CliMag

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Meeting Australia's rainfall forecast challenges

Lying between the Indian, Pacific and Southern Oceans, Australia's climate—in particular its rainfall—is difficult to predict reliably and accurately, driven as it is by the interplay of a complex set of systems known as climate drivers.

New projects that Managing Climate Variability is contracting out to the Centre for Australian Weather and Climate Research are seeking to fit together the pieces of the jigsaw to improve the skill of forecasts and their value to farmers.

'These projects will improve our understanding of rain-bearing weather systems and climate variability', says Colin Creighton, Program Coordinator of Managing Climate Variability.

In one project, CSIRO's Dr James Risbey is trying to tease out the different and linked effects on weather of climate drivers such as the El Niño - Southern Oscillation (ENSO), the Indian Ocean Dipole and the Southern Annular Mode.

'We want to know the relative contributions of these drivers to rainfall variability and how this varies with location and time of year', he says. 'And we want to know to what extent these drivers are independent or dependent on each other in influencing rainfall.'

Research to date has shown that ENSO influences rainfall in the north and east of Australia in all four seasons. While ENSO also influences rainfall in the south during winter, the Indian Ocean Dipole is the dominant driver of rainfall in the south and west of the continent, especially in winter.

When researchers looked at the interaction between ENSO and the Indian Ocean Dipole, they found that a combination of El Niño and a positive Indian Ocean Dipole brought some of the driest years while the combined effects of La Niña and a negative Indian Ocean Dipole brought extreme wet years.

'It's still not straightforward', says Dr Risbey. 'Rainfall in the south-east and south-west is influenced by ENSO and the Indian Ocean Dipole in the tropics as well as by the Southern Annual Mode in the mid-latitudes. How these drivers interact to produce synoptic features like blocking highs or cut-off lows is an important part of predicting rainfall. We need to learn to combine the effects of these climate drivers to better explain and predict synoptic features and rainfall variability.'

Accurate forecasts of the chances of getting high-rainfall events that soak the soil are important. But current global circulation models that forecast seasonal climate are not effective at simulating these events, which are largely brought on by cut-off lows.

Researchers at The Centre for Australian Weather and Climate Research have painstakingly compared the actual cut-off lows experienced from 1948 to 2007, as indicated on weather synoptic charts, with those identified in global circulation models.

'It is clear that a number of models are not getting it right and are under-representing the effects of cut-off lows', says CSIRO researcher Dr Peter McIntosh.

Dr McIntosh believes that this may be due to the difficulty that climate models have in simulating atmospheric blocking. Blocking generates cut-off lows, and slows them down over eastern Australia so that they deposit more rain. The models' inability to properly simulate the latitude of the subtropical ridge is also an issue.

'To have confidence in seasonal forecasts, we must improve the representation of mid-latitude weather systems', says Dr McIntosh. 'We also need to look at how and why rainfall might change under climate change, and compare this to our understanding of current rainfall processes to have confidence in regional climate projections.'

[continued on page 2]

Stop Press

The Australian Government has announced as part of the 2009–10 Budget that Land & Water Australia, the host agent for Managing Climate Variability, will be wound up. We are working assiduously to ensure the research activity is maintained and to hand over the host agency responsibilities to another research and development corporation so that this valuable research can continue.

Michael Robinson
Executive Director, Land & Water Australia

In this issue

MANAGING CLIMATE VARIABILITY
R & D PROGRAM

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Another new Managing Climate Variability project is investigating the connections between mid-latitude synoptic weather systems such as cut-off lows, and seasonal weather drivers such as ENSO, the Indian Ocean Dipole and the Southern Annular Mode.

Global circulation models based on this greater understanding will mean better forecasts for farmers making weather-dependent decisions.

The Western Australia wheat belt offers one of the clearest opportunities for improving this understanding. The project, led by CSIRO's Dr Senthold Asseng, has shown that the forecasts produced by POAMA—the Bureau of Meteorology's global circulation model for Australia—have good skill in the southern sectors of the wheat belt but no skill in the North Eastern Agriculture Region where the Indian Ocean Dipole is believed to be the major climate driver. POAMA, at this stage, does not adequately represent the Indian Ocean Dipole and addressing this is the objective of another Managing Climate Variability project which started recently.

Dr Asseng looked at 27 years of data to determine the benefits, or otherwise, to growers from Katanning, Nyabing and Mullewa of changing their fertiliser applications in response to forecasts from POAMA.

'We found that if growers in the southern town of Katanning had increased their fertiliser applications in forecast good years, they could have increased their profits by more than $50 per hectare. However, there was little benefit from decreasing their applications in forecast poor years. Because of the importance of the Indian Ocean Dipole, POAMA's forecasts at this stage were not useful in the northern part of the wheat belt.'

Dr Asseng stresses that these predicted benefits are only based on 27 years of data, and longer-scale data is needed before recommending that Katanning growers increase their fertiliser applications according to POAMA forecasts.

Recognising the need to rapidly improve Australia's forecasting capability, Managing Climate Variability—representing Meat & Livestock Australia, the Grains, Sugar and Rural Industries Research and Development Corporations, Land & Water Australia, and Dairy Australia—is investing 55 per cent of its budget in improving Australia's overall skill in forecasting. Projects like Dr Asseng's show the on-farm benefit of this approach as Australian farmers adapt to an even more variable and changing climate.

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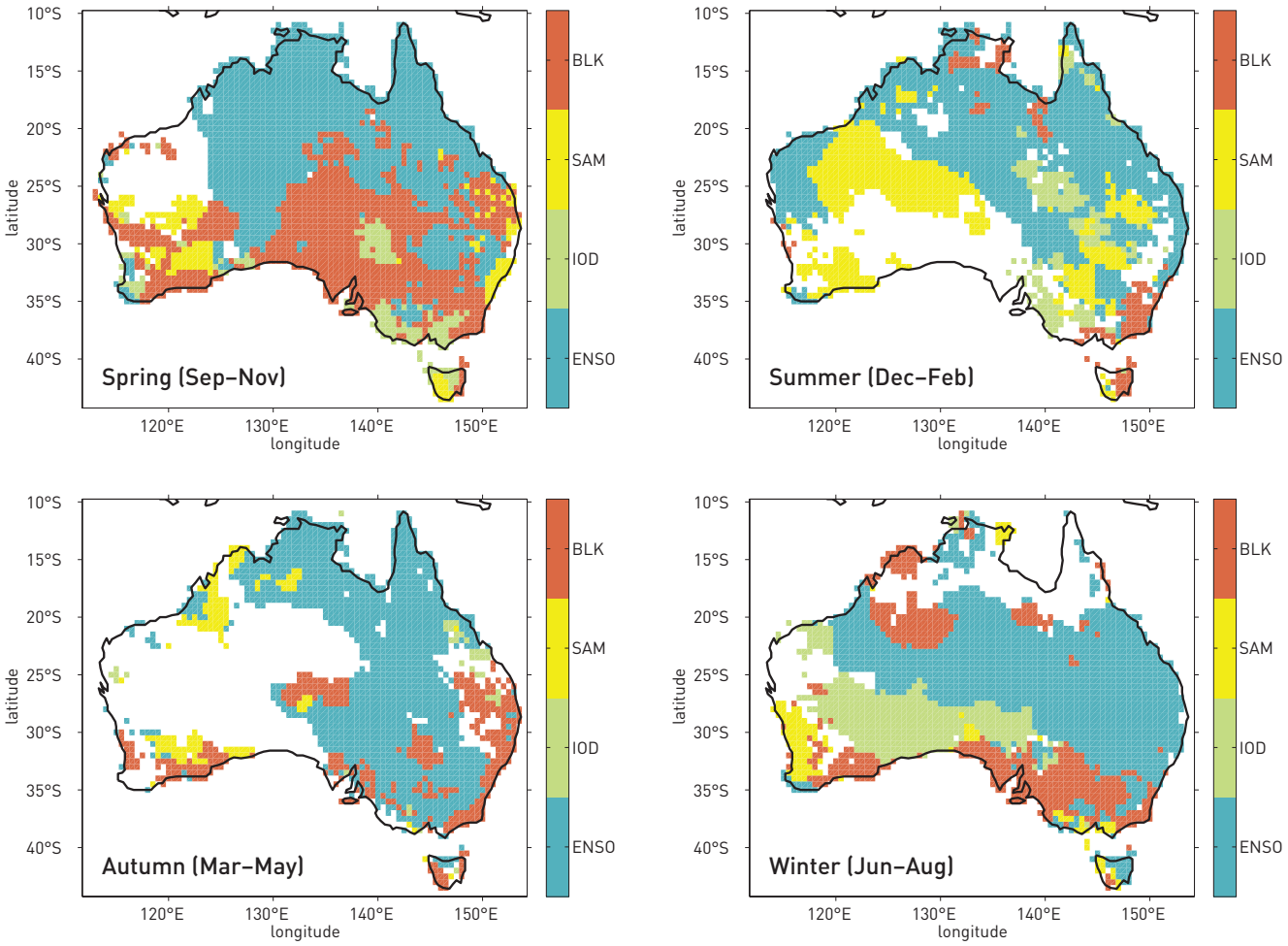
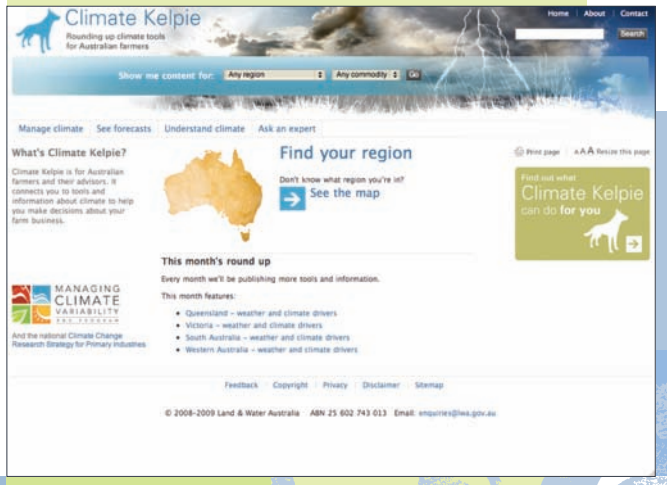


The climate drivers with the greatest relationship (highest correlation) to rainfall for each season. The drivers are:
BLK – blocking, SAM – Southern Annular Mode,
IOD – Indian Ocean Dipole, ENSO – El Niño - Southern Oscillation
Only correlations significant at the 95% level were included in selecting the driver with the highest correlation. In the blank areas none of the drivers has a significant correlation with rainfall. The data span the period 1957–2006.

Rounding up climate information and tools for farmers

Climate Kelpie, Managing Climate Variability's new climate risk management website, is being developed for Australian farmers and advisors as a one-stop shop for climate tools and information that help them respond to our variable climate.



A preview of Climate Kelpie's home page

We initiated the website in response to a survey in 2007 of almost 500 farmers and their advisors from across Australia. More than 90 per cent of farmers surveyed said they wanted and would use a climate risk management website.

The survey, jointly designed by the Bureau of Meteorology and Managing Climate Variability, found that four out of five Australian farmers who responded were regularly using seasonal forecast information from the internet to help them make decisions about planting, harvesting, stocking rates and managing weeds.

Farmers also expressed interest in more region-specific forecast information and in better educational information.

Climate Kelpie, as well as providing summary information about climate drivers, synoptic features and regional climate variability, will 'round up' climate tools and information by providing links to quality-assured climate websites.

'Climate Kelpie, by providing users rapid and reliable access to the latest tools and information about climate variability, will contribute to smarter, more profitable and sustainable Australian agriculture', says Managing Climate Variability Program Coordinator Colin Creighton.

'We will build on the initial development over time, adding new links and tools to the site and adding information from new regions and commodities as this becomes available.'

Users of Climate Kelpie will be able to access:

- information and tools for adapting to a more variable climate
- weather and climate forecasts for their region
- climate drivers and synoptic features for each state/territory
- projected changes to the climate for Australia's agricultural regions
- print-ready versions of the information

The website will also include:

- weather and climate information for all Bureau of Meteorology weather regions in Australia
- climate risk management information for all agricultural commodities
- specific examples and case studies about managing climate variability for each region
- a forum for farmers to discuss on-farm climate risk management practices

Climate Kelpie will be launched in the latter half of 2009. Subject to farmer interest, we will continue to add new content, such as, perhaps, information about greenhouse gas emissions, sourced from Climate Change Research Strategy for Primary Industries http://lwa.gov.au/ccrspi/ partners.

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Project updates

The following table lists our current projects.

Project title	Time	Summary of research objectives	Progress to date	Research contact
Improving seasonal forecasts for south-west Western Australia	April 2008 – May 2011	Increase the value of seasonal forecasts for farmers in south-west Western Australia.	The POAMA model was found to be very useful over the last 27 years for projecting profitability of wheat growers in south-west Western Australia but of no value for the North East Agricultural Region.	**Dr Senthold Asseng** CSIRO senthold.asseng@csiro.au
Integration of climate-related decision-support system tools to improve their relevance	Nov 2008 – June 2009	Critically evaluate decision-support tools designed to support Australian grain growers. Develop a decision-support investment strategy.	Criteria were established for reviewing decision-support systems. Using these criteria, recommendations were made to improve five leading tools developed for Australian cereal growers: Yield Prophet®, PYCAL, Whopper Cropper, the Mallee Calculator and Crop Mate.	**Dr Zvi Hochman** CSIRO zvi.hochman@csiro.au
Critical thresholds and climate change impacts / adaptation in horticulture	Jan 2009 – Jan 2011	Establish a practical understanding of critical temperature thresholds for specific horticultural crops and production regions in Australia. Use this understanding to identify commodities and/or regions which, under climate change, are or will be significantly impacted by increasing temperatures. Assess the impacts and resilience of production systems and/or regions, and identify adaptation strategies to address these impacts.	A literature review inventorying known temperature thresholds for a range of horticultural crops will be available in May 2009.	**Peter Deuter** Queensland Primary Industries and Fisheries peter.deuter@dpi.qld.gov.au
Assessing and managing heat stress in cereals	April 2009 – July 2012	Investigate the meteorology and climatology of spring heat events on the southern grains wheat belt. Develop a risk management package for growers.	The project has just started.	**Dr Peter Hayman** South Australian R&D Institute hayman.peter@saugov.sa.gov.au
Assessing sugarcane production regional impacts of climate change and climate variability	Nov 2008 – Nov 2009	Determine how the sugarcane industry in the Mackay Whitsunday region can best meet the challenge of managing climate change and variability while also ensuring sustainable management of local and regional natural resources.	The 'A' set of management practices for the sugarcane industry are being evaluated against a number of IPCC scenarios for more extreme climate events so that water quality implications can be collated.	**Will Higham** Reef Catchments (formerly Mackay Whitsunday Natural Resource Management Group) will.higham@reefcatchments.com.au
Extremes, climate modes and reanalysis-based approaches to climate resilience	Nov 2008 – June 2010	Using the latest atmospheric reconstructions of the last century of worldwide weather, find ways to help mange climate risk of extreme weather events in Australian agriculture, including adaptation, insurance, seasonal forecasting and future strategic projections for heatwaves, hail and other exceptional circumstances.	Literature reviews of the impacts of extreme weather events were completed for four case studies in Australian agriculture—heat stress in feedlots, storm damage to crops, droughts, and continued and compounding extreme events. The potential for reanalysis procedures and insurance innovations to improve adaptation measures in the associated industries is being assessed.	**Dr Peter Best** University of Southern Queensland cindualpk@bigpond.com
Seasonal forecasting for eastern Australia – scoping study	June 2008 – Dec 2008	Prepare a science plan (outlining opportunities, content and benefits) for increased climate science investment that benefits agriculture in subtropical eastern Australia.	A draft science plan has been prepared. It recommends improving POAMA to include east-coast lows and the phenomena known as the Modoki factor.	**Prof. Roger Stone** University of Southern Queensland stone@usq.edu.au
South-East Australia Climate Initiative	2006 – 2009	Investigate the causes and impacts of climate change and climate variability across south-eastern Australia, home of the Murray-Darling Basin.	Helped define the implications of climate change for runoff in the Murray Basin, the level of climate change already experienced and the role of key drivers (including the Indian Ocean Dipole, the Southern Annual Mode and the Pacific Ocean) in rainfall.	Contact **Murray–Darling Basin Authority** seaci@mdba.gov.au

Projects currently being contracted

- Improve the skill and value of the Bureau of Meteorology's global circulation model, POAMA (three projects).
- Assess the opportunities for multi-week forecasting so that the Bureau of Meteorology can routinely forecast weather beyond the traditional four days and provide seasonal forecasts at shorter time scales than are currently possible.
- Evaluate heat stress and management opportunities for the grape and cereal industries.
- Document climate drivers and synoptic features for New South Wales, Northern Territory and Tasmania to complete the coverage for Australia on the Climate Kelpie website.

Understanding climate extremes increases resilience

Flooded crops

With the nature of extreme weather events—such as hailstorms, extended drought and intense heatwaves—predicted to change in Australia, a new Managing Climate Variability project will improve the resilience of Australia's farms and agribusinesses to these events.

Using new tools to reconstruct the climate by generating 135 years of continuous climate data for most of the world, Dr Peter Best from the University of Southern Queensland and his team are investigating the long-term and future trends in the frequency and severity of storms, floods, cold spells and heatwaves, and their impact on agriculture. They are also finding ways of managing the resulting risks of extreme events.

'To be resilient and viable', says Dr Best, 'farmers need to assimilate the past and future patterns of extreme weather events, their causes and the potential effects of these events on the quantity and quality of crops and livestock.'

Dr Best expects that doing so will encourage farmers to include new techniques for applying forecasting and risk management of extreme weather events in their operational and strategic planning.

'Insurance companies, banks and cooperatives can also use our information to develop new product lines, such as the index-based cover now being successfully adopted in countries such as Peru and India.'

Dr Best and colleagues from the Australian Centre for Sustainable Catchments at the University of Southern Queensland are working with researchers from the Meteorology Office Hadley Centre (UK) in this Managing Climate Variability project.

For more information, download the paper, 'Insuring for resilience in extreme conditions using climate modes and reanalysis products': http://www.bom.gov.au/events/9icshmo/manuscripts/T0945_Best.pdf

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Looking for tipping points as horticultural crops feel the heat

A collaborative project to identify critical temperature thresholds for major horticulture crops around Australia will help producers be more confident about the viability of their region under climate change scenarios.

The project team, led by Peter Deuter of the Queensland Primary Industries and Fisheries, is collecting existing information about the temperature thresholds for Australian crops to help gauge how vulnerable these crops will be to projected temperature increases due to climate change.

'We need to know how many degrees a particular region can warm before the heat significantly damages these crops', says Peter.

'Producers are not only concerned about product yield; they are especially concerned about product quality which is a critical factor for the horticulture industry'.

The project team is choosing crops based on their economic value, their spread across Australia's regions, and the information available. They are currently working on lettuce, cauliflower and bananas, and will then study apples and tropical fruits.

Peter will report on findings from the project's first five crops in May 2009. He hopes to have information on 13 crops by the end of the two-year project in January 2011.

This project is jointly supported by Managing Climate Variability, Horticulture Australia Limited, Landcare Australia (through Woolworths Sustainable Farming Program funds) and the Queensland Primary Industries and Fisheries, an agency within the Queensland Department of Employment, Economic Development and Innovation.

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Will current best management practices give sugarcane growers the edge?

A recently commissioned project responding to the Australian Government's $200M Reef Rescue package will determine to what degree current best management practices for the sugarcane industry can give growers the edge in adapting to the predicted increased climate variability accompanying climate change.

'Reef Rescue recognises that poor water quality with an increasing sea surface temperature results in coral bleaching and together these two stressors place the Great Barrier Reef at risk', says Managing Climate Variability Program Coordinator Colin Creighton, one of the initiators of Reef Rescue and a member of the Great Barrier Reef Outlook Task Force.

'Increases in sea surface temperatures are inevitable with our changing climate and are an issue that must be addressed globally. Poor water quality is the one stressor we can rapidly do something about in the local reef environment.'

Will Higham of Reef Catchments based in Mackay, who is leading the project, says: 'We think soil management practices such as zonal tillage, controlled traffic and crop rotations—which are improving the water-holding capacity of the soil, reducing the run-off of water and improving the soil condition in general—should give growers an advantage under the changing climate scenarios.

Crop rotations and strategic herbicide application may be part of the management response in sugarcane production to a variable future climate.

'These higher-level management practices give farmers a more economical and sustainable way of farming and we hope this flows through under climate change scenarios.'

As part of developing the water quality improvement plan for the region, Will and his team have identified, over the past three years, management practices for the sugarcane industry that improve farm profitability and water quality:

- zonal tillage, controlled traffic and crop rotations
- variable application of fertiliser within the block
- strategic herbicide management, including using knock-down herbicides in preference to residuals and using equipment such as hooded sprays to target chemical application

The project team includes CSIRO, James Cook University and two groups of farmers from different parts of the Mackay Whitsunday region. Together they will test sustainability outcomes using these 'A' level management practices under more extreme climate variability scenarios.

'The idea is to model as closely as possible what farmers may do in response to a more variable climate,' says Will.

'We can't assume that current best-management practices are going to be the best ones for the future—we might need to improve them or identify others, but we'll know what we are dealing with through the results of this study.

'This will help us modify the incentives packages we are providing to farmers under Reef Rescue and, equally importantly, identify areas requiring research to improve practices even further. After all, most farmers are also recreational fishers and they would prefer to keep the soil, nutrients and chemicals on paddock, both for profitability and for a more resilient Great Barrier Reef.'

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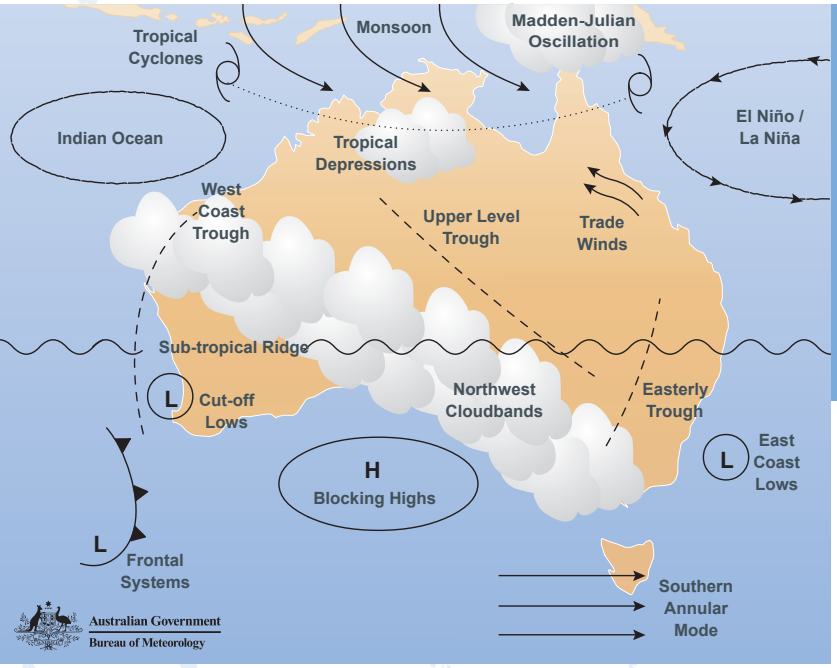
What drives
Western Australia's weather?

Continuing our state-by-state series describing what drives Australia's weather, in this edition we look at Western Australia.



Australia's major climate and weather drivers (Bureau of Meteorology)

The major climatic drivers of the weather in Western Australia are:

- the Indian Ocean Dipole
- tropical systems
- the sub-tropical ridge
- the Southern Annular Mode

These drivers manifest through a series of synoptic features, principally: the west coast trough, blocking highs, frontal systems, cut-off lows and cloud bands.

Climatic drivers

Indian Ocean Dipole

Sea surface temperatures in the Indian Ocean have a profound impact on the rainfall patterns over much of Australia. The Indian Ocean Dipole is a measure of changes in sea surface temperature patterns in the northern Indian Ocean. It is derived from the difference in sea temperature between the western Indian Ocean, near Africa, and the eastern Indian Ocean near northern Australia. These changes in sea surface temperature contribute to the formation of cloud bands.

When the Indian Ocean Dipole is positive, waters are warmer than normal near Africa and cooler than normal near Australia. Cloud near Australia reduces, resulting in less rainfall.

When the Indian Ocean Dipole is negative, waters are cooler than normal near Africa and warmer than normal near Australia. Warmer waters near Australia, particularly near Indonesia, bring more rainfall.

The Indian Ocean Dipole effect was proposed in the late 1990s and is the subject of further research. As modelling of the ocean and atmosphere improves, our ability to forecast these patterns of sea surface temperature is also improving, so that forecasts several seasons ahead may be useful in the near future.

Tropical systems

The southern hemisphere's wet season is experienced between November and April. During this period, tropical systems affect mainly northern and central parts of Western Australia but can occasionally also affect south-west Western Australia.

Tropical systems include tropical cyclones and tropical depressions.

Tropical cyclones are very intense low-pressure systems that produce heavy rainfall, destructive winds and damaging storm surges.

Tropical depressions are moderate strength low-pressure systems, often associated with the monsoon trough. They may develop into tropical cyclones if they are in a favourable location. They often produce significant rainfall.

Sub-tropical ridge

The sub-tropical ridge, an extensive belt of high pressure, is a major feature of the general circulation of our atmosphere. It encircles the globe at the middle latitudes. The position of the ridge varies with the seasons, allowing cold fronts to pass over southern Western Australia in the winter, but pushing them to the south in summer. Conditions along the ridge tend to be stable and dry because of descending air in the high-pressure systems.

Southern Annular Mode

The Southern Annular Mode (SAM) describes a north-south movement in the belt of strong westerly winds across the south of the continent. This region of strong westerly winds is associated with cold fronts and storm activity, and heavily influences weather in southern Australia.

The mode can be in a positive or negative phase. During a positive phase, the belt of strong westerly winds contracts towards the South Pole. This results in weaker-than-normal westerly winds, higher pressure and fewer storm systems over southern Australia. Autumn and winter rainfall may be reduced in south-west Western Australia. Spring rainfall may be increased over parts of the state.

We can identify a SAM event by observing the pattern in westerly wind flow and pressure to the south of Australia, which is measured by the Antarctic Oscillation Index as produced by the US National Weather Service. [continued on page 8]

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Synoptic features

West coast trough

During the warmer months, the west coast trough is a semi-permanent feature of the synoptic pressure pattern near the west coast of Australia. It is the dominant influence on west coast weather at that time of the year.

Depending on the location of the trough, areas to the east of it can experience hot days, with temperatures above 40°C, and the possibility of thunderstorms given sufficient atmospheric moisture. To the west of the trough, milder conditions with sea breezes generally prevail.

Blocking highs

Blocking highs are strong high-pressure systems that form further south than usual, and remain near-stationary for an extended period of time. They block the west-to-east progression of weather systems across southern Australia, and are usually formed in the Great Australian Bight or the Tasman Sea.

They have a wide range of impacts depending on their location and strength. They can produce a hot spell, a cold spell, dry conditions or wet conditions depending on their location and the systems around them.

Blocking highs in the Great Australian Bight are responsible for extended dry weather in south-west Western Australia, and heatwaves in summer.

Frontal systems

Frontal systems, such as cold fronts, generally move from west to east across the Southern Ocean and vary in their intensity and speed. More intense systems are generally associated with heavier rainfall. If frontal systems are slow-moving, rainfall may occur for extended periods and heavy falls are possible.

Cut-off lows

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

Cloud bands

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

Cloud bands can bring good rainfall. They 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.

For more information, visit the Bureau of Meteorology: http://www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.html

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Land & Water Australia

Rural Industries Research and Development Corporation

Sugar Research and Development Corporation

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