Government of **Western Australia**
Department of **Agriculture and Food**

5 May 2008

Committee Secretary
Standing Committee on Industry, Science and Innovation
PO Box 6021
House of Representatives
Parliament House
CANBERRA ACT 2600

Dear Ms Vamvakinou

LONG TERM METEOROLOGICAL FORECASTING IN AUSTRALIA

Please find attached the Department of Agriculture and Food Western Australia submission to the Standing Committee on Industry, Science and Innovation inquiry into long term meteorological forecasting in Australia.

If you seek any further information from the Department, please do not hesitate to contact Acting Executive Director of Research, Dr Mark Sweetingham, on (08) 9368 3298.

Yours sincerely

Ian Longson
DIRECTOR GENERAL

OFFICE OF THE DIRECTOR GENERAL

3 Baron-Hay Court, South Perth WA 6151, Postal Address: Locked Bag 4, Bentley Delivery Centre WA 6983
Tel: (08) 9368 3236 Fax: (08) 9368 1205

Department of Agriculture and Food Submission to the House of Representatives Standing Committee on Industry, Science and Innovation's Inquiry into long-term meteorological forecasting in Australia

May 2009

Introduction

Agriculture and farm-forestry play a major role in the Western Australian economy. In 2007-08 the gross value of agricultural production was estimated at $6.6 billion, with the value of exports being $4.2 billion. The agricultural sector supports around seventeen percent of WA's workforce and also has significant flow on effects to other sectors of the economy. The agri-food industry contributed more than $11 billion to the State's economy in 2007-08, and agriculture. In addition, more than 300,000 ha of tree crops have been established on WA farms in the past 20 years. Although harvesting has now commenced, an estimate of a value of this industry, separate from the broader forest industries is not available.

Industries range from intensive horticulture, through broadacre cropping and animal production, to extensive rangelands grazing. In particular, the gains industry has a strong national presence, producing more than 50% of the national harvest in recent years. Apart from horticulture, these industries are not irrigated. Production, economic and environmental outcomes are highly dependent on seasonal climate.

Rainfall over Southern Western Australia is highly seasonal, with some eighty per cent occurring between May and October. The calendar of operations and business decisions of cropping and animal enterprises in the agricultural area of WA is closely aligned to the rainfall pattern. Key periods are:

- Summer/autumn for weed control and accumulation of stored soil moisture – if any;
- May to July for crop and pasture establishment. This is when the bulk of the variable costs are committed;
- August to October is when vegetative growth of crops and pastures, flowering of crops, grain fill and the beginning of harvest in the northern region occurs; and
- November to December for harvest.

Northern Western Australia is dominated by summer rainfall, with major enterprises being rangelands grazing and irrigated horticulture. Primary interest for forecasting is in prediction of the summer monsoon and tropical cyclone incidence.

Rangeland grazing enterprises dominate the vast central part of Western Australia, commonly referred to as the Southern Rangelands. Rainfall here ranges from summer-dominant over the Pilbara region, to winter dominant over the Gascoyne, Goldfields and Nullarbor. Interannual rainfall variability is very high. Primary seasonal management decisions relate to stock numbers and grazing pressure.

The Department conducts research, and provides a range of services and training to help primary producers and agribusiness better manage impacts from seasonal climate variability. This submission will comment on the terms of Reference from a WA perspective.

Summary of Main Points
Key needs

- Seasonal forecast systems should include climate system influences from other ocean basins such as the Indian and Southern Oceans. These are especially relevant to Western Australia, South Australia and western Victoria.
- Major agricultural management and business decisions are made at specific times of the year, and in response to extremes of seasonal climate. There is a need to develop forecast systems that better match the forecast to the decision-making of agricultural enterprises.
- There is potential to develop advanced statistical methods of seasonal forecasting as an alternative to dynamical methods.
- There is an ongoing need to maintain and enhance weather and climate observing capacity over WA and in the Indian and Southern oceans. This underpins not only dynamical climate methods, but also enables model verification and development of accurate statistics of climate variability and change.
- Innovation and development in forecasting will be incremental and depends on maintaining research capacity and links with the agricultural community.

Term of Reference 1: The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems
Weather and climate forecasts can be separated into two broad groups based on the duration of the forecast period and their lead-time. Short-term forecasts relate to daily weather predicted up to 10 to 14 days ahead, while seasonal forecasts aim to predict climate over 3-6 month periods with lead times of 1 to 12 or more months.

There are fundamental differences in how these forecasts are developed and how they are communicated. Short-term forecasts tend to be categorical (i.e. tomorrow's maximum temperature will be 25 degrees), whereas seasonal climate forecasts are distributions of possible future climate and are often expressed in terms of probabilities. These result in different challenges in communicating the forecast, and can be a major barrier to the uptake or application of the forecast.

In this submission seasonal climate forecasts are considered to be long-term meteorological prediction systems.

There are two main approaches to seasonal climate forecasting; statistical methods using statistical relationships between atmospheric or oceanic indicators and seasonal climate variables such as rainfall or temperature, and dynamical methods using global atmospheric and oceanic circulation models.

Each approach has its own advantages and disadvantages. Statistical methods are computationally simpler, but forecasting skill has been weakened in recent decades by trends in both predictors and predicted climate elements. This is particularly true of methods using linear statistical relationships. The dynamical approach is potentially the best tool for making seasonal predictions as they simulate the physical relationships that make each year's seasonal conditions unique. They also in principle have the ability to cope with changes in variables as climate change evolves. The major disadvantage is that they require complex computational methods and resources, and remain sensitive to errors in the initial conditions for calculation.

The Bureau of Meteorology (BoM) and CSIRO have recently decided to concentrate future development in seasonal climate forecasting technology on dynamical methods, as embodied in the Australian Climate Community Earth System Simulator (ACCESS). Current statistical seasonal climate methods as used in the BoM's Seasonal Climate Outlook are to be eventually discontinued. While the reasons for this understood, it is considered that there remains potential in statistical methods.

Research conducted as part of the Indian Ocean Climate Initiative (IOCI, see www.ioci.org.au) demonstrated the potential for non-linear statistical methods in developing seasonal forecasts. These can cope with trends and jumps in data, and allow the strength of relationships between variables to be tested. They are also computationally simpler than global climate models.

Seasonal climate forecast systems in Australia (BoM Seasonal Climate Outlook, and Queensland Department of Environment and Resource Management's Southern Oscillation Index Phase system) rely heavily on El Nino/Southern Oscillation (ENSO) influences as the major driver. While there is some influence on seasonal rainfall in Western Australia (WA), the relationship is weaker in general, and poor at critical times in the WA cropping calendar, such as early winter.

Research at the Bureau of Meteorology and more recently the University of New South Wales has shown that Indian Ocean sea surface temperatures can affect winter and spring rainfall over southern and south-eastern Australia. This influence is not explicitly captured by current operational seasonal climate forecasts.

Similarly, variation in atmospheric circulation over the Southern Hemisphere is a 'driver' for seasonal climate that is increasingly recognised as being important for southern Australia. This is also not captured by current operational systems. Dynamical systems should be able to simulate these phenomena, but are dependent on good quality weather observations.

In summary, there is a need to include climate system influences from other ocean basins such as the Indian and Southern Oceans. These are especially relevant to Western Australia, South Australia and western Victoria.

Another key need in seasonal climate forecasting is to better match the forecast to the decision-making of agricultural enterprises. As indicated in the Introduction, there are critical times of the year for making major management decisions. Forecasts at these times of the year can have a major influence on the production, economic, environmental and social outcomes over much of WA. Primary interest is in prediction of the extremes of seasonal climate. For instance, particularly dry or wet conditions can be defined by decile or terciles rankings. It is the extremes of the seasonal rainfall range that will drive major adjustments. Current seasonal forecasts are commonly expressed as probabilities of exceeding median rainfall (a two-category outlook). This has little uptake unless the probability is either very low or very high.

Producers are seeking forecasts of the likelihood of seasonal climate (especially rainfall) extremes for specific times of the year, such as May to July, and August to September. After seasonal rainfall, grain producers also seek forecasts of the likelihood of frost events during August to September.

A vital prerequisite for research into seasonal climate prediction is a good network of weather observations over the Australian landmass as well as over the surrounding oceans. This need applies to the development of both dynamical and statistical methods. Weather observations are also vital for model verification, as well as measures of seasonal climate variability, extremes and trends over time. Much of the success of Australian climate research is underpinned by the strength of its historical climate data. The maintenance or enhancement of this strategic asset is continually under threat from budget cuts.

Term of Reference 2: Innovations in long-term meteorological prediction systems

Several suggested innovation needs have been outlined in the response against the first terms of reference. These cover development of new statistical methods and focussing forecasts on specific time periods and extremes. The concept is to better match the climate forecast with needs from primary producers.

Through the last ten years of climate research a number of new innovative methods have been developed by the Department (Stephens, 2008). This research has sought to predict both ENSO events and droughts with lead-time, and following on from this, produce rainfall forecasts for the main May-October growing season (Tennant and Stephens, 2000).

Innovations include:

1) An El Nino Prediction Index (EPI) which indicates in November (previous year) strong El Nino events and severe droughts in the Indo-Australian region (Stephens and Lamond, 1999; 2000),
2) The discovery that the southern mid-latitudes plays a crucial role in the formation and decay of El Nino events (Stephens and Lamond, 2001; 2003a; Stephens et al., 2007).
3) A Mean SOI which is more stable than the SOI and has a 2-month lead over the SOI. The largest falls in this index, combined with a negative value of the index, is a strong indicator of major Australian droughts (Stephens and Lamond, 2003b). This was used to predict the 2002 drought (Profarmer Magazine, June 20th 2002; Stephens et al., 2003), http://www.agric.wa.gov.au/content/LWE/CLI/ENSO_INDEX.HTM)
4) A mid-latitude SOI (MLSOI) which more strongly correlates to rainfall across Australia than the traditional SOI (Stephens, 2008).
5) An ENSO Transition Index (ETI) which indicates with 6-12 months lead-time the transition from El Nino to La Nina (successfully predicted 2007 La Nina compared to most other models which didn't),
6) The new indices derived by the Department were combined in the ENSO Sequence System (ESS). This analogue year approach skillfully predicted

ENSO events from the end of the previous years (Stephens and van Burgel, 2009) and showed potential at predicting May-October Rainfall across large areas of Australia (Stephens, 2008). A summary of how the Department of Agriculture and food (the Department) forecasting indices and the ESS has gone at predicting May-October rainfall is summarized for the WA wheatbelt in Appendix 1.

7) Similar to England et al. (2006), the sea surface temperature gradient to the northwest of Australia (related to Indian Ocean Dipole) was found to strongly relate to wheatbelt rainfall in the southwest and southeast of Australia. Skillful forecasts of May-October rainfall appear possible from early February using this approach (Stephens 2008).

The indices from 1 and 3 (above) and the sea surface temperature gradient northwest of Australia) were combined to form an "Australian Drought Monitoring System". Since 1950, the severe droughts in 1957, 1965, 1972, and 1982 could have been predicted in November (year previous) and the majority of other droughts could have been indicated by the end of May leading into the crop season (Stephens, 2008). This drought scenario warning system should be used in conjunction with the ESS and a summary of local climate indicators. Following the unexpected drought in 2007 it was found that farmers needed a confidence measure to be placed on the forecasts. It was found that the confidence placed in a seasonal forecasts should relate to the "agreement" found in global and regional scale indicators. That is if local indicators are dry and global scale indicators are positive (La Nina), then a low confidence should be placed in forecasts. Farmer feedback has been positive on this format of forecast delivery

One of the main challenges to statistical forecasting systems is climate change and the apparent trends in rainfall in recent decades. To adjust for this in an analogue model, only highly ranked analogues from recent decades could be selected, or a rainfall trend is calculated and added to median rainfall in an operational system. These features and other statistical techniques need to be tested further with appropriate skill measures.

Term of Reference 3: The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism

For agricultural decision-making, accurate weather observations are crucial. The main issues in this case are the spatial occurrence of the observations (i.e. are there climate data in regions of interest?), and the accuracy, continuity and length of record.

Australia has good climate records by global standards, and this has underpinned the availability of information via the Bureau of Meteorology's web site and through computer packages such as Australian Rainman. Major degrading issues at present are the poor coverage over much of inland Australia, and the decline in the number of quality observing sites generally.

Many computer tools or systems developed to assist with agricultural decision-making rely on accurate historical climate data, and so the provision of accurate climate records is vital.

Comments already made against Terms of Reference 1 and matching user needs are also relevant to the accurate prediction of inter-seasonal climate variability. The potential impact of accurate prediction of major seasonal climate anomalies or deviations is enormous in terms of avoidance of economic and environmental downside risk, as well as the opportunity to capitalise on upside risk. As an example, total grain production in WA was more than halved during very dry years in 2002 and 2006. This is despite significant gains that had been made in cropping technology over previous decades. Depending on prices, this represented losses of hundreds of millions of dollars to the state and national economy. These years also saw major soil erosion events, animal welfare issues, regional economic hardship and social stresses.

One of the problems with existing forecasting systems is that they are not designed to predict extreme events, just shifts in rainfall probabilities. The SOI phase system, for example, selects many analogues for each of the five possible phases. Since the median rainfall of these years was not to far from average (even in extreme falling and negative phases) the median rainfall overestimated actual rainfall in drought years (Stephens et al., 2000). In the 2002 drought farmers mentioned that the probabilities of exceeding the median rainfall were not extreme enough (30-50%) for them to warrant changing their management (Stephens et al. 2003). Farmers most need warnings of drought or bumper conditions, so for an analogue year approach to have value there must be a narrowing down of analogue years for the system to predict extreme events. This is the basis for the Department's approach of selecting five analogue years in the ESS.

Historically, despite the expertise and tools available to help farmers manage their business in response to climate variability, application of climate information in decision making has been poor. Reasons appeared to include lack of confidence in forecasts, and lack of appreciation of the economic benefits and the management changes to make when a good or poor season is likely (Dracup, Foster et al. 2003).

A needs analysis, undertaken in 2006 as Stage 1 of a project designed to improve the capacity of WA wheatbelt farmers to manage climatic risk found that about half of WA farmers did not use historical climate information, did not regularly access climate outlook/forecast information and the large majority did not use climate risk decision support tools. While the farm advisory services situation was better, over a third of advisors surveyed did not regularly use climate outlooks and forecasts and about two thirds did not use decision support tools. Of those farmers that did use historical climate information, less than 30% stated that they use that information to assist in making farm management decisions (Beard and Short 2007).

Three key factors influencing the low uptake of seasonal forecasts and other climate information and tools were seen as:

- the accuracy and timeliness of climate information
- the way in which this information is communicated and
- farmer skills in its interpretation and application

An evaluation at the completion of the project in 2008 reached a number of conclusions:

- Many cropping farmers believed there was value in the use of the tools but there were also a significant number who questioned that value with the predominant reason being a lack of confidence in seasonal rainfall predictions, rather than any doubt about the value of the principles underlying yield predictions. Others felt that the lack of accuracy in forecasting the season finish, particularly earlier in the season when the majority of the decisions are being made, decreased their confidence in using this information for decision making (Sherriff, Falconer et al. 2008).
- While the majority of farmers involved or associated with the trial activities claimed to take seasonal outlook information into consideration when making decisions, only a third actually rated the information as being useful and climate outlooks were one of the least important factors they took into account when making management decisions.

Reinforcing the findings of the needs analysis, accuracy and timeliness of climate information is therefore critical to the uptake of that information. (Beard 2009)

Term of Reference 4: Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail and tsunami, in Australia and neighbouring countries.

There are clear benefits for preparedness from forecasting the seasonal risk of extreme events such as bushfires and flood. However it should be noted no system is able to predict individual events at seasonal lead times, that is, at periods of a month or more in advance. Weather forecasting is reliable only to about a week ahead, with a theoretical limit of about two weeks.

A forecast will only describe the risk of such daily extreme events occurring during the forecast period. Some events, such as bushfire will have a set of preconditioning events (like a prolonged dry period) that will raise the risk in addition to any forecast. The risk of bushfires, floods, hail and tropical cyclones is seasonal (ie more likely in summer), and is there in most years. Variation is risk from year to year is linked to ENSO over much of Australia.

While improvements may be possible, there will remain a communication issue to the community. For example, bushfires are an annual risk and regional populations routinely prepare for them. Work needs to be done to determine if the forecast (of either increased or decreased seasonal risk) is of benefit.

Term of Reference 5: Strategies, systems and research over seas that could contribute to Australia's innovation in this area.

They key here is to maintain scientific links with overseas research and to maintain domestic research capacity. The meteorological research community in Australia already has strong international links.

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APPENDIX 1: SUMMARY OF (THE DEPARTMENT'S) SEASONAL OUTLOOKS PRESENTED AT CROP UPDATES CONFERENCES IN FEBRUARY AND WHAT FOLLOWED.

YEAR	ENSO State prediction	ENSO actual	Rainfall outlook (confidence)	Actual Rain in deciles - most of WA wheatbelt	Perth dam Inflow (GL) Ave. 164 GL since 1975	State average wheat yield (t/ha)
2001	2/3 El Nino	neutral	Drier season (low)	2-5	40	1.81
2002	El Nino	El Nino	Average to well below (high)	1	85	0.96
2003	3/5 La Nina 2/5 neutral	neutral	Average to above average (high)	5-8	147	2.14
2004	3/5 neutral 2/5 El Nino	neutral	Average to below average (low)	2-6	88	1.70
2005	neutral	neutral	Average (low)	4-8	112	1.92
2006	3/5 neutral, 2/5 El Nino	El Nino	Below average (medium)	1	15	1.26
2007	La Nina	La Nina	Average (medium)	1 north 2-5 south	130	1.49
2008	4/5 La Nina	neutral	Average (medium)	3-7	60	1.77