Communicating Climate Change
Module 1
An initiative of the National Agriculture and Climate Change Action Plan

August 2008

Weather drivers in Queensland

Key facts

Major weather drivers in Queensland are:

- trade winds
- El Niño - Southern Oscillation
- tropical cyclones and tropical depressions
- the monsoon
- Madden-Julian Oscillation
- the inland trough
- cut-off lows (and east-coast lows)
- cloudbands
- frontal changes

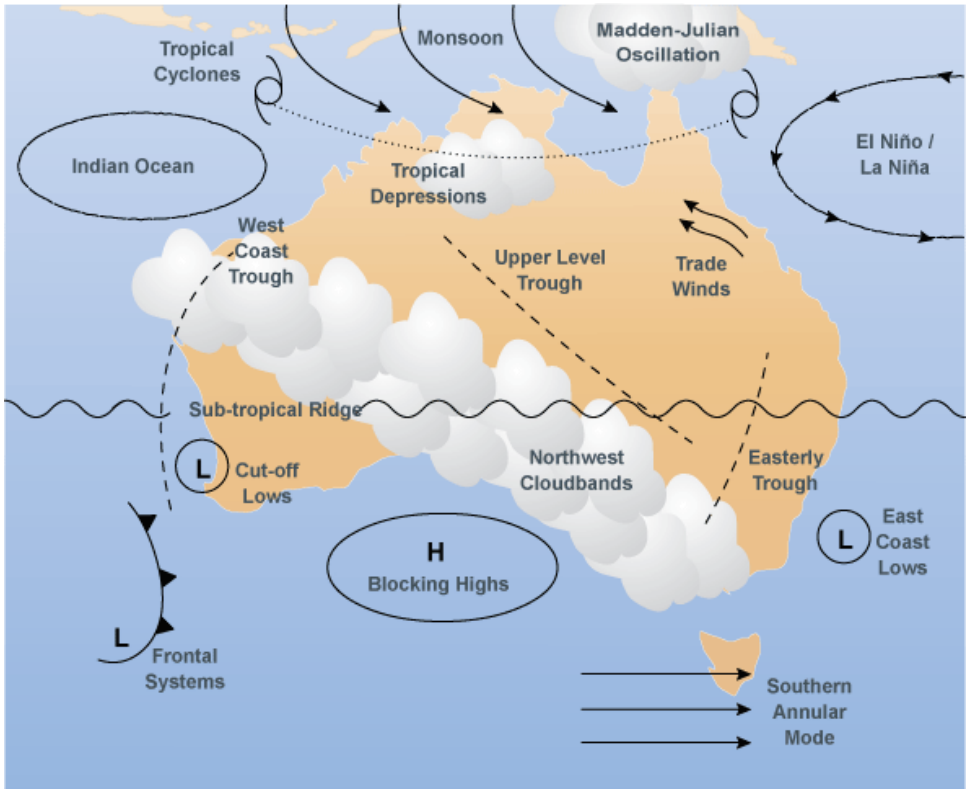


Figure 1: The major weather and climate drivers across Australia

A cooperative venture between

MANAGING CLIMATE VARIABILITY R&D PROGRAM
BCG shared solutions
Australian Government
Department of Agriculture, Fisheries and Forestry
Bureau of Meteorology
QFF QUEENSLAND FARMERS' FEDERATION
mla MEAT & LIVESTOCK AUSTRALIA

Introduction

The climate of Australia varies across many different regions and timescales. Here we introduce the major elements that affect the weather and climate of Queensland.

The driving force behind our weather is the general circulation of the atmosphere, caused by unequal heating of the Earth's surface. Energy from the sun causes evaporation from tropical oceans and uneven heating of land and sea surfaces.

An extensive area of high pressure, known as the **sub-tropical ridge**, is a major feature of the general circulation of our atmosphere. It moves north in winter, resulting in drier conditions over Queensland.

North of the sub-tropical ridge, towards the equator, is the trade wind belt of predominantly south-easterly winds which blow towards a zone of low pressure called the **equatorial trough** or **Australian monsoon trough**. The movements of this trough are relatively small over ocean areas, but as summer approaches and the land heats up it moves as far south as northern Australia. This triggers the **onset of the monsoon** as warm moist air moves in from the northwest, replacing the drier air of the trade winds.

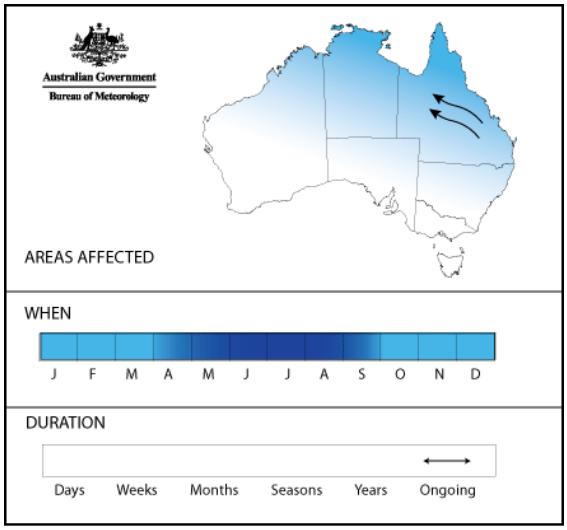
The **monsoon season** in northern Australia usually lasts from December to March; the **wet season** encompasses the monsoon months but can extend several months either side. Generally, April is a transitional month and by May trade winds are well established again over Queensland. Normally the **cyclone season** starts in mid-December and finishes at the end of April; however, some tropical cyclones have been known to form during May.

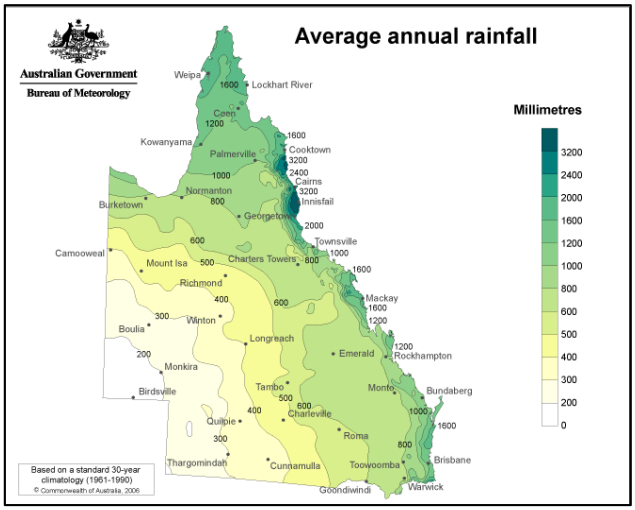
Trade winds

Trade winds blow from an east-to-southeast direction across much of the southern hemisphere tropics. They prevail along the east coast of Queensland.

They collect moisture as they move eastward over the tropical Pacific Ocean towards the east coast of Australia and bring rainfall to tropical and sub-tropical areas of the east coast.

The impact of the trade winds is greatest from April to September (the darker blue on the scale in the diagram opposite).





Trade winds are at their strongest when a slow-moving high pressure system is located off the east coast of Australia in the Tasman Sea.

The most significant rainfall driven by the trade winds occurs on the eastern side of the Great Dividing Range, with some areas there being among Australia's wettest places.

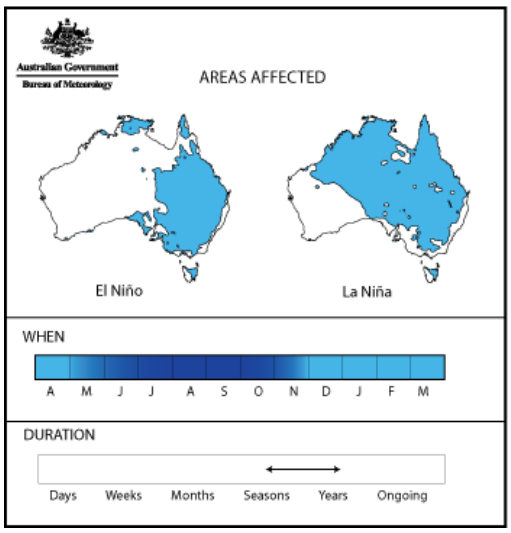
The average annual rainfall map of Queensland (Figure 2) clearly shows the influence of the prevailing southeast winds.

Figure 2: Average annual rainfall in Queensland, 1961–90

El Niño - Southern Oscillation

Sea surface temperatures in the Pacific Ocean can affect rainfall across the eastern half of Australia, including Queensland.

The El Niño - Southern Oscillation (ENSO) is a major influence on our climate. ENSO is the oscillation between El Niño and La Niña conditions, which describe the variations in atmospheric patterns across the Pacific Ocean, and variations in sea surface temperatures in the central and eastern tropical Pacific Ocean.



El Niño is associated with extensive warming of the sea surface in the central and eastern tropical Pacific, and is often associated with below average winter/spring rainfall over much of eastern Australia.

La Niña is associated with extensive cooling of the sea surface in the central and eastern tropical Pacific, and is often associated with above average winter/spring rainfall over much of eastern Australia.

The El Niño event of 2002–03 seriously affected rainfall over Queensland. Rainfall was well below average across the state (Figure 3), with many areas experiencing severe water shortages.

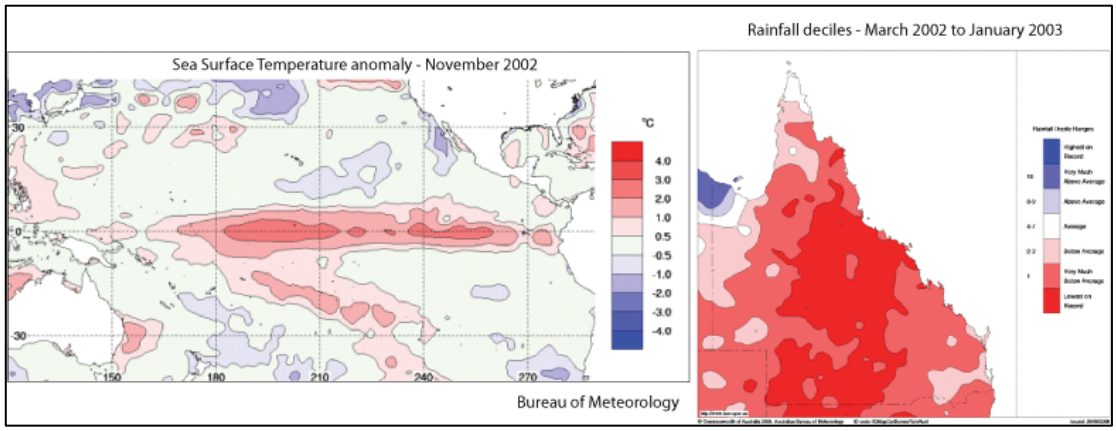
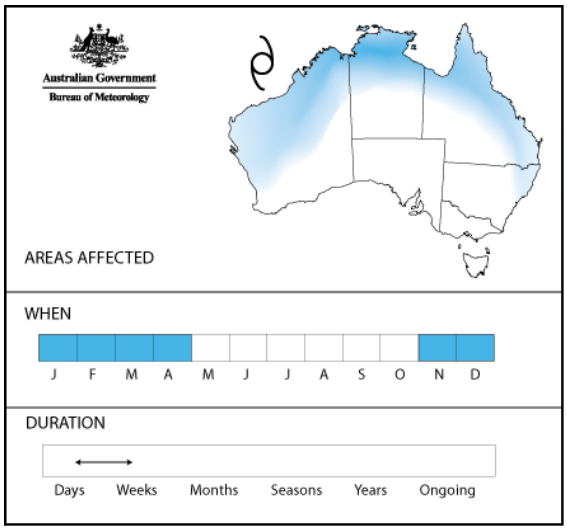


Figure 3: Sea surface temperatures in November 2002 (left) and below average rainfall in Queensland associated with the 2002–03 El Niño event (right)

Tropical systems

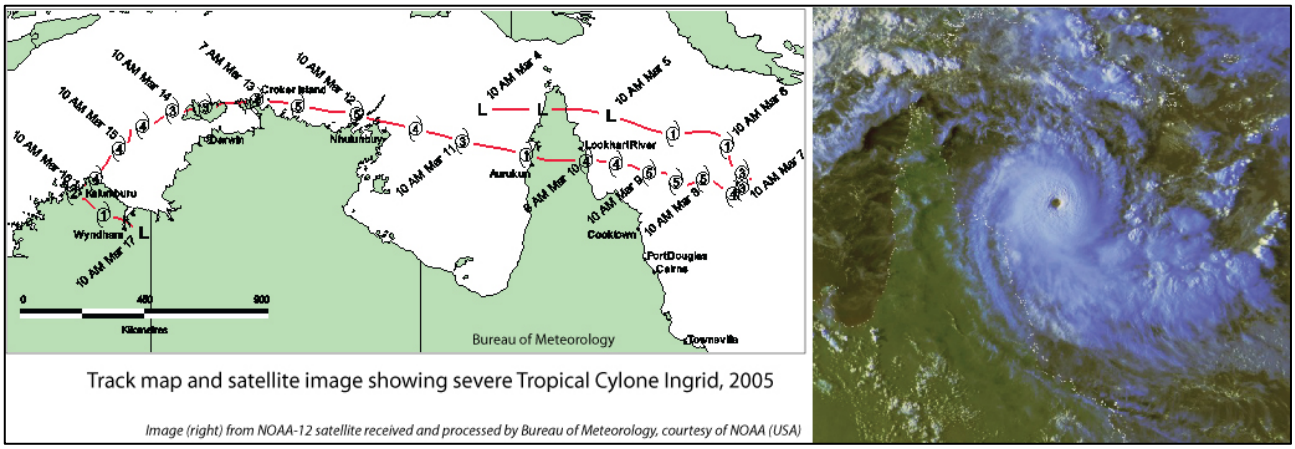
During the north Australian wet season (generally between October and April), tropical systems affect mainly northern and central parts of Queensland, but can occasionally also affect regions further south. These systems include tropical cyclones, tropical depressions, the monsoon and the Madden-Julian Oscillation.



Tropical cyclones

Tropical cyclones are very intense low-pressure systems that produce **heavy rainfall, destructive winds and damaging storm surges**. They have wind gusts in excess of 90 km/h around their centres; in the most severe cyclones, gusts can exceed 280 km/h. These winds can cause extensive property damage and turn airborne debris into potentially lethal missiles.

On **10 March 2005**, severe **Tropical Cyclone Ingrid** crossed the east coast of Queensland, south of Lockhart River. Small in size, but very intense, Ingrid is the only severe tropical cyclone in recorded history to impact the coastlines of three states/territories. At the coastal crossing point, many trees were defoliated, stripped of bark, and felled. A 2.7 metre storm tide inundated the coast 60 kilometres south of the Lockhart River township. Rainfall exceeded 200 mm in parts of far north Queensland—small amounts for a cyclone, partly due to Ingrid's small size.



Track map and satellite image showing severe Tropical Cylone Ingrid, 2005

Image (right) from NOAA-12 satellite received and processed by Bureau of Meteorology, courtesy of NOAA (USA)

Tropical depressions

Tropical depressions are moderate-strength low-pressure systems, often associated with the monsoon trough. They may develop into tropical cyclones if they are in the 'right' place. They often produce **significant rainfall** and **strong and gusty winds**.

The monsoon

The term 'monsoon' is used to describe the seasonal reversal of winds that occurs over parts of the tropics. As the Australian summer approaches, the continent heats up. Low pressure is created, which effectively draws the monsoon trough—a zone of low pressure and rising air—over northern Australia. This trough draws in moist air from the surrounding oceans and we refer to this influx of moist air as the monsoon.

The monsoon can be in either an 'active' or an 'inactive' phase.

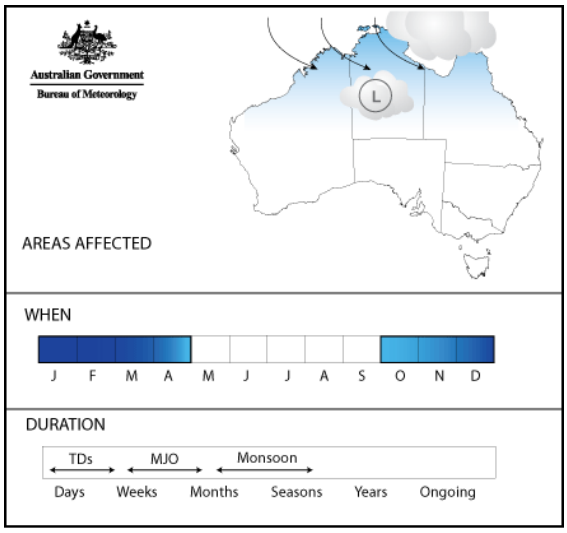
The **active phase** is usually associated with broad areas of cloud and rain, with sustained moderate to fresh northwesterly winds on the north side of the trough. Widespread heavy rainfall can result if the trough is close to, or over, land.

An **inactive phase** or 'break' period occurs when the monsoon trough temporarily weakens or retreats north of Australia. It is characterised by light winds and isolated shower and thunderstorm activity, sometimes with gusty squall lines. A squall line is a long line of thunderstorm cells, sometimes several hundred kilometres in extent.

The Madden-Julian Oscillation

The Madden-Julian Oscillation (MJO) is a large-scale slow-moving band of increased cloudiness that travels eastwards in the tropics. It moves around the globe along the equator, 'pulsing' roughly every 30–60 days. The signal of the MJO in the tropical atmosphere is not always present, making it hard to detect at times.

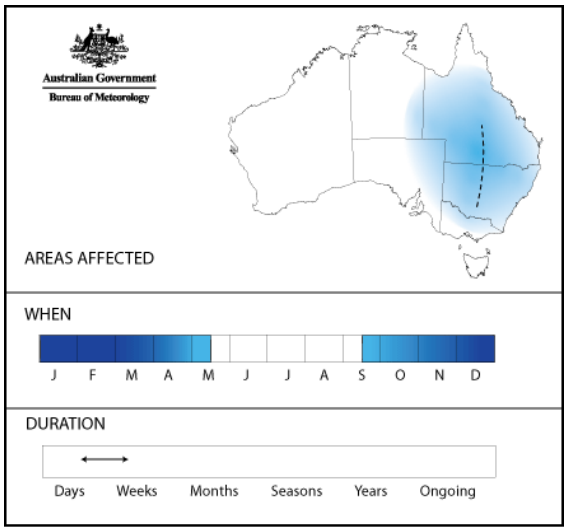
The MJO influences the timing of the onset of the monsoon and can also influence the transitions from active to inactive monsoon phases. Tropical cyclones are more likely to develop when the MJO is active in Australian regions.



The inland trough

The inland trough, or dry line, is a semi-permanent feature of the synoptic pattern over the interior of Queensland. It is most developed and active during the warmer months.

The trough is located on the lee side (inland side) of the Great Dividing Range, forming a boundary between the moist air near the coast and dry air inland. It extends through central Queensland and into central New South Wales. It is partly formed by the intense heating of the land during warmer months, but the topography of the region also plays a role.



As the temperature rises during the day, the trough deepens and moves towards the coast, often causing **showers and thunderstorms** to form in the moist unstable air to its east. Rainfall can be particularly heavy when the trough interacts with other features, such as a cold front or a mid- or upper-level trough in the atmosphere.

On 9 October 2007, showers and thunderstorms developed in the unstable air east of the inland trough. An upper-level trough increased the activity about the southeast of the state and several ‘supercell’ thunderstorms (intense thunderstorms which can last for many hours) developed, producing heavy rainfall, strong winds and large hail (Figure 4).

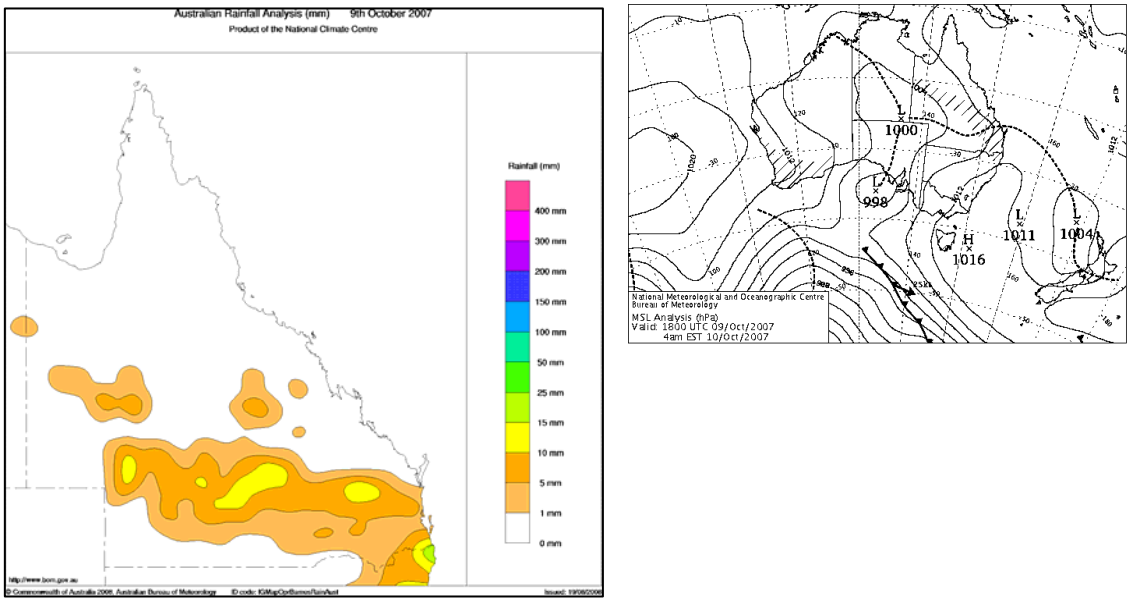


Figure 4: Queensland rainfall (left) associated with the inland trough (right), 9 October 2007

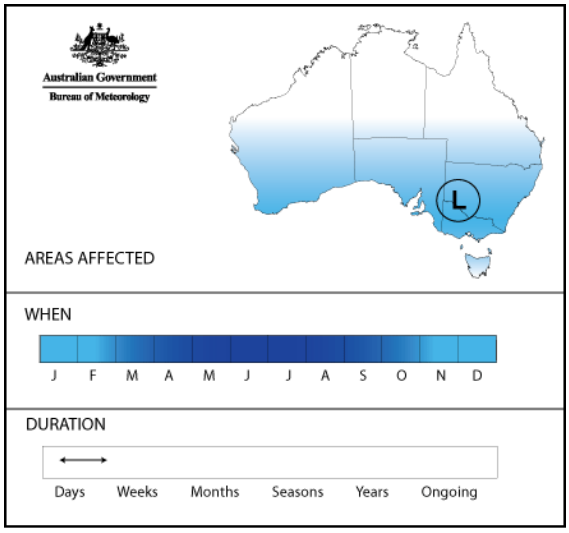
Cut-off lows and east-coast lows

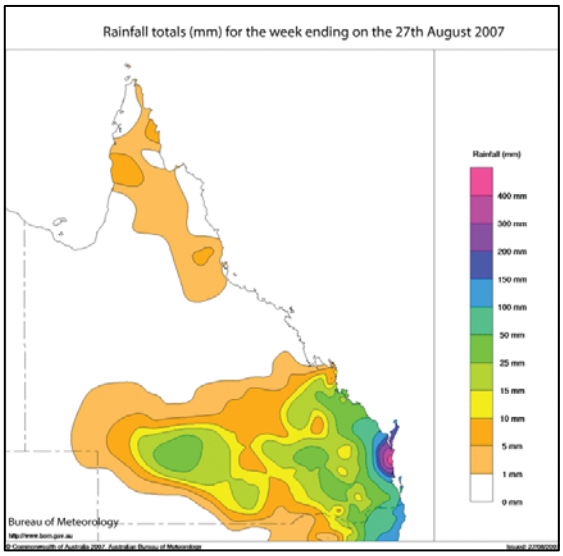
Cut-off lows are low-pressure systems that break away from the main belt of low pressure that lies across the Southern Ocean. They are associated with sustained rainfall and can produce strong, gusty winds and high seas.

If a cut-off low is slow-moving or near-stationary, rainfall may occur for extended periods and may be heavy at times.

East-coast lows are a type of cut-off low that occurs off the eastern coast of Australia, on average several times a year.

The cut-off low in Figure 5 brought strong to gale force winds and dangerous surf to exposed parts of southeast Queensland from 21 to 24 August 2007. Torrential rainfall occurred over parts of the Southeast Coast and Wide Bay districts, with some very high daily totals resulting in flash flooding at Tewantin and Noosaville on the 23rd and 24th. This was a very rare rainfall event for Queensland in August.





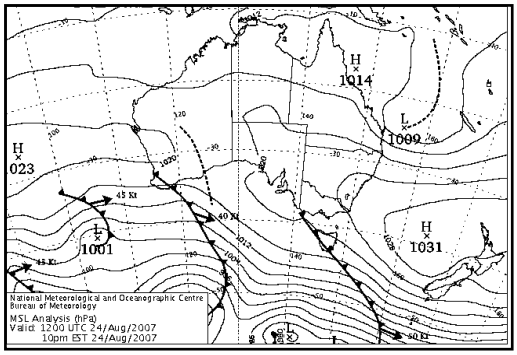
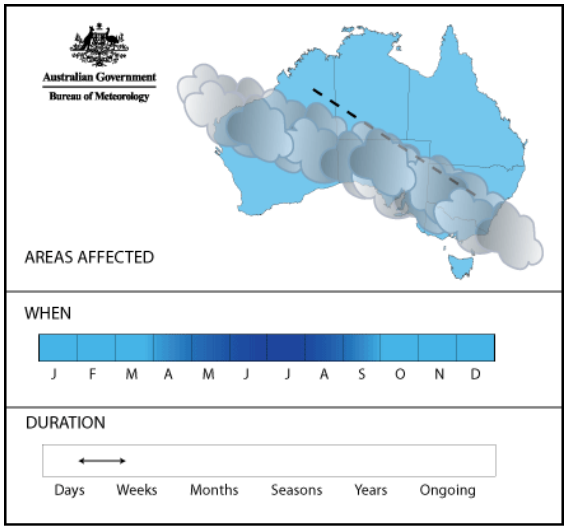


Figure 5: Queensland rainfall (left) associated with a cut-off low (right), August 2007

Cloudbands

A cloudband is an extensive layer of cloud that can stretch across Australia, often from north-west to south-east.

Cloudbands can form when a trough of low pressure occurs in the upper levels of the atmosphere, or when warm, moist tropical air originating over the Indian Ocean moves towards the pole (generally south-eastward), and is forced to rise over colder air in southern Australia.



Cloud bands originating over the Indian Ocean generally slide south-east as they approach Queensland and are often poor rain producers over the state.

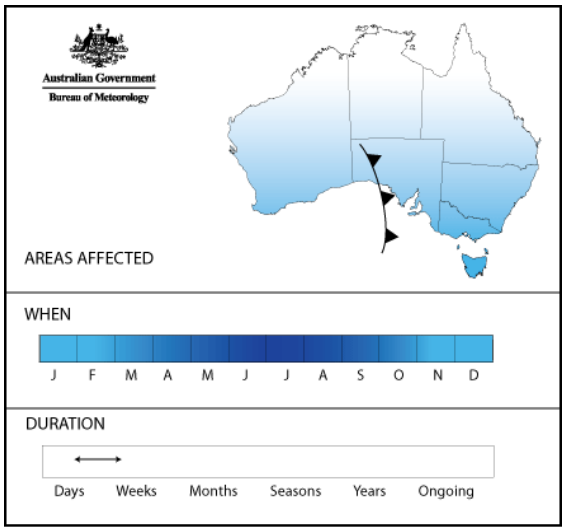
Cloud bands associated with upper troughs that are most developed over central and eastern parts of the Australian continent generally produce much more rain over Queensland. Upper troughs and upper low-pressure systems are often key contributors to widespread rain over central and southern Queensland in autumn and early winter.

Frontal changes

Frontal changes, such as cold fronts, generally move from west to east across the Southern Ocean and vary in their intensity and speed.

Cold fronts affecting Queensland, which are often referred to as troughs or wind changes, are broadly of two types:

- westerly (or south-westerly) changes, which are most common during winter and spring
- south-east changes, which are most common during summer and autumn



Westerly changes keep some of the structure of a cold front, but are altered by their long journey across the Australian continent. They are most developed over southern Queensland, but sometimes extend well into the tropics. They are generally followed by little cloud; however, if there is a deep low-pressure system in the Tasman Sea directing cold moist air over southern Queensland, drizzle may occur about the western slopes of the Great Dividing Range.

The arrival time of a **south-east change** in southeast Queensland is often critical to the development of thunderstorms, with greater heat and instability making the latter part of the afternoon most favourable for thunderstorm development. The over-land section of a south-east change will often merge with the inland trough. The near-coastal section is modified and turned north by the prominent coast of southeast Australia and by the Great Dividing Range, reaching the Queensland coast as a northward propagating south-east (sometimes southerly) change.

Further Information

The Bureau of Meteorology – weather drivers:

http://www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.html