Drivers of Climate Variability in the Murray Darling Basin

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Surrounded by large oceans and in sitting in the mid latitudes, Australia has one of the most variable rainfall patterns on earth. There is no single phenomenon responsible for rainfall variability in the Murray Darling Basin (MBD), but rather a number of interrelated phenomena which operate at different time scales.

Two key drivers of cool season rainfall variability in the MDB during are;

- The El Nino Southern Oscillation
- The Indian Ocean Dipole

El Nino Southern Oscillation

Due to its large size and proximity to the MDB, the Pacific Ocean has a significant influence on rainfall in southern Australia during the winter and spring periods. The El Nino Southern Oscillation (ENSO) is characterised as a coupled ocean atmosphere phenomena which operates on an inter-annual time scale. Typically ocean temperatures on the eastern edge of the Pacific (South America) are cooler than those on the Western Pacific (Indonesian Archipelago) creating a temperature and pressure differential which drives south easterly air flow, known as 'Trades' towards Australia. This circulation pattern known termed 'Walker' circulation can either be enhanced or inhibited by changes in sea surface temperature gradient which subsequent effect and can be reinforced by pressure and air movement across the Pacific.

ENSO has a significant impact of climate conditions across the Pacific Basin and as such is continuously monitored by climatologists. There are three distinct phases of ENSO:

- Neutral
  - This is the most dominant phase, characterised by sea surface temperatures within a ±0.8°C anomaly at the mid-Pacific equator in an area close to the International Date Line (termed Nino 3.4)

- La Nina
  - La Nina is characterised by cool sea surface temperature anomalies below -0.8oC at the mid-Pacific equator at Nino 3.4. These cooler ocean temperature enhance the trade winds air flow towards Australia and increase the probability of rainfall over the MDB during winter and spring.

- El Nino
  - The El Nino is characterised by warm sea surface temperatures above +0.8°C at the mid-Pacific equator at Nino 3.4. The warmer ocean temperatures reduce the south easterly trade winds air flow, and reduce the probability of rain over the MDB during winter and spring.

Neutral

La Nina

El Nino
Indian Ocean Dipole

The Indian Ocean Dipole (IOD) is a similar ocean-atmosphere phenomenon like ENSO operating in the Indian Ocean at an inter-annual time scale. It appears to impact on rainfall in the MDB from June to November, before fading with the onset of the tropical monsoon. The IOD also has three distinct phases:

- Positive
- neutral
- negative

Positive IOD

In its positive phase is characterised by cooler sea surface temperatures in the south eastern equatorial Indian Ocean off the coast of Sumatra and warmer sea surface temperatures in the western Indian Ocean off the coast of Madagascar, Africa. This temperature differential enhances westerly air flows across the Indian Ocean, decreasing the probabilities of rainfall for the MDB during winter and spring period.

Negative IOD

In its negative phase IOD is characterised by warmer sea surface temperatures in the south eastern equatorial Indian Ocean near Australia and cooler sea surface temperatures in the western equatorial Indian Pacific near Africa, increasing the probability of rainfall over the MDB during winter and spring.

Impacts of ENSO and IOD events

Recent studies have shown a strong link between rainfall variability in eastern Australia and sea surface temperatures around northern Australia and Indonesia. ENSO and IOD both influence rainfall over south-eastern Australia. Our wettest winter/spring periods occur when a La Nina and negative IOD interact. Our driest years winter/spring periods occur when El Nino and positive IOD interact.
Impact of ENSO and IOD events

Examining the historic frequency of El Nino Southern Oscillation and Indian Ocean Dipole event assists in quantifying the impact of ENSO and IOD events on cool rainfall in the MDB. Table 1 illustrates the years when ENSO/IOD event combinations have occurred from 1877-2006.

This impact of ENSO and IOD events on rainfall from June to November has been illustrated with the use of simple box plot in Graph 1. Driest years generally occur in corresponding El Nino and positive IOD years. Wettest years generally occurred in La Nina and corresponding negative IOD years. Median values give the best indication of likely rainfall impacts of various combinations.

<table>
<thead>
<tr>
<th>Negative IOD</th>
<th>Neutral IOD</th>
<th>Positive IOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Nino</td>
<td>1930</td>
<td>1877 1888 1899 1905 1911 1914 1918 1925 1940</td>
</tr>
<tr>
<td>Neutral ENSO</td>
<td>1915 1958</td>
<td>1880 1881 1882 1883 1884 1895 1898 1900 1901 1904 1907 1908 1912 1920 1921 1927 1929 1931</td>
</tr>
<tr>
<td>Neutral</td>
<td>1916 1917</td>
<td>1906 1909 1878 1879 1886 1889 1900 1892 1893 1897 1903</td>
</tr>
</tbody>
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Table 1. ENSO and IOD events between 1877 and 2006 (Ummenhoffer et al 2010)

Graph 1. Statistical impact of ENSO and IOD events on winter/spring rainfall in MDB (1900-2006).
Monitoring sea surface temperatures
With both ENSO and IOD influencing winter and spring rainfall patterns in the Murray Darling Basin, farmers are advised to monitor sea surface temperatures in both the Indian and Pacific oceans from May through to November.

This information can be quickly found at the following internet sites.

**El Nino Southern Oscillation SSTs**
http://ioc-goos-opc.org/state_of_the_ocean/sur/pac/nino3.4.php

**Indian Ocean Dipole SSTs**

**Dynamic forecasts for ENSO and IOD can be found at the following site.**

This graph shows forecasts by several dynamical climate models for Pacific Ocean surface temperatures for coming months. The models all show a similar warming trend.

**References**

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Disclaimer: The information contained in this publication is based on knowledge and understanding at the time of writing (May 2011). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of NSW Department of Primary Industries or the user’s independent adviser.

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