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FACTSHEET

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 is large size and proximity to the MDB the Pacific Ocean has a significant influence on rainfall in south eastern 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
- La Nina (girl child)
- El Nino (boy child)

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 -0.8°C 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.

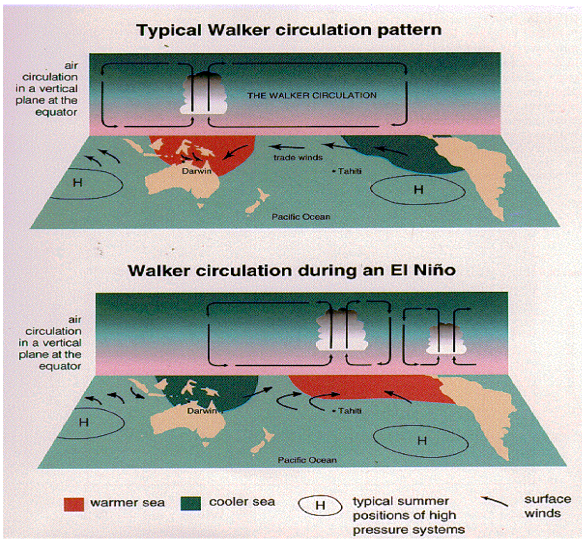


Image 1. Phases of the El Nino Southern Oscillation

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.

Positive Dipole Mode

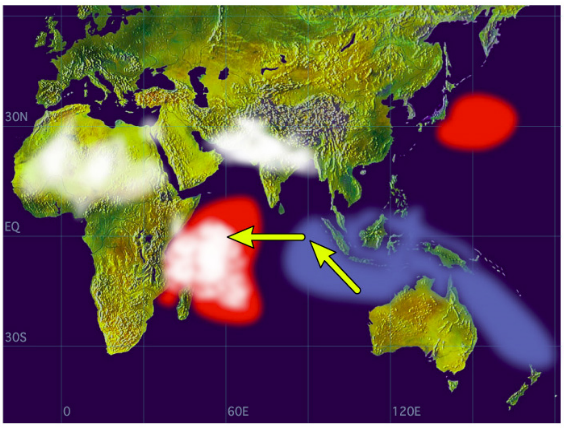


Image 2. Positive phase of Indian Ocean Dipole

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.

Negative Dipole Mode

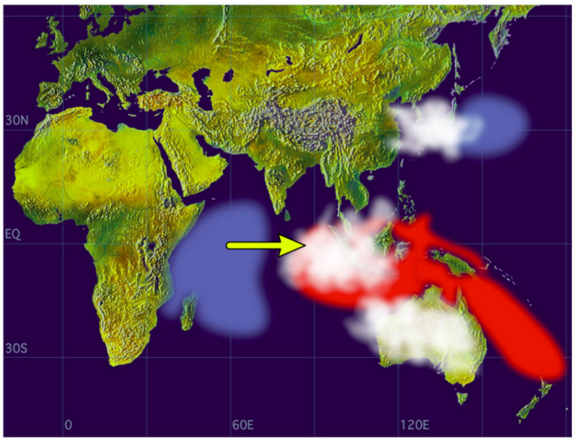


Image 3. Negative phase of Indian Ocean Dipole

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.

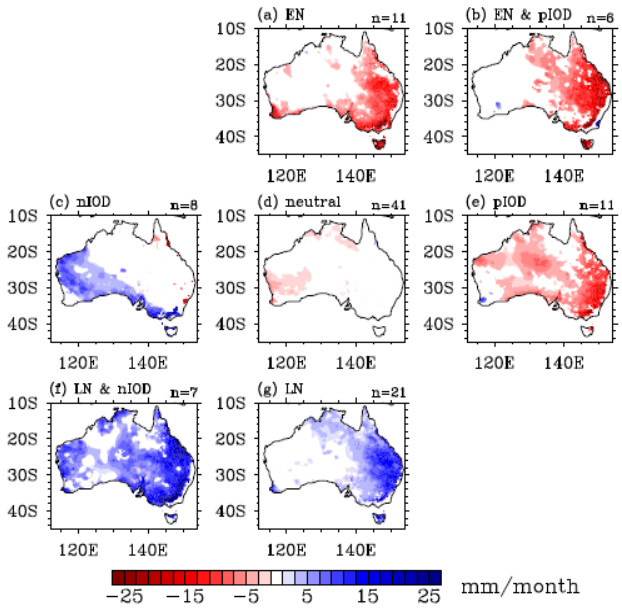


Image 4. Spatial impact of ENSO and IOD events on winter/spring rainfall in Australia (Ummenhofer et al 2010) a El Nino. b El Nino and positive IOD. c Negative IOD. d Neutral. e Positive IOD. f. La Nina and negative IOD. g. La Nina.

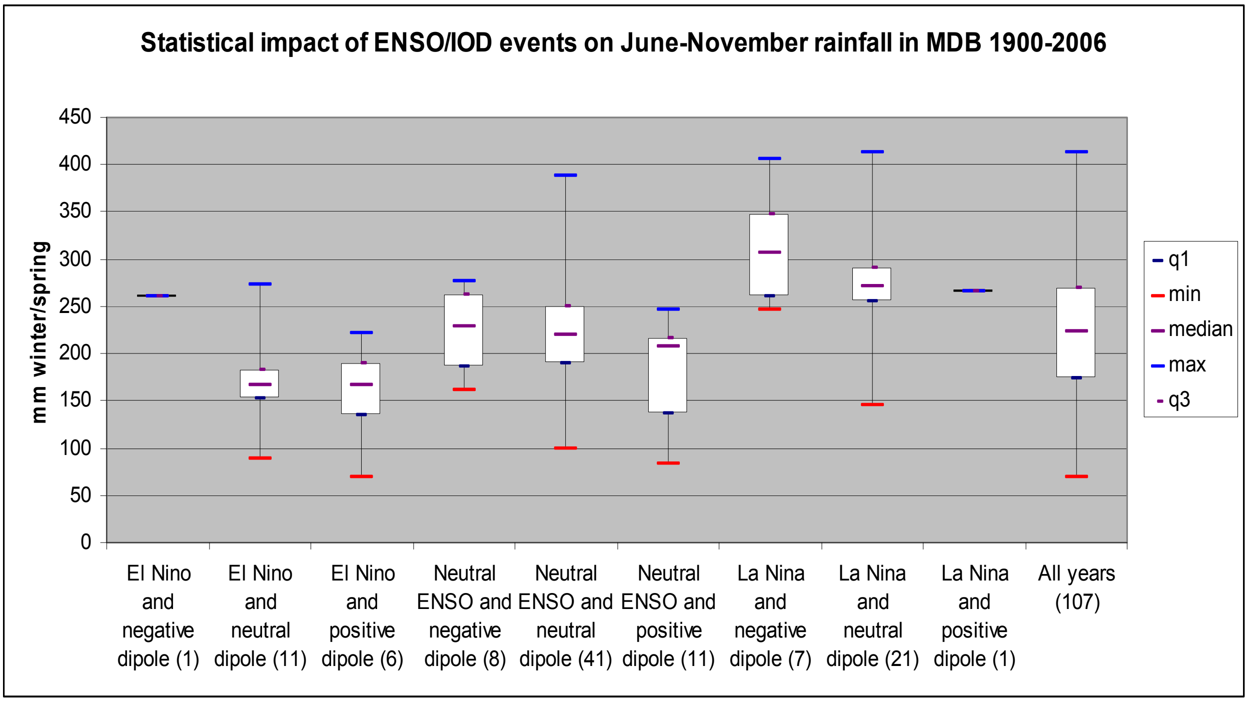
Impact of ENSO and IOD events

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.

	Negative IOD	Neutral IOD	Positive IOD
El Nino	1930	1877 1888 1899 1905 1911 1914 1918 1925 1940 1941 1965 1972 1986 1987	1896 1902 1957 1963 1982 1991 1997
Neutral ENSO	1915 1958 1968 1974 1980 1985 1989 1992	1880 1881 1882 1883 1884 1895 1898 1900 1901 1904 1907 1908 1912 1920 1921 1927 1929 1931 1932 1934 1936 1937 1939 1943 1947 1948 1951 1952 1953 1959 1960 1962 1966 1967 1969 1971 1976 1977 1979 1983 1990 1993 1995 2001 2002 2003 2005 2006	1885 1887 1891 1894 1913 1919 1923 1926 1935 1944 1945 1946 1961 1994 2004
La Nina	1906 1909 1916 1917 1933 1942 1975	1878 1879 1886 1889 1890 1892 1893 1897 1903 1910 1922 1924 1928 1938 1949 1950 1954 1955 1956 1964 1970 1973 1978 1981 1984 1988 1996 1998 2000	1999

Table 1. ENSO and IOD events between 1877 and 2006 (Ummenhoffer et al 2010)



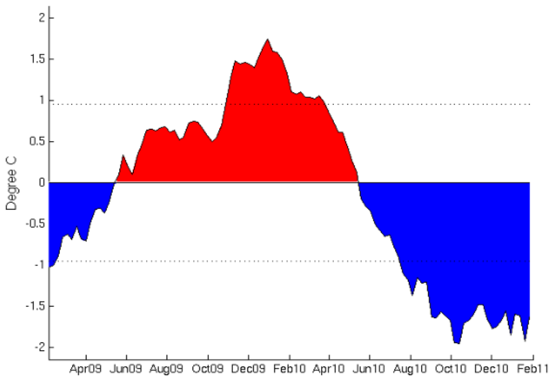
Graph 1. Statistical impact of ENSO and IOD events on winter/spring rainfall in MDB (1900-2006).

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.

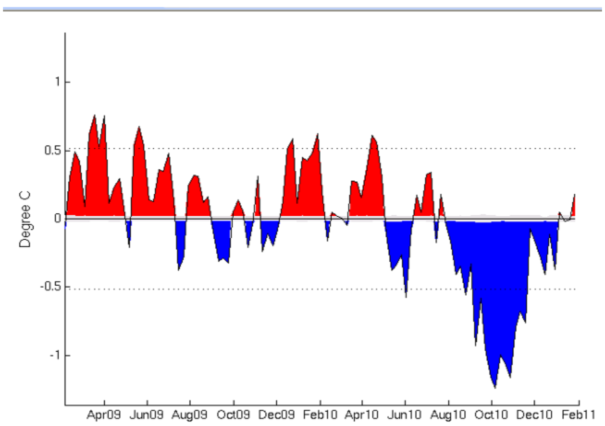
This information can be quickly found at the following internet sites.

El Nino Southern Oscillation SSTs



http://ioc-goos-opc.org/state_of_the_ocean/sur/pac/nino3.4.php

Indian Ocean Dipole SSTs



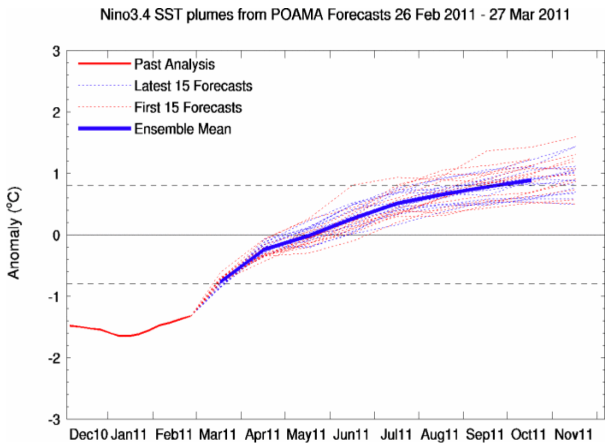
http://ioc-goos-oopc.org/state_of_the_ocean/sur/ind/dmi.php

Forecasting

The Australian Bureau of Meteorology (BoM) continuously monitors conditions in the Indian and Pacific oceans. These observations and an understanding of ocean and atmospheric physics allow the BoM to make rainfall predictions. Historically, such predictions have been based on statistical correlations between events, e.g. Southern Oscillation Index. Now, dynamical models based on physical ocean-atmosphere interactions offer greater insight over longer time frames.

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

http://www.bom.gov.au/climate/coupled_model/poama.shtml



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

Ummenhofer CC, Alexander SG, Briggs PR, England MH, McIntosh PC, Meyers GA, Pook MJ, Raupach MR, Risbey JS (2010). Indian and Pacific Ocean Influences on Southeast Australian Drought and Soil Moisture. Journal of Climate. Published on line in (http://journals.ametsoc.org) DOI 10.1175/2010JCLI3475.1

ISSN 1832-6668

INT11/49879