

# CLIMATE VARIABILITY AND EL NIÑO

*Generations of Australian school-children learned a poet's phrase which described their country as 'a land of droughts and flooding rains'. Today's scientists talk in terms of the continent's large climate variability from season to season, and from year to year.*

The impact of climate variability on Australia has been highlighted by the fluctuating events during the 1990s. While Queenslanders suffered drought for much of the first half of the decade, people in southeast Australia contended with severe spring floods in 1992 and 1993. Drought spread nationwide in 1994, but the pendulum swung the other way in 1995 and 1996 as heavy rain and flooding returned to many parts. Drought once again visited the southeast of the country during 1997 and 1998.

What causes these fluctuations? They are connected with the climate phenomenon called the Southern Oscillation, a major air pressure shift between the Asian and east Pacific regions whose best-known extremes are El Niño events. The Southern Oscillation (strength and direction) is measured by a simple index, the SOI, defined on the next page.

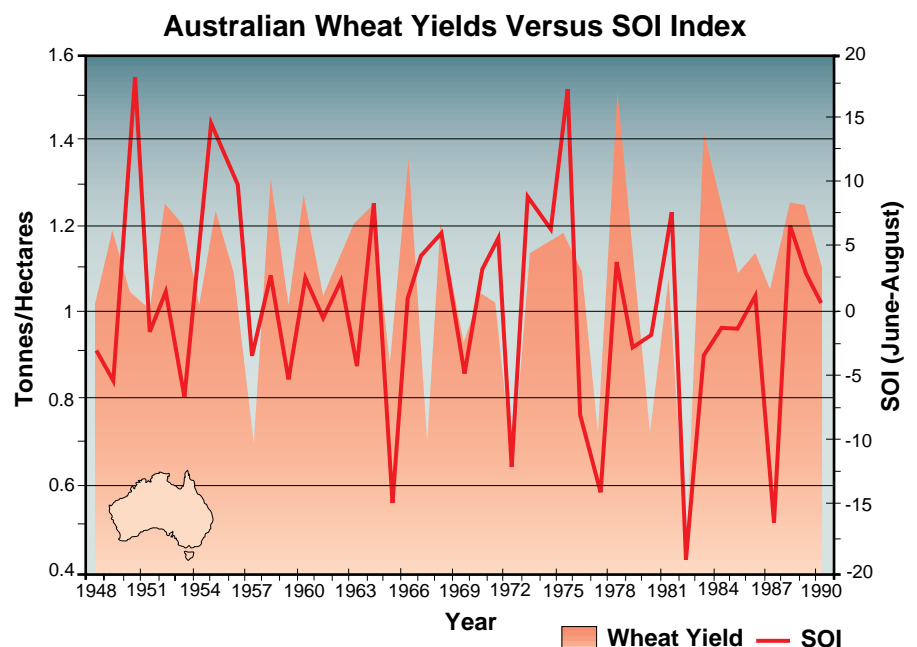
Rural productivity, especially in Queensland and New South Wales, is linked to the behaviour of the Southern Oscillation. The graph opposite shows how Australia's wheat yield\* has fluctuated with variations in the Southern Oscillation. Negative phases in the oscillation (drier periods) tend to have been linked with reduced wheat crops, and vice versa.

Tourism is another industry vulnerable to large swings in seasonal climate. Because climate variability can affect the Australian economy, Australians need the best possible understanding of the physical mechanisms controlling this dramatic feature of their climate.

## Why 'El Niño' ?

El Niño translates from Spanish as 'the boy-child'. Peruvian anchovy fishermen traditionally used the term – a reference to the Christ child – to describe the appearance, around Christmas, of a warm ocean current off the South American coast, adjacent to Ecuador and extending into Peruvian waters.

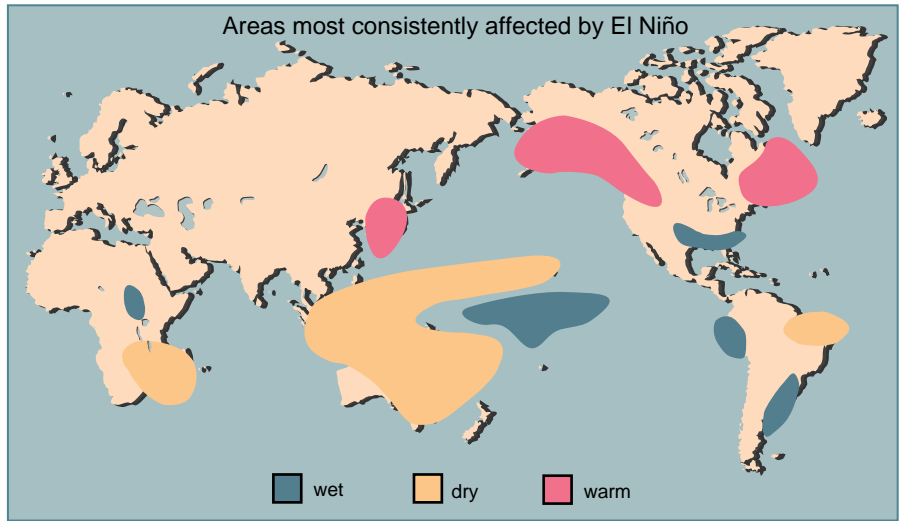
El Niño affects traditional fisheries in Peru and Ecuador. In most years, colder nutrient-rich water from the deeper ocean is drawn to the surface near the coast (upwelling), producing abundant plankton, food source of the anchovy. However, when upwelling weakens in El Niño years, and warmer low-nutrient water spreads along the coast, the anchovy harvest plummets. It was ruined in the four or five most severe El Niño events this century.



\* trend over time removed

### El Niño's Global Effects

The South American El Niño current is caused by large-scale interactions between the ocean and atmosphere. Nowadays, the term El Niño refers to a sequence of changes in circulations across the Pacific Ocean and Indonesian archipelago when warming is particularly strong (on average every three to eight years). Characteristic changes in the atmosphere accompany those in the ocean, resulting in altered weather patterns across the globe.



### The Pacific Ocean's Circulation Features

The Pacific Ocean is a huge mass of water which controls many climate features in its region. Its equatorial expanse, far larger than the Indian or Atlantic Oceans, is critical to the development of the Southern Oscillation and El Niño.

In most years the Humboldt current brings relatively cold water northward along the west coast of South America,

an effect increased by upwelling of cold water along the Peruvian coast. The cold water then flows westward along the equator and is heated by the tropical sun.

These normal conditions make the western Pacific about 3°C to 8°C warmer than the eastern Pacific. However, in El Niño years the central or eastern Pacific may become as warm as the western Pacific.

### The Walker Circulation

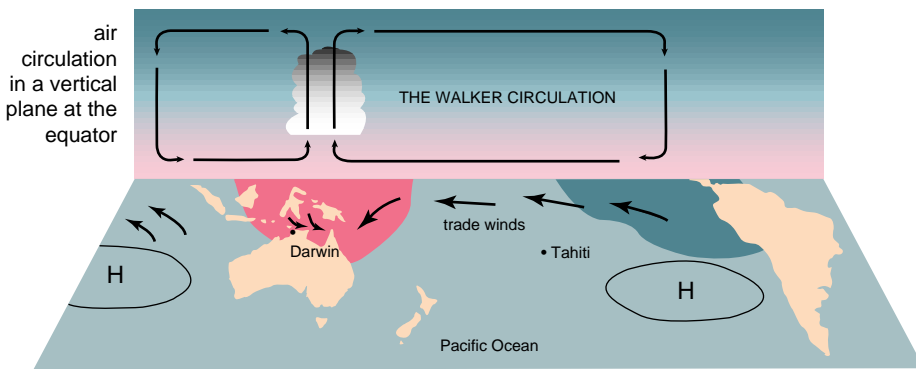
The Walker circulation is named after Sir Gilbert Walker, a Director-General of British observatories in India who, early this century, identified a number of relationships between seasonal climate variations in Asia and the Pacific region.

*I cannot help believing that we shall gradually find out the physical mechanism by which these [relationships] are maintained ...*

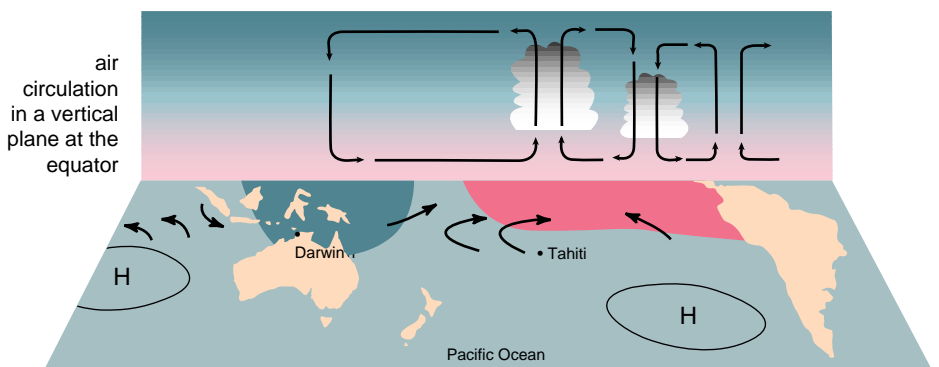
– Sir Gilbert T. Walker, 1918

The easterly trade winds are part of the low-level component of the Walker circulation. Typically, the trades bring warm moist air towards the Indonesian region. Here, moving over normally very warm seas, moist air rises to high levels of the atmosphere. The air then travels eastward before sinking over the eastern Pacific Ocean. The rising air is associated with a region of low air pressure, towering cumulonimbus clouds and rain. High pressure and dry conditions accompany the sinking air. The wide variations in patterns and strength of the Walker circulation from year to year are shown in the diagrams opposite.

### Typical Walker circulation pattern



### Walker circulation during an El Niño



warmer sea    
  cooler sea    
  typical summer positions of high pressure systems    
  surface winds

### The Southern Oscillation

*By the Southern Oscillation is implied the tendency of pressure at stations in the Pacific ... to increase, while pressure in the region of the Indian Ocean ... decreases.*

– Sir Gilbert T. Walker, 1924

This definition remains valid. We now say that the Southern Oscillation occurs because of the large changes in the Walker circulation closely linked to the pattern of tropical Pacific sea temperatures.

### The Southern Oscillation Index (SOI)

The Southern Oscillation Index (SOI) gives us a simple measure of the strength and phase of the Southern Oscillation, and indicates the status of the Walker circulation. The SOI is calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin. The 'typical' Walker circulation pattern shown in the diagram has an SOI close to zero (Southern Oscillation close to the long-term average state). When this pattern is strong the SOI is strongly **positive** (Southern Oscillation at one extreme of its range). When the Walker circulation enters its El Niño phase, the SOI is strongly **negative** (Southern Oscillation at the other extreme of its range).

Positive values of the SOI are associated with stronger Pacific trade winds and warmer sea temperatures to the north of Australia. Together these give a high probability that eastern and northern Australia will be wetter than normal.

During El Niño episodes, the Walker circulation weakens, seas around Australia cool, and slackened trade winds feed less moisture into the Australian/Asian region. There is then a high probability that eastern and northern Australia will be drier than normal.

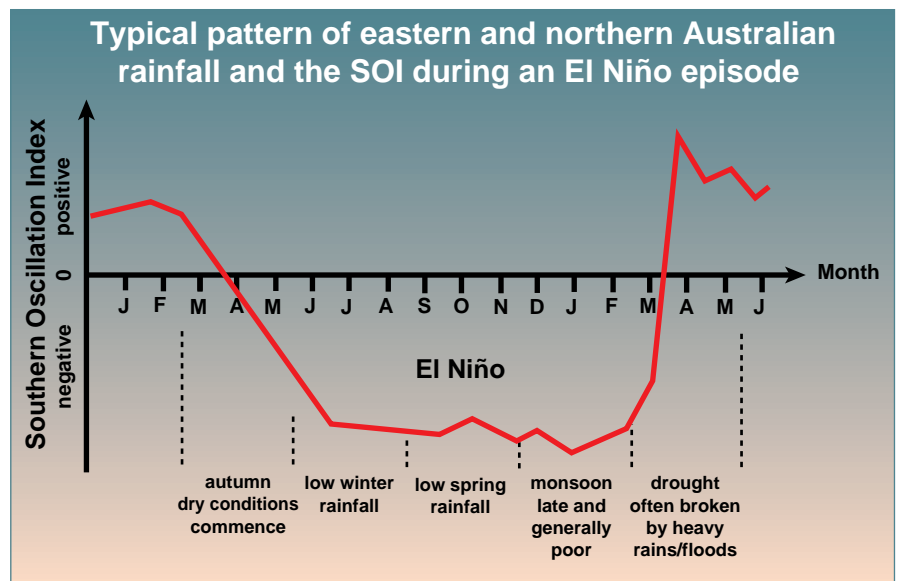
### Climate Clues to El Niño

Meteorologists watch for changes to the atmosphere and ocean circulation which help them detect an El Niño, or forecast its lifetime. Indicators are:

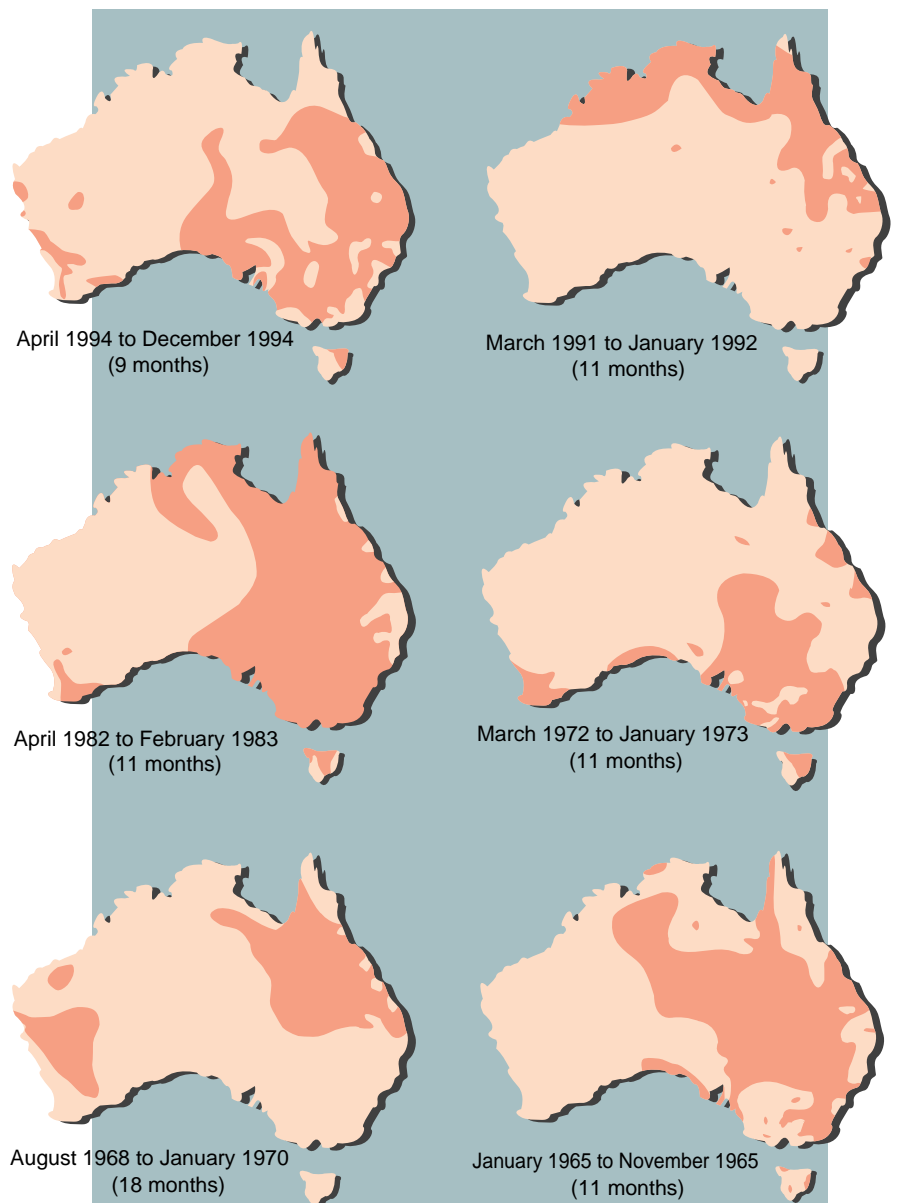
- The Walker circulation and trade winds weaken. During more intense El Niño episodes, westerly winds are observed over parts of the equatorial western and central Pacific.
- The area of warm water usually over the western tropical Pacific cools and the warmest water is displaced eastward to the central Pacific.
- The normally cold waters on the South American coast warm by 2°C to 8°C.
- The Southern Oscillation Index remains negative.
- Enhanced cloudiness develops over the central equatorial Pacific.

### El Niño's Opposite Phase

When the Southern Oscillation Index sustains high positive values, the Walker circulation intensifies, and the eastern



### El Niño related drought areas in Australia since 1965



widespread rain and flooding to Australia – this phase is sometimes called anti-El Niño (or La Niña). Australia's strongest recent examples were in 1973–74 (Brisbane's worst flooding this century in January 1974) and in 1988–89 (vast areas of inland Australia had record rainfall in March 1989).

## Forecasting El Niño

Scientists have made important advances in understanding El Niño/Southern Oscillation phenomena in recent decades. These led to the National Climate Centre's launch of the Seasonal Climate Outlook Service in 1989. The service offers medium-term (three-months ahead)

outlooks of rainfall. Useful predictions of seasonal rainfall have the potential to contribute to the goals of sustainable development in the rural sector.

## Ecologically Sustainable Development in Australia

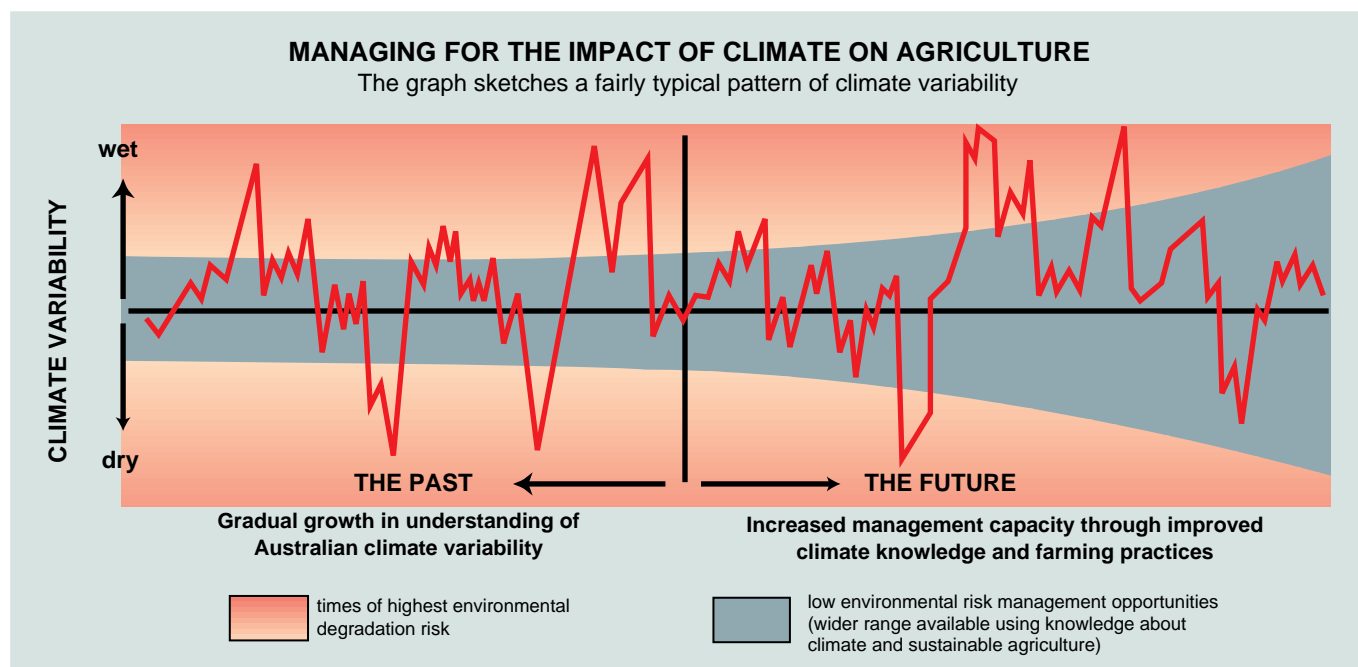
A large proportion of Australia's natural environment is farmed, harvested or managed by farmers. Many renewable resources, from topsoil to wildlife, are broadly under rural sector management.

Rural communities need the best climate advice to help them protect and sustain national ecological resources in the face

of climate extremes. Improved understanding of climate variability, and application of appropriate management techniques, will be crucial to achieving sustainable development goals.

## The Future

Sustainable development requires improved management in all climate ranges, especially during climate extremes, which bring the greatest risk of environmental degradation. The diagram below suggests how improved climate understanding and forecast skill may increase the range of low-risk conditions, and enhance our capacity to better manage high-risk periods.



## More Information

The National Climate Centre monitors the climate of the Australian region. It provides routine information on current climate conditions in Australia. If you would like more information about Australia's climate, El Niño or the Seasonal Climate Outlook service, contact us at the:

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