

Droughts and flooding rains: it takes three oceans to explain Australia's wild 21st-century weather

Australia is a land of extremes, and famously of “droughts and flooding rains”. That’s been truer than ever in the 21st century; since 1999 the country has see-sawed from drought to deluge with surprising speed.

There was the millennium drought, which lasted more than a decade and culminated in disasters such as Victoria’s Black Saturday bushfires in 2009. Then, in 2011, Cyclone Yasi struck Queensland and a large swathe of Australia exploded under a green carpet of grasses, shrubs and trees.

Filming of the movie Mad Max: Fury Road was moved from outback Australia to Namibia after the big wet of 2010-11, because Australia’s luxurious growth of wildflowers and metre-high grasses didn’t quite match the post-apocalyptic landscape the movie’s producers had in mind. In Alice Springs, the Henley-on-Todd Regatta was almost cancelled in 2011 because there was water in the normally dry river.



The Todd River in June 2010 (left) and December 2010 (right). James Cleverly, Author provided

Globally, the big wet on land caused a [5 mm drop in sea levels](#) as large amounts of rain were deposited on Australia, South America and Africa. This coincided with an [unprecedented increase in carbon stored in vegetation](#), especially in arid and semi-arid regions of the southern hemisphere. The greening of Australia in particular had a globally significant impact.

Meteorologists have struggled to explain these wild variations in Australia's weather. Dry years with disappointing crops have been linked to the Pacific Ocean's El Niño phase (part of a cycle called the El Niño-Southern Oscillation (ENSO)). But despite its huge influence, not even ENSO can fully account for Australia's extreme rainfall patterns.

Our research, published this week in [Nature's Scientific Reports](#), offers an explanation. We found that conditions in the three oceans that surround Australia – the Pacific, Indian and Southern Oceans – combine to amplify each other's influences on Australian weather.

Extraordinarily wet and dry years occur when the ENSO phase is in sync with two other cycles, called the Indian Ocean dipole (IOD) and the Southern Annular Mode (SAM).

The three have been synchronised since 1999, which explains why things have been so volatile this century.

Weather engines

ENSO is the biggest driver of global climate and associated rainfall patterns – unsurprisingly, given that the Pacific is the world's biggest ocean. The IOD is generated by a gradient in sea-surface temperatures along the equator in the Indian Ocean, while the SAM represents a north-south oscillation in Southern Ocean sea-surface temperatures.

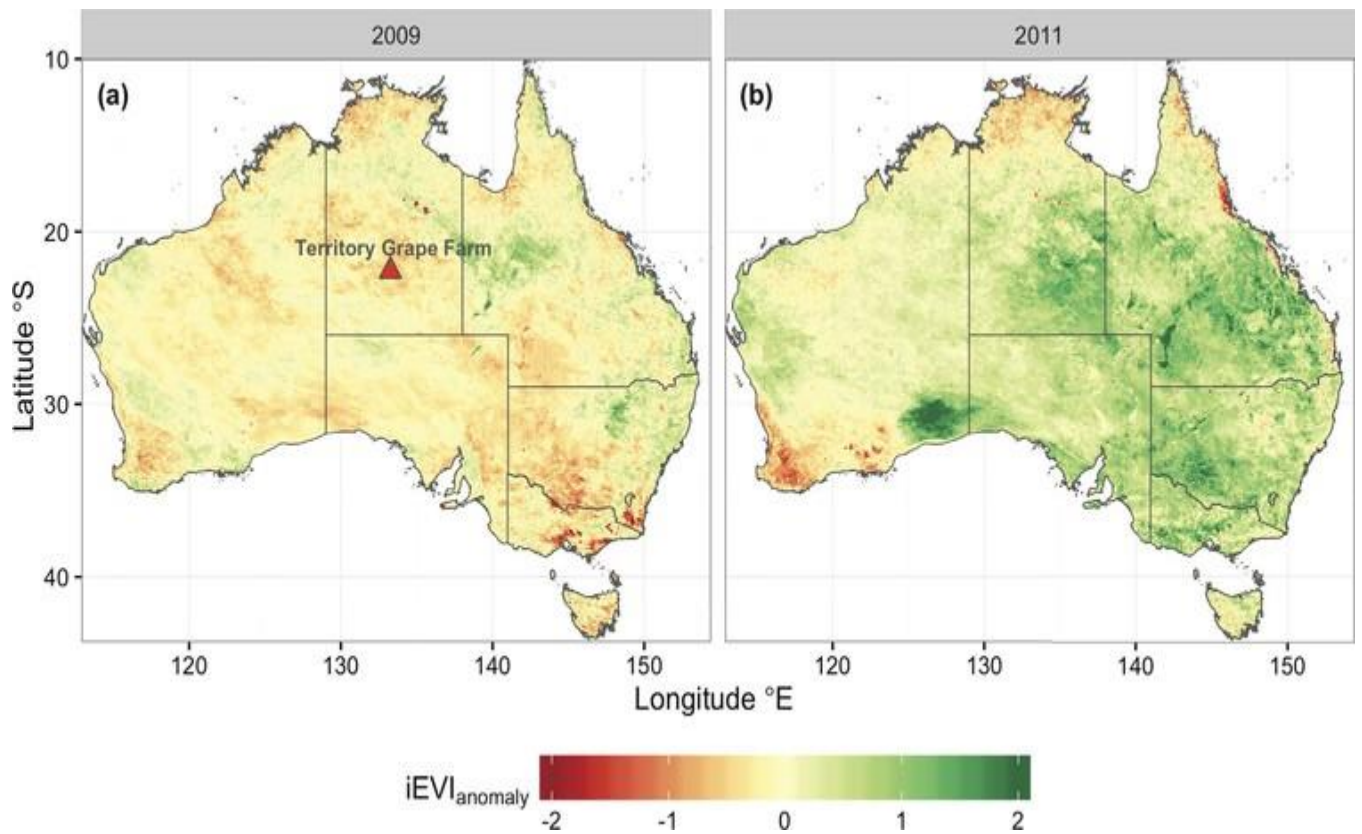
By comparing sea-surface temperatures in the three oceans with rainfall data and satellite images of vegetation growth, we have shown for the first time that abnormally large fluctuations in rainfall across Australia are due to the synchronisation of these three ocean cycles.

For instance, both La Niña and negative IOD bring rain to Australia. When they co-occur, one amplifies the other. This is reinforced still further by a negative SAM, which helps to create the Continental Low, which can interact with the monsoon depression [over a large area of the continental interior](#).

When all of this happens together, it results in extraordinarily heavy rainfall over large parts of Australia, transforming deserts into vast oases teeming with life.

Withstanding the switch

When the rain arrived in 2010, it was abrupt – coming straight after one of the driest years this century. In 2009, only 139 mm fell at the Bureau of Meteorology's [Territory Grape Farm](#) station. The heart of the monsoon depression had been pushed north of Darwin, high pressure blocked rain from central and western Australia, and green plant growth was restricted to a small strip of land from Tennant Creek, in the Northern Territory, into Queensland.



Green plant growth across Australia, compiled via satellite observations. [Nature Scientific Reports, CC BY](#)

Too much or too little rain can each be problematic. When both happen in quick succession, it is hard to profit fully from the wet or to remain solvent through the dry. In natural ecosystems, bushfires become more likely as the plants swing between exceptional growth and subsequent drying and death, leaving behind huge amounts of fuel. Farmers may need to diversify their livestock numbers and crop types to provide extra resilience to the changing conditions.

Understanding how Australia responds to these extremes offers a barometer for emergency services, farmers and everyone else on the land who will need to adapt to Australia's lean times as well as the times of plenty.