Impacts of 2002-03 El Niño on Australian climate

Michael Coughlan, David Jones, Neil Plummer, Andrew Watkins, Blair Trewin & Shoni Dawkins
Bureau of Meteorology

1. Introduction

After Australia emerged relatively unscathed from the 1997-98 “El Niño of the Century”, the 2002-03 El Niño provided a stark and sobering reminder of the influence that the El Niño-Southern Oscillation can exert upon Australia’s climate. Coinciding with the establishment of warm tropical Pacific sea surface temperatures and negative Southern Oscillation Index (SOI) values through the southern autumn of 2002, Australia’s climate turned sharply drier and day-time temperatures warmer from March 2002 onwards, marking the start of one of the severest drought episodes of the past century.

The severe drought conditions continued until January 2003. Above-average rains over large areas of Australia during February 2003 marked the end of widespread severe drought conditions, although some residual areas of drought persisted into the second half of 2003.

2. Evolution of the 2002-03 El Niño

Early in 2002, sea surface temperatures (SSTs) in much of the tropical Pacific Ocean were near normal, with weak warm anomalies (generally less than 1°C) west of 160°W and weak cool anomalies further east. Nevertheless, an accumulation of warm subsurface waters in the west-central Pacific, combined with predictions from a number of coupled ocean-atmosphere models and the occurrence of a Kelvin wave propagating eastward during February 2002, led the Bureau of Meteorology to issue an advice during that month, indicating that the risk of El Niño conditions developing during 2002 was approximately double the long-term climatological level.

The next major Kelvin wave, following a major westerly wind burst in the tropical Pacific, occurred in mid-May. Following this event warm conditions became established through most of the tropical Pacific, with SST anomalies reaching the 1-2°C range as far east as longitude 110°W by mid-June (Figure 1). At this point, the El Niño could be considered to have become established.

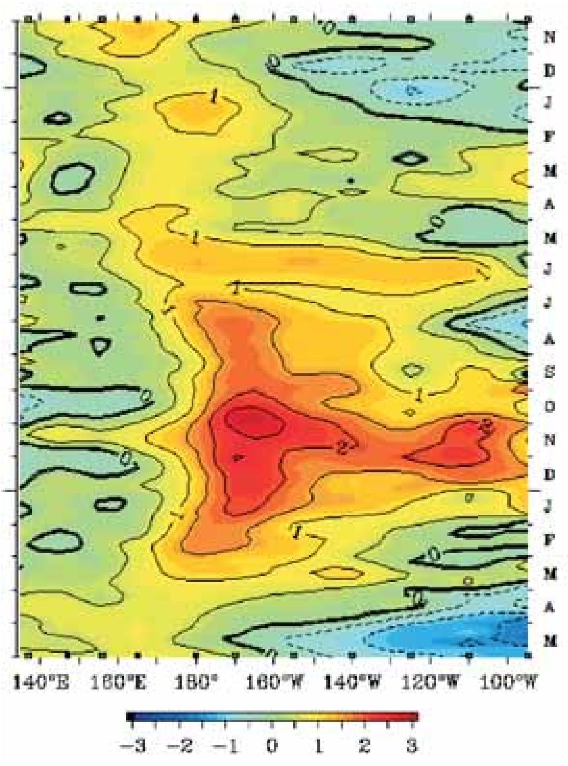

Figure 1. Time-longitude cross-section of equatorial (2°N to 2°S) Pacific sea surface temperatures

El Niño conditions then continued through the remainder of 2002, peaking in November, when SST anomalies exceeded +1.5°C over most areas east of the dateline and reached +2.5°C near 160°W. The El Niño then declined rapidly during February 2003. SSTs had returned to near or-below normal in the eastern Pacific by the end of February, and throughout the Pacific by mid-April. Although the SOI continued to fluctuate for some months, persistent near-zero values became established from July onwards.

An interesting feature of the 2002-03 El Niño was that the largest SST anomalies occurred in the central Pacific, in marked contrast to more "classical" El Niño events (such as 1982-83 or 1997-98) where the largest warm anomalies are in the eastern Pacific. Such a pattern was also observed in 1994 and (as far as can be determined from the limited data available) 1902. On both these occasions, nominally "weak" El Niño events, at least in terms of the magnitude of SST anomalies, were accompanied by particularly severe impacts over the Australian continent. One might conclude from this that the pattern of anomalies is as important, if not more so, than their magnitude.

3. Australian rainfall and temperature during the 2002-03 El Niño

Rainfall

The 2002-03 Australian drought closely followed the classical model for past El Niño-related droughts, being phase-locked to the annual cycle. Widespread rainfall deficiencies first appeared during the autumn of 2002, intensified and expanded during the winter and spring seasons, and continued until January 2003 in phase with the Pacific El Niño event.

Australian rainfall was well below average almost everywhere during the period from March 2002 to January 2003. During the particularly dry March-October 2002 period, rainfall totals were below average over 98.6% of Australia (the only exceptions being western Tasmania and parts of

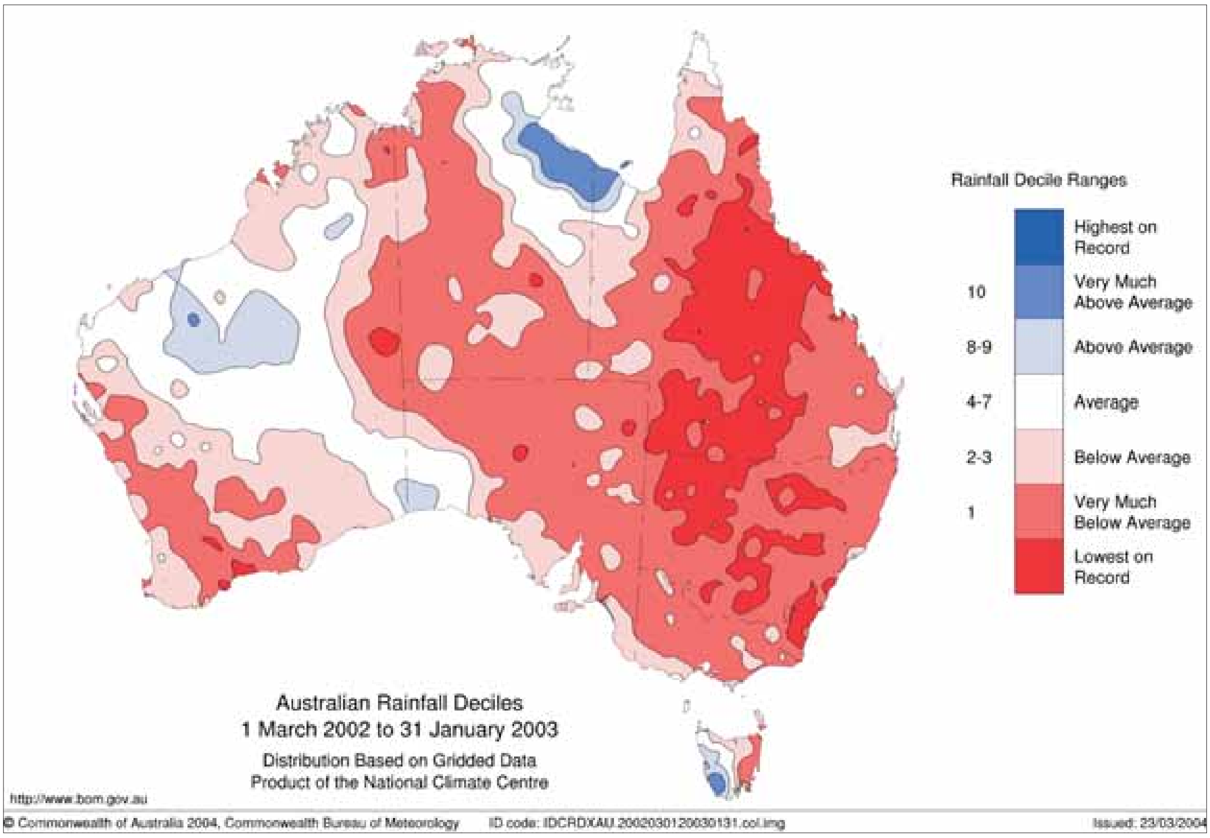

Figure 2. Rainfall deciles for Australia for 11 months March 2002-January 2003.

north-western Western Australia where, at a few locations, the mean total for the period was exceeded as a result of a single event in June). Rainfall totals were in the lowest 10% of previously recorded values (i.e. decile 1) over 71.4% of the country. Both these percentage values are unprecedented for any eight-month period, meaning that the meteorological drought might reasonably be considered to be the most extensive in recorded Australian history. Over the full 11-month period (March 2002-January 2003), the figures had dropped slightly to 90% and 56% respectively (Figure 2), as a result of some rain from November onwards in north-western and central Australia, but were still exceptional, exceeded only in 1901-02 (the end of the 'Federation Drought') and 1982-83.

Each individual season was also very dry, with autumn (4th lowest), winter (6th lowest) and spring (5th lowest) totals, averaged over Australia, each being in the lowest six on record since national records commenced in 1890. The 11-month rainfall total across Australia was the second-lowest on record (after 1946-47), whilst over the Murray-Darling Basin, the 11-month total of 207mm was a full 48mm below the previous record, set in 1902-03. Such figures point to a meteorological drought that was among the most severe in Australia's recorded history, with proportionately large environmental, agricultural, and economic consequences.

Widespread above-average rainfalls during February 2003 marked the end of the most severe phase of the drought for most affected regions. From March to September 2003, rainfalls averaged across the agricultural areas of eastern and western Australia were near normal (Murray-Darling Basin rainfall for April-September 2003 was 92% of normal, compared with 47% for the same period in 2002), although this does contrast somewhat with the well-above average rains that followed some previous severe El Niño-related droughts, such as 1982-83 and 1972-73. Some patches of severe rainfall deficiency persisted into late 2003, most notably along the Queensland coast between Mackay and Cooktown (as a result of abnormally dry wet seasons in both 2001-02 and 2002-03), in southern Victoria from Melbourne eastwards, and the Monaro district of south-eastern New South Wales.

Temperature

The effects of the large rainfall deficiencies were further exacerbated by high actual and potential evaporation rates in response to abnormally high temperatures. The 11-month period from March 2002 to January 2003 saw an Australia-wide maximum temperature anomaly of +1.5°C, 0.6°C above the previous record, with new seasonal records being set in each of autumn, winter and spring. Mean maximum temperatures for the 2002 calendar year also set a new record (Figure

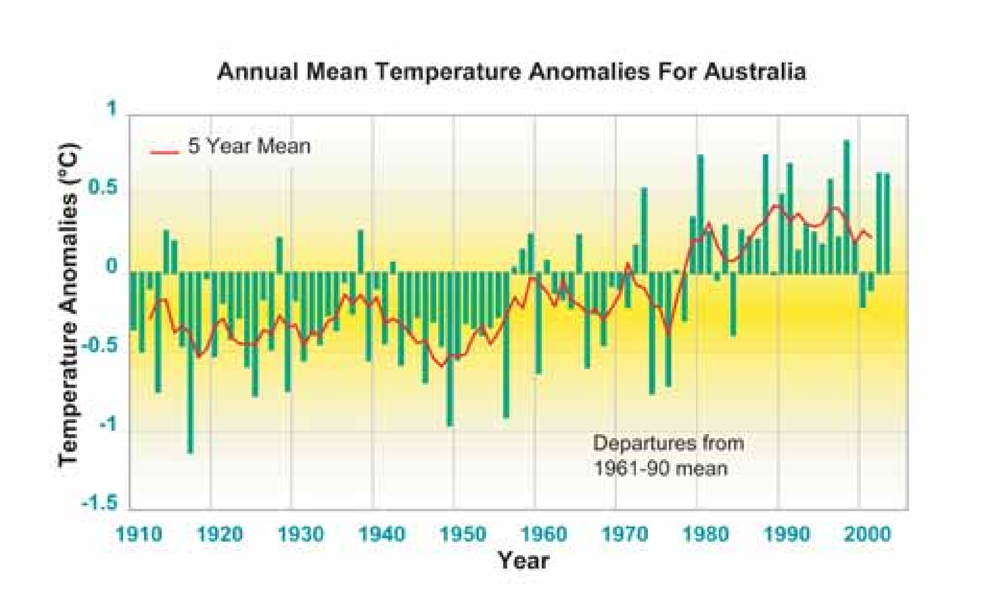

Figure 3. Annual maximum temperature anomalies for Australia, 1910-2003.

3). Interestingly, minimum temperatures were near normal, in contrast to the situation during previous severe drought years such as 1982 and 1994 when they were well below normal. These temperature patterns were largely the result of the amplified diurnal range, characteristic of El Niño-induced drought conditions, superimposed upon a longer-term warming trend, which is also evident at the global level.

The exceptional nature of the temperature records set during this period provide further significant evidence that interannual climate variations are now being significantly affected, and in the case of 2002-03 increased in severity, by climate change. Clearly, it is becoming more important to factor in temperature and other climatic variables into drought monitoring, and not to monitor drought from the perspective of rainfall deficiencies alone, or to consider drought as a product solely of interannual climate variability.

4. Impacts of the 2002-03 drought

The exceptionally dry and hot meteorological conditions contributed to large and devastating bushfires in Queensland, New South Wales, Australian Capital Territory (ACT), Victoria and Western Australia. In total, over 3 million hectares were burnt by bushfires across the eastern states, more than 500 houses destroyed and eight lives lost. Water restrictions were introduced in many areas after water storages reached low levels in parts of eastern Australia. Despite some reasonable rains during the first six months of 2003, a number of major water storages remained below 10% of capacity by mid-year, before (in some cases) commencing a recovery during the late winter and spring of 2003.

The Australian winter 2002 crop (e.g., barley, wheat, canola, and winter pulses) was estimated by Australian Bureau of Agricultural and Resource Economics at only 16 million tonnes, well down from 37 million tonnes the year before, whilst the area sown to summer crops was only 41% of the previous years planting. Apart from the immediate losses, longer term impacts also accrued, due to loss of cattle breeding stock, and in some locations loss of orchard, forestry and viticulture plantings. Australian Bureau of Statistics projections suggest the cut in total value of agricultural production for the 2002-03 financial year, largely due to the drought, to be around $5 billion. This equates to approximately a 1% drop in Australia's Gross Domestic Product, an outcome approaching that of the 1982-83 El Niño event.

5. Bureau of Meteorology climate services and communication during the 2002-03 El Niño

Significant upgrades were made to climate products and services, and in the way they were communicated to stakeholders, during the 2002-03 drought. The El Niño Wrap-Up web page, first introduced in 2001, became a very effective vehicle for delivering information about the status and likely development of the El Niño event, and was the principal tool used to advise, in early 2002, the media and wider community on details of the elevated risk of El Niño development later in the year. The Weekly Rainfall Update was also developed during 2002, and the SILO project, which has been specifically designed to communicate climate and weather information to the agricultural sector, was further developed.

The National Climate Centre and Regional Climate and Consultative Sections of the Bureau of Meteorology were actively engaged with the media throughout the period of the drought, and typically provided 50-100 interviews per month on drought-related matters (one staff member did 15 interviews on a single day!). Regular briefings were required for the Parliamentary Secretary responsible for the Bureau of Meteorology and for other policy-makers, such as the Primary Industries Ministerial Council.

Direct interaction and liaison with users (or potential users) of the Bureau's climate services were matters of high priority for Bureau staff, and numerous presentations, in person or via telephone hook-ups, were provided to user or interest groups. These included farming co-operatives, fire and natural resource agencies, water and energy utilities, and individual groups of farmers. Agricultural consultative committees were active in several states, which allowed representatives of various agricultural interest groups to communicate with the Bureau of Meteorology on how best to obtain and use the climate information that was being made available.

6. The performance of climate science during the 2002-03 El Niño

The 2002-03 El Niño and Australian drought provided a valuable testing ground for the scientific, technological and procedural advances, which have been made in climate prediction in recent years.

Supported by newly-developed dynamical models run by the Bureau of Meteorology and other agencies in Europe, Japan and the United States, it was possible for an early warning to be made of the development of the El Niño during 2002, and to provide accurate guidance on its progression once the event was under way. In particular, the newly-developed Bureau of Meteorology-CSIRO Marine Research coupled climate model, POAMA (Predictive Ocean Atmosphere Model for Australia), became operational during 2002, and provided exceptionally accurate guidance of the mature and decay phase of the El Niño event, including predicting the demise of the event some 6-9 months in advance (Figure 4).

During the event, statistically-based seasonal outlooks successfully predicted many of the broad-scale anomalies observed in Australian climate, with verification results revealing consistently skilled forecasts. However, it is fair to say that no system successfully predicted the magnitude and extent of the severe rainfall deficiencies, which were widely without historical precedent. A preliminary analysis of the experimental output from dynamical coupled models suggests that these models could have provided further useful guidance through the drought, underscoring the need for further investment in, and the operational implementation of, these systems.

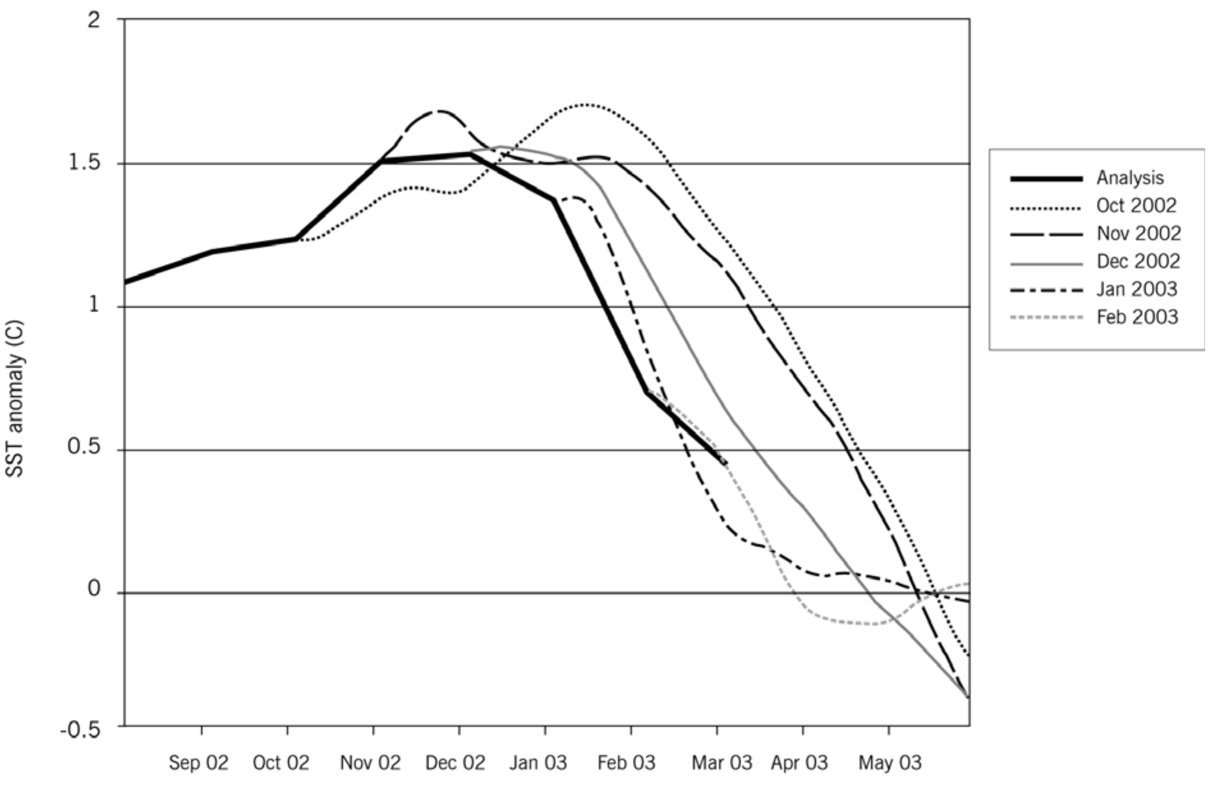

Figure 4. POAMA model predictions for the Niño 3 index (SST anomalies within the areas defined by 5°N to 5°S and 150°W to 90°W), as initialized each month from October 2002 to February 2003, and observed Niño 3 values.

7. Conclusions

The 2002-03 drought was one of the most significant experienced in Australia during the last 100 years, with widespread and substantial impacts on many sectors of Australian life. The event demonstrated the considerable advances that have been made in climate monitoring and forecasting over the last 20 years, with accurate and timely predictions made both of the increased risk of an El Niño event during 2002, and of its breakdown during the early months of 2003.

Climate information was also communicated to the public more effectively than in previous droughts, through the media and with the assistance of rapid developments in the ability to disseminate information through the Internet.

Communication is a field in which continuous improvement is an ongoing goal, and it is hoped that the outcomes from this workshop will lead to the development of improved strategies for the communication of climate information, both by the Bureau of Meteorology and by other national and state-based agencies.

The ability to make climate outlooks is likely to continue to improve with developments in climate modelling, both in terms of the skill of the outlooks and the lead time available. These developments should continue to improve the climate information available to the Australian community.