<u>**Submission No. 13**</u>

Submission to the House of Representatives Industry, Science and Innovation Committee *Inquiry into Long-term Meteorological Forecasting in Australia*

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Purpose of submission:

This submission provides a services perspective on long-term meteorological forecasting in Australia.

Summary of my relevant background

I was head of Climate Analysis and Prediction in the National Climate Centre of the Bureau of Meteorology for nine years in the 1990s and then Head of the National Climate Centre for 3 years. I oversaw the operations of the Bureau's climate monitoring and seasonal outlook services during that time. I have a particular interest in products and services based on good quality climate data and sound scientific understanding of climate. I worked to consolidate NCC as custodian of the highest possible quality national climate record (an important basic resource for delivering climate services to the community, to underpin science-based assessments of pollution, for developing and testing forecast systems, for monitoring climate change and for climate impact assessments).

I have been a casual lecturer in climate at both La Trobe University and the University of Melbourne for approximately 5 years.

I am currently a member of the Australian Meteorological and Oceanographic Society (AMOS) and serve on the Technical Advisory Committee of the Managing Climate Variability Program (LWA), and some of the material contained in this submission was supplied to these organizations for consideration for their submissions.

Preamble

Environmental stress on seasonal to decade timescales and a need for climate services on relevant timescales

This recent summer (2008-09) and early autumn (2009) has been an environmental catastrophe for Victoria. Over 300 heat-wave-related human deaths occurred, nearly 200 bushfire deaths were documented and post-traumatic stress-related deaths are still expected. Hazardous household and farm materials (such as asbestos, toxic ash from burnt treated timbers, medicines, garden and farm chemicals, ash and dusts) were released into the environment during the fires. In the north of the State, approximately 800km of the Murray River is contaminated with toxic algae. In addition, since 2003 a cumulative total of nearly half of Victoria's public lands have burned in bushfires with an as yet unknown impact on the State's biodiversity. The quality of Melbourne's water supply was also under threat for several weeks during the worst of the bushfires. These months have placed a huge burden on Victoria's communities, particularly fire-fighters, police, health workers, environmental protection teams and directly affected communities or demographic groups. How much could taking action on a (possible) decadal forecast of likely continued warming have helped ease this situation?

Touching briefly on Queensland's summer, the extensive and significant flooding led to at least ten deaths, and 935 reported cases of Dengue fever, a very serious disease. Add the emergency response needed in Queensland over the summer months of early 2009 and the magnitude of the national effort to manage a high impact season becomes apparent.

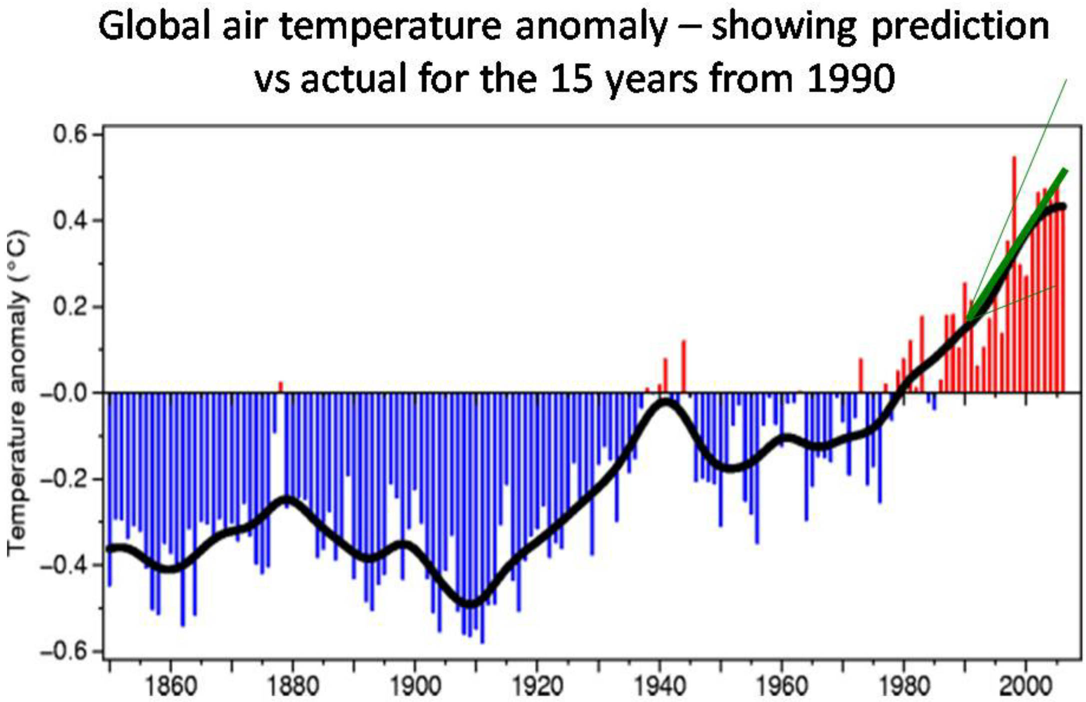
These events/episodes could be characterised as short-term events embedded in anomalous seasons embedded further in an anomalous climate period. They demonstrate the interaction between weather and climate and hence a potential to use forecasts and outlooks on a range of timescales.

In my opinion, the efforts by response teams, health and welfare agencies, etc has been excellent, supported by useful weather and climate information and outstandingly accurate 6 hour to 5 day weather forecasts.

Looking more broadly at environmental goals, it is most likely that the recent disasters, combined with decade-long rainfall deficits[1], have had a negative impact on our efforts to achieve such goals. This suggests that we should be looking more closely at longer-term climate prediction and how it can be used by the community.

Is it time that climate change forecasts at the decadal scale (along with their uncertainties) be prepared routinely for Australian planning purposes? Should some targeted research at preparing these for Australia be commenced now (the UK is making first careful and prudent services in this area). The "climate prediction" below, albeit for the global scale, suggests that some skill already exists.

[1] In some locations in the tropical north there have been decade-long rainfall surpluses



The thick green line shows the best estimate "prediction" made by the IPCC in 1990 and the thin green lines the estimated most likely range, the vertical bars show the actual that occurred for each year and the black curve is a smooth line through the observations. *Note the green lines are my schematic representation of the IPCC predictions (projections) from 1990.*

Terms of Reference 1, 2 and 3:

The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems;

And

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

And

Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail and tsunami, in Australia and in neighbouring countries;

I will concentrate my comments on consideration of the components of an integrated system to deliver robust, timely and relevant information services that can assist planning, management and community activities. I will interpret the term *prediction systems* in its wide context of the prediction methods plus the systems that are required to run forecasts and deliver services.

Following on from the discussion in the preamble above, which highlighted the interaction between weather and climate and the timescales involved in various climate anomalies, the table below (Table 1) illustrates information needs to support a range of activities to help manage climate variability.

Table 1. Framework and context for response to weather and climate-related high impact events/episodes and/or natural disasters

Nature of activity	Supporting information (weather and climate-related)	Products	Activity that is supported	
Strategic	Climatology	Historical climate normals and frequencies of high impact events/episodes	Design of roads, bridges, dams, culverts, storm water systems, irrigation systems, farming systems, drought policy, emergency management systems, natural resource management strategies, etc	Response to weather and climate-related high impact events/ episodes and/or natural disasters
	Climate change information (eg, a decadal prediction)	Very few specific products are currently available that are targeted at decadal timescale	General planning and preparedness	
	Current on-ground information	Status of water resources, ground water, soil moisture, ground heat storage, etc.	Tactical preparedness and assessment of current risk	
	Current climate state	Global climate patterns, status of El Niño, sea surface temperatures, etc	Tactical preparedness and risk assessment for coming few seasons	
Tactical	Seasonal forecast	Probabilities/likelihood of climate conditions one season or two ahead	Tactical planning	
	Few days to 2 week weather outlook	Probabilities/likelihood of weather threats out to two weeks ahead	Weather threat assessments	
	Weather forecast (few hours to few days)	Weather forecasts	Operations	

All of these pieces of information and activities in Table 1 contribute to optimising societal preparedness and response to high impact events/episodes, and all deserve consideration in efforts to improve our preparedness and response. In my opinion the Australian effort is quite well integrated, largely because the fundamental underpinning data and information (the national climate record) is the responsibility of a federal agency and is available to all Australians on an equal footing.

Long-term meteorological forecasts can be categorized by two components: the advance period (how far in advance the forecast is made) and the period of coverage (the length of time the forecast refers to). So they can be outlooks (forecasts) that can commence from a few weeks to years ahead, and cover time-periods of a few weeks to a season to a few years. It should be noted that not all such outlooks will have the same level of accuracy or reliability, but they may also have different uses by different groups that may be able to accommodate different accuracy levels, provided they are well understood.

In considering the efficacy and utility of information and products noted in Table 1, while all areas in the table need to be kept up to date and continuously improved, I suggest that those areas shaded in pink currently warrant additional research and service development effort in Australia.

Terms of Reference 4 – Strategies, systems and research overseas that could contribute to Australia's innovation in this area.

Australia has been one of the pioneering countries in terms of strategies and system design that underpin prudent and robust services. This has been based on using scientifically tested understanding of climate relationships (tested in the peer-reviewed scientific literature), couching seasonal outlook services in likelihood terms (we cannot be and never will be 100% certain that **x** amount of rain will fall at **y** location in season **z**) and in putting together end-to-end systems that ensure good quality data and supporting information to underpin the services. The "flow-chart" below, presented in the form of a table (Table 2) illustrates the components of an end-to-end system. Australia has put effort into all of these components and there is probably little that overseas can teach us in designing the "system" although we should always be alert to new ideas

These Australian systems are well-tested and relatively robust although resource constraints stretch them, and those resource constraints have tightened over the past decade.

However, we need to invest in maintenance (for example maintaining and keeping up-to-date the climate data archive) and continuous improvement of this end-to-end system (Table 2). Any broken link in the chain can affect the service robustness or quality. So we need to ensure that a continuous improvement philosophy is maintained.

In terms of strategies, the BoM-CSIRO-LWA/MCV cooperation has been quite effective in terms of getting users involved. The state-based agencies (such as DSEs and DPIs and water agencies) have also provided an important user focus.

In my opinion, the overseas research that could help Australia and Australian scientists are: large-member ensembles from climate models (this needs a very good supercomputing facility); possibly some of their expertise in the weekly to ten-day timeframe or in a wider spread of service products (see Attachment 1); an IRI-type[2] collaborative institutional framework might help; and assistance with implementation of a full earth system model for use by all relevant Australians, namely all the relevant universities, CSIRO, BoM, etc.

There is much that overseas scientists or research agencies will **NEVER** do for us, that we **must** do for ourselves, because they are locally specific or relevant. Examples of these could include the scientific challenge of the autumn predictability barrier, the Australian monsoon and Australian region tropical cyclones (TCs), robustly capturing signal from all relevant climate drivers combined; blending statistical and dynamical model outputs (if needed, and first needs to be researched), direct forecasting of impacts on Australian regions and Australian activities, and tailoring forecasts/outlooks for different timeframes to suit Australian activities.

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[2] The USA established a major research institute (the *International Research Institute for Climate and Society*, or IRI) aimed at developing and using seasonal-to-interannual forecast methods to “enhance society's capability to understand, anticipate and manage the impacts of seasonal climate fluctuations in order to improve human welfare”. Other countries have also invested in ongoing, focused and stable research arrangements.

Table 2 THE END-TO-END SYSTEM NEEDED FOR ROBUST, RELIABLE VERIFIABLE CLIMATE PREDICTION

<table>
<tr><td>COMPONENT OF END-TO-END SYSTEM</td><td>CONTENTS, METHODOLOGIES, ETC</td><td>SUB-COMPONENTS AND/OR ADDITIONAL INFORMATION</td></tr>
<tr><td>Observations</td><td>Meteorological
Water
Remotely sensed information</td><td>Quality control procedures</td></tr>
<tr><td>Data base</td><td>Climate – present and historical</td><td>Quality control procedures</td></tr>
<tr><td>Current and perspective analyses</td><td></td><td>Also what’s going on with climate impacts overseas</td></tr>
<tr><td>Current state/mode of the large-scale climate system</td><td></td><td></td></tr>
<tr><td>Analysis of climate modes</td><td></td><td rowspan="3">Robustness/ prudence/ relevance checks

Verifications</td></tr>
<tr><td>Climate prediction</td><td>Statistical methodologies and increasingly dynamical climate models</td></tr>
<tr><td>Probabilities /frequencies and relevant prediction model outputs</td><td></td></tr>
<tr><td>Applications and service products</td><td>Relevant to user needs</td><td>Quality control procedures</td></tr>
<tr><td>Service providers</td><td>Both climate information providers and “extension” officers</td><td></td></tr>
<tr><td>Risk analyses</td><td>Techniques for understanding and managing (as far as possible) risk and uncertainty (including education and social systems)</td><td></td></tr>
<tr><td>Client relations, social knowledge, education and training</td><td></td><td></td></tr>
<tr><td>Website and website maintenance</td><td>Primary providers and “extension”” providers</td><td>For example, the Bureau of Meteorology’s website recently withstood the combined onslaught of almost nation-wide severe weather – floods, tropical cyclones, and the worst natural disaster in Australian history (heatwave and bushfires)</td></tr>
</table>

Conclusion

The inquiry is invited to view the long-term meteorological forecast challenge in terms of the logical pathway (continuum) from researching the climate system and developing methods and models to the development and delivery of products and services. The inquiry is invited to consider the extent to which ongoing support is needed along that continuum.

Attachments

Attachment 1:   Examples of products from various operational centres overseas, taken directly from their websites.

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Outlooks Index of CPC NOAA (www.cpc.noaa.gov)

Outlooks

- Implementation Notes
- Base-Period Means

Monthly to Seasonal

- Schedule for Monthly and Seasonal Outlooks
- Monthly Temperature & Precipitation Outlooks
- Seasonal Temperature & Precipitation Outlooks
- Monthly and Seasonal Temperature & Precipitation Outlooks (Color version)
- Monthly and Seasonal Outlooks for Hawaii (text version)
- Monthly/Seasonal Forecast Verifications
- 13-Month Seasonal Outlook for Hawaii
- Tropical Pacific Islands Rainfall Outlooks
- Monthly/Seasonal ENSO Outlook (SSTs)
- 12-Month SST Consolidation Outlook
- Probability of Exceedance Outlook
- Seasonal Drought Outlook

Extended Range Outlooks

- 6-10 Day Temperature and Precipitation Outlooks
- 8-14 Day Temperature and Precipitation Outlooks
- 3-7 Day Excessive Heat Outlooks (Hydrometeorological Prediction Center)
- 6-10 Day Excessive Heat Outlook
- 8-14 Day Excessive Heat Outlook
- 6-10 Day Wind Chill Index Outlooks
- 8-14 Day Wind Chill Index Outlooks
- 1 week ahead meteorological hazard potential outlook

Special Outlooks Products

- Atlantic Hurricane Outlook
- East Pacific Hurricane Outlook
- Current UV Index Forecast
- Palmer Drought Outlooks
- Soil Moisture Outlooks
- Degree Days Outlooks
- Selected El Niño Based United States Forecasts and Corresponding Observed Conditions for 1997-98

National Weather Service (NWS) Forecasts

- Watches & Warnings
- 0-48 Hours
- 3-7 Days
- 8-Day MRF_Based Objective Guidance

UK MET OFFICE (www.metoffice.gov.uk)

the North Atlantic tropical storms forecast for the June to November season.

Day 6 to 15 outlook, updated daily

UK/Europe forecasts for the conventional seasons

Seasonal forecasting: what may happen for a season (a three-month period) ahead.

-- broad trends in temperature and rainfall and normally expressed in probabilistic terms. Examples of products available as of early April 2009 for the coming seasons:

Summer 2009 - Issued: Tue 31 Mar 2009

Spring 2009 - Issued: Wed 25 Mar 2009

Winter 2008/9 - Updated: Thu 22 Jan 2009

Autumn 2008 - forecast appraisal Issued: Wed 4 Mar 2009

They also issue a forecast of the mean global mean surface temperature for a year ahead.

UK produced Forecasts for other regions

They make seasonal forecasts focusing on specific regions where there is particular vulnerability to seasonal anomalies such as droughts, and where relatively good predictability has been identified. These include forecasts for rainfall in the north-east corner of Brazil during their wet season (February-May), in East Africa during the October-December wet season and in tropical West Africa, including the Sahel region, for July to September.

ECMWF: European Centre for Medium Range Weather Forecasts

ECMWF Products

We provide the results from our operational forecast activities to our Member States and Co-operating States, the members of the WMO and the public.

Forecasts

We operate a deterministic forecasting system providing weather predictions out to 10 days. Performance statistics are provided.

The seasonal forecasts out to six months are produced with a coupled ocean-atmosphere model.

The International Research Institute for Climate and Society (IRI)

Climate Forecasts
Forecast Products Overview
IRI Seasonal Climate Forecasts
Net Assessment Forecasts
Interactive Net Assessments
AGCM Predictions

SST Forecasts
Probabilistic ENSO Forecasts
Experimental Tropical Cyclone Activity Forecasts

- ***Seasonal Climate Forecasts***
    - Forecasts in Context of Recent Observations
    - Probability Forecasts for User-Selected Precipitation Amounts

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