CliMag

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Multi-week forecasts will help bridge the gap

When it comes to weather and climate forecasts, farmers will take all the information they can get.

Forecasts currently available to farmers tell them about the specific weather in the week ahead, or the expected climate for the full 3-month season ahead. But more detail about expected variations in weather in the fortnight or month ahead would help farmers make better farm management decisions.

Susan Carn and her husband manage a dryland merino sheep farm with occasional wheat and barley crops in Quorn in South Australia's Flinders Ranges. Being totally reliant on rainfall, every decision they make hedges on predicting how much rain will fall, and when.

Susan Carn, Quorn, South Australia

'We're pretty cautious. I start looking at the long-range forecast in March, three months ahead, to see how the season looks like panning out', says Susan. 'We need to decide how much stock to keep or, if it looks promising, we might buy more stock. With crops, if it looks good on the long-range forecast we'll plant some crop and spend money on fertiliser. If it's not looking good, we won't sow much, if any; we're in marginal country, so we have to be conservative.'

There are two main limitations with the traditional suite of forecasts currently available to farmers like Susan Carn:

- The gap between the 7-day weather forecast and the 3-month seasonal forecast limits the planning decisions farmers need to make on a fortnightly or monthly basis.
- Seasonal forecasts are based on historical records, using statistics about past weather patterns to predict what will happen this season. As a result, statistical models do not perform as well when faced with rare or unprecedented conditions, a situation we are increasingly seeing with climate change.

A new forecasting tool in its early stages of development by the Bureau of Meteorology will help overcome these two limitations. Rather than relying on historical weather statistics, the Predictive Ocean Atmosphere Model for Australia (POAMA) uses global circulation models to predict the weather and climate for the coming months.

Forecasters enter information about the current state of the oceans and the atmosphere into the model which then forecasts the probabilities of the weather and climate being different from typical conditions. For example, the model can calculate the chances of the total rainfall for a forecast period being above or below the historical average.

'The advantage of using a global circulation model is that it naturally takes into account changes in the climate because the forecast is based on today's observations of the atmosphere and the ocean', explains Dr Harry Hendon, one of the developers of POAMA.

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MANAGING CLIMATE VARIABILITY R & D PROGRAM

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Dr Hendon says that the same model used to produce seasonal forecasts can be adapted to produce multi-week forecasts, which would fill the gap between daily weather and seasonal climate forecasts.

'We envision running the model once a week to provide forecasts for the coming weeks. But, rather than forecasting rain for a specific day, as for a weather forecast, we would forecast the likelihood of wet or dry spells during the next two to four weeks. However, to produce the best possible multi-week forecasts will require a significant research effort to improve the model and develop better ways to feed the model with weather and ocean data.'

The Bureau is testing a rudimentary version of the multi-week model, and hopes that routine multi-week forecasts will be available in the next few years. New forecast products will be tailored around feedback from farmers and others, and delivered through the Bureau's Water and the Land website (www.bom.gov.au/watl) once they have been assessed for accuracy and reliability.

Hans Loder, Assistant Vineyard and Technical Manager, Katnook Estate, Coonawarra, South Australia

Susan Carn says she can see many ways in which multi-week forecasts would help them make management decisions on their farm.

'From a grazing point of view, having a 2-week forecast would really help. If there has been a dry spell and we're worried about whether the feed will last, but we know it's probably going to rain in a fortnight, we'll leave the sheep on the paddock. If it's getting to a critical point and we have a heads-up that there will be no rain for the next two weeks, we might sell sheep or move them somewhere else. The worst thing is to run the paddocks down to nothing.

'In terms of cropping, after an opening rain at the end of April, it would be great to know if there was a likelihood of follow-up rain a fortnight after, and then more a fortnight after that', she says.

Darren Ray, the Senior Meteorologist in the Bureau's South Australian Climate Section, talks to a lot of farmers and farming groups. He says a fair bit of his discussion with farmers has been about the new POAMA model, and that farmers want more detail, such as multi-week forecasts.

'One thing we've seen in South Australia in the last couple of months is that the seasonal rainfall forecast suggests it's more likely we'll receive drier conditions from spring this year', says Darren.

'But the POAMA multi-week forecast, which tells us how much below or above average the rainfall might be, has predicted near-average conditions. POAMA has so far proven to be correct and that is quite heartening.

'POAMA also predicted the higher-than-average temperatures that we experienced in August this year. So it has definitely shown some accuracy over the past few months with temperature and rainfall predictions in South Australia.'

Viticulturalist Hans Loder from Katnook Estate, Coonawarra, South Australia has had a successful experience using trial versions of the multi-week forecasting tools. The trial rainfall forecasts for the coming two fortnights have helped him with a range of management decisions.

'This season we had a cool start to January and the week-long forecast said that it would remain cool. But POAMA was suggesting about average temperatures for the month, so we watched that output with interest. We knew POAMA was experimental, so could be wrong; but we remembered last season's March heatwave, so we took a punt on the POAMA forecast. We continued our irrigation through January to maintain good soil moisture. We also adjusted our canopy management in some vineyards to maintain shade over the grape bunches and keep berry temperatures down.'

Hans's decisions turned out to be good decisions, as a heatwave did occur in late January.

Knowing the weather conditions two to four weeks in advance would allow Hans to plan chemical spray programs and foresee periods of high irrigation demand, such as during heatwaves and dry periods. He could also use one-to-two-week weather forecasts to make better decisions about harvest dates and improve the timing of operations such as irrigation.

Both Susan Carn and Hans Loder say that forecasts of extreme conditions such as frost, dust storms and hail storms would allow them time to prepare for these events. For Hans this might be through 'active' preparations (such as protective sprays), or for Susan, by insuring her crops.

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Photo: Michelle Riedlinger

Ian McClelland (left) on his farm at Birchip in Victoria with MCV Program Coordinator Colin Creighton

Farmer takes the helm at Managing Climate Variability

Welcome to Ian McClelland, the new chair of the Project Management Committee of Managing Climate Variability.

Ian and his brother Warrick run mixed grain and sheep enterprises on combined 8300 hectare farms at Birchip and Mortlake in Victoria. Ian is also chair of the Birchip Cropping Group, a farmer-led organisation which aims to find ways of applying research and technology to the major primary industries of the region. His many distinctions include a 2008 Order of Australia Medal for services to agriculture.

For the past 13 growing seasons, Ian's farm at Birchip has experienced below average rainfall. He accepts that some of this is due to climate change, but believes that: 'the bulk is due to climate variability. We need to find ways of using water more efficiently and to develop practices that can cope with the limitations that nature throws at us.'

Ian says he is more than happy to take on the position with Managing Climate Variability. 'I have always been fascinated by climate and weather and see them as the basis of success and failure on farms.'

He believes that a key role for him will be to encourage the government to invest strategically in good science. 'It is vital that money be spent on agricultural research. We must maintain our scientific edge.'

One challenge for managing climate variability, Ian says, is to improve the accuracy of weather forecasting and to give information to farmers in a form that they want. He also recognises that, because all forms of agriculture must learn to cope with variability, organisations need to work together and exchange ideas.

'We must work towards a common goal', he says. 'We must ensure that good research is done, not just by researchers, but by industry and farmers as well. One of our goals must be to break down the barriers between researchers and farmers so that research is as relevant as possible.'

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Better forecasts remain the focus under new administration

For most farmers, adapting to climate change means improving how they respond to Australia's variable climate, such as adopting new practices and plant varieties, changing land uses, and using forecasts to increase profitability.

Managing Climate Variability invests in research that helps increase forecasting accuracy, builds the predictability of attributes such as soil moisture, and translates climate forecasts and resource attributes into decision-support tools for primary industries.

Our research is focused on helping the rural sector continuously respond to climatic variation rather than adjusting for the climate projections for later this century.

'For farmers, the best way to respond to a changing climate is season by season, year by year', says Managing Climate Variability Program Coordinator Colin Creighton. 'It is climate variability they can adapt to and profit from rather than temperatures projected for 50 years time.'

Managing Climate Variability is now administered by the Grains Research & Development Corporation (GRDC) since the Australian Government announced the closure of Land & Water Australia in May of this year. GRDC is already investing $3.5 million over the next five years in research to deliver better weather forecasts.

'We have had a rapid transfer of administrative arrangements with little to no delay in delivery of research', says Colin.

'In particular, we are excited about our investment in research projects that will deliver better forecasts to farmers. Within the next five years, I am confident our farmers will have some of the world's most sophisticated weather forecasting tools to support their decisions.'

Managing Climate Variability's research is shifting the basis of Australia's weather forecasting from statistical models—predicting the weather based on past averages and year types—to dynamic models that forecast based on the current interactions of oceans and the atmosphere, with continuous information feeds from around the world.

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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 accuracy and value of seasonal forecasts for farmers in south-west Western Australia.	Discussions were held with farmers, and it was agreed to improve climate forecasts for the North Eastern Agricultural region, based on their tactical responses to climate variability (dry sowing, top dressing, chemical applications).	**Dr Senthold Asseng** CSIRO senthold.asseng@csiro.au 08 9333 6615
Critical thresholds and climate change impacts / adaptation in horticulture	Jan 2009 – Jan 2011	Understand the critical temperature thresholds for specific horticultural crops and production regions in Australia. Identify commodities and/or regions which 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 documenting known temperature thresholds for a range of horticultural crops was published earlier this year. Work is proceeding to explore how on-farm practices can accommodate these thresholds.	**Peter Deuter** Queensland Primary Industries and Fisheries peter.deuter@dpi.qld.gov.au 07 5466 2233
Climate change and variability: Assessing regional impacts of sugar cane production	2008 – Jan 2010	Determine how the sugar industry in the Mackay Whitsunday region can remain sustainable with the number of extreme weather events set to increase, and more stringent regulations about discharges onto the Great Barrier Reef.	Management practices related to productivity changes and water quality have been evaluated against a number of IPCC scenarios for more extreme climate events so that water quality implications can be collated.	**Will Higham** Reef Catchments Will.higham@reefcatchments.com.au 07 4968 4205
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.	Trials are underway in field plots and glasshouses in South Australia. The impact of heat stress on crop production is being quantified.	**Dr Peter Hayman** South Australian R&D Institute hayman.peter@saugov.sa.gov.au 08 8303 9729
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: heat stress in feedlots; storm damage to crops; droughts; and continued and compounding extreme events. Data from the UK Hadley Centre is being applied to the four case studies.	**Dr Peter Best** University of Southern Queensland cindualpk@bigpond.com 07 3844 1777

Project title	Time	Summary of research objectives	Progress to date	Research contact
Teleconnections between climate drivers and regional climate, and model representation of these links	Oct 2009 – 2012	Improve Australia's dynamical forecasting by investigating the connection between several weather systems, including the Southern Oscillation Index, Indian Ocean Dipole, Madden-Julian Oscillation, sub-tropical ridge and Southern Annular Mode.	The project has just started.	**Dr Peter McIntosh** Centre for Australian Weather and Climate Research Peter.Mcintosh@csiro.au 03 6232 5390
Improving forecast accuracy through improved ocean initialisation	Oct 2009 – 2012	Address the difference in forecasting sea surface temperatures between the tropical Indian Ocean and the Pacific Ocean. Improve predictions of conditions in the Indian Ocean and ultimately predictions of regional climate for western, southern and eastern Australia.	The project has just started.	**Dr Oscar Alves** Centre for Australian Weather and Climate Research O.Alves@bom.gov.au 03 9669 4835
Understanding frost risk in a variable and changing climate	Oct 2009 – 2012	Improve understanding of the variability and changing nature of frost risk at both seasonal and decadal scales for the southern regions of Australia, and implications for the wine and grain industries.	The project has just started.	**Steven Crimp** CSIRO Steven.Crimp@csiro.au 02 6242 1649
Climate drivers and synoptic features – New South Wales, Northern Territory and Tasmania	Oct 2009 – 2010	Improve understanding of the links between climate drivers and synoptic features. Describe the climate drivers for the remaining states/territories [NSW, NT and Tasmania] and provide examples of key synoptic features from the Bureau's record of key weather events.	The project has just started.	**Clare Mullen** Bureau of Meteorology c.mullen@bom.gov.au 03 9669 4859
Understanding frost and heat stress extremes in the Western Australia wheat belt	Oct 2009 – 2012	Quantify the extremes and impact of frost and heat stress on the Western Australia wheat belt. Link with the frost and heat stress projects underway in South Australia and Victoria to improve understanding of frost and heat stress across southern Australia.	The project has just started.	**Ian Foster** Department of Agriculture and Food, Western Australia ifoster@agric.wa.gov.au 08 9368 3333
Improving multi-week predictions	Oct 2009 – 2012	Improve weather predictions 2–4 weeks ahead to make them more useful to agriculture and water management industries.	The project has just started.	**Dr Harry Hendon** Centre for Australian Weather and Climate Research h.hendon@bom.gov.au 03 9669 4120
Multi-week forecasting products (WATL)	Oct 2009 – 2012	Improve the accuracy of multi-week forecasting, using POAMA. Make new forecasting products, tested by Managing Climate Variability's 'Climate Champions', available on the WATL website.	The project has just started.	**Dr Andrew Watkins** Bureau of Meteorology A.Watkins@bom.gov.au 03 9669 4360

Three new projects
aim for better forecasts

Quality forecasts for the weeks ahead

The Bureau of Meteorology is developing a set of products to give farmers quality forecasts more than five days out. The project seeks to fill the gap between the reliable 5-day forecasts and the more general 3-month forecasts.

'The period between several days and three months is a complex mix of weather and climate and is difficult to forecast, but this is not through lack of trying', says Bureau climate scientist Dr Andrew Watkins.

Day-to-day weather forecasts lose their accuracy quickly when predicting more than five days ahead because weather forecast models are affected by small errors in the data that they are initially fed. Seasonal forecasts, on the other hand, are driven by the broader global climate and need to be run for longer periods to reflect the general state of the atmosphere.

'With more powerful computers and increased research, we can develop more accurate climate models capable of better predicting the patterns of temperature and rainfall for the weeks ahead', says Dr Watkins.

Researchers will upgrade the Bureau's Predictive Ocean Atmosphere Model for Australia (POAMA - see the multi-week forecast article on page one of this edition), and then use the complex forecasts generated by POAMA to provide outlooks for periods greater than five days but less than three months. The new forecasts will be tailored around feedback received from farmers and others, and delivered through the Bureau's Water and the Land website (www.bom.gov.au/watl).

The Bureau first produced next-day weather forecasts in 1908. They first produced seasonal rainfall forecasts for the three months ahead in 1989 and for temperature in 2000. In 2006, 7-day weather forecasts started for all capital cities and these forecasts will be available for all of regional Australia within the next few years.

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Young barley crop near Gunnedah, NSW

Photo: David Tudgey

Improving climate models for better seasonal forecasts

Current climate models, such as the Bureau's POAMA, do not properly represent all the connecting influences between remote climate drivers such as ENSO (El Niño-Southern Oscillation) and local weather patterns. As a result, the accuracy of seasonal forecasts is reduced, especially in southern Australia where rainfall is mostly related to mid-latitude weather systems.

'Seasonal drivers like ENSO, the IOD [Indian Ocean Dipole] and SAM [Southern Annular Mode] influence individual weather events to make seasons either wetter or drier', says Dr James Risbey, CSIRO scientist with the Centre for Australian Weather and Climate Research (CAWCR).

'Models like POAMA forecast ENSO with reasonable skill up to six months in advance, but don't forecast rainfall very well at this timescale. The models are not translating the sea surface temperatures of the Pacific and Indian Oceans into the correct rainfall patterns.'

A new project will identify the processes that connect remote seasonal drivers with rainfall patterns.

One of the many floats that measure the temperature and salinity of the upper 2000 metres of the ocean

Photo: Argo JAMSTEC

CAWCR researchers will identify and explain the processes by which climate drivers such as tropical (ENSO and IOD) and high-latitude (SAM) drivers change the behaviour of mid-latitude weather systems.

'In turn, we'll be able to assess these processes in models and improve their ability to forecast seasonal rainfall', says Dr Risbey.

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More accurate forecasts with improved modelling of Indian Ocean surface temperature variations

Variations in sea surface temperatures of the tropical Indian Ocean are now believed to be a prominent driver of Australia's climate variability, but climate models have limited skill in predicting these variations.

Climate models are very skilful at forecasting the sea surface variations of the Pacific Ocean associated with El Niño, another prominent driver of climate variability, but their inability to predict the Indian Ocean temperature variations is limiting the accuracy of seasonal forecasts.

'The Indian Ocean variations are particularly important for forecasting the seasonal climate for Western Australia through to south-eastern Australia', says Dr Oscar Alves, a Bureau of Meteorology scientist working with CAWCR. 'In addition, much of the climate irregularities in south-eastern Australia that develop during El Niño are affected by Indian Ocean sea surface temperature variations.'

Dr Alves is unsure whether the difference in skill of predicting sea surface temperature variations between the two oceans stems from model error, poor data resulting from a lack of sufficient observations, or because it is fundamentally harder to predict variations in the Indian Ocean compared to the Pacific.

A new project, involving CAWCR researchers, will shed some light on the reasons why skill in the Indian Ocean is substantially lower than in the Pacific.

'The project is especially aimed at understanding predictability and improving our predictive skill of the Indian Ocean and, ultimately, the predictive skill of regional climate', says Dr Alves. 'A particular emphasis will be to look at how to make better use of all available observations, given the sparse observing network in the Indian Ocean.'

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Climate Kelpie starts to round up tools

Our Climate Kelpie website, due to be launched early in 2010, is designed to give Australian farmers and rural advisors easy access to tools and information about the weather and climate.

From an assessment of more than 100 decision-support tools, we have selected 26 for inclusion on Climate Kelpie. These tools apply to commodities such as grains, beef, sheep, dairy, sugar, grapes and cotton.

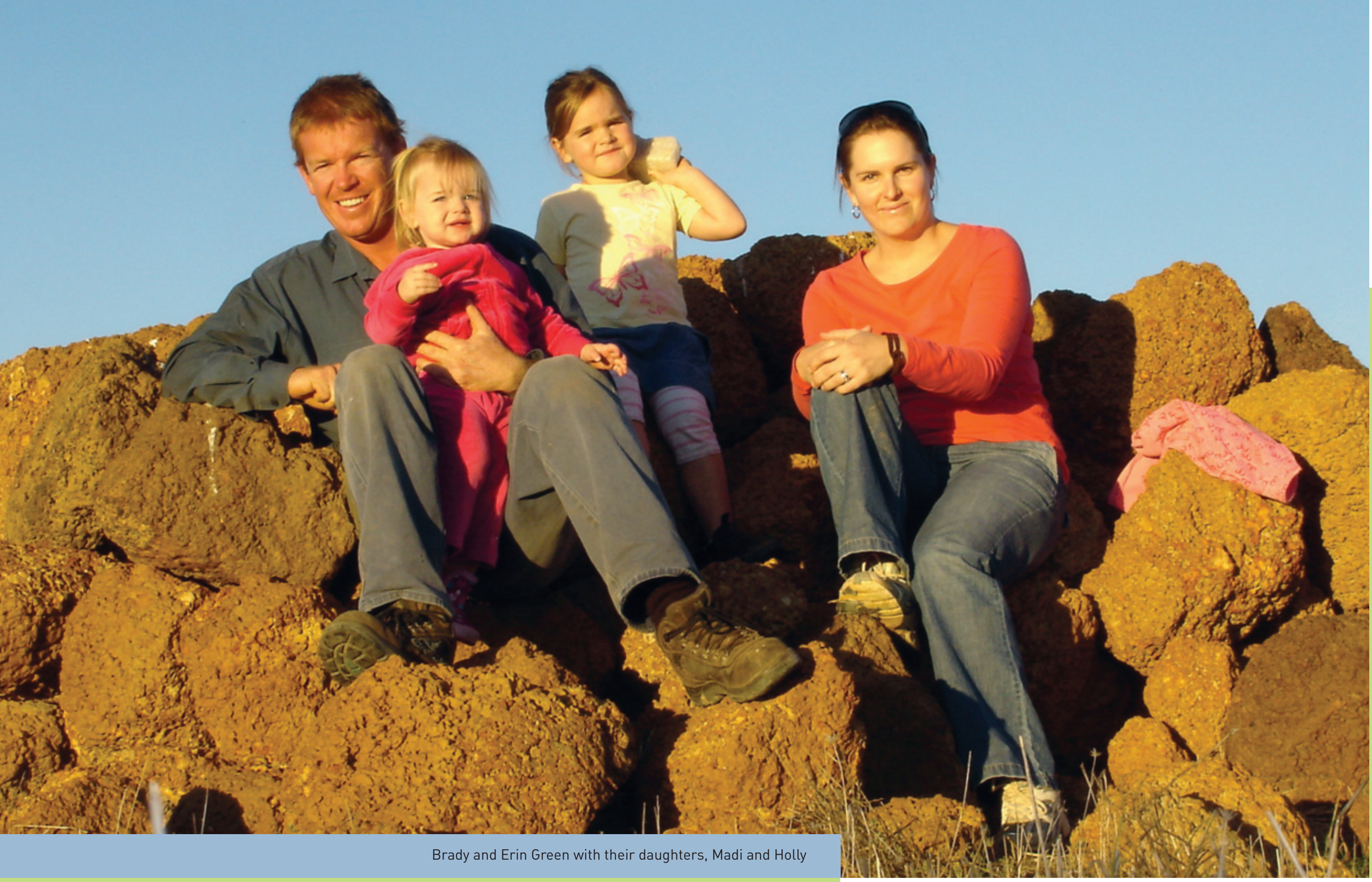
Using the most up-to-date climate data and predictive models from Australia's leading research and meteorological organisations, including CSIRO and the Bureau of Meteorology, the tools can help farmers and their advisors make the best decisions to improve yields, quality and farming practices.

On the Climate Kelpie home page, farmers can select a commodity and click on a map to get a list of tools relevant to their region and commodity. We describe the function of each tool, its history (who developed it), its accuracy, cost (if any), how extensively it has been tested, and, most importantly, how you can get hold of it.

For grain growers who want to know: 'How can I manage my crops to optimise profit with seasonal variability?', Yield Prophet® provides paddock-specific yield forecasts for grains based on specific inputs such as nitrogen levels and soil quality. The tool allows growers to produce reports such as 'the effects of different nitrogen levels on immediate yields', and 'the potential effects of climate variability on cropping in the year 2030'.

Farmers more interested in pasture may want to know: 'What is the grass production forecast in my region?' or 'What is the total standing dry matter in my region?'. AussieGRASS and GrassGro can forecast grass production down to a five-kilometre grid scale. Both tools are applicable nationwide.

For questions such as: 'Which crops should I plant based on water availability?' and 'Where on my farm should I plant them?', Irrigation Optimiser can be used to analyse expected yield prices and costs for each crop to maximise farm profits. These more general tools apply to all farming sectors.



Brady and Erin Green with their daughters, Madi and Holly

Doing what's best for the farm and the environment is challenging

Brady Green is aware that the climate in his region is becoming more variable, and wants to adopt farming practices that will promote crop growth in low-rainfall conditions. He is also conscious of the need to reduce his carbon footprint. But his beliefs are being challenged by the reality of the slow and difficult process of changing farming practices, and he has found that he cannot solve all the issues at once.

The Greens' 8000-hectare family farm is located near Yuna, about 150 kilometres north of Geraldton in Western Australia's North Eastern Agricultural Region. It's a dryland grains farm with rotations of wheat, lupin, barley and canola.

Brady, in partnership with his father, Ray Green, has been managing the farm for eight years. Aware that climate variability is predicted to increase, both father and son want to be proactive in adapting their farming practices.

'We're farming in a drying climate and, as far as we're aware, it's the autumn rain we can expect to decline', says Brady. 'So we're trying to develop a system that will reduce the moisture needed to get the crops out of the ground.'

With the drought of 2006 and 2007 causing a lot of soil erosion on the farm, Brady realised that he could not continue to leave his soil bare. He also realised he could no longer rely on the rainfall they had received in the past. So, over the last two years, he has been trialling three new farming practices: stubble retention, zero till and tramlining.

'The aim of stubble retention is to leave the residue from previous crops on the soil surface rather than burn it or cultivate it into the ground. This helps to maintain soil moisture by protecting the soil against evaporation', he explains. Research has shown that retaining stubble also reduces soil erosion and increases soil microorganisms which break down organic matter and free up carbon and nitrogen for use by crops.

Another way of reducing soil moisture loss is by minimising the disturbance of the soil, thereby reducing the soil's exposure to evaporation. Tillage, by definition, disturbs the soil by turning it over during seeding. Brady is achieving zero till by using a disc machine to sow his crops, rather than the traditional tyne machine.

'The disc machine has flat discs, offset at seven degrees. It rolls along and cuts open a very small slot that you drop seed and fertiliser into. Behind that is a wheel that closes the soil back in. This is the least aggressive method for putting in a crop.'

The third method Brady is trialling—tramlining—aims to reduce soil compaction resulting from driving machinery over the paddock. The idea is to drive all machinery over the same paths or 'tram lines'. By reducing compaction, Brady says he gets more crop growth because the plants grow bigger roots that reach further into the soil profile for nutrients and moisture.

Tramlining is easier said than done. The wheels of every machine need to be the same distance apart. Brady is working towards this by making sure that the dimensions are the same for every machine he buys but this makes the adoption of tramlining a slow process.

Adopting stubble retention and zero till have not been without frustrations either. Both practices need more nitrogen input to help break down stubble residue and encourage early vigour in the first stages of crop growth.

Early vigour helps to discourage the growth of weeds, which are more prolific because the crop rows are now more widely spaced. The production and use of nitrogen fertiliser releases greenhouse gases, so increased nitrogen is not helping Brady to reduce his carbon footprint.

Tramlines on the Greens' farm

Photo: Amanda Hodgson

'What you're trying to achieve and what you're forced into doing are two different things', he says.

Mastering the new machinery brings its own challenges. Getting the sowing depth right has taken a lot of fine adjustments to the disc seeder and a bit of trial and error. But Brady says they are learning and trying to make sure they only make mistakes once and correct them quickly.

'We're not growing better crops than our neighbours and we know we're still learning the new system. We're not really satisfied with our results yet. It's easy to stand back after 10 years and say we've got it right, but it takes that long—we only get one crop a year so there's not much opportunity to correct our mistakes until the next year.'

He is encouraged enough by his successes to date to persist with the new methods. The disc seeding system requires less capital to get the crop in and uses less fuel. And he is enthusiastic about building soil health.

By improving soil health and increasing moisture retention, growers can more rapidly respond to climate variability. Brady Green says that minimising soil moisture loss relies heavily on good weather forecasts, and this is becoming more critical as the climate becomes more variable.

'We check the weather twice a day on the internet and make decisions, so it's a big thing. We need a 14-day lead time to take action. For example, if we want to apply nitrogen before it rains, we can get a lot done in that time. The 14-day forecast is where we feel forecasters need to get a better degree of accuracy—that's where we want research directed.'

Managing Climate Variability is funding two projects to improve forecasts for the coming two to four weeks. A third project aims to improve the accuracy of climate forecasts in areas influenced by the Indian Ocean, which includes Western Australia's North Eastern Agricultural Region.

While Brady Green knows many other farmers are moving in the same direction as him, few are farming in his area. So he has travelled to meet growers in Victoria who are using the new techniques. He was particularly inspired by Robert Ruwoldt, a passionate zero-till farmer in the Wimmera region.

Robert Ruwoldt has been operating his farm under zero-till and stubble retention for 20 years, and is a past president of the Victorian No-Till Farmers Association. At the 2008 No-till On The Plains Winter Conference in Kansas, US, he said that his soils: 'almost have a perceptible heart beat, they are that alive after 20 years of no-till, stubble retention and no burning, grazing or cultivation'.

A disk drill sows canola into maximum retained stubble on the Greens' farm.

'He's doing everything I'm trying to do, except he's doing it properly', says Brady. 'He's the best farmer I've ever seen. He's further down the path of everything I'm doing, but he's working with a different soil type. So it can be done but I've got to prove it in my conditions, with my soil type, and the weeds in my area. I'd like to prove it to other farmers in my area.'

Brady is encouraged by other farmers who are willing to change and adapt, and he gets most of his ideas from talking to others who are trying to make the same changes as him. But he feels there is limited support for individual farmers who are concerned about climate variability and want to adapt their practices.

'We're not encouraged to change our ways, but simply forced by our beliefs and the changes in the climate that we're witnessing. The benefits are up to the individual and are based on our success or failure. There are no external benefits such as getting a better price for grain or receiving carbon credits. It's just a case of us wanting to do the right thing. I want to reduce my inputs and increase my margin but it's not only about that. I want to reduce my carbon footprint and build a healthier soil.'

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What drives Victoria's weather?

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

The subtropical ridge, an extensive area of high pressure, is a major feature of the general circulation of our atmosphere. It is a major influence on the climate of southern Australia. Its position varies with the seasons, allowing cold fronts to pass over Victoria in the winter, but pushing them to the south in summer.

The major climatic drivers in Victoria are:
- El Niño - Southern Oscillation
- Indian Ocean Dipole
- the Southern Annular Mode
- blocking highs

These drivers can modify synoptic features, such as frontal systems, cut-off lows and cloud bands.

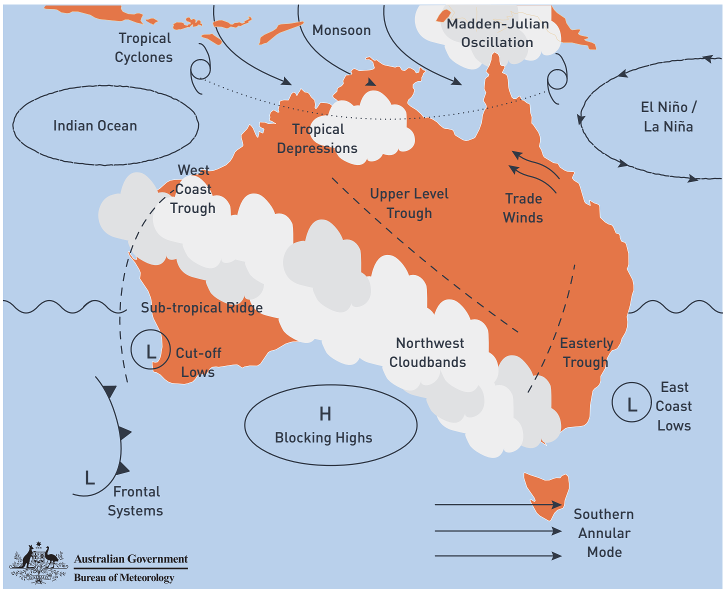

Figure 1. Australia's major climate and weather drivers (Bureau of Meteorology)

Climatic drivers

El Niño - Southern Oscillation

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

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

El Niño is associated with extensive warming of the sea surface in the central and eastern tropical Pacific. It is often associated with below average winter/spring rainfall over much of eastern Australia. The El Niño event of 2002–03 seriously affected rainfall over Victoria. Rainfall was well below average across the state, with many areas experiencing severe water shortages and high bushfire risk.

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

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.

Southern Annular Mode

The Southern Annular Mode (SAM) can affect rainfall in southern Australia. It 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.

We can identify SAM events by observing the pattern of westerly wind flow and pressure to the south of Australia, which is monitored by the Antarctic Oscillation Index as produced by the US National Weather Service.

SAM can be in a positive or negative phase.

Positive phase

During a positive phase, the belt of strong, westerly winds contracts toward the South Pole. This causes weaker-than-normal westerly winds and higher pressure over southern Australia.

In spring and summer, a positive phase can result in increased rainfall over parts of south-eastern Australia, particularly southern New South Wales, by strengthening the moist easterly flow from the Tasman Sea.

In autumn and winter, a positive SAM phase results in fewer storm systems and less rainfall across the southern coastal regions of Australia.

Negative phase

The negative phase is associated with a northward shift in the belt of strong westerly winds. In autumn and winter, this can cause more storms and increase rainfall for southern Australia.

During July 2007, the SAM was in a negative phase. The belt of westerly winds was expanded towards the equator, resulting in slightly stronger westerly winds over southern Australia. These winds brought more cold fronts and higher rainfall to Victoria.

Blocking highs

Blocking highs are strong high-pressure systems that form further south than the subtropical ridge, 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.

A blocking high's impact on the weather varies depending on its location, the time of year and the systems around it. Generally, a blocking high in the Bight produces a cold spell and wet conditions in Victoria, while a blocking high in the Tasman in summer often results in a hot spell and dry conditions.

When blocking highs are associated with cut-off lows to their north, widespread rain frequently occurs. Blocking highs can also contribute to fog and frost occurrence.

Synoptic features

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 slower moving, rainfall may occur for extended periods and may be heavy at times.

A cold front moved across Victoria on 17 July 2007 (Figure 2). Heavy rainfall was recorded in parts of Victoria (Figure 3) and there were reports of extensive storm damage. Many areas reported snowfalls and some roads were closed due to snow and ice.

[continued on page 12]

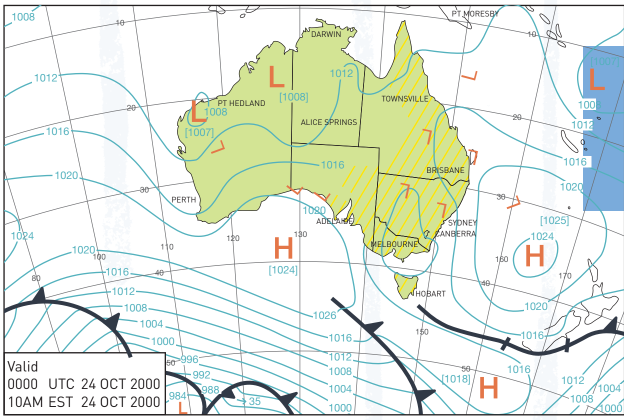

Figure 2. Cold front moving across Victoria, 17 July 2007 (Bureau of Meteorology)

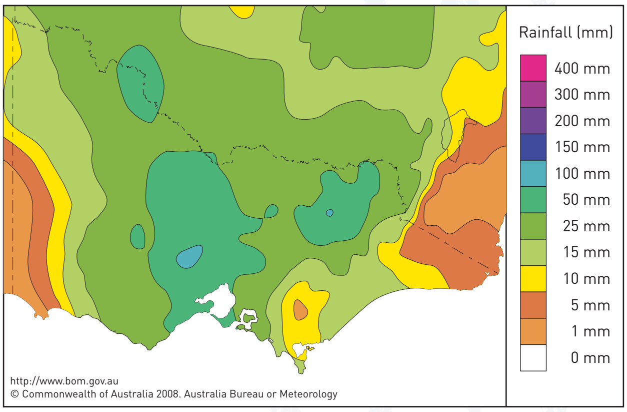

Figure 3. Rainfall in Victoria, 18 July 2007 (Bureau of Meteorology)

Table 1. Summary of Victoria's main climatic drivers of weather and synoptic features

Climatic driver	Potential effect	When	Where in Victoria it has most effect
Subtropical ridge	cold fronts	winter, mostly	statewide
El Niño - Southern Oscillation	El Niño - less rain La Niña - more rain	March – November	most of the state, particularly in autumn
Southern Annular Mode (positive phase)	more rain less rain	spring/summer winter	statewide coastal regions
Southern Annular Mode (negative phase)	more rain	autumn/winter	statewide
Indian Ocean Dipole (positive)	less rain	June – November	statewide
Indian Ocean Dipole (negative)	more rain	June – November	statewide
Blocking highs	generally cold and wet if the high is in the Bight generally hot and dry if the high is in the Tasman Sea widespread rain when associated with a cut-off low fog and frost if centred over Victoria	all year summer mainly April – October	statewide
Synoptic feature			
Frontal systems	rain	all year; mostly winter	statewide, particularly southern half
Cut-off lows	rain with strong, gusty winds	all year	statewide
Cloud bands	rain	April – September	statewide

[continued from page 11]

Cut-off 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.

Cut-off lows are the dominant rain-producing synoptic systems over much of inland Victoria, contributing a higher proportion of annual rainfall than fronts, although other processes can be more important in mountainous or coastal regions. Cut-off lows usually occur in conjunction with a blocking high.

Cloud bands

Sea surface temperatures in the Indian Ocean strongly affect rainfall patterns over much of Australia. In general, warmer-than-average sea surface temperatures in the Indian Ocean near Australia result in increased rainfall, while cooler-than-average sea surface temperatures result in reduced rainfall. This phenomenon contributes to the formation of 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 form when:

- a trough of low pressure occurs in the upper atmosphere
- 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 can be associated with widespread, often heavy, rainfall in Victoria. However, since 1997 there has been a marked reduction in the number of northwest cloud bands associated with rainfall in Victoria.

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

Contact the Victorian Climate Service Centre
Phone: 03 9669 4956 Email: climate.vic@bom.gov.au

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For more information on Managing Climate Variability, visit www.managingclimate.gov.au

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