basis of the Review's projections of emissions, as utilised in Chapter 6,<sup>1</sup> under a no-mitigation and specified global mitigation cases.

## 5.1 Attributing climate change to humans

For climate variables that exhibit only a limited range of natural variability, small deviations can be significant. The role of human influence can be attributed with some confidence. Global average temperature is one such factor.

Changes in climate variables such as rainfall, which can exhibit high interannual and interseasonal variability, are much harder to attribute in this way. For these it is difficult to distinguish the human-induced element from natural variability. Changes in climate variables that manifest themselves over longer timescales, such as decades or centuries, are harder still to attribute to human activity (CSIRO & BoM 2007).

Single events, such as an intense tropical cyclone or a long-lived heatwave, cannot be directly attributed to climate change. Climate change may, however, affect the factors that lead to such events. It may make certain events, like the heatwave that occurred in Adelaide during the summer of 2007–08, more likely (CSIRO & BoM 2007).

Some changes in the Australian climate system have been attributed to human-induced climate change. Examples include the increase in average temperatures since the middle of the 20th century. Up to 50 per cent of the reduction in rainfall in the south-west of Western Australia, and of the decline in snow cover in the south-east Australian alpine region, has been attributed to human-induced climate change (CSIRO & BoM 2007; Cai & Cowan 2006).

Rainfall decline in other parts of the country, such as south-east Australia, has not been definitively attributed to human-induced climate change. By contrast, the higher temperatures that have accompanied and exacerbated the effects of drought conditions have been so attributed.

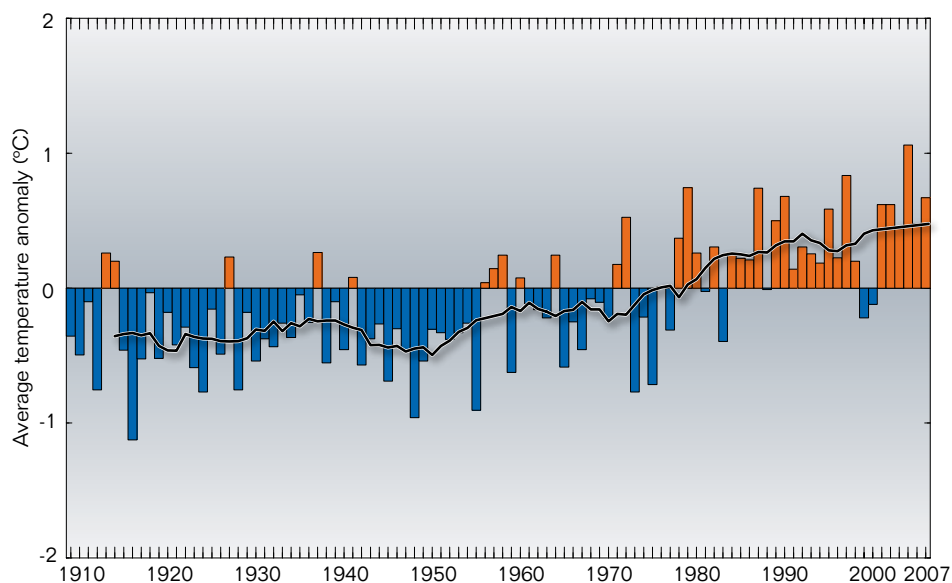
## 5.2 How has the climate changed in Australia?

Over the last century, and the last 50 years in particular, marked changes have been observed in a number of key climate variables.

### 5.2.1 Temperature

Annual average temperature in Australia has increased by 0.9°C since 1910 (CSIRO & BoM 2007). Figure 5.1 shows Australian annual average temperature anomalies from 1900 to 2007.

The warming tendency since the middle of the 20th century has not been uniform across the country. The greatest warming has occurred in central Australia (Murphy & Timbal 2008). In south-eastern Australia, average maximum temperatures have increased. As a result, droughts have become hotter, with effects on rainfall, evaporation and runoff, and, more generally, water availability for human use (Nicholls 2004).

**Figure 5.1 Australian annual average temperature anomalies, 1910–2007**

Note: The data show temperature difference from the 1961–90 average. The black line shows the eleven-year running averages.

Source: BoM (2008).

Ocean temperature has changed at a slower pace, due to the ocean's large heat content and enhanced evaporative cooling. Nevertheless, substantial warming has occurred in the three oceans surrounding Australia. The Indian Ocean is warming faster than all other oceans, with significant warming off the coast of Western Australia (CSIRO & BoM 2007).

### 5.2.2 Rainfall

There has been a major change in rainfall patterns since the 1950s, with large geographic variation. North-west Australia has seen a significant increase in annual rainfall, whereas most of the eastern seaboard and south-west Australia have seen a significant decrease (CSIRO & BoM 2007). Rainfall changes over the longer period from 1900 to 2007 are generally positive and are largest in the north-west. Drying tendencies over this period are evident in south-west Australia, some other parts of southern Australia, including much of Tasmania, and over much of north-east Australia.

In Australia, the rate of change in the frequency and intensity of rainfall extremes is greater than the rate of change for average rainfall (Alexander et al. 2007).

The rainfall decline observed in the 1990s in south-east Australia shares many characteristics with the decline in the south-west, but has only recently become the subject of extensive research (CSIRO & BoM 2007). The factors affecting rainfall decline in the south-east appear more complex. This region is affected to

a greater extent by major systems such as the El Niño – Southern Oscillation and the subtropical ridge (Murphy & Timbal 2008) (see Box 5.1).

Rainfall can be affected by anthropogenic emissions other than greenhouse gases. It has been suggested that the increased rainfall in the north-west of Australia could be attributed to aerosols drifting south from Asia. Aerosols can create a localised cooling effect, which in turn affects convection and rainfall patterns (Rotstajn et al. 2007).

### **Box 5.1 Drought in Australia**

Drought can be defined in many ways. The main contributing factors for all definitions, however, are rainfall, temperature and evaporation. Due to the strong connection between anthropogenic emissions and warming in Australia, the CSIRO and the Bureau of Meteorology (2007) have concluded that the drought in many parts of the country is linked to, or at least exacerbated by, global warming.

Drought can have many causes. For example, the drought in south-west Western Australia has been attributed to a combination of natural variability, an increase in greenhouse gas concentrations, and land-use change (Timbal et al. 2006).

In south-east Queensland, the drought appears to have been caused by changes in two key climate variables: the El Niño – Southern Oscillation and tropical cyclones (Department of Natural Resources and Water 2007). Since 1950, there has been a strong decline in rainfall across eastern Australia, and since 1977 there has been an increase in the frequency of El Niño events (Power & Smith 2007). This shift in the system's El Niño behaviour has been related to a reduction in the number of tropical cyclones in the region. Over time, such cyclones contribute a large amount to total rainfall.

Since 1997, south-east Australia has recorded a number of changes in average rainfall (Murphy & Timbal 2008; B. Timbal 2008, pers. comm.):

- From 1997 to 2007 only one year had rainfall above the 1961–90 annual average.
- Only one autumn from 1990 had rainfall above the 1961–90 autumn average (a critical rainfall period for the establishment of crops).
- Melbourne streamflows have been below the long-term average every year since 1996 (Timbal & Jones 2008).

A similar decline in annual average rainfall in south-east Australia has occurred once before in historical records (Murphy & Timbal 2008; B. Timbal 2008, pers. comm.). This was for the period 1936–45. However, the current drought is marked by reduced interannual variability and an increase in average maximum temperatures, affecting evaporation and further reducing streamflows.<sup>2</sup>

### Box 5.1 Drought in Australia (*continued*)

The decline in autumn rainfall in south-east Australia has strong qualitative similarities with the decline observed in the 1970s in Perth (Murphy & Timbal 2008). Unlike south-west Western Australia, however, the south-east of Australia is affected by several climate systems including the El Niño – Southern Oscillation and the Southern Annular Mode. There is currently no consensus on the magnitude of the influence of these systems, or on how they will respond to global warming (Murphy & Timbal 2008; Timbal & Murphy 2007; Cai & Cowan 2008a; Hendon et al. 2007). One estimate is that the El Niño – Southern Oscillation and the Southern Annular Mode each account for around 15 per cent of the observed rainfall variability in south-west Australia during winter and in south-east Australia during winter, spring and summer (Hendon et al. 2007).

It has recently been suggested that increased temperature has a large impact on streamflow. After accounting for interdependencies, such as the effect of rainfall and clouds on minimum temperatures, Cai and Cowan (2008b) conclude that a 1°C increase in maximum temperature results in a 15 per cent decrease in streamflow in the Murray-Darling Basin.

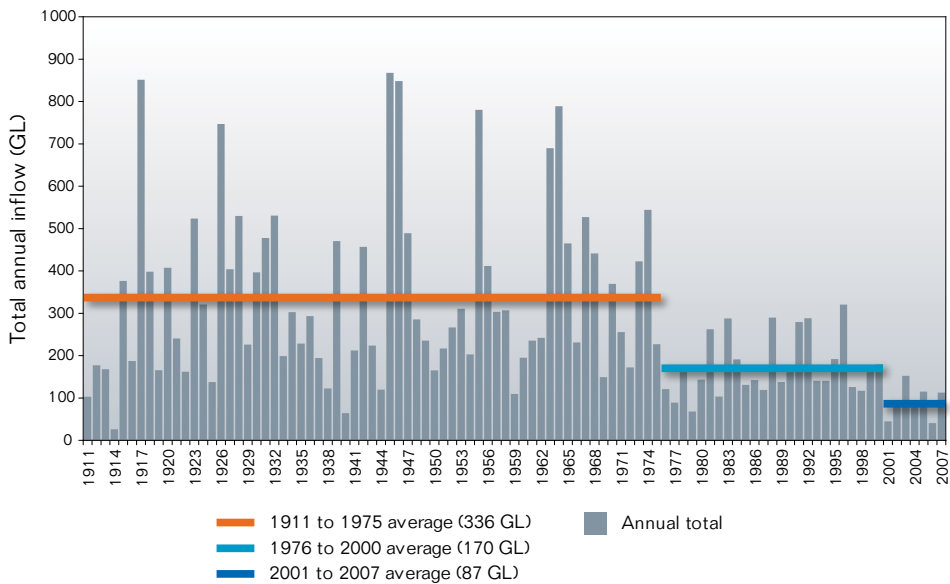
### Streamflows

A reduction in rainfall results in a proportionately larger fall in streamflows. Generally, a decrease in rainfall can result in a two- to threefold decrease in streamflow (Chiew 2006). In the Murray-Darling Basin, a 10 per cent change in rainfall has been found to result in a 35 per cent change in streamflow (Jones et al. 2001).

Low streamflows have been recorded in the rivers supplying most major urban water storage systems over the last decade (Water Services Association of Australia 2007). For Melbourne, Sydney, Brisbane, Adelaide and Canberra, average streamflows over the period 1997–2007 are notably below the long-term average.<sup>3</sup> The period of the long-term average is between 84 and 108 years, depending when measurements began. Recent streamflows supplying Canberra are 43 per cent of the long-term average, in Melbourne 65 per cent, Adelaide 62 per cent, Sydney 40 per cent and Brisbane 42 per cent.

The greatest, and earliest, decline in streamflows of rivers supplying major urban water storages has been observed in Perth (Figure 5.2). There has been a marked decline since the 1970s, which has continued and appears to have intensified over the last decade. Annual streamflows over recent years (2001–07) are only 25 per cent of the long-term average before this observed decline. The decline in rainfall in the region, which occurred at approximately the same time, has been partly attributed to human-induced climate change (Cai & Cowan 2006).

**Figure 5.2 Annual streamflows into Perth’s dams (excluding Stirling and Samson dams)**



Note: Values represent totals for May–April.

Source: Western Australia Water Corporation (2008).

### 5.2.3 El Niño – Southern Oscillation and the Southern Annular Mode

#### El Niño – Southern Oscillation

The El Niño – Southern Oscillation is a naturally occurring phenomenon that temporarily disrupts climate patterns in many countries in the Pacific and Asia, including Australia (Power et al. 2006; Ropelewski & Halpert 1984; Nicholls 1992; Allan et al. 1996). It is often monitored using the Southern Oscillation Index, which is a measure of the difference in mean sea-level pressure across the Pacific Ocean, between Darwin and Tahiti. In Australia, a positive sustained index is associated with stronger trade winds, increased rainfall and flooding, and decreased temperatures across eastern Australia (Power et al. 1998). This is known as a La Niña episode. A negative index is associated with warmer than normal sea surface temperatures in the eastern Pacific, weaker trade winds, and a reduction in rainfall in eastern and northern Australia. This is known as an El Niño episode (BoM 2005; Power & Smith 2007).

Many major Australian droughts are associated with an El Niño event, though not all El Niño events trigger a drought. The effect of the El Niño – Southern Oscillation on climate varies across the country. South-west Western Australia, the west coast of Tasmania and coastal New South Wales are affected less than inland eastern Australia (BoM 2005).

The impact of the El Niño – Southern Oscillation on Australia varies substantially from decade to decade and generation to generation. There was a record high number of El Niño events in the period 1977–2006 and a corresponding record low number of rain-bearing La Niña events. This is the most El Niño-dominated period on record (Power & Smith 2007).

The extent to which the decline in the Southern Oscillation Index is influenced by global warming is unknown. Some climate models anticipate weakened trade winds in response to global warming (Vecchi et al. 2006), so global warming may be contributing to some of the observed changes evident in and around the tropical Pacific (Power & Smith 2007).

### **Southern Annular Mode**

Another dominant driver of variability at high southern latitudes is the Southern Annular Mode. When this mode is in its positive phase, there will be weaker westerly winds in southern Australia and stronger westerly winds at high latitudes (CSIRO & BoM 2007).

The Southern Annular Mode and the El Niño – Southern Oscillation are estimated to drive approximately 15 per cent each of the variability in winter rainfall in south-west Australia and in winter, spring and summer rainfall in south-east Australia (Hendon et al. 2007).

Over recent decades, the Southern Annular Mode has spent more time in its positive phase (CSIRO & BoM 2007). The positive phase is associated with significantly reduced winter rainfall in southern Australia and significant rainfall increases in the Murray-Darling Basin in summer (Hendon et al. 2007).

This shift has led to a decrease in the potential for storm formation over southern Australia. In south-west Australia, a decrease in the number of rain-bearing synoptic systems and a deflection southward of some storms is associated with a reduction in winter rainfall (CSIRO & BoM 2007).

## **5.2.4 Other climate variables**

### **Cyclones and storms**

Tropical cyclones in Australia are subject to multidecadal variability in frequency and intensity (CSIRO & BoM 2007). When this variability is combined with the varying quality of historical records it becomes difficult to draw definitive conclusions on whether observed changes in tropical cyclones can be attributed to climate change (B. Buckley 2008, pers. comm.).

Similarly, hailstorms are highly sensitive to small-scale variations in meteorological and oceanographic conditions, as well as to other factors. Data collection methods have not yet evolved to allow rigorous climate change analyses and attribution.

Limited observations suggest that there was a substantial increase in tropical cyclone numbers on the east coast in the 1950s, followed by a reduction in the 1970s. This reduction appears to be linked to an increasing number of El Niño events. In general, there are fewer tropical cyclones in Australia during El Niño than during La Niña (CSIRO & BoM 2007).

On the west coast, there appears to have been an increase in the proportion of severe (category 3 and 4) cyclones (CSIRO & BoM 2007). During the period 1974–88, severe cyclones accounted for 29 per cent of the total. In the period 1989–98 they accounted for 41 per cent.

## Bushfires

During the period 1973–2007, there was a general increase in the Forest Fire Danger Index across the east and south-east of the country. A recent review of 23 measuring locations over this period analysed the three years with the highest index (Lucas et al. 2007). Fifty out of 69 of the selected years were after the year 2000, with the increasing trend statistically significant above the 95 per cent probability level for most inland locations.

### Box 5.2 Heatwaves

The number of hot days and warm nights per year has increased since 1955 (CSIRO & BoM 2007) and heatwaves have become increasingly common (Lynch et al. 2008).

In February 2004, for example, maximum temperatures were 5–6°C above average throughout large areas, reaching 7°C above average in parts of New South Wales (National Climate Centre 2004). Adelaide had 17 successive days over 30°C (the previous record was 14 days). Sydney had 10 successive nights over 22°C (the previous record was six). Around two-thirds of the continent recorded maximum temperatures over 39°C and temperatures peaked at 48.5°C in western New South Wales (Lynch et al. 2008).

In March 2008, Adelaide had 15 consecutive days of 35°C or above and 13 consecutive days of 37.8°C or above, surpassing the previous record of eight and seven days respectively. Hobart matched its previous record high temperature of 37.3°C and Melbourne recorded a record high overnight minimum of 26.9°C (National Climate Centre 2008).



## 5.3 Projected climate change in Australia

In assessing projections of climate change in Australia, the Review used a combination of the IPCC SRES scenarios, as used by the CSIRO and the Bureau of Meteorology (2007), and global mitigation cases based on stabilisation of greenhouse gas concentrations at 450 and 550 parts per million carbon dioxide equivalent. Emissions scenarios are based on global models that are necessarily simplified. Given the significant uncertainty in the timing of temperature increases, actual outcomes are unlikely to exactly match a given scenario or case.

The future climate is a function of both human-induced climate change and natural climate variability. In some decades natural variability will reinforce the climate change signal. In other decades, it will offset the signal to some degree.

Projections of global average temperature across different emissions cases show little variation up to the decade beginning in 2030. Australian average temperature responds in a similar fashion. After this point, projections of climate variables are increasingly dependent on emissions pathways.

There is no consensus among models as to how climate change will affect the El Niño – Southern Oscillation (see IPCC 2007: 779–80; CSIRO & BoM 2007; Lenton et al. 2008). In some models it intensifies, while in others it weakens.

### 5.3.1 Temperature

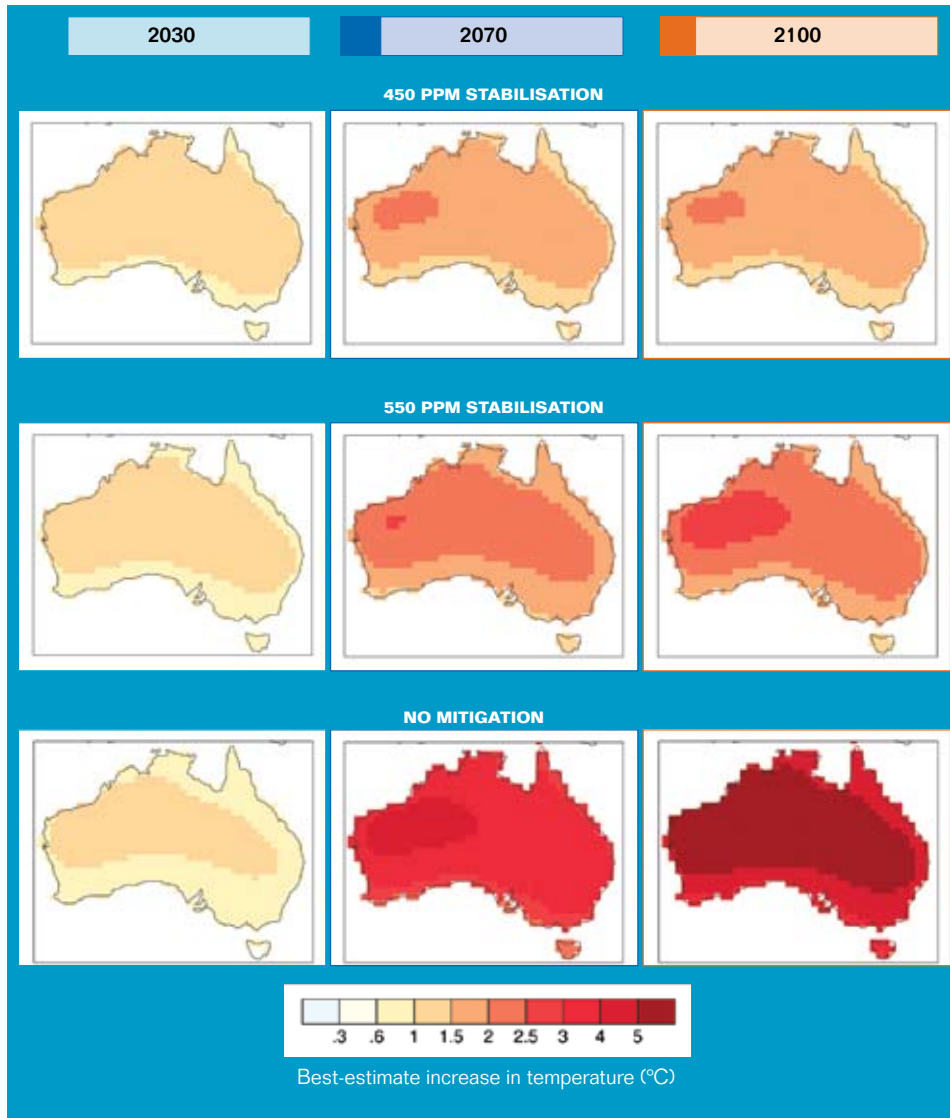
Annual average temperatures in Australia are expected to rise in parallel with rises in global average temperature. Significant regional variation, however, is projected across Australia. In general, the north-west is expected to warm more quickly than the rest of the country.

By 2030, annual average temperature over Australia will be around 1°C above 1990 levels (CSIRO & BoM 2007).<sup>4</sup> The range of uncertainty (10th to 90th percentiles) produces a national increase of between 0.4°C and 1.8°C for 2030. Coastal areas will experience slightly less warming (in the range 0.7–0.9°C), whereas inland Australia will experience greater warming (in the range 1.0–1.2°C).

From 2030 to the end of the century there are marked differences between emissions cases. This is shown in Figure 5.3, which considers the best-estimate 50th percentile.

By 2100, at both the 10th and 90th percentile outcomes, there are noticeable temperature increases across the country in a no-mitigation case. The 90th percentile of outcomes includes an increase of more than 7°C in some areas. The 10th percentile of outcomes shows an increase of more than 3°C for most of the country, increasing to 4.9°C over an extensive area in north-west Australia.

**Figure 5.3** Best estimate (50th percentile) of Australian annual temperature change at 2030, 2070 and 2100 under three emissions cases



Note: The no-mitigation case is based on the SRES A1FI scenario. Values greater than or equal to 5 are represented with the same colour.

Source: CSIRO (2008c).

### 5.3.2 Rainfall

The relationship between local precipitation and atmospheric temperature is complex. Local rainfall patterns are highly sensitive to the amount of water available for evaporation, the local topography and land cover, and atmospheric and ocean circulation patterns. At the global level, a decrease in precipitation is indicated as the best-estimate outcome for Australia. However, because of the localised nature of influences on precipitation, there is considerable regional variation in precipitation change within Australia. Some areas are expected to experience an increase in rainfall. The complexities also lead to disagreement among climate models about the potential extent, and even direction, of the change.

#### Best-estimate annual average change in rainfall

Table 5.1 shows the median or best-estimate (50th percentile) annual average rainfall outcomes for Australia in a no-mitigation case in 2030, 2070 and 2100.<sup>5</sup> The best-estimate outcomes of change in annual average rainfall in 2030 are minimally different between the different climate cases due to climate change commitments (see section 4.3.1), but later in the century the rainfall outcomes are more dependent on the level of mitigation. The changes under the 550 and 450 global mitigation cases follow the same patterns, but the reductions are considerably more subdued. The extent of rainfall change under the 450 mitigation case in 2100 is less than under the no-mitigation case in 2070.

**Table 5.1 Projected changes to statewide annual average rainfall, best-estimate outcome in a no-mitigation case (per cent change relative to 1990)**

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT
2030	-2.5	-3.5	-2.4	-4.2	-4.1	-1.4	-2.5	-2.8
2070	-9.3	-12.9	-8.6	-15.5	-14.9	-5.1	-9.0	-10.3
2100	-13.7	-19.0	-12.7	-22.8	-21.9	-7.6	-13.3	-15.2

Source: CSIRO (2008b).

#### The 'dry' and 'wet' ends of precipitation projections

The best-estimate outcomes do not reflect the extent of the uncertainty in potential rainfall outcomes for Australia under climate change. Rainfall projections are highly sensitive to small changes in model assumptions and inputs. The range of precipitation outcomes predicted by various climate models for Australia is large.

Table 5.2 shows the average annual changes for rainfall in Australia for the no-mitigation case for the 'dry' (10th percentile) and 'wet' (90th percentile) ends of projections in 2030, 2070 and 2100.

**Table 5.2 Projected changes to statewide average rainfall, dry and wet outcomes in a no-mitigation case (per cent change relative to 1990)**

**Dry outcome (10th percentile)**

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT
2030	-10.1	-8.3	-11.5	-13.1	-12.7	-5.2	-11.4	-8.2
2070	-37.0	-30.3	-42.0	-48.0	-46.5	-19.2	-41.8	-30.1
2100	-54.6	-44.7	-61.8	-70.8	-68.5	-28.3	-61.6	-44.4

**Wet outcome (90th percentile)**

	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT
2030	4.2	0.9	6.0	4.0	4.2	2.6	6.0	2.0
2070	15.5	3.4	22.0	14.8	15.5	9.5	22.0	7.4
2100	22.8	5.1	32.5	21.9	22.8	14.0	32.4	10.9

Source: CSIRO (2008b). The methodology for the preparation of these distributions is described in CSIRO & BoM (2007).

**Temporal variation in rainfall**

Changes in annual rainfall often mask significant interseasonal variation. Similarly, average annual rainfall may mask changes in rainfall patterns, rainfall intensity and the number of rain events. For example, it is possible for average annual rainfall to remain the same while rain intensity increases and the number of rain days decreases (see Pitman & Perkins 2008).

In summer and autumn, rainfall decreases are more limited and some areas experience slight increases. Larger decreases in rainfall are experienced in winter and spring (CSIRO & BoM 2007).

As well as changes to annual average rainfall, the character of daily rainfall may change. There is expected to be an increase in the intensity of rainfall events in some areas, and the number of days without rainfall is also expected to increase. This suggests that the future precipitation regime may have longer dry spells broken by heavier rainfall events (CSIRO & BoM 2007; Pitman & Perkins 2008).

Consideration of a progressive change in annual average rainfall does not reflect the considerable interannual and decadal variation in Australian rainfall. In terms of precipitation, observed decadal variability in the 20th century and models run with a no-climate-change assumption show natural variability in rainfall of between 10 and 20 per cent (CSIRO & BoM 2007). Natural variability may therefore mask, or exaggerate, changes that are due to high concentrations of greenhouse gases.

Variation in the intensity and temporal pattern of daily rainfall, differences in seasonal change, and the influence of natural decadal variability could have considerable impacts on sectors such as agriculture and infrastructure.

### 5.3.3 Other climate variables

#### Cyclones and storms

Tropical cyclone frequency and intensity display high variability across seasonal, annual, decadal and longer timescales (CSIRO & BoM 2007). The El Niño – Southern Oscillation has a strong effect on tropical cyclone numbers (Abbs et al. 2006). Since it is as yet unknown what effect climate change will have on the El Niño – Southern Oscillation, it is difficult to project changes in the frequency and intensity of tropical cyclones.

Studies suggest that the frequency of east coast cyclones will either remain the same or decrease by up to 44 per cent (see CSIRO & BoM 2007). Abbs et al. (2006) estimate that category 3–5 storms will increase in intensity by 60 per cent by 2030 and 140 per cent by 2070.

Projections also indicate that the regions of east Australian cyclone genesis could shift southward by two degrees latitude (approximately 200 km) by 2050 (Leslie et al. 2007), while the average decay location could be up to 300 km south of the current location (Abbs et al. in CSIRO & BoM 2007). Models estimate that the number of strong cyclones reaching the Australian coastline will increase, and ‘super cyclones’, with an intensity hitherto unrecorded on the Australian east coast, may develop over the next 50 years (Leslie et al. 2007).

Projections indicate an increase in the intensity and frequency of hailstorms in the Sydney basin region with only a 1–2°C rise in temperature (Leslie et al. 2008).

#### Heatwaves

A strong increase in the frequency of hot days and warm nights is projected. The number of days per year above 35°C for 2030, 2070, and 2100 in all capital cities is shown in Table 5.3.

Most notable is the marked increase of hot days in Darwin. Under a no-mitigation case, there are 221 days over 35°C in 2070. By 2100, this increases to 312 days—or fewer than eight weeks in the year with days under 35°C.

**Table 5.3** Projected increases in days over 35°C for all capital cities under a no-mitigation case

	Current	2030	2070	2100
Melbourne	9	12	21	27
Sydney	3.3	4.4	9	14
Brisbane	0.9	1.7	8	21
Adelaide	17	22	34	44
Perth	27	35	56	72
Canberra	5	8	21	32
Darwin	9	36	221	312
Hobart	1.4	1.7	2.5	3.4

Source: CSIRO (2008a).

## Bushfires

Recent projections of fire weather (Lucas et al. 2007) suggest that fire seasons will start earlier, end slightly later, and generally be more intense. This effect increases over time, but should be directly observable by 2020.

Table 5.4 shows projections of the percentage increase in the number of days with very high and extreme fire weather.<sup>6</sup>

**Table 5.4 Projected per cent increases in the number of days with very high and extreme fire weather for selected years**

	Approximate year		
	2013	2034	2067
Very high	+2–13	+10–30	+20–100
Extreme	+5–25	+15–65	+100–300

Note: This study was based on scenarios producing 0.4°C, 1.0°C and 2.9°C temperature increases, which equate to the years in this table under a no-mitigation case.

Source: Lucas et al. (2007).

The Lucas et al. study defined two new categories of fire weather: 'very extreme' and 'catastrophic'.<sup>7</sup> Of the 26 sites used in the study, only 12 have recorded catastrophic fire weather days since 1973. At a 0.4°C increase in temperature there is little or no change in the number of catastrophic fire weather days. At a 1.0°C increase, catastrophic days occur at 20 sites. For half of these sites, the return period is around 16 years or less. At a 2.9°C increase, 22 sites record catastrophic days. Nineteen of these have a return period of around eight years or less. Seven sites have return periods of three years or less.

## Notes

- 1 The emissions pathways that underpin the Australian climate projections in this chapter and Chapter 6 differ slightly from the pathways used in Chapter 4.
- 2 The standard deviation for annual rainfall for the period 1936–45 was 105.5 mm, compared to 85.8 mm for the current drought (Murphy & Timbal 2008; B. Timbal 2008, pers. comm.).
- 3 Hobart has not been included since normally only 40 per cent of supply is taken from storage facilities. The remainder is extracted from the Derwent River, whose catchment area is approximately 20 per cent of the area of the state. During scarce periods, larger quantities are drawn from the Derwent River, though on average this represents less than 1 per cent of the total streamflow. Darwin has not been included as streamflows in its catchment areas have been largely unaffected over the last decade (R. Young 2008, pers. comm.).
- 4 All temperature increases are from a 1990 baseline.
- 5 Changes in precipitation are reported as percentage changes from a 1990 baseline.
- 6 'Very high' fire weather has a Forest Fire Danger Index (FFDI) of 25–50, and 'extreme' fire weather has an FFDI of 50+. Suppression of fires during 'extreme' fire weather is 'virtually impossible on any part of the fire line due to the potential for extreme and sudden changes in fire behaviour. Any suppression actions such as burning out will only increase fire behaviour and the area burnt' (Vercoe in Lucas et al. 2007).
- 7 'Very extreme' fire weather has an FFDI of 75–100 and 'catastrophic' fire weather has an FFDI of over 100 (Lucas et al. 2007).

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