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# The Australian Climate of 2016: A Strong Negative Indian Ocean Dipole Dominates

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## 1. Introduction/Overview

The very strong 2015–16 El Niño brought dry conditions to many parts of Australia right up until its decay in the austral autumn (March to May). But then the climate flipped: May to November 2016 saw the Australian climate, and indeed many locations surrounding the Indian Ocean, dominated by a strong negative Indian Ocean Dipole (IOD) event, which resulted in very wet conditions across Australia, particularly in the south.

## 2. The Indian Ocean Dipole (IOD)

The IOD (Saji *et al.* 1999, Saji and Yamagata 2003 a, b) is defined by the difference in sea surface temperature anomalies between the western and eastern tropical Indian Ocean (see Fig. 1). A negative phase of the IOD is indicated by cooler than average waters closer to Africa and warmer than average waters closer to Indonesia. These warmer waters close to Indonesia act to favour convection to the northwest of Australia, triggering a Rossby wave train that encourages lower pressures over southeast Australia (Lim and Hendon 2017) and more moisture into the Australian region (Risbey *et al.* 2009). Cooler waters and hence subsiding air in the west reduce rainfall in eastern Africa/Horn of Africa. Typically, IOD events develop during May or June, peak around October, and rapidly decay by November or early December. The IOD pattern is unable to form during December to April. This is because the monsoon trough shifts south over the IOD regions, changing the wind patterns, and upsetting the east/west circulation over the tropical Indian Ocean.

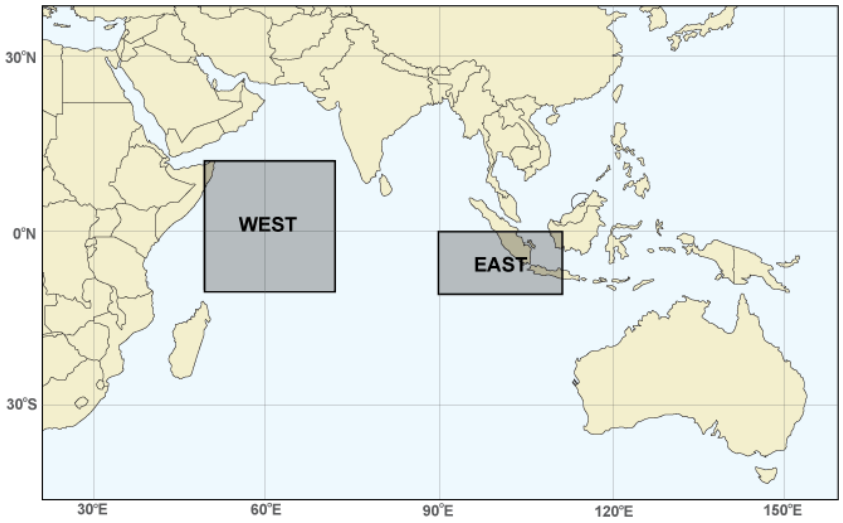


**Fig. 1** East and west nodes of the Indian Ocean Dipole. West node covers the area from 50°E to 70°E and 10°S to 10°N while east node covers the area from 90°E to 110°E and 10°S to 0°S. Source: Australian Bureau of Meteorology.

## 3. Event development

In March and April 2016 (Australian Bureau of Meteorology 2016 a, b), international climate models were suggesting the development of a negative IOD event. Event onset occurred slightly sooner than forecast, with a dipole pattern developing in late May, reaching peak strength in July (Fig. 2), which then persisted through to the end of October. Values were strongly negative at times, with the monthly IOD index value for July the most negative since reliable records began in 1960. Historical index values are based upon the NOAA Extended Reconstructed Sea Surface Temperature Version 5 (ERSST v5), Huang *et al.* 2017, sourced from: http://www.esrl.noaa.gov/psd/.

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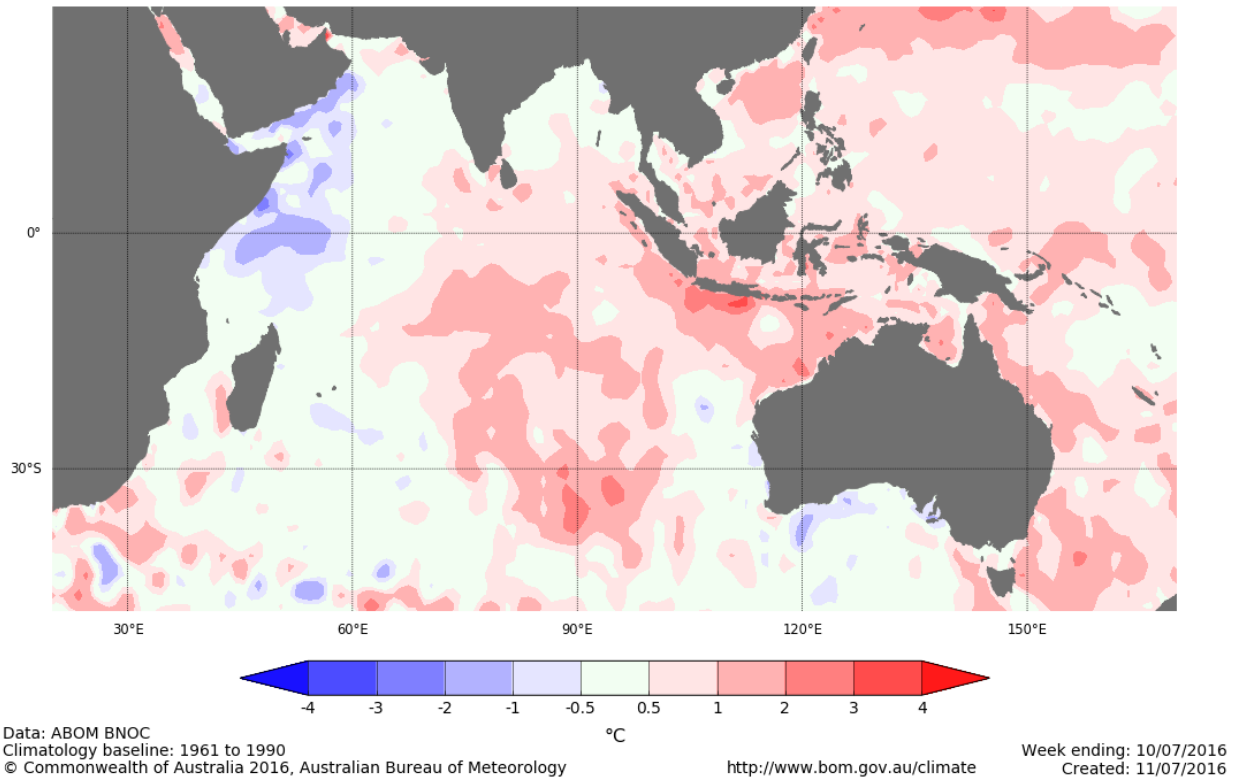


**Fig. 2** Sea surface temperature anomalies showing the negative Indian Ocean Dipole (IOD) pattern during the week ending 10 July 2016. The negative IOD pattern is characterized by cooler than average waters near the Horn of Africa, and warmer than average waters off the Indonesian islands of Sumatra and Java. Source: Australian Bureau of Meteorology.

## 4. Rainfall effect and Australian cropping season

The strong negative IOD heralded wetter conditions for much of southern Australia, and helped bring Australia its wettest May to September period in 117 years of national rainfall records (Fig. 3). This was a much needed turnaround for previously drought-affected regions in Victoria and inland Queensland.

The end of the negative IOD event in November, and a subsequent return to near-average rainfall and temperatures, meant the Australian grain crop of 2016 had experienced a near-perfect growing-season climate. Ideal conditions for the grain crop are good rainfall and few frosts during its growing season, and little rainfall or heatwaves during the harvest time, which is typically around November or December. These ideal growing conditions in 2016 resulted in Australia's largest winter grain crop on record, around 30 per cent above the previous record set in 2011–12 (ABARES 2018).

In contrast, eastern Africa continued to experience dry conditions, with the failure of their long rains (March to May) and short rains (October to December) extending an already significant drought, leading to poor crops and ultimately a food shortage crisis (World Food Program 2016 a, b).

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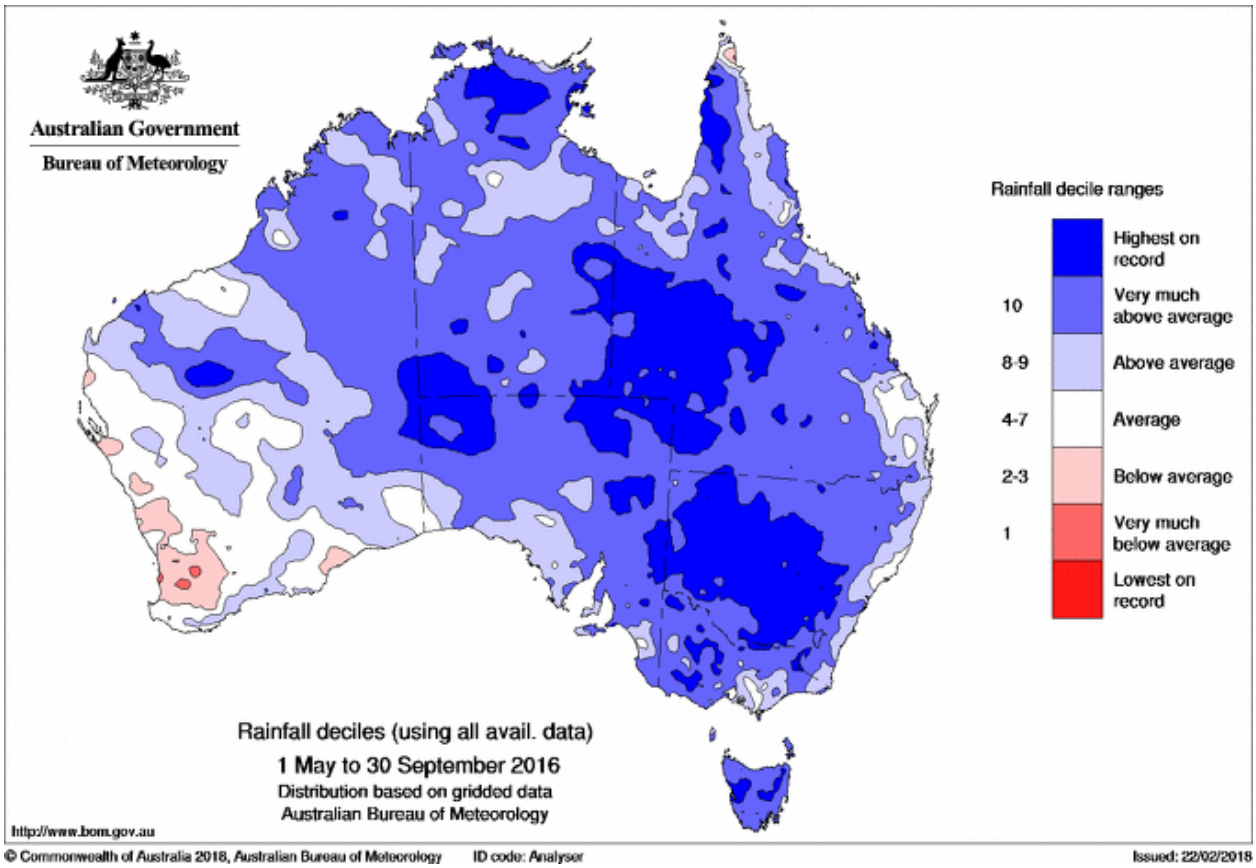


**Fig. 3** Rainfall deciles for May to September 2016 for Australia, based on the 1900–2016 distribution. (Source: Australian Bureau of Meteorology)

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