CLIMATE COMMISSION

The science behind southeast Australia's wet, cool summer.

Key facts:

1. For many years scientists have painted a clear picture: that the Earth's surface is warming rapidly and the climate is changing. Global average temperature has continued to rise over the last decade. 2011 was the warmest La Niña year on record and warmer than all but one year of the 20th century.
2. The quintessential Australian cycle of intense droughts and flooding rains will continue into the future. Across the south, heavy rainfall events will still occur, and high summer rainfall events will continue to be a feature of the climate. However, on average, the south of the continent will likely be drier in the future compared with the early to mid twentieth century, particularly so in the cool months of the year. These changes pose substantial risks to agriculture, water security, natural systems, the Australian economy and our way of life. To minimise these and other risks associated with a changing climate, we, and other countries around the world, must rapidly reduce carbon emissions and move to clean energy sources.
3. Scientists have observed changes to when, where and how much rain falls across Australia. Over the last 40 years much of eastern and southern Australia has become drier. There have been wet years, but the long-term trend in the southwest, and more recently in the southeast, has been declining rainfall. Most of the record rainfall across Australia over the last two years came during spring and summer. This contrasts strongly to the normal rainfall season, which runs from April to November across the south of the continent. Drier than average conditions persisted across southern Australia in 2011 during late autumn and early winter period (April to June). This is consistent with significant drying over autumn and winter which has occurred in the southwest since the 1970s and the southeast since the mid-1990s. It is more likely than not that heavy rainfall events will also become more frequent.
4. Climate change cannot be ruled out as a factor in recent heavy rainfall events. The Sea Surface Temperatures (SSTs) around northern Australia during the spring and early summer of 2010–2011 were the highest on record. This has very likely contributed to the exceptionally heavy rainfall over much of Australia in the last two years. La Niña events bring high SSTs to the seas around northern Australia, but warming over the past century has also contributed to the recent record high SSTs.
5. Recent rains have not been able to make up for the decade of dry conditions with many regions of Australia still experiencing drier than average conditions. Averaged from 1970, and even just the past 15 years, the southeast and southwest, Tasmania and the southeast Queensland coast show an overall drying trend. Rainfall in over half of Victoria and about three-quarters of Tasmania remains at very much below average.
6. The wetter conditions experienced in southeastern Australia in the last two years are consistent with scientists' knowledge and understanding of how the climate is changing in the long term.

Most parts of Australia have experienced exceptionally heavy rains over the past two years, filling many dams around the country and breaking the drought of the 1997–2009 period – the 'Big Dry'. There has been much confusion in the media about what this means for climate change. This report seeks to set the record straight.

To understand the significance of these observations, we need to examine what is happening to the climate over much longer time periods and over the rest of the planet. Without this broader perspective, we could easily misinterpret the natural year-to-year variability in climate, or even the daily or weekly weather, as representing a change in the underlying, long-term trend in global climate.

One of the most important drivers of the year-to-year variation in climate in many parts of the world – and over much of Australia – is the El Niño-Southern Oscillation (ENSO) phenomenon, which, as the name suggests, alternates between El Niño, La Niña and neutral phases. Over eastern Australia La Niña years tend to be cooler and wetter, while El Niño years tend to be hotter and drier. The past two years have seen strong La Niña events, which have left a marked imprint on both temperature and rainfall superimposed on the long-term trends in climate.

Temperature

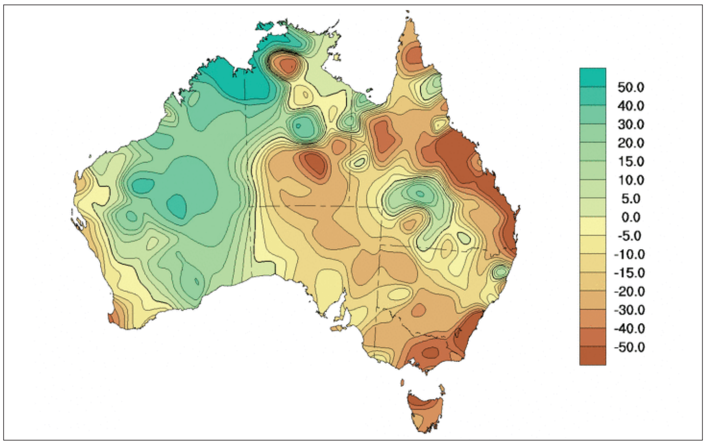
Let's look at temperature first. La Niña events lead to cooler conditions on the global average. In general, the stronger a La Niña event at the start of a year, the cooler the global average temperature for the year as a whole. Consistent with this, the global average temperature for 2011 was lower than all but two of the years between 2000 and 2010. Nevertheless, 2011 was still warmer than all but one of the years in the 20th century. In fact, it was the warmest La Niña year on record. This is even more surprising because it was one of the strongest La Niña events ever recorded, and thus should have been one of the coolest.

As is clear from Figure 1, years with significant La Niña events – the purple bars in the figure – are invariably cooler than the years around them. This is just the well-known year-to-year variability that La Niña and El Niño events bring. However, focusing on just the La Niña years over the past four decades, the long-term warming trend stands out strongly, consistent with the warming trend evident when all years are considered together. The upward trend in global temperature certainly has not ended in the most recent decade, or with a cool La Niña year or two.

Rainfall

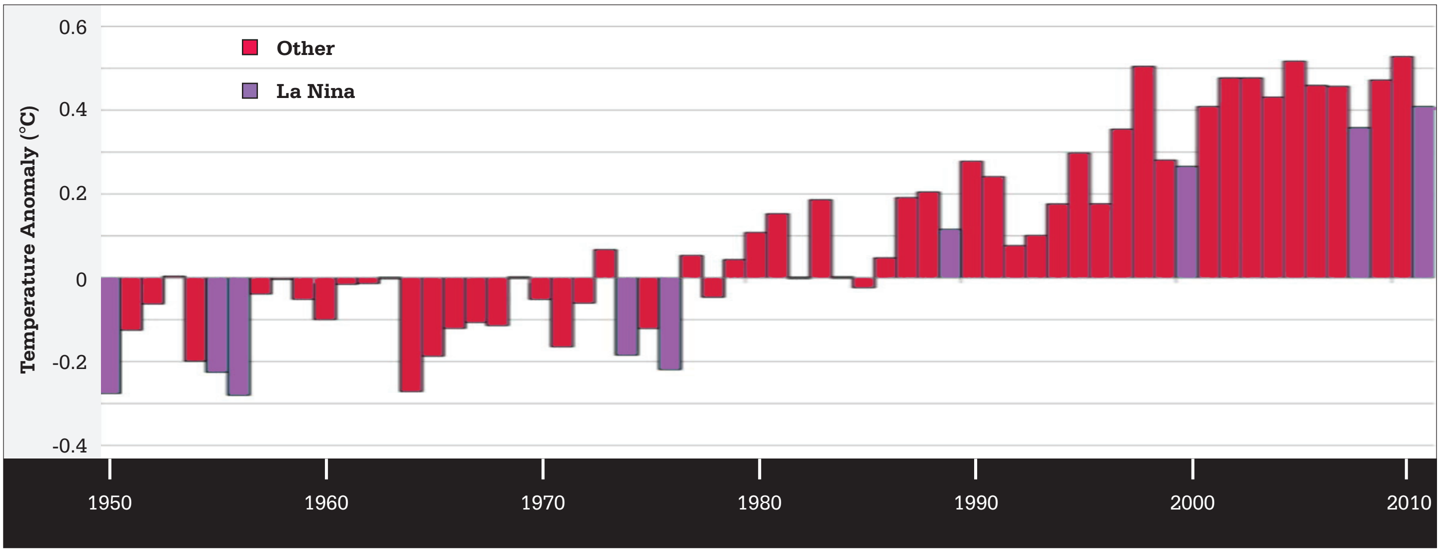
Over the last 42 years much of eastern and southern Australia has become drier (Figure 2). There have been wet years and there will continue to be more wet years in the future, but the long-term trend shows declining rainfall in this period. Research by the CSIRO and Bureau of Meteorology suggests a long-term drying trend in winter for southern areas of Australia, and in spring for southern and eastern areas, with dry years becoming more frequent and wet years less frequent. Droughts are thus expected to become more frequent in southern Australia. Should these changes in rainfall patterns eventuate, the long-term consequences for water supplies in this region are a concern because this is where many major population centres are located.

Figure 2. Trend in total annual Australian rainfall (mm/decade) for the 42-year period from January 1970 to December 2011.



Source: BoM: www.bom.gov.au/cgi-bin/climate/change/trendmaps.cgi?map=rain&area=aus&season=0112&period=1970

Figure 1. Global average temperature from 1950 to 2011, shown as the variation (anomaly) in degrees Celsius from the 1961–1990 average. La Niña years are shown in purple, other years in red.

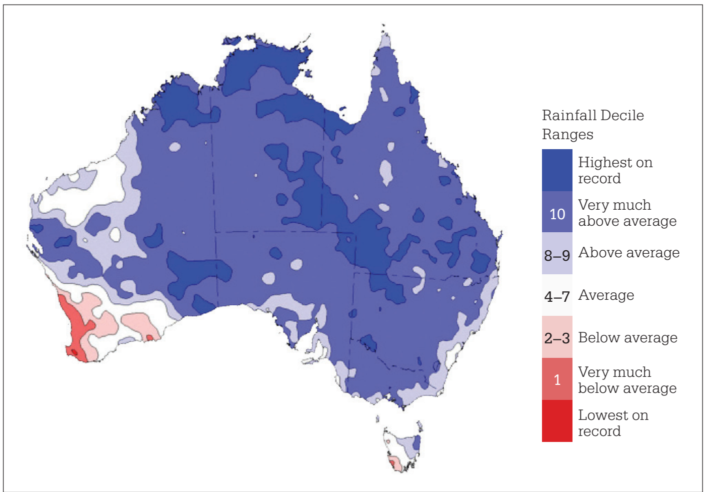


Source: WMO 2012

In Australia La Niña years are most notable for the above-average rainfall that they generally bring to much of the continent. The La Niña phase of ENSO brings higher-than-average SSTs to the seas around Australia, driving higher rates of evaporation from the surface ocean and thus providing more water in the atmosphere for rainstorms.

The 2010–2011 period set a record of 1409 mm of rain averaged over Australia, beating the old two-year record set in 1973–1974, another period with strong and sustained La Niña conditions. It was also remarkable because the heavy rainfall was so widely spread across the country, affecting virtually every region (Figure 3).

Figure 3. Australian rainfall deciles for the two-year period January 2010 to December 2011. Deciles represent 10 categories of rainfall across a range above and below the long-term average.



Source: BoM 2012b.

This wet period has coincided with unusually high SSTs, even for a La Niña event, in the seas surrounding Australia. In fact, the SSTs to the north of Australia during the spring and early summer of 2010–2011 were the highest on record, very likely contributing to the exceptionally heavy rainfalls. The underlying global warming trend contributed to these record high SSTs. Global warming trends thus could have contributed to the strength of the La Niña event and the consequent heavy rainfall and flooding, although this is not yet known with certainty.

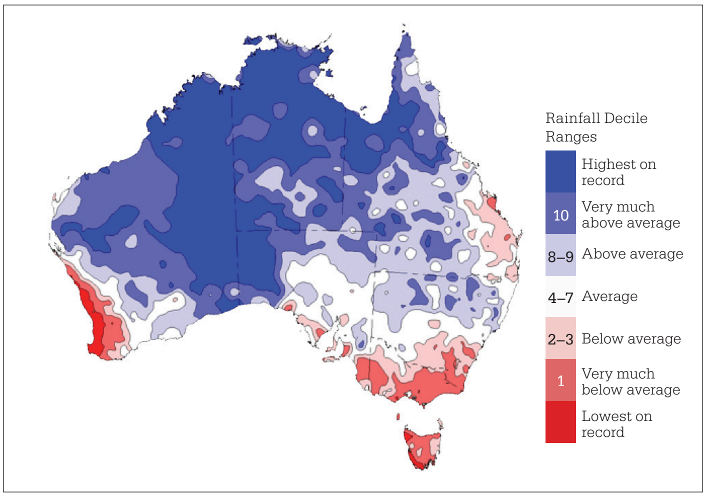
While most of the continent was awash with the very heavy rains, southwest Western Australia stands out because of the record or near-record dry conditions (Figure 3), with 2010 being the driest year on record for this region. This is a continuation, and exacerbation, of the long-term drying in this region. Here rainfall comes mainly in the autumn and winter from rain-bearing fronts sweeping off the Southern Ocean, and these have become much less frequent since the mid-1970s.

Seasonal patterns that were evident during the 2010–2011 big wet in southeast Australia show important similarities to the continuing dry conditions in the southwest. Most of the rainfall in the southeast over the last two years came as heavy rainfall during the summer. Dry conditions persisted across southern Australia in 2011 during the start of the early winter period (April to June).

The southward shift of rain-bearing fronts off the Southern Ocean, which has been associated with the reduction in autumn and winter rainfall in the southeast since the mid-1990s as well as in the southwest since the 1970s, is associated with a strengthening of high pressure systems over the continent. This pattern is consistent with a warmer planet.

Has the recent two-year wet period made up the deficits of the Big Dry? Certainly dams have filled and soil moisture has been topped up. However, the rains have not been able to make up for the decade of dry conditions, as shown in Figures 2 and 4. Averaged from 1970 (the past 42 years – Figure 2), and even just the past 15 years (Figure 4), the southeast and southwest, Tasmania and the southeast Queensland coast show an overall drying trend. Rainfall in over half of Victoria and about three-quarters of Tasmania remains at very much below average.

Figure 4. Australian rainfall deciles for the 15-year period January 1997 to December 2011. Deciles represent 10 categories of rainfall across a range above and below the long-term average.



Source: BoM 2012b.

Another way of addressing the question is to ask how much above-average rainfall is required to eliminate the deficit that has accumulated through the Big Dry. Figure 5 uses this approach for southeast Australia, showing the build-up of the deficit with year-after-year of average or below average rainfall since 1997, followed by some recovery during 2010–2011. The figure shows, however, that the recent two-year wet period has made up for only about one-third of the total rainfall deficit since 1997. We still require many years of wetter than average conditions before we can fully eliminate the rainfall deficit of the Big Dry. These analyses demonstrate again the importance of taking a longer term perspective in separating year-to-year variability from the long-term trends.

The future

What will the future bring? A return to extended droughts like the Big Dry? More heavy rainfall and wet springs and summers? Perhaps a mix of both?

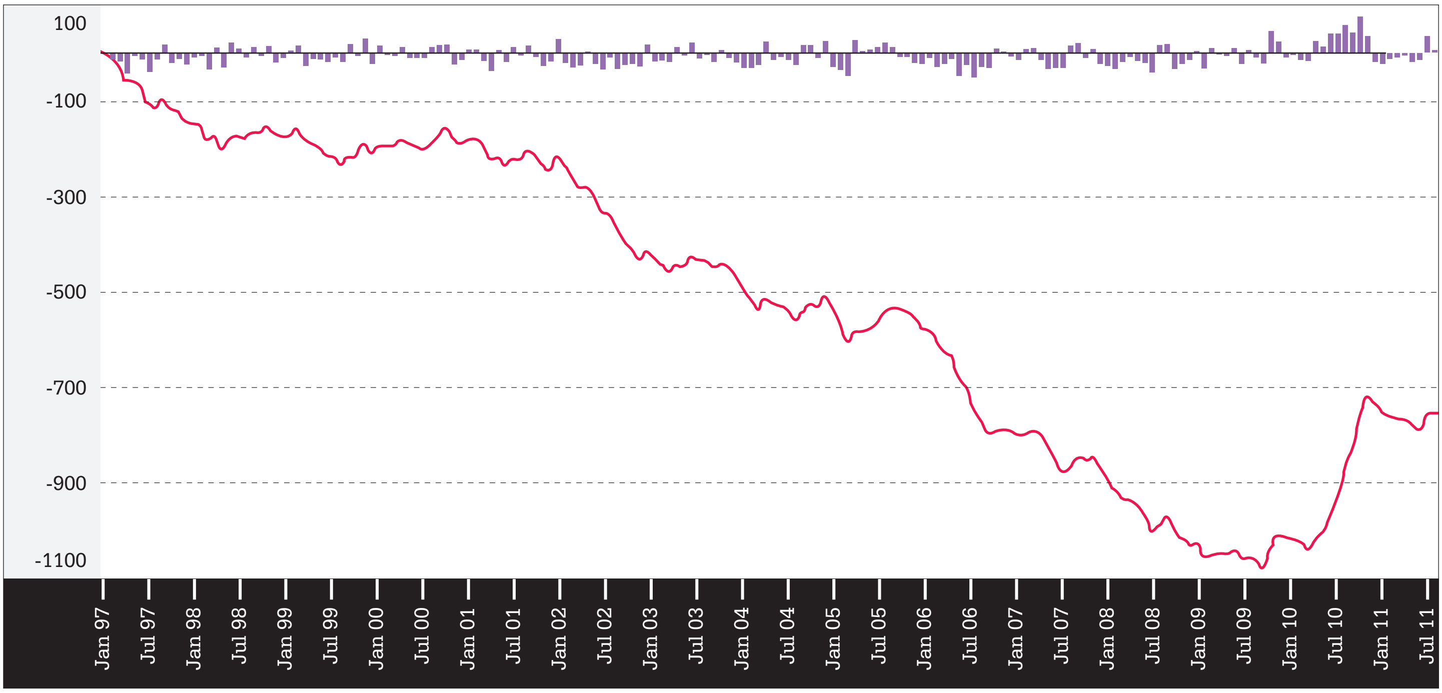
Our confidence in making projections for future trends in temperature is much greater than our confidence in projections for rainfall, Further, there is greater confidence in projections at global and continental scales than at regional and local scales.

It is virtually certain that the global average temperature will continue to rise through the 21st century, which is very likely to lead to an increase in the number, length and intensity of heat waves over many of the regions where we live. For Australia, this trend means that an usually hot day that in the 20th century we experienced, say, only once every couple of decades could occur once every four or five years by 2050 and once in every one or two years by the end of this century.

While we know that rainfall patterns are also changing, there is less certainty about where, when and how much rain will fall in the future. Nevertheless, there are some large-scale features about future rainfall patterns that are becoming clearer.

Extended dry periods are expected to increase by the end of this century for much of Australia, implying a higher risk for drought (see Box 1, bottom panel of figure). Our confidence in these projections is stronger for southwest and southeast Australia than for the rest of the continent. Not only is there agreement among over 90% of the climate models in their simulations of increased dryness for these regions, this projection is consistent with trends that have already been observed and with our current understanding of the physical processes that underpin these trends.

Figure 5. Cumulative rainfall variations (in mm) from the long-term average for southeastern Australia for the period January 1997 to December 2011. Individual monthly variations are shown in the columns.



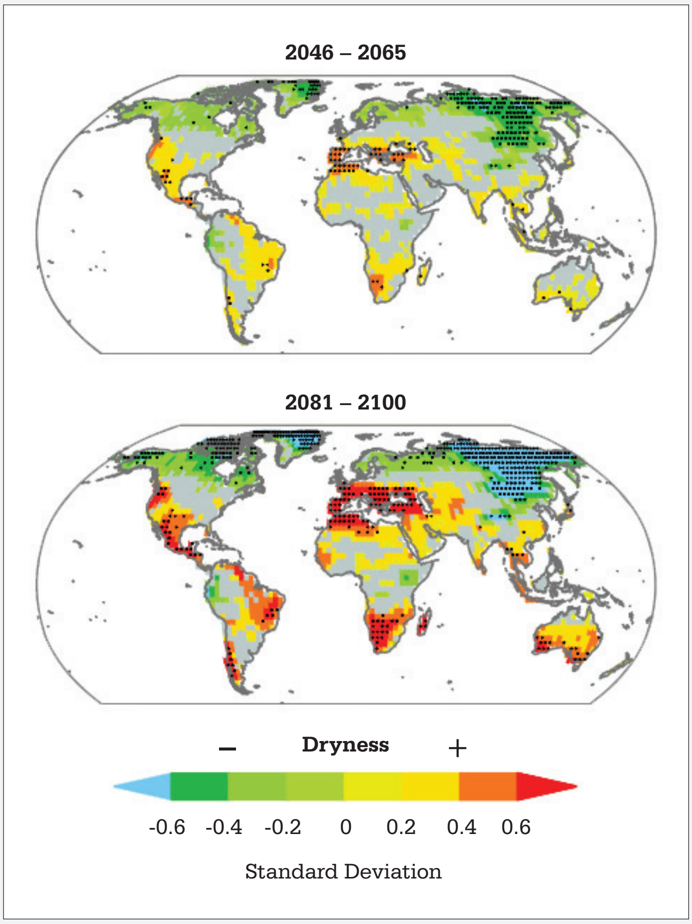
Source: BoM 2012b.

Box 1. There are several ways in which scientists describe dryness or drought, ranging from a strictly climatological definition to measures based on impacts on water resources and agriculture. The Intergovernmental Panel on Climate Change (IPCC) special report on climate extremes used two ways to describe changes in dryness. Perhaps the easier one to understand is based on changes in the number of consecutive dry days (CDD), that is, days with precipitation less than 1 mm. This measure is particularly useful in assessing the risk for droughts.

Figure 6 shows the projected change in dryness using this definition from 17 different climate model simulations. Increased dryness is indicated with warm colours (positive changes in CDD). Differences are expressed in units of standard deviations, which are measures of how much the projections deviate from an average. The higher the number (the 'warmer' the colour), the more pronounced is the projected drying trend.

Figure 6 shows changes for two time horizons, 2046–2065 and 2081–2100, as compared to late-20th century values. The projections were based on simulations of 17 climate models using a specified greenhouse gas emission scenario (SRES A2). Shading is only applied for areas where at least 66% (12 out of 17) of the models agree in the sign of the change; stippling is applied for regions where at least 90% (16 out of 17) of all models agree in the sign of the change. Southwest and southeast Australia and only a few other areas around the world are projected with some confidence to become significantly drier by the end of this century.

Figure 6. Projected annual changes in dryness assessed from change in the number of consecutive dry days (CDD, days with precipitation less than 1 mm).



Source: IPCC 2011.

On the other hand, it is more likely than not that heavy rainfall events will also become more frequent across much of Australia. This means that when long dry periods are interrupted by welcome periods of wet weather, the rain is more likely to fall as heavy downpours than as extended drizzle. For southern Australia, a heavy rainfall event that currently occurs once every 20 years could become more frequent by mid-century, perhaps occurring once every 15 years, and more frequent again by the end of the 21st century – about once in every 10 to 15 years.

So what does all this mean for us?

The planet's surface temperature will continue to rise in the long-term average, and that means an increasing risk of hot days and severe heat waves. In addition, we'll likely see increased frequency in intense rainfall events and more severe droughts. The quintessential Australian climatic pattern of severe droughts and flooding rains will continue into the future. Across the south, heavy rainfall events will still occur, and high summer rainfall events will continue to be a feature of the climate. However, on average, the south of the continent will likely be drier in the future compared with the early to mid twentieth century, particularly in the cool months of the year.

These changes in climatic patterns pose substantial risks to agriculture, water security, natural systems and the Australian economy. They emphasise the need to increase resilience across our society and enhance our capacity to adapt to both floods and long dry periods. Ultimately, to avoid changes in the climate system to which we cannot adapt, we need to do our part along with other countries to drive rapid and deep reductions in the emission of greenhouse gases.

Professor Will Steffen
Climate Commissioner

Professor Matthew England
Climate Commission
Science Advisory Panel

Professor David Karoly
Climate Commission
Science Advisory Panel

Further reading:

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GPO Box 854 Canberra ACT 2601 Australia
P: +61 2 6159 7624 E: info@climatecommission.gov.au
www.climatecommission.gov.au