OBSERVED CHANGES IN AUSTRALIAN CLIMATE

Bureau of Meteorology

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Introduction

This document is one of a series of documents produced by the Climate Impact Group supporting Climate Change projections for Australia CSIRO (2001). It draws heavily upon the ongoing climate monitoring activities conducted by the Bureau of Meteorology. Climate monitoring in Australia is underpinned by an extensive observation network, which include volunteers across the country.

Australia is a large, flat continent ranging from the tropics to mid-latitudes, with an arid interior and highly variable rainfall. The climate of Australia is strongly influenced by the surrounding oceans. Weather systems such as tropical cyclones and cold fronts give each region of the country its own characteristic climate. Dominant weather systems that affect Australia include the monsoon, north-west cloud bands, east coast lows, mid-latitude cold fronts, southerly busters and the sub-tropical ridge. The influence of these systems produces a highly variable climatic pattern across the country, from season to season and year to year. Some of the year-to-year variations of climate in Australia are associated with the El Niño-Southern Oscillation (ENSO) phenomenon, sea surface temperatures in the Indian and Pacific Oceans, and high-latitude circulation systems.

Observed Australian climate change

The Importance of High Quality Climate Data

Reliable detection of long-term climate trends requires long, good quality climate records. Changes in observing instruments, site location and observational practices have led to artificial 'jumps' in the climate records at many climate observing sites throughout Australia. These jumps can be larger than the actual changes in climate and can easily disguise any real trends. Changes in the level of urbanization and land-use practices surrounding a site can also have an impact on the climate record.

The Bureau of Meteorology keeps records of changes made at sites to allow scientists to reconstruct instrumental climate records as accurately as possible. The following analyses use these high quality climate data (e.g. Torok and Nicholls, 1996; Lavery et al., 1997)

Temperature

Australian average surface temperature has increased by 0.76°C over the past 91 years (1910 to 2000) (Figure 1). The last two decades have been particularly warm, with many of the warmest years on record occurring during the 1980s and 1990s (Collins and Della-Marta, 1999). This annual average temperature increase is consistent with the global average warming trend reported by IPCC (2001). The amount of warming has not been uniform across the country, nor has it been the same for maximum and minimum temperatures. Maximum temperature has increased by 0.56°C and minimum has increased by 0.96°C over 91 years (Figures 2 and 3), giving a decrease in the diurnal (day-night) temperature range (Figure 4).

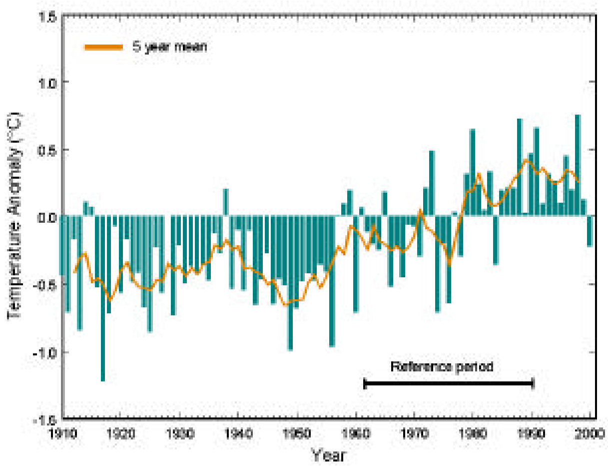

Figure 1. Annual mean temperature anomalies for Australia based on 1961-1990 normal. Source: Bureau of Meteorology

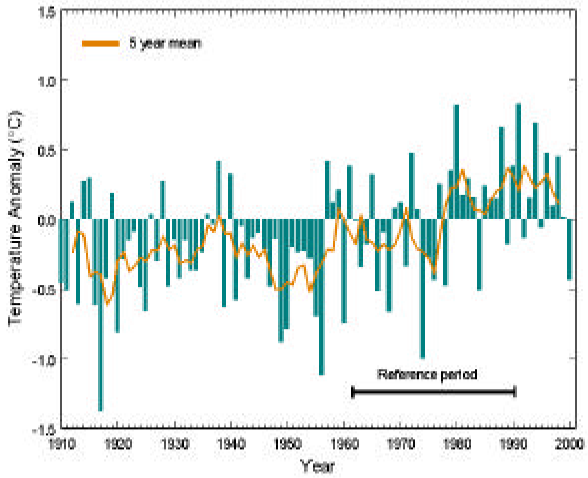

Figure 2. Annual mean maximum temperature anomalies for Australia based on 1961-1990 normal. Source: Bureau of Meteorology

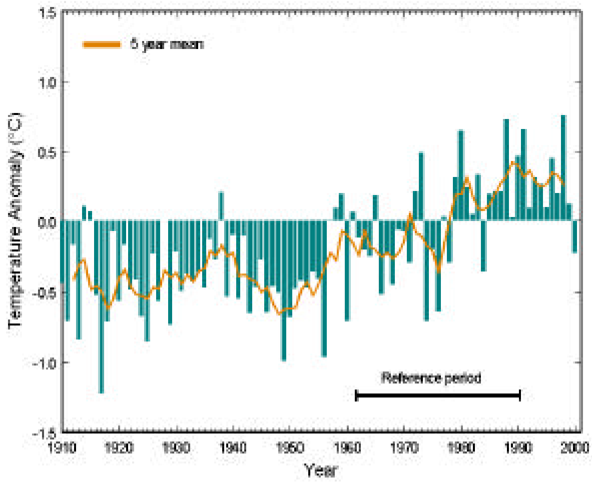

Figure 3. Annual mean minimum temperature anomalies for Australia based on 1961-1990 normal. Source: Bureau of Meteorology

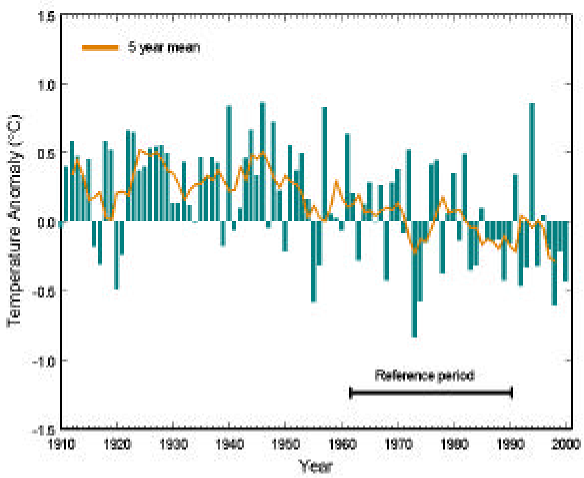

Figure 4. Diurnal temperature range anomalies based on 1961-1990 normal. Source: Bureau of Meteorology.

The geographical pattern of the trend in annual mean temperature shows an increase of greater than 0.1°C per decade at many locations (Figure 5). The greatest warming since 1910 has occurred inland, particularly in Queensland and the southern half of Western Australia, but little warming, and even some cooling is apparent in southern Queensland and New South Wales. Maximum temperature trends (Figure 6) show increases in the western half and some decreases in the eastern half of the continent, over the past century. Minimum temperatures have increased (Figure 7) over most of the country.

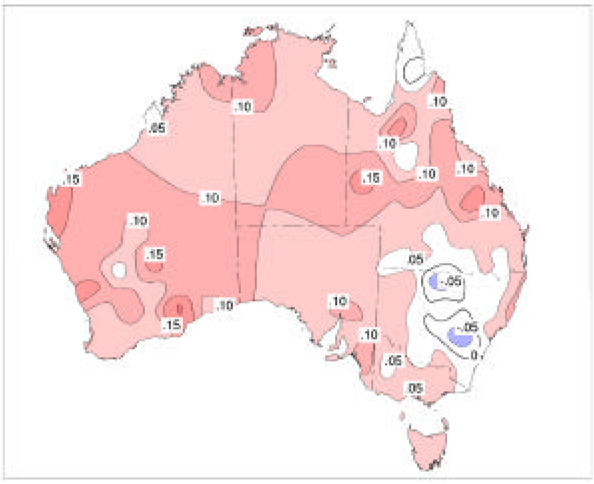

Figure 5. Trend in annual mean temperature (°C/10 year) from 1910-1999. Source: Bureau of Meteorology

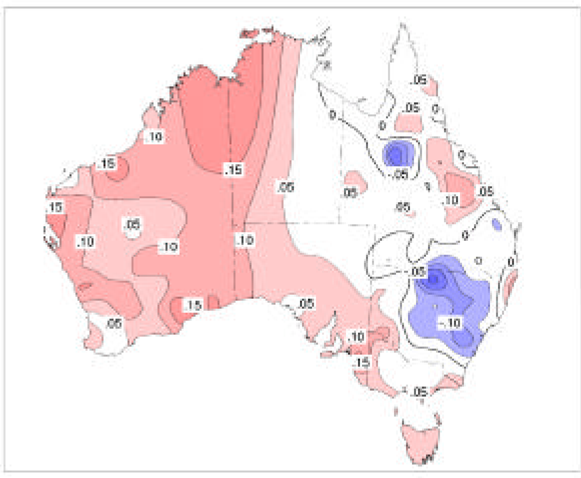

Figure 6. Trend in annual maximum temperature (°C/10 year) from 1910–1999. Source: Bureau of Meteorology

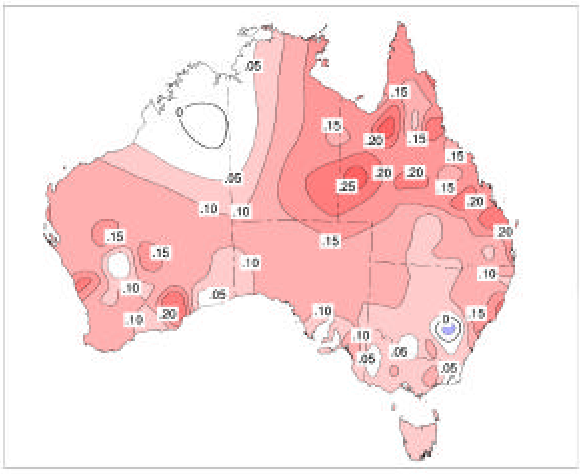

Figure 7. Trend in annual minimum temperature (°C/10 year) from 1910–1999. Source: Bureau of Meteorology

Increases in both annual mean minimum and maximum temperatures have resulted in an increase in the area of Australia experiencing mean temperatures in the top 10 percent of annual mean temperature and a decrease in the area with temperatures in the bottom 10 percent (Figure 8). The area of Australia experiencing extreme warm conditions has increased most rapidly in the last two decades.

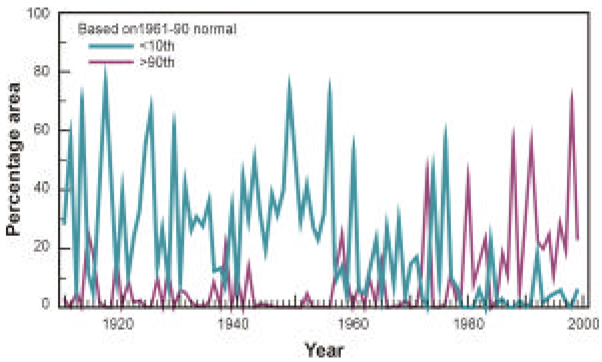

Figure 8. Percentage area of Australia over which annual mean temperature for that year occurred in the top 10 percent (red) and in the bottom 10 percent (blue) of temperatures based on a 1961-1990 normal. Source: Bureau of Meteorology

In areas affected by frosts, the annual number of frost days declined over the period from 1957 to 2000 and the average length of the frost season also shortened. The frequency of hot days (daily maximum temperature above 35°C) has also generally increased throughout the country (Collins et al., 2000).

Rainfall

Australia is a dry country with high interannual rainfall variability. About 80 percent of the country has an average rainfall of less than 600 mm; about half has an average of less than 300 mm; and over a third has an annual average of less than 200 mm. The driest part of the continent is around the Lake Eyre Basin, with an annual average of less than 125 mm (Bureau of Meteorology, 2000).

Since 1900, Australia has become slightly wetter (Figure 9), with more heavy rainfall events. The trend is not statistically significant. However, there has been a significant 10% increase in the number of days of rain (Hennessy et al., 1999; CSIRO, 2001). These changes exhibit strong regional and decadal variability that masks background trends. Some of this variability can be accounted for by the influence of ENSO (El Niño-Southern Oscillation).

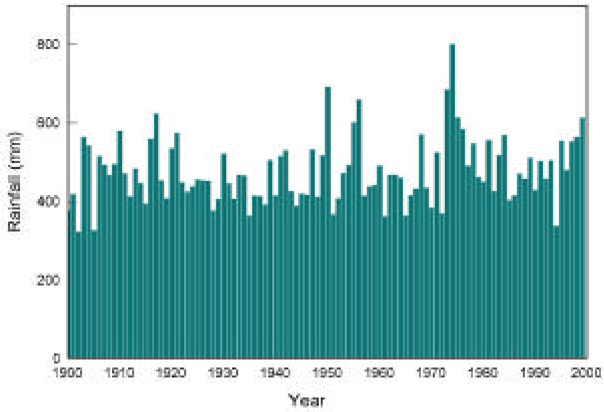

Figure 9. Annual mean total rainfall of Australia. Source: Bureau of Meteorology.

Regional rainfall trends from 1910 to 1999 show both increases and decreases (Figure 10). Large increases (greater than 20 mm per decade) have been observed over northern and eastern New South Wales. Decreases have occurred in south-western Western Australia and the central Queensland coast. During the past 50 years (Figure 11), largest increases have occurred in the Northern Territory and along the north-west coast, while largest decreases have occurred in the east of the country.

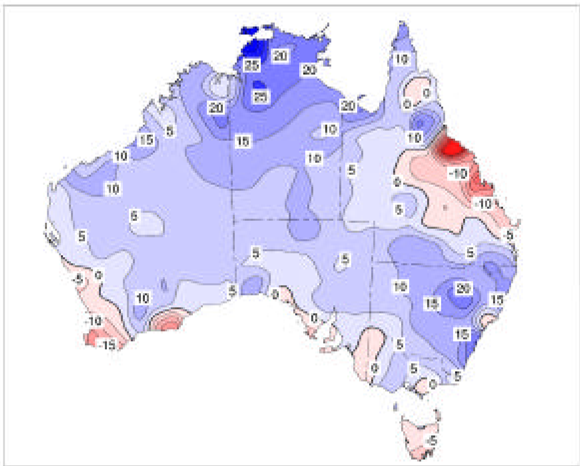

Figure 10. Trend in Annual total rainfall (mm/10 year) from 1910-1999. Source: Bureau of Meteorology

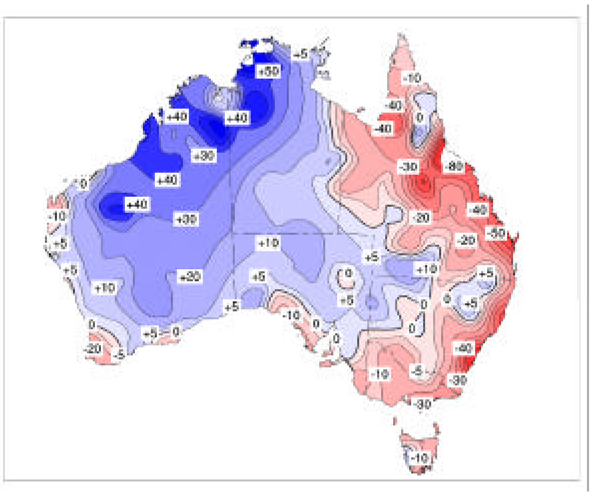

Figure 11. Trend in Annual total rainfall trend (mm/10 year) from 1950-1999. Source: Bureau of Meteorology

Extreme rainfall events have become more common in Australia during the past century (Hennessey et al., 1999). Increases in extreme rainfall events have been observed over most of Australia, except south-western Western Australia where a decline in the number of extreme events has been found in winter.

The percentage area of Australia experiencing extreme wet conditions shows a slight increase since 1910, while the percentage experiencing dry conditions shows a slight decrease (Figure 12).

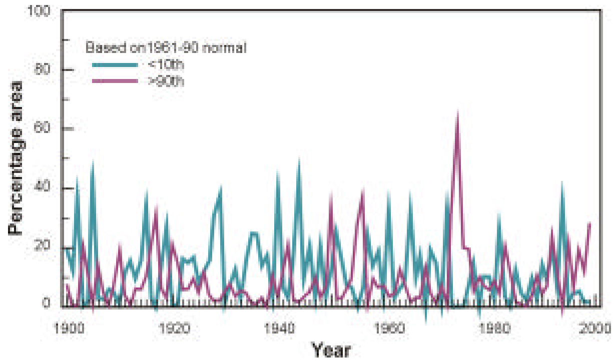

Figure 12. Percentage area of Australia over which annual rainfall for that year occurred in the top 10 percent (red) and in the bottom 10 percent (blue) of rainfall based on a 1961-1990 normal. Source: Bureau of Meteorology

El Niño-Southern Oscillation (ENSO)

ENSO is one of the most important causes of climatic variability over Australia at periods of less than a decade. The effect of ENSO is strong in eastern Australia, having been associated with major floods and droughts. El Niño events are often associated with below-normal rainfall, and drought, over much of northern and eastern Australia. On average, El Niño events occur every two to seven years, when sea surface temperatures in the central and eastern equatorial Pacific become higher than normal. The opposite pattern to El Niño is called La Niña. These events are often associated with above normal rainfall, and floods in northern and eastern Australia.

Variations in ENSO and the intensity of El Niño and La Niña events are well represented by the difference in pressure anomalies between Darwin and Tahiti. The pressure difference forms an index named the Southern Oscillation Index (SOI). Anomalous positive SOI values show La Niña events, while anomalous negative SOI values indicate El Niño events (Figure 13). The SOI has been used to provide rainfall outlooks one season ahead over northern and eastern Australia. During the period after the mid-1970s, a decreasing trend in the SOI has been observed coinciding with the frequent occurrence of strong and prolonged El Niño events.

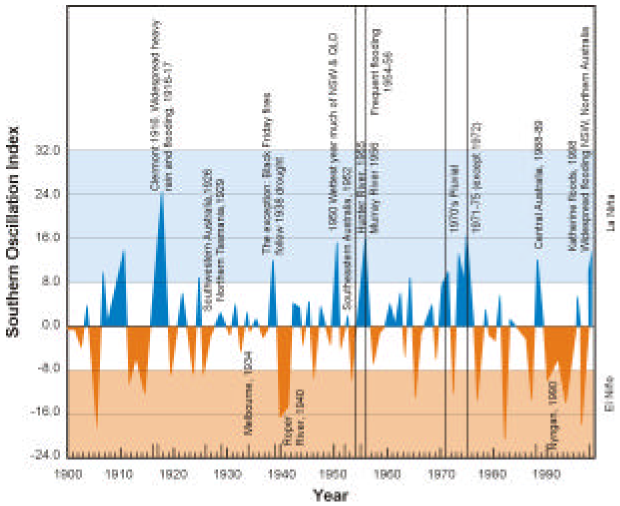

Figure 13. Smoothed variations in the Southern Oscillation Index and major floods and droughts associated with it. Source: Bureau of Meteorology

Other Weather Systems

Tropical cyclones affect the north-western, northern and north-eastern coasts of Australia. The formation of tropical cyclones and their tracks are also influenced by ENSO, with more tropical cyclones tending to form in the Australian region during La Niña years than in El Niño years. Complete reliable records on tropical cyclones are only available from 1967, the start of routine monitoring by satellites. The total number of cyclones shows a slight decrease since 1971, while the number of intense cyclones has slightly increased in this period (Figure 14) (Nicholls et al., 1998).

East-coast lows affect the eastern New South Wales, eastern Victoria and Tasmania. These are intense low pressure systems that bring heavy rainfall to these regions. The latitudinal position and movement of the subtropical anticyclone, and variations in the SOI have been found to be major factors that influence east-coast lows and their related rainfall amounts. The number of east-coast lows (not shown) shows an increasing trend during the last 40 years (Hopkins and Holland, 1997).

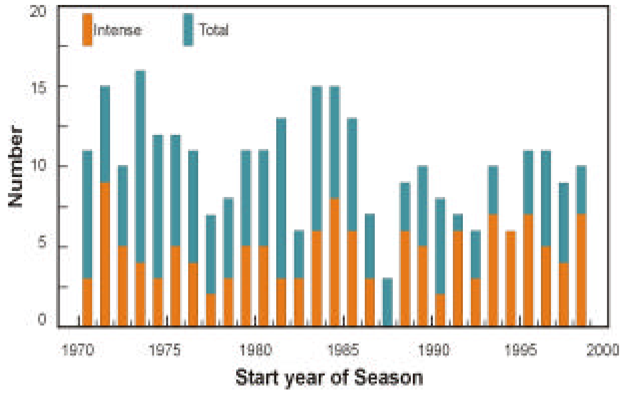

Figure 14: Total number of tropical cyclones (blue) and the number of intense tropical cyclones (orange) in the Australian region. Source: Bureau of Meteorology

Acknowledgments

These results are based on observed climate data from the National Climate Centre of the Australian Bureau of Meteorology, Melbourne. The National Climate Centre kindly provided original figures, which have been re-drawn by Joanne Richmond at CSIRO Atmospheric Research.

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